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Interim Report

Volume II, July 1981

LEVEL III

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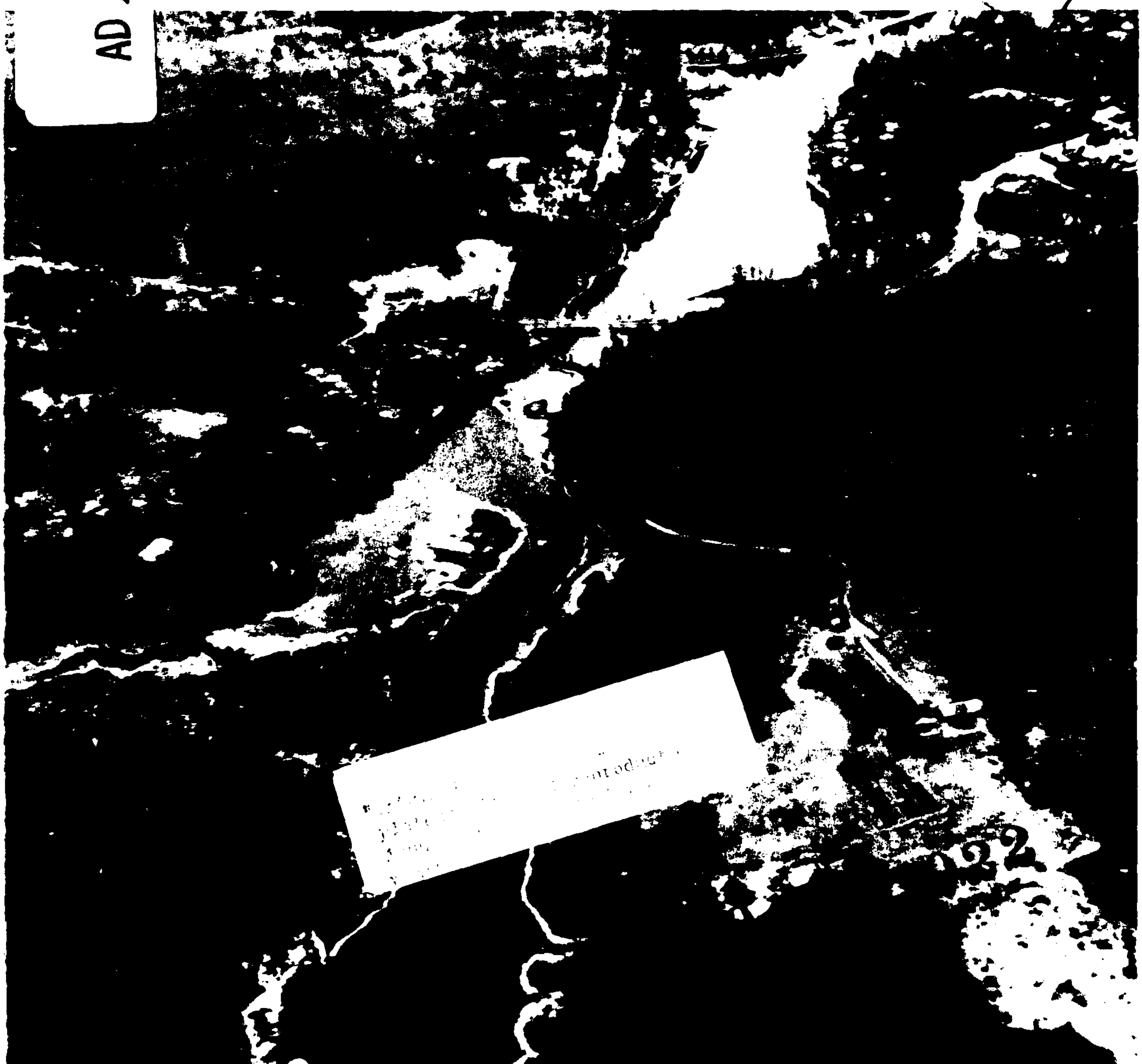
Big River Reservoir Project



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Volume II, Appendices A through G encompasses the aspects of problem identification, plan formulation, public participation, hydrologic analysis, water quality, geotechnical investigations and design and cost estimates.

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

INDEX OF VOLUMES

6

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study,

BIG RIVER RESERVOIR PROJECT,

Volume II,

APPENDIX A - G.

PROBLEM IDENTIFICATION

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APPENDIX A

PROBLEM IDENTIFICATION

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INTRODUCTION

This appendix contains the detailed descriptions and technical data to support the Introduction and Problem Identification sections of the Main Report. In the interest of clarity and presentation, the appendix is presented in essentially two sections. The first section contains information on the study authority and scope, the study area and other studies and reports.

The second section contains information on the existing regional profile and projected future conditions. It also identifies specific water and related land resources problems, needs, and opportunities to be addressed in plan formulation.

STUDY AUTHORITY

Authority for this report is derived from seven Congressional resolutions combined under one resolve and adopted by the Committee on Public Works of the United States Senate. These resolutions provided authority for the Pawcatuck River and Narragansett Bay (PNB) Drainage Basins Study, shown on Plate A-1, of which this interim report is in partial response. The report is also submitted in response to a letter dated 8 January 1978 received from the Governor of Rhode Island which requested the Corps of Engineers to investigate the feasibility of the Big River Reservoir in the interest of flood damage prevention, water supply and allied water uses. The resolutions pertaining to this study and report are the following:

> Resolution adopted 29 March 1968 by the Committee on Public Works of the United States Senate:
>
> "That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, with a view to determining, in light of the heavy damages suffered during the storm of March 1968, in southern New England, the advisability of improvements, particularly in the Pawcatuck River Basin, Rhode Island, and in the Narragansett Bay Drainage Basin, Massachusetts and Rhode Island, in the interest of flood control, navigation, water supply, water quality control, recreation, low-flow augmentation, and other allied water uses."
>
> Resolution adopted 10 July 1968 by the Committee on Public Works of the United States House of Representatives:
>
> "That the Board of Engineers for Rivers and Harbors is hereby requested to review the reports on the Land and Water Resources of the New England-New York Region, transmitted to the

President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, with a view to determining in light of the heavy damages suffered during the storm of March 1968, in southern New England, the advisability of improvements, particularly in the Pawcatuck River Basin, Rhode Island, and in the Narragansett Bay Drainage Basin, Massachusetts and Rhode Island, in the interest of flood control, navigation, water supply, water quality control, recreation, low-flow augmentation, and other allied water uses."

Resolution adopted 2 February 1970 by the Committee on Public Works of the United States Senate:

"That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, and other pertinent reports, with a view to determining whether any improvements for flood control and other water resources purposes are advisable at this time, particularly along the Pawtuxet River, Pocasset River, and Meshanticut Brook, at and in the vicinity of Cranston, Rhode Island."

SCOPE OF THE STUDY

This survey study focused on the identification of water supply, flood damage, and recreation problems in the study area and evaluated these problems in relationship to the overall environmental, social, and economic needs of the people living and working therein. The study resulted in the development of alternative solutions to provide adequate water for study area communities, to protect flood-prone areas and prevent flood damages, and also to meet the recreational needs of people within the study area and within the State. The costs, benefits, and environmental impacts associated with implementing the various alternatives were also investigated as was the selection of the plan that would most effectively solve the problems in a way that would be compatible with environmental and socio-economic needs.

Detailed investigations were limited to those communities within the Pawtuxet River basin, one of five major sub-basins comprising the entire PNB Study region, and, for purposes of water supply planning, within the legislated service area of the Providence Water Supply Board. Not all areas were investigated to the same level of detail but only where improvements warranted detailed study.

This report is based upon area field reconnaissance, topographic surveys, soils investigations, hydrologic and hydraulic investigations, water quality studies, water usage studies, consultation with local interests, review and evaluation of prior studies and reports, and other related studies.

Data concerning basic demographic and economic conditions within the study area were obtained from field investigations, published reports and consultation with local officials. Records of the United States Geological Survey and National Weather Service were utilized for determination of climatologic, hydrologic and hydraulic data, and water supply information was obtained from past and current records of the Rhode Island Department of Environmental Management, Water Resources Board and water supply agencies within the study area. Data concerning flood conditions for past floods were determined by field damage surveys, consultation with local officials, and local and published reports. Initial plan formulation and last stage studies in the preparation of this report were coordinated with other Federal, State, regional and local agencies having expertise in water resources development, special interest groups, and the general public.

The remaining areas of the PNB study region are the focus of other studies being conducted by the Corps of Engineers in total response to the authorizing resolutions.

STUDY AREA

The study area, located in the central section of Rhode Island, is part of the overall Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Study which encompasses five major sub-basins and all or parts of 102 communities in Massachusetts, most of Rhode Island, and part of Connecticut as shown previously on Plate A-1. The study area includes the entire Pawtuxet River Basin and portions of the Providence River Group and Narragansett Bay Local Drainage area. The 469.1 square miles of land that make up the study area comprises the greater portion of Providence County and all of Kent County and Bristol County. The study area includes a major portion of the Providence-Pawtucket-Warwick Standard Metropolitan Statistical Area (SMSA).

The Big River Reservoir study region is generally rectangular in shape with an irregular eastern boundary that runs coincident with the Massachusetts-Rhode Island border. In addition, the area is bounded by Connecticut to the west, the towns of Burrillville, North Smithfield and Lincoln to the north, and Exeter and North Kingstown to the south as shown on Plate A-2. The study area includes 17 cities and towns in Rhode Island, 15 of which comprise the legislated service area of the Providence Water Supply Board (PWSB). The other two communities, East Greenwich and West Greenwich, are included in the study area since they are served by one of the major water supply systems in the study area.

OTHER STUDIES AND REPORTS

CORPS OF ENGINEERS

Pawcatuck River and Narragansett Bay (PNB) Urban Study

In February 1973 the ongoing PNB water and related land resources study was reoriented to urban study status under the direction of the New England Division, Army Corps of Engineers. Areas addressed in the study include inland flood control and flood plain management, water supply, coastal restoration and protection, and navigation.

Drainage basins reported on in the PNB study include the Pawtuxet River, Taunton River, Pawcatuck River, Narragansett Bay Local Drainage, and the Providence River Group, which comprises the Blackstone, Woonasquatucket, Moshassuck, and Ten Mile River Basins. An interim report is scheduled for release in FY 1981 on the Blackstone River Basin. Investigations of the other basins are being completed this year, with findings and recommendations due to be included in the overall PNB report scheduled for publication in FY 1981.

Investigations of the Taunton, Woonasquatucket and Ten Mile Rivers are flood management type studies, because no significant structural solutions were shown to be economically justified. The Moshassuck River study is being carried out as a separate flood plain management study. The Blackstone River Basin flood control study is described later in this section.

Detailed regional water supply alternatives for the entire PNB study area will be part of the overall report.

PNB Water Supply Study

A study of water supply alternatives for the Pawcatuck River and Narragansett Bay (PNB) drainage basins was completed in January 1979 under contract by the New England Division, Corps of Engineers. The draft report proposed alternative water supply plans to serve the PNB region, including surface water, groundwater, and combinations thereof. The study's recommended plan includes development of the Big River Reservoir to help meet future demands of the Providence area.

Blackstone River Basin Study

As part of the PNB study, flood control problems and needs of the Blackstone River Basin have been addressed in a separate report by the New England Division, Corps of Engineers. The final report, to be released in FY 1981, will recommend both structural and nonstructural flood damage reduction measures to meet the basin's needs.

Pawtuxet River Water Quality Study

A one year water quality sampling and analysis program for the Pawtuxet River was initiated in September 1975 by the Environmental Protection Agency and the National Marine Water Quality Laboratory under contract to the New England Division, Corps of Engineers. The program entailed collection of water samples from the Pawtuxet River at three upstream sampling stations and another sampling station near the river mouth, during 20 sampling periods. The program involved bacteriological analyses for total and fecal coliforms and physical-chemical analyses for nonfilterable residue, biochemical oxygen demand (BOD) and various heavy metals.

Flood Control Project Environmental Report

Under the direction of the New England Division, Corps of Engineers, an environmental report was prepared in February 1975 (with minor revisions in May 1975). It concerned measures under consideration by the PNB study to reduce flood damages in the Pawtuxet River watershed. The report discussed the environmental setting without the proposed flood control measures, the probable impacts of the proposed actions, and alternatives to the proposed actions. Findings were summarized in the information pamphlet prepared for the midstage public meetings held by the New England Division at Warwick and Cranston in May 1975.

Flood Plain Information Studies

Flood plain information studies of selected streams in Cranston, Warwick and West Warwick have been completed by the New England Division, Corps of Engineers.

North Atlantic Regional Water Resources (NAR) Study

Authorized by the 1965 Flood Control Act, the North Atlantic Regional Water Resources (NAR) Study was one of 20 regional studies conducted throughout the United States under Level A guidelines established by the Water Resources Council. Published in June 1972 by the North Atlantic Division, Corps of Engineers, the report encompassed all river basins draining into the Atlantic Ocean from Maine to Virginia and all New York and Vermont areas draining into the St. Lawrence River from St. Regis, New York eastward. The objective was to establish a broad master plan or framework as a basis for regional water and related land resources management. Fifteen water resources needs in each of the 21 subregions of the NAR study area were projected through the year 2020. Several alternative planning objectives were utilized: environmental quality, national efficiency (or income), regional development, or mixed objectives. A basic finding for the entire study area was that the NAR water resources cannot support continuation of the customary development and consumption. Research, study and management of water, land and environmental resources are needed to reduce the needs for excessive monetary and natural resource investments.

The report indicated that the PNB area will need help in eliminating its unemployment. Its water resources management program should be oriented toward increasing regional development, but with some environmental quality constraints. Key long-term (2020) needs for the PNB area were water quality management and improvement to meet state standards, availability of power plant cooling water (mostly saltwater sites), water supply withdrawal and importation measures (with future shift expected by many industries from self-supplied to publicly supplied systems), flood damage reduction measures as land becomes scarce, commercial navigation improvements, shore erosion protection for selected sites, and increased opportunities for water-oriented recreation, fish and wildlife recreation, and recreational boating.

Northeastern United States Water Supply (NEWS) Study

Under authority of the 1965 Flood Control Act, a regionwide assessment of water supply problems of the metropolitan areas between Maine and Virginia was made as part of the Northeastern United States Water Supply (NEWS) Study, under the direction of the North Atlantic Division, Corps of Engineers. A draft report was prepared by the New England Division in November 1969 concerning long-range water supply needs in Rhode Island and most of Massachusetts. The surface water project proposed for the Pawtuxet watershed area are the same as those recommended in the 1967 report to the former Rhode Island Water Resources Coordinating Board. No groundwater projects were proposed for the Pawtuxet watershed area by the U.S. Geological Survey, which analyzed all existing groundwater data as their contribution to the study.

Navigation Survey Report

In response to a resolution by the House of Representatives Committee on Public Works, a report prepared in June 1961 by the New England Division, Corps of Engineers recommended provision of a small boat harbor improvement at Pawtuxet Cove, the small tidewater indentation at the mouth of the river. The project was authorized by the 1962 River and Harbor Act and was completed in 1966. It entailed dredging an entrance channel 6 feet deep and 100 feet wide, with a turning basin at the northern end; dredging an anchorage 6 feet deep over a 14-acre area at the south side of the entrance channel; and construction of a 2,200-foot long sheltering dike at the east side of the anchorage.

Narragansett Bay Area Hurricane Survey Reports

Public Law 84-71 study authority, which was adopted following the damaging hurricanes of 31 August 1957, led to the 1958 authorization and 1961-66 construction of the Fox Point Barrier across the upper reach of the Providence River at Providence. A plan for hurricane tidal flood protection for the Narragansett Bay area, known as the Lower Bay Barriers, was completed in January 1965 by the New England Division. The report called for provisions of rockfill barriers (top elevation 25 feet above mean sea level) across the East and West passages to Narragansett Bay and across the upper passage of the Sakonnet River, subject to local agreement for participation in the project. Ungated navigation openings would be provided at each passage and 80 sluice gates would normally remain open to allow additional tidal interchange. The barriers would reduce the wave action level of 18.0 feet at Pawtuxet Cove that accompanied the record hurricane flood of 21 September 1938 (frequency slightly less than once in 100 years) to approximately 10.6 feet, and would reduce the 1938 tide (stillwater) level of 15.3 feet to approximately 7.8 feet.

A majority of the comments made at the 1956 public meeting on the Fox Point Barrier project expressed general approval of the lower Narragansett Bay protection concept. Support by Massachusetts interests continued strong during the course of the Narragansett Bay study. However, support by the

Rhode Island citizens waned and opposition was expressed concerning various biological, aesthetic, tidal interchange, water quality, salinity and navigation aspects of the Lower Bay Barriers plan. In view of this lack of support, the Secretary of the Army's report to the Congress recommended that no project be authorized for the lower Narragansett Bay area until such time as Rhode Island citizens expressed approval of the project.

Flood Control Survey Report

In response to Section 5 of the 1937 Flood Control Act, the Providence District, Corps of Engineers prepared a report in October 1939 that recommended a flood control plan for the Pawtuxet River watershed. The plan entailed local protection works at Clyde (along the North Branch in West Warwick) and a gated diversion dam near Pontiac (along the main river in Warwick) to divert floodwaters from the main river southward through a diversion channel that would discharge at Apponaug Cove, at the head of Greenwich Bay in Warwick. Both projects were authorized by the 1941 Flood Control Act, but authorization expired in 1951 as local participation (lands, easements, right-of-ways, cost sharing in 25 percent of the first cost of the Pontiac Diversion not to exceed $347,000, and operation and maintenance of the project following completion) was not forthcoming.

OTHER FEDERAL AGENCIES

Rhode Island Areawide Water Quality Management Plan

Under Section 208 of the Federal Water Pollution Control Act Amendments of 1972, Rhode Island was awarded an EPA grant to develop an areawide water quality management plan to assure adequate control of all sources of pollution in the state. The final plan establishes management strategies for all activities associated with the generation of point and nonpoint sources of pollution. Nonpoint sources of pollution on which planning emphasis were placed include marinas, landfill sites, groundwater pollution, and urban runoff. Point sources to be discussed in detail include combined sewer overflows and municipal wastewater treatment facilities. Also to be examined will be legal, institutional and financial arrangements for developing the necessary agencies to manage or control wastewater generation. The objective of these investigations is to provide a plan for attaining the Act's 1983 goals of fishable and swimmable water quality, wherever possible.

Cranston Flood Hazard Analysis Report

At the request of the city of Cranston and the Rhode Island Statewide Planning Program a flood hazard analysis report on the Pocasset River and Meshanticut Brook within Cranston was published in September 1973 by the Soil Conservation Service, which assisted the Northern Rhode Island Conservation District. An addendum to this report was published in December 1974. The report contains flood maps, high water profiles and typical valley cross sections which provide a guide for the development of local regulations and other flood management measures for minimizing flood damages. Information was compiled for 10-year, 50-year, 100-year and 500-year frequency floods, except for the flood maps which show only the 50-year and 500-year flood limits. The 100-year flood limits are essentially the same as the 50-year flood limits.

Flood Insurance Studies

Under authority of the National Flood Insurance Act of 1968, Flood Insurance Study reports have been prepared by the Federal Insurance Administration, Federal Emergency Management Agency for the communities of Barrington, Bristol, Warren, East Providence, North Providence, Providence, Cranston, Warwick, Johnston, Smithfield, Glocester, West Warwick, and East Greenwich, which are operating under the regular program. The towns of Foster, Scituate and West Greenwich have flood insurance studies in progress and are now eligible for flood insurance under the emergency program until specific flood zones and actuarial rate are determined and flood plain zoning is enacted. A flood hazard analysis of the Pocasset River in Johnston has been completed by the Soil Conservation Service office in West Warwick.

United States Geological Survey

Water resources investigations have been conducted by the U.S. Geological Survey (USGS) in cooperation with the State of Rhode Island for various regions within the study area. These investigations, ranging from reconnaissance-type studies to detailed studies of water resources for river basins throughout the study area, have centered primarily in southeastern Massachusetts and Rhode Island. These studies have included groundwater availability investigations in the Taunton River Basin, the Lower Blackstone River Basin in Massachusetts and Rhode Island, and the Pawcatuck River Basin. The results have been published in the USGS Hydrologic Investigations Atlases as well as in various reports prepared by both states.

REGIONAL

Report of the Southeastern New England (SENE) Study

As part of the program established by the 1965 Water Resources Planning Act that multipurpose, coordinated plans be developed for each subregion or major river basin in the nation, a comprehensive Level B study of the coastal basins of eastern Massachusetts, Rhode Island and the southeastern corner of Connecticut was authorized by the Water Resources Council. Under the direction of the New England River Basins Commission, a Federal-State study team evaluated existing, 1990 and 2020 needs in the SENE area (including all of the PNB area), principally those concerning water supply, water quality, recreation, marine management, flooding and erosion, mineral extraction, and the siting of electrical power and petroleum facilities. The report to the Water Resources Council, submitted in March 1976, indicated that continuing urban growth in the SENE area can be accommodated but should be guided to protect fragile resources and make development more efficient.

The report made the following key recommendations for meeting 1990 needs in the Pawtuxet River Basin: petition the General Assembly to approve construction of Big River Reservoir; expand Cranston and Warwick secondary treatment plant at Coventry or expand the existing secondary treatment plant at West Warwick; acquire key wetlands and flood plains; and consider nonstructural flood plain management solutions wherever possible under the authority of Section 73 of the Water Resources Development Act of 1974. The SENE study efforts were closely coordinated with those of the PNB study.

The SENE study recognized that specific project proposals to resolve the major flood problems in the lower basin were being evaluated in the PNB study. Therefore, the SENE study concentrated its recommendations on regulatory, soil conservation and forestry measures that all basin municipalities could adopt to reduce flood plain encroachment, erosion and non-point source pollution.

NENYIAC Report

A report by the New England-New York Inter-Agency Committee (NENYIAC) was completed in March 1955. It contained an inventory of resources entailing streamflow regulation, water supply, water quality, flood control, hydroelectric power, navigation, shore erosion, fish and wildlife, recreation, historic sites, land management, mineral production and insect control. The report indicated that benefits could be realized from streamflow regulation and pollution control measures in the Pawtuxet watershed, but no projects were recommended for these or other study elements. Part One (brief summary) and Chapter 1 of Part Two (general discussion) of the report have been published as Senate Document No. 14, 8th Congress, 1st Session, Chapter XVII of Part Two, "Narragansett Bay Drainage Basins," discusses the resources of the Pawtuxet, Blackstone and Taunton watersheds and local drainage into Narragansett Bay and the Sakonnet River.

STATE

Big River Water Supply Project

In 1976, the Rhode Island Water Resources Board engaged Keyes Associates and Metcalf & Eddy, Inc., (KAME) to conduct a five-phase program beginning with preliminary studies and leading to detailed plans, specifications and construction for the Big River Reservoir project. Funds were allocated to undertake Phase 1 of the investigations, which called for the development of basic data and preliminary designs. Reports on geotechnical investigations, water treatment plant design and an inventory of vegetation, wildlife and aquatic biota were produced in November 1977 along with detailed mapping of the reservoir site and aqueduct facilities.

Basinwide Water Quality Management Plans

Prepared by the Statewide Planning Program under Title III, Section 303e, these plans covered water quality management objectives for each of the seven Rhode Island drainage basins. Each plan determined existing water quality, identified pollution sources, and assigned water quality standards to the waters of each basin. The plans also indicated stream pollution level reductions necessary to meet State water quality objectives.

State Land Use Policies and Plan

A report published by the Rhode Island Statewide Planning Program in January 1975 set forth a statewide land use policy and plan for the next 20 years. The purpose of the plan was to guide future land use and development by recommending policies and allocations of areas to various uses. The plan was based on an analysis of alternative development patterns and of factors influencing development. It forms part of the State Guide Plan and is closely related to the other plan elements for transportation, public facilities, economic development, recreation and historic preservation.

Plan for Recreation, Conservation and Open Space

The recreation plan, published in 1971 by the Rhode Island Statewide Planning Program, an element of the State Guide Plan, is closely related to the state's land use policies and plan. Many of the goals and policies expressed in the recreation plan were included in the land use plan, including allocation of land for recreation and conservation purposes and encouragement of orderly urban growth.

Plan for Development of Public Water Supplies

The former Rhode Island Statewide Comprehensive Transportation and Land Use Planning Program published a plan for the Development and Use of Public Water Supplies in September 1969. The report analyzed problems and aspects of public water supply and distribution and methods of dealing with them.

The four major parts of the report are:

- Water supplies and systems in Rhode Island.
- Forecasts of future water needs.
- A plan to provide for Rhode Island's future water needs.
- Implementation of the water supply and distribution plan.

Rhode Island Water Supply Reports

The first comprehensive study on water resources in Rhode Island was made for the former Rhode Island Water Resources Commission in 1952. As part of the study, several reservoir sites were proposed to increase the safe yield of the supply sources of the City of Providence. Recommended sites included Nooseneck River and Big River.

In 1976 a report was made to the former Water Resources Coordinating Board, updating the 1952 and 1957 consultant reports to the Board, to reflect the drought conditions of the early 1960's and the attendant water supply problems. The report proposed a phased development program to meet increased demands expected in 1990 and 2020. The report proposed construction (about 1980) of a reservoir on the Big River just upstream from the existing Flat River Reservoir (industrial water supply) to produce an initial 29 MGD of water supply yield for the Providence metropolitan service area. Also proposed were flood skimming of the Flat River (about 1995) and transfer to Big River Reservoir, plus development of facilities after 2005 that would divert and later store floodflow tributaries of the Thames and Pawcatuck River Basins, located to the west, to augment the yields of Big River Reservoir. In conjunction with these studies, the present Rhode Island Water Resources Board during 1965-1966 acquired 8,270 acres for the Big River Reservoir project.

Early Rhode Island Water Supply Reports

Reports prepared in January 1928 and September 1936 by the Rhode Island State water supply and planning agencies provided information concerning the watershed record flood of February 1886. Additional hydrologic information was compiled by the City of Providence, which had diverted public water supplies from the Pawtuxet River since 1870. Detailed water supply studies were also completed by the City of Providence as the result of the 1915 Water Act of Rhode Island, which authorized the development and 1926 completion of Scituate Reservoir on the North Branch of the Pawtuxet River in Scituate.

LOCAL

Bristol County Water Supply Reports

A report to the Bristol County Water Company was completed by Metcalf & Eddy, Inc. in 1978. The study proposed a program of phased development of local supplies to meet future needs of the water company's service area. Major proposals of the report were development of new local surface and groundwater supplies and construction of a diversion to increase existing surface water yields. The recommendations of this report differed from those of earlier studies, which had proposed construction of a transmission main under the Providence River, to link Barrington, Bristol and Warren with the Providence Water Supply Board system from which additional supplies would be obtained. Rising costs of construction were cited as making the Providence connection less feasible in recent years.

A study on the feasibility of community acquisition of the Bristol County Water system has been conducted for the three communities by Weston & Sampson, Engineers. A report on Part 1 of the study was completed in November 1979.

Pawtuxet Water Quality Report

A study of water quality in the Pawtuxet River was conducted by Brown University under a grant from the National Science Foundation. This report, published in August 1972, stated that previously identified water quality conditions had deteriorated by one or two water use classifications in most reaches since the 1966 analysis by the Rhode Island Department of Health. The report also indicated that existing water quality management is ineffective and a strong regional management agency that can collect monetary charges on effluents is needed. Also required is the formation of a water quality monitoring consortium, consisting of industries and sewage treatment plants for year-round monitoring of the river.

Providence Water Supply Board Report

In 1964, C. A. Maguire and Associates reported to the Providence Water Supply Board on the feasibility of enlarging water treatment facilities at Scituate Reservoir and providing an additional aqueduct to Warwick and Cranston, to which a future connection from Big River Reservoir could be made.

In 1968 a report on improvements for the Providence water service area was prepared for the Board by C.A. Maguire & Associates. Recommendations of this report included development of the Big and Wood River Reservoirs and a reservoir on Moosup River to meet expected needs through 2015.

EXISTING CONDITIONS

CLIMATOLOGY

Temperature

The study area is near 41°40'N. latitude in the northeast continental United States. At this latitude the climate can best be characterized as moderately cool and humid. The average annual temperature is about 50°F., with monthly averages varying from a high of 73° in July to a low of about 29° in January.

Precipitation

The average annual precipitation over the study area varies from about 43 inches in the lower coastal areas to about 48 inches in the uplands in the vicinity of Big River. Some of the precipitation during the winter months is in the form of snowfall, which averages about 40 inches per year over the Pawtuxet River basin.

Mean relative humidity in the area is about 70 percent.

Detailed climatological information is presented in Appendix D, "Hydrologic Analysis."

FLOODS

Floods can occur in the Pawtuxet River basin any season of the year as a result of intense rainfall or in the winter or spring as a result of rainfall in combination with snowmelt. Flood damage potential is generally concentrated along the mainstem of the Pawtuxet River in the lower, more densely developed areas of the basin. Some of the more notable floods that have occurred in the nineteenth and twentieth centuries were in September 1815, February 1886, November 1927, March 1936, July 1938, September 1938, August 1954, March 1968, and most recently in March 1979.

Flood damage surveys conducted in 1972 and 1973 indicated that an estimated 20-year frequency flood would have caused losses in excess of $1,500,000 along the mainstem Pawtuxet River downstream of Natick Dam even had there been no new development. A flood of an estimated 50-year frequency would likewise have resulted in losses exceeding $7 million, (figures are at September 1978 price levels). The heaviest losses would have occurred in Warwick followed by Cranston and West Warwick. Damages in remaining Pawtuxet River basin areas resulting from the 20-year or 50-year flood event are minor in comparison to mainstem losses.

Approximately 2000 structures, including homes and commercial establishments, located along the mainstem of the Pawtuxet River would be flooded to various levels from a flood of Standard Project Flood proportions (maximum flood caused by conditions characteristic of the area).

DROUGHTS

The long-term rainfall of the Pawtuxet River basin of approximately 43 inches per year is the average of many highs and lows. When rainfall is below average for a period of time, the area experiences what is referred to as drought conditions. A drought is defined as a prolonged period of precipitation deficiency which seriously affects both river flow and groundwater supplies. The drought of 1961-1967 in southeastern New England was one of the greatest ever experienced since the beginning of systematic streamflow monitoring near the turn of the twentieth century. The last comparable drought was around 1914-1916. The 1960's drought followed a period of above normal rainfall during the 1950's and was particularly severe because it resulted in two successive years (1965 and 1966) of near record lows in annual precipitation within the Pawtuxet River basin. The average flow of the South Branch was about 57 percent of normal for the period May 1964 to October 1966, equivalent to a runoff deficiency of more than 25 inches. Based on statistical analysis of hydrologic records in the region, the annual probability of the 1960's drought is considered to be not more than 1 to 2 percent.

Detailed hydrological information is contained in Appendix D, "Hydrologic Analysis", and in "Attachment 1", which present specific information on flood hazard areas in the Pawtuxet River basin.

TOPOGRAPHY

The study area consists of an irregular topographic surface with relatively low to moderate size hills in the western section gradually decreasing in relief toward the east. The study area is located entirely within the New England physiographic province, a subdivision of the Appalachian highlands that extends from Newfoundland to Alabama.

The western one-third of the region is located in the New England Upland Section, with elevations varying from 300 feet above sea level at the head of Scituate Reservoir to 730 feet at Chopmist Hill in the northwestern corner of Scituate. Jerimoth Hill, the highest point in Rhode Island, has an elevation of 812 feet and is located along the western divide of the Pawtuxet River basin in the northwestern corner of Foster. This section of the basin has been modified by Pleistocene glaciation which eroded the hilltops and deposited materials in the valleys, thereby adding new relief features to the terrain and reducing the overall relief of the area.

The eastern two-thirds of the basin lies within the Seaboard lowland section, where elevations range from near sea level immediately along the coast to 544 feet at Pine Hill in the western section of Johnston. Typical elevations in other areas of the lower basin range from 50 to 200 feet above sea level.

GEOLOGY

Bedrock

The majority of the bedrock in the study area consists of igneous rocks that have many characteristics of metamorphic rocks. The principal formation is the Scituate granite gneiss which occupies almost the entire central portion of the region. A smaller amount of granite occurs within the general area. At the eastern limit of this formation is a complex of igneous and metamorphic rocks that trend roughly north-south. Farther to the east, the sedimentary sequences of the Rhode Island formation begin. They consist primarily of sandstone, slate, conglomerate and graywacke. The formations located to the north and northwest of the Scituate granite gneiss are mainly gneisses and schists.

Two small faults are located in the study area. The first fault is located within the southwestern limits of Cranston about 500 feet west of the margin of the Narragansett Basin and about one mile northeast of the confluence of the North and South Branches. This small fault displaces bodies of Pondville conglomerate and Esmond granite. The second fault is located at the north end of the Scituate granite gneiss. There is no information on the displacements. Neither fault is considered active or major.

The igneous and metamorphic rocks are hard, highly jointed, weak to strongly foliated and range in compressive strength from medium to very high. In addition, they exhibit slight weathering and high durability. The sedimentary rocks generally have low to medium compressive strength and exposures are less frequent than the other rock types.

Surficial

Unconsolidated glacial deposits mantle the bedrock surface in varying degrees throughout the Pawtuxet River basin. The greatest exposure of bedrock and the thinnest surface cover is evident on the sides and tops of hills in western and northern sections of the basin encompassed by the towns of Coventry, Scituate and Glocester. Surficial deposits such as mixtures of sand, silt, gravel and boulders are primarily derived from deposition from glacial action. Post-glacial deposits are lesser in extent and occur as alluvium and swamp deposits near streams and in blocked drainage areas on hills. Extensive swamps contain varying amounts of soft organic silts and peats.

In the lowland areas glacial deposits occur as unstratified ground moraine (till) and as outwash plains or other deposits laid down by glacial stream action. Post-glacial deposits occur principally as alluvium in the field plains. There is geological evidence that a buried valley exists along a line passing through the western section of Greenwich Bay and extending northward into Cranston in which depths to bedrock could be as much as 150 feet. The principal kinds of deposits are as follows:

Ground moraine (till), including glacial till, consisting of an unsorted mixture of particles ranging from clay-size to boulders. The most extensive and widespread deposits cover hills and lowlands and often reflect the underlying topography. Masses of ground moraine sometimes are formed into hills. The rock particles are mostly from local bedrock. Ground moraine may lie beneath other surficial deposits in some areas.

Outwash plains are flat-topped broad accumulations deposited in open areas by glacial streams. They consist of sands with some interbedded gravel. Some plains have coalesced over wide areas while others are limited deposits in narrow valleys.

Kames are irregular hills usually of poorly sorted sand and gravel that were deposited in contact with a glacier. The deposits are often localized because of the confined conditions during their formation.

Kame terraces are benched deposits of sand and gravel left against valley slopes by glacial streams. Valley train deposits are sands and gravels deposited in valleys and extending across them. Kame terraces and valley train deposits sometimes merge from one into the other.

Kame plains are localized flat-surfaced deposits of mostly sand with some gravels. They were formed by glacial streams in areas confined by the glacier. The bounding slopes that formed may be steep or low. The sands and gravels are usually sorted and stratified.

Alluvium occurs locally as streambanks and flood plains adjacent to rivers and streams. These deposits are silt, sand and gravel and are usually well sorted. Erosion and deposition by the rivers and streams in normal times and during floods determine the local sorting, thickness and distribution of the deposits.

Swamp deposits are mainly silts, fine sands and muck. Most swamps are localized and limited in extent, although a few extensive areas are found. The level of water in swamps fluctuates seasonally with local stream and groundwater levels. The thickness of the deposit is determined by local conditions.

Artificial fills in the study area are extensive enough for mapping. Fill material is usually taken from local sources of till or sand and gravel. The kind of material used depends upon the purpose of the fill.

Deposits of sand and gravel that were not identified with any particular land form were left undifferentiated. The grain size, sorting and stratification within these deposits vary according to the local conditions of deposition. The properties may be those of sands, gravels or mixtures of sand and gravels.

Seismicity

According to the seismic risk map developed by the Environmental Science Administration and the Coast and Geodetic Survey, the Big River Reservoir study area as well as most of the surrounding region is located in Seismic Zone 1. This is a zone of minor earthquake damage. Since the study area lies near the border of zone 1 and zone 2, the Corps of Engineers criteria dictates that project structures be designed for a seismic probability coefficient for the higher area. In accordance with this directive, all hydraulic structures of any project will be designed for a seismic coefficient of 0.05.

Detailed geological information is presented in Appendix F, "Geotechnical Investigations" and "Attachment 1."

NATURAL RESOURCES

Air Quality

Ambient air quality has been monitored throughout Rhode Island since 1968 from a network of stations established, operated and maintained by the Division of Air Resources and Occupational Health and Radiation Control. Ambient air monitoring is required to assess current air quality for comparison with the standards established by the State or Federal government to determine the degree of improvement necessary and measure the results of control actions and strategies.

Monitoring is conducted on two bases: intermittent and continuous. Intermittent monitoring involves the collection of samples over a 24-hour period every sixth or eighth day. These samples are analyzed for pollutant concentration by the Division laboratories. Continuous monitoring requires special equipment which provides an instantaneous readout of pollutant concentrations.

Comparison of current air quality levels to the applicable standards of each pollutant are evaluated on two levels: primary standards to protect public health and secondary standards to protect vegetation and materials.

There were no significant changes in levels anywhere in the study area between 1976 and 1977. Except for Providence, most areas continue to meet both standards. Although an overall trend of improvement has taken place in recent years, in downtown Providence the levels of total suspended particulates (TSP) and carbon monoxide (CO) continue to violate both primary and secondary standards. In addition, some sections of the study area (rural as well as urban) experience temporary violations of photochemical oxidants (O_3) standards during the summertime, with highest levels more than twice the health standard. The air pollutant levels cited above have been obtained from 1977 data and should compare closely with current levels of air quality.

Soils

Narrow bands of poorly drained alluvial soil are found in the bottomlands along many streams throughout the region. Most of the adjoining lowland soil of Cranston and Warwick consists of the well-drained Merrimac fine sandy loam of the granitic outwash plains. In the relatively low hills of Cranston, Johnston, West Warwick, West Greenwich and Exeter the upland soil is principally the well-drained Narragansett stony fine sandy loam.

The predominant soil in the higher uplands of the region consists of the well-drained Glocester stony fine sandy loam, which is one of the least fertile soils in Rhode Island. Sections of southern Scituate, southern Foster and northern Coventry have extensive areas of rough stony land of Glocester soil material (boulders). The principal soils of the depressions in the northwestern part of the study area are the poorly drained Scituate and Whitman stony loams. Many of the depressions in the southwestern section of the study area consist of poorly drained Whitman stony loam.

Hinckley loam sand (a droughty soil) is frequently found where kames were formed in areas such as the Meshanticut Brook section of Cranston, the northeastern section of Scituate, the North Branch section of Scituate, the southeastern corner of Coventry, the northeastern corner of West Greenwich and the foster Center area.

Vegetation

The study area is within the southern portion of the white pine-hemlock-hardwood forest region of New England. This plant association is characterized by a dominance of oaks, hickory, and yellow poplar forest with occasional stands of white pine or pitch pine is disturbed or sandy areas. Wetlands are found in many low-lying poorly drained areas and consist mainly of wooded swamps with red maple, elm and ash.

Detailed vegetation information is contained in Appendix H, "Recreation and Natural Resources."

Fish and Wildlife

Wildlife found within the study region include game species such as white-tailed deer, cottontail rabbit, snowshoe hare, gray squirrel, ruffed grouse, woodcock, bobwhite quail, mourning dove, ring-necked pheasant, and waterfowl such as mallard, black and wood ducks. Furbearing animals include red and gray fox, raccoon, oppossum, weasel, skunk, mink, muskrat and otter. Various song birds, shore and wading birds, raptors and rodents are also common to the area.

The study area has an extensive network of streams, ponds and lakes. Several cold water fish species including brook trout, brown trout and rainbow trout are found in many of the "better" streams, and northern and walleye pike are found in some of the reservoirs. Principal species include largemouth and smallmouth bass, chain pickerel, brown bullheads, and yellow and white perch. No anadromous fishery exists in any of the study area streams because of dams and/or pollution. Buckshorn Brook, Flat River and Wood River support some of the best cold water stream fisheries in the state. Big River is regarded as a warm water stream with largemouth bass and pickerel being the dominant species although some native brook trout exist in one tributary, Nooseneck Brook. Flat River Reservoir (Johnson's Pond) is considered one of the best warm-water lakes in the state with largemouth bass and northern pike being the major species.

Detailed information on the study area's aquatic and terrestrial resources is contained in Appendix H, "Recreation and Natural Resources."

Minerals

Active sand and gravel operations in the study area are located in Coventry, Cranston, Johnston, Warwick, West Greenwich and West Warwick. The State's leading crushed stone producer is located in Cranston. Others are located in Johnston, Warwick and West Warwick. Stone slope protection materials are also produced from the Cranston quarry.

Until recent years a meta-anthracite coal mine was operated intermittently in Cranston. The coal was high is ash and graphite and was used primarily in the manufacture of refractory materials. In colonial times, ilmenite (bog iron ore) was mined in Cranston and Foster, and steatite (soapstone) and granite were quarried in Johnston. Hematite was also mined in Cranston until the early 1800's.

Water

General. The Pawtuxet River Basin lies entirely within the State of Rhode Island and covers a total area of 230 square miles. Drainage is generally to the east with the Pawtuxet River discharging into the Providence River at the Cranston-Warwick city boundary. The headwater regions of the basin are drained by the North Branch and the South Branch of the Pawtuxet River and have watershed areas of 106 and 73 square miles respectively. The North Branch headwater region has been developed extensively for water supply where 92.8 square miles or about 87 percent of the watershed in controlled by the Providence Water Supply Board's Scituate Reservoir, the principal water supply source in the region. This makes the Pawtuxet River Basin one of the most productive water supply regions in southeastern New England.

The South Branch originates at Flat River Reservoir (known locally as Johnson's Pond) which has a drainage area of 56.7 square miles or about 77 percent of the South Branch's watershed. The reservoir was constructed downstream of the confluence of the Flat and Big Rivers. The headwaters of the Flat River originate at the head of Turkey Meadow Brook in the town of Foster, while the principal tributaries of the Big River-Nooseneck, Congdon, and Carr Rivers-originate in the towns of West Greenwich and Exeter.

The mainstem Pawtuxet River, originating at the confluence of the North and South Branches, flows northeasterly for 10.9 miles to its mouth. The river has a total fall of about 50 feet and averages about 100 feet in width and about 4 feet in depth throughout its length. The Pawtuxet dam was constructed near the mouth in 1870 to prevent salt water intrusion. In the lower reach, the main Pawtuxet River is joined by two other tributaries-Meshanticut Brook and the Pocasset River.

Numerous lakes and ponds are scattered throughout the basin which are used primarily to provide recreational opportunities for fishing, swimming, boating, picnicking and nature trails. Some of the largest of these lakes and ponds are used for water supply sources. On the North Branch, the Providence Water Supply Board controls most of the watershed and operates facilities at Ponaganset Reservoir, Moswansicut Reservoir, Westconnaug Reservoir, Barden Reservoir, Regulating Reservoir and Scituate Reservoir. On the South Branch, Flat River Reservoir is used as a source of industrial water supply as well as for swimming, boating, camping and picnicking. The remaining large lakes and ponds in the study area provide a variety of recreational opportunities although public access is not always available.

For complete details of the Pawtuxet River Basin see Appendix D, "Hydrologic Analysis" and "Attachment 1."

Water Supply. Three major water supply agencies are located within the study area, as shown on Plate A-3. Together they supply almost all the municipal water demands of study area communities. The largest of these, as well as the largest water supply system in the State, is the Providence Water Supply Board, which operates surface water reservoirs on the North Branch of the Pawtuxet River. The Kent County Water Authority is the second largest water supply agency in Rhode Island and operates groundwater wells in West Greenwich and Coventry. Part of the demand of the Kent County Water Authority system is supplied from the Providence water system.

The Bristol County Water Company utilizes groundwater sources in Barrington combined with surface water supplies located primarily in Warren and Rehoboth, Massachusetts.

Details of the three existing water supply agencies and the areas they serve are presented in the following paragraphs.

a. Providence Water System: The City of Providence water supply system is operated under authority of the Water Supply Board which is a branch of the municipal government. Supply sources are located in the North Branch of the Pawtuxet River and consist of a series of six surface water reservoirs namely, Regulating Reservoir, Westconnaug Reservoir, Barden Reservoir, Moswansicut Reservoir, Ponaganset Reservoir, and Scituate Reservoir from which water is drafted to supply to system.

Water supply storage provided by the Scituate Reservoir system is approximately 39,700 million gallons. The average demand of the Providence system in 1975 was 62.4 million gallons per day (Mgd) while the maximum day demand was 106.0 Mgd. Communities served by the system include Providence, Cranston, Johnston and North Providence which accounted for about 75 percent of the total demand. Water was also sold to Cranston, East Providence, East Smithfield Water Company, Smithfield Water Department, Greenville Water District, Warwick and Kent County Water Authority on a wholesale basis to supply various parts of their respective communities. Data obtained for the last reported operating year, July 1978-June 1979, shows that the demand of these wholesale customers increased to about 30 percent of total consumption amounting to approximately 19 Mgd on the average day.

b. <u>Kent County Water Authority</u>: Groundwater supplies are operated by the Kent County Water Authority in the Mishnock area of Coventry and in the Hunt River area of East Greenwich. Communities served directly by the system include Coventry, East Greenwich, Scituate, West Greenwich and West Warwick. Water obtained from the Providence water supply system is also distributed to parts of Cranston and Warwick. The average demand in 1975 for this system was 6.0 Mgd exclusive of the water obtained from the Providence system. The maximum day demand was correspondingly 12.3 Mgd.

c. <u>Bristol County Water Company</u>: The Bristol County Water Company is served by four surface water reservoirs, two located in the Palmer River basin in Rehoboth, Massachusetts, and two in the Kickamuit River basin in Warren, Rhode Island and Swansea, Massachusetts. In addition, groundwater wells located in Barrington supplement the supply. Average 1975 demand on the system was 3.4 Mgd while the maximum daily demand was 5.8 Mgd. The water supply system has service areas in each of the Bristol county communities of Barrington, Bristol and Warren.

Pertinent data on the study area's existing water supply systems are shown in Table 1.

<u>Water Quality</u>. The water quality of surface waters in the Pawtuxet River basin varies from Class A (suitable for water supply and all other uses) at the headwaters of the North and South Branches to Class E (nuisance conditions) near the mouth at Pawtuxet Cove. Throughout most of the South Branch and Pawtuxet River mainstem, the water quality classification is Class C (suitable for fish and wildlife habitat) in accordance with criteria established by the State of Rhode Island. The water quality in the Pawtuxet River basin is affected by both point and nonpoint sources of pollution. The major nonpoint sources are stormwater runoff from urbanized areas of the lower basin and leachate from Sanitary Landfill, Inc., a privately-owned landfill operation in Cranston. Major point sources of pollution in

TABLE 1

STUDY AREA WATER SUPPLY REQUIREMENTS - 1975

WATER SUPPLY AGENCY	COMMUNITIES SERVED	MUNICIPAL SYSTEMS: POPULATION SERVED BY MUNICIPAL SYSTEM	GALLONS PER CAPITA PER DAY, GPCD.	AVERAGE DAY RESIDENTIAL & COMMERCIAL DEMAND, MGD.	AVERAGE DAY INDUSTRIAL DEMAND, MGD.	TOTAL AVERAGE DAY DEMAND, MGD.	MAXIMUM DAY DEMAND, MGD.	1975 SOURCES OF SUPPLY (1)	1975 SAFE YIELD, MGD.	MAXIMUM DAY CAPACITY, MGD.	AVERAGE DAY SURPLUS (+) OR DEFICIENCY (-), MGD.	MAXIMUM DAY SURPLUS (+) OR DEFICIENCY (-), MGD.	PRIVATE DEMANDS: POPULATION SERVED BY PRIVATE SYSTEMS	AVERAGE DAY RESIDENTIAL & COMMERCIAL DEMAND, MGD	AVERAGE DAY INDUSTRIAL DEMAND, MGD	AVERAGE DAY AGRICULTURAL DEMAND, MGD	TOTAL AVERAGE DAY DEMAND, MGD	TOTAL MUNICIPAL AND PRIVATE AVERAGE DAY DEMAND, MGD
Bristol County Water Company	Barrington	16,900				1.02		S.W.	2.50	4.0			500	[illegible]	0			
	Bristol	18,300)											400	[illegible]	0			
	Warren	9,400)				2.35		G.W.	0.70	0.70			1,200	0.072	0			
		44,600	59.1	2.64	0.73	3.37	5.82		3.20	4.70	0.17(-)	0.12(-)	2,100	[illegible]	0	-	[illegible].13	3.50
Providence Water Supply Board	Providence	165,100)											[illegible]	0	1.16			
	Cranston	69,200)	138	37.7	10.0	47.7	82.5						5,000(3)	0.30	3.20(3)			
	Johnston	16,800)											7,000	0.42	0			
	N. Providence	18,600)											2,690(4)	0.16	0.45(4)			
	Cranston (2)	2,800	90.1	0.25	0	0.25	0.51						-	-	-			
	E. Providence(5)	49,900	87.8	4.38	1.11	5.49	8.89						900	0.054	6.42			
	N. Providence(6)	1,713)											-	-	-			
	Smithfield(6)	4,157)	81.7	0.48	0.20	0.68	1.26						-	-	-			
	Smithfield(7)	4,360	78.9	0.34	0.001	0.34	0.67						3,283(8)	0.20	0 (8)			
	Smithfield(9)	2,700	86.4	0.23	0.020	0.25	0.51						-	-	-			
	Warwick(10)	68,500	81.7	5.60	1.21	6.81	10.5						10,200(11)	[illegible]	0.080(11)			
	Warwick(2)	10,000	90.1	0.90		0.90	1.85						-	-	-			
		416,830		49.9	12.6	62.4	106	S.W.	72.0	144	9.60(+)	[illegible].0(+)	29,073	[illegible]	[illegible]	-	[illegible]	[illegible]
Kent County Water Authority	Coventry	21,300											4,700	0.28	3.03			
	E. Greenwich	9,800											800	0.048	0.19			
	Scituate	1,400											7,100	0.43	0			
	W. Greenwich	700											1,800	0.11	0			
	W. Warwick	24,000											2,000	0.12	0.24			
		57,200(2)	90.0	5.15	0.87	6.02	11.4	G.W.	10.9	10.9	3.27(+)	[illegible].49(-)	16,400	0.99	3.37	-	[illegible].36	[illegible]
	Foster	0	0	0	0	0	0	none	0	0	0	0	3,100	0.19	0	-	0.19	0.19
	Glocester	0	0	0	0	0	0	none	0	0	0	0	6,400	0.38	0	-	[illegible].38	[illegible]
Total Study Area (Rounded)		518,600		57.7	14.1	71.8	124.2		86.1	159.6	0.2(-)*	[illegible].6(-)*	57,100	[illegible]	[illegible]		[illegible]	[illegible]

*Deficits only

FOOTNOTES TO TABLE 1

1. S. W. - surface water; G. W. - groundwater.

2. City of Providence Water Supply Board supplied water to part of Warwick and Cranston through the Kent County Water Authority in 1975. Entire demand of these communities is listed under the Providence system.

3. Private residential and commercial, and industrial demands are for all of Cranston.

4. Private residential and commercial, and industrial demands are for all of North Providence.

5. City of Providence Water Supply Board supplied water to East Providence through City of East Providence distribution system.

6. City of Providence Water Supply Board supplied water to North Providence and Smithfield through East Smithfield Water District distribution system.

7. City of Providence Water Supply Board supplied water to Smithfield through Greenville Water District distribution system.

8. Private residential and commercial, and industrial demands are for all of Smithfield.

9. City of Providence Water Supply Board supplied water to Smithfield through Smithfield water supply distribution system.

10. City of Providence Water Supply Board supplied water to Warwick through City of Warwick water distribution system.

11. Private residential and commercial, and industrial demands are for all of Warwick.

12. MGD - million gallons per day.

the basin are the Cranston, Warwick and West Warwick municipal wastewater treatment plan effluents and the Ciba-Geigy and American-Hoechst Industrial treatment discharges. Downstream of the Ciba-Geigy discharge, the river is classified Class D and is not suitable for fish habitat due to the accumulation of pollutants in bottom sediments and lack of adequate vegetation.

Other important rivers, streams and ponds in the study area are classified as Class A or Class B including Flat River Reservoir (Johnson's Pond), Moosup River, Bucks Horn Brook, Big River and its major tributary streams.

See Appendix E, "Water Quality" and "Attachment 1" for additional water quality information on surface waters within the study area.

Groundwater. In many areas of the State in which sand and gravel aquifers are present, there appears to be substantial amounts of groundwater, especially where the aquifers include or are bordered by streams. The fact that high yield potentials exist in certain parts of the State, however, does not necessarily imply that ample supplies of groundwater can be delivered on demand to need areas. Distance of transport and water quality considerations limit the availability of groundwater. Unfortunately, the natural concentration of iron and manganese in some groundwater, combined with the pollutants generated by increased urbanization have resulted in groundwater of substandard quality existing in several aquifers throughout the State.

Groundwater reservoirs of much of the study area have been investigated by the United States Geological Survey and the Rhode Island Water Resources Board. Reports of these agencies and other hydrogeologic reports serve as reference sources for the groundwater assessment included in this section. The scope of the study did not allow for field exploration or field testing of estimated yields.

The quality of existing groundwater sources and potential groundwater aquifers within the study area varies significantly. The groundwater aquifers of the Flat River Reservoir-Mishnock Pond area and Hunt River are the sources of supply for the Kent County Water Authority and have been developed to their maximum potential. Likewise, groundwater sources for the Bristol County Water Company in Barrington have been fully developed and in recent years have suffered quality problems due to high concentrations of iron which necessitated closing down one of the well supplies. Other groundwater aquifers in the Chepachet River basin in Glocester are of suitable quality and can be expected to be used to augment existing water supply systems in the area.

Significant groundwater resources have been identified in areas of Providence, Cranston and Warwick as a result of investigations conducted by the United States Geological Survey. Groundwater aquifers in these areas, however, have been impacted by urbanization to the extent that water is of less than suitable quality for municipal water supply systems without extensive treatment.

CULTURAL RESOURCES

Prehistoric occupation of western Rhode Island began at least as early as 6000 B.C.. During most of this period, the inhabitants appear to have ranged the countryside in small hunting and foraging bands, congregating seasonally near falls and wetlands to take advantage of wildfowl migrations and anadromous fish runs. By about 2000 B.C. there was an active long-distance trade in stone for tools, and elaborate burial ceremonies appear to have been practiced.

At about the first century A.D. a greater use of marine resources is evident, coupled with a possible population increase and decreased occupation of the uplands. Agriculture and pottery manufacture were introduced during this period. By the 17th century, the uplands of western Rhode Island appear to have been used as hunting and wild food gathering areas in winter. Population settled in large villages on the coast and major rivers during the spring and summer to grow corn and squashes and exploit the spring fish runs. Warfare appears to have increased between groups, and some villages were palisaded. Long distance trade appears to have decreased dramatically.

After European contact, the Narragansett and Nipmuck groups inhabiting western Rhode Island began commercial trapping to obtain European trade goods. This increased friction between groups competing for the best trapping territory. Many people succumbed to European diseases during the early 17th century, and the defeat of native American forces in King Philip's War (1675-1676) nearly eliminated the native population of southern New England. Only a handful of survivors remained in the area, adapting to the European style of life

Several prehistoric archaeological sites are located in the study area. The time of occupation and activities performed at these sites are generally not yet known, and further study will be needed to determine their significance in the archaeology of the region.

Permanent European settlement of the Big River area began at the start of the 18th century. The early townspeople generally lived on scattered farms, while a small number of innkeepers, craftsmen, and millers provided local services and a few manufactured goods.

During the Industrial Revolution of the early 19th century, numerous textile mill villages arose in eastern Coventry, resulting in a concentration of mill workers and other non-farming individuals residing in that area of the town. West Greenwich and Exeter, however, remained primarily farming communities, and began a period of decline as farmers moved to the western states or to manufacturing centers. Only a few small mill villages, such as Nooseneck in West Greenwich and Fisherville in Exeter, reflected the changes which were transforming eastern Coventry from a farmscape to a mill town.

The lack of industry and abandonment of farms in West Greenwich resulted in reversion of much open land to forest in the late 19th and early 20th century. The purchase of large tracts for the planned Big River Reservoir during the 1960's accelerated the reversion process, which had been slowly underway for over a century.

Historic features in the area include many 18th and 19th century homes, some of which are abandoned, as well as numerous early graveyards. The sites of churches, schools, taverns, village stores, and abandoned farms dot the roadsides. Numerous mill sites, such as those at Nooseneck Village, complete the picture of a vanished economy based upon agriculture and small industries. Many of the roads, such as Sweet Sawmill Road and the New London Turnpike, are still unpaved and present a landscape evocative of a place bypassed by the concerns of the 20th century world.

Detailed information on cultural resources within the study area is contained in Appendix I, "Social and Cultural Resources."

SOCIO-ECONOMIC PROFILE

Population Characteristics

The study area's rate of population increase has been less subject to fluctuation than the State as a whole. Between 1960 and 1970, the population of the seventeen community study area increased at an average annual rate of 0.63 percent, while the State population increased at an average annual rate of 1.0 percent. From 1970 to 1975, the average annual rate of population increase in the study area was 0.35 percent, but 0.052 percent for the State as a whole. These figures indicate that the rate of population growth has slowed at both the State and study area levels, but the period of time for which the downturn has occurred is too short to establish a definitive long term trend (see Table 2).

Total population of the study area increased over the 1960-1970 time frame by 43,400. Providence, however, decreased by 28,398 during the same decade. Between 1970 and 1975 the study area as a whole increased by 10,700 people, and Providence declined by 11,000. The decreases in Providence's population may be due to both out-migration to surrounding cities and towns and to the effects of urban renewal programs in the inner city during the 1970's.

Defining a less rapid growth trend at the State level based on data available for the period 1970-1975 may also be misleading due to the unusual circumstances that contributed to the declining rate. The phasing out of military operations at Newport, Quonset Point, and Davisville alone resulted in an approximate decrease in personnel of 26,000.

Employment and Economy

A strong manufacturing base supports the economies of the study area and of the State of Rhode Island as a whole. However, Rhode Island appears to be increasingly oriented toward the service industries. These industries

TABLE 2

POPULATION OF THE STUDY AREA

AREA	1950	1960	1970	1975
Glocester	2,682	3,397	5,200	6,400
Smithfield	6,690	9,442	13,500	14,500
Foster	1,630	2,097	2,600	3,100
Scituate	3,905	5,210	7,500	8,500
Johnston	12,752	17,160	22,000	23,800
Cranston	55,060	66,766	74,300	77,000
North Providence	13,927	18,220	24,300	23,000
Providence	248,674	207,498	179,100	168,100
East Providence	35,871	41,955	48,200	50,800
Barrington	8,246	13,826	17,600	17,400
Warren	8,513	8,750	10,500	10,600
Bristol	12,320	14,570	17,900	18,700
Coventry	9,869	15,432	22,900	26,000
Warwick	43,028	68,504	83,700	88,700
West Warwick	19,096	21,414	24,400	26,000
West Greenwich	847	1,169	1,800	2,500
East Greenwich	4,923	6,100	9,600	10,600
Total				
Study Area	488,033	521,600	565,000	575,700
State	791,896	859,488	949,700	952,206

Source: 1950-1970: U.S. Census Data; 1975: Rhode Island Statewide Planning Program have accounted for 6 percent more of the working force since 1958, while manufacturing has accounted for 7.5 percent less of the workforce. In 1976, 33.4 percent of Rhode Island's employed population earned their living from the manufacturing sector, followed by 20.3 percent in the wholesale and retail trade sector and 18.8 percent in the service sector. In 1958, the three major sectors accounted for 40.9 percent, 18.5 percent, and 12.8 percent of the working population, respectively.

The largest manufacturing centers in the State are in the study area. The percentage of the working population employed in manufacturing, therefore, closely parallels that of the State. In the study area as a whole, manufacturing employed 34.6 percent of the workforce in 1970. The most accurate data for employment by sector obtainable on city and town levels is from the 1970 U.S. Census (see Table 3). Manufacturing predominates in each of the sixteen municipalities for which data is available, except Barrington, which employs a slightly larger number of workers in the private sector.

The major manufactured products of the study area and the State as a whole are, in the order of size of work force involved in their production: jewelry and silverware, textiles, electrical and nonelectrical machinery, fabricated metals, and rubber and plastics.

The second largest employment sector in the seventeen city project study area is the service sector, accounting for 24.3 percent of the total, followed by 18.6 percent in wholesale and retail trade. Over time, these percentages are expected to reflect the statewide trend toward growth of the service sector.

The employment mix in Coventry, one of the two towns that will be impacted most significantly by the construction of a reservoir, is even more heavily weighted toward manufacturing than the State's average. Manufacturing in Coventry accounts for approximately 43.0 percent of total employment. The second largest category is the service sector at 17.8 percent, closely followed by wholesale and retail trade at 16.7 percent. The largest portion of Coventry's manufacturing employment is involved in production of textiles, followed by electrical machinery, glass, and plastics.

West Greenwich is the other town heavily impacted by the construction of a reservoir. However, data for employment by sector is unavailable from the U.S. Bureau of the Census for the town of West Greenwich because its 1970 population level was below 2,500. Information available from the Rhode Island Department of Economic Development indicates that very few employment offerings exist in the town. Approximately 50 percent of the 1972 total employment of 138 was classified in the service sector.

U. S. Census data for 1970 is also the best approximation available of relative numbers employed in different occupational settings. Although this information is not available on the individual city or town level, it would seem reasonable to assume that the occupational structure of the

TABLE 3

EMPLOYMENT MIX IN STUDY AREA - BY TOWN

	TOTAL	MFG.	TRADE	SERVICE	GOVT.	FINANCE INSURANCE R.I. ESTATE	TRANS. COMMS. UTILS.	CONSTR.	MINING AGRIC.	OTHER
Glocester	2,021	788	254	351	81	128	88	202	-	69
Smithfield	5,564	2,048	877	1,329	380	226	276	369	59	
Foster	985	317	169	204	36	49	48	93	-	69
Scituate	2,898	927	486	549	153	295	153	192	-	143
Johnston	9,311	3,614	1,997	1,610	380	390	421	796	103	-
Cranston	30,059	9,430	6,598	6,945	1,970	1,694	1,372	1,850	200	-
North Providence	11,032	3,967	1,930	2,645	699	535	477	730	31	-
Providence	74,404	24,577	12,800	21,814	4,699	3,232	3,742	3,189	351	-
East Providence	20,357	6,845	4,033	4,627	839	1,312	1,357	1,204	150	-
Barrington	6,742	1,925	1,057	2,189	266	597	290	345	73	-
Warren	4,146	1,729	746	792	229	139	181	234	96	-
Bristol	7,408	3,881	897	1,358	280	208	246	416	122	-
Coventry	9,164	3,953	1,527	1,635	767	295	396	552	39	-
Warwick	34,535	11,285	7,252	7,735	2,413	1,729	1,965	1,965	207	-
West Warwick	10,674	4,410	2,003	2,004	943	354	346	346	44	44
*West Greenwich	-	-	-	-	-	-	-	-	-	-
East Greenwich	3,663	1,058	759	759	337	317	167	175	-	171
Total Study Area	232,973	80,754	43,305	56,546	14,472	11,578	11,525	12,366	1,475	452
State	328,330	120,122	53,940	83,581	19,281	14,396	15,374	17,479	2,481	1,676

* West Greenwich not available because its population was less than 2,500 in 1970.

Source: Compiled from U.S. Census data

labor force in the project study area is very similar to that of the State as a whole because such a large segment of the working population resides in that area. The data for Rhode Island indicates the largest occupational category is Sales and Clerical, totaling 25.1 percent of the 241,017 employed persons and 23.7 percent of the total labor force of approximately 255,325. This category is followed by Operatives, accounting for 21.4 percent of the employed labor force; Craftsmen and Foremen, 14.4 percent; Professional and Technical, 14.0 percent; Managers, Officials and Proprietors, 7.7 percent; and all others, 15.8 percent.

The unemployment rate in the State of Rhode Island tends to increase and decrease according to national trends, but generally at a significantly higher level. Table 4 illustrates this fact for selected years.

Unemployment in the State of Rhode Island currently averages around 8.8 percent. The best approximation of unemployment in the study area can be compiled from administrative reports of the local offices of the Rhode Island Department of Employment Security. The average rate of unemployment for the seven local offices that cover the seventeen cities and towns of the area for December 1978, according to the most recent data available was 6.3 percent. Table 5 indicates the estimated unemployment for each local area and the cities and towns covered.

Another indicator of the general health of an area's economy is per capita income. In 1975, the most recent year for which published estimates are available, Rhode Island ranked twentieth of the fifty states in per capita income at a level of $5,841, below the national average of $5,902. This was an increase from the 1970 per capita income level of $3,960 when the national average was $3,966. Thus, the per capita income level in Rhode Island maintained a fairly constant relationship to the national average over the period 1970-1975, at approximately 99 percent of the United States level. Per capita income figures are not available on the city and town level in Rhode Island.

Family income data is available from the 1970 U.S. Census on both the State and municipal levels. Median family income has seen a ten year increase of 74.2 percent from a 1959 level of $5,589 in the State of Rhode Island to a 1969 level of $9,736. The study area's median family income increased over the same time period by 77.8 percent, from $5,702 to $10,136. Thus, the study area enjoyed a slightly higher median family income and experienced a 3.6 percent greater increase between 1959 and 1969 than the State as a whole.

Median family income in the town of Coventry slightly exceeded that of the total study area and of the State at a 1969 level of $10,630, reflecting a 77.3 percent increase over the 1959 level of $6,031. On the other hand, median family income levels in West Greenwich were slightly lower, estimated at $4,794 and $9,796 in 1959 and 1969, respectively. These median estimates reflect an increase of approximately 104.3 percent over the decade, a growth rate for West Greenwich that exceeded that of the State by about 30 percent.

TABLE 4

RHODE ISLAND UNEMPLOYMENT RATES

YEAR	UNITED STATES PERCENTAGE	RHODE ISLAND PERCENTAGE
1970	4.9	5.6
1973	4.9	6.3
1974	5.6	7.3
1975	8.5	10.9
1976	7.7	8.1
1977	7.0	8.6
1978	6.0	6.7

TABLE 5

UNEMPLOYMENT IN THE STUDY AREA - DECEMBER 1978

LOCAL OFFICE	CITIES AND TOWNS COVERED	LABOR FORCE	UNEMPLOYMENT RATE (%)
Bristol	Bristol	7,350	8.6
E. Providence	E. Providence	24,865	6.1
N. Providence	N. Providence, Scituate, Smithfield	33,390	6.3
Providence	Providence, Cranston, Johnston	121,985	4.9
Warren	Warren, Barrington	13,925	5.9
Warwick	Warwick, E. Greenwich, N. Kingstown	54,830	5.4
W. Warwick	W. Warwick, W. Greenwich, Coventry, Foster	24,200	7.6
Woonsocket	Glocester, Burrillville, Woonsocket, Manville, N. Smithfield	31,790	5.6
Total Area		312,335	Avg. 6.3%

Source: Rhode Island Department of Employment Security

Commercially Valuable Resources

Within the limits of the State-owned Big River Reservoir site, three private contractors are currently removing one million cubic yards of sand and gravel. Since over 30 million cubic yards of sand and gravel are estimated at the site, this resource has been identified as the largest single mineral deposit in the region. The current agreement on one million cubic yards between the State and private contractors is expected to be completed by 1980 or 1981; however, it is estimated that approximately seven million additional cubic yards could be extracted over the next 10 years. This would reduce the remaining amount of sand and gravel to about 20 million cubic yards.

LAND USE

In 1960, less than one-quarter of the land area in Rhode Island was developed for urban uses, including land occupied by residences, commercial and industrial establishments, government and institutional facilities, public utilities, and transportation structures, such as roads, airports, and terminals. A study conducted in 1970 determined that substantial acreage was developed in residential, commercial and industrial use during the 1960-1970 time frame. Table 6 presents the distribution of land use within the study area in eight land use categories as it existed in 1970. The data shows that the urbanized areas surrounding the City of Providence contained the highest density of residential, commercial and industrial land while the more rural communities in the western portion of the study area had by far the largest areas of agricultural, open, forest and wetlands.

During the mid-1960's the State of Rhode Island, acting through its Water Resources Board, acquired approximately 8300 acres of land located in Coventry, West Greenwich and Exeter for the site of the planned Big River water supply reservoir. The site has remained essentially unchanged since coming under State ownership being heavily forested with numerous wetlands, several abandoned and active surface-mining areas, and open land including residences and the site of the former West Greenwich municipal dump. The area is managed for recreational purposes by the Rhode Island Department of Environmental Management.

Land use within the Pawtuxet River Basin is presented in detail in "Attachment 1" of this report.

TRANSPORTATION

Eleven major highways traverse the State, forming the major arteries of an integrated roadway system. Interstate Route 95 runs from the Rhode Island - Connecticut border through Providence to the Massachusetts line, for a total length of 43.3 miles. It is one of the principal routes connecting New York, Providence and Boston. Interstate Route 295 circles the Providence metropolitan area to the west, while Interstate Route 195 services the Fall River - New Bedford - Cape Cod area. Other important highways that serve the region include U.S. and R.I.

TABLE 6

DISTRIBUTION OF LAND USE IN STUDY AREA AND STATE - 1970
(ACRES)

COMMUNITY	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	MINING & WASTE	TRANSP.	OPEN & PUBLIC	OUTDOOR RECREATION	AGRIC.OPEN FOREST. WETLAND
Barrington	2,459	45	15	23	53	199	274	3,716
Bristol	1,609	77	129	74	11	268	1[illegible]7	4,473
Coventry	3,473	148	173	265	81	310	178	35,213
Cranston	4,881	595	335	177	782	1,141	289	9,641
E. Greenwich	1,724	157	62	106	146	337	172	7,939
E. Providence	3,041	373	467	135	646	634	649	3,036
Foster	787	48	26	74	11	25	138	32,350
Glocester	1,355	53	21	93	7	92	64	32,608
Johnston	2,506	208	109	268	260	185	68	11,952
N. Providence	1,766	162	55	15	28	261	148	1,246
Providence	5,254	1,353	867	22	1,167	1,466	651	1,444
Scituate	2,069	37	48	147	-	173	114	32,651
Smithfield	1,749	132	121	275	349	144	55	14,765
Warren	942	110	60	-	27	98	49	3,785
Warwick	8,669	921	344	211	1,537	1,300	1,002	9,680
W. Greenwich	750	15	7	400	194	176	26	31,305
W. Warwick	1,887	215	153	29	77	216	140	2,540
Total	44,921	4,649	2,992	2,314	5,376	7,025	4,204	238,344
Percent of Total	15	1	1	1	2	2	1	77
State Totals								
Area	89,142	7,050	5,344	4,708	10,135	15,792	9,624	552,165
Percent of Total	13	1	1	1	1	2	1	80

Source: Rhode Island Statewide Planning Program - Report No. 22 State Land Use Policies and Plan January 1975

Routes 2 and 4, which connect at Warwick and provide access to the lower Narragansett Bay and South County summer vacation areas; U.S. Route 6, which is the primary east-west route between Hartford and Providence; and two high-speed connectors, Rhode Island P-37 and the connector to the State airport in Warwick.

Four interstate bus companies (Greyhound, Trailways, Almeida and Bonanza) have central terminals at Providence and provide regular service to Boston, southeastern Massachusetts, Worcester, Springfield, Hartford, New Haven and New York City. Intrastate bus service is supplied by the Rhode Island Public Transit Authority and the ABC and Bonanza bus companies, which provide regular runs from Providence to Warwick, Cranston, Johnston, West Warwick and the Washington section of Coventry and Warwick and between Exeter and East Greenwich.

Bulk freight service is provided by Conrail, which has a major freight terminal in Providence and smaller freight yards in Cranston and Warwick. The main line extends from Providence southerly through Cranston, Warwick and Westerly (RI) and then westerly to New Haven and New York. Additional freight lines owned by the Providence and Worcester, Moshassuck Valley, Narragansett Pier, Seaview, and Warwick rail companies carry cargo into Conrail's main line at various points throughout the State. Passenger service is provided by Conrail, which operates the Amtrak service (a Federally assisted public corporation) along the main line between New York and Boston and a commuter line from Westerly through Providence to Boston.

Six State airports in Rhode Island provide passenger and cargo service. The terminal facility at T. F. Greene Airport in Warwick handles the majority of the air passenger and cargo needs of the region with more than 75 flights scheduled daily to areas such as New York, Washington, Albany, Baltimore, Boston, Hartford, Miami, Philadelphia, and Cleveland. A major advantage of Greene Airport is accessability. With direct access provided from I-95, the airport is within a 12-minute drive from downtown Providence. The other five State-operated airports offer private plane and charter facilities.

Most of the waterborne commerce needs of the region are served by the Port of Providence, which has a 40-foot deep main ship channel. The port has facilities for handling many of southern New England's domestic and industrial petroleum products as well as other bulk and general cargo at its 27 public and private docks.

In addition to the facilities at Providence, recently excessed navy bases in Portsmouth, Middletown and North Kingstown provide piers for handling bulk and general cargo.

RECREATION

The primary recreational activities within the study area are boating, camping, fishing, golf, hunting, picnicking, swimming and trails for hiking, horseback riding, recreational vehicles, and snowmobiling. Within the State of Rhode Island most of these activities take place on 30,000 acres of State-owned land, that are utilized for recreation, conservation and open space. The State operates both multi-use areas such as management areas and parks, and specific facilities such as campgrounds, boat launches, and beaches.

Major recreation areas located within the study area include the following:

Name	Location
Arcadia Management Area	Exeter, West Greenwich
Beach Pond State Park	Exeter, West Greenwich
Colt State Park	Bristol
George Washington Area	Glocester
Goddard State Park	Warwick
Haines Memorial Park	Barrington
Pulaski Memorial State Park	Glocester

Besides the State-owned lands at the proposed Big River Reservoir site, two other State management areas lie within the study region. These are the Arcadia management area comprising about 8000 acres and Wickaboxet management area in West Greenwich consisting of about 400 acres. Together, all of these lands provide the majority of the hunting facilities within the study area.

The Big River site is used extensively for a variety of recreational purposes primarily by residents of the surrounding area. Since coming under State ownership several years ago, it has been heavily used for recreation under control of the Rhode Island Department of Environmental Management in coordination with the Water Resources Board. Some of the recreational activities available at the Big River Management Area include boating, camping, fishing, golf, hunting, picnicking, swimming and hiking.

Detailed information on recreation resources within the study area and the State is contained in Appendix H, "Recreation and Natural Resources."

ALTERNATIVE FUTURE CONDITIONS

INTRODUCTION

Major uncertainties are always associated with projections of future conditions for a given study area. Criteria used in the projection methodology may or may not prove true. However, the combination of expressed opinions, assumptions, and probabilities about the study area produces alternatives that could appreciably affect the direction of future development. The Water Resources Council, in its Principles and Standards for evaluation of water and related land resources, requires that alternative future conditions be analyzed that are reasonably probable and that, if realized, would appreciably affect plan design or scheduling. It is, therefore, necessary to designate what is considered to be the "most probable future" condition for the study area and in turn derive planning objectives that reflect not only this "most probable future" but more specifically the condition that would prevail in the absence of implementation of a plan to alter the management of water and related land resources-the "without condition".

In order to develop plans that would be responsive to both the immediate as well as the short term and long-range needs of the study area and to the overall goals of the State of Rhode Island, future conditions were projected based upon available planning data and information obtained from various Federal, State and local agencies.

POPULATION

Population is the single most important element of future development in Rhode Island that has associated with it alternative growth scenarios. Inasmuch as the distribution of population within the study area and the State would have very direct effects on future water resources development plans, analysis of population alternatives was considered necessary to reflect the "most probable future" condition.

Estimates of the population that could be accommodated by 1990 State land use projections are contained in the State Land Use Policies and Plan, Report No. 22, January 1975 prepared by the Rhode Island Statewide Planning Program. Population estimates were based upon three categories of residential development (high, medium and low density), and two other land use categories covering woodland - open land and government/institutional areas. The population capacity of the 1990 land use plan for the study area and the State is shown in Table 7.

In 1975, the Rhode Island Statewide Planning program published updated population projections for the State and its 39 cities and towns. The projections, published as Technical Paper No. 25, dated April 1975, showed gradual reductions in State growth over the 1970-2040 time frame with forecasted percentage increases remaining below those for the Nation. City and town population projections generally showed a tapering in both growth and loss in relation to prior long-range trends and are shown in Table 8 for the State and each of the study area communities.

The 1975 projections were undertaken principally to assess the impact of the closing of U. S. Naval installations in Rhode Island during the early 1970's. Much of the initial population increase represented by the projections was absorbed by the outmigration of naval personnel and their dependents. The overall decrease in the rate of population growth is not reflected in the State projections until after 1990 when the reduction in the number of women of child bearing age would take place.

The population projections contained in Technical Paper No. 25 were utilized by the Corps of Engineers to project future conditions in the study area during the initial problem identification and plan formulation phases of the current study as well as other water resources investigations conducted for the entire PNB study region.

TABLE 7

POPULATION CAPACITY OF 1990 LAND USE PLAN

COMMUNITY	RESIDENTIAL HIGH DENSITY	MEDIUM DENSITY	LOW DENSITY	WOODLAND OPEN LAND	GOVT. INST.	TOTAL PLAN CAPACITY
Barrington	10,500	11,300	2,200	-	400	24,400
Bristol	7,400	11,500	2,900	400	600	22,800
Coventry	7,700	23,200	1,800	3,100	300	36,100
Cranston	75,300	28,800	-	2,900	4,300	111,300
East Greenwich	6,000	5,400	4,600	1,800	-	17,800
East Providence	66,100	7,800	-	-	800	74,700
Foster	-	1,000	400	3,200	-	4,600
Glocester	-	5,600	800	3,100	-	9,500
Johnston	13,600	14,500	1,200	3,400	100	32,800
North Providence	34,200	-	-	-	200	34,400
Providence	164,500	-	-	-	9,100	173,600
Scituate	-	4,500	400	2,100	200	7,200
Smithfield	9,900	8,100	1,500	4,100	300	23,900
Warren	9,700	3,900	-	300	200	14,100
Warwick	63,100	38,800	7,700	-	800	110,400
West Greenwich	-	1,200	400	2,200	-	3,800
West Warwick	18,900	7,800	-	400	100	27,200
Total Study Area	486,900	173,400	23,900	27,000	17,400	728,600
Total State	741,300	340,300	60,800	58,100	51,000	1,251,500

Note: Figures are rounded to nearest hundred

Source: State Land Use Policies and Plan, Report Number 22, January 1975, Rhode Island Statewide Planning Program

TABLE 8

POPULATION PROJECTIONS - STATE STUDY 1975

COMMUNITY	YEAR								
	1970	1975	1980	1990	2000	2010	2020	2030	2040
Barrington	17.6	17.4	17.6	18.1	18.5	19.0	19.4	19.6	19.6
Bristol	17.9	18.7	19.7	21.6	22.1	22.5	22.9	23.1	23.3
Coventry	22.9	26.0	30.4	38.0	43.0	47.5	52.4	55.3	57.0
Cranston	74.3	77.0	81.2	89.0	93.4	99.0	104.2	108.0	112.0
East Greenwich	9.6	10.6	11.2	12.6	13.6	15.2	16.8	18.0	18.6
East Providence	48.2	50.8	54.8	62.3	65.8	70.2	74.2	78.2	82.2
Foster	2.6	3.1	3.5	3.8	4.2	4.7	5.1	5.2	5.2
Glocester	5.2	6.4	6.7	7.2	7.6	8.0	8.4	8.6	8.6
Johnston	22.0	23.8	27.5	31.5	33.2	35.2	37.2	39.2	41.0
North Providence	24.3	26.8	28.8	31.7	34.2	36.8	39.4	41.7	43.1
Providence	179.1	168.1	170.1	177.5	196.0	204.9	209.0	210.0	210.0
Scituate	7.5	8.5	8.8	9.2	9.4	9.6	9.8	10.0	10.0
Smithfield	13.5	14.5	15.5	17.5	19.5	21.5	23.5	25.5	27.4
Warren	10.5	10.6	11.1	12.3	12.9	14.0	14.6	14.7	14.9
Warwick	83.7	88.7	93.6	103.6	117.7	120.6	129.6	137.6	145.3
West Greenwich	1.8	2.5	2.8	3.2	3.6	4.0	4.4	4.7	4.8
West Warwick	24.3	26.0	28.0	31.0	31.9	33.0	33.8	34.0	34.0
Total Study Area	565.0	579.5	611.3	670.1	726.6	765.7	804.7	833.4	857.0
Total State	949.7	952.2	1000.4	1095.4	1173.6	1253.6	1324.7	1377.8	1421.7

Note: Figures are in thousands

Source: Rhode Island Statewide Planning Program
Technical Paper No. 25, April 1975

In 1979, revised population projections for Rhode Island communities were developed by the Statewide Planning Program which showed marked variation from the earlier 1975 forecasts. Both projection series were based on 1970 census figures developed by the U.S. Bureau of the Census. The most significant factor contributing to the differences between the original and revised projections was inclusion of the recent temporary decrease in birth rates below replacement levels prior to 1975. The revised projections considered a gradual return to this level by the year 2000 while the 1975 projections assumed that the base period rates in 1970 would gradually reach this level by the year 2000. Other factors contributing to the overall differences in original and revised population totals were also due to changes in basic assumptions and the use of updated forecasts for survival rates. The revised population projections were published in Technical Paper No. 83 dated April 1979 (which did not become available until August 1979) and are shown for comparison in Table 9 for the State and each community in the study area for the years 1970 to 2040.

Projections reported in Technical Paper No. 83 show reductions, from the earlier 1975 forecasts, of about 19 percent and 27 percent in the population of study area communities for the years 2000 and 2030 respectively. Likewise, State population totals for the years 2000 and 2030 show reductions of about 14 percent and 25 percent respectively, from 1975 figures.

In view of the signficant differences between the population projections developed by the Rhode Island Statewide Planning Program in 1975 and 1979, the forecasts were compared with OBERS Series E projections developed by the U.S. Water Resources Council. Population and economic development projections based on the most recent OBERS figures are used in Federal water resources development programs to form the basis in most studies for the specification of future conditions. Projections were available for the Providence-Warwick-Pawtucket SMSA which includes all of the study area communities. OBERS projections for the Providence-Warwick-Pawtucket SMSA are shown in Table 10. Estimates of population projections were developed for the study area based on data contained in the OBERS figures for direct comparison with those developed by the State. Plate A-4 displays population projections considered in this study in graphical form to better illustrate the differences projected to occur over the study time frame.

It is evident from analysis of Plate A-4 that the 1979 projections reflect a major departure from earlier forecasts. It was, therefore, considered prudent for sound planning to evaluate the impact of these projections on the water resources needs of the study area. The range represented by the 1975 and 1979 population projections was considered appropriate for the development of water resources plans to satisfy alternative future conditions.

MOST PROBABLE FUTURE

Projections of future conditions in the State of Rhode Island presented in the preceding section reflect increased urbanization in most areas over the next several decades. Some of the growth projections represent greater requirements for residential and other urban development, however, all projections reflect increased population within the study area and the State.

TABLE 9

POPULATION PROJECTIONS - STATE STUDY 1979

COMMUNITY	YEAR								
	1970	1975	1980	1990	2000	2010	2020	2030	2040
Barrington	17.6	17.3	17.4	17.8	18.2	18.3	18.3	18.1	17.5
Bristol	17.9	18.2	19.3	21.3	22.1	22.3	22.4	22.2	21.6
Coventry	22.9	25.3	27.1	30.1	31.9	32.8	33.6	33.5	33.1
Cranston	74.3	74.8	73.5	74.9	76.5	77.9	79.3	79.6	79.3
East Greenwich	9.6	10.6	10.9	11.6	12.1	12.3	12.4	12.2	11.6
East Providence	48.2	49.9	48.9	50.0	51.4	52.4	53.3	53.4	53.2
Foster	2.6	3.2	3.8	4.7	5.2	5.4	5.4	5.2	4.5
Glocester	5.2	6.5	7.6	9.5	10.3	10.5	10.6	10.4	9.7
Johnston	22.0	24.1	24.5	26.4	27.9	28.9	29.8	29.9	29.7
North Providence	24.3	26.7	27.3	29.2	30.9	32.1	33.1	33.2	33.0
Providence	179.1	168.5	154.3	139.4	132.0	128.2	128.2	128.0	127.3
Scituate	7.5	8.5	8.9	9.9	10.5	10.7	10.7	10.5	9.9
Smithfield	13.5	14.4	16.4	18.6	20.1	21.2	22.1	22.1	21.7
Warren	10.5	10.1	10.1	10.3	10.5	10.6	10.7	10.6	10.2
Warwick	83.7	86.3	89.1	94.3	97.6	99.4	101.2	101.6	101.4
West Greenwich	1.8	1.9	2.7	3.7	4.2	4.4	4.5	4.3	3.7
West Warwick	24.3	25.0	26.3	28.1	29.3	29.9	30.4	30.5	30.3
Total Study Area	565.0	571.3	568.1	579.8	590.7	597.3	606.0	605.3	597.7
Total State	949.6	936.3	944.7	978.0	1005.6	1023.3	1041.7	1040.0	1024.8

Note: Figures are in thousands

Source: Rhode Island Statewide Planning Program
Technical Paper No. 83, April 1979

TABLE 10

PROVIDENCE - WARWICK - PAWTUCKET SMSA

POPULATION AND ECONOMIC PROJECTIONS

	1950	1970	1980	1990	2000	2020
Population, midyear	676,738	770,824	832,300	890,700	945,500	1,046,600
Per Capita Income (1967 dollars)	2,249	3,513	4,900	6,300	8,300	13,300
Total Employment	275,270	324,303	386,800	414,500	451,600	483,600
Employement/Population Ratio		0.42	0.46	0.47	0.48	0.46
IN THOUSANDS OF 1967 DOLLARS						
Total Personal Income	1,521,829	2,708,062	4,082,900	5,629,700	7,890,700	13,996,800
Total Earnings	1,232,997	2,068,351	3,066,200	4,204,000	5,863,800	10,395,700
Manufacturing	615,879	732,784	945,200	1,172,800	1,511,500	2,399,900
Transportation, etc.	72,490	119,417	177,100	242,200	332,300	563,800
Services	122,051	335,463	608,400	950,600	1,454,200	2,941,300
Government	76,692	263,861	406,900	593,300	864,900	1,623,100

Source: 1972 OBERS Series E Projections, U.S. Water Resources Council

Currently, the State Guide Plan is the principal structure for guiding the growth of the State in the years to come. Adoption of the State Land Use Policies and Plan, as an element of the State Guide Plan, by the State Planning Council in 1975 presented a framework for growth in Rhode Island commensurate with specific goals. The land use plan, being the "core" element of the State Guide Plan, allocated areas to specific activities and in doing so assumed that past trends in population growth and distribution, employment, industrial and commercial development, recreation demand, agricultural production, and so on would tend to continue. Population growth is a key parameter in the projection of future conditions as the critical relationship between increasing population and the utilization of land must always be recognized.

LAND USE

Rhode Island's State Guide Plan was utilized to present future development alternatives for the study area within the overall time frame of the present study. The plan is composed of separate but closely related plans or elements which set forth policies and programs on key issues of future development such as land use, utility services, transportation, recreation, and other public facilities. Land use is the most important element of the State Guide Plan since the future distribution of land use categories must be estimated in order to effectively plan those elements concerned with public facilities and services.

State land use plans and policies are contained in Report No.22, State Land Use Policies and Plan, January 1975, prepared by the Rhode Island Statewide Planning Program. The final plan, upon which development through the year 1990 is addressed, presents a considerable change from existing land use patterns in an attempt to promote compact, directed development throughout the State and balanced urban development. In planning future land use, identification of areas suitable for different uses were made together with estimates of the amount of land needed at specific times in the future.

The State Land Use Policies and Plan serves to guide local governments in making decisions related to land use. The plan was developed with a population ceiling of about 1.5 million people in mind and with about 50 percent of the State's land area remaining as open space. In order to accommodate this type of growth, some basic assumptions were made.

. No development would occur on the approximately five percent of the State's land which is considered "undevelopable."

. No development would occur on the remaining 45 percent of lands which are to be preserved in their natural state and, therefore, remain as open space.

. Land already developed would continue in urban or "committed" use.

. Development would be allowed to occur on all remaining lands not developed or reserved for open space.

. New urbanized lands would be developed to an intensity of about two-thirds of the 1960 intensity (ratio of population to developed area) which would be reflective of the development that is presently occurring within the State. Projections of the distribution of land use within the study area and the State in 1990 are shown in Table 11.

TABLE 11

DISTRIBUTION OF LAND USE IN STUDY AREA AND STATE - 1990
(ACRES)

	Residential	Commercial	Industrial	Govern'l Instit'l	Airports	Open Space Recreation	Open Space Conservation	Open Space Woodland Open Land
Barrington	3,700	100	-	400	-	700	600	-
Bristol	4,000	100	400	200	-	600	200	-
Coventry	8,100	-	500	-	-	1,300	1,200	26,500
Cranston	7,000	100	1,200	900	-	2,100	-	6,400
East Greenwich	4,700	100	400	-	-	400	500	3,900
East Providence	4,200	300	1,400	-	-	2,000	300	-
Foster	800	-	-	-	-	600	1,900	28,500
Glocester	2,600	-	-	-	-	4,100	300	27,500
Johnston	4,900	100	300	-	-	1,900	200	7,000
North Providence	2,900	-	100	100	-	500	-	-
Providence	8,500	300	2,100	700	-	600	-	-
Scituate	1,700	-	-	-	-	-	9,400	18,700
Smithfield	2,900	100	1,400	500	600	1,200	400	8,900
Warren	2,000	100	300	100	-	100	600	600
Warwick	13,200	1,200	1,900	1,100	1,000	2,200	700	100
West Greenwich	600	-	100	-	-	3,200	5,400	19,400
West Warwick	3,000	-	400	-	-	1,000	-	900
Total Study Area	74,800	2,500	10,500	4,000	1,600	22,500	21,700	148,400
Total State	148,300	4,200	20,200	10,000	3,000	75,100	48,600	340,600
Percent of total	23	1	3	2	-	12	7	52

Note: Figures are rounded to the nearest 100 acres.

Source: State Land Use Policies and Plan, Report Number 22, January 1975
Rhode Island Statewide Planning Program

As compared to the distribution of land use within the State in 1970 and previously shown in Table 6, the data presented in Table 11 showing the allocations projected for 1990, reflect significant changes in the amounts allocated to urban and committed lands (governmental/institutional, airports, roads, other transportion and public utilities) and to woodland - open land. More than twice the amount of the former category is projected to occur by 1990 representing about 48 percent of the State's total land area. The woodland - open land category, as well as being approximately 50 percent of the total State land area, represents a reduction from the 1970 level. This is due to the conversion of this land use category to urban and committed land in the 1990 projections.

No land use projections have been developed by the State of Rhode Island beyond 1990 although it is expected that development of the urbanized areas will continue in the future. Future population increases projected for the study area and the State would indicate that much of the undeveloped land existing in Rhode Island will continue to be developed for residential, commercial and industrial use.

ECONOMY

Population is only one of the many economic indicators used in projecting future conditions. Projections for a given area are based upon an objective analysis of past trends. Water and related land resources development is focused on conditions expected to occur in future years and, therefore, projections of economic growth must be undertaken to assure their viability.

In Rhode Island, the goal of economic development is of extreme importance in terms of both the need for change and expansion and the need for consistency within environmental objectives. The economy of the State has changed significantly in recent years showing decline in the manufacturing sector and substantial increase in the services related sector.

Table 10, shown previously, provides data on economic projections for the Providence-Warwick-Pawtucket SMSA that best describe future economic conditions. The data were excerpted from 1972 OBERS Series E projections developed by the U.S. Water Resources Council and reflect a steady growth for the area.

POPULATION

In view of population projections developed by the State in 1975 and 1979 the question of which series most adequately reflects future conditions takes on added significance. Comparison of the population projections with OBERS shows that the 1975 series is much closer to the OBERS projections than those done in 1979. The 1975 projections likewise reflect more closely the degree of development anticipated by the State Guide Plan and are reflective of the population capacity that would be accommodated by the land use element of the plan.

As a consequence, the "most probable future" adopted for analysis in this study incorporates the 1975 population projections developed by the State as the basis for determining water resources development needs within the study area. This was done in order to address the specific water resources problems associated with such projections and the formulation of alternative solutions. In so doing the overall growth assumptions presented in the State Guide Plan would be met while recognizing that estimates of future demands based on the 1975 projections are conservative as compared to past projections.

PROBLEMS AND NEEDS

INTRODUCTION

Municipal and industrial water supply and recreation demands of the study area were estimated based upon projections contained in the "most probable future." Similarly, flood problems resulting from projected urbanization of study area communities were identified and estimates made of the expected flood damages.

The following paragraphs present water resources needs investigated in this study and utilized in the specification of planning objectives. The methodology used in estimating future water demands is also presented to provide the basis of projections.

Other water and related land resources needs within the study area are described in subsequent sections of the report.

WATER SUPPLY

Existing Conditions Summary

Data on existing water supply and demand within the study area were presented in the "Existing Conditions" section earlier in this report. The data shows that in 1975 public systems* serving the study area supplied water to more than 500,000 people or about 60 percent of the entire State population. Also, of the approximately 111 million gallons supplied daily by public systems in Rhode Island, some 65 percent was delivered by systems serving the study area.

Existing public water demand consisted of residential, commercial, and industrial usage and also included "unaccounted for" water associated with leakage and various municipal services such as fire-protection needs. Private water demands were also estimated for the study area and included the same use categories. Table 12 presents a summary of existing water supply and demand in the study area based upon reported 1975 data.

* Public water supply systems refer to municipally-owned and private investor-owned facilities.

TABLE 12

EXISTING WATER SUPPLY AND DEMAND IN STUDY AREA

WATER SUPPLY AGENCY	COMMUNITIES SERVED	MUNICIPAL SYSTEMS: POPULATION SERVED BY MUNICIPAL SYSTEM	AVERAGE DAY RESIDENTIAL & COMMERCIAL DEMAND, MGD	AVERAGE DAY INDUSTRIAL DEMAND, MGD	TOTAL AVERAGE DAY DEMAND, MGD	MAXIMUM DAY DEMAND, MGD.	1975 SOURCES OF SUPPLY	1975 SAFE YIELD, MGD.	MAXIMUM DAY CAPACITY, MGD.	PRIVATE DEMANDS: POPULATION SERVED BY PRIVATE SYSTEMS	AVERAGE DAY RESIDENTIAL & COMMERCIAL DEMAND, MGD.	AVERAGE DAY INDUSTRIAL DEMAND, MGD.	TOTAL AVERAGE DAY DEMAND, MGD.	TOTAL MUNICIPAL & PRIVATE AVERAGE DAY DEMAND, MGD.
Bristol County Water Company	Barrington, Bristol, Warren	44,600	2.64	0.73	3.37	5.82	S.W., G.W.	3.20	4.70	2,100	0.13	0	0.13	3.50
Providence Water Supply Board	Cranston, Providence, Johnston, North Providence, East Providence, Smithfield, Warwick	416,830	49.9	12.6	62.4	106	S.W.	72.0*	144	29,073	1.74	11.3	13.0	75.4
Kent County Water Authority	East Greenwich, West Greenwich, Coventry, Scituate, West Warwick	57,200	5.15	0.87	6.02	12.4	G.W.	10.9	10.9	16,400	0.99	3.37	4.36	10.4
	Foster	0	0	0		0	None	0	0	3,100	0.19	0	0.19	0.19
	Glocester	0	0	0		0	None	0	0	6,400	0.38	0	0.38	0.38
Total Study Area (Rounded)		518,600	57.7	14.1	71.8	124.2		86.1	159.6	57,100	3.4	14.7	18.1	89.9

* Increased to 77 mgd based upon Corps analysis of Scituate Reservoir
G.W. - denotes groundwater
S.W. - denotes surface water
MGD - denotes million gallons per day

Projection Methodology

General. To estimate future water supply requirements for the study area, it was necessary to base projections of future usage on existing data and past trends of water consumption in the region. Where new major developments were considered possible, such as those associated with new coal mining industry in the study area, estimates must be based on similar developments in other areas as well as on available data.

Water requirements were estimated for the years 1975, 2000 and 2030. The year 1975 was taken as the base year while 2000 and 2030 were chosen as the time frames for short-term and long-term needs, respectively.

Estimates of future water demands were developed separately for the following categories of use:

- Municipal water (residential, commercial and industrial)
- Private water (residential and industrial)
- Potential new major industrial water

Municipal Water Demand. Future public water demands for each time period were based on estimates of the following:

- Population of the service area
- Percentage of the population served
- Per capita consumption (residential and commercial)
- Industrial water use

Data on the above were developed to determine water supply usage in 1975, which then formed the basis for projections to 2000 and 2030. The accuracy of estimates of future water use is dependent on the accuracy of the projections and estimates made for the component parameters. In making estimates of future water use no direct allowance was made for the impact of changed policies on water consumption, nor was any allowance made for the possibility that water shortages could restrict population growth.

a. Projected Population: Publicly supplied water demands were projected for the study area using the two population projections developed by the State. These projections for the study milestone years of 1975, 2000, and 2030 by water supply agency are shown in Table 13.

b. Population Served: Projected population served in 2000 and 2030 within the study area was based upon estimates of population served by existing water supply systems in 1975. A community with at least 95 percent of its population served in 1975 was considered 100 percent served by 2000. Similarly, a community with less than 80 percent of its total population served in 1975 was not considered 100 percent served until 2030. Population served projections are shown in Table 14.

c. Average Day residential and Commercial Demand: Values of 1975 average day residential and commercial water demands were obtained by deducting from total demand the industrial water usage for each water supply agency. Industrial demands for existing systems were obtained

TABLE 13

TOTAL POPULATION PROJECTIONS FOR STUDY AREA AND STATE

WATER SUPPLY AGENCY	COMMUNITY	POPULATION 1975 Proj. 1	1975 Proj. 2	2000 Proj. 1	2000 Proj. 2	2030 Proj. 1	2030 Proj. 2
Bristol County Water Company	Barrington	17,400	17,300	18,500	18,200	19,600	18,100
	Bristol	18,700	18,200	22,100	22,100	23,100	22,200
	Warren	10,600	10,100	12,900	10,500	14,700	10,600
		46,700	45,600	53,500	50,800	57,400	50,900
Providence Water Supply Board	Cranston	77,000	74,800	93,400	76,500	108,000	79,600
	Providence	168,100	168,500	196,000	132,000	210,000	128,000
	Johnston	23,800	24,100	33,200	27,900	39,200	29,900
	North Providence	26,800	26,700	34,200	30,900	41,700	33,200
	East Providence	50,800	49,900	65,800	51,400	78,200	53,400
	Smithfield	14,500	14,400	19,500	20,100	25,500	22,100
	Warwick	88,700	86,300	117,700	97,600	137,600	101,600
		449,700	444,700	559,800	436,400	640,200	447,800
Kent County Water Authority	East Greenwich	10,600	10,600	13,600	12,100	18,000	12,200
	West Greenwich	2,500	1,900	3,600	4,200	4,700	4,300
	Coventry	26,000	25,300	43,000	31,900	55,300	33,500
	Scituate	8,500	8,500	9,400	10,500	10,000	10,500
	West Warwick	26,000	25,000	31,900	29,300	34,000	30,500
		73,600	71,300	101,500	88,000	122,000	91,000
	Foster	3,100	3,200	4,200	5,200	5,200	5,200
	Glocester	6,400	6,500	7,600	10,300	8,600	10,400
Total Study Area		579,500	571,300	726,600	590,700	833,400	605,300
Total State		952,200	944,700	1,173,600	1,005,600	1,377,800	1,040,000

Source: Projection 1 - Rhode Island Statewide Planning Program Technical Paper Number 25, April 1975
Projection 2 - Rhode Island Statewide Planning Program Technical Paper Number 83, April 1979

TABLE 14

POPULATION SERVED PROJECTIONS FOR STUDY AREA

WATER SUPPLY AGENCY	COMMUNITY	POPULATION 1975 Proj. 1	1975 Proj. 2	2000 Proj. 1	2000 Proj. 2	2030 Proj. 1	2030 Proj. 2
Bristol County Water Company	Barrington	16,900		18,500	18,200	19,600	18,100
	Bristol	18,300		22,100	22,100	23,100	22,200
	Warren	9,400		12,900	10,500	14,700	10,600
		44,600		53,500	50,800	57,400	50,900
Providence Water Supply Board	Cranston 1)	72,000		93,400	76,500	108,000	79,600
	Providence	168,100		196,000	132,000	210,000	128,000
	Johnston	16,800		29,900	25,100	39,200	29,900
	North Providence 2)	20,300		28,700	25,900	35,100	28,000
	East Providence 4)	49,900		65,800	51,400	78,200	53,400
	Smithfield 3)	11,200		17,100	17,600	25,500	22,100
	Warwick 1)	78,500		117,700	97,600	137,600	101,600
		416,800		548,600	426,100	633,600	442,600
Kent County Water Authority	East Greenwich	9,800		13,600	12,100	18,000	12,200
	West Greenwich	700		2,500	2,900	4,700	4,300
	Coventry	21,300		43,000	31,900	55,300	33,500
	Scituate	1,400		5,900	6,600	10,000	10,500
	West Warwick	24,000		31,900	29,300	34,000	30,500
		57,200 2)		96,900	82,800	122,000	91,000
	Foster	0		2,300	2,900	5,200	5,200
	Glocester	0		4,200	5,700	8,600	10,400
Total Study Area		518,600		705,500	568,300	826,800	600,100

by the total metered water use of major industries within the study area. Unaccounted for and unmetered water was included in the residential and commercial use category for the development of per capita water consumption data. Average day residential and commercial demands for the years 2000 and 2030 were then obtained by multiplying the population served by the per capita water consumption for each water supply agency.

d. Per Capita Consumption: The 1975 per capita consumption figures were obtained by dividing the combined residential and commercial average daily demand by the population served. (It was assumed that towns which had no municipal water systems in 1975 would be served by 1995. Values of 70 and 80 gallons per capita per day (gpcd) were assumed for 2000 and 2030, respectively, except for Glocester where 85 and 95 gpcd were used.) Future values of per capita consumption were largely based on projected increases developed for the "Feasibility Report on Alternative Regional Water Supply Plans for Southeastern New England", Corps of Engineers, 1969. These projections were checked for applicability by selecting from the entire PNB study area 27 communities in which industrial water use was not significant. The consumption patterns of these communities were studies for the period 1965 to 1973 and showed a slightly less increase in per capita usage than projections in the reference report. Per capita increases of 20 gpd between 1975 and 2000 and 10 gpd between 2000 and 2030 were added to all 1975 residential water consumption values, the latter figure being considered representative of a greater public awareness toward water conservation. This results in a greater percentage increase in small communities, which generally have a lower per capita consumption than larger ones. However, it was anticipated that water consumption in small and rural towns would increase at a greater rate than urban areas due to the added installation of water-using appliances such as washing machines and dishwashers.

e. Average Day Industrial Demand: Data for the study area were obtained from the Rhode Island Water Resources Board report entitled "Rhode Island Industrial Water" which contained 1971 data. The data were listed by Standard Industrial Classification (SIC) code and by water supply agency, and were considered valid for 1975. Future projections of publicly supplied industrial water demands were based on a theoretical model described by R. H. Stewart and I. Metzger in their article, "Industrial Water Forecasts," Journal American Water Works Association, March 1971. The methodology employed in the model utilizes a growth factor based on economic and technological parameters.

f. Total Average Day Demand: Values for the total daily average demand include total municipally supplied residential and commercial, industrial, and unaccounted for water. Data on existing water supply agencies in the study area were obtained from unpublished records of the following:

- Rhode Island Water Resources Board
- Rhode Island Department of Environmental Management
- Water utilities

g. Maximum Day Demand: It was assumed for each community presently served that the current maximum to average day consumption ratio would apply throughout the study period. For communities not yet served by a municipal system, it was assumed that a maximum to average day consumption ratio of 2 to 1 would apply when a municipal system was constructed. Data was obtained from the Rhode Island Water Resources Board, water utilities, and the Rhode Island Department of Environmental Management on water supply systems serving the study area in 1975.

Private Agricultural Demands. No allowance has been made for private agricultural water use in the study area since it was found to be negligible at present.

Potential New Major Industrial Water Use. The development of a major water-using industry in the study area would result in much larger water requirements than estimates based solely on past water use. Prediction of a new major industry must be speculative, but consideration of the particular circumstances of the study area permit some general conclusions. First, the major water-using industries are the older primary types such as iron and steel and lumber processing companies. They tend to be located close to major sources of raw materials and, in general, there seems no reason why such industries should relocate into the study area. Second, the technologically new industries tend not to be large water consumers and, in most cases, their development would be included within the estimates of normal industrial development.

An exception to the above rule could occur if large mineral deposits were discovered within the study area and if extraction or processing of these minerals required substantial quantities of water. At first sight, the possibility of such discoveries appears slight in this long settled area. However, technological advances in exploration and extraction techniques can lead to unexpected discoveries in developed areas. Recent examples are the offshore oil discoveries in the North Sea and copper and zinc discoveries in northern Wisconsin. The possibility of such finds cannot be entirely discounted, but for present study purposes no allowance has been made for potential new major industrial water demands in projecting future use requirements.

Water Supply Needs. Municipal and industrial water supply needs were developed for the study area based upon the foregoing methodology and are shown in Table 15 for the "most probable future" condition. Estimates of future demand based upon the State's 1979 population projections are shown in Table 16 for comparison purposes.

As shown in Table 15, average water supply needs within the study area are estimated to increase from approximately 72 mgd in 1975 to almost 109 mgd in the year 2000 and about 142 mgd by the year 2030. Water deficits resulting from these demand projections would amount to approximately 18 mgd and 51 mgd by the year 2000 and 2030 respectively.

Ability to meet average daily demands is not the only concern when evaluating existing systems to supply projected future needs. Fluctuations in demand produces high and low flow requirements which must be accommodated.

TABLE 15

MUNICIPAL WATER SUPPLY REQUIREMENTS FOR STUDY AREA 1)

WATER SUPPLY AGENCY	COMMUNITIES SERVED	1975 SOURCES OF SUPPLY	1975 SAFE YIELD, MGD.	MAXIMUM DAY CAPACITY, MGD	1975 AVERAGE DAY DEMAND, MGD.	1975 MAXIMUM DAY DEMAND, MGD.	2000 AVERAGE DAY DEMAND, MGD.	2000 MAXIMUM DAY DEMAND, MGD	2030 AVERAGE DAY DEMAND, MGD.	2030 MAXIMUM DAY DEMAND, MGD
Bristol County Water Company	Barrington	G. W.	0.7	0.7	1.0					
	Bristol	S. W.	2.5	4.0	2.4					
	Warren									
			3.2	4.7	3.4	5.8	5.3	9.2	6.9	11.9
Providence Water Supply Board	Cranston									
	Providence									
	Johnston									
	North Providence									
	East Providence									
	Smithfield									
	Warwick									
		S. W.	77.0	144.0	62.4	106.0	91.0	155.4	117.4	200.5
Kent County Water Authority	East Greenwich									
	West Greenwich									
	Coventry									
	Scituate									
	West Warwick									
		G. W.	10.9	10.9	6.0	12.4	12.0	24.4	16.9	34.5
	Foster	none	0	0	0	0	0.2	0.3	0.4	0.9
	Glocester	none	0	0	0	0	0.4	0.7	0.8	1.7
Total Study Area			91.1	159.6	71.8	124.2	108.9	190.0	142.4	249.5

1) Based on 1975 population projections
G.W. - denotes groundwater
S.W. - denotes surface water
MGD - denotes million gallons per day

TABLE 16

MUNICIPAL WATER SUPPLY REQUIRMENTS FOR STUDY AREA 1)

WATER SUPPLY AGENCY	COMMUNITIES SERVED	1975 SOURCES OF SUPPLY	1975 SAFE YIELD, MGD	MAXIMUM DAY CAPACITY, MGD	1975 AVERAGE DAY DEMAND, MGD	1975 MAXIMUM DAY DEMAND, MGD	2000 AVERAGE DAY DEMAND, MGD	2000 MAXIMUM DAY DEMAND, MGD	2030 AVERAGE DAY DEMAND, MGD	2030 MAXIMUM DAY DEMAND, MGD
Bristol County Water Company	Barrington	G. W.	0.7	0.7	1.0					
	Bristol	S. W.	2.5	4.0	2.4					
	Warren									
			3.2	4.7	3.4	5.8	5.1	8.8	6.3	10.[illegible]
Providence Water Supply Board	Cranston									
	Providence									
	Johnston									
	North Providence									
	East Providence									
	Smithfield									
	Warwick									
		S. W.	77.0	144.0	62.4	106.0	73.3	125.2	88.1	150.3
Kent County Water Authority	East Greenwich									
	West Greenwich									
	Coventry									
	Scituate									
	West Warwick									
		G. W.	10.9	10.9	6.0	12.4	10.4	21.2	13.1	26.7
	Foster	none	0	0	0	0	0.2	0.4	0.4	0.9
	Glocester	none	0	0	0	0	0.5	0.9	1.0	2.1
Total Study Area			91.1	159.6	71.8	124.2	89.5	156.5	108.9	190.9

1) Based on 1979 population projections
G.W. - denotes groundwater
S.W. - denotes surface water
MGD - denotes million gallons per day

The ability to also meet maximum day requirements is one other criterion used in the evaluation of existing systems. Table 15 shows maximum demands for the study area increasing from approximately 124 mgd in 1975 to 190 mgd in the year 2000 and almost 250 mgd by the year 2030. These demands reflect deficits of approximately 30 mgd and 90 mgd in existing systems projected for the years 2000 and 2030 respectively.

FLOOD DAMAGE REDUCTION

Introduction

Flooding in the Pawtuxet River Basin, which occurs primarily from runoff caused by precipitation of high intensity or of prolonged duration, has adverse effects on the economy and general well-being of the flood-prone areas. Flooding not only causes physical damage to property and non-physical losses of commercial, industrial and public activities, the subsequent loss of business and income and temporary relocation expenses to floodplain evacuees, but also represents a threat to the health and safety of those people who live and work in the flood-prone areas. The extent of flood hazards in the Pawtuxet River Basin are summarized in the following paragraphs while detailed information is contained in "Attachment 1."

Flood Damages

Increased urbanization associated with the "most probable future" condition will result in increased development in non-floodplain areas. This projected growth within basin communities, which has been ongoing since the start of detailed hydrologic studies of the Pawtuxet River Basin in 1972, will contribute to increased rates of runoff, causing higher flood peaks than ever previously experienced. Some development in the basin will continue to occur in land areas between the 100-year floodplain and that associated with the Standard Project Flood. Implementation of the National Flood Insurance Program will tend to reduce unwise development within the 100-year floodplain lands.

The net effect of the above basin development on the lower Pawtuxet River will result in a significant worsening in the intensity and frequency of flood problems. More frequent flooding can be expected and because of increased flood stages, larger areas of development will be subject to inundation. An example of this condition is the Norwood-Belmont Park area of Warwick where three times since 1978 flood levels have exceeded that of the flood of record, whereas only once has the actual flow been exceeded.

The principal flood damage areas in the Pawtuxet River Basin are located along the mainstem in the communities of West Warwick, Warwick and Cranston. Additional damage areas are located on the two downstream tributary streams - Meshanticut Brook and the Pocasset River in Cranston. The most significant damage locations are at the West Warwick Industrial Park, Ciba-Geigy, Inc. industrial complex, the Norwood-Belmont residential area, the Bulova industrial complex and the Warwick and Midland Shopping Malls, surrounding stores and apartment complex.

Areas subject to moderate damages are located at the Wellington Avenue Industrial Park, the Jefferson Avenue Industrial Park, and the Pontiac Mills industrial complex. Other locations within the Basin subject to damages from various degrees of flooding are at the West Warwick, Warwick and Cranston municipal wastewater treatment facilities, and the downstream areas of Meshanticut Brook and the Pocasset River which are influenced by flood stages in the mainstem Pawtuxet River. As the basin has been spared from a major flood in recent years, many of the above areas have experienced only minor losses in comparison to what would be expected from a recurrence of the July 1938 flood.

The effects of increased urbanization in upstream communities within the Basin would result in higher damages to downstream areas even without any new development. Flood losses estimated for the Basin, based upon conditions expected by 1990, would result in damages in excess of $3,650,000 for a flood of 20-year frequency and would rise to over $5,470,000 for flooding of 50-year frequency. This is exclusive of any new construction or increased value of machinery or goods stored in existing structures. Damage figures are at September 1978 price levels.

RECREATION

Recreation demands of the study area were investigated in view of the significance of such activities in the overall plans of the State of Rhode Island. Demands were estimated for three separate use areas to assess the need for additional recreation opportunities and to determine the most appropriate facilities to be included in water resources development plans for the study area. The three use areas investigated included:

- The entire State of Rhode Island.
- The local area consisting of the communities of West Greenwich, Coventry, Exeter, East Greenwich and West Warwick.
- The site of what would become the Big River Reservoir area which is all of the land presently owned by the State.

Estimated demands for recreation, for each of the use areas, as compared to existing supply capacity are shown in summary in Table 17. Projections were developed for the years 1995 and 2020.

As shown in Table 17, the most significant demands for recreation resources are statewide and are principally associated with boating, camping, golfing, hunting, picnicking, and swimming. Recreation demands for each of the other use areas are not nearly as significant and center primarily on the need for additional boating, golfing and picnicking facilities.

In view of the relative size and the short travel time required to reach even the most distant parts of the State, the need for recreational resources in Rhode Island takes on special meaning when planning water and related land resources. Therefore, satisfaction of statewide needs was considered prudent in planning recreation resources as part of the overall water resources development plans for the study area. Detailed discussion of the recreation demands of the study area and optional plans for meeting these demands is contained in Appendix H, "Recreation and Natural Resources."

TABLE 17

ESTIMATED RECREATION DEMANDS
(Persons per day)

ACTIVITY	SUPPLY CAPACITY 1)	PRESENT DEMAND	1995 DEMAND	2020 DEMAND
BOATING				
State	46,471	19,426	34,491	77,614
Local	770	657	1,451	3,341
Big River	342	45	90	207
CAMPING				
State	17,104	14,854	20,936	28,607
Local	2,864	128	180	247
Big River	0	0	0	0
FISHING				
State	26,308	5,939	8,358	11,375
Local	6,176	330	464	632
Big River	360	100	128	174
GOLF				
State	11,328	5,951	10,883	22,462
Local	1,008	793	1,450	2,579
Big River	144	175	286	509
HIKING				
State	17,847	4,534	6,333	9,824
Local	6,210	50	70	94
Big River	2,700	10	13	17
HORSEBACK RIDING				
State	11,940	2,543	4,679	8,370
Local	2,050	55	101	181
Big River	1,500	20	33	59
HUNTING				
State	6,000	2,326	4,160	7,687
Local	3,290	115	206	380
Big River	1,600	100	165	304
PICNICKING				
State	32,047	51,951	58,300	59,881
Local	2,655	2,420	2,627	2,698
Big River	0	100	101	104
SWIMMING				
State	53,792	50,501	74,466	107,777
Local	8,089	2,633	3,883	5,619
Big River	9,450	200	277	401

1) "Supply Capacity" refers to the maximum number of persons which ideally can utilize existing recreational facilities each day. The estimated demands given are based on the "design day demand" which refers to the estimated number of persons wishing to participate in a certain recreational activity on a peak day.

OTHER RELATED PROBLEMS AND NEEDS

Other water and related land resources problems exist in the Pawtuxet River Basin and are presented in the following paragraphs to show their relationship to the problems and needs addressed in this study.

WASTEWATER MANAGEMENT AND WATER QUALITY

The present quality of significant portions of the Pawtuxet River and its tributaries precludes or impairs the use of their waters for many purposes including recreation, fish and wildlife habitat, public water supply, and aesthetic enjoyment.

Water quality management studies of the Pawtuxet River Basin were conducted by the Rhode Island Statewide Planning Program under authority of Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Results of the study indicated that water quality of the Pawtuxet River was impacted by both point and non-point sources of pollution which contributed to its progressive deterioration from Class A (suitable for water supply and all other purposes) in the headwaters to nuisance conditions in the lower mainstem. A survey conducted by the State in 1976 showed that both the South Branch and mainstem Pawtuxet River had bacterial and dissolved oxygen levels in violation of standards for Class B waters (suitable for bathing, fish and wildlife habitat, public water supply with appropriate treatment). Control of pollution sources would be needed to improve the water quality above the Class C and Class D criteria found in the water quality survey.

Alternatives for improving water quality focused primarily on the control of point source pollution discharges which were associated with industrial effluents and existing municipal wastewater treatment facilities in Cranston, Warwick and West Warwick. In addition, three other means of improving water quality were considered: removal of dams along the river, low flow augmentation and maintenance by releases from existing and planned surface water reservoirs, and instream oxygenation.

Recommendations for improvement of water quality in the Pawtuxet River Basin are summarized as follows.

Biological Studies

. A biological survey should be conducted in the South Branch and mainstem Pawtuxet River to determine the fish species present. If no desirable species are found, a bioassay should be performed to determine the cause of this condition.

Point Source Pollution Control

. The NPDES discharge permit for the American Hoechst industrial complex should be amended to eliminate the requirement for chlorination of the discharged effluent.

. Increased treatment of the American Hoechst discharge and/or displacement of the discharge further downstream should be required if the need is indicated by biological and bioassay studies.

. Point source industrial discharges to the North Branch should be eliminated by conveying these flows to the West Warwick wastewater treatment facilities for advanced treatment and discharge to the Pawtuxet River mainstem.

. The eastern portion of Coventry should be sewered with the wastewater conveyed to the West Warwick wastewater treatment facilities.

. The West Warwick wastewater treatment facilities should be expanded to 11.0 mgd to accommodate waste flows from southeastern Scituate, the northeastern portion of West Greenwich and eastern Coventry and should also be upgraded to provide advanced treatment (nitrification) and dechlorination during summer months.

. The Cranston wastewater treatment facilities should be expanded and upgraded to provide 23.0 mgd capacity. Feasibility studies should be made to determine if the Cranston facilities can be expanded to 28.0 mgd to accommodate flows from Warwick for possible future regional approach. Otherwise, Cranston and Warwick facilities should be upgraded to provide advanced wastewater treatment and dechlorination during the summer months at each facility.

Impoundment Removal

. Detailed studies should be conducted to determine the effects of removing the Pontiac and Broad Street (Pawtuxet Cove) dams. The study should be undertaken as part of future 208 planning or as part of the West Warwick 201 facilities plan.

Flow Maintenance

. The Quidnick Reservoir Company, owner-operator of the existing Flat River Reservoir, should continue the policy of maintaining uniform daily flows in the South Branch.

. The planned Big River Reservoir, if constructed, should be operated to release at a minimum the 7-day, 10 year low flow from the watershed.

Instream Aeration

. Studies should be conducted by the U.S. Environmental Protection Agency to determine the feasibility and cost-effectiveness of instream oxygenation for future applications.

FISH AND WILDLIFE

There is a need to solve several problems presently, facing the fish and wildlife resources of the basin. Significant among these are:

- Lack of public access
- Pollution
- Points of extreme low flow
- Single purpose use of the basin's ponded water supply areas
- Barriers to fish passage
- Insufficient amounts of fishing habitat in reasonable proximity to population centers
- Destruction or alteration of wildlife habitat

To satisfy the fish and wildlife resource needs of an expanding urbanized area, adequate controls to protect and enhance the existing resources will depend largely on the use that can be made of existing resources by providing high quality water, improvement of facilities, provision for more public access and supplementation of flows.

WITHOUT CONDITION PROFILE

INTRODUCTION

The "most probable future" condition presented in an earlier section identified projections of basic demographic, economic, environmental and social parameters upon which the water resources needs of the study area were derived. In order to evaluate alternative water resources plans, it was necessary to define the conditions that would most likely occur over the study time frame in the absence of a new Federal project. This "without condition" provides the basis for alternative plan comparison and also facilitates evaluation of each plan's impacts. The following discussion addresses conditions in the study area without the project as they relate to municipal and industrial water supply, flood damage reduction and recreation.

Water Supply

Programs for public water supply management in the study area would continue as at present with existing supply agencies relying on presently developed sources to meet future demands. Only the Bristol County Water Company would be expected to develop new supplies in view of the immediate need for additional capacity in that system.

The Bristol County system has been faced with water shortages over the past several years which resulted in implementation of emergency restrictions on outside water usage, especially during the summer months. All communities served by the system had water restrictions imposed during the summer of 1980 to alleviate supply problems. To meet present and future demand projections, the Bristol County water system would obtain additional supplies through the phased development of groundwater and surface water resources in Rehoboth, Massachusetts as well as implementation of modifications to improve existing water supply facilities.

Metropolitan area water needs served by the Providence Water Supply Board and Kent County Water Authority systems would continue to be met from existing surface water and groundwater supplies. These regional systems would continue to satisfy the needs of their respective service areas until water demands exceeded available supplies at which time water shortages would likely occur. Various economic, social and environmental effects due to water shortages or inadequate system capacity would be faced by municipal and industrial water users.

Other, less urbanized communities in the study area would continue to utilize private on-lot water systems or construct municipal supply systems through the phased development of available groundwater resources. Privately supplied industrial users would also continue to utilize existing groundwater and surface water supply sources to satisfy increased demands.

Flood Damages

Average annual flood losses of about $1,429,000 (September 1978 price levels) would continue to result from flooding in the Pawtuxet River Basin. Continued flooding in basin communities would not ohly result in physical damages to homes and businesses, but would also result in nonphysical damages in lost income to local businesses and lost wages to local employees as a result of closings. Social costs would also be incurred in goods and services becoming inaccessible to consumers and transportation problems causing inconvenience to vehicular and pedestrian traffic. Occurrences of flooding would continue to place a burden upon public services in responding to emergency situations as well as to cause repair of roads and damaged utilities after the flooding had subsided.

Development in floodprone areas would continue to be regulated by the requirements of the National Flood Insurance Program. All communities within the basin subject to major flood damages are entered in the "regular" flood insurance program.

Recreation

Recreation resources needs within the State of Rhode Island would continue to increase during the study time frame. However, recreational demands in the study area would continue to be met with existing resources with the exception of boating and golfing activities. Without the project, demands on facilities in surrounding communities would be increased.

PLANNING CONSTRAINTS

Planning constraints are conditions imposed upon the planning process that limit the range of feasible alternatives available to the planner. These constraints may consist of legal, social and environmental factors of such importance that violating them would compromise the entire planning effort.

One public policy constraint on the planning process results from the State's purchase of lands in the mid-1960's for water supply reservoir development. These State-owned lands include the planned Big River and Wood River reservoir sites. As these lands are already targeted by the State for reservoir development, the selection of other sites would be contradictory to existing State planning policy.

PLANNING OBJECTIVES

The final array of planning objectives were derived from an analysis of the water and related land resources problems and needs of the study area in relation to the most probable alternative future and reflects several iterations of the planning process. Thus, the planning objectives provided the basis for formulation of alternative water resources plans. The planning objectives address the water supply, flood damage reduction, and recreation needs of study area communities, including a thorough evaluation of technical, economic, environmental and social concerns. They evolved through interaction with the public and other agencies during the course of the study.

Objectives addressing water supply management were directed at preservation of existing resources, flexibility in the development of additional supply sources, and conservation of both municipal and industrial water usage. Objectives addressing the associated environmental needs of water supply management were directed principally at protection of unique natural areas, conservation of wetlands values and fish and wildlife resources, and enhancement of human use value of the area's natural resources.

Objectives addressing flood control and floodplain management in the study area were aimed at reduction of flood damages resulting from increased development in the Pawtuxet River Basin and provision of both structural and nonstructural solutions. Objectives associated with environmental needs were directed at preservation of existing stream conditions since no highly productive habitat exists in the Pawtuxet River Basin as a result of the urbanized nature of the watershed.

Comprehensive recreational resource enhancement was considered in view of the diversity of recreational needs within the study area and the State. Planning objectives were directed at enhancement of the value of human use of natural resources in compatibility with the environment.

Wastewater management and water quality problems in the study area were considered under programs of other Federal, State and local governmental agencies and were not addressed in this study except as they related to development of other water and related land resources.

The specific planning objectives developed for the study area are as follows:

WATER SUPPLY

. Contribute to the preservation of existing surface water and groundwater resources to meet short-term (2000) and long-term (2030) needs of the study area.

. Contribute to the modification of water usage within the study area to optimize existing resources and to meet short-term (2000) and long-term (2030) water demands.

. Contribute to the development of additional groundwater and surface water resources to meet the projected short-term (2000) and long-term (2030) municipal and industrial water supply needs of the study area.

. Contribute to the conservation of wetlands values and fish and wildlife resources in the study area through protection and enhancement of other lands during the study time frame (1980-2030) and beyond.

. Contribute to the protection of unique natural areas in the study area during the study time frame (1980-2030) and beyond.

FLOOD DAMAGE REDUCTION

. Contribute to reduction of the flood hazard and associated urban flood damages in Coventry (South Branch) and in West Warwick, Warwick and Cranston (Pawtuxet River) during the study time frame (1980-2030) and beyond.

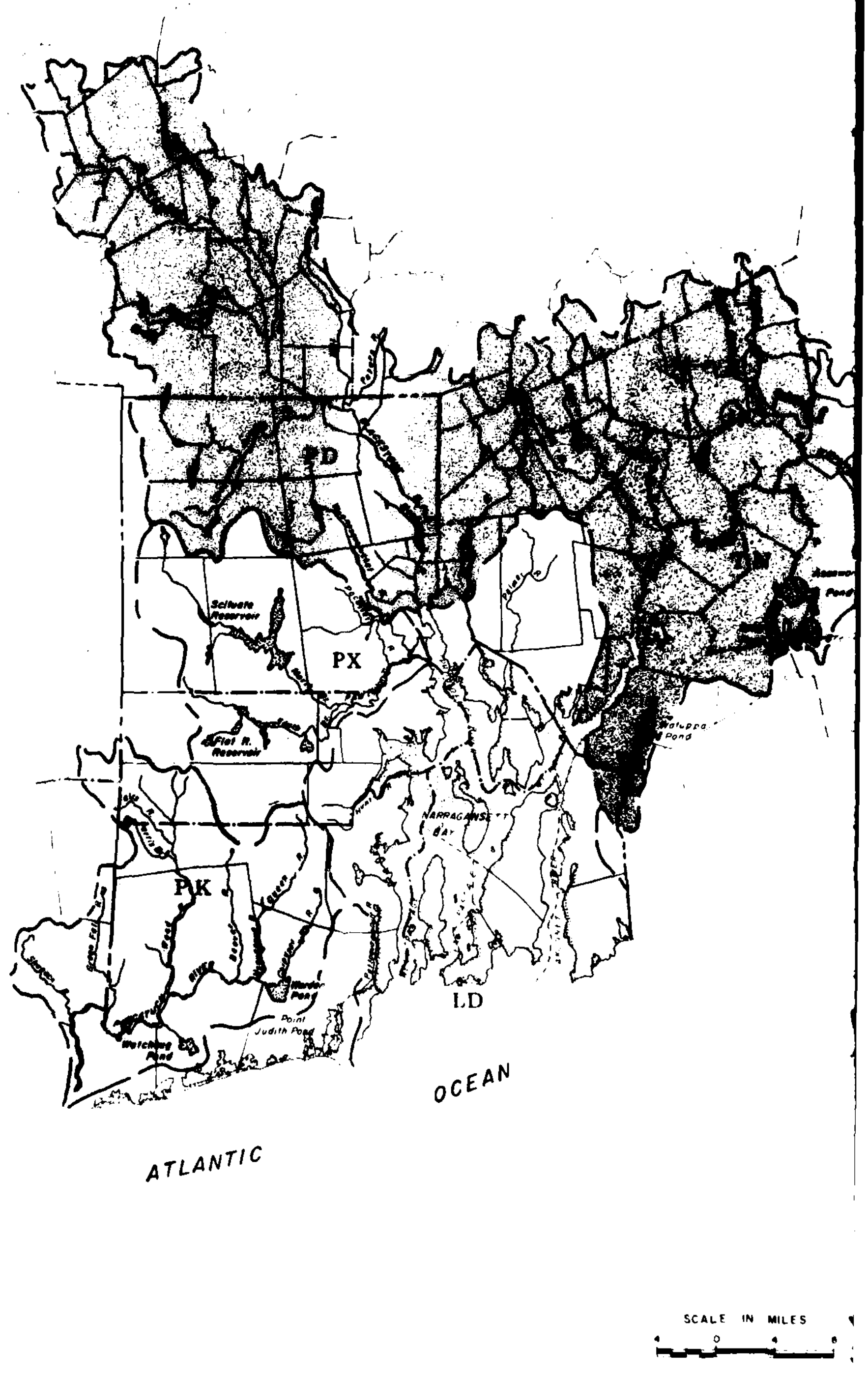
. Contribute to the preservation and maintenance of the resources of existing stream environments within the study area during the study time frame (1980-2030) and beyond.

RECREATION

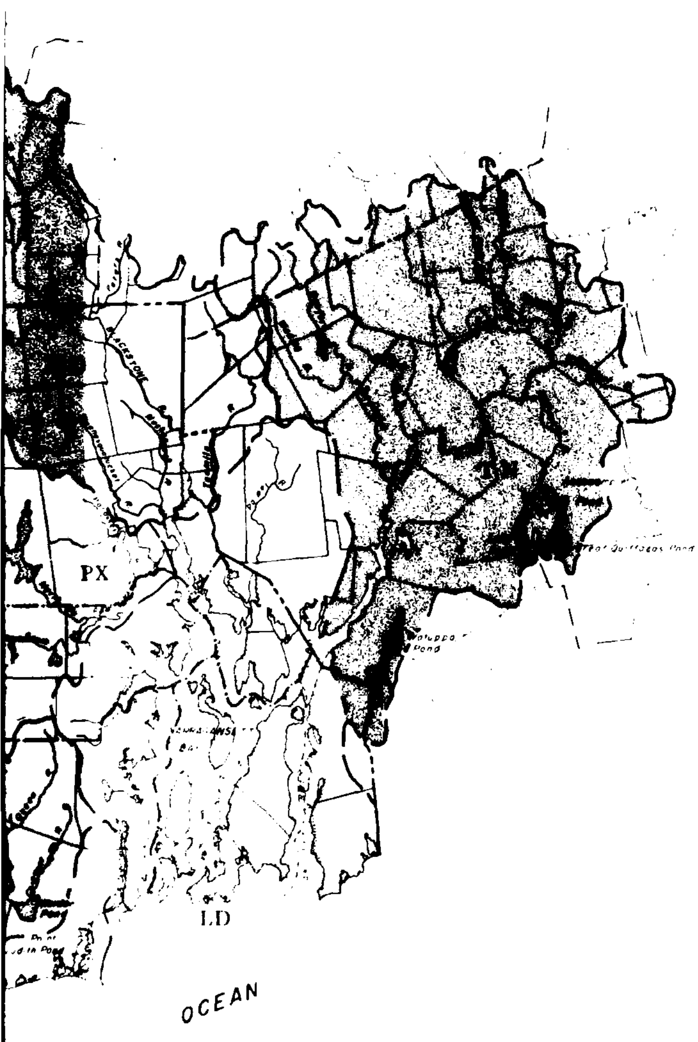
. Contribute to recreational opportunities in the Big River Reservoir area during the study time frame (1980-2030) and beyond.

. Contribute to the preservation of water quality in the Big River Reservoir through discreet siting of recreational resources during the study time frame (1980-2030) and beyond.

. Contribute to the enhancement of the value of human uses of natural resources within the study area during the study time frame (1980-2030) and beyond.



D
Scituate Reservoir
PX
Flat R. Reservoir
NARRAGANSETT BAY
PK
LD
Watchaug Pond
Point Judith Pond
OCEAN
ATLANTIC
SCALE IN MILES



LEGEND

···	COMMUNITY BOUNDARY
— — —	COUNTY BOUNDARY
—·-·—	STATE LINE
PD	PROVIDENCE RIVER GROUP
PX	PAWTUXET RIVER BASIN
TN	TAUNTON RIVER BASIN
PK	PAWCATUCK RIVER BASIN
LD	LOCAL DRAINAGE

SCALE IN MILES

4 0 4 8

2

WATER RESOURCES MANAGEMENT REPORT

PAWTUXET RIVER BASIN
RHODE ISLAND

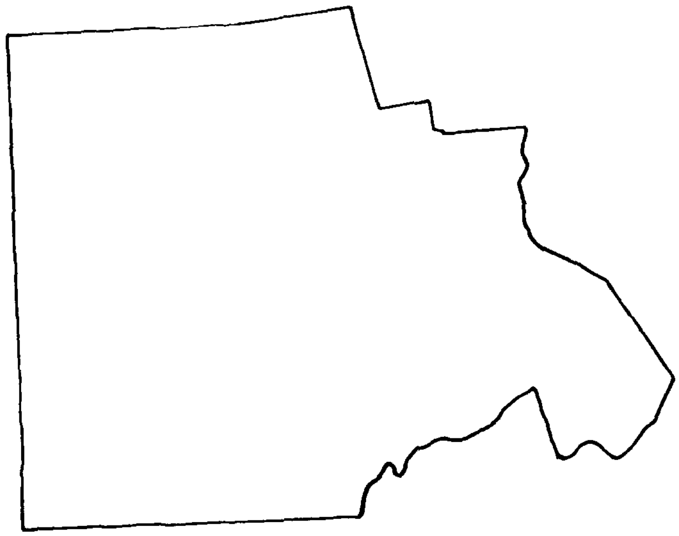
PNB STUDY AREA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE A-1

LEGEND

Community Boundary
County Boundary
State Line
Study Limits



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

STUDY AREA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE A-2

LEGEND

Community Boundary

County Boundary

State Line

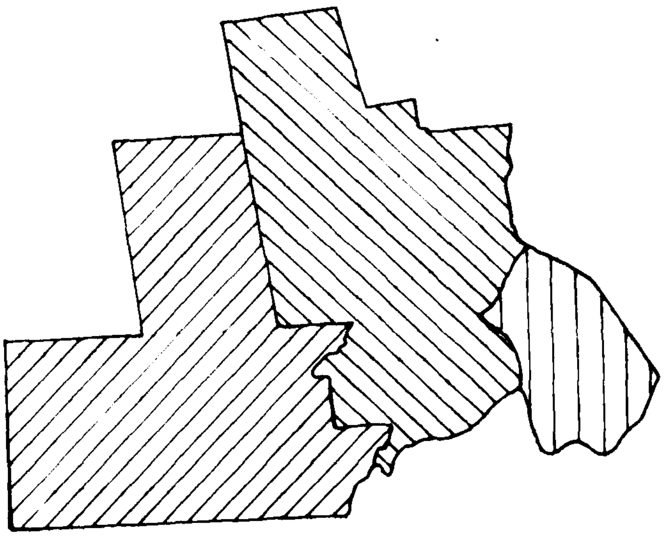
Regional Extent of Water Supply Systems

WATER SUPPLY SYSTEMS:

Kent County Water Authority

Providence Water Supply Board

Bristol County Water Company

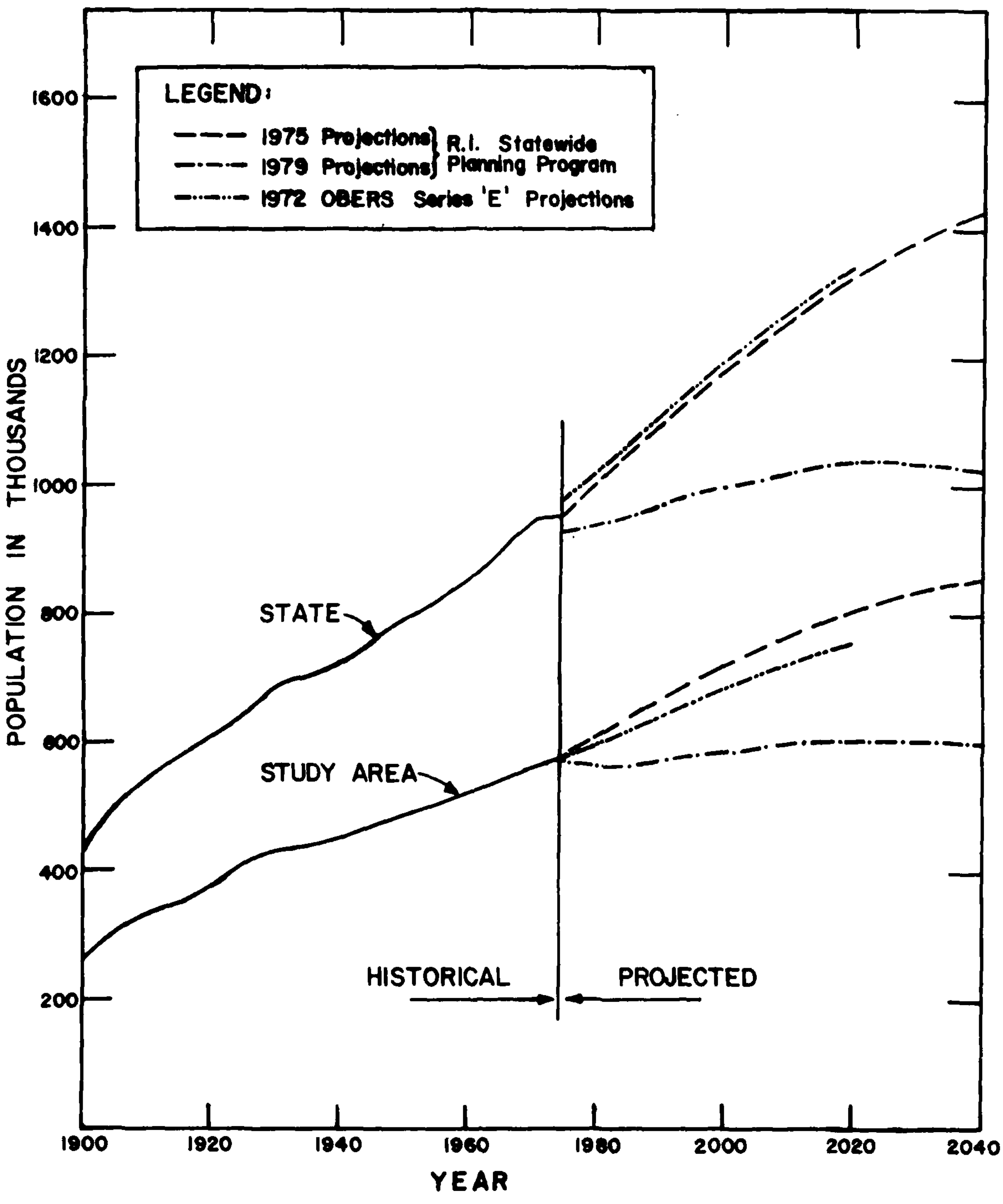


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

REGIONAL WATER SUPPLY SYSTEMS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE A-3



POPULATION TRENDS

PLATE A-4

Population

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX B

PLAN FORMULATION

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX B

PLAN FORMULATION

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LIST OF TABLES

LIST OF PLATES

NOTE: These are all at end of Appendix text.

INTRODUCTION

GENERAL

The plan formulation documented in this appendix represents the final stage of a complex planning process which led to the selection of a plan for water resources management in the study area. The appendix contains information showing the formulation, assessment, and evaluation of alternative water resources plans utilizing the data contained in Appendix A, "Problem Identification" and other appendices accompanying this report, and provides a description of the iterative process utilized in the development of detailed plans. In addition, the appendix summarizes the various interactions that occurred during the planning process and describes their effects on the study outcome.

The plan formulation portions of this study involved development and analysis of alternative water resources plans through repeated iterations of the four functional planning tasks (problem identification, formulation of alternatives, impact assessment and evaluation) to achieve the planning objectives outlined in Appendix A, "Problem Identification". Formulation and evaluation of all possible alternatives were conducted in strict compliance with the U.S. Water Resources Council's Principles and Standards. Analysis and screening of alternatives, through reiteration of the plan formulation process, resulted in plans which were considered to best reflect public desires and to satisfy the planning objectives developed for the study area.

Initial plan formulation identified applicable management measures and preliminary alternatives to solve the study area's needs for water supply, flood damage reduction and recreation. Solutions to flooding in the Pawtuxet River Basin had been formulated in studies conducted by the Corps of Engineers beginning in the early 1970's which resulted in identification of a recommended plan in June 1979. This plan called for construction of a dual-purpose reservoir on the Big River in the watershed of the South Branch of the Pawtuxet River to provide storage for flood flows, implementation of a program for the Norwood-Belmont area of Warwick involving the acquisition of several residential homes, and nonstructural solutions throughout the Basin communities consisting principally of the requirements of the National Flood Insurance Program.

The recommended plan thus provided the central element of plan formulation associated with the feasibility study of the Big River Reservoir which is the focus of this report. The recommendations of flood damage reduction studies and the fact that land acquisition of the proposed Big River Reservoir site had already been implemented by the State of Rhode Island led to the formulation of detailed plans around those having the reservoir as the principal element of water resources management for the study area. Formulation of detailed plans thus centered on the optimum scale and type of reservoir development needed to solve the problems and needs of the study area in conjunction with other applicable and acceptable resource management measures.

The considerable extent of prior water supply planning done by others was also utilized in the development of alternative plans to meet the study area's future needs. Prior investigations, although focused on engineering solutions to the water supply problems of the study area, were incorporated in the overall formulation process.

FORMULATION AND EVALUATION CRITERIA

The development of alternative water resources plans for the study area, including the screening of individual resource management measures and preliminary alternatives, must be conducted within the content of an appropriate set of formulation criteria. Such criteria, including technical, economic, environmental, social and other considerations, permit the formulation of alternatives which make, at the minimum, partial contributions to planning objectives while responding directly to the problems and needs of the study area.

Given the constraints of the planning process, i.e., finite amounts of time, money, and human resources, evaluating all possible alternatives to the same degree of technical detail would be an insurmountable task. Thus, abbreviated planning methods were used in determining the most viable alternatives. These methods are more fully explained in the following sections. Supplemental planning criteria for evaluation of all alternatives considered, including public acceptability, plan completeness, effectiveness and efficiency, economic justification, irreversible effects, and plan stability, were used to refine the number of alternatives to a workable level without disregarding the problems and needs of the study area.

Socio-economic data used in evaluating the benefits and costs of alternative plans were derived from Corps investigations and other basic economic information prepared by other Federal and State agencies. Hydrologic and hydraulic data were developed from Corps investigations while environmental information was obtained from Corps studies and from investigations conducted by the U.S.Environmental Protection Agency.

Technical Criteria

Technical criteria were adopted from appropriate engineering regulations, manuals, pamphlets and technical letters, and supplemented by engineering judgement and technical experience. The following technical criteria were adopted for use in formulating water resources management plans investigated in this study.

- Water supplies would satisfy the requirements of the Safe Drinking Water Act, Public Law 93-523.

- Pumps and transmission mains were sized to accommodate projected 2030 maximum day demands.

- Aqueduct sizing was based upon capacity requirements reflective of estimated development beyond the study's long-term time frame of 2030.

- The existing Providence Water Supply System was considered to form the nucleus of an expanded regional system to meet long range needs.

- Plans would be technically feasible for implementation based upon appropriate engineering standards and guidelines.

- Flood protection plans would protect their specific areas without creating adverse effects on downstream reaches.

. Plans of protection for urban areas would provide against a design storm equal to the Standard Project Flood.

. Protection plans for lesser levels of flood protection would be evaluated to determine economic feasibility. However, reductions in the level of protection below the Standard Project Flood would be avoided whereever possible.

Economic Criteria

Economic criteria applied in the formulation and evaluation of alternatives are summarized as follows:

. Total beneficial contributions (economic and nonmonetary) must exceed total adverse contributions (economic and nonmonetary). A plan must produce net National Economic Development (NED) benefits unless the deficiency is the result of economic costs incurred to obtain positive Environmental Quality (EQ) contributions.

. Each project purpose must provide benefits at least equal to its separable cost.

. The scope of development is such as to provide maximum net benefits except as modified for Environmental Quality and social well-being concerns.

. There are no more economical means, evaluated on a comparable basis, for accomplishing the same purpose or purposes which would be precluded from development if a plan were undertaken. This limitation refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the project were implemented.

Benefits and costs are expressed in comparable quantitative economic terms to the fullest extent possible. Annual costs were based upon a 100-year amortization period and an interest rate of 7 3/8 percent. Annual charges also include the cost of operation and maintenance and major replacements. The costs of alternative plans of development were based on survey scope plan layouts and estimates of quantities at January 1979 price levels.

Environmental Criteria and Social Considerations

Environmental criteria applied in the formulation and evaluation of water resources plans for the study area were directed towards achieving National Economic Development (NED) and Environmental Quality (EQ) as equal objectives, as required by the Water Resources Council's Principles and Standards, and as defined and discussed in the National Environmental Policy Act of 1969 (Public Law 91-190) and Section 122 of the River and Harbor and Flood Control Act of 1970 (Public Law 91-611). The following criteria were considered in formulating alternative plans.

. Analysis of the environmental impact of any proposed action.

. Identification of any adverse environmental effects which could be avoided should the proposal be implemented.

. Evaluation of alternatives to the proposed action.

. Determination of the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

. Accounting of any irreversible and irretrievable commitments of natural resources and biological systems which would be involved in the proposed action should it be implemented.

In order to attain the environmental objectives as specified in the Principles and Standards, the following factors were also considered:

. Management, protection, enhancement, or creation of areas of natural beauty and human enjoyment.

. Management, preservation or enhancement of especially valuable or outstanding archaeological, historical, biological and geological resources and ecological systems.

. Enhancement of quality aspects of water, land and air, while recognizing and planning for the need to harmonize conservation of the resources with the land use objectives of productivity for economic use and development.

. Development and use objectives which minimize or preclude the possibility of undesirable and irreversible changes in the natural environment.

As mandated by Section 122 of the River and Harbor Act of 1970, adverse economic, social and environmental effects of proposed projects should also receive full consideration and thus include the following:

. Effects on air quality, noise levels and water pollution.

. Destruction or disruption of manmade and natural resources, aesthetic values, community cohesion, and the availability of public facilities and services.

. Adverse employment effects and tax and property value losses.

. Injurious displacement of people and businesses.

. Disruption of desirable community and regional growth.

. Public acceptance of proposed improvements and ability and willingness to meet local cooperation requirements.

The following social considerations were also considered in formulating alternative plans:

. Public health, safety and social well-being, including possible loss of life.

. Preservation or enhancement of social, cultural, recreational, archaeological and historical, and aesthetic values in the study area.

. General public acceptance, as determined by coordination with appropriate Federal, State and local agencies, organized groups and individuals, and especially with both the local sponsor and study area interests.

PLAN FORMULATION PROCESS

In the interest of clarity, the results of the plan formulation portions of this study are presented in three separate sections in this appendix. The first two sections describe applicable resource management measures and the development, assessment and evaluation of preliminary plans for each of the study area needs (water supply, flood damage reduction and recreation). The third section presents the combination of detailed single-purpose plans for each water resources component in the development, analysis and evaluation of comprehensive, detailed management plans for the study area.

PLAN FORMULATION - WATER SUPPLY

SECTION 1 - MANAGEMENT MEASURES

Potential Resource Management Measures

General. Water supply problems in the study area are principally concerned with the inability of existing systems to meet projected demands with presently developed supply sources. Accordingly, since some present and all future municipal and industrial water requirements exceed the capacity of existing available supplies, management measures to satisfy the water needs of the study area must consider the reduction of these demands or the development of additional sources. Several alternative measures to satisfy the problems and needs of study area communities are possible, however, some of the measures are either impractical or uneconomical or both. Possible solutions may be divided into the two broad categories of 1) measures to reduce consumption (demand) and 2) measures to increase supply. The former category includes those measures generally classified as nonstructural while the latter category includes various structural measures to obtain supplemental water supplies. Combinations of both nonstructural and structural measures are also possible.

Management Measures. In formulating alternatives, the whole array of both nonstructural and structural management measures including a No Action Program were investigated. These measures were compared to the base condition using the criteria of economic efficiency, environmental enhancement, and social well-being, and were evaluated as acting independently or supplementing one another. Table 1 presents a listing of potential management measures considered in this study. Subsequent paragraphs describe each measure and the rationale used in the initial screening process.

TABLE 1

WATER SUPPLY MANAGEMENT MEASURES

No Action Program

Nonstructural Measures

1. Demand Modification
2. Weather Modification
3. Direct Wastewater Reuse

Structural Measures

1. Surface Water Resources
2. Groundwater Resources
3. Importation
4. Dual Water Supply Systems
5. Desalination
6. Iceberg Harvesting

No Action Program. This measure assumes that maintenance of the base condition for water supply management in the study area would continue. The measure further assumes that no action would be taken, by water supply agencies serving the study area communities, to construct new facilities or to reduce residential water consumption and commercial and industrial demands in the face of increasing water requirements. If no action were taken to increase supply or curb demand, all communities in the study area would experience water deficits prior to the year 2000. In addition, systems such as the Bristol County Water Company would be impacted to an even greater extent due to current deficiencies in both water quantity and quality.

A No Action Program would produce significant socio-economic and environmental impacts within the study area in addition to not satisfying the planning objectives for municipal and industrial water supply management. Use of this measure, therefore, does not offer a realistic solution to the water needs of the study area and was therefore dropped from further evaluation in the formulation of alternative plans.

Demand Modification. When the demand for water increases, the usual response is to construct new waterworks facilities. However, an alternative approach is to reduce demand in conformance with available supplies. Historically, municipal and industrial water demand has increased annually primarily due to increased industrial output and greater numbers of, and a wider distribution of, water-consuming appliances and overall higher standard of living. This increase in usage, coupled with increased population, places great demands on what is, essentially, a fixed natural resource. At this point in time, with worldwide concern focused on food production and consumption, it may be beneficial to realize that the amount of freshwater available each year does not vary greatly and that this resource, too, is finite. In the study region, increasing the source of water supply is generally a question of economics-does a community or group of communities desire to have relatively unlimited water and pay for it through increased water bills/taxes or accept the inconveniences and possible hardships imposed by water restrictions and pay a lesser price for the commodity. In most instances, the cost of water amounts to such a small expenditure when compared with total per capita income, that the increase in supply is opted for. Current trends, however, suggest that increases in water usage can be slowed, and some even suggest stopped, if proper management techniques are employed.

Residential, commercial, industrial and public water use accounts for about 25 percent of the several hundred billion gallons of water pumped daily in the United States. However, in urban areas throughout this country, these usages account for almost 100 percent of the treated water used. It follows, therefore, that the focus of a water conservation/demand modification program for the study area should be concerned with residential, commercial, industrial and public water use.

The following paragraphs provide a summary of several different techniques investigated in this study for managing these water demands.

a. Metering: The installation of meters that measure the amount of water used by consumers has been shown to be effective, to varying degrees, in reducing demand for water supply. With metering, water customers are charged for the quantity of water actually used, instead of being charged a flat rate or some other pricing arrangement for some specific time period regardless of the quantity used.

Use of metering appears, therefore, to present a good opportunity for conservation of this important resource. In the study area, however, application of this technique is quite limited due to the extensive use of metering by existing water supply systems. For example, the Providence Water Supply System is already about 90 - 95 percent metered while the study area as a whole is estimated to have about 90 percent of all water usage metered. Complete metering of services within the study area would have no effect on a substantial portion of all existing usage and, therefore, was not considered a significant water-use reduction technique to affect future demands.

b. Pricing Structures: Rate structures may be charged in a number of different ways. Some alternative pricing policies are:

. Spatial differentiation of prices (i.e., different charges for different areas of the community based on the cost of providing service to each area).
. Seasonal prices - higher prices during times of higher demand.
. Decreasing block rates - users are charged decreasing amounts for incremental increased usage.
. Increasing block rates - users are charged incremental increases with increased usage.
. Average variable cost pricing (i.e., a quantity charge would cover only operation and maintenance costs; a flat rate charge would cover the fixed costs such as debt service).

c. Water Saving Devices: The principle behind the use of water saving devices is to reduce flows from showers, lavatories, and toilets to the minimum necessary to perform their intended purpose. This can be accomplished either by adding flow reducing devices to existing fixtures or by replacing these items with new fixtures designed to reduce flows. Domestic use can also be decreased by reducing service pressures with the use of pressure regulating devices and by replacing automatic dishwashers and clothes washers with water conserving models.

Some of the devices which have the most potential for reducing water use are listed below:

- Water Saving Toilets
- Reduced flush devices (toilet dams, displacement bottles)
- Flow limiting shower heads
- Water conserving dishwashers and clothes washing machines
- Flow control devices for faucets
- Pressure reducing valves (to reduce unnecessarily high system pressures)

d. Conservation Education: A basic solution to the problem of reducing waste in water consumption is modification of water use attitudes and habits. This can be accomplished in part through education and information campaigns directed toward the consumer. As in the case of water saving devices, this technique is aimed at reducing waste by the residential user. The success of these campaigns is based solely on the voluntary efforts of the consumer to conserve water.

Public educational programs instituted throughout the country have included the following items:

- Printed inserts and brochures included with water bills.
- Posters hung in classrooms, on public transportation vehicles and on sidewalk trash receptacles.
- Reminder items such as buttons, T-shirts, litter bags and bumper stickers.
- Radio and television advertising.
- Contact with community groups through the use of public speakers, film presentations, or slides.
- Education in the schools to change attitudes on water use.
- Contests for water conservation slogans or posters.
- Test programs aimed at water conservation such as installation of water-saving devices.

e. Institutional Restrictions: Institutional restrictions have been traditionally regarded as administrative and legislative policy controls which can be implemented by water suppliers and government agencies to insure public welfare and security during times of water supply shortages. They include any legally enforced restriction on the use of water. It is equally important to consider institutional restrictions as methods of conservation to prevent shortage as well as to survive during a period of reduced supply. Water shortages can be a result of a system's inadequacy to deliver water at peak demand rates or of inadequate water supply.

Some institutional restrictions on water use applicable to the study area are:

Restrictions on Domestic Water Use - Mandatory conservation programs have typically been directed toward the residential customer. These restrictions are effective first, because residential use is generally the largest single use of municipal water supplies, and second, because lawn watering, car washing and swimming pool filling can easily be eliminated because of their high visibility and low priority in times of shortage. These outside water uses are coincident with a variety of warm weather practices which create high-peak demands during periods when supplies are most likely to be lowest.

Water Rationing - This technique is the most severe method of reducing consumption. It involves the allocation of water to customers with stiff penalties for exceeding allowable water use. Water rationing is adopted only in cases of extreme shortage.

Building and Plumbing Code Restrictions - These restrictions, requiring the use of water saving devices in new construction such as shallow trap toilets and flow restricting shower heads, can result in significant savings in the future with little or no inconvenience to the consumer. Building code restrictions, in addition to requiring water conserving fixtures in the home, can also set limits on service pressures, thereby requiring pressure reducing valves on some services.

Industrial Reclamation and Reuse - Standards can be established for the reclamation and reuse of industrial water. The economic impacts of this type of control should be carefully assessed since increased costs to industry could discourage industrial development.

Control of Water used for Maintenance - Sanitary procedures involving flushing sewers and washing buildings, streets, and sidewalks can be controlled through regulation during periods of shortage. It is possible that chlorinated river water could be used for these purposes.

Inspections - Municipal or State inspections of the premises of water system customers for leakage and obvious waste is a measure that can be taken during extreme shortage. The potential for reducing consumption on a metered system with this technique is limited.

Fire Hydrant Use Restriction - There is indication that stiffer penalties for illegal use of fire hydrants may result in less unauthorized use through vandalism and illegal connections. In some high-crime neighborhoods, safety harnesses are installed on hydrants to help eliminate this problem.

Landscape Watering - Of the outside domestic uses, landscape watering has the greatest potential for demand modification. This type of irrigation represents approximately 3 percent of the average household use in this area of the country. Much attention has been given to this subject in California conservation programs where irrigation accounts for nearly 50 percent of domestic use. Some of the lessons learned from their experiences are worth mentioning. Effective soil preparation allows plant areas to absorb and retain the moisture needed for plant growth. Deep, slow watering during the late evening and early morning hours is more effective than heavy watering during the heat of the day. California programs have made a strong case for the use of native drought resistant plant materials. This can be an important consideration even in New England.

f. Control of Water System Losses: Water system losses can result from leakage, unmetered connections, fire flows, and illegal uses. The control of these losses increases the operating efficiency of the water system. Unmetered connections are generally associated with municipal uses such as service to municipal buildings, sewer flushing, and street cleaning.

Control of system losses can be accomplished through leak detection and repair, the metering of all uses, and the reduction of illegal water use. A leak detection program involves prompt control and repair of visible leaks as well as detection and repair of hidden leaks through the use of modern sensing equipment. The placement of meters on all services allows the water supplier to better account for system performance and to approximate other losses which are not meterable. The illegal opening of fire hydrants is a major system loss in some areas. This can, however, be reduced through the institution of stiff penalties and through the use of security devices which make fire hydrants more tamper-proof.

Weather Modification. The primary source of water used for public and private water supply in Rhode Island, as in most humid areas, is precipitation falling directly on the areas concerned. It follows then that if precipitation can be increased in a regulated manner, the water supply can also be increased. To this end, several major agencies such as the National Oceanic and Atmospheric Administration (NOAA), the United States Bureau of Reclamation, the American Meterological Society, and the National Science Foundation are investigating ways of productively modifying natural precipitation patterns. The primary focus of research is in the area of cloud-seeding. Other fields of interest are long-term seasonal precipitation forecasting and fog drip augmentation. Since little work has been done on the latter two, and what little has been accomplished is not applicable to the Rhode Island area, only the process of cloud-seeding will be reviewed in this section.

Simply stated, rain falls from clouds when water vapor in the cloud condenses around nuclei and forms rain drops large enough to overcome frictional resistance to falling. In technical terms, this process is the conversion of the water vapor from a state of colloidal stability to one of colloidal instability. The concept of artifically induced precipitation by cloud seeding refers to the introduction of particles of foreign substances, such as dry ice and silver iodine into clouds to serve as condensation nuclei. Theoretically, this action will result in condensation of the water vapor and consequent precipitation. In short, it is scientific rain-making.

The testing of the engineering and economic feasibility of this theoretical process has been concentrated in experimental projects in the Rocky Mountain and Upper Great Plains regions. Evidence gained through NOAA research suggests that winter cloud systems over Lake Erie may be modified to produce additional precipitation. A cost-benefit study was performed for the Connecticut River Basin, but this study was in design only with no actual experimental work involved. Most information regarding the potential of cloud-seeding in the eastern United States is derived from commercial cloud-seeding operations.

Some of the findings resulting from these studies and experiments are summarized below:

. The state of the art is such that most researchers look upon the potential of increased precipitation through cloud-seeding with an air of cautious optimism. Study to date, however, has provided little more than a beginning to the solution of many of the problems involved in weather modification.

. Cloud-seeding is impractical during severe drought conditions when water shortages are most critical. The first requisite for cloud-seeding is the presence of clouds, and droughts are notable for their lack of clouds. Present technology is not even remotely capable of producing clouds by weather pattern modification. During a temporary interruption of drought conditions, clouds may form over an area. Even under these conditions, however, cloud-seeding would not appreciably alleviate water supply problems since most precipitation would be in all likelihood taken up immediately by plants and soil. It would be apparent then that water shortages in periods of drought cannot be solved by cloud-seeding. Any substantial seeding-induced precipitation would have to be produced during nondrought conditions with abundant moisture in the atmosphere.

. There are many problems that must be solved before substantial technological breakthroughs result. One of the most critical is the inability of researchers to satisfactorily define optimum cloud conditions and seeding techniques and to predict seeding results accurately. In other words, there is an inadequate understanding of the basic cloud processes which determine: a) the "seedability" of a cloud or cloud system, and b) the proper seeding treatment to stimulate rainfall production efficiently in a potentially seedable cloud.

Another problem is the possibility of undesirable effects of seeding. Indiscriminate seeding might increase soil erosion and sedimentation in streams through intensification of the normal rainfall rate of natural storms. There is the possibility also that artificial seeding of clouds might in fact reduce the natural rain producing capacity of the clouds.

. Estimates of the feasibility of cloud seeding in the eastern part of the country, including New England, are vague and poorly defined. Most recent cloud seeding research has been conducted in the western states. Atmospheric scientists have cautioned that results of seeding experiments in one area of the country must be viewed with caution when applied to other areas characterized by different topography and climate. It is apparent that much research needs to be done in the eastern part of the country. There is data available for parts of this area from commercial cloud-seeding operations. However, these operations were not performed under proper scientific and statistical control procedures and any data gathered in such a manner must be used and interpreted with care.

Research has continued to improve the state of the art of weather modification by cloud-seeding and other means. However, weather modification is still an inexact science at best. Studies are unable to predict optimum cloud conditions and seeding results with any degree of accuracy. Thus, at this time, weather modification operations to augment water supplies in Rhode Island do not appear to provide a viable solution to water supply problems of the study area.

Direct Wastewater Reuse as a Municipal Supply. Direct wastewater reuse involves returning the effluent from wastewater treatment facilities for municipal or industrial supplies. For use in a public water supply system, the treated wastewater must be of high enough quality so that water quality aspects of the existing supply will not be adversely affected by mixing the two waters. Thus the effluent must be safe for human consumption, which could only be achieved through the use of advanced, sophisticated treatment techniques.

Direct wastewater reuse, especially in industrial process application, has been economically successful in many sections of the country. The Bethlehem Steel Company in Baltimore, Maryland currently uses about 120 mgd of treated municipal effluent from Baltimore in its quenching and cooling processes. The Dow Chemical Company uses treated wastewater from the City of Midland, Michigan for use in its cooling water and fire protection system. In Amarillo, Texas effluent from the municipal wastewater treatment facilities is used as cooling water and boiler make-up water for industries located in that city.

Other uses to which treated wastewater has been applied include irrigation of both crop land and lawns, as a freshwater barrier against salt water intrusion, and in some cases as a source of supply for formation of recreation lakes and ponds.

Direct reuse of wastewater effluent as a public water supply, however, has not been utilized to a large degree. Advanced waste treatment research and development programs at the Federal level are continuing and pilot plant studies such as the noted Lake Tahoe project are apparently meeting with success in producing a high quality effluent.

The Safe Drinking Water Standards do not apply to direct reuse of reclaimed water for domestic consumption. In a series of recent articles, the Division of Water Supply Programs, U.S. Environmental Protection Agency, (formerly Public Health Service) has described a number of potential health problems which could occur with the use of renovated wastewater.

Health officials feel that many questions remain unanswered which must be fully investigated if renovated wastewater is to be considered for drinking water purposes. Much research remains to be initiated in several areas, including studies on viruses and their relation to and removal from wastewater. Studies on health effects of other microorganisms and chemicals present in treated wastewater and studies into increasing the reliability of the technology available for wastewater treatment are also required.

The future of direct wastewater reuse, particularly in industrial applications, seems promising. In fact, industry already appears to be moving in the direction of greater recycling. Use of renovated wastewater as a regular domestic supply, however, requires full results of proposed research. Until such research is completed, wastewater reuse as a municipal water supply is not a viable alternative to meet water supply needs in the study area. Renovated wastewater should not be considered for drinking water needs unless there is no other practical choice.

Surface Water Resources. Surface water development may take one of three forms: continuous draft, selective draft, and impoundage. For communities situated on or near streams, ponds, or lakes of sufficient flow or capacity, continuous draft may be used to obtain water year-round. If a selected stream is of insufficient size to meet year-round needs, or if water quality variations are a consideration, selective draft during high flows may be utilized. In either case, for smaller streams it may be necessary to construct a diversion dam to assure that the intake pipe is submerged during withdrawal of water. Water drawn from larger lakes and streams must generally be treated before use.

Impounding a stream to create a reservoir may be the most desirable method of supply. Generally, impounding reservoirs are built in sparsely settled regions on upland streams, so that water drawn from them is relatively pure and can be supplied to the community by gravity. Impounding reservoirs would be of sufficient capacity to assure adequate supply during dry periods, and are generally large enough, with water of high enough quality, to require minimum treatment when considered as part of a municipal water supply system.

Groundwater Resources. Groundwater storage is much greater than all artificial and natural surface storage in the United States. Wells are commonly used to collect groundwater for use in water supplies. The five types of wells generally in use are dug, driven, bored, drilled and gravel-packed wells. Dug wells and driven wells are generally used for shallow depths, dug wells being lined or unlined depending on the material excavated, and driven wells restricted to use in relatively shallow sand formations. In soil that is sufficiently cohesive to prevent serious caving, wells are bored with augers by hand or machinery. Drilled wells are the most commonly used type, especially for wells of greater depth than feasible for the other types. Drilled wells are lined with a casing grouted in place for sanitary protection, with a strainer at the bottom of the well to keep out unwanted materials. Gravel wall wells are drilled with a larger hole, and an envelope of gravel is placed outside the well screen to increase the effective diameter of the well and improve the well's hydraulic characteristics.

Water supplied by wells is generally less likely to need treatment than surface water, and is considered to be less expensive to develop in most cases.

Importation. This technique involves the diversion of water, either groundwater or surface water supply, from watersheds outside the study area to augment existing water supply resources. In some cases the diversion would be possible from currently developed sources that are underutilized presently and are expected to remain so over the long term. In other cases, the diversion would be made from presently undeveloped resources to meet the water supply needs of study area communities.

Dual Water Supply Systems. An alternative which has been receiving attention of late has been the use of dual water supply systems. In these systems, a hierarchy of water supply would be established whereby higher quality supplies could be used to furnish a potable source for drinking, cooking, dishwashing, cleaning, bathing and laundering. All other uses could be furnished by a second supply of lesser quality.

Two general methods have been suggested for such a dual system. The first is the possibility of recycling at the point of usage. Under this scheme, drinking, washing and bathing water would undergo treatment and then be further utilized for toilet flush water and outdoor uses. It is estimated that such a system could reduce domestic water use by as much as fifty percent. Various systems for inhouse reuse or for outdoor usage have been proposed and some are being marketed on a small scale.

Advantages of this system, beyond potable water consumption decrease, are the reduction in wastewater volume, sewer pipe, pumping and treatment requirements. Disadvantages to this alternative lie with its limited application and accompanying operational experience, potential problems of odor and other aesthetic considerations. Health officials, in general, have not expressed their acceptance or rejection of such systems. However, their general apprehension in introducing less than potable water into the home environment could also reasonably be expected with regard to any system of this nature.

The second method which has been suggested for delivering higher and lower quality water for various uses would require a second distribution system. This second distribution system would carry river water or even sea water to supplement the high quality primary supply source.

Two methods of providing the second (lower quality) distribution system could be employed. The first would involve installation of the entire system immediately. The second and more practical method would be an incremental approach wherein secondary systems are installed in new or replacement buildings above a certain size.

The high capital costs of providing dual water supply systems to furnish a potable source for both drinking, cooking and other domestic uses and for lesser quality needs precludes its use in the study area. Potential health problems associated with the use of such systems are also a basis for rejection.

Desalination. Desalination, the process in which brackish and salt-water is converted to fresh, is currently being used in some parts of the world as a viable, economically feasible source of freshwater. This process thus was considered for its potential as a future alternative solution to the water supply needs of Rhode Island.

The conversion of saline to freshwater is accomplished through four major processes: distillation-evaporation, membrane separation, crystallization, and chemical differentiation. A descriptive summary of each process is given below.

a. Distillation-Evaporation: In this process, water containing salt or other impurities is heated and vaporized. The water vapor, free from the salt and other solids which remain behind as the water boils, is then condensed and collected. The system is basically a simple one requiring only a source of heat energy to boil the water, a method of cooling the water vapor (condensation) and various kinds of plumbing and receptacles for the transfer and storage of the water.

Since distillation, by its nature, results in the complete separation of the water vapor from the dissolved salts of the influent, the process produces freshwater of exceptional purity. Because this method removes the water from the salt, rather than vice versa, the quality of the influent is not critical and the system works equally well on water with a high salt content as on only slightly brackish water. For these reasons, among others, distillation is the oldest and best known process of desalination.

b. Membrane separation: Desalination by the membrane process is based upon the ability of thin membranes to pass molecules of pure water and retain the ions of salts and other dissolved solids. There are three basic variations to this concept: electrodialysis, transport depletion, and reverse osmosis. The first two variations depend on the electrical properties of the ions involved, while the third depends on a pressure differential existing across the membrane. Of these three variations, the electrodialysis and reverse osmosis processes are the most well established, with many commercial installations throughout the world.

In contrast to distillation, the membrane process separates the salt from the water rather than the water from the salt. Each stage of the electrodialysis process removes slightly less than fifty percent of the dissolved solids in the water being treated. The more saline the water, the more stages are needed and hence more energy is consumed. For this reason, electrodialysis and other variations of the membrane process are more economical when used with brackish water with a salinity of between 5,000-10,000 mg/l, as opposed to more saline water. The water can then be refined in stages to the desired degree of purity.

c. Crystallization: This process relies primarily upon the fact that as water freezes, the ice crystals reject ions of salt. Saline water is frozen and the crystals of pure ice are then skimmed or removed for later use from the still liquid brine. A second method of separation by crystallization employs the hydrate process, which is the formation of a crystalline substance by the combination of water with low molecular weight, hydrocarbons or their derivatives. Like ice crystals, these hydrates reject salt ions. It takes less energy to freeze water than it does to boil it, thus this method has an advantage over distillation in that it consumes less energy. The crystallization process has not been widely used; however, further research into its effectiveness is continuing.

d. Chemical Differentiation: In this process, either the water or the dissolved salts are made to undergo chemical reaction to form a substance which can be easily separated from the untreated water. Ion exchange, a method by which the saline water is passed through treated resin and the salt ions selectively removed, is the most widely used method of chemical desalination.

The efficiency of ion exchange decreases with time as the "holes" in the resin become filled with salt ions. Once the resin is saturated, the operation must be closed down and the resin regenerated. For these reasons, the process has had only local exposure and small volume use.

e. Present Application: Sea water can be considered for all intents and purposes an unlimited source of freshwater once the technology of desalination is refined to a point where it is economically feasible. To this purpose, the Federal Government, through the Saline Water Conversion Program, administered by the Office of Water Research and Technology (OWRT), has promoted extensive study and research into the problems of desalination. Several model and testing plants and facilities have been constructed to aid in these studies. The research to date concludes that of the four main processes discussed above, distillation and membrane separation are best suited to large capacity plants. Economic considerations dictate that distillation is best suited for sea water and electrodialysis or reverse osmosis for brackish water.

In 1977, about 1500 land-based desalting plants were providing 24,000 gallons per day (gpd) or more; and more than 350 plants, producing over 1 million gallons per day (mgd) were operating or under construction worldwide.*

Plants are generally located in arid regions where conventional water sources are high cost or unavailable. Principal areas of use are in the Mid-East and Caribbean tourist islands. In the United States, desalting for water supply has thus far been limited to smaller installations with aggregate capacity of only about 120 mgd, compared to total freshwater requirements in the 350-450 billion gallons per day range.

The largest municipal desalting plant in the United States is a 2.6 mgd distillation process in Key West, Florida, Largest in the world is a French-built, 30 mgd distillation plant, constructed in Kuwait.

A distillation plant was recently proposed for San Louis Obispo and Santa Barbara Counties, California, which would have a capacity of 40 mgd. Construction on this plant, which would have been the largest in the world, was scheduled to begin in 1973; however, action on the project has been suspended indefinitely.

The cost of freshwater produced by desalination depends upon the capacity of the plant, the type of process used and the type of energy source used. In general, the larger the plant capacity, the less the cost per unit quantity of water. As has been mentioned previously, distillation is more economical for the desalting of sea water, while membrane processes are better for brackish water. The cost of water from nuclear-fueled plants is approximately 10 percent less than from fossil fuel plants with a large capacity (more than 100 mgd).

The current cost of desalting sea water is about $4-6 per thousand gallons. This estimate is based upon an output capacity of 1 mgd, an amount representative of many plants currently in operation. Desalination of brackish waters by membrane processes is less costly than for sea water but is still in the range of $1 per thousand gallons. Both of these costs have to be weighed against the cost of water from conventional sources, which is up to 40 cents per thousand gallons.

*Desalting Plants Inventory Report #6, U.S. Dept. of the Interior, October 1977.

Desalination by various processes is already feasible in parts of the world where natural water supplies are either scarce, of poor quality or completely unavailable. In these areas, the relatively high costs of water produced by desalination are justified. When larger capacity plants are designed and in production the cost of desalination will likely be reduced, but even at a 50 percent reduction from present costs, *desalination is not* competitive with present costs of developing natural surface and groundwater supplies.

Aside from the economic costs involved with desalination, OWRT is also investigating the potential hazards to the environment. In considering placement for any type of desalting plant, environmental factors are as important as any other factor. Pure water is not the only product. A plant will produce extremely concentrated brine as an effluent, plus any waste emission from the power source, such as soot, heat, smoke, toxic gases, etc.. So far as brine is concerned, the brine from distillation plants is of high temperature, higher chloride content and may contain concentrations of copper, all of which may prove injurious to the environment. Special design procedures would be required in the cases of estuaries or areas with restricted water interchange, as many life forms present might be adversely affected. Two land methods of disposal have been studied: (1) evaporation to dryness; and (2) deep-well injection. Evaporation is expensive, though this varies with land costs. It is now quite costly in urban areas. Injection method costs are estimated at 25 to 70 cents per 1,000 gallons of brine. Such costs must be added to plant production and distribution costs to arrive at a true cost of water with this technology. At present, OWRT is investigating other methods of brine disposal.

Several constraints characterize present desalting operations. The most important are high total annual costs in comparison with conventional water sources, the need for large plant size to take advantage of economies of scale, and the problems of brine disposal. These will become less restrictive in the future, when desalination may prove to be an attractive supplement to conventional water sources in coastal areas. For the short term, however, desalination is not a viable alternative source of water in Rhode Island. When and if the technology and efficiency of this process is refined so that it is economically and environmentally competitive with other methods of supplying water, its feasibility can be re-evaluated.

Iceberg Harvesting. Recent proposals have been made to transport slab icebergs from the polar regions to areas with water supply shortages. The technique involves shaping the selected berg to reduce drag and wrapping it with plastic sheeting to insulate it and slow its rate of melting. The iceberg would then be towed to the needed area by ocean-going tugboats where it would be melted. The water produced by the iceberg's melting would either be treated and used or placed in storage to meet future demands.

There are many technological problems involved with the use of icebergs as a source of drinking water. *The obvious difficulty is in transporting* the selected berg over thousands of miles of open ocean, and then finding a suitable "parking space" for it while the ice is converted to water. The efficiency of such a process is no doubt quite low, due to melting and evaporation losses enroute. Environmental effects may also prove to be significant because the "parked" iceberg would probably have some effect on the temperature and salinity of the surrounding waters. The high cost of the technology involved is the major factor precluding the use of icebergs as a source of supply for Rhode Island in the near future. With increased efficiency of the process and increased costs of conventional sources, this process may become feasible in the distant future, but presently is not being considered to meet water needs of the study area.

Preliminary Screening. The results of the preliminary screening and evaluation process used in the first phase of plan formulation for water supply management in the study area are illustrated in Table 2. During the initial iterations of the planning process, potential measures were evaluated with regard to 1) achievement of planning objectives, 2) cost of implementation, and 3) intangible advantages and disadvantages including social and environmental acceptability.

These investigations indicated that only demand modification among the nonstructural measures and surface water, groundwater and importation development of the structural measures were considered for further evaluation. The No Action Program was not considered an appropriate measure warranting further evaluation.

TABLE 2

PRELIMINARY SCREENING OF MANAGEMENT MEASURES

POTENTIAL MEASURE	FURTHER EVALUATION WARRANTED	EVALUATION CRITERIA NOT MET
No Action Program	No	3, 4
Nonstructural		
Demand Modification	Yes	
Weather Modification	No	1, 2, 4
Direct Wastewater Reuse	No	1, 2, 3
Structural		
Surface Water	Yes	
Groundwater	Yes	
Importation	Yes	
Dual Water Supply Systems	No	1, 2, 3
Desalination	No	1
Iceberg Harvesting	No	1, 2

Evaluation Criteria

1. Economic feasibility
2. Engineering practicality
3. Social acceptability
4. Adequate solution

SECTION 2 - ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

General

As a result of the initial screening of potential water supply management measures, those considered for further evaluation were analyzed to determine their applicability in management plans to meet study area needs. Each measure was investigated to determine its economic, environmental and social acceptability and also to determine its response to fulfillment of study objectives.

Various surface water reservoir and groundwater aquifer sites were studied and evaluated based upon their ability to satisfy the water supply needs of existing systems serving the study area's communities. Developed and undeveloped supply sources, identified in prior studies by others, were screened against economic, environmental and social acceptability criteria and utilized in the development of alternative plans. Only those sites providing adequate quantities of either surface water or groundwater were retained for alternative plan development.

The following sections present information on applicable water supply management measures considered toward the development of intermediate plans. In view of the present need for additional water supply to serve communities in Bristol County, they were included in the formulation of alternative plans for the study area. Likewise, the water supply needs of Glocester and Foster were also included in the plan formulation process to provide comprehensive water supply plans for the entire study area.

Demand Modification

The five techniques suggested for modifying water demands in the study area, and considered applicable as the result of the initial screening, focused primarily on reductions within the residential/commercial use category. This category accounted for approximately eighty percent of the study area's publicly-supplied water in 1975 and is projected to increase to about ninety percent during the planning time frame. Water use by the residential sector will fluctuate significantly depending on the type and location of the home and individual user habits. However, general patterns of residential water usage can be estimated despite variation in specific use patterns.

Typical residential water use can be broken down in the following approximate proportions:

TABLE 3
RESIDENTIAL WATER USE

COMPONENT	PERCENTAGE
Toilet Flushing	41
Bathing	37
Cooking and Washing	9
Drinking	5
Clothes Washing	4
Lawn Watering	3
Car Washing	1
	100

A study was conducted to estimate the effectiveness of the various demand modification techniques in altering residential usage and to determine their feasibility and suitability in the study area. Since water associated with toilet-flushing and bathing constitute about 75-80 percent of all water used inside the home, these functions were the primary targets of water conservation study efforts. The following paragraphs describe the techniques investigated and present information used in their evaluation. Each of the techniques may be used singly or in combination to achieve reductions in total water used.

Pricing Policies. The price charged for water is generally considered to offer the greatest potential as a demand modification technique. Judicious application of the various pricing policies discussed in the previous section was considered to offer significant reductions in water consumption. However, studies conducted for the New England area indicate that due primarily to the low cost of water in the total per capita budget, pricing does not have a significant affect on residential usage. Raising the price of water substantially above the highest prices currently charged in order to control demand would lead to water revenues significantly exceeding the cost of service. Under such circumstances, implementation of an equitable rate structure is difficult to conceive and would be expected to be socially unacceptable. For these reasons, pricing policies were not considered for further evaluation in the development of alternative water supply plans for the study area as other techniques were considered more effective.

Water Conservation Education and Water Saving Devices. While water conservation education and water saving devices have been discussed separately, in practice their effects cannot be analyzed independently since these two techniques are generally undertaken together. Thus, they were evaluated jointly, and estimated reductions were based on the application of both demand modification techniques simultaneously.

Maximum demand reductions attributed to a joint education/devices program have been approximated in prior studies at about 35-40 percent. These figures assumed an aggressive program of installation of devices, and an active public involvement program. Information from actual case studies of these types of programs shows much smaller reductions than the previous estimates. Reductions in demand of approximately five percent have been cited as entirely possible for the study area. The major difference is probably the result of the following: actual programs relied on education and change of habits to achieve water savings rather than wholesale replacement of major appliances, which was not shown to be cost effective. Also, actual data showed that not all the devices distributed were installed, and not all of those installed were maintained properly. Thus, not all consumers changed their water use habits.

In the formulation of alternatives, a five percent reduction in total water usage throughout the study time frame has been considered for these techniques based upon data reported from actual case studies.

Institutional Restrictions. Prior studies have reported that restrictions of the types mentioned in the preceding section of this report could be expected to produce 5-10 percent reductions in overall water demand. However, data obtained from actual case studies show that restrictions alone could be expected

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to produce a 4 percent reduction in water demands by the year 2030. The actual case study conclusion was based on building code restrictions and did not assume water use restrictions on lawn sprinkling, car washing, and swimming pool filling which earlier reports had indicated would likely be implemented for several weeks each year.

The estimated 4 percent reduction is based on the understanding that this type of restriction is readily implementable and could be effected even if less publicly acceptable measures such as bans on outdoor water use were not implemented. In the past, these latter measures have been implemented only during periods of emergency or severe shortage, so that their regular use in reducing future water demand was not assured.

Leak Detection. A program of leak detection and repair would be one of the most effective ways to control water system losses in the study area because the municipal systems involved are almost completely metered. Earlier studies have estimated a 5-10 percent reduction in water demand with implementation of a comprehensive leak detection and repair program. However, in systems where total unaccounted-for water usage is within tolerable limits, the costs associated with such a leak detection and repair program are prohibitively high. Information obtained from case studies for all unaccounted water has been combined t produce an estimate of a 2 percent savings for the study area.

Due to the relatively low unaccounted for water in the Providence water supply system, the potential for reduction by leak detection and repair is small. Therefore, the 2 percent reduction in total water use due to this technique is a reasonable expectation of performance, and was adopted for the demand reduction estimates used in the formulation of alternatives.

Comprehensive Program of Demand Modification. The combined effect of implementing a comprehensive demand modification program in the study area consisting of 1) water conservation education and installation of water-saving devices, 2) institutional restrictions principally concerned with building code changes, and 3) leak detection and repair programs, is expected to reduce projected water demands by 9 percent in the year 2000 and by 11 percent by 2030. Additional water use reduction from techniques presented in preceding sections would also contribute to demand modification, however, their overall effect is small when compared to the comprehensive program considered for this study. Projected future average day demands would be reduced by approximately 10 mgd and 15 mgd by the years 2000 and 2030 respectively through implementation of the demand modification program. This measure was, therefore, carried forward in the development of alternative water supply plans for the study area.

Surface Water Resources

Development of surface water supply sources to meet study area needs centered on an evaluation of sites identified in prior studies conducted for the State of Rhode Island. Of the many sites investigated, twelve reservoir sites were evaluated to determine their applicability in water supply plans. Several proposed reservoir sites lie in the Blackstone River Basin in the northwestern part of the State - two sites in the Chepachet River watershed and four sites in the Branch River watershed. Six other proposed reservoir sites were located in the west-central region of Rhode Island - two sites in the Thames River Basin, three sites in the Pawtuxet River Basin and one site in the Pawcatuck River Basin located southwesterly of the study area. Potential reservoirs are shown on Plate B-1.

Screening criteria utilized in the evaluation of all potential sites included preliminary estimates of the cost of development. Each site was evaluated individually and in combination with other feasible sites to determine its economic feasibility and those offering the most realistic solutions to the study area's water supply problems were retained for further evaluation in the development of alternative plans. Descriptions of the various reservoirs are presented in the following paragraphs. Preliminary estimates of the cost of development are presented in Table 4 for comparison purposes.

Chepachet River Reservoir. Located on the Chepachet River (Blackstone River Basin) in the towns of Burrillville and Glocester, an impounding reservoir at this site would provide a yield of about 18 mgd. The reservoir was dropped from further consideration, however, when it was discovered from field investigations that, in addition to water quality concerns, resulting from increased development within the watershed, unfavorable foundation conditions - a deep underlying water-bearing stratum - existed at the proposed dam site.

Smith-Sayles-Keech Reservoir. This reservoir would be located at the site of the existing Smith and Sayles Reservoir and Keech Pond on the Chepachet River (Blackstone River Basin) in the town of Glocester. The water supply reservoir would be created by raising the present spillway level of the existing dam, and would provide a yield of about 6.9 mgd. Consideration of this site was ruled out, despite relatively low construction costs, when investigations revealed that raising the spillway level would not increase the reservoir's safe yield appreciably due to increased evaporation losses. The existing reservoir and pond are presently used for recreation purposes.

Oak Valley Reservoir. Development at this site would provide a yield of about 6.3 mgd. Located on Tarkiln Brook, a tributary of the Branch River (Blackstone River Basin), in the town of Burrillville, the analysis of possible sites determined that the proposed Oak Valley Reservoir was technically and economically feasible. However, its small size and limited potential for development precluded its consideration in the development of alternative plans to serve the study area.

Nipmuc River - Tarkiln Brook Reservoirs. This reservoir system was proposed for staged development in which Tarkiln Reservoir would be constructed first, with a yield of about 5 mgd. Water would be diverted from the Nipmuc River initially to raise the system's yield to about 9 mgd, and finally a reservoir would be constructed on the Nipmuc River increasing the total yield of the system to 14.4 mgd. The two reservoirs were considered technically and economically feasible, however, they are best suited to supply the needs of northern Rhode Island since the cost of transmission facilities to the Providence area would be excessive, especially when it is considered that the northern part of the State would then have to develop alternative sources of supply. Thus, due to its inapplicability to meet the water supply needs of the study area, this reservoir system was dropped from further consideration.

Wilson Reservoir. Wilson Reservoir is an existing impoundment on the Clear River (Blackstone River Basin) located in the town of Burrillville. Two proposals for this site have been considered: 1) Wilson Reservoir be utilized to divert water to the proposed Nipmuc River Reservoir, thereby increasing the yield by about 8.6 mgd, and 2) constructing a new dam and enlarging the capacity of the impoundment to develop a yield of about 9.6 mgd for diversion to Nipmuc Reservoir. It was determined that the increased yield obtained by construction of a new dam would not justify the cost of the structure. Also, the most economically feasible development of Nipmuc River Reservoir was shown to require all of its storage for runoff from its own watershed, so that any diversion from Wilson Reservoir could not add to the yield of Nipmuc Reservoir. This site was, therefore, dropped from further consideration in the development of alternative plans. The existing reservoir is presently used for recreational purposes.

Nooseneck River Reservoir. An impoundment at this site, located in the Big River watershed in the Pawtuxet River Basin, would provide a yield of about 7.1 mgd and was considered as a potential source to augment the yield of the proposed Big River Reservoir. Because of its small yield alone it would not be sufficient to meet the study area's needs. In addition, when considered as part of a total system with the Big River Reservoir, it would add less than 1 mgd of yield to that facility. Thus, Nooseneck River Reservoir was dropped from further consideration in the development of alternative plans.

Flat River Reservoir (Johnson's Pond). Located on the South Branch of the Pawtuxet River, Flat River Reservoir is an existing impoundment which in addition to providing water supply for industries located within the South Branch watershed, also provides recreational opportunities for boating, camping and picnic areas. The proposed water supply development of Flat River Reservoir consisted of two considerations: 1) the reservoir would be developed as an independent source, and 2) a flood skimming operation would be constructed with diversion to the proposed Big River Reservoir.

The first proposal was rejected for a number of reasons. First, due to its capacity, the reservoir could not meet projected water demands for the study area, so that additional development elsewhere would also be required. Flood skimming would thus be more economically sound since the costs of construction would be considerably less. Secondly, the reservoir is privately-owned and has significant residential development along its shores and in its watershed. Its use as a public water supply source was, therefore, questionable in view of private ownership and potential water quality problems and was dropped from further consideration.

Flood skimming operations circumvent the problems of ownership and reduced water quality. Thus, the proposal to utilize Flat River Reservoir for flood skimming and diversion to the proposed Big River Reservoir was retained for evaluation as part of alternative water supply plans. The diverted waters would be stored in the proposed Big River Reservoir for subsequent use therefrom and would increase the reservoir safe yield by about 13 mgd.

Wood River Reservoir. The Wood River watershed is part of the Pawcatuck River Basin located southwesterly of the study area. Two considerations for development of water supply sources on the Wood River were investigated,

1) construction of flood skimming facilities to divert water to the proposed Big River Reservoir thereby increasing the safe yield of that reservoir by about 18 mgd, and 2) construction of an impoundment in the towns of Exeter and West Greenwich that would provide an estimated safe yield of about 26 mgd for water supply purposes. The Wood River Reservoir was considered for possible diversion to the proposed Big River Reservoir.

Water diverted from flood-skimming operations would be pumped through a transmission main to Raccoon Brook in the Big River watershed for storage and subsequent use therefrom. The Wood River impoundment would be located just northerly of Ten Rod Road in Exeter in the vicinity of the Arcadia Management Area.

Considerations for water supply development in the Wood River watershed were carried forward for further evaluation in the development of alternative plans.

Big River Reservoir. The Big River feeds into the southern end of Flat River Reservoir and has several major tributaries, including Nooseneck River, Congdon River and Carr River. Proposals for the Big River Reservoir development entail construction of a dam at the junction of Big River and Flat River Reservoir, creating an impoundment on Big River and providing storage for possible diversion flows from Flat River Reservoir, Wood River, Moosup River and Bucks Horn Brook. The Big River Reservoir would be the first phase of construction of any proposed reservoir system.

The yield produced by impoundment of the Big River alone was estimated to be about 36 mgd when operated in conjunction with the existing Scituate Reservoir. Including yields obtainable from the several diversions mentioned above, capacity of the Big River Reservoir would produce a water supply yield of about 73 mgd.

The Big River Reservoir was, therefore, carried forward in the development of water supply plans for the study area.

Moosup River Reservoir. The Moosup River watershed located in the west-central area of the State, lies in the Thames River Basin. Construction of a diversion reservoir facility, by impounding the Moosup River near the Rhode Island-Connecticut state line, in the town of Coventry, would provide a yield of about 17 mgd which could be diverted to the proposed Big River Reservoir watershed for storage and subsequent use therefrom.

The Moosup River diversion reservoir was considered applicable for further evaluation and was, therefore, carried forward in the development of alternative plans for the study area.

Bucks Horn Brook Reservoir. Bucks Horn Brook is a tributary of the Moosup River in the Thames River Basin. Construction of a diversion reservoir on Bucks Horn Brook, in the town of Coventry, was considered in conjunction with the proposed Moosup River Reservoir and would provide a water supply yield of about 5 mgd. Water from the Bucks Horn Brook Reservoir would be transported via the transmission main from the Moosup River Reservoir and stored in the proposed Big River Reservoir for subsequent use therefrom.

Due to the estimated high cost of development of the Bucks Horn Brook Reservoir and the limited yield available to meet study area needs, this alternative site was dropped from further consideration in the development of water supply plans.

Reservoir Development Costs. Included in the preliminary screening of applicable surface water resources was the comparison of reservoir development costs as shown in Table 4. Preliminary cost estimates of each proposed reservoir site were made to provide an evaluation of each source in meeting study area water supply needs. Cost estimates included only the basic costs of reservoir development and do not reflect the additional costs of required water treatment facilities and transmission facilities including pumping stations. These preliminary development costs were utilized in screening for the most applicable surface water sources that would be included in alternative plans for the study area. The estimates of cost were based on January 1979 price levels.

TABLE 4

DEVELOPMENT COSTS OF POTENTIAL RESERVOIRS

(In Thousands of Dollars)

LOCATION	YIELD (MGD)	CAPITAL COST	DEVELOPMENT COST PER MGD
Chepachet River	18.1	$13,000	$ 718
Oak Valley	6.3	5,640	895
Wilson Reservoir	9.6	9,690	1,009
Nipmuc River Reservoir	9.0	8,250	917
Tarkiln Brook Reservoir	5.4	4,220	781
Nooseneck River Reservoir	7.1	11,100	1,563
Wood River Reservoir	26.0	11,000	423
Big River Reservoir	36.0	14,000	389
Moosup River Reservoir	17.0	3,980	234

Groundwater Resources

In many areas of the State of Rhode Island in which sand and gravel aquifers are present there appears to be substantial amounts of groundwater, especially where the aquifers include or are bordered by streams. The fact that high yield potentials exist in certain parts of the State, however, does not necessarily imply that ample supplies of groundwater can be delivered on demand to need areas. Distance of transport and water quality considerations limit the availability of potential groundwater resources. If the distance between aquifer source and need area is great, groundwater supply systems are generally not as cost-effective as the higher yielding surface sources. If the quality of groundwater in a given area is poor and the cost of treatment is prohibitive, then both health and economic factors mitigate against its use as part of a public water supply. Unfortunately, the natural concentration of iron and manganese in the native groundwater combined with pollutants generated by increased urbanization, has resulted in groundwater of substandard quality existing in several aquifers throughout the study area.

Groundwater reservoirs of much of the study area have been investigated by the U.S. Geological Survey and the Rhode Island Water Resources Board. Reports of these agencies and other hydrogeologic reports serve as reference sources for the groundwater assessment included in this section of the report. The scope of the study did not allow for field exploration or field testing for the determination of estimated groundwater yields.

Groundwater resources of each of the communities in the study area are discussed in the following paragraphs. Those communities that appeared to have little or no potential for sustained municipal supply are addressed only briefly. Those communities that have higher potential are discussed more fully.

Bristol, Foster, Johnston, North Providence, Scituate, Warren and West Warwick. Investigations show no significant groundwater availability in these communities that would sustain development of a municipal water supply system.

Glocester. This community is mostly situated in the Branch River watershed (Blackstone River Basin). Stratified drift aquifers occur mainly in the stream valleys and exhibit saturated thicknesses of between 40 and 60 feet. Transmissivity measurements range from 5,000 to 8,000 cubic feet per day per foot. Water from wells in this area would be drawn in part from induced infiltration. Based on mathematical modeling by the U.S.Geological Survey, it is estimated that the sustained groundwater yield in the community of Glocester would be about 1.3 mgd. There is presently no municipal water supply system in Glocester.

Smithfield. Groundwater reserves in this area have been mapped mainly on a reconnaissance basis and are located in areas of outwash in the vicinity of the Woonasquatucket River. Based upon the area of the drift and the anticipated recharge from precipitation, it is estimated that the potential groundwater yield in Smithfield would approximate 1.0 mgd. The town is presently served by the East Smithfield Water District, the Greenville Water District, and the Smithfield water system with supplies obtained from the City of Providence water supply system.

Cranston. Reconnaissance level investigations of the potential groundwater resources of this community, located in the lower reaches of the mainstem Pawtuxet River and Pocasset River show an area of moderate to high yielding stratified drift. Much of the area is urbanized and, therefore, impervious to recharge and the quality of groundwater is reported to be poor. Groundwater supplies have an estimated sustained yield of approximately 1.0 mgd, however, due to water quality conditions they have not been considered in the development of alternative plans for the study area.

Barrington. This community located in the Narragansett Bay Local Drainage Areas has an estimated groundwater sustained yield of about 1.0 mgd. Because the drainage is coastal in nature, the possibility of salt water encroachment due to over-pumping is of concern. Iron and manganese contamination is also of concern and has forced the closing of one well operated by the Bristol County Water Company which supplies the town.

Coventry and West Greenwich. Reconnaissance mapping of the aquifers in these two communities in the Pawtuxet River Basin show that the only substantial aquifer areas are located east of the Flat River Reservoir and south of the

South Branch. It is estimated that 4.5 mgd of groundwater could be removed from this area on a sustained basis. The Kent County Water Authority utilizes the supply to provide part of the water for the communities it serves.

Warwick. The City of Warwick is partly located in the lower reaches of the Pawtuxet River Basin with the larger area of the community lying within the watershed of the Narragansett Bay Local Drainage Areas. The portion of Warwick lying north of Greenwich Bay and characterized by low relief has been mapped on a reconnaissance level only. Stratified drift is present in the area in places which exhibit saturated thicknesses to near ground level and groundwater is, therefore, most likely present in significant quantities. One estimate assigns a sustained groundwater yield of 6.0 mgd from this area. Available well data, however, shows widespread distribution of fine grained sediments in drift which tends to severely limit the capacity of wells to yield large quantities of water. Additionally, the potential for pollution of the groundwater is high as the water quality of the Pawtuxet River is poor, and four sanitary landfills (two of which are abandoned but still pose the threat of leachate discharge) as well as two municipal wastewater treatment plants are located in the area.

The Hunt River aquifer, a deposit of stratified drift capable of producing high yields, is found in Warwick south of Greenwich Bay in the area of Potowomut Neck. Well data shows saturated thicknesses of over 100 feet and transmissivity ranges of up to 300,000 gallons per day per foot. The U.S. Geological Survey models of this aquifer estimate that groundwater recharged to the aquifer is in the order of 8.0 mgd. However, if the entire quantity were to be withdrawn, there is a distinct possibility that flows in local rivers would be adversely impacted for extensive periods of time under drought conditions. Present withdrawals from this aquifer by the Kent County Water Authority and formerly by the U.S. Navy total approximately 4.0 mgd. If further development were to occur, then in periods of below average precipitation, the Potowomut River and most probably other local rivers would reach critically low levels and/or dry up completely for lengthy periods of time. It appears then that unless an aquifer capable of producing a substantial sustained yield of good quality water is developed on the drift found north of Greenwich Bay, the community of Warwick cannot furnish any future additional large supplies of groundwater. The City of Warwick is almost totally supplied by the Warwick Water Department supply system, which obtains its water from the Providence water system.

East Greenwich. The town of East Greenwich, found immediately south and east of Warwick, is also located in the Narragansett Bay Local Drainage Areas and its hydrogeologic setting is similar to the southern part of Warwick. The town's border includes parts of the previously discussed Hunt River aquifer. A second smaller aquifer in this community has been identified by the U.S. Geological Survey north of Scrabbletown Brook and the Hunt River. Mathematical modeling of the smaller aquifer suggests a sustained yield of about 1.4 mgd. Since the Hunt River aquifer is presently being used to near capacity, the town of East Greenwich is, therefore, unable to contribute significantly to any additional groundwater supplies for municipal development.

Providence. The City of Providence is the most highly urbanized area in the State. The city is drained by the Woonasquatucket River to the west and the Moshassuck River to the north. These streams flow through the Providence and Seekonk Rivers to upper Narragansett Bay. The water-bearing drift in the city consists of irregular lenses of interbedded sands, silts, clays and gravels forming an outwash plain. A few kames consisting of coarse sands and gravels have also been mapped. The drift, reaching over 250 feet thick in deep bedrock valleys, possesses hydraulic characteristics favorable to the development of high yield wells. Yields of wells in kame fields near Roger Williams Park are reported to range from 300 to 600 gallons per minute (gpm). A high of 8 mgd was pumped for various industrial uses while current withdrawal has declined to approximately 4 mgd.

Historically, no municipal well systems have operated in Providence. The existing and potential severe water quality problems appear to be the principal reasons why no public water supply is drawn from groundwater in the area. The extensive urbanization of the city, as well as the naturally occurring high levels of iron and manganese contribute to the generally very low quality of surface water. The water quality of both the Woonasquatucket and Moshassuck Rivers is C and that of the Pawtuxet River is D and below. There are 65 combined sewer overflows in Providence which discharge to the Woonasquatucket River and its tributaries. Sanitary landfills, toxic wastes and industrial wastewater discharges also contribute to the surface water pollution. Other factors include municipal wastewater treatment plants and salt storage areas. While specific groundwater quality data are unavailable for the City of Providence, the hydrogeologic conditions are such that the quality of the underground water most probably is also poor, a mirror of the conditions found on the surface. Infiltration of contaminants through sediments to the water table will certainly impact negatively on the quality of the groundwater. Additionally, any polluted surface water induced from the area's rivers would severely affect the quality of groundwater. Another limiting factor to be considered is the possible intrusion of salt water in estuarine areas.

There is evidence to suggest that ample supplies of groundwater exist in the Providence area. However, the extensive biological, chemical, and physical pollution of surface water and the several point and non-point sources of pollution existing in the highly urbanized area, tend to preclude the development of any municipal groundwater supplies within the limits of the city.

East Providence. East Providence is located in the Narragansett Bay Local Drainage Areas on the east side of the Providence River. The city, like Providence, is also heavily urbanized and suffers from attendant pollution problems. Stratified drift overlies a major portion of East Providence with the high potential yield aquifers found mainly near the Ten Mile River. The lithology of the Ten Mile River aquifer ranges from medium sand to gravel in the upper layers and grades to fine sands and silts below. Thick lenses of medium to coarse sands in the aquifer have the highest potential for yields and the transmissivity in these deposits has been measured as 31,000 gallons per day per foot. The highly productive portions of the aquifer are widely dispersed and extensive and detailed field investigations would be required to determine any significant additional sources of groundwater.

Water quality of the Ten Mile River is very poor. In the area of greatest potential for induced infiltration, the river has a water quality classification of D. Pollution is biological, chemical, and physical in nature and the severity can be attributed to the urbanized nature of the area. In addition to man-made pollution, the natural background quality of the water contains excessive manganese and iron quite similar to neighboring communities. In 1970 wells in East Providence along Central Pond were shut down due to surface water pollution and iron and manganese build-up.

Available data suggests that an additional 2 mgd might be pumped from the Ten Mile aquifer on a sustained basis. These additional wells would require extensive and detailed investigations to develop fully, and would probably have to be constructed near the Ten Mile River in order to take advantage of induced infiltration. However, the very poor quality of the Ten Mile River renders it unsuitable at the present time for any municipal water supply even if recharged to the groundwater table through induced infiltration. Other sources of surface pollution also impact negatively on the water quality situation. Due to increased impacts on the quality of groundwater resources in the early 1970's, the City of East Providence abandoned its municipal well supplies and now obtains water from the Providence supply system.

A review of the quantity and quality of groundwater resources in the study area, as discussed above, leads to the conclusion that the area can support only limited additional withdrawals of groundwater suitable for use in municipal supply systems. For purposes of planning, consideration was also given to areas with potentially large reserves of groundwater which are located in the general vicinity of the study area to determine their feasibility in meeting study area needs. The following paragraphs describe the areas investigated.

Burrillville. Four areas of the Branch River Basin were evaluated in studies conducted by the U.S. Geological Survey. Mathematical models of aquifers in Slatersville, Harrisville, Oakland and Chepachet were developed utilizing hydraulic data on the surface flow and the hydraulic relationship of surface to subsurface water in addition to the more traditional well development information such as transmissivity, drawdown, specific yield, and the affect of geohydrological boundaries. Model simulations of these aquifers showed that most of the water withdrawn as a result of wellfield development would be derived from infiltration induced from nearby rivers and streams. Estimates of the yield derived from mathematical modeling indicates that a sustained groundwater yield of about 7.0 mgd would be available in Burrillville.

Presently the Harrisville Fire District and Pascoag Fire District water supply systems serve the community of Burrillville.

Lincoln-Cumberland. Substantial groundwater supplies are available within the Lincoln-Cumberland area. Thick deposits of stratified drift form good aquifers along the Blackstone River, Moshassuck River and Abbott Run Brook. Several high yield wells are already in operation in these aquifers and the potential appears to exist for substantial additional withdrawals. Because the aquifers lie under or immediately adjacent to large rivers much of the existing and potential well yield is from induced infiltration of surface water.

Modeling was performed by the U.S. Geological Survey on several different areas of the aquifers within the two communities for different arrays and patterns of well development. The analysis showed a maximum potential yield of approximately 24 mgd for the Blackstone River valley, 5 mgd for the Abbott Run valley and 2 mgd for the Moshassuck River valley. These figures are estimates of safe sustained yield since they assume a 200-day pumping period. This length of time is considered sufficient to simulate conditions of prolonged drought in the study area. With present withdrawals of groundwater estimated at 10 mgd and the potential total yield estimated at 30 mgd, additional groundwater supplies of 20 mgd are available in the towns of Lincoln and Cumberland.

Although the quantity of the groundwater supply is high, the quality is low. Both surface and subsurface water quality is a very important consideration since the potential yield of most of the wells in the area is controlled by the rate of induced infiltration. In both the Blackstone River and Abbott Run valleys, the potential amount of induced infiltration is significantly greater than the water in aquifer storage. In the Moshassuck River valley the estimated amount of water from induced infiltration is approximately equal to that from storage. The Blackstone River water is Class E in its upper reaches in Lincoln because of pollution upstream, further downstream it improves to Class D and then to Class C. The pollution is biological, physical and chemical. Movement of water through sediments of the aquifer, as occurs during induced infiltration, will reduce the biological and physical pollution to various degrees but will not significantly reduce the chemical pollution. There are three landfill sites in the Blackstone River Basin and the natural background quality of the groundwater is poor because of excessive manganese and locally excessive concentrations of iron. Concentrations occur in levels above the limits recommended for safe drinking water.

The Abbott Run Brook surface water is Class A and there are no known existing groundwater quality problems. The Moshassuck River in Lincoln is Class C and iron and manganese concentrations in the river water are reported to exceed recommended limits for drinking water. No data on groundwater quality is available but there is a high probability of excessive concentrations of iron and manganese.

With the exception of the Abbott Run Brook aquifer, the quality of both surface and groundwater in Lincoln and Cumberland is poor. Surface water is contaminated by physical, biological and chemical pollution. Since the yield of wells in the area is derived in large part from induced infiltration, the quality of the surface water severely impacts upon the quality of the groundwater. The generally excessive concentrations of iron and manganese occurring naturally in the groundwater combined with pollutants added through induced infiltration renders the quality of most of the well water unsuitable for municipal water supply without extensive treatment. Importation of groundwater from the Lincoln-Cumberland area was, therefore, dropped from consideration in the development of alternative water supply plans for the study area.

Several communities in the Washington County (South County) area have significant potential yields of groundwater. The proximity of these towns to the Big River study area merited their consideration in the present investigations.

North Kingstown. Aquifers in this community are found in the Hunt River watershed, the Annaquatucket River Basin and the Pettaquamscutt River Basin. The Hunt River aquifer (see previous discussion under Warwick) cannot support any substantial additional groundwater withdrawals. The potential yield of the Pettaquamscutt aquifer is only 1 mgd and there is danger also of saltwater intrusion. Wells presently existing in the Annaquatucket Basin could probably provide a sustained yield of 1 mgd. North Kingstown, therefore, cannot be regarded as a source of significant additional groundwater supply as the individual needs of the community have been impacted by water shortages in recent years.

Exeter, Hopkinton, Richmond, South Kingstown, Charlestown and Westerly. These six communities lie in the Pawcatuck River Basin on the southerly side of the study area. Aquifers of the Pawcatuck River Basin have been examined by several investigators and at least seven groundwater reservoirs along the mainstem of the Pawcatuck River and its tributaries have been studied in sufficient detail to have been mathematically modeled by the U.S. Geological Survey. The modeling assigned a yield of 30 mgd to the lower Pawcatuck River Basin and approximately 25 mgd to the upper Pawcatuck Basin. Additional investigations have also been conducted in recent years in coordination with the Rhode Island Water Resources Board.

Figures for the upper Pawcatuck River assumed withdrawals from aquifer storage during periods of drought and further assumed little or no diversion of water out-of-basin. The yield of 25 mgd is, therefore, not considered realistic and presents a distinct possibility of serious environmental impact of the area's rivers and streams. A groundwater discharge of not more than the 95 percent flow duration of rivers flowing in the aquifers was considered to estimate the safe yield of groundwater supplies and as a result reduces the potential sustained yield of the upper Pawcatuck River Basin to about 9 mgd. The modeling procedure for the lower Pawcatuck River Basin used more conservative assumptions and thus a yield of 30 mgd is considered appropriate for planning purposes.

In addition to the yield calculated for the modeled areas, the town of Westerly is reported to have a potential safe yield of 6 mgd. These more conservative yields, however, assume no export of water from the basin and do not preclude the possibility of some streams going dry in the vicinity of pumping wells during periods of drought.

In summary, the six communities of Washington County that lie in the Pawcatuck River Basin have an estimated potential sustained groundwater yield of approximately 45 mgd. The feasibility of this quantity of water being available as an alternative source of supply for the Big River study area is limited by several concerns not the least of which is the projected future water supply needs of Pawcatuck River Basin communities themselves. Although it would be expected that significant surplus quantities of groundwater would still be available in the basin, their development would need to be carefully planned to avoid unacceptable depletion of flows in the area's rivers and streams. The quantity of 45 mgd would have to be reduced, possibly quite substantially, if groundwater were diverted out-of-basin and if potential stream drying-up were to be avoided. Finally, and probably more significantly, is consideration of the relatively long distances between the Big River study area and most of the aquifers in the Pawcatuck River Basin, especially the lower Pawcatuck River.

Long transmission mains would be required to transport water to the need areas of the Big River study region involving high construction costs and the need for appurtenant facilities such as pumping stations. Also, groundwater withdrawals from the Pawcatuck River Basin would create serious management problems if the quantities required to satisfy the projected needs of the study area were to be met. The groundwater resources of the Pawcatuck River Basin were, therefore, dropped from further evaluation in the development of water supply management plans for the study area primarily due to the uncertainty of adequate available resources.

Rehoboth. Groundwater aquifers in the town of Rehoboth consist mainly of unconsolidated glacial drift composed chiefly of gravels, sands, silts and clays. The aquifers are found in the lower areas of the watershed which lies within the Narragansett Bay Local Drainage Areas. Both medium and high yield aquifers cover approximately eight square miles in Rehoboth and have an estimated sustained yield of about 5.0 mgd. The town of Rehoboth does not have a municipal water system but instead relies on individual private groundwater wells.

Groundwater Summary. Groundwater development appears viable in several areas in or adjacent to the study area. Aquifers in Burrillville, Glocester, and Rehoboth, Massachusetts, could be utilized to meet the needs of Glocester, Foster and Bristol County, respectively. However, the remainder of the groundwater resources in the study area are of questionable quality and were, therefore, considered infeasible for development as a municipal water supply source. Groundwater resources outside the study area were considered inappropriate for importation due to 1) quantities required to meet projected future demands of local communities, 2) unsatisfactory water quality conditions that would possibly require extensive treatment, 3) uncertainty of quantities available for out-of-basin transfer without creation of adverse environmental and associated impacts, and 4) costs of development due in large measure to the high costs of transmission facilities.

Importation

Studies were conducted to determine the feasibility of importing water from other regions of the State to meet the projected needs of the study area that were identified in the preceding paragraphs. Of the various groundwater and surface water supplies investigated only a limited number of potential sources were considered adequate to supply the quantitites of water needed. Among the areas investigated were the groundwater resources of Burrillville, Lincoln and Cumberland to the north of the study area, groundwater resources in Rehoboth, Massachusetts to meet the needs of Bristol County, groundwater resources of the Pawcatuck River Basin to the south of the study area, and surface water supply sources in various basins adjacent to the study area as described previously in the sections under "Surface Water Resources" and "Groundwater Resources."

All possible sites for groundwater and surface water development, whether inside or outside the study area, were screened in the same manner and no distinction was made between sites in the application of selection criteria.

Intermediate Screening

The results of the intermediate screening and evaluation process to determine the most applicable water supply management measures for the study area are shown in Table 5. During this phase of the plan formulation process, described in the preceding paragraphs, attempts were made to assess each management measure in relation to plan formulation alternatives for satisfying the water supply needs of the study area. Only those measures that made positive contributions towards fulfillment of the study's planning objectives and which offered the most economically and environmentally acceptable solutions to the water supply needs identified were retained for development of intermediate plans.

Investigations revealed that of the potential measures passing the initial screening phase, the most applicable resource management measures for development of intermediate plans consist of 1) demand modification, 2) surface water resources in the Pawtuxet, Thames and Pawcatuck River Basins, and 3) groundwater resources within the study area and outside the study area in Burrillville and Rehoboth, Massachusetts.

Development of Intermediate Alternatives

General. As a result of reconnaissance and preliminary type estimates, preliminary screening, and analysis of applicable management measures, an array of alternative plans that would address the planning objectives of the Big River Reservoir study were considered utilizing either one or a combination of the applicable measures for water supply management described in the preceding sections. Alternatives were developed that addressed the water supply needs of the study area incorporating both structural and nonstructural measures and focused on the water requirements projected for both the short term (2000) and long term (2030) planning periods.

Intermediate Alternatives. In the development of intermediate alternatives, consideration was first given to the effects demand modification measures would have in satisfying projected water requirements for the study area. As a result of implementing the demand modification program described in the preceding section, the average day water supply needs of study area communities would be reduced from approximately 109 mgd to 99 mgd in the year 2000 and from approximately 142 mgd to an estimated 127 mgd by the year 2030. Likewise, maximum day water requirements of the study area would be reduced from 190 mgd to an estimated 173 mgd in the year 2000 and from about 250 mgd to 222 mgd by the year 2030. The projected water requirements of existing supply systems and individual communities within the study area showing the reductions resulting from implementation of the demand modification program are presented in Table 6. Additional supplies would still be required to meet the projected needs of the study area even with implementation of demand modification measures. The deficits remaining above the 1975 safe yield and maximum capacity of existing supply systems are shown in Table 7.

TABLE 5

INTERMEDIATE SCREENING OF MANAGEMENT MEASURES

APPLICABLE MEASURE	FURTHER EVALUATION WARRANTED	EVALUATION CRITERIA NOT MET
Nonstructural		
Demand Modification	Yes	
Structural		
Surface Water Resources		
1) Chepachet River Reservoir	No	1,2,3,4
2) Smith-Sayles-Keech Reservoir	No	2,3
3) Oak Valley Reservoir	No	2,3,4
4) Nipmuc River-Tarkiln Brook Reservoirs	No	2,3
5) Wilson Reservoir	No	3,4
6) Nooseneck River Reservoir	No	2,4
7) Flat River Reservoir	Yes	
8) Wood River	Yes	
9) Big River Reservoir	Yes	
10) Moosup River Reservoir	Yes	
11) Bucks Horn Brook Reservoir	No	2,4
Groundwater Resources	Yes	
Importation	Yes	*

Evaluation Criteria

1. Technical Feasibility
2. Economic Feasibility
3. Social Acceptability
4. Adequate Solution

* Included in surface water and groundwater resources measures.

TABLE 6

EFFECTS OF DEMAND MODIFICATION
(In Million Gallons Per Day)

	2000				2030			
	Average Day Demand		Maximum Day Demand		Average Day Demand		Maximum Day Demand	
	Projected	Modified	Projected	Modified	Projected	Modified	Projected	Modified
Bristol County Water Company	5.3	4.8	9.2	8.4	6.9	6.2	11.9	10.6
Providence Water Supply Board	91.0	82.8	155.4	141.4	117.4	104.5	200.5	178.4
Kent County Water Authority	12.0	10.9	24.4	22.2	16.9	15.1	34.5	30.7
Foster	0.2	0.2	0.3	0.3	0.4	0.4	0.9	0.8
Glocester	0.4	0.3	0.7	0.7	0.8	0.8	1.7	1.5
TOTAL	108.9	99.0	190.0	173.0	142.4	127.0	249.5	222.0

TABLE 7

WATER DEFICITS IN THE STUDY AREA
(In million gallons per day)

Water Supply Agency	2000 Avg.	2000 Max.	2030 Ave.	2030 Max.
Bristol County Water Company	1.6	3.7	3.0	5.9
Providence Water Supply Board	5.8	(2.6)*	27.5	34.4
Kent County Water Authority	0	11.3	4.2	19.8
Foster	0.2	0.3	0.4	0.8
Glocester	0.3	0.7	0.8	1.5
	7.9	13.4	35.9	62.4

* Indicates a water supply surplus

In view of the projected needs for Foster and Glocester and due primarily to their geographical location within the study area, groundwater resources were considered the most appropriate measure for meeting each community's future water requirements. Since Foster does not have any groundwater resources sufficient for development of a municipal water supply, investigations looked at the feasibility of obtaining needed supplies from the neighboring community of Glocester. Phased development of groundwater supplies in the Chepachet River aquifer in Glocester was identified as the most feasible alternative for solving Foster's water supply problems. The plan would entail construction of 1.0 mgd capacity wells and pumping facilities in two separate phases and construction of a 12-inch transmission main to deliver the water to the service area in Foster.

The town of Glocester, which is presently supplied by private wells throughout the community, would obtain water from the existing Pascoag Fire District system to satisfy projected requirements. The plan would consist of the development of groundwater wells in two phases, each having a capacity of 1.0 mgd, pumping facilities, and a 16-inch transmission main to deliver water from the Harrisville aquifer in neighboring Burrillville to the service area in Glocester.

The second primary concern in the development of intermediate alternatives for the study area centered on the water supply needs of the Bristol County Water Company system which has had to impose water restrictions in recent years due to inadequacies within the existing system. Since no additional groundwater or surface water sources are available in the company's service area consisting of the communities of Barrington, Bristol and Warren, the immediate and future needs of the system must be met by outside supply sources. Options to obtain additional water supplies include development of groundwater and/or surface water resources in Rehoboth, Massachusetts or connection to the Providence water system in either Cranston or East Providence. Studies conducted by others have identified a connection from the East Providence water supply system as being the most economical alternative to satisfy projected future requirements of the Bristol County system. However, the immediate needs of the system were considered best served by development of groundwater resources in Rehoboth, Massachusetts until the time when regional water supply facilities would be available to meet projected demands through the year 2030. This would allow existing Providence water supplies to be utilized by developing areas adjacent to that system in meeting projected needs. These areas are primarily those communities expected to be served by the Kent County Water Authority system and the Providence Water Supply Board. A connection to the Providence water system in Cranston was ruled out as an option to meet the immediate needs of the Bristol County system because of the time required to construct transmission facilities which would include pumping facilities and a major subaqueous crossing of the Providence River between Conimicut Point in Warwick and Nayatt Point in Barrington as well as other river, railroad and highway crossings.

The plan for meeting the needs of the Bristol County water system through the year 1995, therefore, considered development of groundwater wells, having a capacity of 3.0 mgd, in the vicinity of the existing Shad Factory Reservoir in Rehoboth, Massachusetts, pumping facilities, and construction of a transmission main to deliver water to the existing supply system in Warren. The transmission facility would have capacity to deliver maximum day requirements expected by the year 2030.

Based on the considerations described above for serving the future water needs of Foster and Glocester and the immediate needs of the Bristol County Water Company, development of intermediate alternatives concentrated on the municipal and industrial water supply needs of the Providence Water Supply Board and Kent County Water Authority systems. In addition, the future needs of the Bristol County system were addressed in the formulation process. These three water supply agencies were projected to have the largest deficits facing the study area and, therefore, became the principal focus of the water supply studies.

The development of alternatives was influenced by the size and location of applicable supply sources. Estimated groundwater resources in Rehoboth, Massachusetts were not sufficient to satisfy the needs of the three water systems mentioned above but would only provide capacity for the remaining future demands of the Bristol County Water Company as one alternative solution. Surface water development thus became the principal source of required additional water supplies to satisfy projected needs.

The alternatives described in the following paragraphs were formulated upon the foregoing considerations. They were formulated to meet water supply needs of the three major systems mentioned above only as the solutions proposed for Foster, Glocester and the Bristol County Water Company were considered common to all alternatives. Costs of the water supply alternatives include all facilities required to meet study area needs and are described in Appendix G, "Design and Cost Estimates."

Alternative 1. This alternative would consist of construction of the Big River Reservoir as the initial stage of water supply development followed by diversion of flood flows from the Flat River Reservoir watershed to augment the safe yield in the future. Proposed development of the Big River Reservoir would consist of construction of the impoundment on the Big River to provide an ultimate water supply pool at elevation 292.0 NGVD, having a useable storage capacity of

46,000 acre-feet and a safe yield for water supply purposes of 25 mgd. The reservoir would be placed into service in 1995 and would include water treatment and sludge treatment facilities having a capacity of 55 mgd located adjacent to the dam at the northeast side of Hungry Hill in Coventry. Transmission facilities would consist of a 48-inch pipeline and pumping station having a design capacity of 55 mgd running northeasterly approximately 9 miles to existing Shaft No. 4 on the supplemental aqueduct of the Providence water system in West Warwick.

Flood skimming facilities at Flat River Reservoir would be constructed by 2020 and would consist of pumping facilities having a capacity of 60 mgd and a 48-inch transmission main, approximately 2600 feet long, to divert water to the Big River Reservoir for storage and subsequent use therefrom. The diversion would provide a safe yield of 13 mgd thereby increasing the total safe yield of the system to 38 mgd.

Additional groundwater supplies having a total capacity of 3 mgd would be developed in Rehoboth, Massachusetts in two phases, 2.0 mgd in 1995 and 1.0 mgd in 2015, to meet the remaining needs of the Bristol County water system. Pumping facilities and a 20-inch transmission main, approximately 5.5 miles in length, would deliver water from the well sites in Rehoboth to the existing supply system in Warren. The estimated cost of construction of this Alternative 1 shown on Plate B-2, exclusive of real estate and relocation costs, is $83,100,000.

Alternative 2. This alternative would include development of the Big River Reservoir to supplement existing supplies by 1995 followed by diversion of flood flows from the proposed Moosup River Reservoir in 2020 to increase the safe yield. Development of the Big River Reservoir would consist of construction of the impoundment to provide an ultimate water supply pool at elevation 292.0 NGVD, having a useable storage capacity of 46,000 acre-feet, and a safe yield for water supply purposes of 25 mgd as in Alternative 1. Included in the overall development would be construction of water treatment and sludge treatment facilities having a capacity of 60 mgd located in the vicinity of the proposed dam and adjacent to Nooseneck Hill Road (Route 3) in Coventry. Transmission facilities would consist of a 54-inch pipeline and pumping station having a design capacity of 60 mgd running from the water treatment facilities to the existing supplemental aqueduct of the Providence water system in West Warwick.

Flood skimming of the Moosup River would entail construction of the Moosup River diversion reservoir near the Rhode Island-Connecticut state line, pumping facilities having a capacity of 40 mgd, and approximately 6.0 miles of 48-inch transmission main to divert water to the Big River watershed at the northwesterly end of the proposed Big River Reservoir for storage and subsequent use therefrom. The diversion would provide an additional safe yield of 17 mgd, thereby increasing the total safe yield of the system to 42 mgd. The remaining future needs of the Bristol County communities of Barrington, Bristol and Warren would be served by construction of an 18-inch transmission main, approximately 12.4 miles long, from the Budlong Road connection in the existing Providence water system in Cranston to the Bristol County supply system south of the existing Child Street water treatment facilities in Warren. The transmission facilities would include construction of a pumping station having a design capacity of 4 mgd located near the existing water treatment facilities in Barrington. The estimated construction cost of this Alternative 2 shown on Plate B-3, exclusive of real estate and relocation costs, is $103,000,000.

Alternative 3. This alternative would include construction of the Big River Reservoir by 1995 as the initial stage of a water supply development plan to meet projected needs, followed by diversion of flood flows from the Wood River watershed in the Pawcatuck River Basin to augment the safe yield in the future. Development of the Big River Reservoir would consist of construction of the impoundment to provide an ultimate water supply pool at elevation 292.0 NGVD, having a useable storage capacity of 46,000 acre feet, and a safe yield for water supply purposes of 25 mgd as in Alternative 1. Included in the overall development plan would be construction of water treatment and sludge treatment facilities having a capacity of 60 mgd located in the vicinity of the proposed Big River dam and adjacent to Nooseneck Hill Road (Route 3) in Coventry. Transmission facilities would consist of a 54-inch pipeline and pumping station having a design capacity of 60 mgd running northeasterly from the water treatment facilities to the existing Providence water system supplemental aqueduct in West Warwick as in Alternative 2.

Flood skimming of the Wood River would require construction of diversion facilities by 2020 consisting of pumping facilities having a capacity of 50 mgd and a 48-inch transmission main, approximately 4.2 miles long. Water would be diverted to Raccoon Brook in the Big River watershed for storage in the proposed Big River Reservoir and subsequent use therefrom. The diversion would provide a safe yield of 18 mgd thereby increasing the total safe yield of the system to 43 mgd. The future needs of the Bristol County Water Company system would be met by construction of transmission facilities as in Alternative 2 to deliver water from the Providence system in Cranston to the existing supply system in Warren. The estimated cost of construction of this Alternative 3 shown on Plate B-4, exclusive of real estate and relocation costs, is $102,500,000.

Alternative 4. This alternative would consist of construction of the Big River Reservoir by 1995 to provide a water supply pool at elevation 300.0 NGVD, having a useable storage capacity of 73,600 acre feet and a safe yield for water supply purposes of 36 mgd. Development would include construction of water treatment and sludge treatment facilities having a capacity of 55 mgd located at the northeast side of Hungry Hill as in Alternative 1. Transmission facilities would be the same as in Alternative 1 providing for the transport of water to the existing Providence system in West Warwick.

Groundwater development in Rehoboth, Massachusetts, having a total capacity of 3 mgd, would be the same as in Alternative 1 to serve the future needs of the Bristol County Water Company system through the year 2030. The estimated construction cost of this Alternative 4 shown on Plate B-5, exclusive of real estate and relocation costs, is $81,700,000.

Assessment of Intermediate Alternatives

In accordance with the requirements of the Principles and Standards, assessment and evaluation studies were conducted to identify, measure, and compare the significant economic, environmental and social impacts of the alternative water supply plans considered in the intermediate planning stage. These effects were analyzed, and formed the basis for evaluation of the beneficial and adverse contributions of each alternative, while also providing the basis for subsequent iterations of the planning process. Finally, these effects served in selection of the most desirable plans for water supply management in the study area. The significant impacts of alternatives considered in intermediate planning are presented in the following paragraphs. Other appendices of this report principally Appendix H, "Recreation and Natural Resources", Appendix I, "Social and Cultural Resources", and Appendix J, "Economics", contain detailed information on the various economic, environmental and social impacts of detailed plans formulated from the alternatives considered in the intermediate planning stage.

Impact Assessment. The economic assessment of the four basic alternatives developed in the intermediate planning stage was limited to consideration of the first costs of construction as the planning of required facilities under each of the alternatives was essentially the same. As shown by the estimates, those alternatives requiring future diversions to satisfy projected water demands of the study area were significantly less economical than Alternative 4 which proposed development of the Big River Reservoir only as the major additional water supply component. In Alternative 1, the close proximity of the existing Flat River Reservoir, for future diversion of flows to increase the safe yield of the Big River Reservoir, provided the second most economical solution for the study area. The cost of transmission and pumping facilities associated with Alternatives 2 and 3 to divert flows from the much more distant watersheds of the Thames and Pawcatuck River Basins respectively, have the overall effect of making the cost of these alternatives higher than the cost of Alternative 4.

All of the alternatives considered in the intermediate planning stage for the study area would be expected to produce various temporary and permanent environmental and social impacts. Air quality, noise levels, water quality and the general appearance of specific work areas would be adversely affected by the proposed construction activities associated with additional water supply development. The movement of construction materials by trucks through local areas and the operation of construction equipment at the various work sites would result in noise generation and would also contribute to decreased air quality as the result of windblown dirt and exhaust emissions. Installation of transmission facilities would create social disruptions in the areas planned for their construction as well as producing interference with normal traffic conditions. Likewise, dam construction for the various reservoir facilities would create water quality impacts downstream of the facilities unless precautionary procedures were undertaken. However, all of these impacts would be temporary, lasting only during the actual construction.

Additional impacts associated with the alternative water supply plans would be expected to create certain long-term effects. The major beneficial impact of course would be the provision of dependable, suitable water supplies to satisfy the municipal and industrial water requirements of the study area. Each alternative would also minimize hazards to public health and the threat to human life, aside from the adverse effects on social well-being and regional development, associated with water shortages. The various reservoirs included in the water supply alternatives would cause reduction of wildlife habitat and recreational opportunities especially at the proposed Big River Reservoir area. However, the impact of project construction activities would generally be limited since recovery of any adverse effects would ultimately be expected should mitigation measures be included.

Implementation of the demand modification program to reduce water supply requirements of the study area would create only relatively minor social impacts as each of the measures proposed could be effected on a purely voluntary basis. The most significant beneficial effect of demand modification would be in reducing projected future demands such that no other additional water supply development would be required within the study time frame. Likewise, groundwater development, where considered in the alternative plans, would be expected to create minimum adverse environmental impacts on the region's human and natural resources as construction activities would be of relatively short duration. Structural elements of each water supply alternative would require the permanent acquisition of real estate to construct the proposed facilities. In the case of the proposed Big River Reservoir, the lands required for water supply development were acquired by the State of Rhode Island in the mid-1960's specifically for this intended purpose. Both temporary and permanent easements would also be required for construction of the required measures for water supply management in the study area.

Significant impacts of the proposed Big River Reservoir and water treatment facilities are presented in the assessment and evaluation of detailed plans in subsequent sections of this appendix. Likewise, the impacts resulting from implementation of the demand modification program and groundwater development for Foster and Glocester are not presented here but are also contained in the assessment of detailed plans. Only those major impacts associated with each of the water supply alternatives developed in this intermediate planning stage are addressed in the following paragraphs.

a. Alternative 1: Construction of the aqueduct to convey water from the proposed Big River Reservoir would create significant environmental and social impacts in the area as a result of installing the pipeline by cut and cover methods. Residents of homes and commercial establishments along the route of the aqueduct would experience temporary disruption of access, normal traffic flow and on-street parking availability especially in the areas of Main Street, Washington Street, and Fairview Avenue in Coventry and Main Street and Wakefield Street in West Warwick. Blasting operations in conjunction with aqueduct construction would also create temporary impacts in those areas where necessary.

Aqueduct construction outside of public ways would impact on the general ecology of these areas in addition to potential impacts on wetlands in the area of Mishnock Swamp in Coventry. Other environmental impacts would be experienced where the aqueduct crosses the North and South Branches of the Pawtuxet River in Coventry. Increased turbidity as the result of construction operations at these locations would have adverse impacts on water quality in addition to aquatic resources and stream habitat, however, the impacts are expected to be temporary, lasting only during construction.

The impacts of diverting water from the existing Flat River Reservoir to increase the available water supply yield of the proposed Big River Reservoir are many. The most significant economic impact of the diversion would be in having to construct such facilities at all to provide against the possible, but unpredictable, development of a drought which cannot be forecasted. As flows would have to be pumped, much unnecessary and costly pumping and transmission facilities would need to be constructed to account for the drought possibility. Diversion of flows from the existing Flat River Reservoir would create adverse environmental impacts during the construction of the flood-skimming facilities, pumping station and transmission main. These impacts would be associated with increased turbidity, unless precautionary measures were implemented, and also on aquatic resources and habitats. Much more significant impacts of the diversion would be associated with reduced flows entering Flat River Reservoir and in the South Branch watershed, reduced water for industrial supply purposes, fluctuating pond levels with resultant effects on recreation, and the adverse effects of reduced stream flow on the pond and river ecology. Transmission main construction would not in itself create long-term impacts, however, clearing for installation of the pipeline and construction of the pumping station would be required as part of the permanent easement and land-taking and would cause some environmental disruption of woodlands and wildlife habitat in the area.

Groundwater development in Rehoboth, Massachusetts, would create short-term impacts during construction of the individual wells, pumping station, and transmission main. The more significant impacts would be associated with the acquisition of lands required, however, no displacement of people would be expected to occur as wells would be constructed in primarily undeveloped areas. Development of supply sources in Rehoboth for use by the Bristol County communities of Barrington, Bristol and Warren in Rhode Island would create the additional impact of requiring interstate legislation and agreements between Rhode Island and Massachusetts and also legislation and agreements between local communities. Impacts from construction of transmission facilities would have adverse effects on terrestrial resources in the construction area, however, land requirements could be minimized by installing the pipeline adjacent to the existing 18-inch supply main which runs from the existing Shad Factory Reservoir in Rehoboth, Massachusetts, to the water treatment facilities of the Bristol County Water Company in Warren.

b. Alternative 2: Significant impacts of this alternative are similar to Alternative 1. Construction of the aqueduct from the proposed Big River Reservoir would create essentially the same economic, social, and environmental impacts in the construction area as in Alternative 1 since the method of installing the pipeline would be the same.

Diversion of all flows in excess of minimum downstream flow requirements from the Moosup River watershed under this alternative would create significant impacts, both during the construction period and over the long term.

Creation of a permanent water supply diversion reservoir on the Moosup River would inundate an area of about 600 acres in what is essentially forest-land. The existing State-owned Carbuncle Pond would be inundated by construction of the reservoir resulting in the loss of a stocked fishery and recreational resource. Garbuncle Pond is managed by the Rhode Island Division of Fish and Wildlife and offers trout fishing, boating and swimming. The reservoir would impact on existing wetlands and would also cause the elimination of over five miles of streams of good quality cold water fishery. Construction of the reservoir for diversion purposes to increase the available water supply yield of the proposed Big River Reservoir would also result in reduced stream flows below the impoundment creating adverse effects on aquatic resources and wildlife habitats.

Besides the economic impact of constructing costly facilities to provide against the possible but unpredictable development of a drought, which cannot be forecasted, diversions from the Moosup River would create the added impact of transferring water from an interstate river basin. The Moosup River watershed is located in the Thames River Basin and diversion would require interstate legislation and agreements between Rhode Island and Connecticut. Construction of pumping facilities would cause adverse impacts on water quality resulting from increased turbidity unless suitable procedures were implemented. Likewise, construction of transmission main would have detrimental environmental impacts on Bucks Horn Brook during construction of the pipeline across this waterway, on wetlands in the vicinity of the Trestle Trail, and on the Trestle Trail itself, which provides hiking opportunity from Coventry Center near the existing Flat River Reservoir to the Oneco area in Connecticut. The Trestle Trail follows an abandoned railroad right-of-way and embankment and now affords the hiking enthusiast a view of farm land, the river, and lowland marshes as it traverses through the area. Social disruption of the villages of Greene and Summit would also result from construction of the diversion transmission facilities by cut and cover methods. Land taking for development of the Moosup River Reservoir and pumping station and easements for construction of transmission facilities would also create both adverse economic and social impacts.

Future needs of the Bristol County Water Company would be served from the Providence water supply system under this alternative. Construction of transmission facilities would create significant impacts during the construction period by installation of the pipeline by cut and cover methods. Transmission facilities would be constructed in various public ways and permanent easements and would necessitate subaqueous crossings of the Pawtuxet River, Providence River and the Warren River with the resultant adverse impacts on water quality and aquatic life. The crossing of the Providence River between Conimicut Point in Warwick and Nayatt Point in Barrington, a distance of about 6000 feet, would also create the adverse impacts of interfering with commercial shipping into the City of Providence which utilizes the existing Federal navigation channel in the area. Construction operations would necessarily have to be coordinated with port operations to minimize these impacts and would probably result in higher construction costs as a consequence. Pleasure craft activities in the construction area would also be affected, however, both of these impacts would occur only during actual construction of the pipeline and would be expected to be temporary.

Crossings of the Pawtuxet and Warren Rivers would not have the major impacts associated with them as the Providence River pipeline crossing but would also create adverse environmental impacts as the result of construction activities. The pipeline crossing the Pawtuxet River would be constructed by diverting the river to afford installation of the pipe which would then be encased in concrete to prevent the possibility of pipeline damage resulting from bottom scouring or other potential problems. Increased turbidity resulting from these operations would affect water quality as well as causing adverse impacts on aquatic resources and habitats. The Warren River pipeline crossing would require installation of about 850 feet of pipe under the river, having a minimum cover of about 5 feet, and placement of backfill over the pipeline so as to reduce pipeline damage from scouring and by boats. Similar environmental impacts would result from the construction as described for the Pawtuxet River crossing, however, marine life would also be impacted by construction operations associated with the Warren River pipeline crossing.

Major highway crossings under Budlong Road, Reservoir Avenue (Route 2) and Pontiac Avenue in Cranston, and Boston Post Road (U.S. Route 1), Warwick Avenue (Route 117 Alt.), West Shore Road (Route 117) and Shore Road in Warwick would be constructed by jacking sleeves under the highway through which the pipeline would be installed. No significant impacts would result from these construction operations on traffic flow in the general area. Likewise, construction of the transmission facilities under trackwork of Conrail-Amtrak in Cranston and Warwick and the Penn-Central Railroad in Warren would be accomplished by the use of jacking sleeves for installation of the pipe and thus would not create any significant impacts on railroad operations. Real estate costs associated with permanent and temporary construction easements and crossings of the various railroad rights-of-way would create economic impacts in Cranston, Warwick, Barrington and Warren as the result of transmission main construction. Local streets in these communities would receive the most significant detrimental impacts from construction of the transmission main due to traffic detours, inconvenience with access to homes and businesses in addition to the other social, economic and environmental effects of the construction in general.

c. Alternative 3: Impacts associated with this alternative would be similar to Alternative 2 since construction of the aqueduct from the proposed Big River Reservoir and transmission facilities to serve the Bristol County Water Company would be identical. Significant differences would be created under this alternative as the result of construction of diversion facilities from the Wood River watershed.

Diversion of flows from the Wood River located in the Pawcatuck River Basin would create significant impacts, both during construction and over the long term. The most major effect of the diversion facilities would be in the reduction of natural streamflows downstream of the diversion. Impacts on water quality and stream habitat in addition to the adverse effects on trout fisheries would be created by transferring flows out-of-basin in order to supplement the water supply yield of the proposed Big River Reservoir. Diversion, utilizing flood-skimming facilities was considered more acceptable than construction of a diversion reservoir on the Wood River since the projected water demands of the study area would be satisfied by such measures in conjunction with the Big River Reservoir facilities. Construction of a reservoir would create more significant adverse impacts in the area even though the reservoir site is State-owned land. The site is incorporated within the approximately 8000 acres included in the Arcadia Management Area, Beach Pond State Park, Arcadia State Park, and Dawley Memorial State Park which are used for recreation and conservation purposes. This multiple-purpose area, managed by the Department of Environmental Management, is one of the most extensively developed areas in the State. Land for the site of the proposed Wood River Reservoir is used for a variety of recreation and management uses including campsites, horseback-riding trails and motor bike trails. The Wood River and Flat River provide some of the best trout fishing in Rhode Island which would be adversely affected by construction of the proposed reservoir.

Impacts associated with diversion facilities would create detrimental effects on water quality during construction of flood-skimming facilities and the pumping station. Increased turbidity would result from construction operations, however, they would be expected to be temporary, lasting only during the construction period. Adverse environmental effects would also be experienced during construction of transmission facilities outside of public rights-of-way. Loss of wildlife habitat would result from clearing required lands for permanent easements between Ten Rod Road (Route 165) and Raccoon Brook into which water from the Wood River would be discharged for storage and subsequent use in the proposed Big River Reservoir. Loss of vegetation in these areas would also be caused during construction.

d. Alternative 4: Construction associated with this alternative is similar to Alternative 1. The major difference is that remaining water supply needs of the study area would be met by construction of the proposed Big River Reservoir alone without any supplemental facilities required in the future. Impacts of the finished water aqueduct, to deliver water from the Big River Reservoir to the Providence water system, would be identical to Alternative 1.

Effects of reservoir development at the Big River are presented in subsequent sections of this appendix relating to detailed water resources plans for the study area.

Evaluation and Screening of Intermediate Alternatives

Evaluation studies were conducted to identify, measure and compare the beneficial and adverse impacts of each alternative developed during the intermediate planning stage, and the impacts of the "without condition", towards determination of the plans that would be carried through to the final planning stage. These initial evaluation activities involved determination of each alternative's response to planning objective fulfillment, public acceptance towards implementation, and formulation criteria. Based on this type of evaluation, the number of alternatives considered most responsive was reduced to a single plan - Alternative 4, from which a final iteration of the planning process would be undertaken to satisfy the requirements of the Principles and Standards. Screening of water supply management alternatives for the study area is presented in the following paragraphs.

All of the alternatives evaluated achieved the planning objectives for water supply management although not equally. The high construction costs of Alternatives 2 and 3 with the associated requirements of out-of-basin transfers of water to satisfy projected study area demands were considered the least feasible of the intermediate alternatives and were therefore dropped from further consideration towards development of detailed plans. Additional land requirements under Alternatives 2 and 3 for not only construction of diversion facilities but also to provide some control of the watershed, reservoir shores and mitigation requirements were not considered acceptable in view of the State-acquired lands for development of the Big River supply facilities which are also needed to satisfy study area water demands.

Water supply development under Alternative 1 would also require future diversions to meet study area water needs. In this case, diversion of flows from the existing Flat River Reservoir, downstream of the proposed Big River Reservoir, would be required to satisfy the long-term water demands of the study area. Significant impacts affecting the acceptability of this alternative are concerned with water quality degradation in the Big River Reservoir as the result of diversions from the Flat River watershed. The present use of the Flat River Reservoir for recreational activities including boating, swimming, camping and picnicking in addition to the high extent of development within the watershed which reduces the overall quality of waters being diverted, precludes the choice of this alternative for water supply management in the study area. Adverse impacts associated with the diversion on Flat River Reservoir levels, recreational activities and industrial water supply requirements also contributed to the non-acceptability of this alternative and it was therefore excluded from detailed plan investigations.

The only alternative emerging from the evaluation of intermediate plans that provided the most efficient solution for water supply development in the study area was Alternative 4. Under this plan, water supply needs of study area communities would be met by construction of the Big River Reservoir on lands acquired by the State of Rhode Island solely for that purpose. The reservoir would be sized to provide sufficient supplies for satisfying future municipal and industrial water requirements without the need to develop any additional sources during the study time frame. Delivering water to the Providence supply system as considered in this alternative is also in keeping with the planning of existing major aqueduct facilities of that system. Design of the existing supplemental aqueduct of the Providence water system provides for connection from the proposed Big River Reservoir at existing Shaft No. 4 in West Warwick. The existing supplemental aqueduct was purposely designed and constructed to run southeasterly from the Scituate Reservoir purification works to the Warwick area before tying into the main aqueduct of the system in the vicinity of Budlong Road in Cranston. Capacity provided by the supplemental aqueduct would be severely impacted should the Big River supplies not be constructed. Likewise, service to the water need areas of the study region would be adversely impacted should development of the Big River Reservoir not be considered. Connections from the existing supplemental aqueduct and the proposed aqueduct facilities from the Big River Reservoir would provide service to these areas in fulfillment of the study's planning objectives. This Alternative 4 was therefore found to provide the most feasible water supply management plan for the study area with the least adverse economic, environmental and social impacts and was carried forward in the development of detailed water resources plans. Elements of other alternatives eliminated in the screening process were considered for incorporation in the final iteration to provide an array of water supply plans from which a preferred alternative would be selected. Results of the screening process for selection of alternatives for detailed analysis are shown in Table 8.

Alternatives Considered for Detailed Analysis

As a result of the evaluation and screening processes applied to the intermediate alternatives, Alternative 4 was found to provide the most feasible water supply management plan for the study area. Accordingly this alternative formed the basis for a further iteration of the planning process that was undertaken in the final planning stage. Three alternative plans were formulated that included all the elements of Alternative 4 namely: demand modification, groundwater development, and surface water development at the proposed Big River Reservoir. In addition, consideration was given to meeting the water requirements of the Bristol County Water Company by connection to the Providence water supply system as in Alternatives 2 and 3. Since the Big River Reservoir was the principal component of additional water supply in each plan, further consideration was given in the final reiteration to the formulation of plans oriented toward the enhancement of National Economic Development and Environmental Quality that would provide decision-makers with a choice of management alternatives for the study area in compliance with national objectives. In this regard, consideration was given to the design of aqueduct facilities for the proposed Big River Reservoir that would satisfy not only requirements identifed in this study but also water needs beyond the planning time frame 1980 to 2030. Analysis of these facilities included investigations to convey water from the Big River Reservoir by gravity thereby eliminating the requirement for costly pumping facilities. Both cut and cover pipeline and tunnel alternatives were considered in the investigations.

Consequently, alternatives were developed that incorporated features included in the intermediate alternatives and that provided the basis for designation of plans that best addressed the national objectives of National Economic Development (NED) and Environmental Quality (EQ) in compliance with the Principles and Standards. The results of the final iteration of water supply management plans for the study area are described in subsequent sections of this appendix under the comparison of detailed water resources plans.

TABLE 8

COMPARISON OF INTERMEDIATE ALTERNATIVES

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
PLANNING OBJECTIVES				
Preservation of Existing Water Supplies	4	4	4	4
Water Conservation	4	4	4	4
Water Supply Development	4	4	4	5
Environmental Conservation and Protection	3	2	2	4
EVALUATION CRITERIA				
Acceptability	3	1	2	4
Completeness	5	5	5	5
Effectiveness	4	5	5	5
Efficiency	4	2	2	5
Certainty	5	4	4	5
Geographic Scope	5	5	5	5
Reversibility	2	1	1	2
Stability	4	4	4	4
Implementability	3	1	2	4

LEGEND

1. Low
2. Low to Medium
3. Medium
4. Medium to High
5. High

PLAN FORMULATION - FLOOD DAMAGE REDUCTION

SECTION 1 - POTENTIAL MANAGEMENT MEASURES

The formulation and analysis of alternative flood protection plans for the Pawtuxet River Basin are presented in detail in "Attachment 1" of this report. Alternatives were investigated to a degree sufficient to determine their economic and engineering feasibility, the environmental, social and other related impacts resulting from their implementation, and their overall acceptance by all segments of the affected public.

The following paragraphs provide a summary of the formulation process in the development of single-purpose flood protection alternatives for the Pawtuxet River Basin. The description of resource management measures and preliminary and detailed alternatives that were investigated to solve the study area's flooding problems are presented including the iterative process used to screen and evaluate them.

In formulating alternative plans an array of potential measures was considered and compared against the baseline condition using the evaluation criteria defined earlier. Measures were comparatively evaluated acting either independently or in combination with one another. These measures are listed in Table 9.

Potential measures for flood damage reduction can be divided into two broad categories, regulatory measures and corrective measures. The regulatory measures by themselves do not reduce, eliminate or prevent the threat of flooding. They regulate or discourage the use and development of floodplains lessening the potential for flood damage and possible loss of life. Corrective measures are modifications of the natural flood regime, designed to change the extent and timing of floodflow to lower elevations and to partially or wholly protect individual structures or entire areas from flooding.

In addition to regulatory and corrective measures, a No Action program was considered. Such a program would entail no Federal participation, and assumes that all communities would control growth within their floodplains to at least meet the minimum requirements of the National Flood Insurance Program (NFIP). The NFIP provides a subsidy to private insurers so that flood-prone properties may be eligible for flood insurance. Communities not participating in the NFIP become ineligible for Federal expenditures within flood-prone areas, and property owners in those areas would be ineligible for financing from Federally-insured lending institutions.

Regulatory Measures

National Flood Insurance Program. This program is specifically designed to provide limited amounts of flood insurance previously unavailable to property owners from private insurers. In return for the Federal subsidy making the insurance possible, local governments must adopt and enforce specific land use measures to restrict future development in flood-prone areas.

TABLE 9

POTENTIAL MEASURES - FLOOD DAMAGE REDUCTION

No Action Program

Regulatory Measures

1. National Flood Insurance Program
2. Floodplain Regulations
3. Land Use Programs
4. Others

Corrective Measures

1. Reservoirs
2. Land Treatment
3. Walls and Dikes
4. Reservoir Management Programs
5. Hurricane Barriers
6. Stream Improvements
7. Floodproofing or Relocation

Floodplain Regulations. These are considered to be the most effective nonstructural means of alleviating or reducing flood damages. They can help avoid the repetition of past building errors by preventing construction in already developed floodplains. They may be more stringent than the measures required by the NFIP, and require the enactment of ordinances to implement and enforce land use planning programs. Floodplain regulations are classified into three major categories: encroachment lines, zoning, and subdivision regulations.

Encroachment lines are the lateral limits along each side of the stream within which growth must be restricted to preserve the flood carrying capacity of the stream. The floodway area, as denoted on floodplain maps, is that portion of the floodplain necessary to pass a large flood. The floodway fringe is the remainder of the floodplain, upon which limited encroachment or filling may be allowed.

Zoning is a legal measure that governmental agencies can use to effectively reduce the flood damage potential of floodplain areas. Zoning ordinances can control the amount and type of development in the floodplain by designating classes of use and lot sizes.

Subdivision regulations are used to prevent future flood problems in undeveloped areas, controlling development by specifying requirements for street widths, minimum elevations, drainage and lot size and other conditions to prevent encroachment in the floodway.

Land Use Programs. Conservation, scenic or flood control restrictions may be used to restrict the amount and type of development in the floodplain. Land use restrictions can be used to prevent development that would be incompatible with public objectives, while retaining private ownership of the land.

Other Regulatory Measures. Other measures could be effective in reducing flood losses and possible loss of life. Some are:

- Building codes. Minimum standards for construction can minimize structural and other related damages to buildings subject to possible flooding.

- Urban Redevelopment. Urban redevelopment presents an opportunity for communities to remove development from the floodplain and assure that new development can withstand flooding.

- Tax adjustments. Adjusting tax rates can help preserve land dedicated to agriculture, recreation, and conservation.

- Warning signs. Warning signs to inform prospective buyers of potential flood hazards may discourage development. A more effective means is to require sellers of property to have it certified as reasonably flood-free.

- Health and Fire Regulations. Contingency plans for temporary evacuation, water supplies, sanitation facilities, and provision for emergency systems for fire fighting should be drawn up by flood-prone communities.

- Flood Forecasting. Reliable, accurate and timely forecasts of potential flood-producing storms can be a valuable asset in reducing property damage and loss of life.

Corrective Measures

Reservoirs. These can provide high levels of flood protection to downstream communities by controlling flood waters from a large area, and can also be used for other purposes, such as recreation, water supply and power generation.

Land Treatment Measures. Land treatment measures can be effective in reducing erosion, runoff and sediment movement into streams and floodplains, especially in lands undergoing changes from agricultural to urban uses.

Walls and Dikes. These confine flood flows to the channel or flooway area, and provide protection to localized, high-risk areas.

Reservoir Management Programs. Coordinating storage at existing reservoirs so that they would be drawn-down to accommodate storm runoff could reduce flood peaks in downstream reaches.

Hurricane Barriers. These walls, dikes and/or jetties, together with pumping facilities, prevent high tides from intruding upstream and raising flood heights along the lower reaches of major rivers.

Stream Improvements. The flood carrying capacity of floodways can be increased by channel improvements such as: eliminating abrupt turns, widening and deepening channels, improving areas at bridges and culverts, and removing shoals, sandbars, debris and erosion problems. Diversion of flood flows to bypass heavily congested flood-prone areas can provide high protection yet minimize social and environmental impacts.

Floodproofing or Relocation. These measures protect individual buildings and their contents. They include:

. Permanent measures such as waterproofing, installation of drain systems and pumps, raising the structure, protecting immovable equipment, bricking windows, relocating entrances and drawing up plans for emergency protection procedures.

. Contingency measures, such as manually closed sewer valves and removable bulkheads for windows, doors and vents.

. Emergency measures such as sandbagging, pumping, and removal of contents to higher elevations.

. Permanent evacuation of developed areas by land acquisition and removal of structures, and relocation of the population to other areas. Flood-prone areas are thus returned to a natural habitat or used for agriculture, parks or playgrounds. Temporary evacuation could be accomplished when a flood is imminent, in conjunction with a reliable flood warning system.

SECTION 2 - ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

The regulatory and corrective measures discussed above, as well as the No Action program, were evaluated using engineering judgement and brief study for the entire Pawtuxet River Basin. Each measure was judged on its own merits. Those not considered adequate, feasible, practical or realistic engineering solutions, or those measures socially or environmentally unacceptable or economically unjustified, were eliminated from further consideration.

The screening process gave consideration to both nonstructural (all regulatory, floodproofing, relocation) and structural (dikes, floodwalls, reservoirs, diversion, etc.) measures. Future action measures such as reservoir management, the construction of the Big River Reservoir, and land treatment measures, were also examined.

Initial Screening. The following management measures resulted from the application of evaluation criteria during the initial screening process.

Reservoirs were investigated at numerous sites throughout the basin, and twelve sites were considered for investigation. Of these, seven were within the Pocasset River watershed and one within the Meshanticut Brook basin. Four were on the North and South Branches of the Pawtuxet River. Only one potential project, the Big River Reservoir, could provide substantial flood control benefits, and therefore, was retained for further evaluation.

Land treatment measures in the area near the Big River were retained for future evaluation in conjunction with potential construction of the Big River Reservoir. Ongoing gravel mining operations and soil erosion due to the possible construction of the reservoir make land treatment measures valid possibilities in this area. Throughout the rest of the basin, erosion and sedimentation problems were not deemed significant enough to warrant retaining land treatment measures as possible solutions in those areas.

Modification of Scituate Reservoir to incorporate flood control storage was not found to be economically justified, as the cost of either raising the dam or providing a sub-impoundment within the reservoir would exceed the flood damage reduction benefits received by downstream communities.

Walls and dikes can be effective in areas where numerous structures are subject to high flood losses. Several areas in the basin met these high risk conditions, and wall and dike measures were retained for further evaluation in those areas.

Reservoir management programs involve lowering the levels of existing reservoirs to allow some flood storage, thus reducing peak flood discharges. Scituate and Flat River reservoirs were carried forward for further consideration; all other impoundments in the basin would be impractical to manage in this way due to their small storage capacities.

Hurricane barriers to alleviate tidal flooding were considered for the mouth of the Pawtuxet River and at the entrance to Pawtuxet Cove. Both sites were rejected as being too costly and having adverse social and environmental impacts.

Stream improvements were considered for several areas. Removal of dams to reduce backwater type flooding was found to be uneconomical or impractical due to the small benefits accrued or to adverse environmental impacts.

Intrabasin diversion schemes were evaluated but none were justified and, therefore, dropped from further consideration. An interbasin diversion seemed viable for the West Warwick/Cranston area of the mainstem Pawtuxet River, as it could provide substantial flood damage reduction to heavily populated areas downstream and would create a minimum of environmental and social disruption. This measure was, therefore, carried forward for further evaluation.

Channel modifications to improve stream flow hydraulics were investigated for both the mainstem and tributaries. For mainstem reaches, the channel modification was found to be impractical in solving existing problems due to their nature and severity. On tributary reaches, the minimal problems now extant would not be dealt with effectively by channel modification. This measure was thus removed from further consideration.

Floodproofing and relocation were found to warrant further evaluation for most of the basin's flood-prone areas in addition to the No Action program.

Advanced Screening. Measures that passed the initial screening were analyzed further to see if they could effectively provide protection in flood-prone areas. A nonstructural program was evaluated first due to local interest. A structural program was then analyzed, followed by consideration of future action measures.

The nonstructural program utilized floodproofing as a major element. Floodproofing involves techniques to make buildings and their contents less vulnerable to flood damages, but must be applied in a logical manner. Thus certain evaluation criteria were applied as follows:

Unreinforced concrete walls were considered capable of withstanding hydrostatic pressures due to a 3-feet differential head on either side of the wall without collapsing. Wood frame structures could not be floodproofed above the sill level. For aesthetic reasons, buildings could be raised only 3 feet. Depths of water for the design flood condition exceeding the 3 feet criteria would require that the building be relocated. Ring wall enclosures were considered only to tie in a building's wall to high ground. Even if only nuisance basement flooding occurred, a building would be raised or floodproofed if it could be inundated at the design flood. The drag line effect (difference in water levels due to flow through soil) and uplift pressures were not considered due to the complexity of the analysis required.

To determine the viability of floodproofing, costs were developed for structures for both 100-year and Standard Project Flood (SPF). The results indicated annual costs of $3,971,000 to protect against the 100-year flood and $20,321,000 to protect against the SPF. Annual benefits received were $480,000 at the 100-year level and $760,000 for the SPF. All figures are based on 1978 conditions and price levels. The resulting Benefit to Cost ratios of .10 and .04 under 100-year flood and SPF conditions, respectively, show the economic infeasibility of floodproofing alone. Floodproofing was dropped as an independent solution, but retained for consideration in combination with other measures.

Two types of structural flood control programs were considered to protect the heavily urbanized lower mainstem floodplain areas. A system of walls, dikes and channel modifications was considered to protect against the Standard Project Flood and the 100-year frequency event. In addition, two flood diversion projects were also considered. The two wall and dike protection plans, each entailing thirteen individual local protection projects in three communities, were not economically justified, but local protection projects at Warwick Avenue, Elmwood Avenue and the Bulova Complex warranted further study. The plans are shown on Plates 2-2 and 2-3 in "Attachment 1".

Additional investigation of the Bulova local protection project, however, showed that modifications to the original preliminary plan were necessary to provide the projected benefits. The resulting increase in cost caused the project to lose its economic justification, and so it was removed from further consideration.

Alternative diversions were considered at Natick Dam and at Pontiac Dam on the mainstem of the Pawtuxet River in West Warwick and Cranston. The Pontiac diversion project was developed with four different configurations requiring an open channel and/or tunnel. All were rejected, the open channel versions for adverse environmental and social effects, and the tunnel due to excessive construction costs. The Natick diversion project utilized a tunnel and could provide a higher level of protection at lower cost, was economically justified. This alternative was reserved for further consideration.

Future action programs to be implemented by local interests were found to be applicable in three areas: reservoir construction,reservoir management and land treatment measures.

Construction of the Big River Reservoir as a multi-purpose project would provide flood control benefits to the entire downstream area and would have minimal cost and environmental impact on these areas. Management of the Scituate and Big River Reservoirs for operation as a system would allow floodwater storage in both reservoirs without adversely affecting the primary purpose of each, provision of drinking water. Erosion control measures at the Big River site could be instituted by local interests if deemed necessary during construction of the reservoir.

Nonstructural floodproofing, although not economically feasible as an independent measure, was retained for consideration as a supplement to the three structural measures (Natick Diversion and Elmwood Avenue and Warwick Avenue local protection projects). Reservoir construction, reservoir management and land treatment measures were retained as future action programs. The elements contained in the No Action and regulatory programs were also retained for further evaluation and as supplements to specific corrective measures.

Assessment and Evaluation of Detailed Single-Purpose Flood Control Plans

From the plans analyzed in preliminary planning, ten detailed plans were formulated to attempt to address the flood problems of the basin in a wide variety of manners. Table 10 shows the major plan components, benefits and costs.

Plans A, B, C, and G included the Natick Diversion tunnel as a major element. Plans A & B considered a 30-feet inside diameter tunnel, while Plans C & G considered a tunnel of 21-feet inside diameter. Plan A consisted of the diversion alone while Plan B added the Warwick and Elmwood Avenue local protection projects. Plan C decreased the diameter of the tunnel to 21 feet and used the same local protection projects, but with the walls and dikes several feet higher to accommodate the additional undiverted flows. Plan G was the same as Plan C except that the Elmwood Avenue local protection project was not included.

All four of the plans containing the Natick Diversion developed high annual benefits due mainly to the inclusion of the diversion tunnel. However, Plans A & B did not produce a greater than unity benefit-to-cost ratio. Additionally, all plans containing the Natick Diversion were found publicly unacceptable due to adverse environmental impacts expected in Greenwich Bay. Thus these plans were all dropped from further consideration.

Plan D consisted of the Warwick and Elmwood Avenue local protection projects alone. By deleting the Natick Diversion tunnel, it avoided the associated adverse environmental effects and thus was favored by local interests. However, increased construction costs due to unfavorable foundation conditions resulting in higher cost sharing for such a project was unacceptable to the City of Warwick, and so the plan was dropped from further consideration.

Plan E involved the provision of flood control storage at the Big River Reservoir, a proposed water supply reservoir. This plan assumed that the Big River Reservoir would be built by non-Federal interests (the State or the City of Providence) and, therefore, would not have to be a multi-purpose project. It is similar to the two plans involving the Big River Reservoir as a Federal project, but did not include any local protection works.

TABLE 10

SUMMARY OF FLOOD CONTROL ALTERNATIVES

December 1978 Price Level, 6 7/8 % Interest Rate
(In Thousands of Dollars)

PLAN	MAJOR ELEMENT	TOTAL ANNUAL BENEFITS	TOTAL ANNUAL CHARGES	BENEFIT TO COST RATIO	ANNUAL RESIDUAL LOSSES
A	Natick Diversion - 30 ft. tunnel	$4,042	$4,650	.87	$1,103
B	Natick Diversion - 30 ft. tunnel and Warwick & Elmwood Ave. Local Protection Projects	5,000	5,552	.90	360
C	Natick Diversion - 21 ft. tunnel and Warwick & Elmwood Ave. Local Protection Projects	4,363	4,260	1.03	522
D	Warwick & Elmwood Ave. Local Protection Projects	1,450	1,160	1.25	2,150
E 1)	Flood Control Storage at Big River Reservoir	725	500	1.45	2,395
F	No Action Program	0	0	0	3,120
G	Natick Diversion - 21 ft. tunnel and Warwick Ave. Local Protection Project	4,303	4,050	1.06	532
H 2)	Flood Control Storage at Big River Reservoir and Warwick & Elmwood Ave. Local Protection Projects	2,001	1,810	1.11	1,499
I 2)	Flood Control Storage at Big River Reservoir, Warwick Ave. Local Protection Project & Norwood Land Bank	2,058	1,315	1.56	1,442
J 3)	Nonstructural	3,120	26,143	.12	0

Notes:
1) Built by Non-Federal Interests
2) Big River Reservoir built by Corps of Engineers for plans H & I
3) Floodproofing, Relocation and Regulatory measures to minimize flood losses

Plan F, the No Action program did not effectively meet the planning objectives, as it did not provide any flood protection and had extremely high residual damages. It was, therefore, removed from consideration.

Plans H & I involved provision of flood control storage at the Big River Reservoir and local protection works. Both plans assumed that Big River Reservoir would be built as a multi-purpose project by the Corps of Engineers. Plan H included local protection projects at Warwick and Elmwood Avenues, and Plan I included the Warwick Avenue local protection project and the Norwood Land Bank. Both plans were economically justified, but Plan I provided larger net benefits and was more economically feasible, so it was preferred.

Plan J involved floodproofing, relocation and regulatory measures as necessary to provide a nonstructural solution. However, this plan was extremely expensive and economically unjustified.

Preferred Plan

The only plans that fulfilled the planning objectives and were economically, environmentally, and socially acceptable were Plans H & I. As noted above Plan I was preferred over Plan H, and thus Plan I was the plan recommended for flood protection in the Pawtuxet River Basin. Since local support for the Warwick Avenue Local Protection Project has not been forthcoming, this part of the plan was eliminated so that the plan now consists of flood control storage at the Big River Reservoir and the Norwood Land Bank. The land bank proposal would involve the relocation of residents of the Norwood area in Warwick. The land would then be developed as a park, and future development prohibited. Local support has been strong for this proposal, especially among the affected residents.

In light of the urgent need for improvements in the area, the Norwood Land Bank proposal is currently being studied for implementation as provided in the Flood Control Act of 1948, Section 205, which authorizes construction of small flood control projects not specifically authorized by Congress. Implementation of the Norwood Land Bank under the Section 205 authority would be greatly expedited as compared to authorization in conjunction with the rest of the comprehensive water resources plan developed in this study. The Norwood Land Bank proposal is thus not included in the description, impact assessment and evaluation of the detailed plans developed in this appendix. It is described in detail, including benefits, costs and associated impacts in "Attachment 1" of this report.

PLAN FORMULATION - RECREATION

SECTION 1 - MANAGEMENT MEASURES

Potential recreational sites and activities to meet the projected needs of the area were investigated and are presented in detail in Appendix H, "Recreation and Natural Resources." The region analyzed for recreational needs included an area which is within a one-hour's drive, or about 40 miles, from the proposed Big River Reservoir site.

Existing use patterns and expected trends in recreation development, along with population density and developmental pressures, were analyzed to determine the appropriateness of recreational activities development at the Big River site. Other potential recreation sites were also investigated to determine their overall effectiveness in meeting projected needs.

Development trends in the State showed that the Big River area would be under low development pressure, thus would be likely to remain a desirable recreation area during the study time frame. Moreover, its location close to the Providence metropolitan area would increase its desirability as a recreation area. Because of the relatively large supply capacity available at the Big River site for a wide variety of recreational activities (as compared to the rest of the local area) enhancement of the site's natural attributes was deemed a sensible approach for development in the local area.

Potential activities for development at the Big River site include swimming, camping and picnicking, wildlife and freshwater fisheries, boating and extensive outdoor recreation. Swimming needs could be met by developing new areas, either by creating an impoundment or by utilizing existing local ponds, or by expanding and improving existing swimming areas. Camping and picnicking facilities would need to be developed to meet local needs. Existing areas should be protected from encroachment and improved if possible.

Wildlife and freshwater fisheries management programs would continue as at present in the area, including stocking of certain ponds and streams. Acquisition of wetlands and upland wildlife habitat for management to increase productivity would increase fishing and hunting opportunities in the area. Providing better access to these areas would also help meet projected demands.

Boating in the area is confined mainly to canoes and some small powerboats on the major streams and ponds in the area, and is often in conjunction with fishing. Creating new boating areas with an impoundment, or providing better access to the existing areas with additional boat ramps would help to meet the projected needs for this type of recreation.

Extensive outdoor recreation refers to those activities which generally require large areas of land per person. The Big River site is suitable for many of these activities, some of which it is being utilized for at present. These activities include nature study, wilderness camping, informal picnicking and trail uses such as hiking, trail biking and cross-country skiing. Proper management of the Big River site could provide adequate trails and areas to accommodate these activities.

SECTION 2 - DEVELOPMENT OF RECREATION OPTIONS

The recreation activities described above were combined into several levels of recreation development for the Big River site. As shown in Table 11, the projected demands of the Big River area are only a small percentage of the overall statewide demand. However, the impact of the Big River site on local supply and demand for recreation is significant. Therefore, the plans developed for recreational facilities attempted to address primarily local needs.

TABLE 11

SELECTED RECREATION NEEDS AND SUPPLY CAPACITY

(Persons per Day)

ACTIVITY	SUPPLY CAPACITY	PRESENT DEMAND	1995 DEMAND	2020 DEMAND
BOATING				
State	46,471	19,426	34,491	77,614
Local	770	657	1,451	3,341
Big River	342	45	90	207
CAMPING				
State	17,104	14,854	20,936	28,607
Local	2,864	128	180	247
Big River	0	0	0	0
HUNTING				
State	6,000	2,326	4,160	7,687
Local	3,290	115	206	380
Big River	1,600	100	165	304
SWIMMING				
State	53,792	50,501	74,466	107,777
Local	8,089	2,633	3,883	5,619
Big River	9,450	200	277	401

"Supply Capacity" refers to the maximum number of persons which ideally can utilize existing recreational facilities each day.

As noted above, the Big River site is presently being utilized on a largely informal basis for many of the recreational activities that could be included in a potential recreation plan. Were an impoundment to be constructed, the character of the site would change vastly and some activities presently available would be reduced in scope or eliminated. Others would be enhanced or created. Thus existing recreational activities at the Big River site would not be expected to continue should a reservoir be built.

Demand for certain recreational activities is expected to increase should a reservoir be built including those shown in Table 12. The increase would be due to the provision of improved facilities over those presently available, which would be expected to generate additional demand.

TABLE 12

2020 DEMAND FOR SELECTED RECREATION ACTIVITIES
(Persons per day)

ACTIVITY	WITHOUT RESERVOIR CONSTRUCTION	WITH RESERVOIR CONSTRUCTION
Boating	207	300
Camping	0	100
Hunting	304	350
Swimming	401	800

Three use level options were developed for consideration in conjunction with reservoir development at the Big River site. They range from Option I, no admittance, to Option III,development of a large scale facility.

Option I. This option would prohibit all access to the site for recreation. All existing activities on the approximately 8,300 acres making up the Big River site would cease. This option is somewhat similar to the Providence Water Supply Board's policy regarding the existing Scituate Reservoir. Future local recreational demands, as well as existing demands, would have to be absorbed by other existing or proposed facilities.

Option II. This option would satisfy most future recreation needs by providing opportunities for boating, fishing, hiking, horseback riding, hunting, picnicking and swimming at four use areas. These areas would be at Zeke's Bridge, Big River Reservoir, Carr Pond and hunting access south of the Big River Reservoir. The Zeke's Bridge area would be developed for boating, fishing, picnicking and swimming, which would center on the existing Flat River Reservoir. The Big River Reservoir recreation area would serve as an activity center for picnicking, shoreline fishing and access to a multi-purpose trail system. At Carr Pond, facilities would be limited to picnicking and shoreline fishing. Option II was designed to minimize water quality impacts from recreation activities, while providing a level of recreational opportunity roughly equivalent to that available at the site were the Big River Reservoir not constructed. Thus Option II would represent a restoration of the "without condition" in the local area in terms of recreational opportunities.

Option III. This option would provide a maximum recreation development plan that would meet projected demands through the year 2020. It includes all of the features considered for Option II and in addition facilities for boating at the Big River Reservoir; swimming, boating and trails at Carr Pond; swimming and picnicking at Phelps Pond and camping at Hungry Hill and Harkney Hill are also included.

Analysis of Recreation Options

Impacts of the three recreation options were then assessed in view of the identified recreation problems and needs to be addressed. As discussed earlier, the major impact of any plan of development would be felt primarily in the local area. The impact of the three options on local recreation opportunities in 2020 is shown in Table 13, which also shows whether each option meets on-site demands for recreational activities. It should be noted that the demands which Option II is targeted to meet are not the same as those for Option III.

Option I, by prohibiting access to the site, would create shortages in most recreational activities in the local area, thereby creating negative impacts for several activities. Boating and hunting opportunities are the most negatively affected. This option does not meet any of the on-site demands, thus negatively affecting potential users. This option does have positive impacts on some environmental quality factors. It assures that water quality in the reservoir will be as high as possible. Fish and wildlife habitat would avoid any negative impacts associated with recreation, as would wetlands.

Option II would provide a level of recreation development that would approximately equal that which would exist in the absence of reservoir development. Thus, Option II is essentially a mitigation plan for recreation in that it restores opportunities lost by the construction of a reservoir. By accommodating most projected on-site demands, this option does not lead to overcrowding of other local sites. It does not satisfy all projected demands, however, and shortages could still be expected in capacity for boating and swimming. Option II is not expected to significantly affect water quality in the reservoir, as intensive activities would be sited outside the watershed.

Option III provides recreation opportunities to benefit not only the local area but, in some cases, to help absorb statewide demands too. Thus it makes positive impacts on each recreational use planned and would not be expected to have any more significant water quality impacts than those expected for Option II. By developing a wider range of facilities at the use areas, Option III would more fully exploit the recreational resources available at the site than under Option II.

Conclusions

The three recreation options considered in this study to satisfy demands projected by the year 2020 provide a choice of management practices. Option I would essentially prohibit recreational development at the site of the proposed

TABLE 13

COMPARISON OF RECREATION OPTIONS

(2020 Demands)

Activity	OPTION I[1] Impact[3]	OPTION I[1] Meets Demand	OPTION II[1] Impact[3]	OPTION II[1] Meets Demand	OPTION III[2] Impact[3]	OPTION III[2] Meets Demand
Boating	--	No	+	No	+	Yes
Camping	0	No	0	Yes	+	Yes
Fishing	-	No	+	Yes	+	Yes
Hiking	0	No	+	Yes	+	Yes
Horseback riding	0	No	+	Yes	+	Yes
Hunting	--	No	+	Yes	+	Yes
Picnicking	0	No	+	Yes	+	Yes
Swimming	-	No	+	No	++	Yes

Legend:
- ++ Highly positive
- + Positive
- 0 Neutral or minimal
- - Negative
- -- Highly negative

Notes:
1. Demand without reservoir construction
2. Demand with reservoir construction
3. Impact on local area recreational opportunities

Big River Reservoir and would not offer any opportunity for meeting the projected needs. Option II considered a level of development which primarily offered a mitigation plan for the loss of recreational opportunities resulting from reservoir development. As such, this option satisfied most of the recreation demands for the local area and was not expected to impose any significant impacts on water quality.

Option III, providing a maximum plan for recreational development, was shown to satisfy projected demands with a wider range of opportunities. This option developed the full use of available recreational resources and was not expected to impact any more severely on water quality than Option II. In view of this, Option III was carried forward in the development of water resources management plans for the study area.

PLAN FORMULATION - WATER RESOURCES MANAGEMENT PLANS

SECTION 1 - DEVELOPMENT OF DETAILED PLANS

General

Based upon the preceding evaluation and screening studies, alternative plans for the study area were identified for investigation in the final planning stage. Increased analysis of the identified alternatives towards development of detailed water resources management plans that more completely address the planning objectives, and ultimately the selection of the most publicly acceptable plans, is contained in subsequent sections. Of the intermediate alternatives investigated for water supply, flood damage reduction, and recreation management in the study area the following were carried forward for detailed analysis.

- Water Supply

Alternative 4 - Demand modification in conjunction with groundwater development for Foster, Glocester and the Bristol County Water Company service area, and surface water development at the proposed Big River Reservoir.

- Flood Damage Reduction

Plan I - Inclusion of flood storage in the proposed multiple - purpose Big River Reservoir, plus continuation of the National Flood Insurance Program. As noted earlier, the Norwood Land Bank is not included in the flood protection plan as it is bieng considered for implementation under Section 205 authority. The Warwick Local Protection Project, likewise, is not included due to a lack of public support for this element of the overall plan of protection.

- Recreation

Option III - Development of facilities for boating, camping, fishing, hiking, horseback riding, hunting, picnicking, and swimming at six major use areas within the State-owned property at the proposed Big River Reservoir site.

Since only one alternative for water supply management in the study area emerged from the evaluation and screening of intermediate alternatives that would be combined with other water resources purposes in the development of detailed management plans, a final iteration of the planning process was undertaken. During this iteration, plans were formulated from the single-purpose intermediate alternatives that emphasized the national objectives of National Economic Development (NED) and Environmental Quality (EQ) in addition to more fully addressing the planning objectives. Detailed estimates of the costs and benefits of each plan were derived in conjunction with specific natural and cultural resources studies and social analysis investigations. Three water resources management plans for the study area were formulated and are described in the following paragraphs. To facilitate further analysis, evaluation and comparison the identified alternatives were re-designated for clarity.

Plan A

General. This plan was formulated around those elements of the intermediate alternatives that were oriented towards the enhancement of NED. Further refinement, by modifying or deleting measures to develop a plan that was fully implementable and represented the best plan formulated on the basis of economic criteria, was undertaken during the final re-iteration of the plan formulation process.

Measures identified in Plan I of the detailed single-purpose flood damage reduction alternatives developed for the Pawtuxet River Basin and Option III of alternative recreation plans were included in this Plan A. The flood protection measures were incorporated as the direct result of public response to this preferred plan of protection for the Basin and from the desirability of State officials for a compromise plan in view of the non-acceptance of other alternatives for flood damage reduction. All elements of Alternative 4 for water supply management in the study area were incorporated in the plan.

Water Supply. Under this plan, additional municipal and industrial water supply requirements to meet study area demands of approximately 127 mgd and 222 mgd projected for the average day and maximum day by the year 2030 respectively, would be obtained by implementation of a demand modification program (water conservation) throughout the study area, by development of groundwater resources in Burrillville and Glocester, and in Rehoboth, Massachusetts, and by construction of the Big River Reservoir facilities as shown on Plate B-6.

The demand modification program would have the effect of reducing water supply needs in the study area by approximately 15 mgd on the average day and 28 mgd on the maximum day by the year 2030. Elements of the program would consist of 1) water-conservation education including the distribution and voluntary installation of water-saving devices for use in residential homes, 2) institution of building code restrictions requiring the installation of water-conserving devices in all new or replacement construction, and 3) introduction of a leak detection and repair program to reduce water demands.

Groundwater development would include the construction of wells, pumping facilities and transmission mains to transport water from the various wellfields to connections in existing supply systems and areas of need. The Bristol County Water Company (BCWC) system, which serves Barrington, Bristol and Warren, would develop groundwater in three phases to meet immediate and projected future demands. Since no additional groundwater resources are available in Bristol County, construction of required supplies in Rehoboth, Massachusetts, would be undertaken. The initial development of 3.0 mgd would be needed to supplement existing supplies and to meet average and maximum day requirements projected by the year 1995. Additional supplies of 2.0 mgd by 1995 and 1.0 mgd by 2015 would be developed to meet average and maximum day demands projected by 2030. Construction of about 5.5 miles of 20-inch transmission main, running southerly from the well sites in Rehoboth, Massachusetts, to the existing system in Warren, would be included in the initial phase of development. The pipeline would be constructed adjacent to the existing 18-inch transmission main that runs from Shad Factory Reservoir in Rehoboth, Massachusetts to Kickamuit Reservoir in Warren, so as to minimize adverse environmental and social impacts and required easements.

Projected demands for Foster, presently without any municipal water supply system, would be met by developing 1.0 mgd from groundwater sources in neighboring Glocester in two separate phases, 0.5 mgd in 1990 and 0.5 mgd in 2010. Approximately 6.2 miles of 12-inch transmission main, running southwesterly from the wellfields would be constructed in 1990 as part of the initial development to deliver water to the service area in Foster.

The town of Glocester is presently supplied by private wells throughout the community. The combined future demands of Glocester, and a portion of Burrillville to the north, would be served by the Pascoag Fire District system under this plan with development of additional supplies constructed in Burrillville. Development of groundwater supplies would be in two phases, 1.0 mgd in 1990 and an additional 1.0 mgd in 2010. Approximately 2.8 miles of 16-inch transmission main, running southwesterly from the wellfields to the service area in Glocester, would be constructed in 1990 as part of the initial phase of development.

The principal component of additional development in this plan would be construction of surface water supplies on the Big River located in Coventry and West Greenwich, as shown on Plates G-2 through G-9 and described in Appendix G, "Design and Cost Estimates". The Big River Reservoir would be developed immediately upstream of the existing Flat River Reservoir (Johnson's Pond) in the South Branch watershed of the Pawtuxet River Basin. Construction of the project, required by 1995, would include water treatment and sludge treatment facilities and an aqueduct to deliver water needed to augment existing supplies of the Providence Water Supply Board (PWSB) and Kent County Water Authority (KCWA) systems. The dam would be a rolled earth-fill structure with rock slope protection on both faces, located where Harkney Hill Road crosses the Big River, having a maximum height of 70 feet and a length of about 2240 feet. The impoundment created by the dam at the maximum water supply pool of Elevation 300.00 NGVD would inundate 3240 acres of forestland and streams. All growth 2-inches in diameter or greater and over 6 feet high would be removed within the reservoir area below Elevation 303.0 NGVD. Flood control storage would increase the pool height to Elevation 303.0 NGVD and, providing for surcharge storage, wave action and freeboard, would set the top of dam at Elevation 312.0 NGVD. The reservoir would contain a total storage capacity of 95,400 acre-feet consisting of 12,300 acre-feet for conservation storage, 73,600 acre-feet for water storage, and 9,500 acre-feet for flood control storage. The outlet works located in the left abutment would consist of an intake channel, gatehouse, two conduits on rock under the dam, a junction structure, outlet structure and outlet channel. The gatehouse would be a twin-well structure equipped with multiple level outlets for water supply releases. Flood control regulation would be by means of a 5 feet x 5 feet reinforced concrete conduit, whereas water released through the dam for water supply purposes would be by means of a 90-inch reinforced concrete pipe approximately 3200 feet long, that would deliver raw water from the reservoir to water treatment facilities as shown on Plate G-4 in Appendix G. A chute-type spillway, with a 400-feet uncontrolled concrete weir, would be located in a rock cut in the left abutment with the spillway crest at Elevation 303.0 NGVD. The area of the water surface at spillway crest would be 3,400 acres. Discharge would be directly into the upstream end of Flat River Reservoir.

A section of the impoundment, between Division Street and Interstate Route I-95 extending easterly from Nooseneck Hill Road (Route 3) for about 8000 feet, would require construction of an impervious blanket to control seepage. Details of the seepage control measure are as shown on Plates G-8 and G-9 in Appendix G.

Water treatment facilities, having a capacity of 55 mgd, would be located on the northeast side of Hungry Hill adjacent to Nooseneck Hill Road (Route 3) in an area presently occupied as a trailer park and would provide conventional treatment of the impounded Big River waters. Preliminary analysis of expected raw water quality indicates that treatment processess would include possible aeration, chemical mixing, coagulation and flocculation, sedimentation, filtration, disinfection and chemical stabilization. Facilities for treatment of residues from water treatment processes would be constructed as an integral part of the total treatment complex. The facilities would include units for sludge thickening and conditioning, pumping, and structures for the housing of dewatering equipment. Alum recovery units would also be included as part of the sludge treatment facilities. Ultimate disposal of the sludge would be in an approved landfill area.

Investigations of aqueduct facilities, to deliver water from the proposed Big River Reservoir to the Providence water supply system, were undertaken to determine capacity requirements to not only satisfy demands identified for the study time frame but beyond, in view of the significance of such facilities in plans for water supply management. Both cut and cover and tunnel alternatives were investigated for different capacity requirements as described in Appendix G.

A design capacity of 100 mgd was selected to provide capacity for water supply needs beyond the planning time frame, in the investigation of alternative aqueduct schemes. The studies were aimed at minimizing adverse economic, environmental, and social impacts of construction of such facilities and also the feasibility of conveying water from the Big River site by gravity to the existing system. An 84-inch inside diameter, conrete-lined tunnel was selected as the result of preliminary analysis. The tunnel would be constructed from the proposed water treatment facilities to Shaft No. 4 on the existing supplemental aqueduct of the Providence water supply system in West War..., a distance of approximately 6.7 miles, as shown on Plates F-2 through F-... in Appendix F, "Geotechnical Investigations". An inlet structure incorporating provisions for metering all flows discharged through the tunnel and positive shut-off would be constructed between the proposed water treatment facilities and the upstream shaft of the proposed tunnel. A watertight structure would also be constructed to provide access to the tunnel near the Pawtuxet River crossing and an outlet structure, between the downstream shaft of the proposed tunnel and Shaft No. 4, would be constructed to provide connection to the existing supplemental aqueduct.

Operation of the proposed Big River Reservoir as part of a total system in conjunction with the existing Scituate Reservoir would provide a safe yield for water supply purposes of about 113 mgd, sufficient to meet average and maximum day demands of the study area projected by the year 2030.

Flood Damage Reduction. Flood control storage, equivalent to 6 inches of runoff from the 29.7 square mile watershed above the dam, would be provided above the maximum water supply pool. Flood stage reductions from provision of flood storage at the Big River Reservoir would vary depending upon the type of flood development, antecedent conditions and storm orientation. It is estimated that in a repeat of floods such as experienced in July 1938 and March 1968, the flood control element of the proposed reservoir would reduce flood stages in the South Branch and upper mainstem Pawtuxet River by about 1.5 to 2.0 feet. On the lower mainstem, in the vicinity of the Warwick Industrial Park, reductions would be in the order of 0.5 feet. Continued compliance with the requirements of the National Flood Insurance Program by all affected communities would be part of the overall plan for flood protection in the Basin and to reduce future flood losses of new development.

Recreation. Future recreational needs of the study area would be met by providing opportunities for boating, camping, fishing, horseback-riding, hunting, picnicking and swimming at six major use areas within the State-owned reservoir property, as proposed under Option III. The Zeke's Bridge area would be developed for boating, fishing, picnicking and swimming with all of the activities centered on the shores of Flat River Reservoir outside the watershed of the proposed reservoir. The Big River recreation area would serve as the center for picnicking, shoreline-fishing, limited boating and access to a multiple-purpose trail system extending along the southerly and easterly shores of the reservoir. Facilities at Carr Pond would include picnicking, shoreline-fishing, swimming, boating and trails, while additional swimming and picnicking opportunities would be provided at Phelps Pond. Both of these sites are located within the reservoir watershed. Camping would be provided at sites on Hungry Hill and Harkney Hill, while hunting areas would be accessible on the south side of the proposed reservoir.

Management Measures. In order to minimize the adverse EQ contributions of the proposed Big River Reservoir, measures were incorporated to mitigate these impacts. Such measures were considered appropriate for the overall development of a plan that emphasizes NED since coordination with Federal and State agencies indicated that provisions of this type would be necessary for recovery of losses resulting from implementation of the project. Natural resources mitigation measures, developed in coordination with the U.S. Department of the Interior, Fish and Wildlife Service, and divisions of the Rhode Island Department of Environmental Management, would consist of the following:

. Multiple-level outlets for low flow regulation, creation of a reasonably stable hypolimnion in the Big River Reservoir and provisions for positive control of the temperature of water released downstream would be included in the construction of outlet works.

. Development and management of a cold-water fishery including the stocking of various fish species such as rainbow trout, brown trout and smallmouth bass would be undertaken in the proposed Big River Reservoir to expand the fisheries resource. In addition largemouth bass, pickerel and forage species present in the watershed would be reestablished in the reservoir pool.

. Selective stripping of limited reservoir areas would be undertaken to enhance water quality and to assist in maintaining a cold-water fishery resource in the proposed reservoir.

. A comprehensive wildlife management plan would be undertaken in all the lands remaining within the State-owned property outside the proposed reservoir. A forest management plan to increase wildlife habitat productivity, by enhancing the availability of food and other habitat requirements, would be implemented. In addition, reclamation of existing surface mining areas by proper management of topography and vegetation patterns would provide greatly enhanced major habitat requirements for many species of wildlife.

Lands within the approximately 8300 acres of State-owned property, outside of the impoundment, would also be utilized to facilitate recreational demands of the local area as described in previous paragraphs.

All existing roads within the limits of the impoundment area would be abandoned under this plan with the exception of those necessary to maintain continued access as shown on Plate G-3 in Appendix G. Harkney Hill Road in the vicinity of the proposed dam and Hopkins Hill Road on the easterly side of the impoundment would be relocated while reconstruction and relocation of Nooseneck Hill Road (Route 3) would also be undertaken. The northbound roadway of Interstate Route I-95 has been designed to accomodate the relocation of Nooseneck Hill Road in anticipation of reservoir development. No other road relocations would be constructed under this plan. Existing water, gas, sanitary and storm sewers affected by road relocations would be reconstructed as necessary while power and telephone facilities impacted by development of the Big River Reservoir would be relocated within the State-owned property under contract with the respective utility company.

Fourteen small cemeteries having historical significance within the inundated areas of the reservoir would be relocated to a site(s) within the project area as determined by detailed investigations during advanced study and design phases of project implementation. Mitigation measures for various other cultural resources impacted by the proposed reservoir would also be undertaken. In addition to the historically significant cemeteries mentioned above, 12 possibly significant historic features (including the New London Turnpike, Sweet Sawmill Road, Old Kit Matteson Tavern and the sites of the Nooseneck Factories recommended for the National Register of Historic Places) are located within the impoundment area. If these properties are found to be of national significance, impacts of construction or inundation would be mitigated through removal or architectural recording as determined by detailed investigations. Sixteen recorded sites of potential archaeological significance are also located within the proposed reservoir area which, if shown to be significant through detailed studies, would be mitigated for by modification of construction activities and/or archaeological salvage.

Impact on downstream riparian owners resulting from development of the proposed Big River Reservoir have not been included in the mitigation measures as detailed studies to provide a thorough analysis of riparian damages would be necessary in advanced engineering and design investigations.

The estimated first cost of this Plan A is $47,963,000 (Present Worth Value) based on January 1979 price levels. Details of the cost of the plan are contained in Appendix J, "Economics".

Plan B

General. This plan includes the same elements for flood damage reduction and recreation as in Plan A, however, the plan component for water supply management was formulated on the basis that it address the planning objectives for the study area while emphasizing contributions to EQ. Thus as in Plan A, the EQ contributions of groundwater development that would satisfy study area needs was included in the formulation process for this Plan B. To further emphasize EQ contributions, various resource management activities at the site of the proposed Big River Reservoir were also incorporated in the formulation of the plan.

Water Supply. This plan is similar to Plan A with the exception that the Big River Reservoir area would include additional measures to enhance environmental quality as well as to reduce significant adverse social impacts in local communities. Facilities included in the plan are shown on Plate B-6.

A full-scale demand modification program to reduce study area water requirements would be implemented as in Plan A. This would have the effect of precluding the need for additional water supply development, beyond that being considered, to satisfy average and maximum day demands projected through the year 2030. Groundwater development, to meet present and future requirements within the BCWC service area and other locations within the study area more economically served by such development, would be the same as in Plan A to lessen the quantity of water required from development of surface water resources. Adverse environmental and social impacts would thus be minimized.

Under this plan, water supply development at the proposed Big River Reservoir would be the same as in Plan A. The reservoir and dam, water treatment and sludge treatment facilities, aqueduct and access roads, and mitigation measures would be the same as in Plan A, however, additional features would be incorporated in the reservoir development and site management to further contribute to EQ enhancement. Immediate and future water quality of the proposed reservoir would be improved by the removal of vegetative growth and other organic materials that would otherwise exert a demand on the oxygen resource of the impoundment and cause the release of nutrients and color-causing substances in the reservoir's ecosystem. In addition, the reservoir stabilization process and development of a cold-water fishery would be enhanced by removal of such materials. Grubbing and stripping of all vegetative growth within the impoundment area below Elevation 303.0 NGVD, in addition to the clearing operations considered in Plan A, would be undertaken in this Plan B to reduce the oxygen demand in the hypolimnion due to reactions resulting from decomposition.

Loss of wetland habitat resulting from development of the proposed reservoir would be partially offset by creation of subimpoundments in selected areas of the reservoir along the southerly shoreline as shown generally on Plate B-7. Four areas would be developed to establish and maintain wetland vegetation by means of control structures and limited planting of desirable species. The sites would be developed by constructing facilities to retain desired water levels during periods of reservoir drawdown. These facilities would consist of rolled earth-fill dikes incorporating reinforced concrete water control structures equipped with spillways and gates. Water would be retained behind the dikes at Elevation 300.0 NGVD for the establishment of aquatic plants and by effective management, areas adjacent to the subimpoundments would provide a mixture of various types of vegetation that would have benefit on wildlife species.

Both primary and secondary roads impacted by the reservoir would be reconstructed and/or relocated under this plan to permit continued use within the affected area. However, Division Street, Burnt Sawmill Road, Sweet Sawmill Road, Hopkins Hill Road, Harkney Hill Road, Fish Hill Road and Phillips Road within the reservoir area would be abandoned since the impoundment would inundate the major portions of them as in Plan A and as shown on Plate G-3 in Appendix G, "Design and Cost Estimates". Relocation of Harkney Hill Road, Nooseneck Hill Road (Route 3) and Hopkins Hill Road would be the same as in Plan A and in addition Congdon Mill Road and the New London Turnpike would be relocated under this Plan B to afford accessibility throughout the State-owned property and to the various recreational hunting areas on the southerly side of the proposed reservoir.

Flood Damage Reduction. Flood control storage in the proposed Big River Reservoir in conjunction with the floodplain management requirements of the National Flood Insurance Program would be the same as in Plan A.

Recreation. Facilities to satisfy projected recreational demands of the study area would be the same as in Plan A.

The estimated first cost of this Plan B is $54,212,000 (Present Worth Value) based on January 1979 price levels. Details of the cost of the plan are contained in Appendix J, "Economics".

Plan C

General. Plan C includes the same elements for flood damage reduction and recreation as considered in Plan A, however the water supply component of the plan was formulated on the basis of providing a regional approach to water supply management in the study area involving the maximum capacity of the proposed Big River Reservoir. This plan was also developed to provide an alternative solution for serving the Bristol County area in view of the complex institutional arrangements required for implementation under either Plans A or B. Mitigation requirements and measures to minimize adverse social impacts in the communities affected by the proposed reservoir were developed from consideration of such features in Plans A and B.

Water Supply. This plan is similar to Plan A except that it provides a more regional system for the study area. Development of groundwater resources to serve the BCWC would not be as great as in Plan A since future needs of the system would be supplied from the Providence water system.

A demand modification program that would preclude the need for additional water supply development, beyond that being considered, to satisfy study area needs through the year 2030 would be implemented as in Plan A.

Groundwater development to satisfy present and short-range needs of the BCWC until supplies from the proposed Big River-Scituate system are available, would be constructed in Rehoboth, Massachusetts as in Plan A. As noted in previous sections of this appendix, optional supplies might be obtained from the East Providence water supply system on an emergency basis, however, this option has not been investigated in this study. Development of 3.0 mgd from groundwater sources in Rehoboth would be required to supplement existing supplies of the BCWC and satisfy average and maximum day demands projected through the year 1995. Construction of a 16-inch transmission main, similar to Plan A, for delivering water from the wellfields to the existing supply system in Warren would also be undertaken.

Water supply needs of Foster and Glocester by development of groundwater sources would be the same as in Plan A.

Surface water development at the proposed Big River Reservoir would be similar to Plan A with the exception that facilities would be of sufficient capacity to satisfy not only the projected needs of the PWSB and KCWA systems but also the future demands of the BCWC. Water treatment and sludge treatment facilities would be similar to Plan A, however the capacity would be increased to 60 mgd. All other features of the proposed Big River Reservoir development including mitigation measures would be the same as in Plan A.

Future needs of the BCWC would be satisfied by construction of transmission facilities to deliver water from the existing Providence supply system to the BCWC system in Warren. The proposed facilities would include construction of about 12.4 miles of 18-inch pipeline by 1995 from the existing connection on the 102-inch aqueduct of the Providence water system at Budlong Road in Cranston, to the existing BCWC system in Warren south of the Child Street water treatment facilities. The main would by constructed primarily in public ways by cut and cover methods except as otherwise required. Construction would entail subaqueous crossings of the Pawtuxet River, Providence River (including the 40-feet Federal Channel) and Warren River, as described in previous sections of this appendix under intermediate alternatives, in addition to highway and railroad crossings. A booster pumping station, constructed at the site of the existing Nayatt Road water treatment and pumping facilities in Barrington, and having a capacity of 4 mgd would also be included in the transmission facilities to serve the BCWC. No costs are included for upgrading the existing BCWC supply facilities that would probably be undertaken to increase the flexibilty and efficiency of the various components.

Road relocations under this plan would be the same as in Plan B to minimize the impacts on transportation facilities resulting from construction of the proposed reservoir. Accordingly, major primary and secondary roads would be relocated to provide access throughout the State-owned reservoir property and accessibility to proposed recreational areas.

Flood Damage Reduction. Flood control storage in the proposed Big River Reservoir in conjunction with the floodplain management requirements of the National Flood Insurance Program would be the same as in Plan A.

Recreation. Facilities to satisfy projected recreational demands of the study area would be the same as in Plan A.

The estimated first cost of this Plan C is $51,301,000 (Present Worth Value) based on January 1979 price levels. Details of the cost of the plan are contained in Appendix J, "Economics".

SECTION 2 - COMPARISON OF DETAILED PLANS

Selection of a plan for implementation was based upon a comparative analysis of each plan's contributions towards fulfillment of planning objectives and various other evaluation criteria. The process used to compare the identified plans consisted of a trade-off analysis of the contributions to the planning objectives, the beneficial and adverse impacts of each alternative plan, and responses to specific evaluation criteria such as acceptability, completeness, effectiveness, efficiency and stability. This type of comparison was utilized to categorize the various beneficial and adverse effects and afforded their display in terms of the components of the System of Accounts as required by the Principles and Standards.

Since the flood damage reduction and recreation components of each of the detailed plans are the same, and represent 1) the preferred alternative for flood protection in the Pawtuxet River Basin and 2) the degree of development needed to provide new recreational opportunities for assisting in meeting overall Statewide recreation demands in addition to offsetting the opportunity lost by development of the proposed Big River Reservoir, the impacts of both components are likewise the same. The beneficial and adverse effects of providing flood control storage in the Big River Reservoir to reduce existing and future flood damages are therefore the same for each of the comprehensive water resources management plans as are the impacts associated with the development of recreational opportunities in and adjacent to the State-owned property. Major differences between the plans are associated with the water supply component and more specifically the proposed Big River Reservoir development.

Examination of the data displayed in Table 15, System of Accounts, at the end of this section, indicates the significant tradeoffs made between the detailed plans. The major beneficial monetary effects that would result from the alternative plans are 1) provision of safe, dependable water supplies for the entire study area, 2) reduction of existing and future flood damages primarily along the mainstem Pawtuxet River, and 3) provision of recreational opportunities to serve the needs of the local area in addition to alleviating some of the Statewide demands. Plan A produced the greatest economic return and therefore was selected as the NED Plan in that it addressed the planning objectives in the way that maximizes net economic benefits. Plans B and C likewise produced net positive economic benefits but not as great as those produced by Plan A. These differences can be attributed to the higher overall cost of Plans B and C associated with additional measures for enhancement of EQ in the case of Plan B and the larger water supply costs for serving the BCWC service area in the case of Plan C.

Plan B was selected as the EQ Plan in that it addressed the planning objectives in the way which makes net positive contributions to the EQ account when compared to the "without condition". Plan B provides significantly greater measures to minimize the adverse environmental and social effects of the proposed Big River Reservoir by additional facilities and higher level of management. Measures included under Plan B would enhance fish and wildlife resources and habitat value and in addition would provide increased access to the Big River management area and minimization of transportation disruption in the local area. Plans A and C would each result in negative EQ contributions although measures are included to mitigate the adverse effects of the proposed reservoir development.

Plan C has the advantage of being more implementable than either Plans A or B in as much as interstate and intercommunity agreements for water supply management would be less. More importantly legislation already exists allowing the BCWC service area to be served from the Providence water supply system in the 1967 amendment (Chapter 162) to Chapter 1278 of the Public Laws of Rhode Island, approved 21 April 1915. As noted in the preceding sections, in the absence of obtaining groundwater supplies from Rehoboth to satisfy the immediate needs of the BCWC system, interim supplies could be obtained from the East Providence water system until the time when water would be available from the combined Scituate - Big River system. In addition, Plan C has less negative EQ effects while developing net positive economic benefits and so represents the plan having the best mix of contributions to the National Objectives.

Various other evaluation criteria were considered in the selection of a plan for implementation and are shown in Table 14. Although all of the final detailed plans are generally acceptable, Plan C appears to be the alternative with the strongest public support.

The Tentatively Selected Plan

Development of the most desirable plan for water resources management in the study area involved the comparison and trade-offs among the detailed plans as described in preceding paragraphs and presented in Tables 14 and 15. Plan C, which includes elements of both the NED Plan and the EQ Plan, offers the best mix of these contributions in one plan but more importantly responds to water resources needs of the study area in the most satisfactory manner by providing the strongest choice for implementation. Plan C was therefore chosen as the Tentatively Selected Plan for the study area subject to overall public acceptance during the final phases of the planning process.

The degree of Federal participation in Plan C and the project proposed for Federal implementation are described in the Main Report.

System of Accounts

Consistent with the requirements of the Principles and Standards for Planning Water and Related Land Resources published in September 1973 by the US Water Resources Council, evaluation studies were conducted to determine the beneficial and adverse contributions of each alternative plan. Plan impacts were analyzed to determine the beneficial or adverse value of the contributions each plan would make when compared to the "without condition" (absence of the Federal project). These evaluation activities primarily involved determining the responses of the alternative plans to the National Economic Development (NED), Environmental Quality (EQ), Social Well-Being (SWB), and Regional Development (RD) accounts of the Principles and Standards. The System of Accounts presented in Table 15 is used for displaying the results of these activities. Effects can be readily discerned, and trade-offs between plans

TABLE 14

COMPARISON OF DETAILED PLANS

Criteria	Plan A	Plan B	Plan C
1. Acceptability by affected public	Less acceptable	Most acceptable environmentally and socially	Acceptable
2. Certainty of achieving planning objectives	Positive	Positive	Positive
3. Completeness of necessary investments and actions to assure plan attainment.	Complete	Complete	Complete
4. Effectiveness of meeting planning objectives	Effective	Effective	Most effective
5. Efficiency in responding to planning objectives	Most efficient	Least efficient	Efficient
6. Benefit - Cost Ratio	1.24	1.12	1.16
7. Geographic scope encompassed by plan	Study Area	Study Area	Study Area
8. Reversibility	Low	Low	Low
9. Stability to alternative futures	High	High	High

compared. The accounts specified in the WRC Principles and Standards and utilized in the System of Accounts are described briefly in the following paragraphs.

. National Economic Development (NED)

This account reflects the benefits and cost associated with a particular plan to determine an increase (or decrease) in the value of the nation's output of goods and services as well as improving (or deterioriating) national economic efficiency. The account is filled out in monetary terms. Benefits and costs are expressed as average annual values using appropriate periods of analysis and the current interest rate and represent June 1980 price levels.

. Environmental Quality (EQ)

This account involves identifying the beneficial and adverse contributions of a proposed plan in relation to the environmental objective of managing, conserving, preserving, creating, restoring, or improving the quality of certain natural and cultural resources and ecological systems in a specified geographic region.

. Social Well-Being

This account reflects a plan's impact on real income, security of life, health and safety, education and cultural and recreational opportunities. The account includes most of the benefits identified in a qualitative, rather than quantitative, manner.

. Regional Development (RD)

This account involves determining a proposed plan's effects on the region's income, employment, population and other related factors.

The System of Accounts also displays information concerning the geographic regions in which a significant portion of any beneficial or adverse impact would occur. The following paragraphs define the various regions analyzed.

. Within the Study Area

This constitutes the 17-community region in central Rhode Island including the entire drainage area of the Pawtuxet River Basin. The 17 communities are Barrington, Bristol, Coventry, Cranston, East Greenwich, East Providence, Foster, Glocester, Johnston, North Providence, Providence, Scituate, Smithfield, Warren, Warwick, West Greenwich, and West Warwick.

. Within the Rest of the State

This geographic region refers to the remainder of the communities located outside the immediate study area but within the State of Rhode Island.

. Within the Rest of the Nation

This refers to the remainder of the nation outside the State of Rhode Island and the immediate study area.

Consistent with ER1105-2-921, the use of footnotes in the System of Accounts analysis specifies the timing, uncertainty, exclusivity and actuality of the proposed plans. The index of footnotes are as follows:

Index of Footnotes

a. Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

b. Uncertainty

4. The uncertainty associated with the impact is 50 percent or more.
5. The uncertainty is between 10 percent and 50 percent.
6. The uncertainty is less than 10 percent.

c. Exclusivity

7. Overlapping entry; fully monetized the NED account.
8. Overlapping entry; not fully monetized in NED account.

d. Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

*. Items specifically designated in Section 122 of Public Law 91-611 and ER 1105-2-240

ACCOUNTS	Footnotes	WITHOUT CONDITION Within the Study Area	Within the Rest of the State	Within the [illegible] of the Nation	Within th
1. National Economic Development (Present Worth Values)					
A. Beneficial					
1. Increased Output					
Water Supply Benefits	2,3,6,9				6,
Flood Control Benefits	2,3,6,9				.
Recreation Benefits	2,3,6,9				
2. Value of Output Resulting From External Economies					Non-Qu
3. Total Annual NED Benefits					6,
B. Adverse					
1. Project Costs	1,2,3,6,9				62,
2. Losses Resulting From External Diseconomies					Non-Qu
3. Total Project Costs	1,2,3,6,9				62,
4. Total Annual Costs					5,
C. NED Benefit-Cost Ratio					
D. Net NED Benefits					1,
2. Environmental Quality					
A. Natural Resources*					
1. Wetlands	1,6,8,9	Increased usage of existing surface and groundwater resources would create adverse impacts especially in periods of below average precipitation.	Increased usage of existing water supply sources would create adverse effects on wetland areas especially during preiods of below average precipitation.	Approx. 130 acres lost as the result of surface water development in Rehoboth and Swansea, Mass. Temporary disruptions during construction of transmission mains.	Approx. 520 a result of the voir construc disruption in mission main Mitigation me minimize the after constru
2. Streams and Ponds	1,6,8,9	Reduced flows and lowering would result from increased surface and groundwater utilization.	Reduced flows would result from increased utilization for municipal and industrial water supply.	Approx. 2 miles of streams inundated by construction of Rocky Run Reservoir.	Approx. 20 mi and 40 acres inundated by the Big River
3. Vegetation	1,6,8,9	Construction of transmission mains would require acquisition of both permanent and temporary easements. Approx. 5 acres of vegetation of varying densities and species would be affected.	None	Construction of Rocky Run Reservoir in Rehoboth, Mass., enlargement of Swansea Reservoir in Swansea, Mass. and development of groundwater resources in Rehoboth, Mass. would require land takings. About 300 acres of vegetation would be lost by inundation. In addition, approx. 25 acres of both permanent and temporary easements for transmission main construction would be required affecting vegetation areas of varying densities and species.	Approx. 2,300 wood, softwoo forest would struction of Reservoir. M measures woul permanent eff struction. A acres each of wells in Glou permanent and ments for tra construction and Foster, w vegetation ar densities and
4. Terrestrial Ecosystems	1,6,8,9	None	None	Limited terrestrial wildlife forms inhabit the construction sites. Approx. 300 acres of habitat would be eliminated.	Approx. 3,10(would be lost of the Big Ri Mitigation me minimize the after constru disruption of during const and transmis

TABLE 1[illegible]

SYSTEM OF ACCOUNTS

PLAN A			PLAN B			
Within the Study Area	Within the Rest of the State	Within the Rest of the Nation	Within the Study Area	Within the Rest of the State	Within the Rest of the Nation	Within the Study Area
6,658,000	--	--	6,658,000		--	6,658,000
289,000	--	--	289,000		--	289,000
22,000	--	--	22,000		--	22,000
Non-Quantifiable	--	--	Non-Quantifiable		--	Non-Quantifiable
6,969,000	--	--	6,969,000		--	6,969,000
62,370,000	--	--	70,617,000		--	66,830,000
Non-Quantifiable	--	--	Non-Quantifiable		--	Non-Quantifiable
62,370,000	--	--	70,617,000		--	66,830,000
5,608,000	--	--	6,217,000		--	6,008,000
1.24	--	--	1.12			1.16
1,361,000	--	--	752,000			961,000
Approx. 520 acres lost as the result of the Big River Reservoir construction. Temporary disruption in areas of transmission main construction. Mitigation measures would minimize the permanent effects after construction.	None	None	Similar to Plan A except development of sub-impoundments at the Big River Reservoir would provide increased mitigation measures.	None	None	Same as Plan A
Approx. 20 miles of streams and 40 acres of ponds inundated by construction of the Big River Reservoir.	None	None	Same as Plan A	None	None	Same as Plan A
Approx. 2,300 acres of hardwood, softwood, and mixed forest would be lost by construction of the Big River Reservoir. Mitigation measures would minimize the permanent effects after construction. Also, about 30 acres each of land taking for wells in Gloucester and both permanent and temporary easements for transmission main construction in Gloucester and Foster, would affect vegetation areas of varying densities and types.	Land taking for well field development in Burrillville would require about 30 acres. In addition, construction of transmission mains would require about 15 acres of both permanent and temporary easements. Vegetation areas of varying densities and species would be affected.	Development of groundwater wells in Rehoboth, Mass., would require approx. 70 acres of land taking and about 20 acres of both permanent and temporary easements for transmission main construction. Vegetation areas of varying densities and types would be affected.	Same as Plan A	Same as Plan A	Same as Plan A	Similar to Plan A except a[illegible] additional 15 acres of bot[illegible] permanent and temporary easements would be require[illegible] for construction of transmission facilities from th[illegible] Providence system to serve Bristol County.
Approx. 3,100 acres of habitat would be lost by construction of the Big River Reservoir. Mitigation measures would minimize the permanent effects after construction. Temporary disruption of habitat areas during construction of wells and transmission mains.	Limited loss of terrestrial wildlife forms as the result of groundwater development. Temporary disruption of habitats during construction.	Limited loss of terrestrial wildlife forms during construction of groundwater facilities in Rehoboth, Mass.	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A

2

PLAN B Within the Rest of the State	PLAN B Within the Rest of the Nation	PLAN C Within the Study Area	PLAN C Within the Rest of the State	PLAN C Within the Rest of the Nation
	--	6,658,000		--
	--	289,000		--
	--	22,000		--
	--	Non-Quantifiable		--
	--	6,969,000		--
	--	66,830,000		--
	--	Non-Quantifiable		--
	--	66,830,000		--
	--	6,008,000		--
		1.16		
		961,000		
None	None	Same as Plan A	None	None
None	None	Same as Plan A	None	None
Same as Plan A	Same as Plan A	Similar to Plan A except an additional 15 acres of both permanent and temporary easements would be required for construction of transmission facilities from the Providence system to serve Bristol County.	Same as Plan A	Similar to Plan A except approx. 40 acres of land taking would be required for groundwater development in Rehoboth, Mass.
Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A

	Footnotes	Within the Study Area	Within the Rest of the [illegible]	[illegible]	Within t
		WITHOUT [illegible]			
2. Environmental Quality (Continued)					
5. Aquatic Ecosystems	1,6,8,9	Temporary disruption due to construction of transmission mains. More significant adverse effects as a result of increased surface and ground-water utilization.	Adverse effects as the result of increased usage of surface and groundwater resources for municipal and industrial water supply.	[illegible]	Loss of about [illegible] general [illegible] minimize [illegible] after [illegible]
6. Surface Water Quality*	1,5,8,9	Overdrafting of existing surface water supplies to satisfy increased demands would result in reservoir lowering and possible usage of less potable water. Increased treatment might also be required. Waste assimilation at downstream discharges would be affected due to reductions in streamflow. Downstream reaches of Pawtuxet River would become worse.	Adverse effects as the result of increased usage for water supply purposes and reduction in average stream flows.	[illegible]	[illegible]
7. Surface Water Quantity	1,6,8,9	Reduced stream flows due to increased withdrawals to satisfy municipal and industrial water demands.	Negative effects due to increased utilization for water supply purposes.	Reduc[illegible] stream fl[illegible]ws as the result [illegible] transf[illegible] water t[illegible] Bristol County.	Maximum with[illegible] supply purp[illegible] average [illegible] Reservoir [illegible] Reservoir [illegible] minimize eff[illegible] periods of [illegible] water suppl[illegible] development resources.
8. Air and Noise*	1,5,8,9	None	Air and noise pollution levels would be increased slightly during the construction period.	Air and noise pollution levels would be increased slightly during construction.	Air and noise would be incr[illegible] during the [illegible] period.
9. Groundwater Regimen	1,5,8,9	Increased pumping of existing wells may lower water table and induce higher levels of iron and manganese in supplies.	Increased pumping of existing supply sources may create adverse water table and quality effects.	None	Undefined [illegible] water level [illegible] Big River Res[illegible] measures wou[illegible] possible miti[illegible]
10. Mineral Resources	1,6,7,9	None	None	None	Loss of appr[illegible] cubic yards resources at River Reserv[illegible] Rhode Island to mitigate [illegible] loss.
B. Aesthetics*	1,2,5,8,9	Adverse effects due to outside water restrictions resulting from inadequate supplies throughout. Unsightly conditions possible due to excessive reservoir drawdown.	None	Construction of Rocky Run Reservoir would change the site from a forest/stream to a lake environment. Minor degradation due to construction of other water supply structures.	The Big River be changed fr[illegible] stream envir[illegible] (reservoir) [illegible] degradation water supply degradation [illegible] supply struct[illegible]
C. Cultural Resources*					
1. Archaeological and Historical Sites	1,2,4,7,9	None	None	None known	Fourteen smal[illegible] teries having significance, sites (inclu[illegible] for National archaeologic[illegible] tial signifi[illegible] affected by [illegible] the Big River Mitigation m[illegible] minimize the after constr[illegible]

Table [illegible] (continued)

[illegible]	PLAN A Within the Study Area	PLAN A Within the Rest of the State	PLAN A Within the Rest of the Nation	PLAN B Within the [illegible] Area	PLAN B Within the Rest of the State	PLAN B Within the Rest of the Nation	Within t[...]
[illegible]	Loss of about [illegible] miles of natural fishing streams and several artificial ponds. [illegible] measures would [illegible] the permanent effects after construction. Negative effects downstream of the Big [illegible] Reservoir due to [illegible] streamflow.	Temporary disruption due to construction of transmission mains in Burrillville.	Temporary disruption due to construction of transmission main in Rehoboth and Swansea, Mass.	Similar to Plan [illegible] except mitigation measures would be enhanced by increasing the development of a cold-water fishery in the Big River Reservoir.	Same as Plan A	Same as Plan A	Same as Plan temporary dis[...] biota during [...] transmission [...] the Providen[...] Rivers.
[illegible]	[illegible] reduction in average streamflow. However, reservoir regulation would [illegible] the effects during periods of less than maximum withdrawal for water supply purposes. Combined operation [illegible] and the Big River reservoirs would be undertaken [illegible] improved water quality conditions. Temporary increase in turbidity levels in South Branch during construction.	None	None	Similar to Plan A except increased reservoir site preparation would enhance stabilization process with resultant increase in quality of released waters.	None	None	Same
[illegible]	Maximum withdrawals for water supply purposes would reduce average inflow to Flat River Reservoir by about 43 percent. Reservoir operation would minimize effects during periods of less than maximum water supply usage obtained by development of groundwater resources.	None	None	Same as Plan A	None	None	Similar to Pla[...] measures to mi[...] downstream eff[...] be as frequent [...] study area wat[...] requirements w[...] the combined [...] River system.
[illegible] levels [illegible]	Air and noise pollution levels would be increased slightly during the construction period.	Air and noise pollution levels would be increased slightly during construction.	Air and noise pollution levels would be increased slightly during construction.	Same as Plan A	Same as Plan A	Same as Plan A	Same a[...]
	Undefined increase in groundwater level in vicinity of the Big River Reservoir. Control measures would be included in possible mitigation measures.	None	None	Same as Plan A	None	None	Same a[...]
	Loss of approx. 30 million cubic yards of sand and gravel resources at site of the Big River Reservoir. State of Rhode Island developing plans to mitigate the potential loss.	None	None	Same as Plan A	None	None	Same a[...]
[illegible] Run [illegible] the stream to [illegible] Minor construc- [illegible] supply	The Big River site would be changed from a forest/stream environment to a lake (reservoir) environment. No degradation as the result of water supply shortages. Minor degradation due to water supply structures.	Minor degradation due to construction of water supply structures. Temporary disruption due to construction activities.	Minor degradation due to construction of water supply structures. Temporary disruption due to construction activities.	Same as Plan A	Same as Plan A	Same as Plan A	Same a[...]
[illegible]n	Fourteen small private cemeteries having historical significance, 12 historical sites (including 4 recommended for National Register) and 16 archaeological sites of potential significance would be affected by construction of the Big River Reservoir. Mitigation measures would minimize the permanent effects after construction.	None	None	Same as Plan A	None	None	Same a[...]

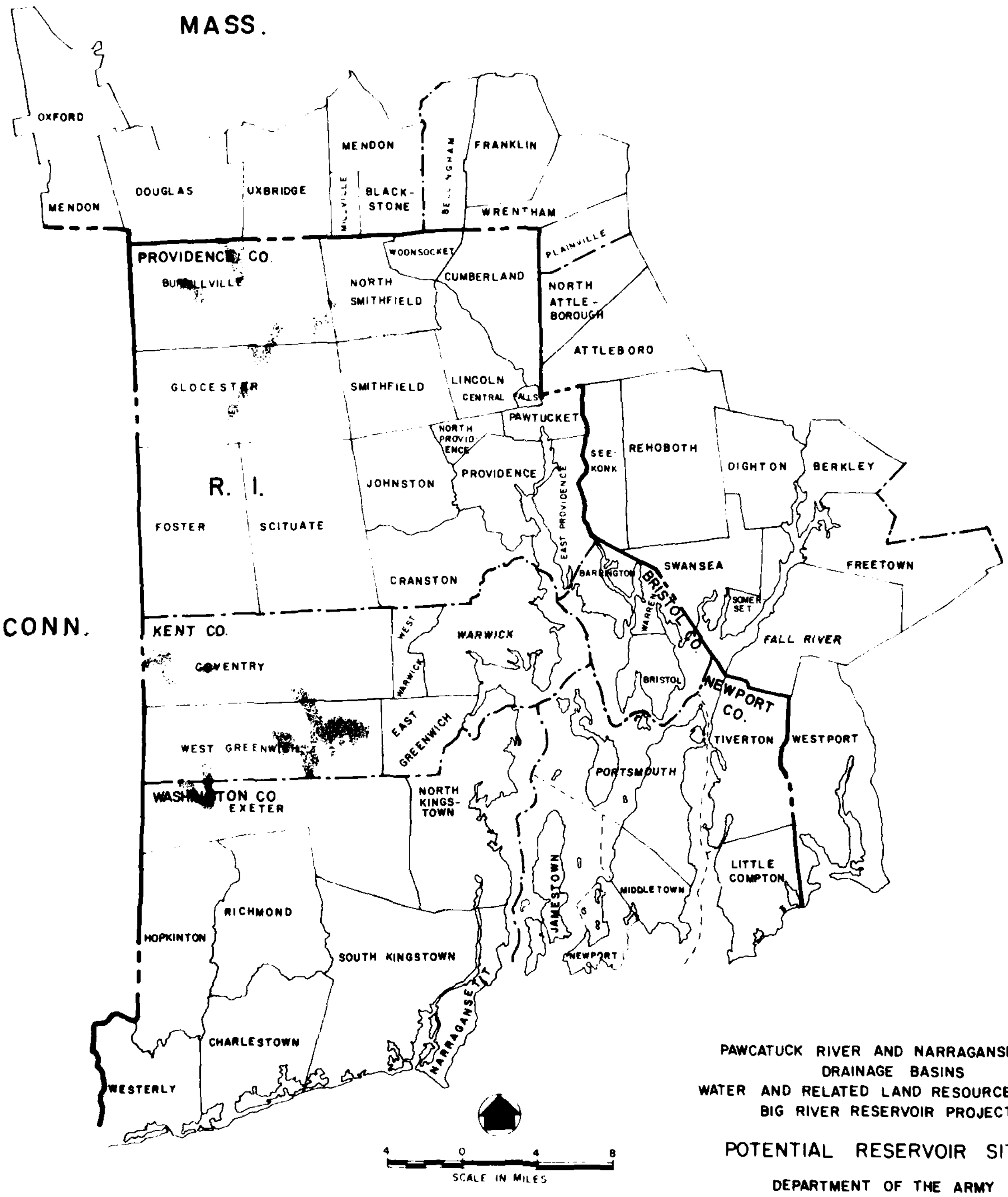
2

...y Area	PLAN B Within the Rest of the State	Within the Rest of the Nation	PLAN C Within the Study Area	Within the Rest of the State	Within the Rest of the Nation
...cept ...would be ...ng the ...d-water ...iver	Same as Plan A	Same as Plan A	Same as Plan A. In addition, temporary disruption of marine biota during construction of transmission facilities under the Providence and Warren Rivers.	Same as Plan A	Same as Plan A
...cept ...site ...bance ...s with ...n quality	None	None	Same as Plan A	None	None
...A	None	None	*Similar to Plan A except* measures to minimize adverse downstream effects would not be as frequent as most of study area water supply requirements would be met by the combined Scituate-Big River system.	None	None
...A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A
...A	None	None	Same as Plan A	None	None
...A	None	None	Same as Plan A	None	None
...A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A
...A	None	None	Same as Plan A	None	None

3

	Footnotes	[illegible] CONDITION: Within the Study Area	Within the Rest of the State	Within the Rest of the Nation	PLAN A: Within the Study Area	Within the Rest of the State	
[illegible] Well Being							
A. [illegible] People*	1,6,7,9	8 residential dwellings acquired and the residents relocated.	None	None	109 residential dwellings acquired and 440 residents relocated.	None	
B. [illegible]*	2,3,5,8,9	Disrupted (Enhanced in Bri[illegible] County).	None	None	Generally enhanced by addition to potable water supply and reduced flood threat.	None	
C. [illegible]*	2,3,5,8,9	Restricted (Unaffected in Bristol County).	None	None	Opportunities for growth increased with additional water supply and reduced flood threat.	None	
[illegible]							
[illegible] Protection		Flood damage potential will increase significantly with continuing urbanization.	None	None			
[illegible]	2,3,6,7,9				21	None	
[illegible]	2,3,6,7,9				7	None	
[illegible]	2,3,6,7,9				5	None	
[illegible]	2,3,6,8,9				1	None	
[illegible] Waste Treatment Facilities	2,3,6,8,9				1	None	
[illegible] Buildings	2,3,6,8,9				2	None	
[illegible]	2,3,6,8,9				0	None	
[illegible] Structures Protected					8	None	
[illegible] Protection		Flood damage potential will increase significantly with continuing urbanization.	None	None			
[illegible]	2,3,6,7,9				85	None	
[illegible]	2,3,6,7,9				2	None	
[illegible]	2,3,6,7,9				3	None	
[illegible]	2,3,6,8,9				0	None	
[illegible] Waste Treatment Facilities	2,3,6,8,9				[illegible]	None	
[illegible] Buildings	2,3,6,8,9				0	None	
[illegible]	2,3,6,8,9				0	None	
[illegible] Structures Protected					5	None	
[illegible]	2,3,6,7,9	Continuing development will increase downstream flood stages.	None	None	Reduction in flows will reduce downstream flooding potential.	None	
[illegible] Health, Safety	2,3,6,8,9	Threat to life, health and safety of residents will increase without adequate water supply or flood protection.	None	None	Reduced threat to life, health and safety of residents.	None	
[illegible]	1,6,7,9	Road relocation at proposed Rocky Run Reservoir.	None	None	Harkney Hill Road, Hopkins Hill Road and Nooseneck Hill Road would all be relocated.	None	
H. Public Facilities	2,3,6,8,9	Public facilities would be restricted as a result of water supply shortages.	None	None	Public facilities would be enhanced as a result of providing adequate water supplies.	None	
I. Public Services	2,3,6,8,9	Public services would be restricted as a result of water supply shortages.	None	None	Public services would be expanded as well as enhanced as a result of providing adequate water supplies.	None	
J. Recreation	1,2,3,6,7,9	Curtailment in the usage of existing recreational facilities would result from water supply shortages.	None	None	Temporary disruption of recreation during construction. Enhanced recreational opportunities would result from the project.	None	
K. Noise*	1,6,8,9	Temporary adverse effects during construction.	None	None	Temporary adverse effects during construction.	None	
4. Regional Development							
A. Employment*	1,2,3,6,8,9	Increased employment opportunity for construction workers in Bristol County during construction.	None	Increased employment opportunity for construction workers in Rehoboth, Massachusetts during construction.	Increased employment opportunity for construction workers during construction of projects.	None	In[illegible] ni[illegible] in[illegible] du[illegible]
B. Regional Growth*	2,3,6,8,9	Restricted except in Bristol County due to inadequate water supplies and lack of flood protection.	None	None	Water supplies and flood protection provide basis for residential, commercial and industrial growth and stability.	None	
C. Tax Revenue*	2,3,6,8,9	Decreased except in Bristol County due to inadequate water supplies and lack of flood protection.	None	None	Increased as result of adequate, dependable water supplies and reduced flood damages.	None	
D. Property Values*	2,3,6,8,9	Decreased except in Bristol County due to inadequate water supplies and lack of flood protection.	None	None	Increased as result of adequate, dependable water supplies and reduced flood damages.	None	
E. Business and Industrial Activity*	2,3,6,8,9	Restricted except in Bristol County due to inadequate water supplies and lack of flood protection.	None	None	Enhanced as result of adequate, dependable water supplies and reduced flood damages.	None	
F. Displacement of Farms*		None	None	None	None	None	

PLAN A			PLAN B			PLAN C	
Within the Rest of the State	[illegible]	n the Study Area	Within the Rest of the State	Within the Rest of the Nation	Within the Study Area	Within the Rest of the State	Within the Rest of the Nation
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None		me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	an A with the addi- ngdon Mill Road and ndon Turnpike.	None	None	Same as Plan B	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	Increased employment opportunity for construction workers in Rehoboth, Massachusetts during construction.	me as Plan A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A	Same as Plan A
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	me as Plan A	None	None	Same as Plan A	None	None
None	None	ame as Plan A	None	None	Same as Plan A	None	None
None	None	None	None	None	None	None	None

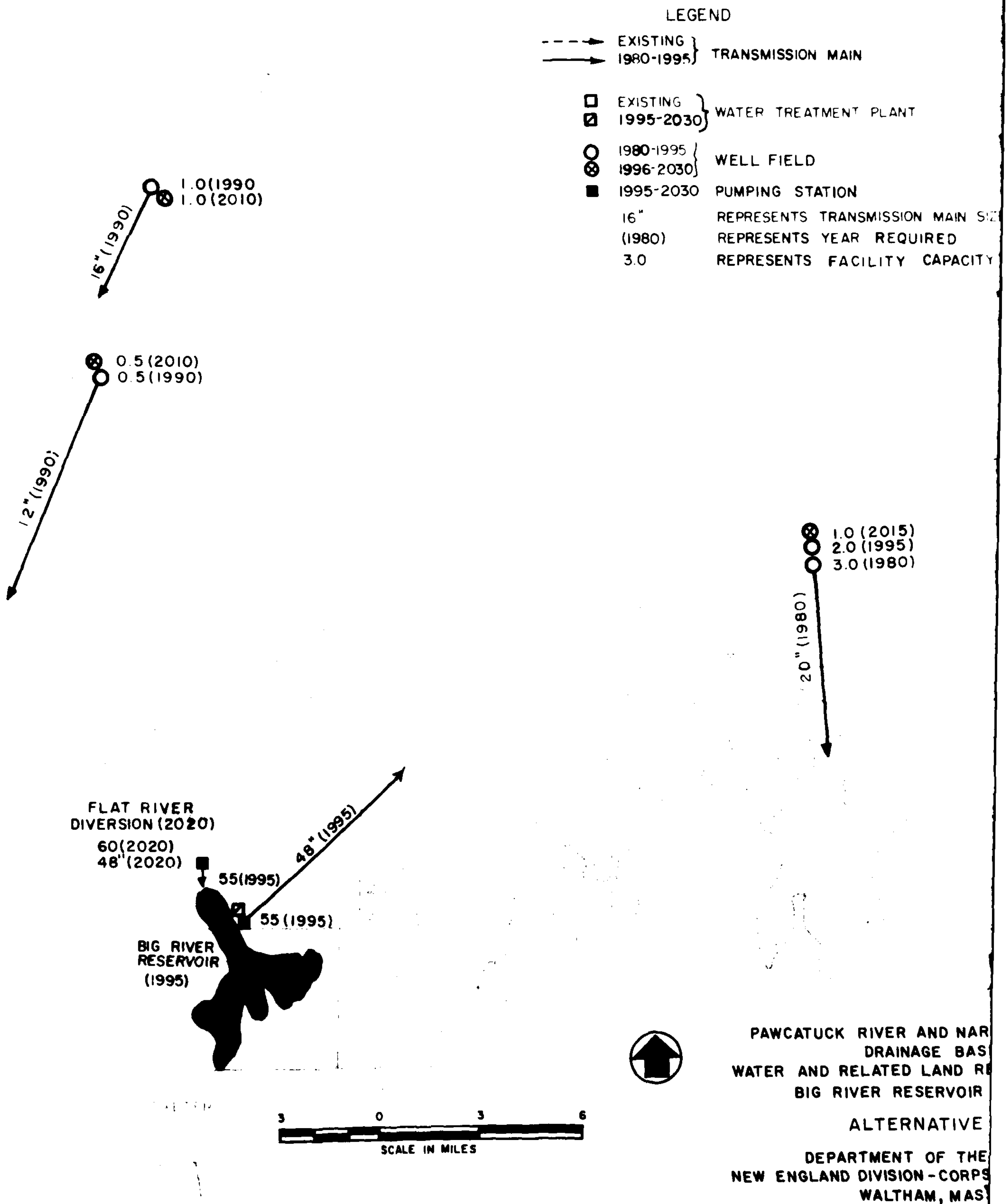


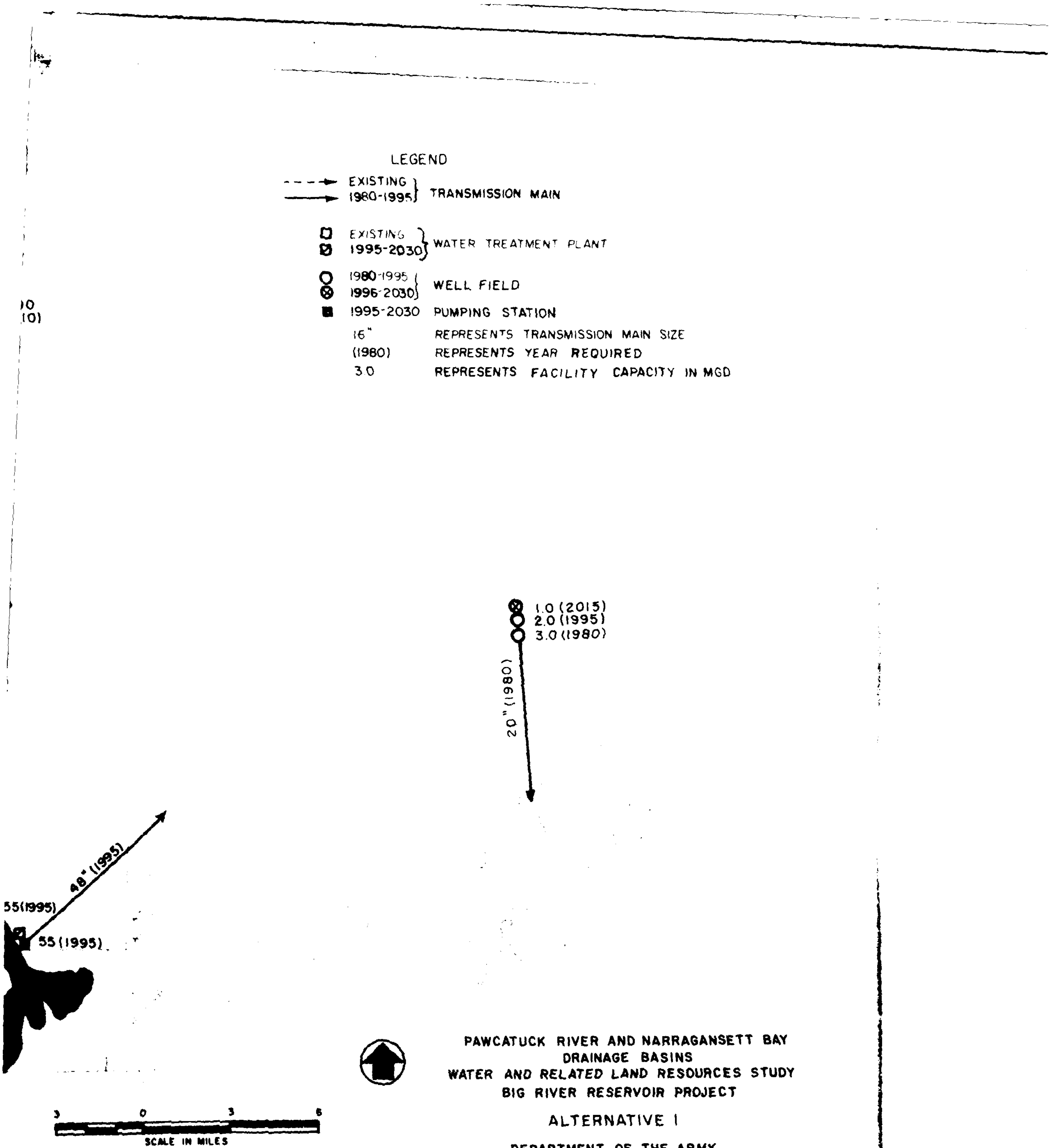
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

POTENTIAL RESERVOIR SITES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE B-1


LEGEND
EXISTING
1980-1995
TRANSMISSION MAIN
EXISTING
1995-2030
WATER TREATMENT PLANT
1980-1995
1996-2030
WELL FIELD
1995-2030
PUMPING STATION
16"
REPRESENTS TRANSMISSION MAIN SI
(1980)
REPRESENTS YEAR REQUIRED
3.0
REPRESENTS FACILITY CAPACITY
1.0(1990
1.0(2010)
16"(1990)
0.5(2010)
0.5(1990)
12"(1990)
1.0 (2015)
2.0 (1995)
3.0 (1980)
20"(1980)
FLAT RIVER
DIVERSION (2020)
60(2020)
48"(2020)
55(1995)
48"(1995)
55 (1995)
BIG RIVER
RESERVOIR
(1995)
3
0
3
6
SCALE IN MILES
PAWCATUCK RIVER AND NAR
DRAINAGE BAS
WATER AND RELATED LAND R
BIG RIVER RESERVOIR
ALTERNATIVE
DEPARTMENT OF THE
NEW ENGLAND DIVISION - CORPS
WALTHAM, MAS

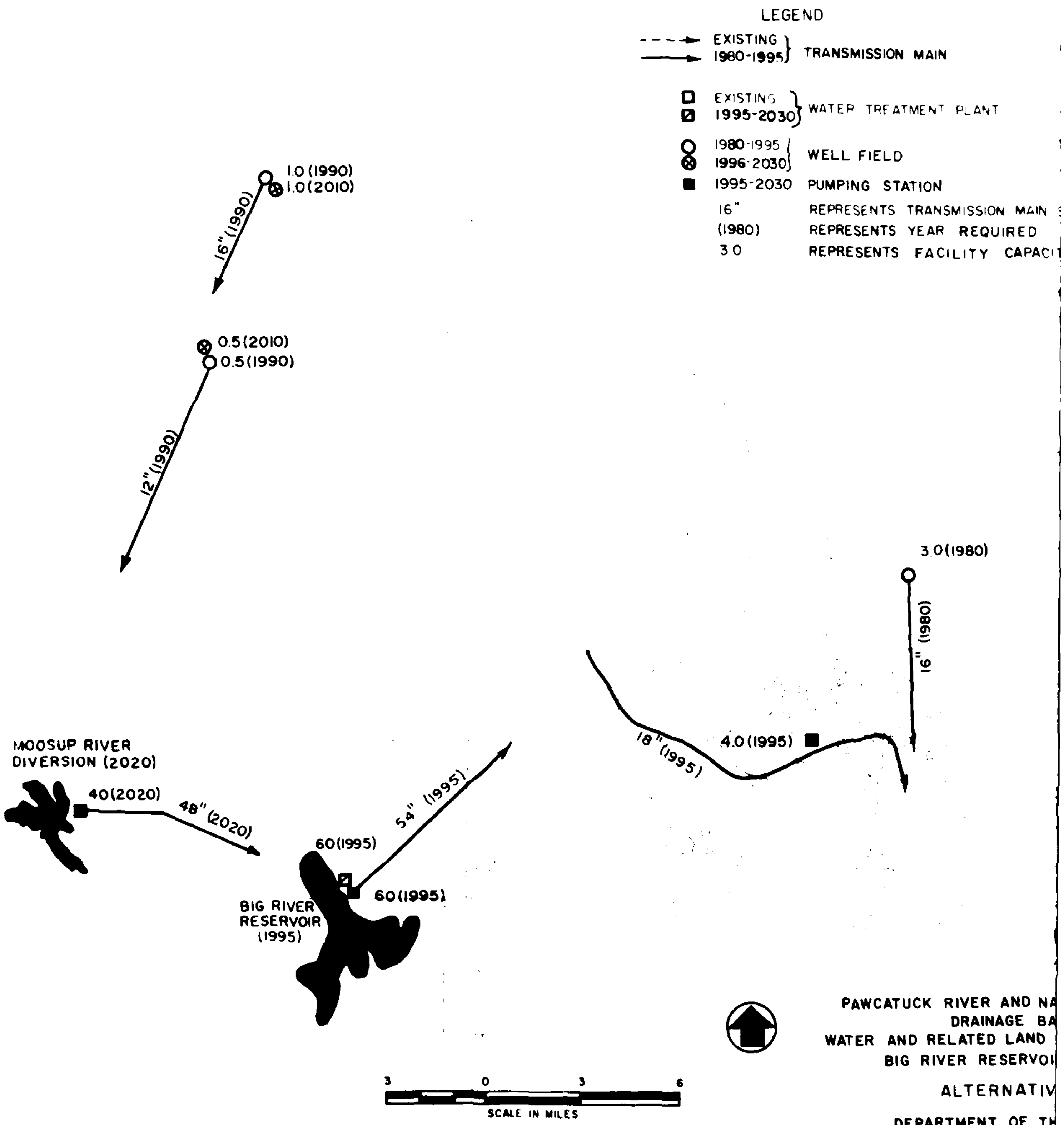


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

ALTERNATIVE I

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE B-2


LEGEND
EXISTING
1980-1995
TRANSMISSION MAIN
EXISTING
1995-2030
WATER TREATMENT PLANT
1980-1995
1996-2030
WELL FIELD
1995-2030 PUMPING STATION
16" REPRESENTS TRANSMISSION MAIN
(1980) REPRESENTS YEAR REQUIRED
3.0 REPRESENTS FACILITY CAPACI
1.0 (1990)
1.0 (2010)
16" (1990)
0.5 (2010)
0.5 (1990)
12" (1990)
3.0 (1980)
16" (1980)
18" (1995)
4.0 (1995)
MOOSUP RIVER
DIVERSION (2020)
40 (2020)
48" (2020)
54" (1995)
60 (1995)
60 (1995)
BIG RIVER
RESERVOIR
(1995)
3 0 3 6
SCALE IN MILES
PAWCATUCK RIVER AND NA
DRAINAGE BA
WATER AND RELATED LAND
BIG RIVER RESERVOI
ALTERNATIV
DEPARTMENT OF TH
NEW ENGLAND DIVISION - COR
WALTHAM, MA

LEGEND

EXISTING	TRANSMISSION MAIN	
1980-1995	TRANSMISSION MAIN	
EXISTING	WATER TREATMENT PLANT	
1995-2030	WATER TREATMENT PLANT	
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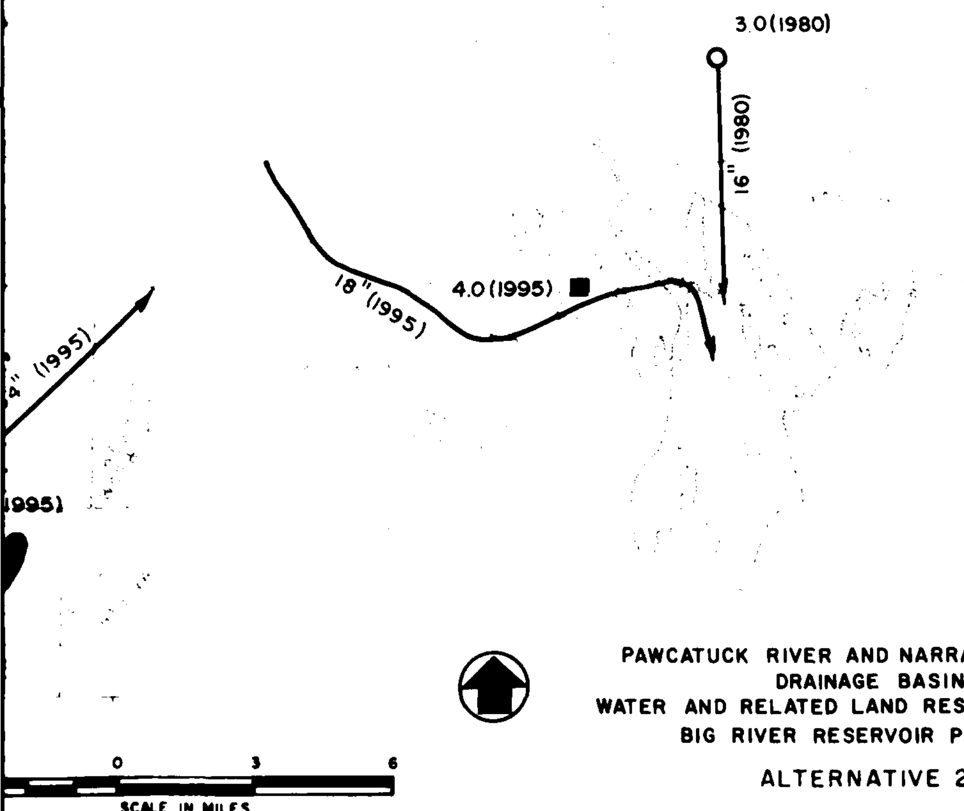

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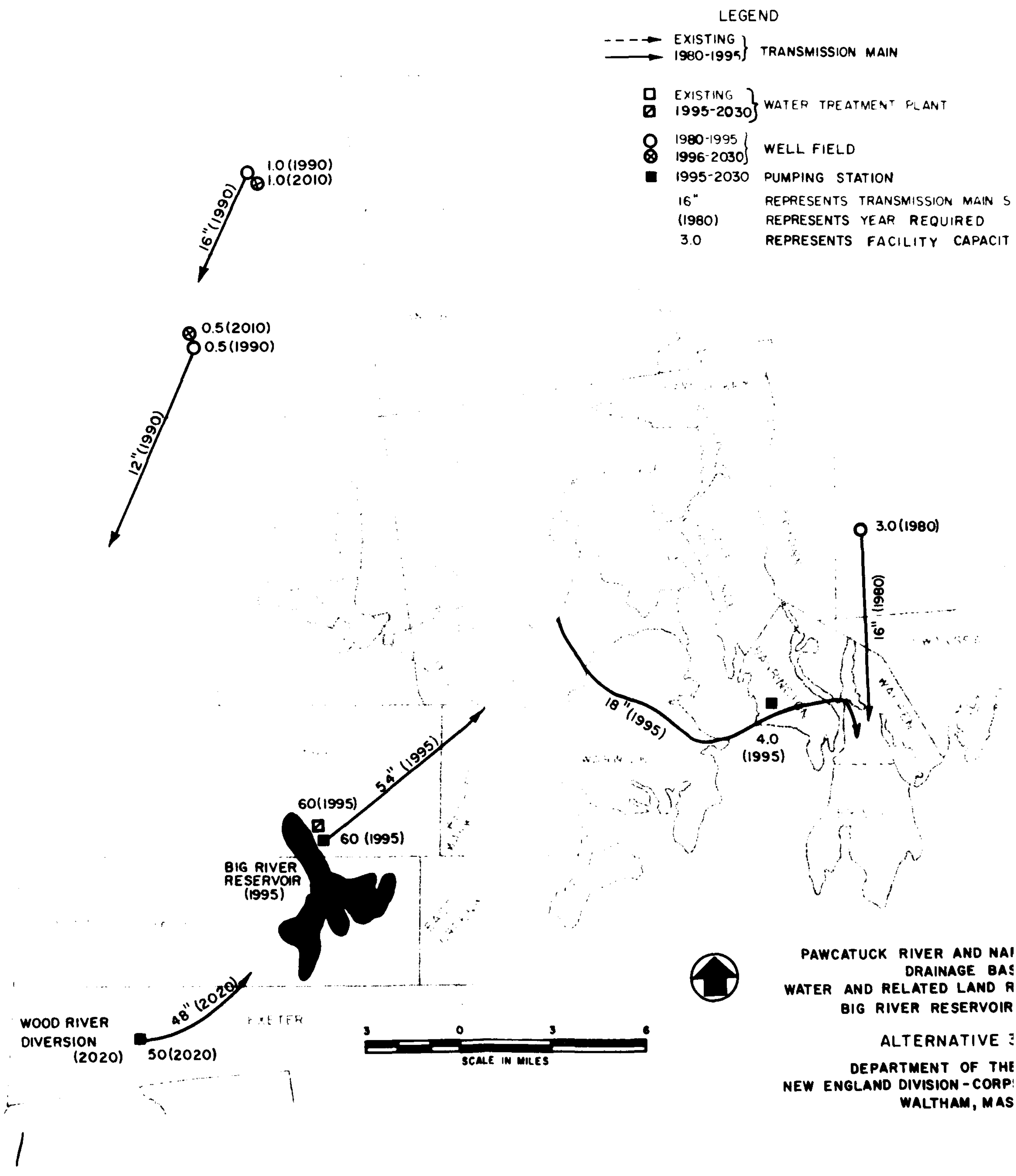

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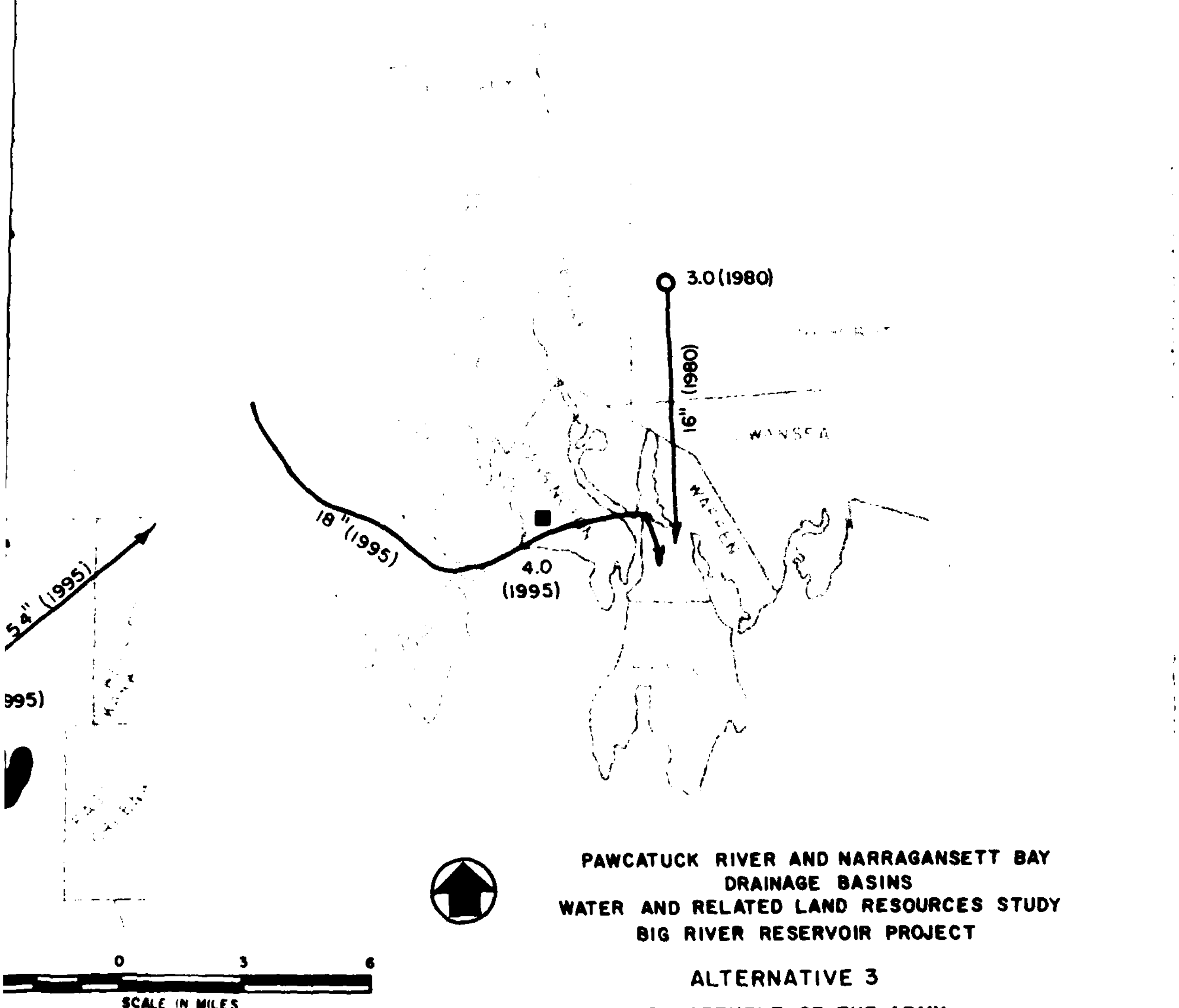

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BIG RIVER RESERVOIR PROJECT

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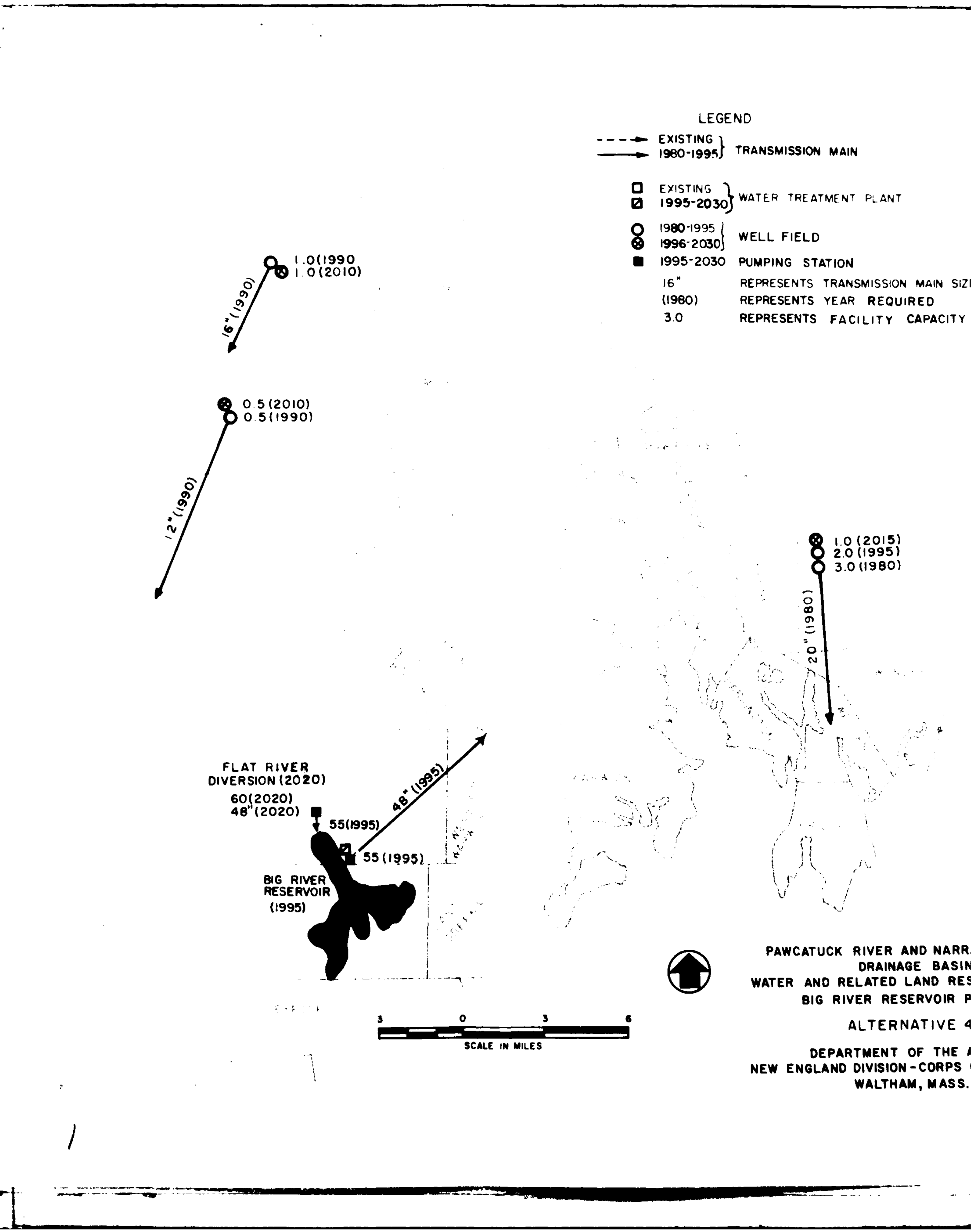
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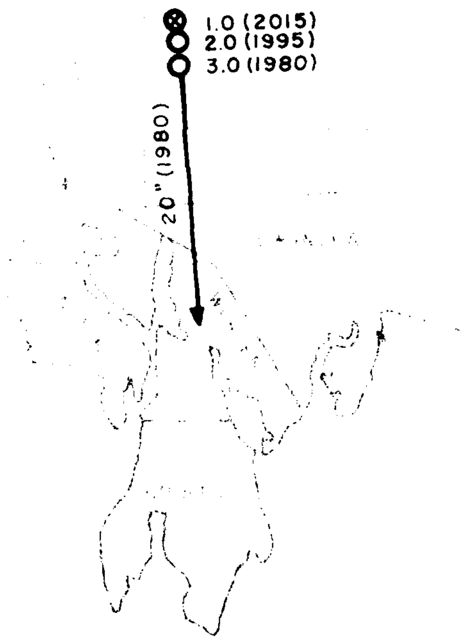

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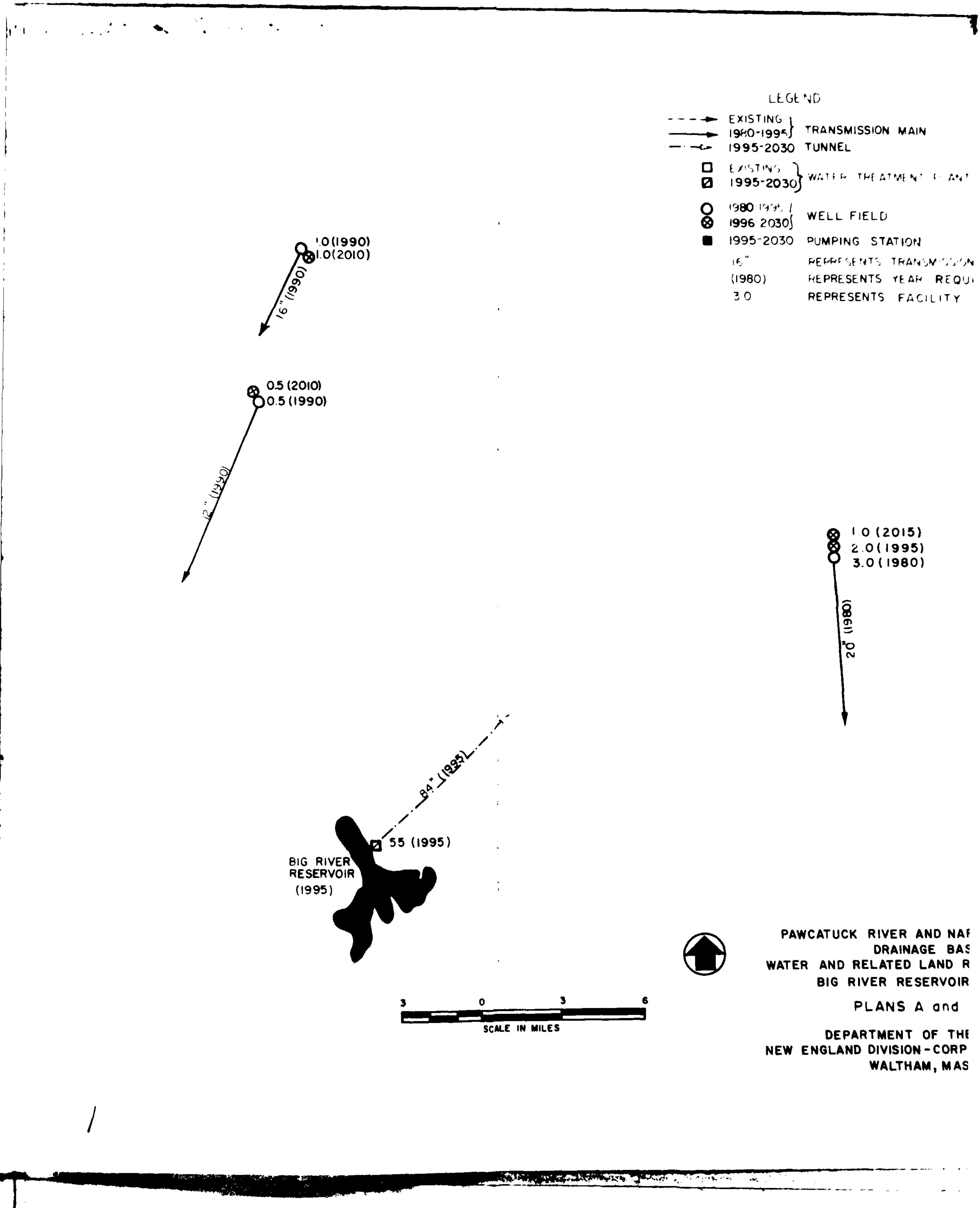

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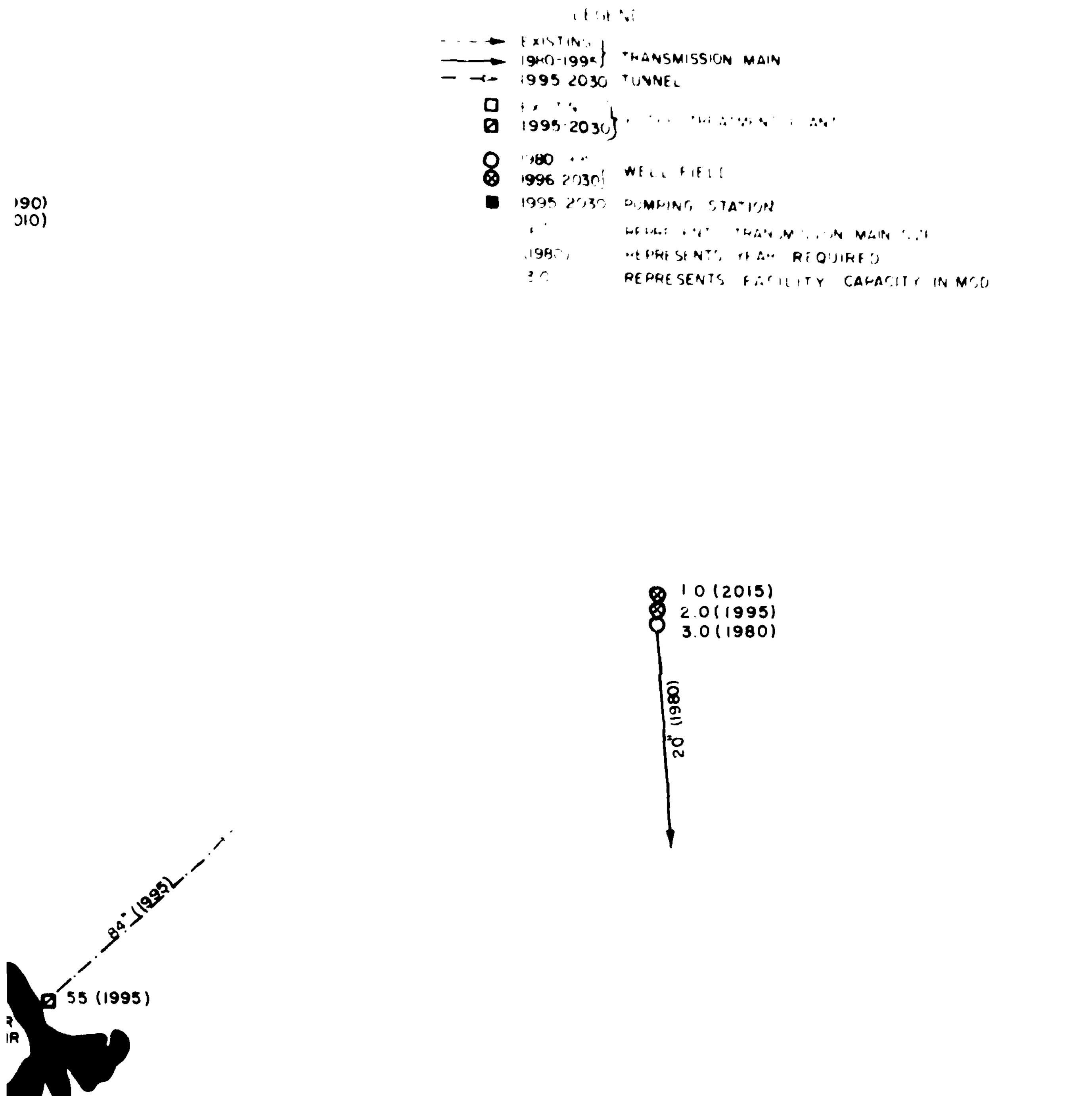

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WALTHAM, MASS.

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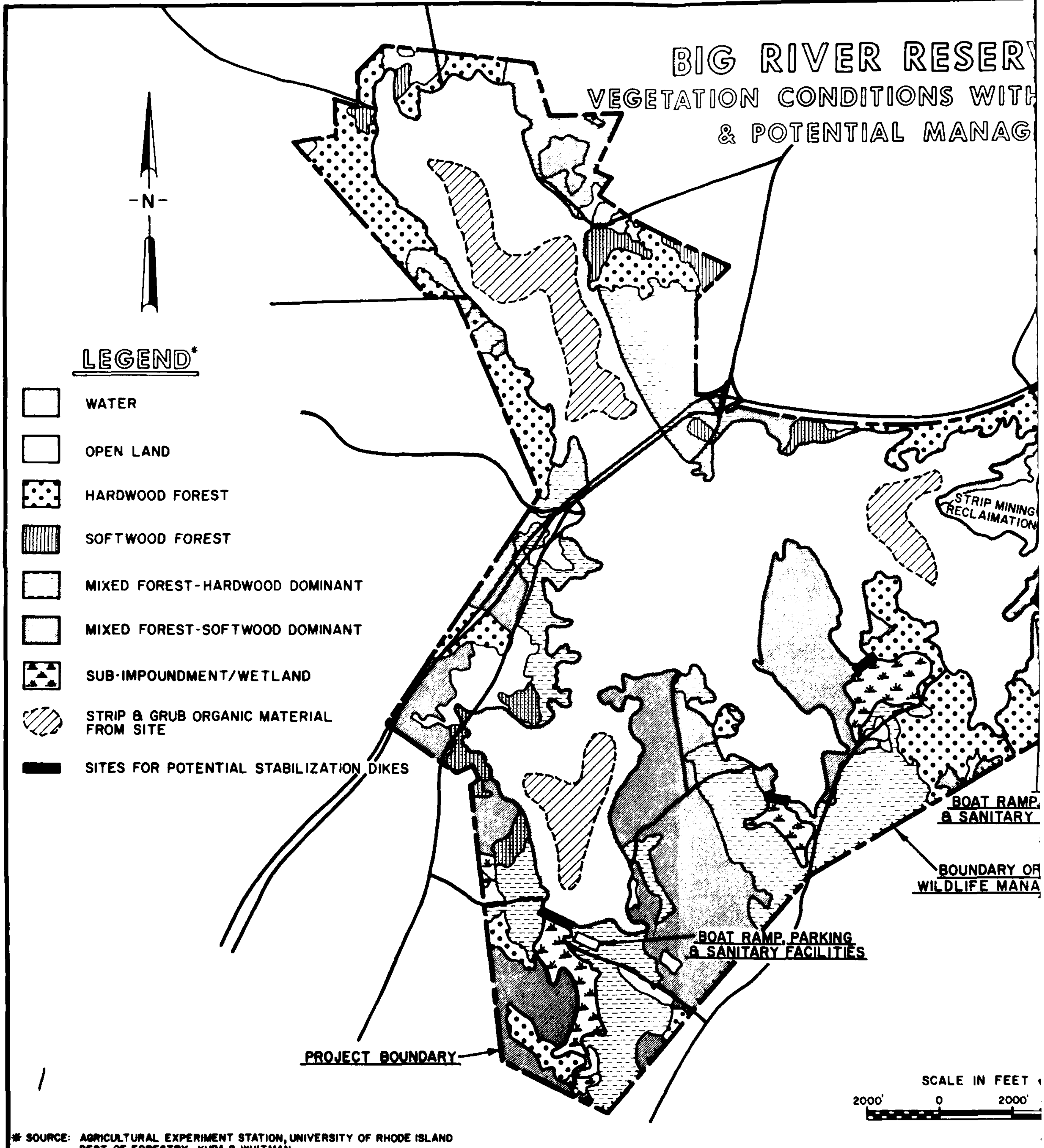

* SOURCE: AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF RHODE ISLAND
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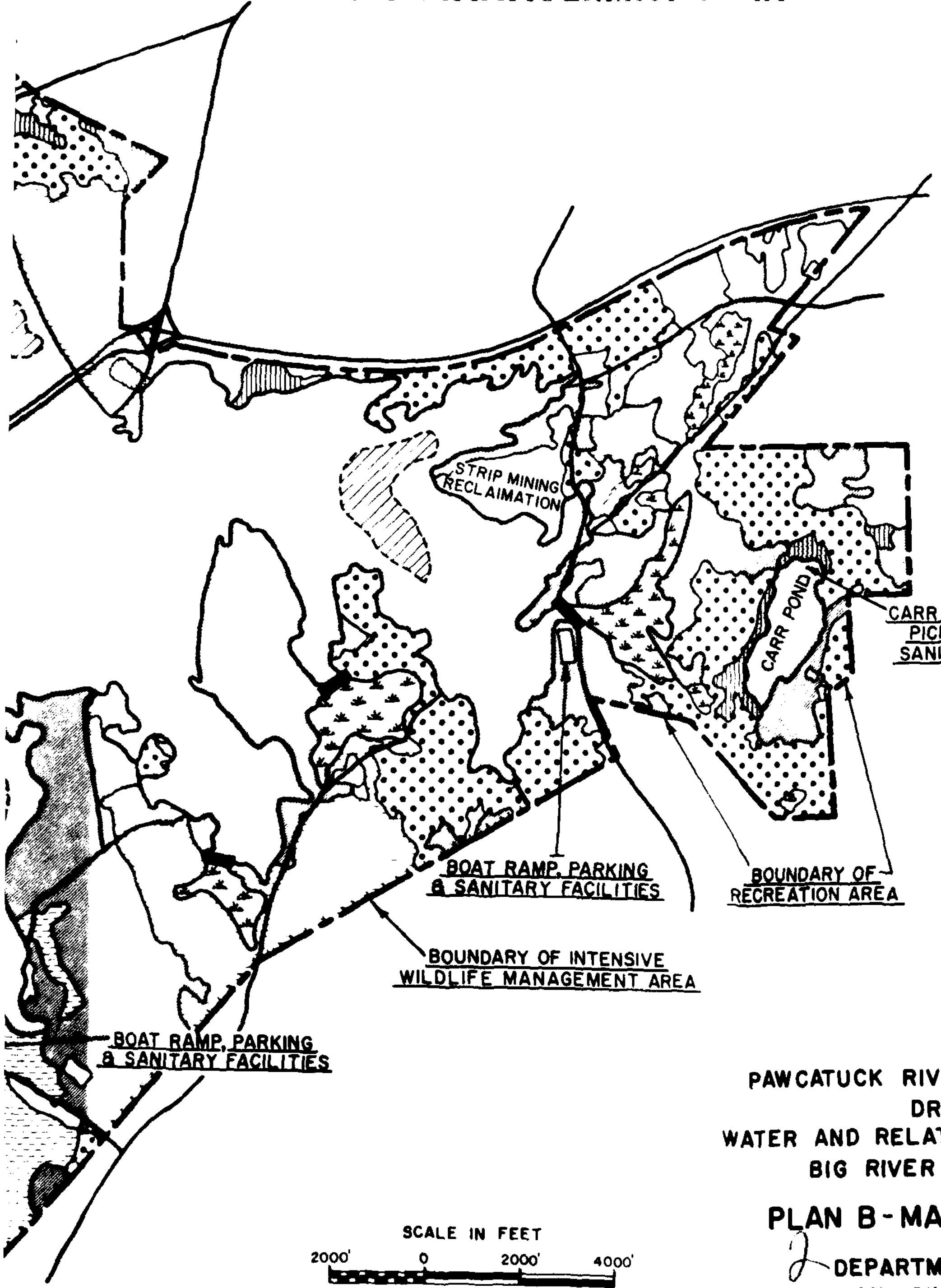
BIG RIVER RESERVOIR AREA

EGETATION CONDITIONS WITH POOL AT 300' M.S.L. & POTENTIAL MANAGEMENT PLAN



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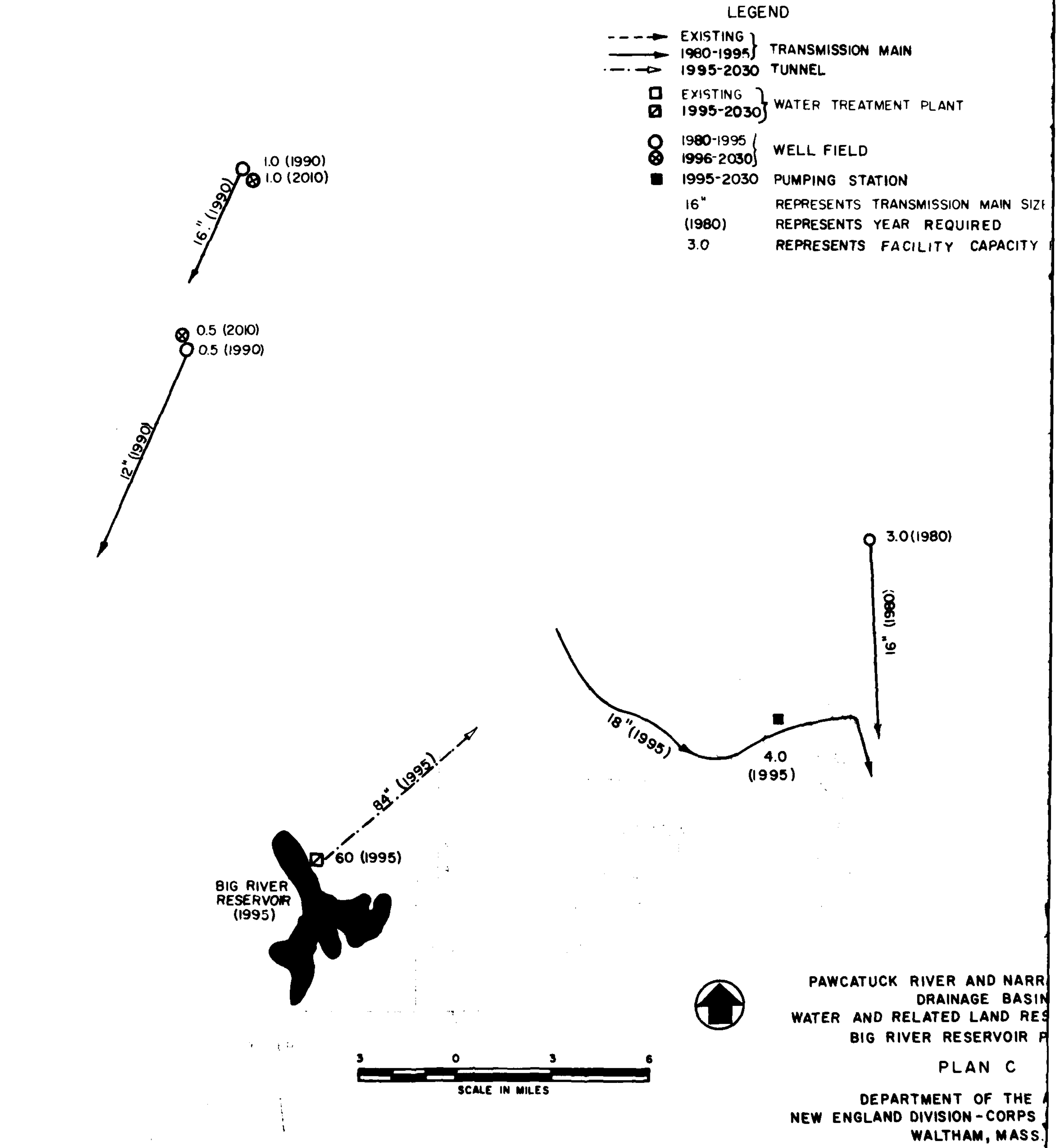
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PLAN B - MANAGEMENT MEASURES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE B-7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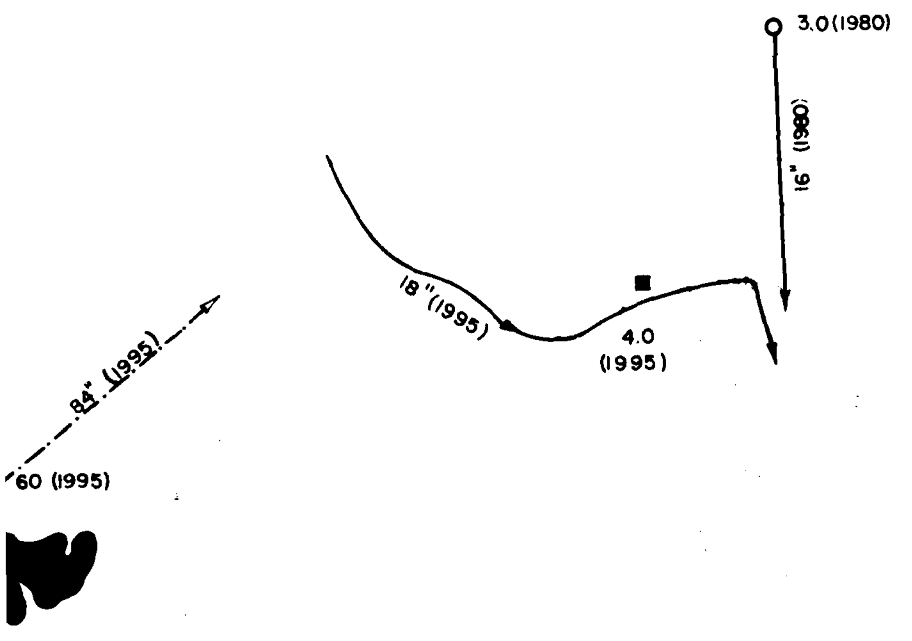

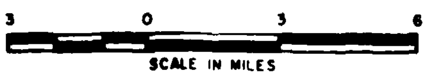

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BIG RIVER RESERVOIR PROJECT

PLAN C

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE B-8

2

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX C

PUBLIC PARTICIPATION

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX C

PUBLIC PARTICIPATION

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SECTION 1

SUMMARY OF PUBLIC INVOLVEMENT PROGRAM

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SECTION 1

SUMMARY OF PUBLIC INVOLVEMENT PROGRAM

Public involvement efforts for this study were undertaken as two independent projects, due to the differences in scope and timeframe for the Pawtuxet River Basin flood control and Big River Reservoir studies. The respective public involvement programs are thus described in two sections below.

Flood Control

Public involvement for the flood control aspect of this study began in 1969 with the initiation of the PNB study. In May 1969 an initial group of four meetings was held to gather information on publicly perceived problems and needs in the overall PNB study area. State-sponsored water supply plans were presented to the Corps at that time in order that any plans developed during the study would coordinate with existing State planning.

During the early stages of the Pawtuxet River Basin flood control study numerous meetings, both formal and informal, were held with various Federal, State and local governmental agencies, public and private interest groups, and interested individuals. These meetings were basically designed to provide a two-way exchange of information to help direct study activities, to involve all interested parties in a meaningful way, and to allow coordination of study proposals.

In May 1975, following the formulation of preliminary plans, additional large public meetings were undertaken to present preliminary study results and ascertain public views on the alternative approaches to solving the basin's flooding problems. Included in the plans presented were both structural and non-structural alternatives, including systems of walls, dikes and channel modifications, and diversions of flood flows, along with floodproofing or relocation in some areas.

Public input at these meetings was favorable. The diversion plan, being the most effective at reducing damages in the basin, was given the most emphasis in both the presentations and responses by the public. The diversion proposal was given conditional support by local governmental agencies and interest groups pending the outcome of environmental impact studies.

In October 1976 a late stage public meeting was held to present the results of the detailed planning for flood control in the Pawtuxet basin. The plan presented included the Natick Diversion with the Warwick Local Protection Project and regulatory measures. At this meeting the recommended plan was found unacceptable by the public, with opposition to the plan centering around the high construction costs and potential environmental damage to Greenwich Bay. Many elements of the public expressed the desire that the study continue and be redirected towards other possible solutions.

Meetings in 1977 with state and local officials helped shape a compromise flood control plan consisting of the Warwick Local Protection project in conjunction with flood control storage at the proposed non-Federal Big River Reservoir. This plan was favorably received at a public meeting held in May 1977, with the only concern being that the City of Warwick did not agree with the proposed cost sharing responsibilities, believing that costs should be shared among the communities in the region contributing to the flood problem, not just by Warwick.

In March 1979 a workshop meeting was held in Warwick to present the final plans for flood protection in the Pawtuxet Basin. The Norwood area land bank proposal was explained and was well accepted by the affected homeowners. The Warwick Avenue Local Protection Project was dropped at this time due to the formally announced non-support by the City of Warwick.

Big River Reservoir

In January 1978, the Governor of Rhode Island requested the Corps of Engineers undertake a feasibility study of the proposed Big River Reservoir Project, under the overall PNB study authority. In conjunction with Corps involvement in the study, the University of Rhode Island was engaged to assist in developing and coordinating a public involvement program for the Big River study.

Three workshops were held in September 1978 to assess the issues of concern to the public and to inform the public of the Corps' role in the planning process. Six broad topic areas were identified as important as a result of the workshops and an additional working seminar. These were:

1) Assessment of Study Area Needs
2) Fiscal and Management Issues
3) Access to the Reservoir and Multi-Use of Lands
4) Legal Issues
5) Impact on Local Communities
6) Comprehensive Planning and Citizen Participation

As a result of the issues emerging from the public involvement efforts during the problem identification stage of the study, several potential strategies for future public participation were considered for the plan formulation and evaluation stages of the feasibility study. These included:

Option I - Core Professional staff for a Consumer Advocacy Organization
Option II - Governor's Task Force on Big River
Option III - Independent Staff to Corps

A combination of Options I and III was chosen for the remainder of public involvement efforts, again utilizing the University of Rhode Island as a consultant. During the development of intermediate plans, public comment was desired both to react to the Corps' efforts at that stage, and to shape the more advanced plan formulation. Several major elements of public involvement were developed to meet the objectives of Stage 2. These included:

A core staff of URI personnel, which coordinated public involvement activities on a day-to-day basis. The staff's duties included dealing with the different publics, managing the participation techniques utilized, and acting as a communications link between the Corps and the public.

A Project Working Committee (PWC), which was established after the June 1979 workshops to provide an independent citizens' forum on issues emerging from the public involvement process. The PWC was intended to facilitate discussion on critical issues, to speed information dissemination informally, and to obtain a diverse representation of interests involved in the discussion of issues. It was also designed to allow closer review of issues than might ordinarily have been undertaken by the general public at a workshop.

Multi-faceted participation mechanisms were utilized, including comprehensive communications strategies, such as targeted mailings, media involvement, information bulletins, and public contact such as workshops, briefing sessions and various formal and informal smaller meetings.

An expanded mailing list was developed, allowing better coverage of affected publics, and stratified, enabling targeted mailings of specific segments of the public.

Public participation activities undertaken during the study are classified under two broad categories - Information Exchange and Public Meetings.

Information participation techniques were varied according to the targeted public and desired response. Notification of upcoming meetings and workshops was accomplished through direct mailings, newspaper advertisements, press releases, flyers, and personal telephone contact. The mailing list was constantly updated and was stratified to allow better targeting of the various publics. Technical abstracts or fact sheets were developed to assist public understanding of technical documents, providing all participants with a common information base for discussion at briefing sessions and workshop meetings. Meeting summaries were published and distributed as documentation of public input during meetings. News media coverage of various meetings and issues was also encouraged. Formal public input techniques, including interviews with key persons and formal written statements, were also utilized.

Public meetings of three types were utilized: Workshops, Briefing Sessions, and PWC Meetings. Workshops were chosen as the principal large scale public forum during the study. Three workshops were held during June 1979, during the formulation of intermediate plans. These workshops were designed to give the public an opportunity to comment on the plans presented. Some of the more important issues broached at that time were:

1) Is the reservoir needed? Are population projections accurate?
2) Who will own and operate the reservoir, and what level of recreation (multi-use) will be allowed?
3) What are the environmental effects of the reservoir development?
4) What social and economic effects will there be, and how will they be dealt with?
5) How much effect does public input have on the planning process?

Although a clear consensus of opinion was not produced at the June 1979 workshops, the direction of the study was shaped, and efforts were made to answer questions raised at the meetings. Briefing sessions were utilized to explore in greater detail the Corps' efforts on various technical issues of concern to the impacted citizens. Briefing sessions were held in August and September 1979, to address historic preservation and engineering, geotechnical and hydrologic issues. These sessions followed similar formats to the public workshops, with the Corps representative making the presentation, followed by public questions and comments.

Project Working Committee (PWC) meetings were held throughout the June-October 1979 timeframe. These meetings helped give a focus to the public concerns expressed during the planning process, and at several meetings discussions of technical issues were held, in the manner of the briefing sessions. The water demand projection model used by the Corps and the impact of the reservoir on future water treatment needs were addressed at PWC meetings.

During 1980 coordination meetings were held with several state agencies on the project. A preliminary draft of the feasibility report was released for limited review by the Rhode Island Water Resources Board and the Governor's Office. The draft feasibility report and Draft Environmental Impact Statement (DEIS) were released in January 1981 for public review and comment. A final public meeting was held on 26 March 1981 at which time the results of the draft feasibility report and DEIS were presented and formal public comments were solicited. The final public meeting showed that while some issues of import had been adequately addressed earlier, other issues were still perceived as insufficiently dealt with, including differing population projections and questions of mitigation requirements, as well as other areas of the report. These issues would have to be addressed in the final report and EIS.

For a more complete description of the activities undertaken and issues raised during the public involvement efforts for the Big River Reservoir study, and for the mailing list and examples of printed materials and public inputs, see the attached FINAL REPORT, Big River Reservoir Project Public Participation Activities, August 1978 - November 1979, prepared by: the University of Rhode Island, Graduate Curriculum in Community Planning and Area Development, Marcia Marker Feld, Ph.D., principal investigator.

For more detailed information on the public involvement program undertaken for the Pawtuxet River Basin flood control study, see "Attachment 1" to the Big River Interim Report (Volume IV of the report).

ATTACHMENT C-1

Big River Reservoir Project

Public Participation Activities

August 1978 - November 1979

FINAL REPORT

Prepared For:

NEW ENGLAND DIVISION
Basin Management Branch
Urban Studies Section
U.S. ARMY CORPS OF ENGINEERS

Contract DACW33-79-C-0061

By:

THE UNIVERSITY OF RHODE ISLAND
Graduate Curriculum in Community Planning
and Area Development

MARCIA MARKER FELD, PH.D.
Principal Investigator

May 16, 1980

ABSTRACT

This report describes and reports the findings developed from the Big River Reservoir Public Participation Project. The activity period covered is from August 1978 through November 1979. The concept and reality of citizen participation and its role in the U.S. Army Corps of Engineers project planning process is reviewed. The use of workshops, briefing sessions, media strategies, and participatory institutions are described. The resulting input from the various publics to the Corps' project planning is presented in detail, pinpointing major and minor issues and identifying those that require more attention by the Corps in the future.

The report concludes with a set of recommendations to the U.S. Army Corps of Engineers for future public participation activities in connection with the Big River Reservoir Project. It is recommended that the Corps continue its commitment to a multi-phase public participation component. Continued use of citizen participation consultants on a contractual basis seems appropriate given the level of expertise required to conduct such a component within the framework of a complex water resource development planning project.

PROJECT STAFF

Marcia Marker Feld, Ph.D.	Project Director/Principal Investigator
Howard Foster, Ph.D.	Primary Investigator/Media Specialist
Alan P. Sharkey, MCP	Project Manager
Linda Carmeroto	Workshop Specialist
Patricia Krause	Graduate Assistant
Kevin Flynn	Graduate Assistant
Patrice M. Duffy	Project Secretary

SUBCONTRACTOR

Robert McMahon	Urban Systems Research and Engineering, Inc.

ACKNOWLEDGEMENTS

The staff of the Big River Public Participation Project would like to express appreciation and thanks to the many agencies, groups, and individuals who, through their participation, cooperation, and critiques assured the success of this phase of the public participation effort.

Particularly, we would like to thank the members of the Project Working Committee and those who actively attended the Briefing Sessions and Workshops. It is only through such a commitment of effort that a public participation program becomes a reality.

Mr. John Smith and his study team at the U.S. Army Corps of Engineers, Mr. John Craig and Mr. Mark DeSouza have been most supportive of the work of the URI Project Staff.

I would also like to thank Mr. Robert McMahon of Urban Systems Research and Engineering, Inc. who participated as a subcontractor and abstracted the technical material.

Lastly, my gratitude extends to the staff of the Public Participation Project, Dr. Howard H. Foster, Jr. (Primary Investigator); Mr. Alan P. Sharkey (Project Manager); Ms. Linda Carmeroto (Workshop Specialist); Mr. Kevin Flynn and Ms. Patricia Krause (Graduate Research Assistants); and Ms. Patrice M. Duffy (Project Secretary). They had a multiplicity of roles and tasks which they performed exceedingly well. Dr. Foster created and developed the media strategy as well as shaping the second phase of the citizen-based process of identification of critical issues; Ms. Carmeroto, Mr. Flynn, and Ms. Krause organized and maintained the direct citizen interface with the local community. Mr. Sharkey has been the lead person on this core team. He has set the framework for the process, managed the project, developed close liaison with the U.S. Army Corps of Engineers, local agencies, state agencies, and the Office of the Governor. He has accomplished these activities with a deep commitment to citizen participation which has permeated this project and has resulted in its being held in respect within the state. It is no easy matter to, at one and the same time, be a "neutral site" for all concerned parties, an information dissemination mechanism, a forum for public dialogue, under contract to the U.S. Army Corps of Engineers, employed by the University of Rhode Island, perceived as a citizens

advocacy group staff, and maintain the credibility and integrity of the mandate of public participation. In this, Mr. Sharkey and the Project Staff were eminently successful.

I appreciate their efforts and their commitment to meaningful citizen participation.

Marcia Marker Feld, Ph.D.
Principal Investigator
Big River Reservoir Project
and
Associate Professor
Graduate Curriculum in Community
Planning and Area Development
University of Rhode Island

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CHAPTER 1

INTRODUCTION

BACKGROUND

In January, 1978, the U.S. Army Corps of Engineers was requested by Governor J. Joseph Garrahy of Rhode Island to undertake a feasibility study concerning the proposed development of the Big River Reservoir. He did so, in part, to ensure that the public would have an opportunity to participate in the decision-making process concerning water resources in Rhode Island. The Feasibility Study, as employed by the Corps, is an umbrella document which includes an Environmental Impact Statement (EIS) in addition to studying the various elements inherent in the construction of a reservoir such as engineering, economics, and institutional arrangements.

University of Rhode Island involvement in the project has been in two phases. The first phase commenced in June, 1978 when faculty of the Graduate Curriculum in Community Planning and Area Development submitted a proposal designed to conceptualize, initiate, and carry out the public participation component of the Feasibility Study. The proposal was accepted and the first phase of University involvement commenced in August, 1978 under contract number DACW 33-78-C.

During the first phase, which was completed in October, 1978, URI's principal role was to develop a public participation program that would identify specific issues and concerns from the public while also informing the public of the proposed Big River Reservoir Project.

The format of the citizen participation effort was developed from meetings with many citizen groups and state agencies and focused on facilitating discussion rather than enforcing formal "one way" public hearings. The shape of the model was greatly influenced by the URI project goal of citizen-based identification of issues which the participants felt to be important in an assessment of the impact of the reservoir. The meetings were held as an open forum, and background materials were distributed in order to encourage knowledgeable debate.

Three workshops were conducted in September, 1978. One workshop was held in Providence and the other two workshops were held in the potentially impacted area of Coventry-West Greenwich. As a way to achieve a cumulative impact, a final "working seminar" session was held with those participants who had attended the three earlier sessions and had expressed an interest in reviewing the citizen-based draft report emanating from the workshops. The Final Report highlighted issues emerging from these fall 1978 workshops. 1. (Ed. Note: The reader should note that "Final Report" refers to a cumulative report ending the first phase of URI involvement.) The issues were organized into six broad topic areas for study by the Corps.

I. Assessment of Needs
II. Fiscal and Management Issues
III. Access to the Reservoir and Multi-Use of Land
IV. Legal Issues
V. Impact on Local Communities
VI. Comprehensive Planning and Citizen Participation

At the Corps' request, the Fall 1978 report contained a chapter recommending potential strategies for future public participation in the next planning process phase of the feasibility study. Three options were identified by the Public Participation Project staff and citizen groups as possible models for future public participation. Option I called for a "Core Professional Staff for a Consumer Advocacy Organization"; Option II envisioned a "Governor's Task Force on Big River"; Option III highlighted an "Independent Staff to (the) Corps."

In December, 1978 the U.S. Army Corps of Engineers published a request for proposals (RFP) in the Commerce Business Daily. It asked for proposals to carry out a citizen participation project to run through the completion of the Feasibility Report and required public hearings.

In response, the URI Public Participation Project team submitted a proposal in February, 1979. Negotiations with the Corps were subsequently held and in March, 1979 a final proposal was accepted by the Corps retaining the University under contract number DACW 33-79-C-0061 to continue the public participation program for the proposed Big River

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1. Final Report: Public Participation Workshops: Big River Reservoir Project, Graduate Curriculum in Community Planning and Area Development, URI, October, 1978.

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Reservoir. The purpose and general objectives of the 1979 public participation activities were as follows:

Purpose: To design, develop and implement a public participation program for the Big River Reservoir Project.

Objectives: To provide a mechanism for the two-way flow of communication between the Corps of Engineers and the interested public during the period March 27 to November 27, 1979, when final water resource alternatives would be developed and evaluated.

To inform the public of progress on the study.

To facilitate public input to the decision-making process as detailed alternatives are developed, evaluated and recommendations made.

URI assumed a multiple role in the public participation component of the planning process. URI has served in an intermediary capacity; serving both the Corps and citizen alike; it has played a key role in plan definition; it has been a catalyst in bringing together concerned individuals and state officials in an organized consumer advocacy model, the Project Working Committee (PWC); it has structured a mechanism within a public forum for two-way dialogue, and it has provided an information exchange; reports, reviews and bulletins for the citizens, newspaper articles and memoranda documenting citizens viewpoints, and critiques of Corps presentations. It has focused the Corps Feasibility Study through its use of social planning techniques, particularly the citizen-based identification of issues and issue elaboration, and has acted as a conduit for resources to and from the greater Rhode Island community.

On a more fundamental level, the URI Big River Public Participation Project team conceptualized and designed this approach for public participation. It is oriented to meet the goal of informed citizen participation in the decision-making process, in the formulation of alternatives and initial identification of the preferred alternatives for the proposed Big River Reservoir Project. The public participation component has been an on-going process running concurrently with the Corps planning phases.

SCOPE OF THIS REPORT

While a Final Report was developed summarizing the outcomes of the Fall 1978 public participation activities, this report encompasses all of URI's public participation activities during the entire planning process to date.

The next chapter examines the concept and reality of public participation and its role in the Corps planning process. Public participation is a requirement in all such federal undertakings; and the means used to incorporate such participation within the planning process is critical to the success of the Feasibility Study. Succeeding chapters establish the development and modification of this model to the Corps planning process. Chapter 3 specifically indicates how the model was employed to facilitate the public involvement necessary for a successful input into the Feasibility Study. Chapter 4 highlights the themes and issues emerging from URI involvement and identifies the remaining critical issues still to be dealt with by the Corps in the Feasibility Study. Finally, Chapter 5 presents recommendations on future strategies for public participation.

CHAPTER 2

THE CORPS PLANNING PROCESS AND PUBLIC PARTICIPATION

BACKGROUND

The past several years has witnessed an increasing involvement by the public in governmental decision-making. This involvement has been shared by citizens directly impacted by governmental decisions and also those citizens possessing a broad interest in a particular decision. These latter participants possess, in many cases, a right of intervention as powerful as those who are directly impacted. Public participation in federal programs, unlike that in local government, has emerged only during the past two decades. It is a right won through Congressional legislation, judicial decisions and the weight of public opinion.

A strong impetus to public participation came in 1954 when regulations of the U.S. Department of Housing and Urban Development, promulgated under the Housing Act of 1949 and concerning urban renewal funding, required a city to encourage public participation through the establishment of a citizens' advisory committee to examine program goals (Section 701). But it was not until 1964, when the Economic Opportunity Act was signed into law, that the concept of public participation in government gained momentum.

> "Section 202" (a) provided the term "community action program", meaning a program... (3) which is developed, conducted and administered with the maximum feasible participation of residents of the areas and members of the groups served...

In 1966, Title 42 U.S.C.A. chapter 41, Demonstration Cities and Metropolitan Development Program (Model Cities) provided that a city demonstration program be eligible for assistance only if there was documented widespread citizen participation, and often power was obtained by direct elections of the Model Cities Board by the neighborhood residents.

Along with these and other programs, the National Environmental Policy Act (NEPA) of 1969, (Public Law 91-190) provided that all agencies of the Federal Government shall consider all significant impacts on the environment caused by their actions. Under this act there is a requirement to prepare an Environmental Impact Statement (EIS) as part of the federal agency decision-making process. The statement, and any comments from appropriate federal, state and local agencies, must be made available to the public for review.

Pursuant to the passage of NEPA, it was left to the Courts to decide the specific interpretation to be placed upon its various provisions. The necessity of preparing an EIS and agency guidelines have been decided in cases such as Calvert Cliffs' Coordinating Committee, Inc., v. AEC, 146 U.S. App. D.C. 33,449 F.2d 1109(1971); Natural Resources Defense Council, Inc. v. Morton, U.S. App. D.C. 458 F.2d 827 (1972) and Conservation Council of North Carolina v. Fraehlke, 473 F.2d 664, 4 ERC 2039 (1973).

It is this historical background of legislation, litigation and public sentiment that sets the framework for the current Corps procedures on public participation. These procedures are incorporated in a planning process which attempts to take full cognizance of public comments and viewpoints throughout the project, from problem identification to selection of a preferred plan.

CORPS PLANNING PROCESS

Central to the success of the Corps planning process (as shown in Exhibit 2-1) is the provision for dissemination of as much information as possible to the public.

There are three benefits accruing to the Corps from a carefully constructed citizen participation model. The first is the identification of alternatives by the impacted citizen so that fresh and varied approaches may be evaluated. Second, a sound citizen participation program can better combine existing Corps material and planning resources with local area inputs. One outcome may be the integration of local-federal planning efforts. A third benefit is the meaningful participation of impacted communities into the decision-making process. This benefits a project since a sense of cooperation is fostered among all parties.

The Handbook for Environmental Impact Analysis[2] outlines a range of citizen participation techniques which have been employed by Federal

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[2] Handbook for Environmental Impact Analysis (Dept. of the Army, Washington, D.C.) 1975.

EXHIBIT 2-1

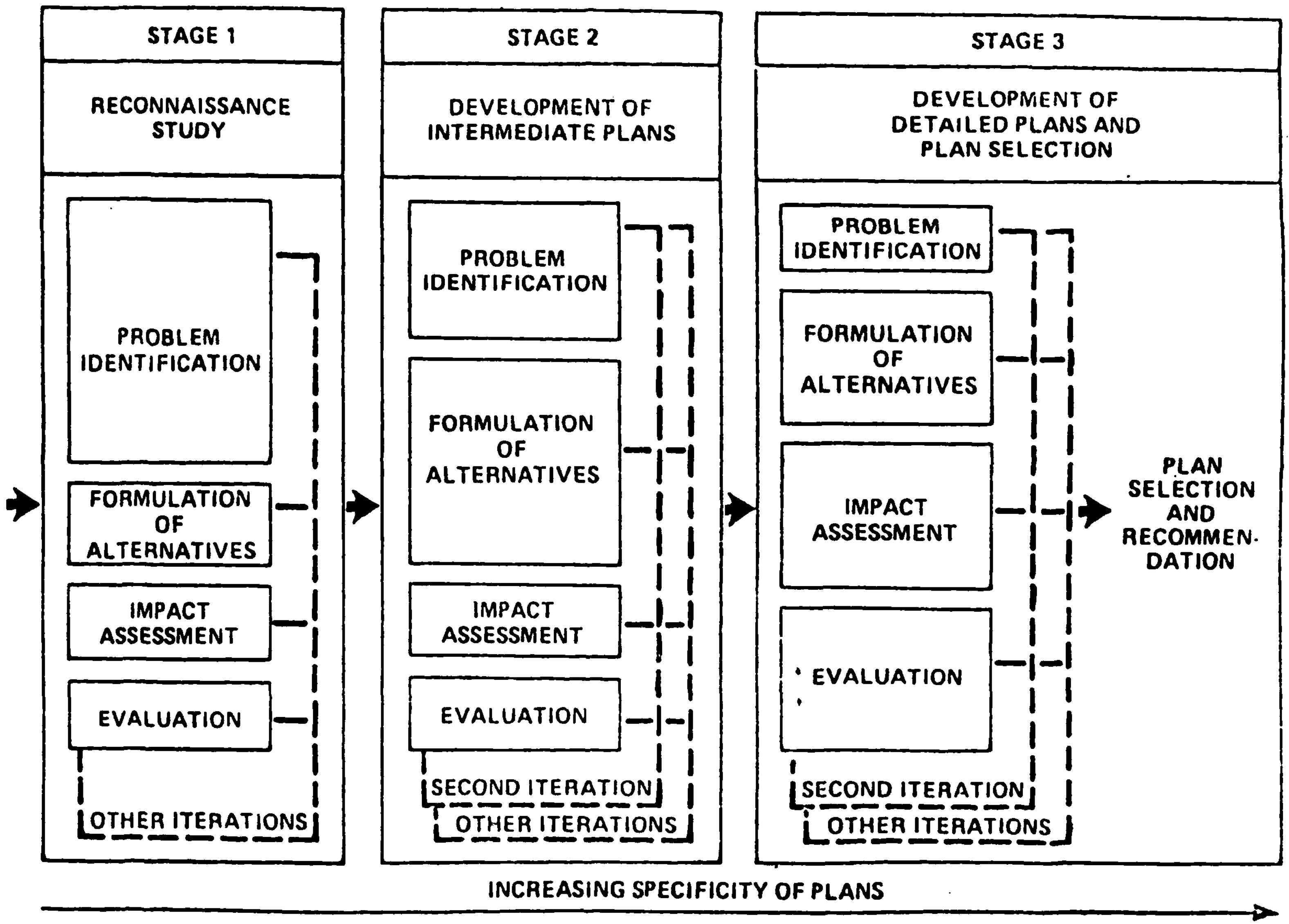

FIGURE 1: GENERAL RELATIONSHIP OF PLAN DEVELOPMENT STAGES AND FUNCTIONAL PLANNING TASKS

Source: U.S. Army Corps of Engineers

agencies to obtain citizen information (see Exhibit 2-2). Each achieves certain objectives and can be characterized by varying degrees of citizen involvement. The strategy in the 1978 series of workshops involved the following elements:

1. Public Meetings
2. General Public Information Meetings
3. Information Coordination Seminars
4. Information Brochures and Pamphlets
5. Material for Mass Media
6. Response to Public Inquiries
7. Letter Requests for Comments
8. Workshops
9. Informal Small Group Meetings

As the report for the Fall 1978 workshops stated:

> "An analysis of these techniques, using the assigned values and matrix of planning objectives, reveals that a medium degree of communication of the Corps' involvement in Big River to the public was achieved by the development of this particular model. The level of contact sufficiently meets the program objectives of citizen participation and has increased as the Feasibility Study proceeded. Further, an examination of the techniques utilized in the program shows that major efforts have been made to inform and educate the public in the Corps' involvement, obtain community input on issues which would receive the Corps' review and gain feedback from the public on other areas to be looked at by the Corps."

In the June, 1979 workshops the elements discussed earlier were integrated with techniques of a more intensive nature, eighteen in all were utilized:

1. Public Meetings
2. Informal Small Group Meetings
3. General Public Information Meetings
4. Presentations to Community Organizations
5. Information Coordination Seminars
6. Local Planning Visits
7. Information Brochures and Pamphlets
8. Field Trips and Site Visits

EXHIBIT 2-2

Communication Characteristics			Public Participation Techniques	Planning Objectives					
Degree of 2-Way Communication	Level of Public Contact Achieved	Ability to Handle Specific Interest		Inform/Educate	Identify Problems/Values	Get Ideas/Solve Problems	Feedback	Evaluate	Resolve Conflict/Consensus
2	1	1	Public Hearings		X		X		
2	1	2	Public Meetings	X	X		X		
1	2	3	Informal Small Group Meetings	X	X	X	X	X	X
2	1	2	General Public Information Meetings	X					
1	2	2	Presentations to Community Organization	X	X		X		
1	3	3	Information Coordination Seminars	X			X		
1	2	1	Operating Field Offices		X	X	X	X	
1	3	3	Local Planning Visits		X		X	X	
1	3	1	Class Action Litigation	X		X	X		X
2	2	1	Information Brochures and Pamphlets	X					
1	3	3	*Field Trips and Site Visits*	X	X				
3	1	2	Public Displays	X		X	X		
2	1	2	Model Demonst ation Projects	X			X	X	X
3	1	1	Material for Mass Media	X					
1	3	2	Response to Public Inquiries	X					
3	1	1	*Press Releases Inviting Comments*	X			X		
1	3	1	Letter Requests for Comments			X	X		
1	3	3	Workshops		X	X	X	X	X
1	3	3	Charettes (Intensive decision-making, setting)			X		X	X
1	3	3	Advisory Committees		X	X	X	X	
1	3	3	Task Forces		X	X		X	
1	3	3	Employment of Community Residents		X	X			X
1	3	3	Community Interest Advocates			X		X	X
1	3	3	Ombudsman or Representative		X	X	X	X	X
2	3	1	Environmental Impact Statement Review by Public	X			X	X	

1 = Low; 2 = Medium; 3 = High

Source: Handbook for Environmental Impact Analysis. Dept. of the Army, Washington, D. C., 1975.

9. Public Displays
10. Material for Mass Media
11. Response to Public Inquiries
12. Press Releases Inviting Comments
13. Letter Requests for Comments
14. Workshops
15. Advisory Committees
16. Community Interest Advocates
17. Ombudsman or Representative
18. Environmental Impact Statement Review by Public

The assessment, based on the Corps weighted matrix, characterized these techniques as achieving a strong degree of two-way communication, a high level of public contact and a medium/high ability to handle specific interests. This result meets the goals and objectives of this study as described in the Proposal and Contract.

URI PUBLIC PARTICIPATION APPROACH

The public participation approach developed by URI and approved by the Corps, was influenced by the Corps' planning process. As seen in Exhibit 2-1, there are three distinct planning stages. For the Big River Reservoir planning process, the Reconnaissance Study stage largely took place in 1978 while Stage 2, the development of intermediate plans, began in Spring, 1979. URI's involvement in public participation during August and September 1978, the Reconnaissance Study stage, was largely committed to issue identification. The specific purpose and scope were:

Purpose: To identify specific issues and concerns and to obtain input and response on the issues while informing the public of the proposed Big River Reservoir Project.

Objectives:

A. Inform and involve the public who were to be asked to identify important issues.

B. Obtain inputs to be used in the development of further planning strategies.

C. Question formulation and explicit identification of important issues.

D. Attempt to identify preferred options.

E. Development of a final report to be utilized in future citizen participation efforts.

F. Through the workshop format, identify future steps to be taken in the public participation program.

The meaningful involvement of citizens included two broad activities: First, the dissemination of information about the workshops and, second, the development of the workshops themselves. The former was a multi-faceted process and is described in Chapter 3. It was, given the time constraints, as complete as possible.

The U.S. Army Corps of Engineers encouraged a format for the workshops which would meet the goal of meaningful input on the part of the citizens of Rhode Island. The staff development of the workshop models was brought about through discussions with many groups. The significant objectives of the models were that it would be:

1. Open to all.

2. A forum where participants had equal opportunity to join in the dialogue and have an impact on the study.

3. An atmosphere conducive to informed discussion.

Therefore, the general format which emerged was a workshop or seminar discussion group rather than a formal series of public hearings. The latter usually deteriorating into one way pronouncements rather than a means for encouraging dialogue. Moreover, since informed discussion was desired, a set of background materials was prepared for the meetings and resource persons were invited to attend the workshops.

URI's involvement in the 1979 public participation activities largely coincided with the Corps' "development of intermediate plans" stage. Because the Corps wanted public reaction to its specific alternative proposals, the public participation process called for a more comprehensive strategy. As originally intended, the Corps desired initial public reaction to its alternative plans in June, 1979. This public input would then be used by the Corps to screen its alternatives into fewer and more detailed proposals. These proposals would then be presented to the public in September, 1979 for review prior to the Corps embarking on Stage 3. Because of delays in developing detailed costs, a crucial input in the development of any proposal, the more refined and detailed proposals were not developed during the course of URI's public participation involvement. Whereas two series of workshops were planned in June and September, only one series was ultimately held.

Despite the delays in the Corps' planning process, the nature of Stage 2 Corps planning called for public participation mechanisms that could accomplish the following:

- Inform a wide variety of publics about the Corps planning process and proposals.

- Define and consider specific issues across a number of disciplines associated with the Big River project.

- Develop two-way interaction between the Corps and the different publics impacted by the Big River project.

URI developed several major public participation components to accomplish these general objectives. These included:

- A Core Staff. URI developed a public participation staff to accomplish all of the public participation activities during the planning process. This staff provided an on-going team of personnel ready to deal with all the different publics; a means for managing each of the specific participation techniques; and a link between the Corps and the public.

- A Project Working Committee (PWC). The PWC was established after the June 1979 workshops to provide a citizen-based on-going intermediary between the Corps and the public. Specifically, the development of the PWC:

  "is predicated upon three main objectives: First, to provide a structure for a dialogue on critical issues and to provide for information dissemination in addition to the formal workshops through an informal atmosphere. Second, to obtain a diverse representation of interests, agencies, and groups which would provide their own membership with information on specific issues of concern to each of those groups. Third, to create a group that would have an opportunity to review proposed alternatives in greater detail than might ordinarily be available during a large workshop. The PWC provides a formal independent forum for the recommendations emerging from the citizen participation process into the Corps' decision process. It acts as a separate entity from the project staff and advises both the staff and the Corps on the technical and policy issues. It also brings together a newly developed constituency which reviews the Corps work from a public interest and multi-dimensional approach."

- Multi-faceted Participation Mechanisms. The Corps' Stage 2 planning required a variety of techniques to disseminate information to the public and to provide input to the Corps. For example, a more comprehensive communications strategy was designed to ensure public awareness of the Corps' proposals and their impacts. Briefing sessicns to deal with complex, in-depth issues raised during the June, 1979 workshops were developed. Chapter 3 describes each of the participation mechanisms employed.

- An Expanded Mailing List. While the project staff developed a more comprehensive communications strategy involving use of print and broadcast media, they also realized that direct mail is still one of the best ways of reaching the public interested in, and impacted by, the Big River project. Consequently, the initial mailing list developed in Fall 1978 was expanded and further stratified to enable targeted mailings. A mailing list is a key lifeline in any public participation strategy. Appendix A reproduces the mailing list as of October, 1979.

CHAPTER 3

PUBLIC PARTICIPATION ACTIVITIES DURING THE BIG RIVER RESERVOIR FEASIBILITY STUDY

INTRODUCTION

As discussed in Chapter 2, type and extent of public participation activities conducted by URI and the Corps during the current planning process has been influenced by the Corps' planning stages. The 1978 public participation activities were primarily focused on issue identification using a citizen-based approach. Many of these issues were addressed by the Corps during the plan development stage in 1979. As the Corps presented more refined proposals to the public for consideration in 1979, the focus of the public participation efforts included issue identification. In addition, the public participation mechanism also accommodated the public's reaction to specific proposals. Thus, the public participation activities in the 1979 phase of URI's effort were structured to provide the public with information on the Corps' proposals; to refine and further identify issues; and to allow the public to state its preferences for specific alternatives.

This chapter is organized around specific activities used during the public participation process throughout the Big River Reservoir planning process to date. Because of distinct differences between the Corps' planning process in 1978 and 1979, the public participation activities have also differed. Where appropriate, differences in the manner in which activities were implemented between 1978 and 1979 are noted.

The activities have been broadly categorized under two classifications - Information Exchange and Public Meetings.

INFORMATION EXCHANGE

URI employed a variety of techniques to provide the public with information about the Corps' planning process and the Big River Reservoir issues, and, in turn, used a number of techniques to receive input from the public.

Meeting Notifications

A significant portion of the pre-workshop and pre-meeting efforts by URI was devoted to publicity with the intention of informing as many citizens, interest groups, and State agencies as possible about upcoming Corps meetings. The following techniques were used:

- Direct mail
- Newspaper advertisements
- Press releases
- Radio public service announcements
- Flyers
- Personal telephone calls

Examples of the first two techniques are shown in Appendix B.

As discussed in Chapter 2, a stratified mailing list was developed and continuously revised during the course of the project. This list was used for stratified direct mailing of meeting notifications for workshops, PWC meetings, and briefing sessions.

These efforts were expanded to include as wide a public as possible in the study area and nearby communities. The media strategy increased significantly between the 1978 and 1979 public participation phases. The media mailing list (as of August, 1979) included twenty-six newspapers, fourteen radio stations, and all three local television stations. These media contacts are shown in Exhibit 3-1. At several critical points during the project, the media published stories about the Big River Study in conjunction with information about Big River workshops. Example stories are shown in Appendix B.

EXHIBIT 3-1

UNIVERSITY OF RHODE ISLAND/U.S. ARMY CORPS OF ENGINEERS
BIG RIVER RESERVOIR PUBLIC PARTICIPATION PROJECT

Media Mailing List
August 1979

Newspapers

Chariho Times
Coventry Townsman
Cranston Herald
Cranston Mirror
East Greenwich Pendulum
East Providence Post
East Side-West Side Newspaper
Echo
Evening Times
Fresh Fruit
Lincoln-Cumberland Observer & News
Narragansett Times
New Paper
North Smithfield-Burrillville Observer
Observer Publications, Inc.
Pawtuxet Valley Daily Times
Phoenix-Times Newspapers
Providence Journal-Bulletin
Providence Visitor
Rhode Island Pendulum
Standard Times
The Observer
Warwick Beacon
Waterways (RI 208 Newsletter)
Westerly Sun
Woonsocket Call

Radio Stations

WBRU, Providence
WCVY, Coventry
WEAN, Providence
WERI, Westerly
WHIM, East Providence
WHJY, East Providence
WICE, Providence
WJAR, Providence
WKRI, Providence
WPJB, Providence
WPRO, East Providence
WRIB, East Providence
WWON, Woonsocket
WLKW, Providence

Television Stations

WJAR, Channel 10
Providence

WPRI, Channel 12
East Providence

WTEV, Channel 6
Providence/New Bedford

Newspaper advertisements to publicize meetings were run in area newspapers. The following newspapers were used during the study to formally advertise public workshops:

- Coventry Reminder
- Coventry Townsman
- Cranston Herald
- Pawtuxet Valley Times
- Providence Journal-Bulletin
- Warwick Beacon

Flyers were initially employed to announce meetings prior to the second and third workshops in 1978. A major publicity thrust was then developed canvassing the impacted towns of West Greenwich, Coventry, East Greenwich and Exeter. Flyers were distributed advertising the workshops to be held in the area and were placed in business centers and Town Halls; five hundred flyers were distributed to the Exeter/West Greenwich schools prior to the June, 1979 workshop in Coventry. Following the second meeting, 4000 flyers were distributed to school age children (K-8) attending school in the towns of Coventry, Exeter and West Greenwich with the approval of the Superintendent of Schools.

A "radio spot" message was provided to several radio stations prior to the June, 1979 workshops. Many stations, including WPRO in East Providence which has the largest radio audience in the state, broadcast the message prior to the June workshops. See Appendix B.

Technical Abstracts

Technical abstracts or fact sheets were primarily used during the 1979 public participation activities to assist public understanding of the Corps technical documents. The material was a summary of technical reports by Corps' consultants and provided a common information base for discussions at the workshops and informal briefing sessions. The material was mailed to participants prior to the meetings and copies were also available at the meetings (see Exhibit 3-2). The Historic Preservation Fact Sheet presented key tables showing pertinent structures and relevant maps. The Geotechnic, Engineering, and Hydrologic

EXHIBIT 3-2

TECHNICAL ABSTRACTS

TITLE	DATE DISTRIBUTED	PURPOSE/MEETING
1. Public Workshop Information Package	May/June 1979	Pre-workshop Information
2. Background Material: Walter Nebiker Report on Historic and Cultural Resources	August 2, 1979	Briefing Session I
3. Fact Sheet: Engineering, Geotechnic and Hydrologic Issues	September 18, 1979	Briefing Session II
4. Fact Sheet: U.S. Army Corps of Engineers Assessment of Needs for the Big River Reservoir	August 29, 1979 September 18, 1979	PWC Meeting Briefing Session III
5. Fact Sheet: Sensitivity Analysis of Existing Water Demand Projections for the Big River Reservoir Study Area	September 21, 1979	Follow-up for PWC Meeting
Source: Compiled by URI Big River Reservoir Staff, November 1979		

Fact Sheet was somewhat more comprehensive and complex with attached maps and comments. Both were useful to the citizen participants and the speakers.

A fact sheet discussing the Corps' methodology for projecting water demand was initially presented at a Project Working Committee meeting and made available at the second briefing session. Additional memoranda by PWC participants were developed in response to specific requests for further study of the Corps Demand Model and its underlying population projections (see R.I. Statewide Planning Program, Technical Paper No. 25, April 1975). The material, which ultimately was quite extensive, was quite helpful in understanding the structure of the model, its variables and assumptions and in assessing the impact of the population projections utilized due to the timeline of the Corps. The demand model was also discussed within the context of impacts of conservation measures and a technological policy response to the energy crisis.

Meeting Summaries

An essential activity in any public participation program is documentation of public input during meetings. URI used three techniques to ensure such input:

- Direct mailing of meeting minutes
- Press coverage of workshops
- Project newsletter

Great care was taken throughout the project to record the minutes of each of the types of meetings held - workshops, PWC meetings, briefing sessions. All of these minutes were forwarded to the Corps for their files. Fortunately, through implementation of the media strategy, coverage of the workshop meetings occurred. An example of this coverage is shown in Exhibit 3-3.

Big River Reservoir UPDATE, Bulletin of the URI Public Participation Project was a very successful communications/information exchange technique which had the additional advantage of keeping the issue of Big River Reservoir before the public at the time when meetings, briefing sessions, or other direct face to fact activities were not scheduled. (See Exhibit 3-4).

EXHIBIT 3-3

EXAMPLE OF NEWSPAPER FOLLOW-UP
STORY TO BIG RIVER RESERVOIR WORKSHOP

Reservoir's nearness to highway defended

By GREGG KRUPA
Journal-Bulletin Staff Writer

West Greenwich

WEST GREENWICH — Representatives of the University of Rhode Island and the Army Corps of Engineers sought last night to persuade property owners in the area of the proposed Big River Reservoir that their land will not be affected by the project's seepage, and that the reservoir will not significantly increase the chances of flooding along the Pawtuxet River.

The 52 persons who attended the session at the Metcalf Middle School seemed most interested in whether the drinking water to be produced by the proposed reservoir is actually needed and of the effect of Route 95 on the project.

The federal Environmental Protection Agency recently objected to the state's plan to build Route 84 across the Scituate Reservoir, saying such construction would unduly risk fouling the waters.

John Craig, who managed a $500,000 feasibility study conducted by the Corps, said that specific protections against possible contamination from Route 95 were not included as part of the study. He did say, however, that the study concluded that the project was feasible even though the highway would cross the reservoir once and run adjacent to the water for about 3,000 feet.

Craig said the problems of protecting the reservoir from the highway would be addressed in further engineering studies.

He told area residents and officials who attended the meeting that Route 128 in Massachusetts runs adjacent to the Cambridge, Mass., water supply without apparent problems.

Craig also said that while recent studies released by the Rhode Island Division of Statewide Planning indicate that the population increase in the next century will not be as severe as once expected, the Corps study indicates that the reservoir is still needed.

"It seems to be the most feasible alternative to the need for the water supply of the 17 communities in question," Craig said.

Source: Providence Journal-Bulletin, September 19, 1979

UPDATE, Vol. 1, No. 1, (July 1979) presented preliminary information on the Historic Preservation Briefing Session, discussed the formation of the PWC and invited membership. It also described the key issues raised at the workshops and indicated that follow-up meetings with the Corps would take place leading to more specific responses.

UPDATE Vol. 1, No. 2, (August 1979) sent to a larger mailing list, reviewed the Historic Preservation Briefing Session, discussed the next public meeting and continued to report on the activities of the PWC.

UPDATE Vol. 1, No. 3 (October 1979) was, by demand, a much expanded Bulletin. It reviewed the second Briefing Session which explored the engineering and hydrologic aspects of the proposed reservoir construction, and then focused on the next meeting of the PWC which was organized to discuss state plans for the coordination of water quality management with water resource development. Other items covered in the expanded bulletin were the Interim Report of the University of Rhode Island staff, the August 29th discussion by the PWC of the Corps' methodology for assessing projected water demand and a formal statement of PWC purposes and goals.

Exhibit 3-4

UPDATE Newsletter Distribution

MAILING DATE	TITLE	SENT TO
July 26, 1979	Big River Reservoir UPDATE Vol. 1, #1 July 1979	800 on revised mailing list
August 10, 1979	Big River Reservoir UPDATE Vol. 1, #2 August 1979	590 on revised mailing list
October 5, 1979	Big River Reservoir UPDATE Vol. 1, #3 October 1979	625 on revised mailing list

Miscellaneous Media Coverage

In addition to newspaper stories and radio announcements concerning upcoming Big River meetings, the media also covered the Big River Reservoir issue at other points in the public participation process. This coverage was directly attributable to URI's media strategy and efforts. As an illustration, the chief environmental reporter for the Providence Journal has become much more aware and interested in the issues and has written articles and an editorial since the inception of URI's public participation activities. Some examples of the Journal's coverage is shown in Appendix C.

Finally, "Area 12", a local program of Channel 12, which serves all of Rhode Island, featured the Big River Reservoir issue. The program was presented on Sunday, June 10 and included as participants: Mr. John Craig, U.S. Army Corps of Engineers; Mr. Robert Russ, Rhode Island Water Resources Board; and Mr. Alfred Hawkes, Rhode Island Audubon Society. These persons represented various stands on the issues under discussion.

Formal Public Input Techniques

The meetings with the public and different groups and agencies discussed below were the principal means of public participation/interaction during the project. The minutes of these meetings are, of course, a record of the public comments. In addition, however, a number of specific techniques were employed to gather public viewpoints. Three techniques were used at various points in the process:

- Key informant interviews
- Written public statements
- Structured survey instruments

Key informant interviews were principally used during the 1978 portion of the planning process. These interviews were conducted after a review of previous Big River documents. The review of the relevant documentation on Big River allowed the staff to identify some of the key persons who would be concerned or involved in the development of Big River as a reservoir. Interviews with key State agency members, along with advocacy and interest groups, highlighted and brought additional insight to the issues and concerns. These persons were able to relate their agency and group's perspective on the proposed development and focused on those issues which should receive attention in a public forum. The State agencies and public citizen groups included:

Agency	Contact
Audubon Society of Rhode Island	Alfred Hawkes
Ecology Action of Rhode Island	Bonnie Cimino/Barry Schiller
Environmental Consultant	Dr. John Kupa
Kent County Water Supply	Norman St. Serveire
Natural Resources Group	Dr. Arthur Jeffrey
Office of the Governor	Anne Stubbs
Providence Dept. of Planning and Urban Development	John R. Kellam
Providence Water Supply Board	Peter J. Granieri
R.I. Dept. of Environmental Management	Calvin Dunwoody
R.I. Federation of Riding Clubs	Joan Burgeault
R.I. Department of Health	John Hagopian
R.I. Trail Advisory Group	Jack Deary/Joan Burgeault
R.I. Water Resources Board	Peter Calise
R.I. Statewide Planning Program	J. Deary/V. Parmentier George Johnson
Town of Coventry	James Clarke
Town of East Greenwich	J. Burke/S. Deutch
Town of West Greenwich	Robert Maguire
U.S. Army Corps of Engineers	John Craig/Larry Bergen

These interviews provided a basis from which to develop a preliminary identification of issues surrounding the Big River Reservoir.

The public was encouraged to develop their viewpoints into formal public statements and to submit them for inclusion in the public participation materials presented to the Corps. This was most successful during the 1978 phase of the project. Two examples, one from the 1978 phase and one from the 1979 phase are included in Appendix D.

The project staff developed a questionnaire for the June, 1979 workshops in order to solicit views concerning Corps' alternatives and impact issues. This survey instrument, and its results, are shown in Appendix E.

MEETINGS

As discussed in Chapter 2, a number of different public meeting formats were employed during the project to provide a forum for public discussion of the Big River Reservoir. The three major types of meetings - Workshops, Briefing Sessions, and PWC meetings - are discussed briefly below. Also discussed are the agency follow-up meetings.

Workshops

Public workshops were the principal mechanism employed in providing a forum within which the public and representatives of the Corps could interact. A key characteristic of the public workshops was the audience - a comprehensive and varied group of participants were invited to the workshops. See Appendix A for the mailing list. The workshops were designed to be conducted using an open discussion format rather than a traditional public hearing format. Because of the inherent differences between the planning stages, the 1978 workshops differed somewhat from the 1979 workshops. The Fall, 1978 workshops were intended to identify issues of importance associated with a potential Big River Reservoir. Thus, formal presentations were kept to a minimum. The basic components common to all three of the Fall, 1978 workshops were the following:

- First, a statement of the purposes of the meeting by the moderator, an explanation of the focus on issue identification due to the needs of the feasibility study, then an introductory discussion by concerned state agencies and public interests followed by a short question and answer session to clarify the position of those resource-concerned interests who agreed to speak.

- A second component had participants break up into small groups for a roundtable discussion whose goal was an analysis of the preliminary issue list and development of specificity on particular issues in order to elaborate and add to the initial preliminary list of issues. Specificity about issues of concern to the participants was requested by the Corps in order to better address those issues within the Environmental Impact Statement.

- A third component phase had the total group reconvene and a member of each roundtable discussion group would report upon the issues that the group felt to be of significance. An attempt at setting priorities was made by the group.

These components were varied slightly during the first three workshops.

During the June, 1979 workshops, the Corps presented its preliminary alternative proposals. This necessitated a different format than used in the 1978 workshops. About 50% of the workshop time during the 1979 workshops was devoted to Corps' presentation of its findings and alternatives. Consequently, the second major component of these workshops was public reaction to the Corps' proposals. As in the first session of workshops held in 1978, URI moderated the workshops and helped to stimulate public input and Corps response.

The workshop locations were carefully considered prior to scheduling. Exhibit 3-5 illustrates the location and dates of the workshops. The communities were selected based on the project staff's understanding of which publics would be impacted by the Big River Reservoir. Facilities were selected after consideration of accessibility and availability. The facilities had to be suitable for a workshop format, large enough to hold 50-200 people, yet not so large as to constrain public input.

Briefing Sessions

One briefing session was held in the 1978 phase and four briefing sessions were held during the 1979 phase. The 1978 briefing session was held after the formal workshops. The purpose of the briefing sessions was to focus on specific issues. Exhibit 3-6 indicates the briefing session dates, topics, and attendance.

The 1978 briefing session, held in September, 1978, was designed to allow key project participants to review the draft of the Final Report on the September workshop series. That report has been previously submitted to the Corps.

The 1979 briefings were originally intended to provide a link between a June, 1979 series of workshops and a September, 1979 workshop series. The latter did not occur because of delays in getting Corps' proposals finalized.

EXHIBIT 3-5

BIG RIVER RESERVOIR PROJECT
PUBLIC PARTICIPATION WORKSHOPS

Fall, 1978 and June, 1979

WORKSHOP	DATE	LOCATION
Workshop I	September 7, 1978	University of Rhode Island Extension Division Providence, Rhode Island
Workshop II	September 14, 1978	Metcalf Middle School West Greenwich, Rhode Island
Workshop III	September 18, 1978	Coventry High School Coventry, Rhode Island
Workshop IV (Working Session)	September 25, 1978	State House Providence, Rhode Island
Workshop I	June 13, 1979	University of Rhode Island Extension Division Providence, Rhode Island
Workshop II	June 14, 1979	Warwick Community Center Warwick, Rhode Island
Workshop III	June 18, 1979	Coventry High School Coventry, Rhode Island

EXHIBIT 3-6

BRIEFING SESSIONS

TOPIC	DATE	ATTENDANCE
Working Session on 1979 Workshop Final Report	September 25, 1978	30
Briefing Session I: Historical Preservation	August 2, 1979	38
PWC Meeting: Corps' Water Supply Demand Model	August 29, 1979	10
Briefing Session II: Engineering, Geotechnic, and Hydrologic Issues	September 18, 1979	50
PWC Meeting: "208" Wastewater Treatment	October 23, 1979	15

Source: Compiled by the URI Big River Reservoir Project Staff, November 1979

The purpose of the 1979 briefings was to examine several critical issues that were raised by participants in the June, 1979 workshops.

It was determined as an outcome of the June public workshops that at least six issue areas remained of critical concern to citizens.

1. Historic Preservation
2. Recreation and Wildlife Management
3. Geotechnical and Hydrological Concerns
4. Demand Projections
5. Waste Water Treatment
6. Financial and Management Issues

as well as the following issues involving State policies:

1. Cost to the state of the project, the timing and the way in which fiscal inputs will be made.
2. Selection of an agency to manage the project.
3. Coordination of waste water treatment with water resource development.

The Briefing Sessions were designed to examine these issues separately and in-depth. Moreover, since several of the Corps' component studies were not completed on schedule, it allowed for a continuity of discussion concerning critical issues of concern to the participants.

Of the six critical areas, Number 1, Historic Preservation, and Number 3, Geotechnical and Hydrological concerns, were held as Briefing Sessions. Number 4, Demand Projections and Number 5, Waste Water Treatment, were discussed at PWC meetings. These meetings all included substantial pre-meeting information materials, evaluation questionnaires and follow up referrals.

Each Briefing Session followed the same general process and format. The identification of the issue/problem area was determined and approved by the Corps and the PWC from the list generated by the June workshops. Corps personnel working on the issue/problem were asked to speak. Each presentation continued for approximately one half hour. Usually the Corps organized its own segment of the program.

Two weeks prior to the meeting, a mailing was sent to the general mailing list with background material and a preliminary agenda. Radio spots, newspaper stories, advertisements and flyers were also distributed. Previous notification was also done through the bulletin and other mailings.

The location for the major Briefing Sessions was in the impacted area. The first, concerning the historic preservation issues, was held in Coventry at the Payne Community Center on Route 117. The second, at the Metcalf Middle School in West Greenwich, dealt with geotechnical and hydrological engineering issues. Site selection is a critical aspect of the participation process since the meeting should be located in an area of maximum accessibility to the potentially impacted citizens. When the meetings have been held elsewhere in the study area, attendance has been much lower.

Project Working Committee Meetings

As discussed in Chapter 2, the Project Working Committee (PWC) was developed to provide an on-going mechanism for public participation in the Big River Reservoir planning process.

At the conclusion of the first workshop series, the role of the PWC was expanded and emphasized. It became the continuity and link with the various publics concerned with the reservoir issues. The July 19th meeting participants adopted by-laws and thus formalized the PWC as an entity. The participants also approved an important statement, developed by the staff, of the critical issues which emerged from the Workshops and a preliminary strategy to address these issues in the interim state until the Feasibility Report was published. On August 2nd, a business meeting was held prior to the Briefing Session on Historic Preservation. The membership nominated officers for the PWC and approved a final strategy paper.

The August 29th PWC meeting was of note for its discussion of a possible extension of the URI contract, since the Corps had said that it could not meet the original due dates. The PWC supported this extension. The second part of the meeting was devoted to a presentation and an intensive discussion of the Corps water demand model given the implications of the new population projections by Statewide Planning. The PWC directed URI staff to send a formal memorandum requesting the Corps to reconsider the demand curve based on new information.

The last meeting of the PWC took place on October 23rd, whence the staff announced the Corps' decision not to extend the contract and to continue public participation through an in-house staff. Many concerns were expressed as described in the minutes. The last part of the meeting consisted of a discussion under the leadership of Tom Bruekner, "208" Study Project Manager, concerning the relationship of wastewater treatment to the Big River Reservoir. Exhibit 3-7 indicates the dates and topics of the PWC meetings.

Agency Follow-up Meetings

Throughout August and early September follow-up needs assessment meetings were held with sixteen participants. (See Exhibit 3-8.) These meetings reviewed the work of the URI Big River Staff in conducting the June workshops. The meetings also reviewed the initial list of specific issues identified by the participants as those in need of further study and an in-depth discussion of specific impact concerns. These meetings, along with the review by the PWC of the issues, provided a strong input for issue analysis.

EXHIBIT 3-7

PROJECT WORKING COMMITTEE MEETINGS

DATE	TOPIC/ISSUE	ATTENDANCE
June 7, 1979	Organizational Meeting	15
June 1i, 1979	Preview and Critique of Corps Presentation at Workshop Series I	15
July 19, 1979	Approval of By-Laws and of Statement of Issues and Response Mechanism	9
August 2, 1979	Business Meeting/Sponsoring of Briefing Session on Historic Preservation	15
August 29, 1979	Business Meeting/Interim Report/ Discussion of Corps Water Demand Model	9
October 23, 1979	Business Meeting/Discussion of Impact of Proposed Big River Reservoir on Water Treatment -- Tom Brueckner, Project Manager of "208" Study/Discussion of Future of PWC	13

Source: Compiled by URI Big River Reservoir Project Staff, November 1979

EXHIBIT 3 [illegible]

AGENCIES IN THE FOLLOW-UP
NEEDS ASSESSMENT MEETINGS

Agency
Office of the Governor
R.I. Statewide Planning Program
R.I. Water Resources Board
R.I. Audubon Society
Providence Planning and Urban Development
Providence Historic Preservation
R.I. Historic Preservation
R.I. Department of Environmental Management
R.I. Heritage Program
AMC Trail Advisory Committee
Johnson Pond Civic Association
Blackstone River Watershed Association
Coventry Tax Association
Warwick City Planning
R.I. League of Cities and Towns
Providence Water Supply Board

CHAPTER 4

THEMES AND ISSUES EMERGING FROM THE BIG RIVER RESERVOIR PUBLIC PARTICIPATION PROCESS

INTRODUCTION

As discussed in Chapter 2, the U.S. Army Corps of Engineers' planning process for the Big River Reservoir consists of three stages:

- Reconnaissance Study
- Development of Intermediate Plans
- Development of Detailed Plans and Plan Specification

The public participation effort conducted by URI for the Corps in the fall of 1978 was a part of the Reconnaissance Study. The most recent public participation effort during 1979 has accompanied the Corps' development of intermediate plans.

One of the most important objectives of the initial Public Participation Project in 1978 was the identification of issues for the Corps to address during its development of intermediate plans. Specifically, these issues would be considered by the Corps in evaluating water supply needs, in the development of water supply alternatives, in the measurement and evaluation of impacts associated with different alternatives, and in the measurement and evaluation of impacts associated with different alternatives. The 1978 portion of the public participation process was successful in identifying a number of issues considered important by the participants.

The development of intermediate plans by the Corps, initiated in the spring of 1979, has incorporated many of the concerns initially raised in 1978. Not surprisingly, as the Corps' plans have become more developed and specific, additional issues have emerged. The purpose of this chapter is to review how issues have changed in the on-going planning process and to identify for the Corps those issues that should be addressed in the remainder of the planning process.

ISSUES RAISED IN 1978

While participants in the first portion of URI involvement did not have a detailed plan to respond to, the workshop format did precipitate discussion and elaboration on a number of issues. The issues were explicitly not prioritized.

The issues identified in 1978 were classified into the following groups:

- Assessment of Needs
- Fiscal and Management Issues
- Access to Reservoir and Multi-Use of Land
- Legal Issues
- Impact of the Local Communities
- Comprehensive Planning and Citizen Participation

Under each of these categories, issues were presented to the Corps as part of the report for the public participation activities during 1978. There were, for instance, 12 separate issues listed under "Needs Assessment" and these issues ranged from supply alternatives, to demand projections, to gravel sales, to reservoir leakage.

As discussed below, several new issues emerged during the 1979 portion of the public participation process. In order to clarify and classify the various types of issues raised during the entire process, the following issue breakdown is utilized in this chapter:

- Needs Assessment
- Management and Planning Coordination
- Environmental Effects
- Social and Economic Effects
- The Planning Process and Public Participation

Based on this breakdown, the issues listed below reflect the concerns raised by the public during the 1978 portion of the public participation process. While some of these issues were later addressed by the Corps during the 1979 plan development process, it is important to indicate these issues as they were raised in 1978 since they reflect an accurate accounting of how and when issues were raised in the overall public participation process.

Issue Category #1: NEEDS ASSESSMENT

Water Supply Alternatives. Are there other means of meeting the future water supply needs of the State, such as groundwater development, water conservation, or waste water recycling?

Will the Big River Reservoir obviate the need for additional reservoirs such as Wood River?

Can a smaller scale Big River Reservoir satisfy future needs?

Demand Projections. Will the water demand projections reflect current population and land use trends?

To what extent will demand projections be based on projections developed in the State's 1967 Development Plan for Water Supply Resources.

Will future demand projections be integrated with the State's economic development policies?

Issue Category #2: MANAGEMENT AND PLANNING COORDINATION

Who should build, own, and manage the reservoir?

How would alternative institutional arrangements affect the use of the reservoir and its watershed?

Is there a coordinated state water resources management policy?

How should future state water supply decisions be coordinated with state land use and urban growth policies, with waste water disposal, and with water conservation?

How should future water supply from the reservoir be allocated?

Who should make the allocation decisions?

What are the alternative financial arrangements for the construction and operation of the Big River Reservoir?

How should considerations of equity, water conservation, and waste water disposal be incorporated into rate structure decision-making? Who should set and review the rate structure?

How should multiple uses, such as water supply, recreation, flood protection, and wildlife management, be coordinated under the proposed reservoir scheme? Who should determine their compatibility?

How can access to the reservoir area be legally managed and restricted?

Should recreational uses of the reservoir area be financed by user fees?

What are the legal implications of using the reservoir and its watershed?

Issue Category #3: ENVIRONMENTAL EFFECTS

How will the Big River Reservoir's impact on downstream flows affect the following?

- fish and other ecological species
- assimilative capacity of the Pawtuxet River for municipal and industrial wastewater discharges
- flood control
- recreational and boating uses in the Flat River Reservoir

What changes will the reservoir itself have on fish and wildlife in the immediate area?

Will the reservoir affect the groundwater aquifer in the area? Will there be leakage from the reservoir into the surrounding groundwater?

What will be the effect of increased water consumption on municipal waste water treatment plants and the water bodies in which they discharge?

Issue Category #4: SOCIAL AND ECONOMIC EFFECTS

Should reservoir communities be compensated for loss of tax lands?*

How should less quantifiable effects, such as the disruption of the social and physical fabric of the reservoir communities, be considered in the planning process?

What are the rights of former property owners in the reservoir area if the reservoir is not built? What should be the disposition of the land if the reservoir is not built?

If recreation access to the proposed reservoir and to its watershed is limited, what will be the loss in recreational opportunities?

How should the proceeds of gravel and timber sales in reservoir land be used?*

How will the reservoir's impact on downstream flows affect property owners and industrial users of the Flat River Reservoir?

How will riparian rights in the reservoir watershed be resolved?

How will different water supply alternatives affect future land use patterns?

What will be the fiscal (tax base and service costs) impacts of development associated with altered water supply capacity in the state?

Issue Category #5: PLANNING PROCESS AND PUBLIC PARTICIPATION

Can all issues raised during the planning process be addressed?

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* This is an issue which must be decided by the State of Rhode Island

How should public input continue during the Corps' feasibility planning process?

How should a comprehensive water resources management policy be developed to include all affected interests?

ISSUES RAISED IN 1979

While many of the issues raised during the plan development phase in 1979 coincided with the concerns raised in the Fall of 1978, there were some significant differences. Several factors accounted for issues changing or being redefined during the Corps' plan development phase.

Level of Planning

With the presentation by the Corps of more specific plans during the 1979 workshops, additional issues were raised by participants. In some cases, this additional information allowed participants to redefine the comments made initially in 1978.

Public Participation Format

The 1979 public participation mechanisms - workshops, PWC meetings, and briefing sessions - were generally more focused than the 1978 public participation activities. This permitted issues to be discussed in more detail than in 1978.

Participants

While the 1979 public participation efforts attracted many of the same participants as 1978, there were changes. Some of the earlier participants did not participate in the 1979 activities. The 1979 activities, however, attracted many new participants. This may have been due to the more specific nature of the Corps' plans and also due to a better definition of issues addressed in the briefing sessions.

Despite the many changes in issues from 1978 to 1979, there are a significant number of central issues that have remained constant. Presented below is a list of issues raised during 1979. New issues or significant variations on prior issues are noted in CAPITAL LETTERS. Issues that are not repeated from 1978 were either answered or not raised again in 1979. They still may be of concern, however, to various members of the public. It is also important to point out that the issues raised below incorporate the phrases and vernacular used by the participants who raised the issues. Thus, "South County" is used because that is how the issue was stated.

Finally, this represents a comprehensive listing; obviously, not every issue is shared by every participant. The most significant issues, as viewed by the PWC and by URI's interpretation of the public participation process, are discussed in the next section.

Issue Category #1: NEEDS ASSESSMENT

Water Supply Alternatives. Why hasn't more consideration been given to water conservation/demand modification as a supply alternative?

Why hasn't more consideration been given to the development of existing groundwater supplies for meeting future needs? WHY WASN'T DRILLING CONDUCTED TO DETERMINE THE AVAILABILITY OF GROUNDWATER?

CAN THE FLAT RIVER RESERVOIR BE USED AS A WATER SUPPLY SOURCE?

Demand Projections. THE ASSUMPTIONS USED BY THE CORPS ABOUT INCREASING PER CAPITA CONSUMPTION ARE QUESTIONABLE.

THE CORPS' PROJECTIONS ARE BASED ON POPULATION PROJECTIONS (1975 STATEWIDE PLANNING ESTIMATES) THAT OVERSTATE MORE RECENT FORECASTS OF FUTURE POPULATION TRENDS IN THE STUDY AREA. (See Exhibit 4-1.)

WHY WASN'T SOUTH COUNTY AND NARRAGANSETT INCLUDED IN THE STUDY AREA?

Issue Category #2: MANAGEMENT AND PLANNING COORDINATION

Who will build, own, and manage the reservoir?

WHO WILL MAKE THE DECISION AS TO WHAT AGENCY WILL BUILD, OWN, AND MANAGE THE RESERVOIR?

How can increased water supply availability be coordinated with future waste water treatment needs? EXISTING WASTE WATER PLANNING IN THE STATE ONLY GOES TO 1995, YET THE TIME FRAME FOR THE BIG RIVER RESERVOIR IS 2020 AND BEYOND.

CAN THE SCITUATE AND BIG RIVER RESERVOIRS BE JOINTLY MANAGED TO CONTROL DOWNSTREAM FLOW AND FLOOD?

How will recreation access be managed: what uses will be allowed?

How will the costs of the reservoir be allocated among users? HOW WILL THE COSTS ASSOCIATED WITH FLOOD CONTROL AND WATER SUPPLY BE DETERMINED? WHAT IS THE PAYBACK PERIOD FOR THE WATER SUPPLY COSTS?

HOW WILL THE FOLLOWING ISSUES BE MANAGED IN ORDER TO PROTECT THE WATER QUALITY OF THE RESERVOIR?

- USE OF FLAT RIVER RESERVOIR

- USE OF SALT ALONG I-95; USE OF VEHICLES WITH HAZARDOUS WASTE ALONG I-95

- USE OF LAND IN THE WATERSHED NOT PUBLICLY OWNED

<u>Issue Category #3: ENVIRONMENTAL EFFECTS</u>

Will the reservoir be able to maintain the expected water capacity? What will be the effect on nearby groundwater levels? How will this affect septic systems in the area?

Will the proposed dam structure be able to prevent leakage?

How will the reservoir's impact on downstream flows affect the following?

- fish and other ecological species

- assimilative capacity of the Pawtuxet River for municipal and industrial waste water discharges

- flood control

- recreational and boating uses in the Flat River Reservoir

What changes will the reservoir itself cause on fish and wildlife in the immediate area?

What will be the effect of increased water consumption on municipal waste water treatment plants and the water bodies in which they discharge?

Issue Category #4: SOCIAL AND ECONOMIC EFFECTS

Will local communities be compensated for loss of land by some type of in-lieu-of-tax payment?

WHAT HISTORIC RESOURCES WILL BE AFFECTED BY THE RESERVOIR? HOW WILL THESE LOSSES AFFECT THE DECISION-MAKING PROCESS? HOW WILL ADVERSE EFFECTS BE MITIGATED?

IS IT APPROPRIATE FOR THE RHODE ISLAND HISTORIC PRESERVATION COMMISSION TO DO THE HISTORIC RESOURCES INVENTORY GIVEN THAT THE STATE HISTORIC PRESERVATION OFFICER IS ALSO ON THE STATE WATER RESOURCES BOARD?

HOW, IF AT ALL, WILL DOWNSTREAM USERS AND FLAT RIVER RESERVOIR PROPERTY OWNERS BE COMPENSATED FOR DOWNSTREAM FLOW LOSSES?

If recreation access to the proposed reservoir and to its watershed is limited, what will be the loss in recreational opportunities?

HOW MANY CANOE MILES WILL BE DISPLACED BY THE RESERVOIR?

Issue Category #5: PLANNING PROCESS AND PUBLIC PARTICIPATION

WHAT EFFECT WILL THIS PUBLIC PARTICIPATION EFFORT HAVE ON THE CORPS' FINAL PLAN? HOW DO THE STATE AGENCIES AFFECT THE CORPS' DETERMINATION OF A FEASIBLE PROJECT?

HOW CAN THE PUBLIC PARTICIPATE IN THIS PLANNING PROCESS WITHOUT COPIES OF THE DRAFT PLAN AND EIS AVAILABLE FOR ALL TO REVIEW?

HOW WILL THE CORPS HANDLE PUBLIC PARTICIPATION AFTER URI'S PARTICIPATION IS COMPLETED?

ISSUES TO BE ADDRESSED BY THE CORPS DURING THE REMAINDER OF THE PLANNING PROCESS

As seen in an examination of the two lists, many of the issues from 1978 do not appear. This reflects the fact that the Corps addressed these issues in the public participation process. And, many new issues, such as historic preservation, have been adequately addressed by the Corps given the better level of detail provided in 1979.

It is also clear that many of the issues raised by the public, both in 1978 and 1979 cannot be adequately addressed until more detailed, site specific, planning is conducted. Many of the geotechnical issues, particularly those relating to groundwater effects, will require the Corps to provide additional information to the public.

One attempt made during the 1979 public participation effort was to determine the public's concerns and preferences through the use of a survey instrument at the workshops. The results of this survey are shown in Appendix E. Based on this questionnaire, and more importantly on a qualitative evaluation of the issue discussions at the workshops, the PWC meetings, and the briefing sessions, the following issues appear to be key areas the Corps should focus on during the remainder of the reservoir planning process.

Issue Category #1: NEEDS ASSESSMENT

While the workshop survey did not reveal the needs issue as a critical one, the development of new population projections by the Office of State Planning in April 1979, after the 1978 workshops, clearly makes the issue one of fundamental importance. The PWC felt a need for additional work on the Corps' demand projections as a result of the 1979 population projections. The participants clearly expressed a strong interest also in the water conservation alternative presented by the Corps. In light of this preference, the Corps should clarify the changes in their demand model due to the new population projections and then readdress the adequacy of a water conservation alternative as a short-term or intermediate-term solution for the study area.

Issue Category #2: MANAGEMENT AND PLANNING COORDINATION

Cost and Management Issues. These major issues have not been addressed to date in the overall planning activities. They are of critical importance and must be addressed before the feasibility planning process is concluded. This issue should be jointly addressed by the State and the Corps.

Issue Category #3: ENVIRONMENTAL EFFECTS

Direct Effects of Big River Reservoir on Downstream Flows. The direct impacts of the reservoir on downstream flows involves ecological, water quality, waste water treatment and flood control issues. Comments by the 208 Project Director indicate that the Corps' low flow assumption (6 CFS for the South Branch Pawtuxet River) is at odds with the 208 project's expectations of a 7.4 CFS low flow requirement. This variation needs to be resolved and may require a joint Scituate Reservoir/Big River Reservoir flow management scheme.

Indirect Effects of the Big River Reservoir on Future Waste Water Treatment Requirements. To a large extent, this is not an issue within the Corps' jurisdiction. The fact that the time frame for waste water planning and water supply planning are not integrated in Rhode Island, however, demands that the State develop an integrated water resources management policy to coordinate water supply and waste water. The continuing planning by the 208 project should emphasize this activity.

Issue Category #4: SOCIAL AND ECONOMIC EFFECTS

Indirect Effects of the Big River Reservoir on Future Population and Development Trends. The Corps uses population and economic projections as independent variables in the planning process, i.e. population and economic changes will trigger water supply needs. The relationship works, of course, both ways. Water supply availability will influence population and economic development trends in the study area. What are their possible effects?

Direct Effects of the Big River Reservoir on Wildlife. The State Department of Environmental Management has raised serious methodological questions about the Corps' techniques in inventorying existing wildlife in the reservoir area.

Issue Category #5: RESERVOIR PLANNING PROCESS AND PUBLIC PARTICIPATION

How will future public participation activities for the Big River planning process be conducted? Will similar open dialogue formats be utilized? Who will moderate the meetings and communicate citizen comments to the Corps? How can the citizen be assured of an impact into the planning process and decision-making mechanism?

In addition to these substantive issues that the Corps should address during the remainder of the planning process, there are a number of procedural issues that the Corps should consider. These are presented below:

Impact Relationships

Every effort must be made to summarize and show linkages between impact issues. Many of the impact issues raised in the planning process are higher order impacts dependent on primary and secondary impacts occurring. It would be useful for the Corps to show how impact issues relate to each other.

Evaluation Procedures

The considerations that the Corps will use in judging the feasibility of the reservoir are not yet fully articulated in the minds of most participants. If the decision-making process and evaluation criteria are stated, then the public participation process could further focus on critical issues. As an example, how does the Corps consider the following issues:

- Historic Preservation impacts
- Reservoir Management issues
- Riparian (Water) Rights issues

From what has been mentioned in the workshops, historic preservation impacts will not affect the decision to build or not to build the reservoir. Rather, they will be considered as impacts to be addressed by mitigation measures. On the other hand, it has been stated that the construction of the reservoir will not be recommended until a management agency has been designated. How does the issue of riparian rights affect the feasibility analysis of the Corps? What about other issues raised in the public participation process - are their impacts to be mitigated or are they to be used as evaluation criteria in the feasibility analysis?

State Role

There are many issues which have joint Federal and State implications which are not being addressed by either level of government from the citizens' perspective. The participation by state agencies in the public participation activities has been sometimes sporadic. State issues will continue to be important in the public's acceptance or rejection of a reservoir. State issues raised include:

- Project cost to the State.
- Schedule and timing of State funds which are based upon Corps cost-estimate analysis.
- Selection of an agency to manage the project.
- Public use of the reservoir and its adjacent uplands.
- Coordination of waste water treatment, stream flow, and water quality.

CHAPTER 5

RECOMMENDATIONS FOR FUTURE CITIZEN PARTICIPATION STRATEGIES

INTRODUCTION

During the course of the Public Participation activities for the Big River Reservoir Project, the staff implemented an intensive, integrated citizen participation strategy. This strategy, based on considerable previous experience with effective citizen participation programs in a range of functional areas, was multi-faceted in attaining a complex set of objectives.

The purposes of the citizen participation project were to inform the various publics about the Corps' proposals; to gain the public's inputs, views, and assessment of the Corps' proposals at different levels and stages; and to transmit this information to the Corps for use in their planning process. This included preliminary informational processes; articulation of issues; critiques of Corps technical reports; and direct feedback to the Corps from State agencies, interest groups, and the general public.

In addition, considerable emphasis was placed on the process of public involvement. The mechanics of informing the participants, use of media, structuring of the advisory process and defining the role of URI in relation to the reservoir project were primary process issues.

It should be recognized that citizen participation is a very perishable commodity; it is a fragile process whose product can endure only through constant attention. The URI staff has responded to this truism by recommending possible future public participation strategies which the Corps should consider pursuing.

Given the Corps decision to continue the public participation component "in-house", the following steps are recommended:

I. Establish Accessible Data Files

1. Corps should establish easily accessible data files to facilitate easy retrieval. This should include:

a. Name and address file with affiliation of all contacts made by URI in the course of the Project. These should be accessible by name, affiliation, and zip code on printed mailing labels.

b. Media contact file of all radio, television, and newspaper contacts established by URI.

II. Assign Participation Component Appropriately

1. Corps should assign citizen participation component to an individual who has direct access to Corps public relations office and research planning office.

2. Continuity and consistent attention to this task on the part of the individual is important.

3. One day per week, at the very least, should be devoted to this activity.

III. Continue and Strengthen the Project Working Committee

1. Hold regular meetings and provide status reports on the progress of the Feasibility Report.

2. Mailings of notices and materials should be timely and useful.

IV. Continue Media/Information Strategy

1. Disseminate abstracts of forthcoming studies as completed.

2. Contact and meet with media representatives regularly for question and answer sessions.

3. Utilize the intervening time period to develop policy responses to the critical issues still remaining to be addressed.

4. Corps should continue to publish UPDATE on a bi-monthly basis until release of the Draft Feasibility Report makes more frequent issues appropriate. The UPDATE is a valuable means of communication. It serves as a continuing record of citizen participation efforts.

5. Corps should build a scale model of the Big River Reservoir Project for viewing by the public of Rhode Island in order to facilitate understanding of the physical and hydrogeological relationships within the Project.

V. Meet the Briefing Session Commitments Made by the Corps

1. Hold the briefing sessions as outlined in Chapter 3 on those issues which the Corps has not yet addressed.

2. Provide a mechanism for response to issues by citizens and other participants.

VI. Hold Preliminary Meetings, Particularly in the Impacted Areas

Prior to the formal Public Hearings, present the Final Draft Feasibility Report through an informal public approach as outlined in Chapter 3, i.e.

1. Widely advertise such meetings;

2. Schedule these meetings in advance with timely notice;

3. Provide background informational materials;

4. Schedule a follow-up mailing of materials and questionnaires concerning the issues and options.

VII. Subsequent to the Public Hearings, provide a mechanism for follow-up comments and further review through the next stage of the planning process.

Some of these steps are particularly important to the success of the public participation process and should be stressed in the Corps' public participation strategy. For example, it is essential that the PWC be maintained as a part of the participation component. Attention should also be given to expanding the role of the general public participants on the Committee. The PWC is an essential component of the process for a number of reasons. First, it serves as a synthesis of general citizen viewpoints and provides a forum to evaluate and review these inputs. Second, it serves as a cohesive and legitimate voice of the public interests aiding in the conciliation of differing points of view which occur during such an effort. Third, the Committee provides a forum for public agencies to have an input into the Corps planning process. This permits them to voice their concerns publicly while still maintaining their more traditional relationships with the Corps.

Therefore, it is recommended that the Corps meet with the PWC bi-monthly. These meetings should be held in Providence or some other convenient location in the study area.

Once the Draft Feasibility Report is ready for public review through the formal Public Hearings, it is recommended that the public participation activities that have been a part of the URI strategy be continued. These are discussed in Chapter 3 and listed below:

1. Technical issue meetings;

2. Written briefing reports on elements of the studies, findings, and recommendations of the Corps;

3. Presentations by Corps staff members on substantive issues;

4. Continued education of the public on the Corps planning, administrative, and construction processes. Clear definition of the role of the Corps in the Big River Reservoir Project is essential for the interests of the Corps as well as the state.

5. Meetings of impacted groups in order to formulate responses to be reviewed by the Project Working Committee. These groups include residents of the West Greenwich/Coventry area, special interest groups such as sportsmen, industries along the Pawtuxet River, and municipal water supply officials.

It is recommended that the citizen participation staff of the Corps be expanded during the next active review stage to include workshop specialists, aides, and technicians. The Corps should consider using space in one of the existing Federal or State offices in Providence in order to allow on-going access to the planning process materials. This cannot be effectively done from the Waltham location.

Lastly, it is suggested that an outside public participation contract be reconsidered. The expertise needed to attain and document citizen participation in a project as complex as the Big River Reservoir is acquired, in part, from theory, and, in part, from experience with a variety of public participation projects involving a wide range of governmental policy issues. Moreover, the touchstone of any public participation process is its perceived objectivity, which will, in turn, frame its credibility. This is a difficult, not to say vulnerable, situation at best, given Big River Reservoir's history, both prior to the Governor's invitation to the Corps to intervene in the process and then, following their entry into it. It seems appropriate that the work of an independent public participation staff be reconsidered for the completion of the Corps' planning process.

APPENDIX A

Mailing List

GENERAL MAILING LIST

BUSINESS AND INDUSTRY

Chamber of Commerce
Howard Building
Providence, RI 02903

Chamber of Commerce
Johnston, RI
02919

Mr. Joseph O'Donnell
Keough-Kirby
1625 Diamond Hill Road
Woonsocket, RI 02895

So. Kingstown Chamber of Commerce
11 North Road
Peacedale, RI 02883

Chamber of Commerce
7 Homeland Avenue
Narragansett, RI 02882

Mr. Robert Brustlin
Schoenfield Assoc.
210 South Street
Boston, Mass. 02110

Mr. James J. Bolster
Chamber of Commerce
P.O. Box 79
No. Kingstown, RI 02852

No. Kingstown Chamber of Commerce
2497 Boston Neck Road
Saunderstown, RI

Vice President
New England Telephone Co.
234 Washington Street
Providence, RI 02903

Mr. Warren L. Salter
Chamber of Commerce
P.O. Box 95
East Greenwich, RI 02818

Secretary
Cranston Chamber of Commerce
1060 Park Avenue
Cranston, RI 02910

President
Providence Gas Company
100 Weybosset Street
Providence, RI 02903

Chamber of Commerce
Coventry, RI
02816

Secretary
Greater Providence Chamber of Commerce
10 Dorrance Street
Providence, RI 02903

President
New England Electric System
20 Turnpike Road
Westboro, MA 02769

Chamber of Commerce
West Greenwich, RI
02816

Warren Dietz
Coventry Road and Boat Club
78 Columbia Avenue
Coventry, RI

Mr. Kevin Donahue
Algonquin Gas Company
1284 Soldiers Field Road
Boston, MA 02135

Chamber of Commerce
Exeter, RI
02882

Mr. Gus Anderson
Coventry Pines Golf Club
Harkney Hill Road
Coventry, RI 02816

Mr. Erskine N. White, Jr.
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APPENDIX B

Examples of Workshop Promotional Materials

University of Rhode Island, Kingston, Rhode Islanc 02881
Graduate Curriculum in Community Planning
and Area Development (401) 792-2248

APPENDIX B-1

UNIVERSITY OF RHODE ISLAND/U.S. ARMY CORPS OF ENGINEERS
PUBLIC PARTICIPATION PROJECT
BIG RIVER RESERVOIR

Agenda

Briefing Session II
Engineering, Geotechnical, and Hydrological Issues
September 18, 1979

I. Introduction: URI Public Participation Project Staff

   A. Dr. Marcia Marker Feld
   B. Dr. Howard H. Foster, Jr.

II. U.S. Army Corps of Engineers

   A. Mr. John Craig - Moderator and Study Manager, Basin Management Branch
   B. Mr. James Blair - Foundations and Materials Branch
      Discussion
   C. Mr. Mark Geib - Water Control Branch
      Discussion

III. Summary

   A. Mr. John Craig
      Discussion

IV. Next Steps

APPENDIX B-2

BIG RIVER RESERVOIR
PUBLIC PARTICIPATION WORKSHOP

The Graduate Curriculum in Community Planning and Area Development of the University of Rhode Island under contract with the U.S. Army Corps of Engineers invites all interested citizens to a series of three public workshops on the proposed Big River Reservoir. The workshops are being held to present the findings contained in the draft Feasibility Report and the draft Environmental Impact Statement, which will be presented at each of the first three workshops. A second series of workshops will be held in the fall to present the final results of the Feasibility Study. For additional information, contact Ms. Patty Krause or Mr. Alan Sharkey at 277-3982. The three workshops will begin at 7 p.m. on the following dates and locations.

June 13	**URI Extension Division** **Providence, Rhode Island**
June 14	**Warwick Community Center** **Warwick, Rhode Island**
June 18	**Coventry High School** **Coventry, Rhode Island**

Source: The Providence Journal-Bulletin, June 11, 1979

APPENDIX B-3

Example Press Release Story
About Big River Reservoir Workshops

Big River talks slated

A series of three public workshops on the proposed Big River Reservoir in Coventry and West Greenwich, have been scheduled by the University of Rhode Island's Urban Field Center.

The first workshop will be held on Thursday, Sept. 7 in Providence at URI's Extension Division (Promenade and Gaspee Streets) in Room 304. A week later (Thursday, Sept. 14) a workshop will be presented at Metcalf Middle School (Nooseneck Hill Rd.) in West Greenwich. The final session is planned for Monday, Sept. 18 at the State House. All workshops will begin at 7 p.m.

The three workshops will discuss the issues surrounding the proposed Big River Reservoir. Much of metropolitan Providence receives water from the Scituate Reservoir, and five tributary reservoirs. Will there be a significant increase in the state's demand for water? Is an additional reservoir needed? These questions will be raised at the three workshops.

The Big River has been identified as a potential reservoir for more than a decade. The proposed Big River Reservoir would be located in the towns of West Greenwich, Coventry, and East Greenwich. When fully operational, it could provide 26 million gallons of water per day.

The general public is welcome at all three sessions. For more information please contact Kevin Feeney at the URI Urban Field Center in Providence, 277-3949.

Source: Coventry Townsman, September 6, 1978

APPENDIX B-4

Example Press Release Story
About Big River Reservoir Workshops

Corps to give its views on Big River reservoir

WEST GREENWICH — The Army Corps of Engineers will tell how it would build the Big River reservoir, if the state picks it for the job, at a public meeting to be held here Tuesday.

The Corps is completing a $500,000 study Governor Garrahy asked it to make because of the state's inability to finance the project since taking 13,001 acres for it and the related Wood River reservoir in East and West Greenwich, Coventry and Exeter in 1966 at a total cost of $11 million.

The Corps has said it would build the reservoir, and bill the state for the $84.6-million cost over 50 years, but that the state would have to put up $7 million first. The state is seeking independent advice on alternate financing methods because it lacks the $7 million.

The meeting at 7 p.m. at the Metcalf Middle School, Nooseneck Hill Road, takes the place of one last Thursday that was canceled because of a power failure caused by heavy rain from Hurricane David.

The sponsor is the University of Rhode Island graduate curriculum in community planning, which holds a Corps contract to promote public participation in the project.

Source: The Providence Journal-Bulletin, September 13, 1979

APPENDIX B-5

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

NEWS RELEASE

PUBLIC PARTICIPATION WORKSHOPS
ON THE PROPOSED BIG RIVER RESERVOIR SET BY
THE U.S. ARMY CORPS OF ENGINEERS

A series of three public workshops on the proposed Big River Reservoir have been scheduled by the University of Rhode Island's Graduate Curriculum in Community Planning and Area Development under contract with the U.S. Army Corps of Engineers.

The University is conducting the public involvement program for the Corps' New England Division to obtain the widest possible understanding of the proposed reservoir project.

The first workshop will be held on Wednesday, June 13 at URI'S Providence campus, (Promenade and Gaspee Streets) in the Student Center. One night later, (June 14), in Warwick a workshop will be held in the Community Center, (99 Veterans Memorial Parkway). The final session will be presented on Monday, June 18 in Coventry at the High School, (Reservoir Road). All workshops will begin at 7 P.M. Each workshop will present the same information.

The workshops will provide a forum to discuss the Draft Environmental Impact Statement and the Draft Feasibility Report. In part, they are based on the Phase One public participation process as identified at workshops held in September, 1978. There has been continuing disagreements over social, economic, and environmental issues surrounding the proposed Big River Reservoir. The bond issue for engineering studies was defeated in November, 1978.

The Big River Reservoir Study is being conducted to determine whether there is a need for a multiple purpose project for water supply, flood damage reduction, and other water used, and if so, what scope would be feasible.

The Big River has been identified as a potential reservoir for more than a decade. The proposed Big River Reservoir would be located in the towns of West Greenwich, Coventry, and Exeter. When combined with the Scituate Reservoir, it could provide thirty-three (33) million gallons of water per day.

The general public is very welcome at the workshops. For more information, please contact Mr. Alan Sharkey at URI's Providence Office, 277-3982.

NEW ENGLAND DIVISION, PUBLIC AFFAIRS OFFICE
WALTHAM , MA 617-894-2400 EX. 237/238

APPENDIX C

Examples of PROVIDENCE-JOURNAL BULLETIN
Ad Hoc Press Coverage of the
Big River Reservoir Issue

APPENDIX C-1

C-4 The Providence Journal, Tuesday, June 12, 1979

Corps sees R.I. running dry without Big River reservoir

By ROBERT C. FREDERIKSEN
Journal-Bulletin Environment Writer

PROVIDENCE — Seventeen of Rhode Island's 39 communities face water shortages totaling 73 million gallons a day by the year 2020 unless the state's long-stalled Big River reservoir is built, the Army Corps of Engineers says.

Rising population and increasing per-capita use of water will cause the shortages, says the Corps of Engineers in a preliminary report on a $500,000 study it made, at the request of Governor Garrahy, on reservoir construction and Pawtuxet River flood control.

The report was prepared for public workshops to be held tomorrow at the University of Rhode Island Extension Division, 199 Promenade St.; Thursday at the Warwick Community Room, 99 Veterans Memorial Parkway, Warwick, and next Monday at Coventry High School, all at 7 p.m.

The Corps hasn't completed its study, or decided whether to undertake the project yet, John Craig, the study manager, said in Waltham, Mass., yesterday.

He said the Corps hopes to complete the study by October so that, if it decides to go ahead, there will be time to seek an appropriation from Congress next year.

The state took 13,001 acres of land on the Big and Wood Rivers in East and West Greenwich, Coventry and Exeter in 1966 with $7.5 million in bond issues, and has spent $500,000, revenues from sand and gravel sales, on design studies. Voter defeats of bond issues to finish the design, and stalled negotiations with Providence on building the reservoir, led Garrahy to ask the Corps to consider doing the job and recovering the cost from the state over 50 years.

The state suddenly learned in April, however, that under a new Carter administration policy it would have to put up $7.6 million before the Corps could undertake the $84.3-million construction project.

The state doesn't have $7.6 million for the project, but the Corps is going ahead with its study on the chance that the state will be able to come up with the money, Craig indicated

He added that the total cost would be somewhat less than the Corps' previous $84.3-million estimate. The new figure won't be announced until the workshop tomorrow evening. He did not say why.

• • •

MEANWHILE, he said, the Corps has determined that rising population and per capita water use will create deficits of up to 28 million gallons a day (mgd) by 1995 and 73 mgd by 2020 in 17 communities.

They are Providence, Cranston, Johnston, North and East Providence, Smithfield and Warwick on the Providence water supply system; Coventry, East and West Greenwich, Scituate and West Warwick on the Kent Count Water Authority System; Barrington, Warren and Bristol on the Bristol County Water Company system; and Glocester and Foster.

A combination of building the Big River reservoir, skimming flood water from the Flat and Wood Rivers, drilling wells and launching water-conservation programs would provide up to 142.4 million gallons a day to cover the deficits, the report said

The study rejected water-price increases, which some environmentalists see as the most effective conservation technique, as well as cloud seeding, desalting sea water and even melting icebergs that would be towed here from the Arctic as water sources.

Flooding the Big River site would cover up to $30 million worth of sand and gravel, but much of this could be removed before flooding, the study said. Reservoir leakage would not be a problem, it added.

The study said 110 tenants of the Big River site would have to move and 108 historic and cultural sites might be affected by the project.

It said this would be offset by population and industrial growth and use of the reservoir for recreation, which is against state policy, but would be required if the Corps undertook the project.

APPENDIX C-2

Big River project is getting attention

Water Resources Board moves to seek advice on financing reservoir program

Source: The Providence Journal-Bulletin
September 12, 1979

By ROBERT C. FREDERIKSEN
Journal-Bulletin Environment Writer

PROVIDENCE — The state Water Resources Board, with Governor Garrahy's blessing, moved quickly yesterday to seek expert advice on the best way to finance construction of its long-stalled Big River reservoir project.

The action contrasted sharply with the coolness shown to a proposal that Big River and other new water developments be deferred until there are adequate facilities to treat the resulting increased sewage.

In other action, the board:

- Approved a $1,118,492 budget request for the next fiscal year, starting July 1, 1980, up $25,172 from the General Assembly's allowance for this year.
- Received, but deferred action until next month on personal appeals by Mayor Edward D. DiPrete of Cranston and Makram H. Megalli, Woonsocket public works chief, for local water-system improvement loans totaling $736,000.
- Eased its policy on evicting tenants in the Big River area who fall behind in their rent to cover hardship cases resulting from increased heating costs this winter.

The board unanimously approved appointment of a subcommittee to seek and screen bids from outside financial consultants on whether the Big River project should be built with federal, state or city aid.

John Doherty of the Providence Water Supply Board will head the subcommittee.

THE BOARD took 13,001 acres in East and West Greenwich, Coventry and Exeter for the Big and Wood River reservoirs in 1966 with two bond issues totaling $7.5 million, which will be raised to $11 million with financing costs.

The Wood River project has been [illegible] because of dwindling demand, [illegible] the board has continued to press for Big River despite four straight defeats of [illegible] issues for design and construction.

Acting on a study request by Governor Garrahy, the Army Corps of Engineers, said it would be glad to build Big River, but the state first would have to put up $7.6 million of the $84.6 million cost.

Lack of the $7.6 million, plus past defeats of bond issues, led Garrahy, the state Budget Office and the board to seek other financing methods, Peter Calise, a board engineer, and Ann Stubbs of Garrahy's office said in reporting on a meeting with the Budget Office last Tuesday.

Calise added that the Budget Office regards construction of the reservoir as "a priority capital project."

John Murray, Garrahy's top fiscal adviser, used almost the same words last week in describing the administration's willingness to help Providence reduce its pollution of the Providence River and Narragansett Bay.

One of the best ways to reduce pollution is to defer new reservoir construction until there are adequate facilities to treat the increased sewage, Harold R. Ward of the Conservation Law Foundation told the board.

IN JUNE the board rejected a foundation petition that it adopt such a policy, but agreed to hear Ward, a Brown University dean, chemist and lawyer yesterday.

He stressed that the foundation petition was based on the state's 1978 Environmental Rights Act, which requires state agencies to consider the environmental consequences of their actions and the need to conserve water and reduce sewage.

The U.S. Environmental Protection Agency, Governor Garrahy, the Statewide Planning Program and Mayor Vincent A. Cianci Jr. of Providence recently have embraced water conservation to reduce pollution.

Ward added that the foundation would be willing to exclude existing combined sanitary-storm sewers in Providence, Pawtucket, Central Falls and Newport from its proposed policy because they dump untreated sewage only after storms.

Board members took no action on the foundation proposal, pending comment by Daniel Schatz, environmental advocate in the attorney general's office. Some said after Ward left that his real aim seems to be blocking the Big River project.

ROBERT L. BENDICK of the state Department of Environmental Management and Robert M. Silva, board lawyer, cautioned the board to take the foundation's proposal seriously because of its record.

A foundation suit in federal court delayed state acquisition of former Navy lands around the bay for a year until the General Services Administration prepared an environmental-impact statement, they said.

Cranston wants a $225,000 loan to build a pumping station to boost water pressure in Garden Hills, and Woonsocket needs loans of $241,000 and $270,000 to stop reservoir leaks, DiPrete and Megalli said, respectively.

Robert B. Russ, general manager, said the board has only $450,000 available from sales of Big River sand and gravel now, but that he will study and report next month on other ways of meeting the loan requests.

The Evening Bulletin, Tuesday, October 9, 1979

Study supports development of Big River water system

By BRIAN C. JONES
Journal-Bulletin Staff Writer

PROVIDENCE — Providence's old, but well-regarded water system, is reaching is maximum limits and new sources of water should be developed soon, according to the city's top water official.

But Peter P. Granieri, chief engineer for the Providence Water Supply Board, said current supplies are adequate to serve the present needs of the city and surrounding communities which are linked to the city's system.

The proposed Big River reservoir project would go far in suppling future water demands, Granieri said. But he said even when the long-discussed project is finally approved, it will take 10 years to build and operate.

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IN ADDITION, THE current physical plant, which includes 1,000 miles of pipes, some of them more than 100 years old, is in "excellent" shape, in part because water quality is such that it doesn't corrode the pipes, he said.

Granieri's comments came in light of a report released yesterday by a coalition of groups representing northeastern states, which called for extensive federal aid to upgrade the region's water supply systems.

The report said that while most northeastern cities could meet current water demands, future shortages are possible in Boston, New York City, Pittsburgh and Providence.

In addition, it said that while some engineering standards say water lines should be replaced every 75 years, the replacement rate in New York City is 300 years and Boston loses about half its water through leaky pipes.

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THE REPORT ALSO mentioned related topics of concern to Rhode Island, hazardous waste disposal and sewage treatment.

- Although New England generates about 28 percent of the nation's industrial chemical wastes, the six-state region currently has no approved dangerous waste disposal site.
- It will take an estimated $5 billion dollars for the Northeast to achieve "fishable-swimmable" federal water quality goals.

Granieri said the water supply board's system is approaching the limits of its "safe yield," the amount of water the system's massive watershed can guarantee during a period of prolonged lack of rain.

The amount of water which could be expected in such a period is 72 million gallons a day — and the system's average daily use now is about 64 million gallons a day, Granieri said.

If Barrington, Warren and Bristol are tied into the system, something currently being discussed, another 4 to 5 million gallons a day would be used immediately, pushing the system toward its maximum limits, he said.

"At the present time, we have plenty of water," Granieri said. "As we look to the future, the next 10 to 15 years, there certainly is a definite need for another source of supply."

Under study now is development of a major new supply from the proposed Big River reservoir project, which Granieri said would add about another 20 million gallons a day to the state's resources.

The state "does have an answer" to future water supply needs, the chief engineer said. "It is just a case of getting it done and getting it rolling before it's too late. You don't do these things overnight, and we should actually be starting it now."

The Providence system serves Providence, North Providence, Johnston and parts of Cranston. East Providence, Warwick, the Kent County Water Authority, Smithfield and Greenville buy water at wholesale rates.

The Providence system, which city officials have said is considered one of the best in the nation, is in excellent shape, he said, despite the fact that some cast iron lines are between 100 and 120 years old.

But because the water which runs through the lines is "non-aggressive" in nature — it doesn't corrode the piping — the distribution system is in good shape, Granieri said.

And although the report said that Boston loses about half its water supply through leaks, the Providence system can "account for 92 to 94 percent" of its water.

The system has been making regular improvements, and operates the largest filtration plant in New England, Granieri said.

Hazardous waste — chemical materials left over from manufacturing — is considered a threat to water supplies if the materials leak from landfill dumps into ground water.

RHODE ISLAND HAS DEVELOPED a strong set of regulations limiting dumping, but the state, along with the other five New England states, is wrestling with the issue of where to locate new and costly landfill sites.

In addition, Providence currently is studying another phase of the water quality problem — sewage — and mapping long-range plans to stop pollution of Narragansett Bay from its outdated and over-taxed sewage system.

The report was released by a consortium of seven regional organizations, including the Northeast-Midwest Congressional Coalition, the Northeastern Governors Coalition, the Council for Northeast Economic Action and the Coalition of Northeast Municipalities.

It was prepared by a private study group, the Nova Institute.

The study urged support of bills to give the area a greater percentage of the $4 billion the federal government allocates nationally for water projects.

Reservoir costs cut sharply by Army

APPENDIX C-4

By ROBERT C. FREDERIKSEN
Journal-Bulletin Environment Writer

PROVIDENCE — The Army Corps of Engineers now says it can build the Big River reservoir for the state for $48.4 million, or a little more than half of the $84.3 million price tag it quoted last April.

The state Water Resources Board, *which sought Corps help last year because* of its inability to finance the project, received the report skeptically yesterday.

There were indications, however, that the project is on a fast track after years of delays compounded by abundant rainfall, which made the reservoir seem unnecessary, and financing and environmental problems.

The Corps' new estimates produced the strongest reaction among board members at their monthly meeting.

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MEMBERS WERE delighted that the new estimate would cut from $7.7 million to $4.4 million the "up-front money" the federal government requires the state to provide before the Corps could start work.

But they also feared that the Corps' eagerness to build the reservoir might have affected its estimate, and that the state would get stuck if it proved too low.

"The Corps is quite enthusiastic," Robert B. Russ, general manager of the water board, observed. "But we must remember that cost overruns are a fact of federal life."

"And that opponents will say 'What are they trying to sell us now?'" said Sen. Walter R. Hazard, D-Coventry, chairman of the General Assembly's joint water resources committee.

"We want to build the reservoir, but we want to build it right," added Peter Calise, a board engineer who delivered the Corps' new estimates.

Board skepticism stemmed chiefly from the fact that Corps estimates for parts of the project were so much lower than the board's 1967 estimates, even after allowing for inflation and new construction methods.

Major cost reductions were as follows:

- The board estimated it would cost $24.8 million to lay a 94-inch pipe hooking the Big River reservoir into the Providence water distribution system in West Warwick. The Corps said an 84-inch tunnel through rock would cost $15 million.
- The board proposed a $13-million contingency fund, $5 million for architectural and engineering services and $5 million resident engineering inspection costs, the Corps $9 million, nothing and nothing, respectively.
- The board estimated that it would cost $7.3 million to dig and fill a 250-foot-deep trench with impermeable material to prevent reservoir water from leaking out through the earth beneath. The Corps said laying a concrete "blanket" on the reservoir bottom for $3.3 million would solve the problem.
- The board estimated that it would cost $4.2 million to cut and clear trees from the heavily wooded 8,000-acre reservoir site. The Corps said leaving the cut trees in place would reduce costs to $2.2 million.
- The board estimated that building the earthen reservoir dam would cost $5.3 million and the concrete spillway $5.2 million, the Corps $2.6 million and $2.2 million, respectively.

On the other hand, the Corps increased its estimate for related flood-control work on the Pawtuxet River from $1.5 million to $5.6 million, but gave no explanation, Calise said.

There would be no change in overall financing arrangements under which the Corps would build the reservoir and bill the state for the cost, plus about 6 percent compound interest over 50 years, beginning when the project starts earning money, he added.

It has not been decided yet, however, how the board would meet the "up-front money" requirement imposed by President Carter last year, Calise said.

The board would like to put up the $11 million it cost to acquire the reservoir site in East and West Greenwich and Coventry in 1966, but the Corps has not said yet whether it will go for this, he said.

If not, it would be up to Governor Garrahy to decide whether to ask the next General Assembly for an appropriation or to schedule a bond-issue referendum, or to let the board issue revenue bonds, he said.

• • •

VOTERS HAVE DEFEATED the last three state bond issues for completing the reservoir's engineering and design. The board has authority to issue revenue bonds, which do not need voter approval, but never has used it.

Ann Stubbs, one of Governor Garrahy's planning aides, was present, but said only that the state Budget Office would study the Corps' new estimates closely.

It appeared, however, that the Corps' new estimates have speeded up the Big River reservoir project, despite the board's first reaction to them. Russ, for example, said the Corps wants the state to submit by November a formal request for the Corps to undertake the project, so there will be time to prepare an appropriation request for Congress.

Source: The Providence Journal-Bulletin, October 10, 1979

Time has come for action on Big River project

An urban study organization's report listing metropolitan Providence among major northeastern cities that face future water shortages is a timely reminder for Rhode Island to get about building the long-planned Big River Reservoir.

The study, done by the private Nova Institute for concerned regional development groups, coincides with renewed indications this week that the Army Corps of Engineers is willing to undertake the Big River project. While the state Water Resources Board is still mulling the details of such an arrangement, it does seem to be the likeliest way to proceed.

Money has been the holdup since the Big River plan first took shape in the mid-60s, with a $7.5 million site acquisition in East and West Greenwich, Coventry and Exeter. The Corps of Engineers cannot provide all the needed construction funds — and what it puts up will eventually have to be repaid — but working with the Corps would bring the rest of the financing within range.

Before going into the financial specifics, it is well to note the urgency facing the state. Peter P. Granieri, chief engineer of the Providence Water Supply Board, which serves about half the Rhode Island population, estimates the present Scituate Reservoir system as near capacity. Now, he said, "We have plenty of water," but, "As we look to the future, the next 10 to 15 years, there certainly is a definite need for another source of supply." The Nova study reemphasizes that.

Since it takes a decade or more to build a reservoir of the 20 million gallons daily capacity of Big River, no more delay is warranted in getting started. Even employing every conservation tactic, as should be done — zoning to hold down new water use, industrial and household cutbacks, and the like — the demand for more water will continue. Action is required to meet this demand.

In a new estimate of Big River costs, the Corps of Engineers says it can build the reservoir for $48.4 million. That looks like a cutback from earlier price tags of $80 million or more, but the difference is misleading. The Army engineers' involvement is limited to what can be related to flood control work. This could include the reservoir proper, a dam and transmission lines, among other items. But it leaves to the state other costly aspects, among them a treatment plant priced at up to $30 million. Also, the state would have to furnish "up front" money of nearly $5 million before the Corps could start work.

How to obtain these considerable sums is a major problem for Rhode Island. With the Corps of Engineers eager to begin moving on the project, a solution ought to be found quickly. Robert B. Russ, general manager of the Water Resources Board (WRB), sees three possible answers: either state or Providence Water Supply Board bonds, or revenue bonds issued by the WRB. Of the three, perhaps the last is most feasible.

State voters have rejected additional Big River borrowing four times since approving the acquisition bonds. The experienced Providence agency is a natural to develop the new reservoir, but a hassle over its picking up the site-purchase costs has stymied that. WRB revenue bonds, authorized by the General Assembly several years ago, could raise the money faster, although probably at higher interest expense.

Despite that, it will be cheaper in the long run in order to hasten Big River's construction. Waiting will only escalate the overall price due to inflation. And delay brings a future water shortage crisis that much closer. This is a matter which state authorities, including Governor Garrahy (who asked the Corps of Engineers for help), should address promptly.

Beyond the financing details, there are other concerns that the WRB has to consider in reviewing the Army engineers' proposal. But these basically are of a technical nature and should not pose any major hurdle. Working them out ought to be easy, once the money problem is resolved. No more time should be wasted in resolving that.

Source: The Providence Journal-Bulletin, October 15, 1979

APPENDIX D

Examples of Formal Statements/Inputs Received from the Public

APPENDIX D-1

STANLEY BERNSTEIN
DIRECTOR

VINCENT A. CIANCI, JR.
MAYOR

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

40 FOUNTAIN ST., - PROVIDENCE, R. I. 02903 - TEL. 401-831-6550

December 20, 1979

Big River Reservoir Public
Participation Project Staff
URI Graduate Curriculum in Community
Planning and Area Development
400 Wickenden Street
Providence, Rhode Island 02903

Re: Draft Final Report to U.S. Army Corps of Engineers

Dear Staff:

My general approval of the draft of Chapter IV should be combined with a statement of satisfaction I have felt for the excellent organization of the public participation effort you have given to the proposed Big River Reservoir project, ever since the initial workshop on September 7, 1978. It would be difficult to imagine a more effective opportunity being provided for all interested individuals and groups in Rhode Island to attend, be briefed, to consider all information offered by the Corps of Engineers, and to respond during the development of Stage 1 and Stage 2 of the planning process.

Of particular value is the chance to hear each other's concerns, questions, biases and statements in favor of or opposed to the project and each element of data being developed, and to know the identity of various viewpoints held by other participants. Especially helpful, I think, has been the care taken by the URI staff, and allowed by the Army Corps personnel, to prevent any cogent question or issue from being glossed over or suppressed by the promotional momentum exerted in favor of the project. I am somewhat apprehensive that the termination of the URI involvement three weeks ago may cause in some degree the loss of these vital advantages during the remainder of the planning process, because it seems a reasonable assumption that the Corps can not achieve the same objectivity towards its own plans that the URI staff has maintained, in dealings with the public.

I have several observations to make with respect to the draft of Chapter IV specifically. First, the assessment of needs (pp. 4-5, 7-8, 10) appears to be an intensified issue due to the emergence of a superseding population projection for the State of Rhode Island in Technical Paper Number 83 dated April, 1979. In the study area the expectation for population growth is reduced by a greater proportion than for Rhode Island as a whole, and the percentages of reduction for the years 1995, 2020 and 2040 are 15.7%, 24.5% and 29.3% respectively, involving for the last date a study area total population of only 600,600 instead of 850,100 projected in the 1975 report (T.P. 25). This is a most substantial downward revision, and should necessitate an overall reappraisal of need, including study of other factors affecting demand, before Stage 3 planning can be either continued or dropped.

Second, Exhibit IV-ONE should be so referred to in item 3 of the preceding discussion of questionnaire responses, as there is no page titled "Table I". Also, the ranking table (IV-ONE-4) contains seven numerical errors in the "overall rating" column, and their correction will change all the rankings except the first four. (Example: weighed responses for line three "Population/Development Efforts" add up to 27 points, not 24 as indicated; six other lines also are erroneously totalled). The following table (IV-ONE-5) contains two erroneously added overall ratings: Alt. 3 adds to 53, not 45; and Alt. 4 adds to 46, not 38. This table is not labelled "Table II" as referred to on page IV-ONE-1.

Third, I agree wholeheartedly that management issues need coordination with planning before Phase 3 (Stage 3) planning begins. A key question on this concerns whether the ratepayers within the "entitlement" municipalities, having already amortized the construction and subsequent improvement of the present Scituate supply, treatment works, and aqueduct system should henceforth be asked to share equally the cost of amortizing a new set of supply, treatment and transmission facilities which they don't need. The new system, if required, would be necessitated by demand growth principally from beyond the boundaries of the "entitlement" area, and only to a minor degree by per capita increases in consumption that might be somewhat reduced by leak reduction and conservation activities. Providence, incidentally, having lost one-third of its 1940 population, has not increased its consumption level during the 1960's and 1970's. The original eleven communities, for which Scituate was created, do not by themselves need any additional source of supply, and in my opinion should not be asked to shoulder the second burden of capital costs for creating Big River, even though the waters be commingled and governed by the same metropolitan water authority representative of all communities in the expanded service area. By analogy, the earlier cities and towns do not get asked to pay for sewerage in the suburbs built later, even though necessitated by water supply extensions to the original system. A similar logic should apply to the cost of a new source of water supply, and a separate tier of rates should apply the marginal cost to the marginal uses outside of the areas of entitlement established by law in 1915, for the period of amortization of Big River bonds, after which rates should be equalized.

Again, my compliments to Marcia Feld and her staff for excellent service in facilitating effective public participation in this planning program.

Sincerely yours,
John R. Kellam
John R. Kellam
Supervisor of Long Range Planning

JRK/cd

APPENDIX D-2

THE AUDUBON SOCIETY OF RHODE ISLAND

40 BOWEN STREET • PROVIDENCE, RHODE ISLAND 02903

ALFRED L. HAWKES
EXECUTIVE DIRECTOR

TELEPHONE 401-521-1670

September 22, 1978

Marsha Feld
Urban Field Center
400 Wickendon Street
Providence, Rhode Island

Dear Dr. Feld,

Enclosed is some information that I promised to send you several weeks ago. I apologize for the delay, but I have spent a rather hectic two weeks trying to finish my report and trying to begin another school year. The information refers to the Department of Health regulations about water supply watershed protection and its effect on the proposed water supply plans in Rhode Island. The first concern is that if all the proposed reservoirs were built, their watershed area would be about 25% of the State's total land area, and it would all be subject to section 1, title 46, chapter 14 of the Rhode Island Laws. This severely restricts many land uses. Secondly, the law could hamper recreational plans. The Audubon is concerned because the "requirements" projections seem to indicate that the build-up of these supplies will be warranted. If so, the land use restrictions not only lessen the developable area of the State but also could prevent access to the reservoir lands for the citizens of the State.

Page 3-7 of the Martel report depicts the full water supply development plan as it appeared in the 1969 water supply element of the State Guide Plan. The exeerpts form report #22 indicate that nothing has changed. The 1972 NEWS study notes on p.222 that the Corps is aware of the problem. The excerpt from the Rhode Island Laws is particularly interesting because it disallows swimming in a reservoir (not proven hazardous to health by irreparably damaging drinking water) yet it permits fertilizing agricultural lands, known sources of non-point source pollution. In conclusion, we hope that the Corps will submit evidence that recreational activities are compatible with water supply purposes. But more importantly, we hope the Corps will reevaluate water consumption habits and redo the projections of "need."

I trust I have told you nothing new; I'm sure these points came up at the meetings. Good luck in "summing up" for the Corps. I'm very glad that you and Mr. Hawkes had the opportunity to speak informally. I'll remember you to Mr. Grigsby when I return to the University of Pennsylvania to catch up on the fall semester.

Sincerely,

Tina Suarez-Murias

Christine M. Suarez-Murias

Serving Rhode Island Since 1897

APPENDIX E

Big River Reservoir Study Workshop Questionnaire

APPENDIX E

BIG RIVER RESERVOIR STUDY WORKSHOP QUESTIONNAIRE

The following questionnaire was distributed at all three public workshops. Twenty-five questionnaires were completed. The responses to the questions are as follows:

1. Do you feel there is a need for additional water supply development in the study area by:

	YES	NO
1995	17	6
2020	14	4

2. Do you feel that the question of needs should be addressed on a state, regional, or community basis?

State	11	Community	2
Regional	8	All	2

3. Given the present information that you have, which alternative for meeting future water demands do you favor: (Please rank the alternatives #1, #2, etc.)

See attached.

4. Which of the following water conservation policies do you prefer? (Please check one or more.)

a.	Pricing policies	14
b.	Installation of water saving devices	13
c.	Water conservation education programs	20
d.	Water use restrictions	7
e.	Control of leakage from water systems	15
f.	None of the above	0

5. Which of the following do you agree with?

a.	Water should be managed as a public utility commodity.	10
b.	Water should be managed as a finite natural resource.	14

APPENDIX E (Continued)

6. Of the following factors presented below, please rank (#1, #2, etc.) the five most important factors that should be used in evaluating the proposed water supply alternatives for the study area.

See attached.

7. If the Big River Reservoir is built, which of the following recreation uses would you favor (check one or more) at the site?

None 8

Water based		Land based	
swimming	6	hiking	16
motorized boating	1	camping	11
non-motorized boating	17	horseback riding	4
fishing	14	snow mobiling	2
		trail biking	2
		other (hunting, trapping)	1

8. If the Big River Reservoir is built, who should operate and manage the Reservoir?

Providence Water Supply Board	7
R.I. Water Resources Board	5
R.I. Department of Environmental Management	11
Other	3

9. If the Big River Reservoir is built, should the communities within the Reservoir site (West Greenwich, Coventry, Exeter, East Greenwich) receive some type of payment in lieu of taxes?

Yes 22

No 1

10. If the Big River Reservoir is built, who should pay for the Reservoir?

a.	All Rhode Islanders	8
b.	Reservoir users	9
c.	A combination of a. and b.	9

3. GIVEN THE PRESENT INFORMATION THAT YOU HAVE, WHICH ALTERNATIVE FOR MEETING FUTURE DEMANDS DO YOU FAVOR? (PLEASE RANK ALTERNATIVES #1, #2, etc.)

(Each Star Represents One Response)

RANK	1	2	3	4	5	OVERALL RATING
ALT. 1 NO ACTION	*	*		*	**	13
ALT. 2 DEMAND MODIFICATION (Water Conservation)	*********	******	***			78
ALT. 3 GROUNDWATER DEVELOPMENT	***	****	******	**		45
ALT. 4 BIG RIVER RESERVOIR WITH DIVERSIONS FROM EITHER FLAT RIVER OR WOOD RIVER	***	****	**	****	*	38
ALT. 5 COMBINED ALTERNATIVES (Alternatives 2,3,4)	****	***	***	*		43

NOTE: The responses were weighted so that an alternative ranked #1 was given 5 points; one ranked #2 was given 4 points; #3 was given 3 points; #4 was given 2 points; and #5 was given 1 point to get this overall rating.

6. OF THE FOLLOWING FACTORS PRESENTED BELOW, PLEASE RANK (#1, #2, etc.) THE FIVE MOST IMPORTANT FACTORS THAT SHOULD BE USED IN EVALUATING THE PROPOSED WATER SUPPLY ALTERNATIVES FOR THE STUDY AREA

(Each Star Represents One Response)

	Ranking	OVERALL RATING	RANK 5	RANK 4	RANK 3	RANK 2	RANK 1
COST	3	41	*	*****	*	**	****
MANAGEMENT CONSIDERATIONS (Financing, ownership, operation)	1	56	****	**	*	*****	*****
POPULATION/DEVELOPMENT EFFORTS	6	24	*	**	****		**
EMPLOYMENT EFFECTS	15	4	*		*		
RECREATION EFFECTS	11	7	*		**		
HISTORIC & CULTURAL EFFECTS	10	9		**			*
WATER QUALITY EFFECTS	2	49	**	**	**	***	*****
DISPOSITION OF SAND & GRAVEL AT RESERVOIR SITE	12	5					*
FLOOD PROTECTION EFFECTS	7	23	*	****	***	**	
GROUNDWATER EFFECTS	8	16	****		***	*	
FISH & WILDLIFE EFFECTS	4	28	*		*	******	
VEGETATION & WETLAND EFFECTS	5	27	**	*	**	***	*
HIGHWAY ACCESS IN RESERVOIR AREA	15	4		**			
VISUAL/AESTHETIC EFFECTS	12	5	*			*	
CONSTRUCTION IMPACTS	12	5	*			*	
OTHER (Need)	9	10					*

NOTE: The responses were weighted so that an alternative ranked #1 was given 5 points; one ranked #2 was given 4 points; #3 was given 3 points; #4 was given 2 points; and #5 was given 1 point to get this overall rating.

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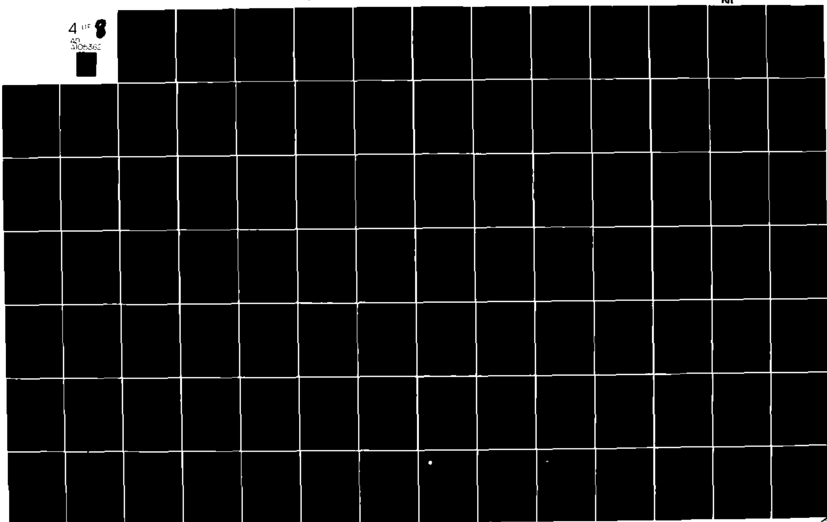

2.00 COMMENTS AND RESPONSES - DRAFT ENVIRONMENTAL IMPACT STATEMENT

2.01 Federal Agencies

2.01.1 U.S. Department of Housing and Urban Development

COMMENT: 1

The Big River Reservoir is to be located where two (2) major highways (I-95 and 3) cross the area. Consideration should be given to developing a "risk analysis" of a potential hazardous material spill onto the Reservoir as well as ways to mitigate the spill and a plan to contain and clean up the spill.

RESPONSE: Consideration of these concerns will be addressed during the project design should it be approved for construction.

COMMENT: 2

There is no discussion on herbicides, pesticides, and fertilizers with fecal matter and nutrients that may have been used on agricultural lands and what its effects would be upon the Big River Reservoir and the watershed area.

RESPONSE: A water purification plant, which is part of the project, will remove nutrients. There is no evidence that other chemicals will show up in quantities that will cause problems. However water sampling and testing will be part of the project design work.

COMMENT: 3

There is no discussion on two sites in Coventry that have been reported by the Rhode Island Department of Environmental Management as having accepted chemical wastes in the past. The two sites are located on Arnold Road northeast of Route I-95. Since these areas are adjacent to the reservoir watershed areas, what, if any, effect would it have upon the surface runoff and the groundwater?

RESPONSE: The so called "Picillo" dump site has been under surveillance by the Environmental Protection Agency (EPA). Observation wells have indicated a westerly flow of groundwater, away from the Big River Project. Surface waters also drain in the same westerly direction. We do not anticipate any impacts from this disposal site. EPA is expanding its surveillance program and the Corps will continue to coordinate with them.

COMMENT: 4

Page EIS-29 states that boating within Big River Reservoir "would be restricted to small fishing boats." The report does not specify whether these boats are to be "dry" or motor powered. If the fishing boats are motor powered, then consideration should be given to banning them from using the Reservoir. Motor boats can cause pollution/degradation of water through discharge of oil, gas, and other chemicals. Protection of the water quality of the reservoir should be of utmost concern in view of the many areas where surface and groundwaters have become contaminated.

RESPONSE: Rhode Island Law (Title 46, Chapter 14, Section 1) as discussed in Appendix H, "Recreation and Natural Resources," prohibits the discharge of refuse or other matter which may pollute a water supply source used for drinking purposes. Certain recreational activities such as swimming and bathing are also prohibited, however other activities such as boating and fishing are not prohibited. There have been a number of studies which have presented evidence indicating that recreation does not have a significant impact on water quality, especially with moderen water treatment systems. Other New England water supply reservoirs, such as Quabbin Reservoir in Massachusetts for example, allow motor powered boats and provide excellent fishing opportunities. It is also in the interest of safety on a large lake to allow motors, as well as to insure that fishermen are able to fully utilize the potential of the fishery resource. Therefore, it is not desirable to prohibit motor powered boats from Big River Reservoir.

2.01.2 U.S. Department of Energy

COMMENT: 1

We have reviewed your draft Environmental Impact Statement on the Big River Reservoir Project. It appears that the evaluation of energy related issues has not been included. These issues range from the amounts and types of energy used for construction to alternative energy resources which may be affected by the creation of this project.

Therefore, we would suggest adding a new section entitled "Energy." This section could be numbered as either 5.03 or 5.01.8 depending upon whether it is written as an additional Environmental Effect or a subsection under Socio-economic Effects.

RESPONSE: While the reservoir is filling and then when the Big River develops its full water supply capability (about 2030) it will discharge only the minimum flow required to maintain water quality and the fishery downstream. This flow will be measured with a downstream gage and the flow will be a combination of seepage, leakage and valved released. The remaining water will go directly into a conduit to the water treatment plant then via a 7 mile tunnel into the Providence water supply system. The water delivered into the water supply system requires the full head of the Big River Reservoir to force water through the treatment plant and conveyance system and deliver it at the service area with sufficient remaining head to get it through the distribution system. There is no excess head for hydro development.

During the project design an operational plan will be developed whereby Big River and the existing Scituate reservoirs will act in concert to meet the water supply demands. When Big River goes into operation it would provide its full share of the load. This would mean that less water supply would be needed from Scituate and excess water at Scituate would be used to generate hydro. This excess water would, however, diminish through the years as demand for water supply increases.

This increased energy output at Scituate was not estimated because it is contingent on a system operational plan that has not yet been developed. The additional revenue, while it could be significant, would only slightly enhance project economic viability.

The energy cost of construction was included as part of the construction cost estimates.

2.01.3 U.S. Department of Agriculture - Soil Conservation Service

COMMENT: 1

The USDA Soil Conservation Service recently completed Important Farmlands map indicates that over 8,000 acres of the Big River Management Area is either prime farmland or farmland of Statewide importance. Since Governor Garrahy is putting new emphasis on preserving our State's agricultural lands, it would seem appropriate to address existing agriculture and the soils associated with agricultural production and what its future would be in the management area. The Important Farmlands maps and the Ag and Open-lands maps of Rhode Island are available along with the soil survey for that area. These can be obtained from Robert E. Lee, P.O. Box 392, Robinson Street, Wakefield, RI 02880.

RESPONSE: A discussion of existing open land uses has been included in Section 4.02 of the Final EIS. Existing land use is also discussed under Problem Identification in the Main Report.

A description of soil types found in the study area is included in the Main Report under Problem Identification, Existing Conditions, Soils. The principal soil type is Glocester stony fine sandy loam. According to soil interpretation tables provided to us by SCS, Glocester stony fine sandy loam is not suitable for cropland, and crops generally are not grown on the soil. Types of crops and pasture sampled were sweet corn, corn silage, Irish potatoes, Alfalfa hay, grass-legume hay, grass hay, and pasture.

As discussed in the Main Report on page 19, land use projections for 1990 show a significant decrease in forest and open land use, from 70.2 percent in 1970 to 51.9 percent in 1990.

COMMENT: 2

The report indicates recreational benefits to be derived from the project. This indicates a change from present Rhode Island policy, which clearly does not include multiple use of watershed management areas.

RESPONSE: The recreational benefits to be derived from the project indicates a change from present Rhode Island policy, which clearly does not include multiple use of watershed management areas.

The plan does include recreation as a project purpose. The type and location of the various activities recommended are consistent with generally good management policies of water supply source areas.

The recreation plan is designed to be consistent with Rhode Island State Law. The law is quoted and some precedent is provided in Volume IV - Appendix H, "Recreation and Natural Resources," Section 1, Pages 5 thru 11. As noted on page 9 the stance of the State agencies ranged from supportive to non-commital. Also, refer to response to U.S. Dept. of HUD, Comment 4.

2.01.4 U.S. Fish and Wildlife Service

COMMENT: 1

GENERAL COMMENTS ON MAIN REPORT, DRAFT EIS, SECTION 404 EVALUATION

We consider information presented in the above documents, for the most part, to be of a general nature with insufficient detail to predict and detect changes in environmental conditions. They lack sufficient depth and detail concerning environmental factors to afford a reasonable understanding of predicted impacts without constant reference to the Technical Appendices. We believe these documents should stand by themselves and contain sufficient information, albeit of a succinct nature, to allow an understanding of the project's overall impact upon fish and wildlife resources within the study area.

RESPONSE: Your comment is included in the record and you are entitled to your opinion. In accordance with current Corps regulations for the organization and content of EIS's for feasibility studies, "References are to be provided should the reviewer require additional detailed technical information relative to the environmental consequences of the proposed action and reasonable alternatives considered," and, "EIS prepared for feasibility studies will not duplicate lengthy documentation of the substantive requirements of NEPA contained elsewhere in the Main Report and Appendixes." We feel that this directive has been complied with and that the document adequately describes the impacts associated with this project.

COMMENT: 2

The ambiguities in the Main Report and DEIS pertaining to mitigation measures for the tentatively recommended plan (Plan C) precludes identification of the most desirable plan (A, B, or C) from a fish and wildlife viewpoint. However, we note that all of these plans are deficient in addressing adequate measures to compensate for losses of fish and wildlife habitat and fall far short of offsetting habitat value losses.

RESPONSE: The discussions in the Main Report have been modified in accordance with your comment to provide greater detail on fish and wildlife mitigation measures proposed for Plans A, B, and C. These management plans adequately address mitigation for loss of fish and wildlife resources at this feasibility stage of project planning, utilizing the data obtained so far. Should Advanced Engineering and Design be authorized, a more comprehensive and detailed fish and wildlife mitigation plan would be developed.

COMMENT: 3

Neither document seriously attempts to project fish and wildlife habitat values over the project life for without and with the project conditions. The only place where such projections occur are in our Fish and Wildlife Coordination Act Report (Appendix H, Section 4) and these are largely ignored in both the Main Report and DEIS.

RESPONSE: The Fish and Wildlife Coordination Report was included in Appendix H, "Recreation and Natural Resources" to accompany that information found in the EIS; in other words, as a supporting appendix. The Coordination Act Report has been referenced in the EIS so that the reader can refer to the Appendix for additional information. This is in accordance with CEQ guidelines on size of EIS's.

Projections of fish and wildlife resources for with and without project conditions are discussed in Appendix H, Section 3 - Terrestrial Ecosystem Assessment, Chapters 4 and 5.

COMMENT: 4

In addition, neither document adequately addresses the secondary impacts of the project upon fish and wildlife resources within the study area.

RESPONSE: Secondary impacts associated with the proposed action were discussed in Appendix H, Section 3, Terrestrial Ecosystem Assessment, Chapter 5, Impacts of the Proposed Action and also in Section 2 of Appendix H, Aquatic Ecosystem Assessment, Chapter 10. A discussion of secondary impacts is included in the EIS under Section 5, Environmental Effects.

COMMENT: 5

DETAILED COMMENTS ON MAIN REPORT

Problem Identification

Page 9, para. 7 - States that "The forests in the Big River Reservoir study area are characterized by a predominance of oak, hickory and yellow poplar trees." The extensive areas of evergreen forest (white pine and pitch pine) are not mentioned. In addition, yellow poplar (Liriodendrom tulipifera) is not listed in Appendix H, Section 3, as one of the species of plants found in the Big River Study Area. Therefore, it should not be considered as a predominate species in the study area.

RESPONSE: This section in the Main Report has been modified to reflect your concern.

COMMENT: 6

Page 9, para. 8 - We note that this is the only place in the Main Report where fish and wildlife resources are discussed under their own separate heading. Throughout the Main Report, fish and wildlife resources are discussed either under recreation or scattered under other headings. We believe that fish and wildlife resources are of sufficient interest and value to be accorded a separate heading for discussion, whenever appropriate, throughout the report. Sufficient information for such discussion, especially as pertains to Big River Reservoir, is contained in our Fish and Wildlife Coordination Act Report, September, 1979.

RESPONSE: Fish and wildlife resources were discussed in Section 4.0, Affected Environment, under General Environmental Setting and Significant Resources, as directed in Corps regulations, ER-200-2-2, for organization and content of EIS's for Feasibility Studies. Also, in Section 5.0, Environmental Effects, fish and wildlife resources were presented in Section 5.02, Natural Resources, under the headings of Aquatic Ecosystem and Terrestrial Resources.

COMMENT: 7

Page 10, para. 1 - Specifically classifies Big River as a warm-water fishery. While it is predominately a warm-water fishery, it should be noted that Rhode Island Department of Environmental Management lists Big River as a Class B trout fishing area, and it is annually stocked with about 2,000 trout by the Division of Fisheries and Wildlife. In addition, native brook trout are found in many of the tributaries.

RESPONSE: The text of the Main Report and EIS has been revised to reflect your comment.

COMMENT: 8

Pages 16 and 17 - Concludes that, ". . . the 1975 population projections represent the most probable future condition as the basis for determining water resources development needs of the study area." We question the rational [SIC] justifying the use of these 1975 population projections. It appears that the revised 1979 population projections would more accurately reflect population trends in the study area. When compared with preliminary Bureau of the Census data (November, 1980), the 1975 population projections exceed the study areas [SIC] 1980 population by over 40,000 and the states [SIC] population by nearly 55,000. However, the 1979 population projections are nearly in complete agreement with 1980 census data. We believe that a reanalysis of the most probable future condition is in order, inasmuch as the distribution of population within the study area and the State would have very direct effects on future water resource development plans that could adversely impact fish and wildlife resources.

RESPONSE: The 1975 RI Statewide Planning Program population projections are favored in making a determination of future water supply needs for the needs for the study area for a number of reasons.

Long term trends in population growth for both the State of Rhode Island and the study area tend to support the use of the 1975 projections. Events that create variations in single year or short term population do not normally cause significant changes in long term growth trends, either up or down.

The uncertain availability of existing supplies throughout the study area, particularly the everpresent chance of groundwater contamination, requires that projections of need be conservative with regard to the ability of present systems to meet needs. The importance of examining the certainty of existing sources is shown by the incidence of contamination of wells in the eastern Massachusetts area, which is comparable to the study area. When wellfields are shut down due to contamination they cannot be reopened in many cases for several years, if ever, due to the slow rate of cleansing of most aquifers. The discovery of hazardous toxic waste dumps in locations throughout New England, and the consequent threat to water supply systems posed by leachate, further adds to the uncertainty of some of the study area's water supplies.

The uncertainty inherent in population projections and available supplies for the long term necessitates a conservative approach in determining other parameters of need. The projected rate of increase in per capita consumption for the study area was assumed to be approximately 0.55 gallons per year. This takes into account some amount of conservation by consumers even without implementation of any demand modification program.

In summary, many uncertainties exist in the available data for projecting water supply needs. Although our present studies favor the 1975 population projections as a basis for computing water supply needs, part of the process of advanced engineering and design studies would be to review all the assumptions that have been made regarding needs to determine if they are still valid. Thus, the projected needs for future water supply development would be refined, and the time frame for the construction of Big River Reservoir could be adjusted if conditions so warrant.

COMMENT: 9

Page 21, para. 4 - We question the validity of the following assumptions: "Population served was assumed to gradually increase until by 2030 the entire study area would be 100 percent served. Likewise, per capita consumption would increase over the entire study area, with rural area consumption growing by more than that of urbanized areas." Both of these assumptions inflate the need for water supply. From our perspective, it does not seem reasonable to assume that the population segment served by private wells will be forced to utilize a municipal water supply system. Based on the evidence presented, we fail to see the need for significantly increasing per capita consumption.

RESPONSE: The assumptions made for per capita consumption increases are conservative when compared to historical trends and other methodologies. Historically, per capita consumption has increased approximately 1.3 gpcd per year according to the Northeastern United States Water Supply (NEWS) Study. The same study projects that increases would tend to level off over the next fifty years, from about 1.2 gpcd/year throughout the 1970's to about 0.60 gpcd/year by about 2020. For the Big River Reservoir Study, consumption was assumed to increase by 20 gpcd from 1975 thru 2000 and 10 gpcd from 2000 to 2030. This represents an average increase of 0.55 gpcd/year for the study timeframe. The comparable average increase for the NEWS study would be approximately 0.78 gpcd over the same timeframe. Thus the annual per capita consumption increase chosen for this study seems well justified.

The assumptions made about population served do not have a major impact on the projected need for water supply in this case, as the major population centers and need areas in the study area are already close to 100 percent served, and thus are not affected by the increase in population served. In 1975 the study area was approximately 90 percent served. The towns significantly less than 90 percent served were Foster and Glocester (0 percent), Scituate (16 percent), and West Greenwich (28 percent). Of these towns, Foster and Glocester are expected to develop local sources, and are not included in the planned area to be served by the combined Big River - Scituate Reservoir system. Thus the percentage served in those towns does not affect the needs projected to be met by new major water supply development.

Scituate and West Greenwich are each less than one third municipally served, and as a worst case, if no further municipal system extensions were made, the resulting difference in population served from that projected in the study would be approximately 11,800 persons or about

1.4 percent of the study area. Thus, even in the worst case, the need projections for the study would not change by much, showing that the assumption made for population served is not a major factor in determining water supply need in the study area.

COMMENT: 10

Page 26, para. 4 - States that, "Objectives associated with environmental needs were directed at preservation of existing stream conditions since no highly productive habitat exists in the Pawtuxet River Basin . . ." What is the basis for this statement? We believe that data presented in Appendix H, Section 2, are indicative of a diverse and productive aquatic system within the area studied. The stated objective more clearly limits itself to existing downstream conditions (below Flat River Reservoir) and does not consider potential water quality improvements and subsequent increases in stream productivity. With improved water quality conditions, it is most likely that a productive warm-water fishery would prevail in the downstream area and the possibility of restoration of American shad and alewives to the Pawtuxet system could become a reality. Therefore, objectives associated with environmental needs should be directed at future stream conditions and appropriate changes should be made throughout the report.

RESPONSE: The term "highly" is a subjective term which we believe to apply in this instance and therefore have used it. The purpose of this paragraph was to point out that objectives for environmental needs would attempt to conserve and maintain the existing stream environments within the study area. This would include potential water quality improvements in the downstream areas, particularly in the Pawtuxet River, due to flood damage reduction measures. As stated on page 27, flood damage reduction objectives would "contribute to the preservation and maintenance of the resources of existing stream environments within the study area during the study time frame (1980-2030) and beyond."

COMMENT: 11

Formulation of Preliminary Plans

Page 35, Ground Water - This section as well as Appendix B, pages 25-32, discusses the availability of ground water in various communities and points out that in many areas ground water is of unacceptable quality and would require extensive treatment. However, we find no detail or indepth analysis on the feasibility of such treatment. The cost of such treatment should not be of great concern since paragraph 6 states that "The price of water in the study area is so low that pricing policy changes would have little, if any, effect on use." Therefore, we suggest that the feasibility of utilizing ground water supplies be more fully explored.

RESPONSE: As noted in the report, most of the groundwater believed to be available in the study area is of poor quality due to the urbanized nature of the locations of the aquifers. The types of pollutants that would occur in such groundwater would require advanced treatment methods, and the resulting cost of the water would be greater than utilizing surface water with minimal treatment. In addition, even if the cost of treatment were low enough to make the use of locally available groundwater feasible, the quantity of such aquifers is insufficient to meet study area needs.

Further, it is not believed that the available groundwater supplies are suitable for industrial use.

COMMENT: 12

Assessment and Evaluation of Detailed Plans

Page 50, para. 4 - The 8,300 acres referred to includes the entire Big River Management Area and not just the lands surrounding the reservoir.

RESPONSE: The entire 8,300 acres was acquired by the State in the 1960's and is now known as the Big River Management Area. The recommended reservoir would frequently inundate 3,240 acres with a full water supply pool at elevation 300 NGVD (mean sea level). In flood situations the inundated area would increase and an extremely severe flood could inundate up to 3,400 acres (at 303 NGVD) for a very short period of time. To put it in other terms, 4,900 acres of the project lands would be free from inundation. These are the proposed lands that would be managed for mitigation of fish and wildlife resources.

COMMENT: 13

Page 51, para. 1 - Recreation facilities proposed for Plan A are not shown on Plate 8 as indicated. This is also true of Plan C.

RESPONSE: The text has been modified to reflect your comment.

COMMENT: 14

Page 51, para. 3 - Indicates that downstream flow into Flat River Reservoir would be reduced by 43 percent. However, this includes the entire drainage area of Flat River Reservoir. According to information contained in Appendix D, Hydrological Analysis, the average annual stream flow at the Big River dam site is about 60 cfs. With the project, this flow would be reduced to 6 cfs, a reduction of 90 percent. In addition, the project would reduce average annual stream flow below Flat River Reservoir by as much as 40 percent and as much as 15 percent in the mainstem Pawtuxet. The potential impacts of these reduced flows on the aquatic biota of Flat River Reservoir and the downstream area has not been addressed in Plans A, B or C.

RESPONSE: The drainage area into Flat River Reservoir is 56.7 square miles. This figure includes 29.7 square miles that is controlled by the

Big River Dam. Therefore 27 square miles or 48% of the Flat River Reservoir drainage is not and can not be controlled by Big River.

While it is noted that average flows are substantially reduced by the project it must be noted that the critical 7 day 10 year low flow would remain undiminished. That is the purpose of maintaining a dependable flow during low flow periods; to prevent damage to fish and wildlife habitat and to prevent the deterioration of water quality.

We do not believe the project will cause significant damage to quality or habitat in the Flat River Reservoir. However, water sampling and testing will continue throughout the design period and estimates will be made of impact of the project on Flat River Reservoir.

COMMENT: 15

Page 51, para. 6 - The recreation activities allowed under all plans may not be compatible with wildlife management objectives and efforts to mitigate habitat losses. This should be addressed in Plans A, B and C.

RESPONSE: The interrelationships between recreation, wildlife management and mitigation are addressed in the Environmental Impact Statement and in Appendix H. There have been no indications that development of additional shoreline recreation facilities, primarily at existing recreation areas, would be incompatible with wildlife management or mitigation, or that horseback and hiking trails or hunting would be incompatible in any way. Only the proposed camping areas on Hungry and Harkney Hills under Option III of the recreation development plan might be subject to question as to total compatibility should they ever be proposed for construction, depending on what wildlife management plans may actually be undertaken.

COMMENT: 16

Page 53, para. 2 and 3 - Discusses mitigation of adverse impacts of reduced downstream flows on riparian water uses. Potential aquatic resource losses or studies needed to determine such losses are not mentioned. We believe this should be addressed in Plans A, B and C.

RESPONSE: Those measures discussed for mitigation of impacts on downstream riparian users under Plan A are the same for Plans B and C. Discussion was included under Plan A, and, for the sake of reducing repetition, was referenced under Plans B and C to the effect that mitigation measures would be similar as pointed out in Plan A. It was indicated in Plan A that "Advanced engineering studies will determine the costs of such efforts." It was assumed that the advanced engineering studies would include further investigation and identification of downstream mitigation measures, along with a determination of associated costs once the specific operational configuration of the project is designed.

COMMENT: 17

Page 55, para. 6 and page 56, para. 6 - Indicates that Plan B includes additional mitigation measures, compared to Plan A, such as subimpoundments, stripping and grubbing of selected areas and reclamation of strip mining areas. Yet on page 57, paragraph 5, it states that "For Plan B, mitigation of impacts will be identical to the requirements of Plan A." On page 60, paragraph 4, it states that mitigation requirements under Plan C would be the same as under Plan A. The Draft Environmental Impact Statement, pages 17-18, indicates that subimpoundments, stripping and grubbing and reclamation of strip mining areas are included in the recommended plan, Plan C. We suggest that this entire section be clarified in order to more fully understand the extent of efforts undertaken to mitigate fish and wildlife resource losses under Plans A, B and C.

RESPONSE: The discussion of mitigation measures associated with Plans A, B and C in the Main Report have been modified to provide greater detail on the level of proposed fish and wildlife management.

COMMENT: 18

Page 57, para. 1 - Suggests that mitigation under Plan B would be of such an extent that negative fish and wildlife impacts would be minimal. We do not agree with this statement since our Fish and Wildlife Coordination Act Report (contained in Appendix H, Section 4) indicates that while intensive management of the reservoir (subimpoundments) and surrounding State-owned land would mitigate about 68 percent of the total wildlife Habitat Unit losses, it would mitigate only about 20 percent of the wetland losses. Acquisition and management of an additional 5,800 acres of land would be required to compenste for all of the Habitat Unit losses. Additional studies would be needed to determine the magnitude of potential adverse impacts of reduced stream flow on the aquatic biota of Flat River Reservoir and the downstream area. The information contained in our Coordination Act Report has not been utilized in your assessment and evaluation of detailed plans, and we urge you to utilize this information to assure equal consideration of fish and wildlife resources in the planning process.

RESPONSE: The Main Report has been modified to provide greater detail on the purpose of the mitigation proposals. At this level of study we feel that the mitigation plans presented in the Final EIS adequately mitigate the loss of resources. With this plan, adverse environmental impacts would be minimized to such an extent to be feasible and viable at this time, and not conflict with the purpose of the project. Refer to the proposed fish and wildlife management plan in the Final EIS for further rationale and justification of mitigation.

COMMENT: 19

Comparison of Detailed Plans

Page 62, para. 5 - States that "Plan B includes more extensive measures to enhance environmental productivity, thus would produce more benefits to the local environment, particularly on fish and wildlife resources." We do not view measures taken under Plan B to enhance but rather to mitigate fish and wildlife resource losses, therefore, no benefits would occur over the existing situation. We suggest that this paragraph as well as others in the report that use the terms enhance, enhancement and benefits, be revised for context and appropriately rephrased. In addition, see our comments for page 57, paragraph 1.

RESPONSE: The appropriate sections in the text of the Main Report and EIS have been revised to reflect your concerns.

Also, refer to response to Comment 18 in this section.

COMMENT: 20

Page 64, para. 6 - See our comments offered for pages 55-56, paragraph 6, page 57, paragraph 1; and page 62, paragraph 5.

RESPONSE: Refer to responses to Comments 17, 18 and 19 in this section.

COMMENT: 21

DETAILED COMMENT ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

1.0 Summary

1.01, page 1, para. 3 - We are not convinced that the figures shown represent the most probable demand estimates for water supply. Projected population growth is the most important element in developing a most probable future condition and we believe the projections utilized by the Corps are open to question. Therefore, we believe that a reanalysis of the most probable future condition is in order, inasmuch as the distribution of population within the study area and the State would have very direct effects on future water resources development plans that could adversely impact fish and wildlife resources. This issue should be addressed in the DEIS (see detailed comments on Main Report for pages 16-17 and page 21, paragraph 4).

RESPONSE: Refer to response to Comment 8 in this section.

COMMENT: 22

1.01, page 2, Plans A, B and C - There appears to be a discrepancy in these plans with regard to mitigation features. Plan C, as outlined in the Main Report, does not appear to include addition [SIC] features such as subimpoundments and reclamation of strip mining areas that is included in Plan B and shown on Plate 9 of the Main Report. Yet, these individual features appear on Figure 2 in Appendix H, Section 4, as basic mitigation features and are discussed as part of the recommended plan, Plan C, in the DEIS. Therefore, we question if the DEIS addresses the correct plan of development or if our confusion is due to the phrasology in the Main Report. (In addition, see detailed comments on Main Report for pages 55 and 56).

RESPONSE: Section 1.01 in the EIS has been modified to reflect your comment, in addition to the appropriate sections in the Main Report. Also refer to response to Comment 17 in this section.

COMMENT: 23

1.01, page 2, last para. - States that, "Basic mitigation recommendations (Appendix H, Vol. IV) have been presented which would offset impacts to terrestrial and aquatic resources." We suggest that the basic differences between the Corps and the Service's mitigation plans be summarized in this section. In our opinion, the Corps' plan does provide for mitigation but fails to offset impacts by a substantial margin. The Service's plan would more completely offset impacts to terrestrial and aquatic resources.

RESPONSE: Section 1.01 in the EIS has been revised to reflect your comment. Also, refer to Comment 13 in this section.

COMMENT: 24

3.0 Alternatives

3.01.6, page 10 - This section should address the feasibility of adequately treating groundwater supplies of unacceptable quality to provide potable water. (See detailed comments on Main Report for Page 35, Ground Water).

RESPONSE: Refer to response to Comment 11 in this section.

COMMENT: 25

3.03 (5), page 17 - See detailed comments for 1.01, page 2, Plans A, B and C. In addition, this section is remiss in that potential adverse impacts to downstream aquatic biota, due to a reduced streamflow regime, is not recognized and mitigation measures that could reduce these impacts are not discussed.

RESPONSE: Refer to response to Comment 22 in this section.

Potential measures for mitigation of downstream impacts are discussed in the Main Report under the description of Plan A. Potential impacts to downstream aquatic biota due to reduced streamflows are discussed in the Final EIS in Section 5.0, Environmental Effects.

COMMENT: 26

3.03 (5), page 19, last para. - States that, "The creation of subimpoundments would mitigate the loss of wetlands." We contend that while subimpoundments would mitigate some of the wetland losses, they fall woefully short of offsetting wetland losses. The subimpoundments as proposed by the Corps have been reviewed by the Service and checked on a map depicting four-foot contour intervals (Keyes Associates and Metcalf & Eddy, Inc., undated). Subimpoundments in the Congdon River and Tarbox Pond areas are relatively deep with maximum depths of over 20 and 12 feet, respectively, with the greater portion of each being over 8 feet in depth. The two smaller subimpoundments fair somewhat better but we do not consider either of them as providing first rate wetland areas. We feel that the Service has been generous in evaluating subimpoundments in its Fish and Wildlife Coordination Act Report (contained in Appendix H, Section 4). The value attributed to subimpoundment development reduced the area required for compensation of wetland losses by over 1,400 acres. An additional 4,500 acres of wetlands would still have to be acquired and managed in order to fully compensate for wetland losses. This should serve to rebutt the statement, contained in the Preface to Appendix H, Section 4, that the Service did not adequately consider the value of subimpoundments. We believe the above should be recognized and discussed in the DEIS.

RESPONSE: Since the publication of the Draft EIS, additional coordination has taken place with the Rhode Island Dept. of Environmental Management to further refine and develop recommendations for mitigation of wetland habitat. The plans that the Corps has developed, which also take into consideration USFWS recommendations, are presented in Section 3.03, Detailed Project Planning. The test has been modified to indicate that the extent of wetland mitigation is still an unknown quantity but that mitigation of losses to wetland can be achieved.

COMMENT: 27

4.0 Affected Environment

4.01, page 20 and 4.02, page 21 - We believe these sections should address the Flat River Reservoir and the South Branch and mainstem Pawtuxet Rivers since a reduction in streamflow would obviously affect these areas. Neither section adequately addresses the significance of 570 acres of wetlands (National Wetland Inventory) that would be inundated by the project. While hunting use is noted, it is not mentioned that Big River Management Area is one of the largest areas of State-owned land in Rhode Island and hunters utilize the area to near capacity during the deer hunting season.

RESPONSE: Flat River Reservoir, the South Branch and mainstem Pawtuxet Rivers are included in the discussion under Section 4.01, General Environmental Setting at Big River. Table 5 in this section includes a presentation of wetland resources, under aquatic ecosystems. Predominant vegetation, predominant wildlife, and estimated acreages have been included. The figure of 524 acres of wetlands, and others in the table, were estimated at the time of the terrestrial ecosystem study. Discussions in the Final EIS concerning wetland habitat have utilized the 570 acre figure provided by the Service. By including wetlands in Table 5 under the section of Significant Resources, we feel that the significance of this habitat in the Big River study area has been realized. However, Section 4.01 has been modified in the Final EIS to further describe significant resources in the reservoir study area.

Paragraph 2 on p. EIS-22, states that the Big River site offers about 10 percent of the hunting capacity of the State of Rhode Island, with a reference to Appendix H, "Recreation and Natural Resources." Pages 59-60 state: "The Big River Site is one of the most popular hunting areas in the State," and, "During the 1973-1975 seasons, deer harvested at Big River accounted for over one-third of the State total." A table showing statistics for shotgun deer seasons at Big River for years 1971-1976 is given. These figures were obtained from the Rhode Island Division of Fish and Wildlife. This information clearly shows the importance of deer hunting in the Big River Reservoir Study Area.

COMMENT: 28

5.0 Environmental Effects

5.01.2, page 24, para. 1 - The 5,326 acres for State-owned lands surrounding the reservoir site seems out-of-line with other figures quoted in the DEIS and Main Report. We believe that the heading as listed in the report (5.02.2) is incorrect.

RESPONSE: Refer to response to Comment 12 in this section. Section 5.02.2 has been corrected in the Final EIS to Section 5.02.1.

COMMENT: 29

5.01.2, page 24, para. 2 and page 25, para. 1 - The developments discussed in these paragraphs would have a significant secondary impact upon fish and wildlife resources of the area. These secondary impacts have not been adequately addressed in the DEIS.

RESPONSE: On page 19 of the Main Report it states: "Land use projections for 1990 show a significant increase in residential land use, from 16.6 percent in 1970 to 26.1 percent predicted for 1990. Forest and open land show a significant decrease, from 70.2 percent in 1970 to 51.9 percent in 1990." Recreation lands increase from 1.0 percent in 1970 to 7.8 percent in 1990. Other land use categories show little project change during the

20-year period used for these projections. These figures indicate that land use areas suitable for fish and wildlife resources would decline because of the expected rise in development. However, the State of Rhode Island has set aside many areas to be managed specifically for fish and wildlife, including the Arcadia Management Area and the Burlingame Management Area. It is expected that these areas would continue to be managed as they have been in the past, and possibly on a more intensive basis to increase wildlife habitat due to its loss in other areas of the State due to development pressure.

COMMENT: 30

5.01.5, page 28, para. 4 - States that cultural mitigation could be accomplished by creating a "Historical Park" on a portion of the State-owned land surrounding the reservoir site. The extent of such a development and its impact on wildlife habitat has not been addressed.

RESPONSE: Creation of a "Historical Park" on a portion of the adjoining State-owned lands is one out of many possibilities that could be implemented for cultural resources mitigation. As stated in the EIS, this is one "potential" method that could be recommended. Should the project be authorized for Advanced Engineering and Design, (AE&D), a cultural resource survey would be performed. At this time, the feasibility of creating a "Historical Park" would be studied in detail, along with associated impacts on fish and wildlife resources.

COMMENT: 31

5.01.6, page 29, para. 1 - States that "Access to the reservoir and adjoining lands northeast of I-95 would not be allowed . . ." Exactly what this means in terms of opportunities lost to mitigate fish and wildlife habitat values has not been adequately addressed.

RESPONSE: This paragraph has been modified in the Final EIS to provide greater detail on the proposed level of recreation. Option III, described in Appendix H, has been selected as the best plan that would meet the future recreational needs of the study area. Under this option, access will be provided in specified areas in the reservoir watershed. There would be no loss of opportunities to mitigate for fish and wildlife resources. Also, refer to response to U.S. Fish and Wildlife Service, Comment 15.

COMMENT: 32

5.02.2, page 29, para. 1 - See detailed comments on Main Report for page 62, paragraph 5.

RESPONSE: Refer to response to Comment 19 in this section.

COMMENT: 33

5.02.2, page 29, para. 2 - We do not view the Fish and Wildlife Coordination Act Report appended in Appendix H, Section 4, as a Planning Aid Report.

RESPONSE: The text has been revised to reflect your views.

COMMENT: 34

5.02.2, entire page 30 - The Corps rejects many of the recommendations contained in our Fish and Wildlife Coordination Act Report based on a lack of justification and spells out their rational [SIC] for such rejection. We offer the following rebuttal:

We stand by our recommendation that the project not be constructed. An area of over 8,000 acres of State-owned lands in proximity to a large population center, utilized for hunting, fishing and other recreational pursuits, is a rare commodity in Rhode Island. Based on our analysis wildlife habitat in general is better than average quality and the 570 acres of wetlands are of significant value to a wide array of wildlife species. The area is not extensively managed for fish and wildlife resources and, in light of the unknown, we projected this to continue over the life of the project. However, this does not foreclose future options for such management if the project is not constructed. We believe that data presented in our Fish and Wildlife Coordination Act Report portray habitat values of sufficient magnitude to warrant the no construction recommendation. In addition, the questionable validity of population projections and the need for water supply as presented in the Main Report reinforces our recommendation that the project not be constructed.

RESPONSE: Your comment has been noted.

COMMENT: 35

The Corps claims that the Habitat Evaluation Procedures are not an established nor verified procedure. We refer you to the Federal Register, Vol. 46, No. 15, January 23, 1981, where it states on page 7659 (column 1, d) that "The Habitat Evaluation Procedures will be used by the Service as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation . . ."

RESPONSE: The rationale behind the subject statement is that the Habitat Evaluation Procedues are not procedures established by the Corps in developing a fish and wildlife mitigation plan. The use of HEP is the specific policy of the U.S. Fish and Wildlife Service, as stated in the regulation quoted in your comment.

Direction on mitigation for the Corps is provided in policy set forth in the Fish and Wildlife Coordination Act (16 U.S.C. 661-666c; Pl 85-624).

The Act directs that the Corps develop a plan which includes ". . . such justifiable means and measures for wildlife purposes as the reporting agency finds should be adopted to obtain maximum overall project benefits . . ." HEP has been used by the Corps as a tool to identify lands of similar habitat type composition for management. The Corps has rejected only the USFWS' additional acreage requirements for mitigation at Big River. The plan represents the level of management which the Corps feels is justifiable and in the public interest for fish and wildlife mitigation in conjunction with the proposed Big River Reservoir Project.

The EIS text has been modified to provide greater detail on this position.

COMMENT: 36

The Corps claims that the wildlife benefits associated with acquisition and management of an additional 5,800 acres of land do not outweigh the social and economic impacts of such an acquisition. We do not view the acquisition and management of an additional 5,800 acres of land as a wildlife benefit but rather as mitigation to offset the loss of habitat values that would occur with development of the reservoir. This is consistent with the Service's Mitigation Policy as published in the aforementioned Federal Register. We classified wetlands of the project area in Resource Category 2, which is defined in the Federal Register (page 7657, column 3) as "Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section." The mitigation goal is "No net loss of inkind habitat value." Uplands of the project area are classified in Resource Category 3 (page 7658, column 1) which is defined as "Habitat to be impacted is of high to medium value for evaluation species and is relatively abundant on a national basis." The mitigation goal is "No net loss of habitat value while minimizing loss of in-kind habitat value." Therefore, we believe that our Coordination Act Report adheres to existing policy and that the recommendation for acquisition and management of an additional 5,800 acres of land to compensate for habitat value losses represents a legitimate effort to protect and preserve fish and wildlife resource values.

RESPONSE: Your comment is acknowledged and included in the record. Also, refer to response to previous Comment 35 in this section.

COMMENT: 37

The Corps claims that benefits for increasing downstream flows from 6 cfs to 18 cfs have not been justified. We are not claiming benefits for reducing average annual streamflow at the Big River dam site from 60 cfs to 18 cfs, a reduction of 70 percent. Rather, we are trying to establish an aquatic base flow in order to sustain most requisite life cycle needs for the endemic aquatic organisms downstream of the project area. We have recommended that additional studies be conducted of the downstream flow regimen utilizing a flow of 18 cfs from Big River Reservoir (Coordination

Act Report, page 15). This information would be used to determine the impact of changed streamflow regimen upon the environmental characteristics of Flat River Reservoir, the South Branch and mainstem Pawtuxet.

RESPONSE: Benefit is a poor choice of words. The minimum 7Q10 low flow discharge is maintained to prevent damage to downstream fish habitat and the deterioration of downstream water quality. The 7Q10 low flow is considered by both the Corps and the State of Rhode Island to satisfy existing and ambient conditions in low flow situations. Also, see response to Comment 14 in this section.

COMMENT: 38

The Corps claims that fishery studies that have been conducted (Appendix H) are adequate to explain the effects of the impoundment on the fishery resources of the area. We find that these studies do not adequately define standing crop or productivity for either existing or future conditions. The impact of reduced downstream flows has not been adequately addressed. The amount and extent of organic material which would have to be removed from the pool area in order to establish a cold-water fishery has not been clearly defined. Therefore, we believe that the additional studies recommended in our Fish and Wildlife Coordination Act Report are germane in that they would more clearly define the impacts of Big River Reservoir on the aquatic biota of the area.

RESPONSE: The studies presented in Appendix H are considered by the contractor's professional judgement to be of *sufficient* detail in addressing fish and wildlife resources in the study area for this feasibility stage of project planning. The studies mentioned in your comment would be addressed should the project be authorized for Advanced Engineering and Design.

COMMENT: 39

5.02.2, page 30, last para. - We agree with this paragraph in that mitigation measures for recreation, cultural resources, etc., could have a significant adverse impact upon management opportunities to increase wildlife habitat values. However, we encourage multiple use insofar as it does not unduly interfer [SIC] with the basic purpose of mitigating wildlife habitat values. Impacts above this level would necessitate additional measures to compensate for wildlife habitat losses due to noncompatible use.

RESPONSE: Section 5.02.2, Fish and Wildlife Management Plans, discusses U.S. Fish and Wildlife Service Mitigation recommendations, and the fact that even though mitigation is designed to compensate for impacts incurred by project implementation, there are nevertheless impacts associated with implementing mitigation and management programs. There is no discussion of mitigation for recreation and cultural resources in Section 5.02.2, or whether mitigation measures for recreation and cultural resources would have any adverse impact on fish and wildlife management.

COMMENT: 40

5.02.2, page 31, para. 3 - The meaning of this paragraph is not clear and we suggest that it be rephrased to indicate what clearing operations are actually being addressed.

RESPONSE: In order to establish a viable cold-water fishery in the reservoir, selective removal of organic material from the pool would be necessary. This removal is called "clearing operations." Further discussion of clearing operations is included in Appendix E - "Water Quality." Impacts on the aquatic and terrestrial ecosystem due to clearing operations are discussed in Appendix H, Sections 2 and 3, "Recreation and Natural Resources."

COMMENT: 41

5.02.2, page 31, last para. - See detailed comments on DEIS for 3.03 (5), page 19.

RESPONSE: Refer to response to Comment 26 in this section.

COMMENT: 42

5.02.3, page 33, para. 4 - States that "No significant effects on downstream (Flat River Reservoir or Pawtuxet River) aquatic biota are expected." What is the basis for this statement? We can find no scientific data in the Main Report, DEIS or Appendices that are relevant enough to support this statement. Therefore, we suggest this issue as recommended in our Fish and Wildlife Coordination Act Report.

RESPONSE: Downstream flow regimes are discussed in Appendix D, "Hydrology" and Appendix E, "Water Quality." When minimum low flow occurs, there would be reduced D.O. levels along with elevated temperatures. Those species most tolerant under these changed conditions would survive. At normal flow conditions there would be no significant impacts on the aquatic biota. The 7Q10 minimum low flow is considered by both the Corps and the State of Rhode Island to satisfy existing and ambient conditions in low flow situations.

Section 5.0 has been modified to include an additional discussion on downstream impacts.

COMMENT: 43

5.02.4, page 35, para. 1 - States that "Impacts on avifauna would be minimal . . ." We find this statement erroneous in that over 3,000 acres of nesting habitat would be destroyed resulting in a reduction of the total bird population in the area.

RESPONSE: This paragraph is part of the discussion concerning impacts on the terrestrial ecosystem during construction of Big River Reservoir. It stated ". . . during the spring and early summer there could be a high mortality of eggs and young, along with destruction of nesting habitat." However, in the other seasons, most birds would flee the area and direct mortality would be minimal. Habitat removal would result in a decline of wildlife populations in the area. These losses would be mitigated by the management of upland habitat in the lands surrounding the reservoir, as discussed in Section 3.03, Detailed Project Planning. Further discussion of impacts on avifauna is in Appendix H, Section 3.0, Terrestrial Ecosystem Assessment.

COMMENT: 44

5.02.4, page 35, para. 3 - States that "The open reservoir would result in a greater environmental diversity . . ." We cannot logically follow the reasoning that a 3,240-acre body of water inundating wetlands, open field, forestland, shrubland, and small streams and ponds would result in a greater environmental diversity.

RESPONSE: This paragraph points out that the creation of an open reservoir would add a different landscape component than what now exists in this area of Rhode Island. The existing landscape pattern in the study area is similar to others in the region, and the creation of a reservoir would provide a diversity in landscape. The definition of "environment" according to NEPA is the human environment, including fish and wildlife resources. See Appendix H, "Recreation and Natural Resources," Section 3, Terrestrial Ecosystem Assessment.

The EIS text has been modified in accordance with your comment.

COMMENT: 45

DETAILED COMMENTS ON SECTION 404 EVALUATION

Evaluation Summary

Page 4, para. 1 - Based on National Wetland Inventory data, there are 570 acres of wetlands within the Big River Reservoir site, not 524.

RESPONSE: Refer to response to Comment 27 included in this section.

COMMENT: 46

Page 4, para. 2 - States that "Proper management of these adjacent regions would significantly ameliorate this impacct . . ." We believe the extent of mitigation should be addressed. See detailed comments on Main Report for page 57, paragraph 1.

RESPONSE: The text has been modified to provide greater detail on the proposed fish and wildlife mitigation plan.

Also, refer to the response to Comment 18 on Main Report for page 57, paragraph 1.

COMMENT: 47

Page 4, para. 3 - States that the Corps' plan emphasized mitigation of wetland losses. We do not believe that the Corps' plan adequately addresses mitigation of wetland losses. The subimpoundments proposed as mitigation for wetland losses are relatively deep and are not conducive to intensive wetland management. See detailed comments on DEIS for Section 3.03 (5), page 19, last paragraph.

RESPONSE: Refer to response to Comment 26 concerning comments on the Draft EIS for Section 3.03 (5), page 19.

COMMENT: 48

Page 5, para. 1 - States that streams and ponds of the project area are of low productivity and unable to sustain a significant fishery. We do not believe that the aquatic biota analysis contained in Appendix H, Section 2, indicates that streams and ponds of the project area are of low productivity. In addition, Flat River Reservoir which would be impacted by the project sustains a significant fishery.

RESPONSE: Based on the studies carried out for the Aquatic Ecosystem Assessment found in Appendix H, the sport fishery potential in the study area has differing levels of value, depending on the type of habitat. The existing ponds support excellent sport fisheries for pickerel, sunfish, largemouth bass and perch. However, the streams offer a limited warm-water fishery potential as compared to the cold-water stream fishery due to a successful trout stocking program. Refer to Appendix H for additional discussion on sport fishery potential.

The text has been modified to provide greater detail on this subject.

COMMENT: 49

Page 5, last para. - States that efforts would be made to minimize undesirable degradation in the downstream area where possible. Since the Corps has rejected our recommendation for further studies in the downstream area to assess the extent of undesirable impacts (DEIS, Section 502.2, page 30), how can the impacts be minimized until the extent of the impacts are known. See our detailed comments on DEIS for Section 502.2, page 30.

RESPONSE: The efforts to minimize degradation downstream would be defined by studies deemed necessary during the advanced design stages. The Corps has only rejected undertaking further studies at the feasibility level. The necessary work would be done at a more advanced stage of design.

COMMENT: 50

Ecological Evaluation

230.4-1 (A-1), page 6 - This section implies that the loss of wetland habitat values will be substantially mitigated through appropriate project modification, i.e., stabilization structures in shallow coves. The degree or extent of such mitigation is not addressed. We contend that only 20 percent of the wetland losses will be mitigated by the Corps' proposed mitigation measures. See our detailed comments on DEIS for Section 3.03 (5), page 19.

RESPONSE: Refer to response to Comment 26 in this section concerning wetland mitigation.

COMMENT: 51

Chemical-Biological Interactive Effects

230.4-1 (B-2), page 8 and 9 - This section implies that Big River Reservoir would be similar to Scituate Reservoir and support a productive fishery. Yet, it acknowledges that "no data on aquatic life in Scituate Reservoir is available . . ." This section also acknowledges that potential impacts on downstream aquatic biota is as yet unpredictable. However, we note no mention for additional studies (as recommended in our Fish and Wildlife Coordination Report) to determine potential standing crop and productivity of Big River Reservoir (relate to Scituate Reservoir) or to determine the potential impacts of a reduced streamflow regimen on downstream aquatic biota. We believe that the need for additional studies should be addressed.

RESPONSE: Refer to response to Comment 38 and 42 section regarding downstream impacts.

As stated in Appendix H, Section 2, Aquatic Ecosystem Assessment, projection of limnological characteristics of the proposed reservoir by comparison with Scituate Reservoir was not possible because of the lack of aquatic studies on Scituate. However, Big River was compared with Beach Pond and Wallum Lake which exhibit similar chemical and biological characteristics as projected for Big River, and have recent limnological and fishery data.

A comparison of water quality data obtained from Scituate Reservoir to the proposed Big River Reservoir is provided in Appendix E, "Water Quality."

Section 230.4-1 (B) of the 404 Evaluation has been modified to provide greater detail on this information.

COMMENT: 52

Conclusion, page 20

We do not agree that "Every attempt has been made to provide for . . . reasonable minimization and/or mitigation for adverse environmental impacts." The recommended studies contained in our Fish and Wildlife Coordination Act Report to more clearly define many of the potential adverse impacts have been rejected by the Corps. Only 20 percent of the wetland habitat value losses would be mitigated if the Corps' proposed mitigation plan is adopted.

RESPONSE: Refer to responses to Comment 18, 26, and 35 in this section concerning fish and wildlife mitigation.

COMMENT: 53

Therefore, based on all of the above, we stand by the recommendations contained in our Fish and Wildlife Coordination Act Report (Appendix H, Section 4) and reiterate that our main recommendation is that the project not be constructed.

RESPONSE: Your comment is acknowledged and included in the record.

2.01.5 Advisory Council on Historic Preservation

COMMENT: 1

We have received your request for comments (you reference NEDPL-BU) on the draft environmental impact statement for the proposed construction of the Big River Reservoir in Coventry and West Greenwich, Rhode Island, pursuant to Section 102(2) (c) of the National Environmental Policy Act of 1969. The Council has determined that your draft environmental statement entions [SIC] properties of cultural and/or historical significance, but we need more information on the effects of the undertaking on these resources. Please furnish documentation that you have fulfilled the requirements set forth in 36 CFR Section 800.4 (b) of the Council's regulations "Protection of Historic and Cultural Properties" (inclosed). Specifically, the study conducted in 1978 by the Big River Cultural Resource Reconnaissance was not included in your draft interim report of July 1980 (Appendix I). This study mentions 12 possibly significant historic features within the impoundment area. A determination of these properties' eligibility for the National Register and an analysis of steps to mitigate any adverse effects of construction or inundation of these properties must be fully addressed in your report.

RESPONSE: We are currently in the Preauthorization Phase of planning for Big River Reservoir. As noted in the comment, a Cultural Resource Reconnaissance was performed to identify potentially significant cultural resources within the project impact area. This level of study is commensurate with the Preauthorization Phase, as outlined in our regulation (Civil Works Projects: Identification and Administration of Cultural Resources: 33 CFR Part 305), and is understood to fulfill our Cultural Resource responsibilities within this Phase. Should Congressional authorization and funding be approved for further study, determinations of eligibility and detailed mitigation plans will then be developed, as appropriate.

COMMENT: 2

Please remember that compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470f, as amended, 90 Stat. 1320), the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800), and Executive Order 11593 (May 13, 1971) are independent requirements of law that must be fulfilled unless it has been determined in accordance with 36 CFR Section 800.4(a) of the Council's regulations that no properties that are included in or that would be eligible for inclusion in the National Register of Historic Places are located within the area of the undertaking's potential environmental impact and this finding is clearly set forth in the draft environmental impact statement. Accordingly, you should coordinate NEPA compliance with these separate responsibilities as provided for in 36 CFR Section 800.9 of the Council's regulations and the final environmental impact statement should contain the comments of the Council obtained pursuant to 36 Sect. 800.6 or 800.8 of the Council's regulations.

RESPONSE: So noted.

2.01.6 U.S. Environmental Protection Agency

COMMENT: 1

From the standpoint of EPA's areas of jurisdiction and expertise, we believe the project could have significant adverse impacts. In addition, we believe the DEIS does not provide sufficient information on:

-- impacts on the water supply of highway runoff, chemical spills, and secondary development, and methods to be used to mitigate these impacts;

-- the impact of reduced streamflows on the water quality of the Flat River Reservoir and the South Branch of the Pawtuxet River;

-- mitigation measures to minimize adverse impact on wildlife and wildlife habitat (while several conceptual measures are described none are detailed or endorsed);

-- potential water quality impacts related to multiple-use and recreational activities;

-- impacts associated with construction of the pipeline across Narragansett Bay;

-- impacts resulting from development of groundwater resources in Bristol County, Rhode Island;

-- actual flood protection benefits associated with Big River Reservoir.

RESPONSE: Refer to the responses to the following comments provided in this section.

COMMENT: 2

Water Quality

In our view, two critical issues associated with this project are the threat that I-95 will pose to the quality of the drinking water, and the impact of reduced flows on the already degraded quality of the lower stretch of the Pawtuxet River.

1. As you know, our concerns about the effect of locating an interstate highway across a surface drinking water supply were developed in detail in our position on the Interstate 84 project, proposed to cross Scituate Reservoir. We believe Interstate 95 could similarly degrade Big River Reservoir through spills of hazardous materials, road runoff, and development in connection with the highway and its interchanges. Clearly, these impacts could never be completely mitigated or prevented, but we believe it should be of highest priority to apply the most stringent mitigation measures. In this regard, the importance of a comprehensive watershed management plan cannot be overemphasized.

RESPONSE: See Comment 1 - U.S. Dept. of HUD letter. The watershed management plan would be the responsibility of the operating agency. The Providence Water Supply Board presently operates Scituate Reservoir and has developed a management plan for that source. However, since recreational activities would be allowed in the Big River watershed, the management plan is more critical to water quality and must be carefully designed and monitored.

COMMENT: 3

The EIS does not contain sufficient information on the impacts of I-95 and other roads in the watershed, and on potential mitigation measures. Based on the maps provided, it is difficult to identify the roads which will remain within the watershed after the proposed reservoir is built; this pertains both to roads which will cross the reservoir (i.e., Interstate 95 and Nooseneck Hill Road/Route 3) and to those which will lie within the area draining into it. In addition to an identification of all roads expected to remain, a detailed discussion of the mitigation measures planned to prevent both highway deicing compound and toxic materials runoff from entering the reservoir should be presented in the Final EIS. We request the opportunity to work with you and the State to develop highway mitigation measures. These might include closed drainage systems throughout the watershed, barriers to prevent vehicles from entering the water supply, and other measures.

RESPONSE: Proposed road relocations are shown in Appendix G, "Design and Cost Estimates." The details of road relocations will be addressed in the advanced design, and changes to the present proposals may be undertaken at that time. Likewise mitigation measures will be addressed in advanced studies. See Comment 1, EPA letter.

COMMENT: 4

2. The proposed Big River Reservoir will have a negative impact on the water quality on the Pawtuxet River. This negative impact will occur not only at low flow but during all flow regimes of the Pawtuxet River. The lower stretch of the Pawtuxet River is currently in nuisance condition and much of the remainder of the River is not meeting its proposed Class C classification. The major sources of pollution on the River are the Cranston, Warwick, West Warwick, Ciba-Geigy and American Hoechst wastewater treatment plants. Over the next several years, more than $58 million in Federal and State grants will be needed to bring the Pawtuxet River up to the proposed Class C classification. The impact on downstream water quality was not addressed in the interim Report of the Big River Reservoir Project. The EIS should assess the project impact for all flow regimes on downstream water quality, wetlands, potential fisheries, wildlife, recreational resources, industrial riparian rights (i.e. American Hoechst) and other aquatic resources. This evaluation should take into consideration the possibility that due to budget cutbacks, Cranston, Warwick and West Warwick might not be able to provide advanced treatment. Also, the EIS should note that the water flow could affect seven hydroelectric projects on the South Branch of the Pawtuxet River which initiated permit processing procedures with the Federal Energy Regulatory Commission. Finally, the EIS should identify alternative minimum flow releases and assess how they would affect the project and how they would minimize downstream quality degradation.

RESPONSE: Downstream water quality impacts, including those resulting from construction of the proposed Big River Reservoir, were addressed in the 208 Water Quality Management Plan for Rhode Island, August 1979 and incorporated in the current study. The conclusions presented in the Section 208 report indicated that control of point sources is needed to obtain fishable - swimmable waters in the South Branch and mainstem of the Pawtuxet River. However, the attainment of fishable waters could possibly be prevented by the impact of nonpoint sources of pollution such as urban runoff and leachate from sanitary landfills. Whether or not funding for improvement of point source treatment, presently estimated at about $58 million, will be affected by budget cutbacks is not something that can be addressed in the Big River Reservoir study.

The effects of reduced flows on downstream wetlands, fishery and wildlife resources, recreational resources and other aquatic resources that can be projected at this stage of study are discussed in the Final EIS. Impacts on potential hydroelectric projects and riparian ownerships will be included in assessments required as part of the non-Federal responsibilities for project implementation.

COMMENT: 5

3. According to the EIS, water quality analyses have indicated the presence of mercury in the waterways which will feed the proposed reservoir. We believe this finding warrants an investigation into the probable source of the mercury and a prediction of levels expected in the future.

RESPONSE: Appendix E, "Water Quality," states that mercury has been detected in some samples taken in the Big River watershed, but only occasionally at levels that are above National Drinking Water Standards. The predicted levels in the reservoir would be well below the standards based on the sampling that has been done. An investigation into sources of mercury does not seem warranted at this time due to the low amounts detected.

COMMENT: 6

4. The report indicates that swimming will be prohibited in the Big River Reservoir. In addition, the types of recreational activities which may be deemed permissible are discussed to a limited extent. We believe it might be advantageous to utilize existing water quality information from other reservoir systems where similar recreational activities are permitted (e.g., the New York City system). Perhaps the experience from other reservoir systems can be used as the basis upon which the appropriate level of permissible recreation can be determined.

RESPONSE: As discussed in detail in Appendix H, "Recreation and Natural Resources," swimming and water contact recreation activities are prohibited in Rhode Island water supply reservoirs by State law. The extent of other types of permissible recreation activities was based on a comprehensive evaluation of recreation needs in the State, region and local area, and the potential in the project area to meet these needs. Water supply reservoirs throughout the nation, with the exception of the northeast, and New England in particular, often provide extensive recreation opportunities including swimming, however, local and State public health laws and policy in New England are usually very restrictive, thus limiting the amount and type of permissible recreation.

COMMENT: 7

Projection of Water Demand

It appears that the per capita water supply consumption rates provided in the report represent equivalent rates based on an averaging of domestic, commercial and industrial demands. Utilizing this projected demand rate, the future water supply demand was calculated based on population projections. Although water conservation measures were incorporated into the projected demand estimates, it appears that reductions from industrial recycling were not.

RESPONSE: Per capita water supply consumption was utilized in projecting residential and commercial demands. Projected industrial demands were then added to arrive at the total demand projection. The industrial demand projection methodology employed a factor for industrial recycling. Thus when residential, commercial and industrial demands were combined into total average day demands, the appropriate factor for industrial recycling was included.

COMMENT: 8

The EIS acknowledges that there is some dispute as to which population projecton cost closely represents future growth patterns. In our view, many of the assumptions that the Corps used in predicting future water demand that are found in Appendix A are invalid especially those relating to population projections and future industrial water use:

1. The Corps has used Rhode Island SPP 1975 population projections which were basically in agreement with the 1972 OBERS projections. Since that time the Bureau of Economic Analysis (BEA) of the Department of Commerce (in 1977) and RISPP (in 1979) have revised downward the population with the 1980 census. EPA's Regional Administrator approved the RISPP 1979 population projections and they are the projections currently used for all of our construction grants, water quality planning and air quality planning. In determining future water demands, we believe the Corps should use RISPP 1979 projections.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 9

2. The Corps, on plate 7 of the Main Report, estimates that per capita consumption will increase by 60% between 1975 and 2020 even if strong conservation practices are adopted in Rhode Island. We question the validity of this estimate, and believe justification of the projected increase in per capita consumption should be provided in the EIS.

RESPONSE: Plate 7 shows estimated increases in average daily demand, not per capita consumption. Average daily demand incorporates several other factors, including population growth, percentage of population served, and industrial demand growth. The rationale for estimating average daily demand is given in Appendix A, "Problem Identification."

COMMENT: 10

3. The Corps notes that the demand for future industrial water use was based on a theoretical model utilizing a growth factor based on economic and technological parameters. We question the use of this model for Rhode Island's situation. Each of the communities in the Providence and Bristol water supply district have NPDES requirements to develop a pretreatment program for their industries. A recent study for the metal plating industries in Rhode Island has estimated that they could reduce water use by 70% if pretreatment requirements are placed on them. Pretreatment requirements on other industries could have a similar benefit for decreased water use. This appears to be the trend. According to the U.S. Department of Commerce and the Water Resources Council's second national assessment, industrial withdrawals are expected to drop nationally from 50.8 billion gallons a day to 19.4 bgd by the year 2000. This information should be taken into account in calculating water demand.

RESPONSE: Refer to response to Comment 6, Environmental Protection Agency. The growth factor referred to in this comment is not necessarily a positive effect, so the industrial demand model could reflect the national trend in industrial water use mentioned in this comment.

COMMENT: 11

Flood Protection Benefits

As the watershed controlled by Big River only represents about 12 percent of the total Pawtuxet River watershed, the resulting downstream flood reductions on the mainstem Pawtuxet River would appear to be quite limited. The flood benefits should be more clearly stated in the Final EIS.

RESPONSE: Flood stage reductions provided by Big River Reservoir are limited, but are significant in terms of damages prevented due to the highly urbanized nature of the lower Pawtuxet basin. The most significant stage reductions occur on the South Branch, for which the Big River Reservoir would control approximately 41 percent of the total watershed.

COMMENT: 12

The report claims benefits for flood damage reduction to three municipal treatment plants along the Pawtuxet River. The EIS should note that all three treatment plants are presently undertaking protection measures to mitigate flood impacts. In addition, if the proposed Warwick local protection project is built, involving the construction of dikes and walls along the Pawtuxet River, then some of the flood control benefit claimed by the Big River Reservoir would be negated.

RESPONSE: The report also notes that the proposed Warwick local protection does not have local support, which would be essential for construction.

COMMENT: 13

We believe mitigation is a very important element of this project. Page 29 of the DEIS states that "refined specifications for implementation of the plans (fish and wildlife management plans) would be developed should the project be authorized for further study." We believe these mitigation measures to minimize the adverse impacts of the project should be identified in the EIS, described in detail, associated with responsible agencies or parties that can implement and manage the mitigation plans, and finally be connected with sources of initial and continual funding resources. Mitigation costs for both highway impacts and fish and wildlife impacts are likely to be very substantial, and should be included in the benefit/cost analysis.

RESPONSE: A final recommended fish and wildlife mitigation plan for the Feasibility Level Report has been developed in coordination with the U.S. Fish and Wildlife Service and the Rhode Island Dept. of Environmental Management and included in the Final EIS (See Section 3.00). Estimated development and operation and maintenance costs are also included. However, this fish and wildlife mitigation plan has been developed only to the extent of detail necessary for the feasibility stage of study. Should the project be authorized for Advanced Engineering and Design (AE&D), this plan would be further refined and developed. The Rhode Island Dept. of Environmental Management would be responsible for implementing and managing the mitigation plan. Costs for fish and wildlife mitigation have been included in our benefit-cost analysis. See Appendix J, Economics, and Tables 7 and 8 in the Main Report.

COMMENT: 14

Finally, we wish to comment on the concerns raised at your public hearing regarding the potential impact on the Big River Reservoir of the Picillo hazardous waste site in Coventry. We have investigated the matter and have determined that Picillo waste site is not within the watershed of the Reservoir. Examinations to date at the Picillo site do not indicate an eastward component of groundwater movement, nor does it appear at this time that contamination exists in or is migrating toward the Quidnick Reservoir. Additional bedrock wells are planned to be installed in the immediate future to confirm this premise. We will keep you apprised of the situation as more information becomes available.

RESPONSE: As we have noted in other correspondence, we thank you for your assistance in this matter.

2.01.7 U.S. Department of Labor

COMMENT: 1

This office can offer no input for the proposed Big River Reservoir Project Coventry and West Greenwich, Rhode Island.

It is appreciated, however, that the Employment & Training Administration is being kept informed of the proposed projects being undertaken by the Corps of Engineers.

RESPONSE: Thank you for responding to the Big River EIS. Your office is on the project mailing list and will be included in any future public distributions of documents pertaining to the project.

2.02 State Agencies

2.02.1 State of Rhode Island, Statewide Planning Program, A-95 Coordinator

COMMENT: 1

The Technical Committee of the Statewide Planning Program was presented the staff findings as a result of the review at its meeting of March 6, 1981. The Technical Committee recommendation is as follows:

1. The tentative selection of Plan C (pp. 64-65) appears to be the logical action based on the material presented in this study. Plan C is generally consistent with the applicable elements of the State Guide Plan. In carrying this study beyond the interim report, two subalternatives should be evaluated in conjunction with Plan C: Recreation Options II and III.

RESPONSE: The ultimate choice of a recreation plan for the Big River site would lie with the non-Federal interests - either the sponsor or operating agency, as appropriate. However, the tentatively selected plan included Option III in keeping with Corps policy of maximizing site potential for each project purpose. Detailed studies undertaken should the advanced design stage of the project be authorized may aid the determination of exactly what recreation activities should be included in the project.

COMMENT: 2

2. Aquidneck Island and North Kingstown should be added to the study area. Use of the Big River Reservoir to get future water needs for these areas may be the best solution for this problem. This addition might also change the timing recommendation for construction of the Reservoir. This variation is reinforced by the discussion of the current State Comprehensive Water Resources Development Plan (prepared in 1967) on page 37. (not attached)

RESPONSE: The study area was chosen for having the most pressing water resources problems in the State, and the study area water supply is also that presently legislated for service from the Providence Water Supply Board system. In the 1979 report to the PNB Study "Water Supply Alternatives," Aquidneck Island and North Kingstown were not included in the areas to be served by the Providence system. Other ways of serving these areas were found to be more efficient. However, the construction of a pipeline to serve Bristol County from the Providence system would be undertaken by State or local interests. At that time, the State could decide to serve other areas from the Providence system.

COMMENT: 3

3. The discussion of the 1975 and 1979 population projection by RISPP on pp. 16-19 presents a dilemma which cannot be fully resolved at this time. The study utilizes the 1975 projections primarily because these are closer to the OBERS Series E projection. However, the OBERS Series E projection was made in 1972, prior to Navy base closings, and appears to be much too high. On the other hand, the RISPP 1979 projection for 1980 is below the census count for the same year.

The importance of this issue is demonstrated on page 67 of Volume I, the Main Report. The study points out that the 1979 projections, combined with demand modification techniques, would move the date to which Big River Reservoir's need for water supply purposes from 1995 to 2025. The report also points out that this would not delay the need for flood damage reduction.

If possible, a conclusion as to "the best" population projection to use should be deferred until a new projection can be made incorporating the results of the 1980 census and other information concerning recent changes in water demand conditions, such as the contamination of groundwater supplies by chemicals, and increased industrial activity. In the interim, the 1975 and 1979 RISPP projections should be considered to establish a range of probable future projections for each target year.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 4

4. The report develops three complimentary needs to be met by the plan eventually selected. These are water supply, flood control, and recreation. The discussion of flood damage reduction on pages 23-24 emphasizes necessity to incorporate flood protection in the design and construction of the Big River Reservoir. There are no other feasible and acceptable methods for reduction of downstream flooding on the mainstem of the Pawtuxet River. Incorporation of flood control in the Big River Resevoir project is reinforced by the fact that this aspect of the project would have a higher benefit-cost ratio than the water supply or recreation components (p. 69).

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 5

5. The study finds, on page 34, that development of a reservoir on the Wood River is not justified by the yield available and the resulting environmental impacts. This is an important conclusion of this study which should be reflected in all related planning.

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 6

6. The report discusses the possibility of meeting needs of Foster and Glocester by development of local groundwater sources (p. 35). State and local plans and land use controls should attempt to avoid the need for public water systems in these two communities, except, possibly, for Chepachet.

RESPONSE: The report does not advocate conversion to public systems for the towns of Foster or Glocester until such time as private systems are not longer capable of meeting their demands. At that time the report would have local groundwater development as the preferred choice, over extension of the Providence system.

COMMENT: 7

7. The conclusion that pricing policy changes would have little effect on water use because of present low prices (p. 35) requires further consideration. A substantial price increase of a low-base price might be effective in modifying usage.

RESPONSE: Demand for water is not expected to reach measurably to price increases that might be implemented. Huge increases would obviously cause people to conserve water. However, increasing the price of water much beyond the cost to collect, process and deliver it will cause severe social and economic impacts. It will take spending money from the consumer and can put businesses at an economic disadvantage. This will cause secondary and tertiary impacts which are hard to define but nonetheless real.

COMMENT: 8

8. The report makes reference to the findings of the "208" project concerning the effect of the Big River Reservoir on downstream water quality and users. The specific minimum release recommendations of the "208" study for maintenance of low flows for both the Big River and Flat River watersheds were transmitted to the Corps of Engineers on July 12. The current study should state in Volume I whether or not these recommendations would be followed.

RESPONSE: The minimum release recommendation of the "208" study was stated to be 7.43 cfs based on the calculated 7Q10 low flow, and has since been updated to 8.0 cfs by the EPA Region I office. The minimum release of 6 cfs calculated by the Corps, based on the releases currently made from Scituate Reservoir, is not greatly different from the "208" study's recommendations, and is subject to revision during advanced engineering studies. The results of recent studies will be included in the determination of minimum releases.

COMMENT: 9

9. The Corps of Engineers should investigate downstream hydropower because the proposed hydroprojects on the downstream portion of the mainstem of the Pawtuxet may be affected by this project.

RESPONSE: Construction of the Big River Reservoir project will result in reduced flows in the South Branch and mainstem Pawtuxet River. The reductions in both average and extreme discharges will undoubtedly impact on any proposed or potential hydroelectric projects in the South Branch. Inasmuch as the mitigation of impacts of reduced flows on downstream riparian owners is part of the total non-Federal responsibilities for implementation of the project, the effects on proposed hydroelectric projects are expected to be assessed prior to authorization for construction of the proposed Big River Reservoir project. See also response to Comment 1, U.S. Department of Energy.

COMMENT: 10

10. Recreational Use

The 1976 SCORP commits the State to a policy of "Making multiple use of water bodies and considering the multiple use potential of all water resource development projects for recreation and other purposes wherever possible." Part 5-4-3 of the SCORP provides information concerning recreational use of reservoirs in Rhode Island and nationwide. It recommends that an assessment of the water quality impact of recreational uses be accomplished.

The Corps of Engineers should do a more extensive assessment of the impacts on water quality be done for the different recreation options to determine how to limit adverse impacts in the quality of the reservoir water. Secondary implications of opening the area for recreation, such as the need for added enforcement and the increased possibility of others seeking to illegally dump, cut wood, etc., should also assessed. The final decision about recreational use of the Big River Reservoir area will be decided by the Rhode Island General Assembly who will need as much information as possible to try to carry out the policy stated in the 1976 SCORP concerning the multiple use of reservoirs (p. 02-01.2).

RESPONSE: Since no water contact recreational activities are permitted on Rhode Island water supply reservoirs, there is no reason to believe that there will be any significant impact on water quality. The project area is already "open" for recreation, even though there are relatively few developed facilities. There are, therefore, not expected to be any increased possibilities for illegal dumping, cutting wood, etc., although there may be a need for more law enforcement if new recreational facilities are developed and more people are able to take advantage of increased recreation opportunities.

COMMENT: 11

Attachment #1 is a copy of a comment from the Coastal Resources Management Council.

The Coastal Resources Management Council is aware of the plan to construct an aqueduct from Conimicut Point in Warwick to Nyatt Point in Barrington to serve Bristol County and perhaps even Aquidneck Island. This project will require a CRMC permit, and to expedite the review process, early project level coordination with the Council and its staff is requested.

RESPONSE: The proposed transmission main from the Providence Water Supply Board system to the Bristol County Water Company system is included in the overall water resources development plan for the study area, but is not a part of the proposed Federally implemented project. Thus, this transmission main would not be included in the advanced engineering and design that would be undertaken by the Federal government for the Big River Reservoir, but would be implemented by non-Federal interests.

COMMENT: 12

Attachments #2 and 3 are information for the Corps of Engineers concerning Recreation (2) and Air Pollution (3) is also attached.

ATTACHMENT #2

1. Main Report: p. 24 Recreation

Paragraph 2 under this section states that projections for the years 1995 and 2020 "show that the most significant needs on a statewide basis are for boating, camping, golfing, hunting, picnicking and swimming facilities." (emphasis added) This statement is largely consistent with the findings of the 1976 SCORP, however the following considerations and qualifications should be noted:

a) The 1976 SCORP projected demand only to the year 2000. Since details of the model used to extend the SCORP data to the year 2020 are not provided, we make no assessment of the validity of this expansion.

b) The 1976 SCORP's projections of statewide deficits in the year 2000 indicate the greatest needs (in order of magnitude) will be for: fresh water swimming; picnicking; tennis; boating; and camping. Of these, the forecasted deficits for fresh water swimming and picnicking are the most severe in terms of unmet design day demand. Both activities show deficits in excess of 20,000 activity occasions on the year 2000 design day.

c) Our projections for golfing indicate only a relatively modest facility shortage by the year 2000. A capacity deficit of approximately 1,100 activity occasions is forecasted for the year 2000 design day. (approximately 9% of total design day demand.)

d) The 1976 SCORP did not estimate supply capacities for several activities including hunting and sightseeing, thus precluding the forecasting of future supply/demand relationships. It should be noted however that total year 2000 demand for hunting is projected to be relatively modest in comparison to most other activities (forecast to be the next to least popular activity with a design day estimate of 5,030). In-state demand for sightseeing, on the other hand is projected to be quite significant (42,890) ranking 5th (out of 18) activities.

e) The 1976 SCORP did not measure or project demand for recreational off-road vehicle (ORV) usage. However, the most recent nationwide demand survey found this activity to fairly popular nationally, with 20 percent of the population participating on 5 or more occasions per year. (It is not known if this figure is representative for R.I.). However quite intensive recreational ORV usage is currently occurring in portions of the Big River site which have characteristics deemed by enthusiasts to be quite rare in southern New England. The displacement of this demand by the reservoir development has the potential for creating conditions of overuse and multiuse conflicts at other areas proximate to the site (particularly within the Arcadia Management Area).

RESPONSE: The 1976 SCORP was the basis for the recreation projections and supply and demand analysis discussed in the Main Report and Appendix H. We concur with your comments.

COMMENT: 13

2. Appendix H, Part I,E

Given the fact that the Interim Draft Report recommends incorporation of recreational activities within the watershed and is in this respect a radical departure from previous thinking in the state concerning the compatibility of recreational usage and water supply, a review of the SCORP's position on recreation and reservoirs should be incorporated into this discussion of agency policy. The SCORP commits the State to a policy of "Making multiple use of water bodies and considering the multiple use potential of all water resource development projects for recreation and other purposes wherever possible." While this policy is, quite appropriately, constrained by parallel goals and policies for preservation of water quality, it nevertheless represents a recognition that simultaneous achievement of recreation and water quality objectives with regard to a specific water body or development project can be both feasible and desirable from the standpoint of resource use efficiency. Part 5-4-3 of the SCORP provides extensive information on agency policy and experience concerning recreational usage of reservoirs both in Rhode Island and nationwide and includes a specific recommendation that an empirical assessment of the water quality impacts of recreational usage be accomplished.

RESPONSE: Seven pages of Appendix H are devoted to a discussion of recreation development policy and use on water supply reservoirs, and the SCORP's position on recreation and reservoirs was the basis for the entire recreational development plan as discussed in Appendix H. Water quality impacts due to the potential recreational use of the Big River Reservoir project area are not considered to be significant since no water contact recreation is permitted on water supply reservoirs in Rhode Island.

COMMENT: 14

3. Main Report p. 47-48

Recreation Options and Conclusions - Option III, representing the maximum development plan for recreation, is most desirable from the sole standpoint of expansion of recreational opportunities. The plan provides for replacement of most opportunities lost through development of the reservoir and includes additional increments of supply capacity for several activities needed to meet forecasted statewide deficits. Because this option is most extensive and because of its inclusion of water contact activities, it also raises the greatest concern over the possibility of adverse water quality impacts.

As Option III is carried forth in future development of the water resources management plan, a goal of providing the maximum recreational experience while incorporating appropriate water quality safeguards should be adhered to. Specifically, as the Option is advanced beyond the conceptional stage, the following modifications to it should be considered:

a) restriction on the use of gasoline-powered boats in the primary and secondary reservoirs;

b) careful siting and design of trails, separation of motorized and non-motorized trail users and establishment of an on-going trails monitoring and maintenance program to minimize erosion and sedimentation problems;

c) basing the siting and design of the sanitary facilities on a careful analysis of soils, water table, groundwater flow and other site-specific conditions;

d) determination of a (numerical) maximum recreational use density for various facilities or portions of the watershed;

e) enforcement of these density levels via restricted access points and a permit and registration system which identifies who is in the watershed and for what purpose;

f) institution of a user fee schedule in connection with the permit system with proceeds going for enforcement and maintenance;

g) development and adoption of specific rules and regulations for recreational activities designed to minimize potential conflicts with water quality objectives;

h) inclusion of a visitors' center oriented to meeting demands for the sightseeing activity. The center could provide information and education on water quality, supply and conservation in general and the Big River Project in particular.

With inclusion of safeguards and planning considerations such as those presented above, a modified version of Option III should be capable of optimizing both recreational and water quality objectives of the Big River Project.

RESPONSE: Comment (a) - Refer to response to U.S. Dept. of Housing and Urban Development Comment 4.

Comments (b and c) - Careful site analysis and design of all recreation facilities with consideration for maintenance and management is always standard procedure.

Comment (d) - The detailed plans for development of recreation facilities as discussed in Appendix H did include a determination of the maximum recreational use density for various facilities, however the actual development plan recommendations are based on an optimum use with consideration for minimizing any environmental impacts.

Comment (e) - Restricted access points are already an inherent part of the proposed recreation design and development plans as discussed in Appendix H. A permit and registration system to identify who is in the watershed and for what purpose is considered to be an unworkable, extremely expensive and totally unnecessary attempt at control which would accomplish nothing but harass the public for whom the recreational facilities are planned. Refer also to State of Rhode Island, Department of Environmental Management, Comment 2 and 3.

Comments (f and g) - A user fee schedule and adoption of rules and regulations would be up to the management authority who ultimately would assume responsibility for the operation and maintenance of the Big River Reservoir project area. It is considered to be a likely possibility that if the project is constructed on state owned land and managed by the State, perhaps as a State Park, then a user fee could be charged to help recover operation costs.

Comment (h) - Inclusion of a visitor center at the project is a good idea and should be given future consideration for development as part of the Big River Dam project operations facilities.

COMMENT: 15

ATTACHMENT #3

Air Pollution

Page 9 in the Draft Main Report should be more specific in discussing different pollutants. More recent air quality sampling data is available (1979) from the R.I. Division of Air and Hazardous Materials.

For CO and TSP, only Providence is non-attainment (in 1979, CO standard was violated on nine days).

For ozone, the entire state is non-attainment (in 1979, ozone was violated on no days in Providence and nine days in West Greenwich).

See attached tables.

RESPONSE: Thank you for supplying the additional information on air quality in the study area. The section on Air under Existing Conditions in the Main Report has been revised to reflect this new information. The tables included in your letter have been referenced in the Main Report as a source for additional discussion on air quality standards in the study area.

2.02.2 State of Rhode Island, Office of State Planning, Rhode Island Statewide Planning Program

COMMENT: 1

1. Choice of Plans and Options

The Report's findings support the tentative selection of Plan C (pp. 64-65). Plan C is generally consistent with applicable elements of the State Guide Plan. We would urge, however, that the Corps consider amending Plan C as follows:

A. Add Aquidneck Island to the study area. Big River Reservoir may be the best solution for Aquidneck Island's water supply problems. Addition of Aquidneck Island to the study area may warrant greater priority for the project than our analysis of the Report in its current form indicates below.

RESPONSE: See response to Comment 2, R.I. Statewide Planning Program, A-95 Coordinator.

COMMENT: 2

B. Change the recreation option incorporated in Plan C from Option III to Option II. The latter would provide recreation opportunities roughly equivalent to those currently available. Prohibition of off-road vehicles, which is entirely consistent with prevalent attitudes toward recreational use of drinking-water reservoir watershed areas, may cause undesirable impacts on nearby private lands and on the Arcadia Management Area. We suggest that consideration of these impacts be weighed against the possibility of allowing off-road vehicle use in watershed areas where water quality impacts of such vehicles can be mitigated or prevented.

RESPONSE: The Main Report recommends Option III for all three Plans - A, B, and C. Option III offers more recreation use potential than Option II, principally in the form of swimming at Carr Pond and Phelps Pond, and camping at Hungry and Harkney Hills. Limited off-road vehicle use would be accommodated under both options consistent with minimizing environmental impacts and conflicts with other recreational activities and fish and wildlife management.

COMMENT: 3

2. Population Projections - Water Needs of Study Area

We believe that the Report's greatest shortcoming lies in its analysis, or lack of analysis, concerning the population growth and the water needs of the study area. The Corps' efforts in this regard are the subject of some fairly exhaustive regulation, which contemplates a more thorough analysis than that provided in the *Interim Report*. Part of this regulation, which controls the Corps' evaluation of water needs, stipulates:

Considerable attention must be given to examining the relationship of the traditional water resources 'needs' categories to the overall study effort. It is mandatory to update or confirm the authenticity of the 'needs' in light of differing public preceptions and interim public actions that may have been undertaken. 33 CFR 292.6

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 4

In our judgement, the Report fails to update or confirm satisfactorily the findings of the 1967 Metcalf and Eddy Report, which findings rely on demographic and water-supply data from the mid 1960's and earlier. After acknowledging the fallibility and the proven inaccuracy of the OBERS Series E population projections and the 1975 projections issued by this Office, the Report goes on to justify their use by reason of convenience. It should be noted that the Corps, prior to completing and issuing the Report, had available to it this Office's 1979 population projections, which have proved remarkably accurate with respect to the 1980 census. By contrast, both the OBERS Series E projections, which were made in 1972 and do not account for the Navy base closure, and the 1975 projections have proved to be inaccurate overestimations of population growth in Rhode

Island. While the Report recognizes the disparity between these projections, it does account for or attempt to incorporate the more recent and reliable projections in its estimation of future conditions.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 5

We recommend that the Corps update its demographic data before drafting its final specification of future conditions. Use of more reliable demographic data may serve to clarify the issue whether and when the Big River project is needed. The Corps' impact statement preparation regulation suggests the use of more timely and accurate data when the OBERS data are insufficient:

Specification of future conditions should reflect projections currently used by Federal, State and local planning agencies. OBERS Series E Prime projections will be used as a basis for most studies. In certain instances, because of conditions unique to the study area or the limited size of the study area, OBERS may not be totally satisfactory . . . When the study area is very small in size, other projections will be needed to provide sufficiently detailed projections of those conditions which affect the definitions of planning objectives over time. 33 CFR 292.9(b).

Such updating is necessary to insure that the enormous capital investment and environmental costs the project involves are warranted. The OBERS Series E projections and the 1975 projections have little more validity today than do the grossly inaccurate predictions for population growth and water need which spawned and have been used to justify the original Metcalf and Eddy 1967 Report and Water Supply Plan.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 6

Flood Reduction

We concur with the Report's emphasis on the necessity of incorporating flood protection in the design and construction of the proposed reservoir. There are no other feasible and environmentally acceptable methods to reduce downstream flooding on the mainstem of the Pawtuxet River. Furthermore, the flood control aspect of the proposed reservoir would appear to have a higher benefit-cost ratio than the water supply or recreation components.

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 7

4. Wood River Reservoir

The Report finds (p. 34) that development of a reservoir on the Wood River is not justified by the potential yield and would entail undesirable environmental and recreational impacts. We support this conclusion and recommend that no additional State or Federal funds be devoted to planning for the construction of a reservoir on the Wood River.

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 8

5. Groundwater Development in Foster-Glocester

If the Corps wishes to maintain the option of developing local groundwater resources to meet the drinking water needs of Foster-Glocester, State action should be taken to encourage or effect the implementation of land use controls to maintain groundwater quality. Commensurately, State and local planning efforts should guide development so as to maintain groundwater quality in the Foster-Glocester area.

RESPONSE: Refer to response to Comment 6, State of R.I. Statewide Planning Program, A-95 Coordinator.

COMMENT: 9

6. Water Demand Modification

The Report concludes (p. 35) that price changes would have little effect on current water use in the study area because of current low prices. This conclusion appears to be a variance with basic business logic and common sense and deserves reconsideration. Comments from this office regarding a similar instance of illogic in the draft version of the 1979 PNB Study are also relevant here:

The discussion of consumption-price sensitivity could be improved on several accounts. Given the importance of this topic and the large quantity of research material available, the superficial discussion of the professional literature is disappointing. Although the bibliography contains a number of citations which appear relevant to a discussion of demand elasticity, only two studies were referenced in the text and neither of these were given more than cursory analysis.

The final rationale presented for diminishing the potential for consumption reduction through pricing policy changes is that, given the current low average daily cost for water use within the study area ($0.16) the typical customer would not significantly alter present water use habits even if the cost doubled or tripled. While it may be true that a three-fold increase in the cost of water computed on a daily basis could be perceived as of insufficient consequence to motivate conservation; when realistically viewed in the context of the annual billing cycle, the corresponding rise from $58.40 to $175.20 may be a sufficient inducement.

In consideration of the above points we feel that a reassessment of the consumption - price sensitivity assumptions applied in the study may be in order.

The PNB Study failed to resolve the price elasticity issue. We request that further consideration be given to this important, nonstructural measure before the Report is issued in final form.

RESPONSE: Pricing was not included in the methods utilized for water demand modification in the study area due to the low price of water in the area, and the relative inelasticity of demand in the area. The NERBC report, "Before The Well Runs Dry," (June 1980) describes a procedure for designing a water conservation plan, and discusses various demand modification measures, including pricing. It is noted in that report that both residential and industrial usage is relatively inelastic with respect to price in New England. Thus, if prices were increased in some manner, demand would not be appreciably reduced by excess system revenues would be generated, creating unacceptable social problems for the water utilities.

Additionally, in the study area, water-using industries have already undertaken much water conservation efforts as a result of stricter waste-water discharge standards enacted during the past few years. The less water used by an industry, the less that must be treated - thus industrial users are already price-constrained from the other side of the supply cycle, and are thus that much less likely to be able to respond to increased prices.

COMMENT: 10

7. Maintenance of Low Flows

We would like clarification regarding the Corps' intent to implement the 208 Study's specific minimum release requirements to maintain low flow levels for the Big River and Flat River Watershed.

RESPONSE: Refer to response to Comment 8, R.I. Statewide Planning Program, A-95 Coordinator.

2.02.3 State of Rhode Island, Department of Environmental Management (April 1981)

COMMENT: 1

In reviewing the interim report it became readily apparent that the updated report does not reflect comments previously directed to the Corps in reference to the "preliminary draft" report. Comments expressed in our letter of 7/10/79 remain valid, and at the risk of being redundant, the inclosed remarks encompass or reiterate those concerns.

RESPONSE: Comments expressed in your 10 July 79 letter have been addressed and responded to in Section 2.02.4.

COMMENT: 2

While the Department basically supports the development of the Big River Reservoir as a future water supply, the interim report leaves numerous unanswered questions as to the future demand for water in the study area, and the potential for water conservation efforts to reduce these needs.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service, and Comment 6 in this section.

COMMENT: 3

In addition, the effects of reservoir development on water quality and fish and wildlife has not been satisfactorily addressed. Further study is recommended to determine adverse effects and to formulate acceptable mitigation measures, as detailed in the attached comments.

RESPONSE: The effects of reservoir development on water quality and fish and wildlife have been addressed and in our opinion are adequately so addressed for the feasibility level of study. Further studies deemed necessary to refine the assessments made will be conducted at such time as the project is approved and funded for advanced engineering and design.

COMMENT: 4

Thank you for this opportunity to contribute to the environmental review process. The Department has extensive field experience in the Big River area and would like to offer our assistance in setting up field studies to augment existing baseline information and evaluate impacts to terrestrial and aquatic ecosystems. The Department would also like to request that formulation of a comprehensive mitigation program be conducted in close cooperation with DEM staff.

RESPONSE: Your comment is acknowledged and included in the record.

Refer to response to U.S. Fish and Wildlife Service's Comment 26 concerning development of a fish and wildlife mitigation plan.

COMMENT: 5

Scope of Work

An economic feasibility study for the construction of a water supply transmission line to Bristol County and Aquidneck Island from supplies maintained by the Providence Water Supply Board was recently completed as a possible solution to meeting the area's projected water needs. Construction of a water supply transmission line to Bristol County with development of the Big River Reservoir considerably increases the feasibility of extending water mains to Aquidneck Island to meet the existing water supply system. Given the possibility that Aquidneck Island may eventually be included in the service area of the Scituate and Big River Reservoirs, the scope of the EIS should be expanded to include Aquidneck Island.

RESPONSE: Refer to response to Comment 2, R.I. Statewide Planning Program, A-95 Coordinator.

COMMENT: 6

Need Assessment

Accurate estimation of future water demand is essential not only in determining the need for the Big River Reservoir but also in establishing a time frame for use of the Big River Reservoir water supply and in measuring the capacity of the Reservoir to satisfy future water needs. The projected need for water in the study area will therefore be a major factor in assessment of the time available to fill the reservoir, in calculation of optimum release rates, and in planning for development of additional water supplies. Specific concerns regarding the adequacy of the need assessment for the project include the following:

A) The reasonably attainable reduction in water use through water demand modification was determined to be 10% by the year 2030. This figure was derived without taking into account much more optimistic results of recent programs. Most importantly, the effect of pricing policies on water demand warrants serious consideration and should not have been excluded from in-depth review. Conclusions that pricing policies would have little effect due to the currently low cost of water is unfounded, and inconsistent with the preceding statement that "the price charged for water is generally considered to offer the greatest potential as a demand modification technique" (p. B-20). Residential water demand is offered to support this conclusion. The effect of pricing policies on commercial and industrial use also appears to have been under estimated and further study of both residential and non-residential water demand modification potential is justified.

Other water conservation methods discounted as impracticable may become more attractive when used in conjunction with other techniques. For example, direct wastewater reuse may be feasible with elimination of declining block rates.

Establishment of a State water policy is primary to efficient management of existing water supplies and should have been considered a central issue in assessment of water supply strategies. A comprehensive water policy will help to guide water supply use and development, putting into perspective construction of the Big River Resevoir in the scheme of water supply alternatives.

RESPONSE: The projected reduction in water use was determined based on conditions in the study area, results of previous water conservation efforts throughout the nation, and estimations of the effectiveness in actual use of the various techniques to be applied. Larger reductions cited in earlier studies done for the overall PNB study, and in other programs, were determined to be unrealistic as long term savings for the study area, due to the existing and expected conditions in the area.

Methods such as leak detection and repair, while still cost effective, would not achieve the degree of reduction cited earlier due to the low unaccounted for water and almost complete metering of services in the study area. Other techniques would likewise be unable to obtain high percentage reductions in demand, except in the short term, when emergency situations might apply.

For a discussion of pricing as a technique see response to Comment 9, R.I. Statewide Planning Program.

COMMENT: 7

B) Population and economic growth projections on which future water demand estimates are based do not clearly reflect actual trends. Recent population projections made by the R.I. Statewide Planning Program (technical paper #83, 1979) show stabilizing population levels, rather than the steady growth projected by the older estimates (R.I. Statewide Planning, Technical Paper #25, 1975) used by the Corps.

The validity of 1972 economic growth projections is also questionable given the shift in population trends and increases in energy costs that have occurred since that time and in light of recent studies that predict a decline in economic vitality for the Northeast region.

Projections for population to be served by public water in the study area are based on 1975 information and also require updating.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 8

C) p. EIS-4. DEM is incorrectly recorded as having no expressed concern regarding Need for Reservoir Alternative Assessment, when in fact, one of the major concerns in review of the preliminary draft report concerned the need for the project and the assumption of increased per capita water consumption. Also, Table 1 fails to address DEM's concern for water quality under Environmental Consideration. These concerns are addressed below and in our 7/10/79 letter to the Corps.

RESPONSE: The text of Table 1 has been modified in the Final EIS in accordance with your comment.

COMMENT: 9

Recreation

DEM supports multiple use of the reservoir and endorses the proposed recreation plan. The Department's position is that commitment of such a large tract of land to a single purpose is not in the best interest of the State and that recreational use will provide some compensation for loss of existing recreation area. The use of a permit system to oversee activity in the reservoir area and to generate fees to cover the cost of management and enforcement is also recommended.

RESPONSE: The ultimate management authority, presumably the State, will have the responsibility of determining whether a fee should be charged for use of the various recreation facilities to be provided should the project be constructed.

COMMENT: 10

Water Quality

A) The Department is seriously concerned about the extremely low release rate of 6 CFS proposed by the Corps. Minimum release from the Big River Reservoir should not be less than 7.7 CFS (5.0 MGD) average flow for a 24-hour period. This figure is based on the unit 7Q10 flow of 0.26 CFSM at the Washington Gage. The use of the 0.2 CFSM figure based upon Scituate Reservoir release (Appendix D-p. 27-28) has no relevance to conditions in the South Branch of the Pawtuxet River. Maintenance of this flow should occur during reservoir filling as a normal operation.

A corresponding requirement should be placed upon the regulation of the Flat River Reservoir to release no less than 14.8 CFS (9.5 MGD) average flow in a 24-hour period.

It must be stressed however, that 7.7 CFS is the absolute minimum flow considered necessary to maintain adequate waste assimilation levels. As this low flow normally occurs for only very brief periods during drought conditions, additional studies are needed to assess the effect of sustained low flows on downstream water quality. As previously discussed, more accurate projection of water needs in the study area is needed to determine if greater flows can be released without jeopardizing availability of the Big River Water supply when required.

RESPONSE: Refer to response to Comment 8, R.I. Statewide Planning Program, A-95 Coordinator.

COMMENT: 11

B) The effect of runoff from existing roads in the watershed, particularly I-95, on water quality has not been properly addressed. An assessment of highway runoff, with evaluation of the cost and effectiveness of suitable control measures, should be included in the discussion of environmental impacts and mitigation measures. The cost of runoff mitigation should be included in estimation of a cost-benefit for the reservoir.

Extremely hazardous waste transporters are barred from traveling routes where spills would be especially harmful. This route prohibition of the Hazardous Waste Management Act would apply in the Big River area as well and application would have to be made by extremely hazardous waste transporters to use I-95 in the watershed area.

RESPONSE: Refer to response to Comment 2, U.S. Environmental Protection Agency.

COMMENT: 12

Terrestrial and Aquatic Resources

A) DEM strongly favors implementation of a fish and wildlife mitigation plan without which there would be no compensation for extensive loss of upland habitat, stream fisheries, and wetlands diversity.

Rejection of the U.S. Fish and Wildlife Service mitigation plan (EIS-30(2)), which is based on Habitat Evaluation Procedure (HEP) is not justified, particularly without an alternative mitigation proposal. The HEP program is based on the most current knowledge of wildlife habitat, and the plan should not have been dismissed without serious consideration of at least partial, if not total implementation of the proposal.

While the mitigation plan developed by the Corps appears to offer some degree of compensation for this loss, questions concerning the adequacy of mitigation, and possible negative effects of the plan, point out the need for further study of possible mitigation measures, and their effects, both positive and negative, on fish and wildlife. Adverse impacts of the mitigation plan include potential interference with migration of aquatic organisms and negative recreational impacts with subimpoundments. In addition, upland wildlife habitat management may decrease overall species diversity through loss or reduction of species intolerant of human intervention.

The Department of Environmental Management has conducted extensive field studies in the Big River area and should be consulted in development of a fish and wildlife mitigation plan.

RESPONSE: Refer to response to U.S. Fish and Wildlife Service's Comments 26 and 35 concerning development of a fish and wildlife mitigation plan. Also, see Section 1.01 and 3.03 in the Final EIS.

COMMENT: 13

B) Minimum low flows established by DEM as previously discussed, are minimum standards for waste assimilation, and are not based on biological demands. The Department recommends that studies be completed to determine the effects of reduced flow to downstream fisheries as proposed by the Fish and Wildlife Service. Little is known about the impacts of low flows to aquatic life and further study will help to identify these effects and provide a reference point for development of mitigation measures.

RESPONSE: Refer to responses to U.S. Fish and Wildlife Service's Comments 16, 25 and 42 concerning downstream impacts.

COMMENT: 14

C) There is serious concern over the validity of the terrestrial and aquatic ecosystem analysis. Sampling techniques used and the short duration of field studies has resulted in numerous generalizations and inaccurate conclusions.

Comments submitted in our letter of 7/10/79 relating to analysis of terrestrial and aquatic resources have not been addressed in the interim report. These concerns remain pertinent and your attention is directed to them.

RESPONSE: The studies presented in Appendix H are considered by the contractor's professional judgement to be of sufficient detail in addressing fish and wildlife resources in the study area for this feasibility stage of project planning. Should the project be authorized for Advanced Engineering and Design further analysis would be carried out.

Also, refer to response to Comment 1 in this section.

COMMENT: 15

Several of the conclusions presented in the draft report are addressed briefly, as follows. These concerns and those previously identified demonstrate the necessity for establishment of more accurate baseline data. The Department recommends that additional field studies be conducted in the Big River area to determine more accurately the actual impacts to the terrestrial and aquatic systems of the site. This field work should not only include random, baseline studies, but careful assessments of identified unique habitats should also be made. In addition, area biologists, more familiar with the ecology of Rhode Island, should be contacted to attain accurate data of these ecosystems.

RESPONSE: Refer to response to U.S. Fish and Wildlife Service's Comment 26, and also to previous Comment 14 in this section.

COMMENT: 16

Page EIS-22

"Vegetation surveys and wildlife habitat evaluations were conducted within the proposed Big River Reservoir Site."

Again, we must reiterate that an inadequate amount of field work (1 week) was used to assess the flora and fauna of the area. So short a period of in-field analysis can not properly assess the effects of a project of this magnitude.

RESPONSE: Refer to response to previous Comment 14 in this section.

COMMENT: 17

Page EIS-35

Regarding avifauna, the data presented in Appendix H, and the conclusions drawn, are highly speculative. In Table 6 of Appendix H, birds are listed as being observed on the site, and the conclusion presented that these species probably breed in the area. Two of the species listed (Alder Flycatcher and Nashville Warbler) have been recorded as nesting in Rhode Island only once, and two additional species (Wilson's Warbler and Tennessee Warbler) have <u>never</u> been recorded breeding in this state. If indeed these 4 species were nesting, the significance of the Big River area, as habitat for unique species, is highly increased. This criticism is used as an example of the type of inaccuracies found repeatedly in the assessment.

RESPONSE: Refer to response to previous Comment 14 in this section. The data you have put forth as it relates to the warbler and flycatcher is included here and is part of the record.

COMMENT: 18

It is also stated that the reservoir would provide suitable habitat for several species of diving ducks. This statement must be qualified to read resting or feeding habitat, and should not imply nesting areas, since these species do not breed in Rhode Island. Counts of migrating waterfowl at the Scituate Reservoir are generally insignificant, when compared to coastal localities, and the creation of a new inland water body will not greatly benefit populations of diving ducks in this region.

RESPONSE: The paragraph in question has been modified in accordance with your comment to provide greater detail.

COMMENT: 19

Inadequate data has been presented to support the statement that "the open reservoir would result in a greater environmental diversity by the creation of different types of habitat in the region which would support a higher diversity of species." Suitable open water habitats exist in other sections of the state, and the removal of particular terrestrial and aquatic (especially bogs) habitats would probably decrease natural plant diversity. Examples include some rarer plants, as identified by the DEM Heritage Program, as well as other species which would be lost from the area.

RESPONSE: Refer to response to U.S. Fish and Wildlife Service's Comment 44 concerning this statement.

2.02.4 State of Rhode Island, Department of Environmental Management (July 1979)

COMMENT: 1

Recreation Plan

The Department of Environmental Management generally endorses the Option III Recreation Plan proposed in the Big River Reservoir's EIS (preliminary draft) 95-97. DEM's position is that the commitment of such a large tract of land to a single purpose use is not in the best interests of the population. The construction of a reservoir offers unique opportunities to provide water-related or water-enhanced recreational experiences. Furthermore, with proper management, recreational experiences in the watershed can be provided without compromising water quality. This contention has been well examined and substantiated in research done by Statewide Planning (see Technical Paper #47, R.I. Statewide Planning).

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 2

Specifically, the following activities should be permitted in the Big River Watershed Area under the following conditions:

A. Boating - Boating should be limited to boats powered by electric motors, sailboats, and row boats.

B. Fishing - Fishing activity would be heavily controlled by the Division of Fish & Wildlife so as to establish and maintain a strong fish population during the early life of the reservoir.

C. Swimming - Swimming and water skiing would not be allowed in the reservoir. However, swimming would be allowed at Carr's Pond and Phelp's Pond.

D. Trial Bikes - The Big River Area is presently one of the most popular areas for this activity. Although it is presently unregulated and uncontrolled, a well defined and planned trial system must be implemented in order for this activity to continue. This can be accomplished through coordinating efforts between the DEM Planning Division, the trail riding organizations, and the Trail Advisory Committee.

E. Camping - This activity is to be permitted under highly controlled conditions and only outside the watershed.

Other recreational activities such as picnicking, horseback riding, hiking, cross-country skiing, ice skating, and hunting should also be permitted but conditions need not be as restrictive as the above mentioned. Although less restrictive, these activities would be regulated under a permit system.

RESPONSE: Comment A - Refer to response to U.S. Dept. of Housing and Urban Development, Comment 4.

Comment B - Concur, however, if motor powered boats were not permitted on Big River Reservoir it could be expected, as experience elsewhere has repeatedly confirmed, that utilization of the fishery resource, and in turn the quality of the fishery, would suffer, since fishermen would not have good, safe and practical access to the relatively large lake, and would not fish far from their launching point without motors.

Comments C, D and E - Concur, as discussed in Appendix H.

In regard to the reference of a permit system to regulate recreation activities in the project area, if this means charging admission to the area for use of the facilities, this is considered to be a sensible way of controlling most high density recreational activities such as swimming and picnicking, as well as providing revenue to offset operation and maintenance costs. If, however, it means that the tax paying public must fund an arbitrary, very expensive, bureaucratic system where by anyone desiring to recreate in any way, whether it be fishing or sightseeing, must obtain a permit in order to use any of the project lands, then it would seem that this is a totally unnecessary and meaningless harassment of the public for no good reason. Refer also to the following Comment 3, and State of Rhode Island, A-95 Coordinator, Comment 14.

COMMENT: 3

A controlled permit system for the users in the watershed and reservoir areas should be instituted. In this way, changes in water quality relative to density in use can be researched. A permit system would also supply the permitter with a record of who is and has been on the land and also acknowledge their responsibility and the conditions whereby permission to use is granted. It is also proposed that fees collected for the permits be used to finance the additional personnel needed to enforce and manage the use regulations.

RESPONSE: Refer to previous comment and also to State of Rhode Island, A-95 Coordinator, Comment 14. It is difficult to comprehend how a permit system, as opposed to charging a user fee or admission for high volume day use recreation and camping, would provide any useful information, especially in regard to water quality. It would be an expensive, difficult to enforce, bureaucratic harassment of the tax paying public, and most likely discourage recreational use to the point of making the development of recreational facilities not feasible.

COMMENT: 4

No recreation would be permitted in the northern arm of the reservoir, which is the point of treatment and distribution.

RESPONSE: This is consistent with safety and environmental common sense to minimize adverse impacts on water quality.

COMMENT: 5

A flora and fauna management plan for the reservoir and watershed should be developed jointly by the Fish & Wildlife Division, the Forest Environment Division, and the Water Resources Division.

RESPONSE: Refer to response to U.S. Fish and Wildlife Service's Comment 26 concerning the development of a fish and wildlife mitigation plan.

COMMENT: 6

WATER QUALITY

A. The Corps has stated that based upon the 208 modeling work on the Pawtuxet River, 6 cfs as a release from the reservoir should suffice in meeting downstream water quality standards. A general comparison of drainage areas impacted by the project and seasonal low flow conditions would indicate that at least a 9 cfs release is necessary. At our meeting on June 26, 1979, Mr. Brueckner indicated that the 208 modeling should be further reviewed in developing an impact assessment for the project.

RESPONSE: See response to Comment 9, R.I. Statewide Planning Program, A-95 Coordinator.

COMMENT: 7

B. As the release from the Flat River Reservoir is controlled by private industry, what mitigation methods could be recommended to obtain a desired low flow condition release from the reservoir?

RESPONSE: Among the items of local cooperation to be agreed upon prior to construction of the project would be a requirement that non-Federal interests make appropriate arrangements for releases from Flat River Reservoir so as to coordinate with those from Big River Reservoir, both to maintain minimum low flows for water quality purposes, and to provide effective flood storage discharges.

COMMENT: 8

C. What will be the release and impacts to the river during the three year filling of the reservoir?

RESPONSE: A minimum 7Q10 low flow release will be made throughout the construction and filling period. Utilization of the downstream areas of the river will be examined to determine what releases above the minimum should be made and when they should be made. The 7Q10 low flow is considered by both the Corps and the State of R.I. to satisfy existing and ambient conditions in low flow situations.

The 3 year filling period is based on historical average river flows. If inflow should be more or less than average during the fill period the fill time would decrease or increase accordingly. If it is decided to increase releases above the minimum this would also increase the fill time.

COMMENT: 9

D. A change in water temperature may occur upon completion of the reservoir. What impact will this have on dissolved oxygen and will the increased temperature lead to nuisance conditions; i.e. stimulation of bluegreen algae, in Flat River Reservoir?

RESPONSE: A multiple level outlet would be provided to adjust the temperature and dissolved oxygen of downstream releases to maintain satisfactory levels. It is not expected that existing downstream conditions will be worsened by the impoundment. Further studies would be necessary to determine what operational scheme would allow optimal conditions downstream and in the water supply withdrawals.

COMMENT: 10

E. To the best of our knowledge, the Corps of Engineers has not involved the Division of Water Resources in this project prior to the release of this preliminary draft.

RESPONSE: The Corps has coordinated efforts with the Department of Environmental Management, through the Director's office, and the Division of Fish and Wildlife, as well as other offices within DEM. Subsequent to the date of this letter (7/12/79), the Division of Water Resources has been involved in study coordination efforts through meetings and report review procedures.

COMMENT: 11

TERRESTRIAL AND AQUATIC ECOSYSTEMS

These comments are directed primarily to Appendix H, Volumes II and III (Terrestrial Ecosystem Assessment Report and Aquatic Ecosystem Assessment Report, both prepared by Normandeau Associates, Inc., 1979). The most serious problem with the report is that only one week of field work was utilized to assess the flora and fauna of an 8000-acre area. Many of the following comments reflect this lack of field work which has resulted in generalized and inaccurate conclusions.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 12

Specific Comments:

A. There are many unanswered questions regarding the sampling techniques used to assess the flora and fauna of the study area. The methods used to select stands for vegetation surveys and transects for bird surveys are not described. In addition, the schemes used to sample vegetation of the selected stands have not been described.

RESPONSE: Discussion of methods used to assess vegetative cover types in the study area are described in Sections 2.1 of Appendix H, and the forest resources inventory is described in Section 2.2. Methods for assessing wildlife populations are described in Section 2.3. Field surveys were conducted to determine avian species composition, relative abundance and habitat utilization. Six different census transects were established. This analysis is described in Section 2.3.2.1.

COMMENT: 13

B. In Section 3.1.2.4 is a discussion of the aquatic vegetation of two ponds in the study area, (Capwell Mill and Tarbox Ponds). Other ponds in the study area should also be assessed in this manner. Also, the accompanying figures (Numbers 5 and 6) in this section have not been updated with 1970 and 1975 photo-revisions present on current U.S.G.S. topographic maps.

RESPONSE: As stated in the Aquatic Ecosystem Assessment, eight sampling locations were established in 1976 by Keyes Assoc. and Metcalf & Eddy, Inc. (KAME) on the major rivers and ponds within the Big River study area. Seven sampling locations were surveyed during this 1979 study which included six of the original locations identified by KAME in 1976. Tarbox Pond and Capwell Mill Pond were included in the survey. Therefore, these bodies of water were analyzed because of the presence of this existing background data, which is lacking for the other ponds in the area. This analysis is considered to be of sufficient detail for this feasibility stage of project planning.

At such time as the project is funded for further detailed studies, the most up to date data available will be utilized.

COMMENT: 14

C. The Vegetation Cover Map (Figure 7 - Section 3.1.2.6) is inadequate in assessing environmental impact to the area. A more accurate map delinia-ting wetland types and forest community types would be valuable. Also, this figure, as well as Figure 14 (waterfowl breeding habitat) are not scaled and contain no orientation symbols.

RESPONSE: Lengthy discussions of the compositioin of the various vegeta-tive cover types existing in the reservoir area provided under Section 3.1.2, Vegetation of the Big River Study Area. See also Comment 13 in this section.

COMMENT: 15

D. The data for birds presented in Section 3.2.1.1 does not reflect the breeding population of the study area in that field work was conducted in late summer. Four species in Table 1, (Alder Flycatcher, Tennessee Warbler, Nashville Warbler, and Wilson's Warbler), have not been recorded as nesting in the State of Rhode Island. Also, it is likely that some species not listed are nesters in the study area.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981. Also, Section 3.2.1.1 describes the results of the census operations and observations made from these results.

COMMENT: 16

E. Data for mammals was compiled only through direct observations over a one-week period; therefore results presented for this animal group are not reflective of the mammal populations presented in the area.

RESPONSE: Refer to response to Comment 14, for R.I.D.E.M., 1 April 1981.

COMMENT: 17

F. In Section 3.2.1.5, data is presented on the carrying capacities of nine selected animal species. Many questions are raised in this section. Why were these nine, and only nine, species selected for analysis? Of what value is using data collected in Denmark and Great Britian without stating the habitat parameters of these other study areas? In our opinion, the data presented in this section is of little value in evaluating the caliber of the habitat in the Big River study area.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981. Also, the rationale for selecting these species for carrying capacity estimates is presented in Section 2.3.2.3 and Section 3.2.1.5.

COMMENT: 18

G. In Section 5.3 (Beneficial Effects of the Project on the Terrestrial Ecosystem), a statement is presented in the first paragraph that "Presence of a large open water body would result in greater environmental diversity of the region." It is doubtful that the addition of a large open body of water would result in greater diversity for the region due to the presence of other aquatic systems nearby; i.e., Scituate Reservoir, Flat River Reservoir, Stump Pond, and Quidneck Reservoir. The benefits of this addition are also doubtful. It is true an additional "landscape component" would be added to the area ecosystem but it would occur at the expense of existing stream ecosystems and adjoining uplands. The net effect may be a loss in total landscape components.

RESPONSE: Refer to response to U.S. Fish and Wildlife Service's Comment 44 concerning this statement.

COMMENT: 19

Also, the conclusion is drawn ". . . this water body will provide suitable habitat for such waterfowl species as scaup, common goldeneyes, buffleheads, and other diving ducks which prefer large bodies of water." Although the species mentioned might use the open water during migration, these birds do not breed in Rhode Island and probably would not benefit greatly from the creation of the Reservoir.

RESPONSE: Refer to response to Comment 18, R.I.D.E.M., 1 April 1981.

COMMENT: 20

H. In considering the adverse effects of the project, an assessment should be made concerning the impacts of the proposed increase of recreation on the flora and fauna of the area.

RESPONSE: These impacts have been discussed in the Environmental Impact Statement, along with all other impacts, temporary and permanent, associated with construction and management of the project.

COMMENT: 21

I. The techniques described in Section 6.0 (Mitigation Techniques) may increase productivity and diversity in certain areas but, on the whole, the net result would be to increase man's influence beyond the area directly affected by the creation of the reserver. Establishment and periodic maintenance of openings and plantings creates an unnatural environment for wildlife species. Certain animals, particularly game species, are able to respond to this form of management; however, certain other, more sensitive species will be greatly reduced or eliminated, thus decreasing overall natural diversity. The goal, in attempting to mitigate the effects of creating the reservoir, should be in maintenance of total natural diversity now present in the Big River area. Suggested methods should simulate, as closely as possible, natural disturbances (windthrow, fire, etc.) rather than the creation of an artificial habitat.

RESPONSE: The proposed fish and wildlife management plan described in the Final EIS attempts to provide just such measures as described in your comment. Mitigation would attempt to increase wildlife habitat productivity by increasing overall habitat diversity. Management of fish and wildlife resources would offset losses due to creation of Big River Reservoir. Should advanced Engineering and Design studies be authorized, further investigations in regard to acceptability of management for certain wildlife species would be carried out.

COMMENT: 22

J. In Section 2.3.1 (p. 12) it is stated that "contact was made with the R.I. Department of Conservation, the U.S. Fish & Wildlife Service, the Audubon Society of Rhode Island, and the University of Rhode Island to obtain information on rare and endangered wildlife, critical habitats and wildlife populations." It would be advantageous for reviewers of the statement to know which individuals of these groups were contacted and what literature or information was obtained. Correspondence from qualified individuals should be published along with the assessment.

RESPONSE: Literature obtained from contacted agencies and individuals is listed in Section 9.0, Literature Cited. Pertinent correspondence received in response to coordination efforts has been published in Appendix C, "Public Views and Responses."

COMMENT: 23

K. Appendix - Table 4: Species and seasonal status of birds occurring in the area should be listed according to a local publication; i.e., The Rhode Island Ornithological Club Checklist of Rhode Island Birds - 1973. The list presented in Table 4 contains many mistakes in status and habitat of some species and some species which might be present have been omitted.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 24

Appendix - Table 5: The data presented on winter birds is of questionable value in that the data was obtained from Christmas Counts conducted in Newport and Washington Counties, and not in Kent or Providence Counties where the reservoir would be located. Proper winter resident bird surveys should be conducted to improve on this data.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 25

Appendix - Table 6: More recent information, preferably field surveys conducted at the site, should be utilized in determining mammal populations.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 26

L. In considering alternate sites (Wood River, Moosup River, and Bucks Horn Brook) very few sites were visited. These areas were inventoried in a general manner by using USGS topographic maps in combination with visits to sites representative of the major vegetative categories. USGS topographic maps are not intended to provide floral or faunal information and the number of sites visited is inadequate to make serious determinations.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 27

M. Throughout the report literature is seldom cited making evaluation of methods and results difficult. Since this preliminary report is based in large part on literature review and limited field study, it is imperative that all citations be identified so that the literature used to draw conclusions may be evaluated.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981. References have been cited throughout the report in the text, tables and figures. Literature citations are listed in Section 9.0 of the report.

COMMENT: 28

N. Aquatic Section (Appendix H - Volume III): In this section the same inadequacies exist as with the terrestrial studies. Populations of aquatic species are extremely variable and each group must be sampled extensively on a seasonal basis. Results obtained are also dependent on the time of day of sampling. For example, electroshocking for fish, although an adequate means for sampling, should be performed diurnally and nocturnally to account for the habits of various species.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981. Section 8.0 of the Aquatic Ecosystem Assessment discusses in length the sampling methods conducted for the study area, including electroshocking.

COMMENT: 29

The list of reptiles and amphibians (Table 7.2-1) contains inaccuracies. For example, the Diamondback Terrapin is a turtle species of brackish waters and would undoubtedly not be found in the study area. More recent literature and field studies should be used to evaluate these species.

RESPONSE: Refer to response to Comment 14, R.I.D.E.M., 1 April 1981.

COMMENT: 30

Whereas only one week was utilized to collect field data, the results do not adequately represent the status of the flora and fauna of the Big River Reservoir Area. It is recommended that additional year round field studies be conducted utilizing established sampling techniques. Vegetation should be sampled throughout the year on permanently established sampling plots. A field program for wildlife assessment should follow a similar program suggested by Dressler (1976).[1]

Under this system small mammals are surveyed through mark-recapture on permanent grids during each season. Larger mammals can be surveyed through direct observations supplemented by appropriate sampling schemes for individual species. Birds should be analyzed throughout the year utilizing the appropriate survey for the given season (Breeding Bird Survey: April-July; Winter Resident Survey: December-February; Spring and Fall Migratory Surveys). These surveys should be conducted in every major vegetative community. Reptiles and amphibians should also be evaluated using appropriate schemes.

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[1]Dressler, Richard L. 1976. Wildlife Resource assessment for environmental impact statements. Trans. Northeast Fish & Wildlife Conference, 33:133-136.

RESPONSE: Refer to the following Comments in response to your comment:

State of Rhode Island D.E.M., 1 April 1981, Comment 14, State of Rhode Island D.E.M., July 1979, Comments 11, 12, 14, 15, 16, 25 and 29.

COMMENT: 31

More knowledgeable individuals should be contacted in determining the presence of rare and endangered species. The Rhode Island Heritage Program is presently compiling data on the locations and status of rare and endangered plants and animals in Rhode Isalnd and, therefore, has become involved in the review process for the Big River Reservoir. Other people to contact should also include George Seavey, Coordinator of the New England Natural Areas Survey of 1971 in Rhode Island; Richard Champlin, well-known Rhode Island botanist; Al Hawkes, Director of the Audubon Society of Rhode Island; James Myers, Wildlife Biologist for the Department of Environmental Management's Division of Fish & Wildlife; and authorities at the University of Rhode Island including Dr. Robert Shoop, Dr. Frank Golet, and Dr. Robert Chipman.

RESPONSE: Your comment is acknowledged and included in the record. The Federal interest in Rare and Endangered Species specifically resides in those species currently listed or proposed for listing in the Federal Register. We do consider those species considered rare or unique by other standards. However, for purposes of a feasibility report the Federal Government is specifically concerned with those protected by Federal law.

COMMENT: 32

It is evident that rare and endangered species of plants and animals have not been properly evaluated. Information obtained by the Rhode Island Heritage Program shows that three species of plants, rare in Rhode Island, occur at the Big River Area. These are: Northern Fly-honeysuckle (Lonicera villosa), Northern Prickly-Ash (Xanthoxylum americanum), and Lily-leaved Twayblade (Liparis lilifolia). Also, no mention is made in the report of individuals contacted in determining the presence of rare animals at the site. It is imperative that knowledgeable individuals, specifically the persons named above, be contacted to obtain accurate information regarding rare and endangered species.

RESPONSE: Your comment is acknowledged and included in the record. Section 2.1 of the Terrestrial Ecosystem Report explains the research methods used for rare and endangered species. See also response to Comment 14, R.I.D.E.M., 1 April 1981, and the previous comment, this section.

COMMENT: 33

NEED

In analyzing the preliminary draft report, one of the major concerns was the need for the project. The assessment of water quantity need was based primarily on increased per capita consumption of water. While we realize that you have studied the possible impacts of water conservation on water demand, it does not appear that conservation reductions are sufficiently taken into account in computing total demand. While conservation would not remove the need for the Big River Project, it might reduce the need for subsequent water resource development.

RESPONSE: See response to Comment 6, R.I. Dept. of Environmental Management, 1 April 1981.

COMMENT: 34

CULTURAL RESOURCE

The study has two components, the first being an evaluation of archaeological resources prepared by the Public Archaeology Laboratory at Brown University. The approach to prehistoric research questions and techniques appears to be thorough and includes a good use of information gathered from local collections, previous research, and informants.

The only question arises in the discussion of expected prehistoric sensitivities (p. 31-33), which can be more appropriately answered by the archaeological staff at the Rhode Island Historical Preservation Commission in their review of this study.

RESPONSE: The Rhode Island Historical Preservation Commission has been sent a copy of this report for their review.

COMMENT: 35

There are good suggestions in the section on historic archaeology for the use of primary sources and oral history techniques. However, I do question the claim that no time was available for thesis location (p. 35).

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 36

The second component of the study is a report on the historical and cultural resources within the project area prepared by the Rhode Island Historical Preservation Commission. The historical background provided by the report is certainly sufficient for an understanding of the economic and social rise and fall of the area. Tables I and II (p. 35-38) are especially useful in showing the relationship between the cultural resources and, more significantly, their relationship to the projected reservoir.

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 37

Each resource is assigned a level of significance which is helpful in ascertaining its historical value. These levels range from "National Register potential" to "important" to "contributing." All assignments seem valid with the possible exception of (S)-IND-10, the Hopkins Mill site, a former National Register property which is listed as only "contributing." This may be a result of its removal from the Register following its destruction in 1978 (p. 96).

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT: 38

Editorial corrections in this report include:

P. 50 - CEM-6 "Door War" should read "Dorr War."

P. 132-137, misnumbering of features in the Transportation section:

TRN-5 should be New London Turnpike.

(S)-TRN-6 should be site of Webster Gate.

TRN-7 should be Nooseneck Hill Road.

TRN-8 should be Big River Bridge, #34.

TRN-9 should be Nooseneck River Bridge, #36.

TRN-10 should be Interstate 95.

RESPONSE: Occasionally during final printing of reports, editorial errors are overlooked. Those noted in your comment have been corrected by an Addenda and Errata sheet for Appendix I.

COMMENT: 39

In general, both studies clearly indicate the presence and potential presence of prehistoric and historic cultural resources in the project area and thereby satisfy their intended goals. They serve as useful tools for the location and evaluation of these resources. However, they fail to indicate either the time necessary or the type of further study which will presumably include recommendations for mitigation of any National Register properties adversely affected by the reservoir project.

RESPONSE: In the case of prehistoric resources, further study would involve field investigation of those areas having prehistoric site potential, and determinations of National Register eligibility for all located sites. Further study of historic sites and structures would involve National Register determinations for located sites. Mitigation options would depend upon nature and location of significant resources.

These studies would constitute a Cultural Resource Survey, to be performed during the next stage of project planning, and are currently estimated to be 1-2 years in duration.

2.02.5 State of Rhode Island, Department of Transportation

COMMENT: 1

We have reviewed the Draft report and offer the following comments:

1) Many roadways will be eliminated by the building of the reservoir.

a) How will these increase travel time and total VMT?

RESPONSE: All of the residences in the management area will relocate and the associated traffic will be eliminated. This will significantly reduce travel time and VMT (assumed to mean vehicle miles untraveled). The project will, however, cause an influx of people (and autos) to take advantage of the new recreation opportunities. No estimate has been made of the net reduction (or increase) of travel time or VMT.

COMMENT: 2

b) How will this impact energy consumption?

RESPONSE: Since the net change in travel time was not estimated the change in energy consumption was not calculated. Such an estimate would be extremely complex, as residents of the area would establish new travel patterns in their relocated area, and recreation seekers would be coming to the Big River Area instead of some other area. Net energy gains (or losses) would be near impossible to calculate with any degree of confidence.

COMMENT: 3

c) What effects will this have on Public Safety - Police, Fire, rescue, etc. reponse time?

RESPONSE: The project should have no appreciable effect on local police, fire and rescue services. Response time should not be affected as all major roadways through the project area will be maintained in operation.

COMMENT: 4

d) What impact will this have on school districts? increased bus transportation, etc.

RESPONSE: The inhabitants of the management area will have to decide where they will relocate. They may choose to move into another school district. This could affect school populations. The project would result in less children being picked up. No assessment was made of the reduction (or increase) in total or per capita cost of school transportation.

COMMENT: 5

2) The EIS (pg. EIS-26) states that Nooseneck Hill Road will be relocated along I-95 where it presently crosses the Big River. What provision has been made for where it crosses Nooseneck River?

RESPONSE: Road relocations are as shown on report PLATE G-3, (Appendix G). Nooseneck Hill Road will be reconstructed in the area of the Nooseneck River crossing to maintain its present alignment, while accomodating the raised water surface of the reservoir.

3) The document states that if subimpoundment dikes are not built for Hopkins Hill and Congdon Mill roads it would not be feasible neither economically or environmentally to relocate these roadways. These roadways are important to the area's traffic network and special consideration should be given to them.

RESPONSE: The plan includes the relocation of both Hopkins Hill Road and Congdon Mill Roads. The roads would be along subimpoundment dikes. If the dikes were not constructed alternate relocation routes would be followed. Relocations are shown on report PLATE G-3 (Appendix G). The EIS text has been corrected to reflect this response.

COMMENT: 7

4) Surrounding roadways will be forced to carry a heavier burden because of the elimination of roads through the reservoir. This raises the following questions:

a) What improvements, if any, will be made to these roadways to protect the reservoir from roadway drainage, hazardous spills, etc.?

RESPONSE: See response to Comment 3, U.S. Environmental Protection Agency.

COMMENT: 8

b) What improvements to these roadways will be made to make them safe for the increased traffic?

RESPONSE: Improvements to existing roads are not contemplated, since the traffic level is not expected to increase appreciably because of the project. If studies during the design of the project indicate there is, in fact, increased traffic on certain roads and the roads need upgrading to accommodate the added traffic, then improvements will be made to be commensurate with appropriate design standards.

COMMENT: 9

c) Will these improvements be paid for under the Reservoir Project Contract? with Reservoir Project funding?

RESPONSE: The relocations shown on report PLATE G-3 (Appendix G) are planned for implementation as part of the project. This plan may, however, change during the preconstruction phase of the work. Such changes could come about as a result of further studies changing condition, public desires, etc.

COMMENT: 10

5) Your report states that this area will have an increase in recreational usage. This will cause an increase in the traffic on roadways surrounding the reservoir.

a) What effect will this have on air quality? CO microscale and a NMHC meso scale analysis desired.

RESPONSE: This type of detailed analysis would be undertaken should Advanced Engineering and Design studies be implemented.

COMMENT: 11

b) What effect will this have on existing noise levels?

RESPONSE: The major effect on noise levels is expected to occur during the construction period with the movement of heavy construction equipment and the actual site work creating increased noise levels. This impact, as noted, is temporary. The impact of increased vehicular traffic on area noise levels over the long term has not been quantitatively determined, but is not expected to be significant.

COMMENT: 12

6) What temporary impacts will the construction equipment have on the project area? noise and air pollution emissions, roadway deterioration, etc.?

RESPONSE: Refer to response to Comment 11 in this section.

2.03 Local Government and Private Organizations

2.03.1 The Conservation Law Foundation of Rhode Island

COMMENT: 1

The Conservation Law Foundation of Rhode Island would hope that the primary goal of the Big River EIS would be to determine whether or not the Big River Reservoir is a necessary component of a broader comprehensive water resources plan for Rhode Island. This would be consistent with NEPA's policy of requiring full analysis of the alternatives and impacts of a proposed project.

The conclusion that the EIS reaches will depend in part on how well it analyses what our future water needs will be. The specific calculations which are used to determine this will go a long way toward wither [SIC] showing the need or lack of need for the reservoir. In the Draft EIS, several factors are taken into account in calculating this. The first factor is what our future population will be. The Rhode Island Statewide Planning Program developed such figures in 1975 and then again in 1979. The 1979 figures reflect trends, such as declining regional birth rates, which could not be foreseen in 1975, and which show a gradual drop in the Rhode Island growth rate. We believe the Corps should use these more accurate figures throughout its calculations in the final EIS. That the 1975 figures are more consistent with the State Guide Plan (which was also developed in 1975) does not seem to be a valid rationale for using these figures. This assumption alone increases the projected water needs for the study area in the year 2030 by over 30% according to Table 15 and 16 in the report.

RESPONSE: Refer to response to Comment 8, U.S. Fish and Wildlife Service.

COMMENT: 2

The methodology used in the EIS to calculate future water needs is based, secondly, on what percentage of the population will be served by a municipal water system in the year 2030. We question the Corps's assumption on page A-46 that the study area, which includes the towns of Foster, Glocester, Smithfield, Coventry, Scituate, and West Greenwich, will be 100% served by a municipal system in the year 2030. There has been no indication from our rural towns that they are planning this sort of urbanization, that they will allow development trends to continue if it begins to change the character of these towns, or that they are interested in giving up their private systems for conveniences of an urban system.

RESPONSE: Refer to response to Comment 9, U.S. Fish and Wildlife Service.

COMMENT: 3

Thirdly, projected water needs are based on future per capita water demands. Again, the EIS seems to rely on outdated information. In this case it is on a "Feasibility Report" done in 1969 by the Corps of Engineers, according to page A-49 of the Draft. The report works from a graph which extrapolates future needs based on rates of demand between 1950 and 1965. This method predicts an increase in water demand per person over the next 50 years of approximately 90 mgd, up from the present 60 mgd. On page A-46, the EIS states that "in making estimates of future water use no direct allowance was made for the impact of changed policies on water consumption." We do not believe it is valid to assume that conservation-oriented policies will have no effect in the future, that the wasteful water practices of the 1950s and 1960s will continue into the distant future, or that appliances which use major amounts of water will come into demand. More realistically, a conscientious water conservation program would lower the amount of water demanded per person -- it should be able to go below 60 mgd. This aspect of water demand projection would be clearer in the EIS if assumptions regarding per capita needs were explained in more detail.

RESPONSE: It is assumed that this comment refers to water demand per person in "gallons per capita per day" or gpd, as opposed to mgd (million gallons per day). See the response to Comment 9, U.S. Fish and Wildlife Service.

COMMENT: 4

Fourth, predictions of industrial water demand are figured into the calculations. The Corps makes use of a mathematical model developed in 1971 (a period of rapid industrial growth) to predict this. We would request that the final EIS state the actual gpd increase which it calculates would result from this formula, and how parameters of the formula, such as "E", "D", "R", and "T", were chosen. This would allow the figures to be judged; readers would have more to go on than that results were figured into the overall demand calculations.

RESPONSE: The industrial demand projection methodology utilized in this study relies on a theoretical model proposed by Stuwart and Metzger in 1971. This forecasting model considers factors related to industrial water utilization in addition to measurements of production. It is considered to produce more reasonable forecasts than are obtained when recirculation and technological change are neglected as is the case when other projection methodologies in use. The model is expressed as follows: $F = (E \times O)/(R \times T)$.

Where F is the ratio of future to present industrial water needs; E is the employment factor, a ratio of future employees to employees in the base year; O is the output per employee factor, a ratio of future to base outputs per employee; R is the recirculation factor; and T is the technological improvement factor.

The numerator of this equation is primarily based on economic parameters of a geographic area, while the denominator accounts for technological improvements in industrial water using processes. These four factors are designed to account for the major variables governing changes in industrial water use.

When employment rises, production is assumed to rise, causing an increase in water usage. Likewise, when output per employee rises, more water is assumed to be used. However, if an industry increases its recirculation, water use will be decreased, and if technological improvements allow an industry to use less water per unit of production, T will increase, meaning decreased water use.

The combination of these four components into one projection factor allows for an estimate of the net effects of growth or decline of an industry (measured by "E"), changes in employee efficiency (measured by "O"), and changes in processes (measured by "R" and "T").

The four factors were determined for each industry by using Standard Industrial Classification [SIC] codes on a town-by-twon basis. Consumption was then projected by SIC code, and totalled for each town. The use of the SIC codes allowed expansion or decline of each individual industry to be reflected in the overall projections.

It should be noted that industrial demands made up about 20 percent of total average daily demands in 1975, and would decrease to about 17.5 percent of the total by 2030 according to the projection methodology used. Thus, should industrial demands vary from the projections, the effect on total demand should not be significant.

One of the purposes of an EIS is to summarize those impacts associated with implementation of a proposed project, not to teach evaluation methods. Technical presentations are included in the supporting technical appendices. Water demand figures have been summarized in the EIS.

COMMENT: 5

We concur with the EIS on page A-43 that "the economy of the state has changed significantly in recent years, showing decline in the manufacturing sector and decrease in the services sector." Does this throw into question the assumption that industrial demand will increase at all over these years, since the services sector is much less water-demanding than the manufaturing sector?

RESPONSE: This comment refers to a statement made on page A-43 of Appendix A, "Problem Identification," not the EIS. See response to

Comment 9, U.S. Environmental Protection Agency. Also, the industrial demand projection model takes into account growth (or decline) in water using industries, and would thus reflect a decline in manufacturing and growth in service industries.

COMMENT: 6

Just as in the area of energy use, another important influence on how much additional water will be needed in the future is the degree to which conservation measures are encouraged. While most of the nation has very much approved of conservation measures (which don't lower the quality of life) in energy as sound and efficinet [SIC], the Corps has hardly acknowledged the relevance of this outlook in the EIS with respect to water. Water is quickly becoming a scarce and precious resource, and Rhode Island will want to steward it more carefully in years to come. A good deal of attention was paid to the concept of demand modification in a study prepared by the Corps just two years ago, entitled "Water Supply Alternatives for the Pawcatuck River and Narragansett Bay Drainage Basins." It concludes that use in old and new homes of low-flushing devices (such as toilets, showers, dish washers, and washing machines) to replace the less efficient ones, only in cases where it would be cost-effective, would save a minimum of 30% of water demand by the year 2030. An aggressive educational program to encourage voluntary conservation would save an additional 5%, according to the report. Overall, a conservative estimate of the water which could be saved by conservation measures would amount to 35% of demand. If this figure is used together with the 1979 population projections of Statewide Planning, according to Table 16 of the EIS we'd have a water surplus of 5 mgd in the study area by 2030. So a thorough consideration of the amount of water which could be saved through "demand modification" seems worth careful study.

RESPONSE: Refer to response to Comment 6, R.I. Department of Environmental Management, April 1981.

COMMENT: 7

The 1979 report goes as far as to say that, based on all studies available, we could theoretically save up to 70% of our water demand through these measures. In light of these figures (35%-70%), it is not at all clear why the Big River EIS concludes that only 9% can be saved by the year 1995 and 11% by the year 2030. We believe that these figures are not consistent with recent studies such as the Corps own report of two years ago. Should the Draft's original figures be used in the final EIS, an explanation of what the reasoning was based on would be important.

RESPONSE: Refer to response to Comment 6, R.I. Dept. of Environmental Management, April 1981.

COMMENT: 8

Questions remain about the potential of other conservation measures also. To our knowledge, no Rhode Island study has estimated the impact which could result from price restructuring in the industrial sector, which consumes about 50% of our total water, and especially the impact of wastewater recycling in this sector, should pricing structures by [SIC] changed to encourage it. Also, no studies that we know of have analysed the responsiveness of the different sectors -- residential, commercial, industrial -- to conservation measures in general. Until these studies are done, we don't believe that the true possibilities of demand reduction in R.I. can be known.

RESPONSE: See response to Comment 9, R.I. Statewide Planning Program. Also, the Methodology used in projecting industrial demands includes a factor for conservation and recycling.

COMMENT: 9

We also have several questions concerning reservoir impact. The Public Participation Program conducted by the University of Rhode Island for the Corps of Engineers in 1978-79 identified several key topics that it determined would be desirable for the EIS to answer. Several important ones don't seem to have been discussed in the EIS.

First is the question of how water quality would be affected downstream from the Reservoir due to reduced flow. Although the Corps may consider actual study of this to be outside of its jurisdiction, we don't believe the final EIS can be complete without having resolved this potentially significant impact. It would be desirable for the EIS to address the effects of concentrated pollutants in the rivers (especially of community health downstream), the combined effects of reduced flow in the Pawtuxet River from Big River plus the Scituate Reservoir, siltation effects, and of how present and potential uses of the river will be altered due to the new flow conditions. Perhaps the EIS could draw from recent workshops and studies of the New England River Basins Commission.

RESPONSE: Refer to response to Comment 4, Environmental Protection Agency, and Comment 8, Rhode Island Statewide Planning Program, A-95 Coordinator.

COMMENT: 10

Secondly, numerous costs of building the reservoir could stand further analysis. The Corps concentrates throughout its study only on direct costs of the reservoir, such as for building transmission facilities, the cost of obtaining real estate for the Reservoir, engineering and design expenses, and so on. Inclusion of all these factors results in the tenuous cost/benefit ratio for the reservoir of 1.16/1. How much would this figure change if all indirect costs were included, such as taxes lost to the state and local communities due to state ownership of the reservoir land; the additional expenses of upgrading community sewage treatment plants to handle the additional water supply created by the reservoir, or, assuming that local communities will not have the money to do this, of the additional costs of polluting Narragansett Bay because of insufficient sewage capacity; the costs of losing sand and gravel resources which would be flooded over by the reservoir; health effects of concentrated pollutants downstream due to reduced flow, or alternatively of the additional costs which industries will have to pay to maintain downstream water quality at its present level when flow is reduced; and so on. Federal regulations (40 CFR 1502.22 and 23) require that "if information relevant to adverse impacts (such as reservoir costs) is essential to a reasoned choice among alternatives and is not known . . . the agency shall include the information in the EIS. Furthermore, " . . . the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities." -- in other words, all indirect costs.

RESPONSE: The State of Rhode Island presently owns the Big River management area, and has given no indication that this land would be returned to local ownership should the reservoir not be built. Thus the construction of a reservoir would not alter the tax status of the lands so the lost taxes should be included in the cost of the reservoir.

Projections of sewage treatment capacity needed have been made in other studies (RI "208" Areawide Water Quality Management Study) and are based on projected water supply needs for the area. The development of new water supply sources is also predicated on the same needs, and thus does not create the need for additional sewage treatment capacity; therefore the costs of treating wastewater should not be included in reservoir costs.

The economic value of the sand and gravel resources which will be inundated has been estimated and included in the report.

Industries discharging into the Pawtuxet downstream of Big River are required to meet water quality standards based on the so called 7 day/10 year low flow. This flow would be preserved as a minimum flow under the proposed reservoir operation. Thus water using industries downstream should not have additional costs imposed on them by reservoir development.

Also, refer to Comment 12, Environmental Protection Agency.

COMMENT: 11

Third, barely any mention is made in the EIS of how satisfactorily runoff from I-95, which passes right through the reservoir, can be controlled. Only on page EIS-26 is mention made of this, to the effect that runoff control and stilling basin facilities would be desirable. The final EIS should analyse the probability of accidents occuring along this stretch --

an EPA survey of highway spills in New England lists 109 spills and 14 hazardous chemical spills involving surface water areas since 1972, some of which were in reservoir watersheds. The state of art in highway runoff control technology is so poor that EPA ruled against the I-84 proposal in western Rhode Island partly on these grounds. The agency cited the unreliability of such technology. An engineer with EPA's Boston office stated in a September 30, 1979 Providence Journal article ("Roads and Reservoirs Can't Coexist Despite Best in Planning, EPA says") that settling basins and drainage pipelines are little more than theory: "We really don't know how well any of this is going to work in practice . . . The truth is there are no proven techniques." One serious hazardous waste spill could contaminate the reservoir indefinitely. The Big River EIS needs to go into this in more than just a paragraph.

RESPONSE: Refer to response to Comments 2 and 3; U.S. Environmental Protection Agency.

COMMENT: 12

We believe that other areas of the EIS need clarification also:

1) What will be the environmental effect of a proposed trans-Narragansett Bay pipeline for carrying drinking water to the East Bay? This is part of the proposed project under Alternative C and must be considered in the Adverse Environmental Impacts section of the EIS.

RESPONSE: A discussion of those impacs associated with pipeline crossings of the Pawtuxet, Providence and Warren Rivers is included in Section 5.02.3 Aquatic Resources, in addition to Section 5.02.4 Terrestrial Resources of the Environmental Impact Statement. See also Figure 3, Locus Plan, in the EIS which illustrates the crossing of the Providence Connector pipeline. The Main Report also discusses impacts of the Providence-Bristol connector under Plan C, Impact Assessment.

COMMENT: 13

2) What is the legal and political basis of the statement on page 64 that importing water from Rehobeth, Massachusetts would not be feasible of interstate institutional restraints, which thereby would necessitate the pipeline. Are institutional constraints so costly as to warrant the extra 3 million dollars plus the environmental disruption of the pipeline?

RESPONSE: Importation of groundwater from Rehoboth, Massachusetts to meet the short-term needs of Bristol County communities was included in each of the alternative plans proposed for the study area. This in itself would require interstate legislation and agreements between the Bristol County communities of Barrington, Bristol and Warren and watershed communities in Massachusetts.

The remaining water supply needs of the Bristol County Water Company to meet requirements through the year 2030 were planned to be obtained from the Providence water supply system. This proposal is in keeping with water supply development alternatives identified in studies conducted for the Bristol County service area and would minimize the requirements for groundwater importation from outside the State. More importantly, implementation for the water supply connection from the Providence water system is contained in legislation enacted by the State of Rhode Island Chapter 1278 P.L. 1915 Section 18, amended in 1967, Chapter 162, P.L. Section 18.

Environmental impacts, primarily on marine environments, resulting from construction of the subaqueous crossing of the Providence River are expected to be temporary and evident only during the construction phase.

COMMENT: 14

3) Groundwater is identified in the EIS as generally being the most economical and least environmentally disruptive way of increasing municipal water supplies. Yet throughout the EIS, groundwater development is routinely dismissed as either too expensive or too impractical. On page 35, for instance, the EIS says "transmission costs from the Pawcatuck Basin to the rest of the study area would be excessive due to long distances involved. Development of groundwater in southern Rhode Island was thus ruled out . . . We would like to see a full analysis in the "Alternatives" section of Rhode Island's groundwater reserves. Figures cited in the EIS, for instance, indicate a large aquifer of drinkable water in the Pawcatuck Basin and surpluses elsewhere around the state. What are the actual economic costs and environmental consequences of developing them (the amounts which are available is partly addressed in the Draft; but these figures apparently combine values of what is theoretically available with a judgement of how much is socially and environmentally acceptable to use. We would like to see all figures spelled out in much more detail).

RESPONSE: The quotation referred to is found in the Main Report. The same paragraph notes that the major reasons for eliminating Pawcatuck River Basin groundwater from consideration are that the aquifers would be better utilized locally, and the yields mentioned would be considerably reduced should water by transferred to another part of the State. Further detail on the rationale used in screening groundwater sites is found in Appendix B, "Plan Formulation."

COMMENT: 15

4) The EIS also describes large reserves of groundwater in Providence, Cranston, Lincoln, and elsewhere which are of poorer quality. This water appears suitable for industrial purposes (which demand over 50% of the state's water at present), yet there is no discussion of the feasibility of using these supplies in the future for these purposes.

RESPONSE: Refer to response to Comment 11, U.S. Fish and Wildlife Service.

COMMENT: 16

We believe that a discussion of water resource needs in our state is most timely right now, and applaud the Corps of Engineers for undertaking these studies. We are not opposed to expansion of water supplies in Rhode Island if they are needed, but believe that whether or not supplies such as the Big River Resrvoir are really needed now has not yet been shown. Too many questions about the future need for water and the desirability and potential of alternatives remain to be answered before determining this. We hope the Corps continues to stay involved in the analysis of these questions.

RESPONSE: Your comment is acknowledged and included in the record.

2.03.2 Rhode Island Canoe Association, River Conservation Committee

COMMENT: 1

Our main interest, as canoeists, in this project relates to the recreation plan. Our 150 member organization presently uses the Big River Area for recreational canoe trips during the warm weather months. In a sense, we would prefer to canoe on a relatively small stream, rather than on a large, sometimes windy reservoir. But if the stream is taken for the reservoir project, we strongly urge that canoeing be permitted. From the research I have done on Plan C of this feasibility study, it appears that developing the recreational potential of the reservoir area is an important aspect of the total plan. If canoeing is not included in the reservoir recreation plan, we as a special interest recreation group would obviously suffer by not having canoe access to the reservoir. But it should also be realized that canoeists will be affected in a more profound sense than other recreation groups, because once the reservoir is built we would no longer be able to use the Big River itself for canoeing.

We would like our opinions to be considered in this study and we also request that this letter be considered as part of the review process.

RESPONSE: Canoeing is recommended to be permitted in Big River Reservoir as discussed in Appendix H, Recreation and Natural Resources, along with other forms of non-water contact boating.

Your letter is included in this document and is, therefore, part of the record.

2.03.3 City of Providence, Department of Planning and Urban Development

COMMENT: 1

At the outset we acknowledge the probability, but as a likelihood rather than as a certainty, that construction of the Big River Reservoir will become necessary to serve a larger geographic area of water users than are served by the Scituate Reservoir currently. However, we feel now that the need is developing later than trends indicated a decade ago, and that construction should be scheduled at least five to ten years later in order to avoid an expensive prematurity of capital investment due to excess capacity during the interim. At the same time we continue to appreciate the wisdom with which, some decades ago, the State of Rhode Island acquired the entire site in order to prevent further accumulation of private investment and needlessly increasing acquisition, site clearance and other expense.

RESPONSE: Should advanced engineering studies be authorized the exact need for and time scheduling of the project would be re-evaluated. At each stage of design, the need for any project is reviewed to see if it still exists, or if construction should be deferred from previous timetables.

COMMENT: 2

Two factors have deferred demand for the water supply, including our interrupted population growth in the potential and prospective water service area, as well as a sharply diminishing per capita rate of increase in demand. The first of these factors is less debatable than the second, and was revealed two years ago this month in the 1979 population projections of the Statewide Planning Program, which for good and sufficient reasons superseded their own 1975 projections. Both of these projections were fully competent and properly responsive to trends discernible at each epoch, but the 1975 work became obsolete by reason of the sharply dropping birth rate and the closing of the Quonset naval base. For similar reasons the 1972 projections of the Office of Business Economics/Economic Research Service ("OBERS") were additionally obsolete despite their competency at that date, and should not have been used to justify a "choice" between two apparently conflicting state projections.

On the basis of the 1979 projections, for the design year 2030, the population in the service area was in 1975 overprojected by 37.7% (833,400 vs. 605,300), and for the year 2040, by 41.5% (850,100 vs. 600,600). Both projections were done by the same Principal Research Technician, Mr. Chester J. Symanski, with supporting staff in the Rhode Island Statewide Planning Program, who have the respect of the Population Advisory Committee of the State Planning Council as well as of the U.S. Bureau of the Census. Aside from the advantage held by the 1979 projection by virtue of four more years of development in actual data trends, there were four more years of professional experience by staff. The 1980 population counts were close to those projected in 1979 for the Rhode Island municipalities.

Increasing public awareness of the need for conserving all resources including water and energy can be reasonably expected to put some damper upon the rise in per capita consumption, more effectively than could be anticipated as long ago as 1969 and 1975, the base years mentioned on Page A-49 in the discussion, unsupported by data presentation, of per capita consumption. The assumptions made appear in need of re-evaluation and updating.

Consideration of these demand factors may help to prevent any mis-timing or mis-sizing of water supply development, and to support public credulity for the Corps' analyses of needs.

RESPONSE: Refer to response to Comments 8 and 9, U.S. Fish and Wildlife Service.

COMMENT: 3

Our second major comment on the Draft Report relates to the omission of an electric power generation facility at the proposed Big River dam. At the March 26, public meeting it was stated by John C. Craig, study manager, that "hydro power at Big River is not considered feasible at this time." However, since the report preparation was completed as of July 1980, the Federal Energy Regulatory Commission has commenced effectuation of the Public Utility Regulatory Policies Act of 1978 which requires encouraging cogeneration and small power production at facilities such as this. The Rhode Island Public Utilities Commission on March 20, 1981, issued its decision and order regulating sales and purchases of electricity between electric utilities and small power production facilities, and established the formula by which the energy cost avoided by Narragansett Electric Company's wholesale supplier, New England Power Company, must be determined for on-peak and off-peak periods and adjusted for line losses, and used as the basis for rates to be paid for cogenerated power. By April 9, 1981, tariffs must be filed including the calculated rates. We expect that the rates will at times vary in the range of about $.075 to $0.080 per kilowatt hour, or about 14 to 15 times the rates currently paid to the Providence Water Supply Board for cogenerated power sold to Narragansett Electric Company at the Scituate Reservoir dam. These developments affect substantially the picture of economic feasibility for the proposed Big River dam, and we therefore call upon the Corps to make a careful evaluation of power co-generation under these new conditions.

RESPONSE: The feasibility of hydropower generation at the Big River dam would be studied in more detail should advanced engineering and design studies be authorized. Also, see response to Comment 1, Coventry Rod and Boat Club, Section 3.

COMMENT: 4

Our third major comment concerns the extensive discussion given in several of the report volumes to justifying the abandoned proposal for the Natick Diversion tunnel project and refuting points of official and public objections against it. In Volume VII, Appendix 3 entitled "Public Views & Responses" contains a section presenting "Correspondence from 1976 Public Meeting" beginning on Page 3-26, in which eight letters appear. Omitted from this section is a letter constituting the official response of the City of Providence to the proposal, dated October 14, 1976, presented with the approval of the Mayor and the Director of the Department of Planning and Urban Development at the late stage public meeting on that date. Although the official status of that communication was acknowledged on Page 3-23 in the summary of that meeting, the contents are withheld from the present volume.

The importance of that omission arises from the manner in which the comments in that letter were summarized by the Corps so selectively on Pages 10-7 and 10-8 as to omit vital portions of those comments. For example, we did recognize the advisability of providing some simplified backflow prevention device to check abnormal (but not normal) tides from inundating most of the Warwick and Cranston flood plain areas along the Pawtuxet River's mainstem. Also, in re-wording our comments the Corps omitted our suggestion that, if found safe after engineering analysis, the simple use of a few additional stop logs in the existing slots at the top of the Scituate Reservoir spillway would accomplish a modest utilization of the effective height of the dam, according to its original design, for brief periods during and following flash floods. By this omission the Corps made room for objecting to "a costly procedure to outfit the dam with new appurtenant flood control facilities, and therefore, is not considered feasible."

RESPONSE: The comments noted here, as part of the October 1976 public meeting submission were addressed at that time, in the EIS and technical appendices. Responses made at that time still stand, as several coordination meetings were undertaken in early 1977 between the Corps and representatives of the City of Providence to clarify the Corps' responses and positions on issues raised at the public meeting. Differences were settled during the 1977 coordination, and changes made when appropriate to the report.

In response to the specific suggestions noted in these comments, the effect of such actions as the addition of stoplogs at Scituate Reservoir, drawing down mainstem dams, and removal of the Broad Street Dam and/or other obstructions to flow in the lower mainstem would be insignificant in protecting against major flooding in the basin, which was the intent of the study. These types of measures, if feasible, could be undertaken by local interest, but would not be of significant value in an overall basin-wide flood damage prevention plan which could reduce losses resulting from a major flood event.

COMMENT: 5

Comment 4-1 regarding the Broad Street Dam, the concrete wall jutting across its spillway, and the sediments, rubble, and obsolete foundations of old weirs and bridges, was so summarized by the Corps as to exclude our description of the elevation of the natural riverbed which, before construction of the earliest dam at Broad Street, was several feet lower for several miles than the present silted-in river bottom. The Corps' response again discounts almost completely the value of restoring the original cross-section and gradient of the Pawtuxet River's mainstem, without justifying that discounting, with the unsubstantiated statement that "the removal of such objects would only have a minor effect on riverine flooding."

RESPONSE: Refer to response to Comment 4, City of Providence, Dept. of Planning and Urban Development.

COMMENT: 6

Comment 4-3 was similarly re-worded by the Corps to imply that we had grossly over-estimated the storage volumes behind existing dams along the Pawtuxet River. The response by the Corps pointed to "insufficient storage capacity to be an effective element in a flood control system," but did not indicate what that total of capacity would be assuming the routine drawdown of whole series of dams that are not needed as reservoirs, as a portion to be added to whatever flood storage volumes might be available at Scituate, Flat River and Big River reservoirs. We merely sought to indicate that "every little bit helps," especially in non-structural solutions costing very little, and we did not miscalculate those capacities as being unrealistically large.

RESPONSE: Refer to response to Comment 4, City of Providence Department of Planning and Urban development.

COMMENT: 7

In our view the Corps has not justified its preference for leaving in place the obstructions and sediments which can only add to the hazards menancing all the flood plain investments surrounding the river's mainstem. Respectfully we suggest the presentation of our letter of October 14, 1976, as written, and that the Corps re-work its responses to handle our comments more directly, in the final project report.

RESPONSE: Refer to response to Comment 4, City of Providence Department of Planning and Urban Development.

COMMENT: 8

On other issues, we have these recommendations to make:

1) That decisions about allowing recreational use of the reservoir water areas and surrounding forest management areas are policy issues to be resolved by the water supply management agency under Rhode Island law according to their experience with water quality requirements.

RESPONSE: The recreational activities proposed for the Big River Reservoir site have been selected for their compatibility with the water supply purpose of the reservoir, and in keeping with State law. Recreation is economically justified as a project purpose, and has been included as a project purpose as part of the Corps' policy of providing multiple uses at Federal water resource projects, as well as because of the strong public desire for recreation facilities at the project, and the regional need for such facilities. However, the specific recreation activities ultimately to be allowed at the site would be determined during more detailed design efforts in the future through coordination with the management agency.

COMMENT: 9

2. That the final report detail methods and costs for insulating Route I-95 drainage and hazardous spills from the Big River watershed according to standards applicable to newly constructed interstate routes.

RESPONSE: Refer to response to Comments 2 and 3, U.S. Environmental Protection Agency.

COMMENT: 10

3. That the final report provide that materials to be excavated for use in constructing the dam and dikes and relocated highways be taken only between the elevations 267' and 300' NGVD unless impervious fill material is in short supply within that interval, so as to contribute to the water supply volume exclusively.

RESPONSE: The location of materials to be utilized in constructing the dam and dikes would be ascertained should advanced engineering and design studies be authorized, on the basis of site investigations and wherein possible come from within the pool limits.

2.03.6 Quidnick Reservoir Company

COMMENT: 1

1. <u>Non-Recognition of the Quidnick Reservoir Company in the Draft Report</u>

Despite the nearly 2,200 pages of text, tabulated information, and 2-1/2 years of research, the Draft Report does not address the Quidnick

Reservoir Company, its water rights, or its plans to redevelop hydroelectric power along the South Branch of the Pawtuxet River. This proposed redevelopment of hydropower is an obvious competing use of the water, which was not resolved in the study, nor was it even considered.

RESPONSE: Although the report on the proposed Big River Reservoir Project does not address the Quidnick Reservoir Company by name, the impacts of reduced streamflows on downstream riparian owners, terrestrial and aquatic resources and water quality were addressed in the Main Report and technical appendices. Detailed studies related to impacts on potential hydroelectric projects in the South Branch of the Pawtuxet River will be undertaken during the advanced engineering and design phase of project implementation. The mitigation requirements and costs thereof will also be identified during advanced planning phases of the study as part of the total non-Federal responsibilities for implementation of the Big River Reservoir project.

The final feasibility report will include appropriate information on the Quidnick Reservoir Company, its water rights and the plans for hydropower development on the South Branch.

COMMENT: 2

Further, despite the efforts of Quidnick to maintain a high profile for their hydroelectric development plans, and their numerous meeting [SIC] with State agencies regarding the conflict of water use, the Draft Report has for all intents and purposes, ignored them.

RESPONSE: Refer to response to Comment 1 in this section.

COMMENT: 3

2. Competing Water Uses

The Hydroelectric Feasibility Study reached its half-way mark this fall, and on October 23, 1980, a Mid Study Report was filed with the Department of Energy for approval. Approval of that report was received by D.O.E., and the balance of the loan monies to complete the study were released.

Contained within the Mid Study Report were computer printouts of the U.S. Geological Survey's Program of river flow data as measured along the South Branch of the Pawtuxet. Based upon the data generated from that program, a flow duration curve was developed for each site, indicating a design flow for the 8 hydrostation's of 180 cfs, (Q 25%). Using that flow of 180 cfs, along with the available net head at each site, powerhouse capacities were developed and equipment selected. Annual kilowatt hour production for each site was then calculated, and estimated revenues were compared with estimated costs.

The results of those analyses indicated that based upon those historic flows, the given heads, and costs, the projects were all technically and economically feasible.

The Final Draft Report for the Big River Reservoir proposes to reduce the contributing drainage area of the South Branch of the Pawtuxet River at the Washington Gauging Station from 63.8 square miels to 34.1 square miles.

This in effect will reduce the average flows at the Washington Gauging Station from 128 cfs, to 79.7 cfs, a 37.7% reduction in flow. By impounding this amount of the flowage from the contributing Big River, all of the proposed hydroelectric plants along the South Branch of the Pawtuxet River will be rendered economically infeasible. Because of the relatively low heads at each of the dam sites (14 to 30 feet), and the already modest flows of the Pawtuxet River, (Q @ 128 cfs), none of these proposed hydroelectric projects could sustain a 38% reduction in flows, and be expected to amortize itself.

RESPONSE: Refer to response to Comment 1 in this section.

COMMENT: 4

3. Water Quality

The Quidnick Reservoir Company owns the riparian rights to the Flat River Reservoir and they operate the gates controlling the flow to the South Branch. The minimum 7Q10 flow of 23 cfs must be released from the reservoir gates at all times to assure adequate flow to mix with the American Hoechst discharge. The R.I.D.E.M. expressed concern that the development of the proposed Big River Reservoir would further compound the dissolved oxygen problems of the South Branch. By considerably reducing the flows into the Flat River Reservoir, the average annual flows of the South Branch will be reduced by approximately 40 percent with the minimum downstream release capabilities of the Flat River Reservoir also adversely effected, thereby reducing the overall assimilative capacity of the river. While the Army Corps of Engineer's Preliminary Feasibility Analysis of the Big River Reservoir Project has discussed the reduction of flows, the effect this project would have on the dissolved oxygen levels in the South Branch must be analyzed in much greater detail in the final report. It would appear that the dissolved oxygen water quality standard of 5 mg/l may be violated by the proposed Big River Reservoir Project.

RESPONSE: Water quality impacts resulting from construction of the proposed Big River Reservoir project were addressed in the 208 Water Quality Management Plan for Rhode Island, August 1979 and have been incorporated in the current study. Releases from the Big River Reservoir would be as recommended in the Section 208 report producing dissolved oxygen levels in the South Branch and mainstem Pawtuxet River in compliance with recommended water quality standards.

COMMENT: 5

4. Ownership of Flowage Rights

Quidnick Reservoir Company and its membership maintain a threefold right of ownership and usage of the water flowage rights. Quidnick Reservoir Company itself maintains two major forms of ownership and each member of the company maintains rights separate and apart from Quidnick but arising from its ownership of land.

Quidnick's two-fold rights refer to its outright ownership of land and also its ownership of flowage rights. Both forms of ownership are documented by deeds recorded in the land evidence records in the various towns involved which deeds were recorded in the period of approximately 1865-1878.

The outright ownership of land is ownership in "fee simple absolute" and ownership of flowage rights is the right of flow waters over land owned by others. These two forms together when read together give Quidnick the right to create a reservoir of water in the West Warwick and Coventry area where the ownership exists. It is these rights which Quidnick has owned continuously from the time they first obtained them, some 100-120 years ago, and still owns them today. This ownership has never been diminished by any condemnation, purchase or easement by any person, corporate body or municipal government.

The area created by Quidnick Reservoir Company is approximately 938 acres. Many of the exact bounds may be difficult to locate due to the meandering and flowing of the Big River over the past 100 years, but the land and flowage rights exists and are owned by Quidnick Reservoir Company.

The owership of the lands and flowage rights to the south of the proposed Big River Reservoir is set forth in the map in the attached Exhibit B and the deeds creating this ownership are as follows:

#	Grantor	Grantee	Town	Book/Page	Date
1	David Howard	QRC	W.G.	Bk13 Pg.543	May 26, 1873
2	Sara Matteson	QRC	W.G.	Bk13 Pg.544	May 30, 1873
3	Wm. B. Whitford	QRC	W.G.	Bk12 Pg.404	Oct. 15, 1875
4	John W. Howard	QRC	W.G.	Bk12 Pg.346	May 28, 1874
5	Spencer Greene	QRC	W.G.	Bk12 Pg.394	Aug. 19, 1875
6	Thurston Hall and Wife	QRC	W.G.	Bk12 Pg.399	Sept 6, 1875
10	Moria Wickes	QRC	W.G.	Bk14 Pg.143	May 28, 1878
7	Amos Sweet	QRC	W.G.	Bk12 Pg.418	Aug. 7, 1876
8	Searles Capwell	QRC	W.G.	Bk12 Pg.332	Feb. 24, 1874
9	Dexter M. Johnson	QRC	W.G.	Bk12 Pg.313	Mar. 12, 1873

#	Grantor	Grantee	Town	Book/Page	Date
11	Phillip A. Sweet	QRC	Coventry	Bk28 Pg.160	Sept 22, 1870
	Benedict Lapham	QRC	Coventry	Bk28 Pg.307	Oct. 23, 1872
12	Phillip Sweet	QRC	Coventry	Bk28 Pg.159	Sept 22, 1870
13	Richard T. Mitchell	QRC	Coventry	Bk27 Pg.267	Sept 19, 1868
14	Phillip Sweet	QRC	Coventry	Bk28 Pg.160	Sept 22, 1870
15	Benedict Lapham	QRC	Coventry	Bk28 Pg.207	Oct. 23, 1872
16	Stephen Andrew, Jr.	QRC	Coventry	Bk26 Pg.614	Aug. 8, 1867

The third fold of ownership arises through the individual member of Quidnick. Each member of Quidnick also owns land on the bank of the River and as such has certain riparian rights. These rights given each owner the right to have the water flow past its property undiminished in quantity and quality as well as the right to put the water to reasonable and beneficial use.

Each member and land owner has use for the water flowing by its property. Some use the water for cooling purposes while others use the water as an integral part of the business. Any interruption in the quantity, quality or their use of water would greatly effect their business operations. The Army Corps report does not acknowledge the real effect the Reservoir will have on these downstream users nor does it acknowledge the magnitude of the damage to these business and to the jobs, taxes and other economic issues of the towns and the people if these businesses are forced to relocate due to changes in their water quality or quantity.

RESPONSE: Refer to prior responses to comments in this section.

COMMENT: 6

Because of the aforementioned facts, the Quidnick Reservoir Company strongly recommends that the Draft Report in its present form, be either rejected in its entirety, or be amended to rectify its deficiencies and become compatible with the plans of the Quidnick Reservoir Company.

RESPONSE: As noted in the previous responses to comments contained in this section, impacts associated with construction of the proposed Big River Reservoir Project will be fully evaluated during advanced engineering and design studies in compliance with non-Federal responsibilities for project implementation.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
BOSTON AREA OFFICE
BULFINCH BUILDING, 15 NEW CHARDON STREET
BOSTON, MASSACHUSETTS 02114

REGION I

IN REPLY REFER TO:

1981

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Attention: Mr. Joseph L. Ignazio

Re: Draft Report - Big River Reservoir Project - Coventry, West Greenwich, Rhode Island

Dear Mr. Ignazio:

The above draft report which was sent to the HUD Regional Office has been referred to the Boston Area Office for review and comment. In review of the draft report, the following observations were made and are offered for your guidance:

1. The Big River Reservoir is to be located where two (2) major highways (I-95 and 3) cross the area. Consideration should be given to developing a "risk analysis" of a potential hazardous material spill onto the Reservoir as well as ways to mitigate the spill and a plan to contain and clean up the spill.

2. There is no discussion on herbicides, pesticides, and fertilizers with fecal matter and nutrients that may have been used on agricultural lands and what its effects would be upon the Big River Reservoir and the watershed area.

3. There is no discussion on two sites in Coventry that have been reported by the Rhode Island Department of Environmental Management as having accepted chemical wastes in the past. The two sites are located on Arnold Road northeast of Route I-95. Since these areas are adjacent to the reservoir watershed areas, what, if any, effect would it have upon the surface runoff and the groundwater?

4. Page EIS-29 states that boating within Big River Reservoir "would be restricted to small fishing boats." The report does not specify whether these boats are to be "dry" or motor powered. If the fishing boats are motor powered, then consideration should be given to banning them from using the

Reservoir. Motor boats can cause pollution/degradation of water through discharge of oil, gas, and other chemicals. Protection of the water quality of the reservoir should be of utmost concern in view of the many areas where surface and groundwaters have become contaminated.

Development of the Big River Reservoir will not have any conflicts with the goals and objectives of the Boston Area Office of HUD.

Thank you for the opportunity to review and comment on the above draft report.

Sincerely,

Edward Machado
Environmental Officer

Department of Energy
Region I
150 Causeway Street
Boston, Mass. 02114

MAR 16 1981

Colonel C. Ernest Edgar III
Division Engineer
New England Division
U.S. Army Corps of Engineers
24 Trapelo Road
Waltham, MA 02154

Dear Colonel Edgar:

We have reviewed your draft Environmental Impact Statement on the Big River Reservoir Project. It appears that the evaluation of energy related issues has not been included. These issues range from the amounts and types of energy used for construction to alternative energy resources which may be affected by the creation of this project.

Therefore, we would suggest adding a new section entitled "Energy". This section could be numbered as either 5.03 or 5.01.8 depending upon whether it is written as an additional Environmental Effect or a subsection under Socio-economic Effects.

Thank you for this opportunity to comment.

Sincerely,

Hugh Saussy, Jr.

Hugh Saussy, Jr.
Deputy Regional Representative

United States Department of Agriculture
Soil Conservation Service
46 Quaker Lane
West Warwick, Rhode Island 02893

March 16, 1981

Division Engineer
New England Division
US Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Sir:

I have reviewed your Draft Report for the proposed Big River Reservoir Project in Coventry and West Greenwich, Rhode Island and have the following comments:

1) The USDA Soil Conservation Service recently completed Important Farmlands map indicates that over 8000 acres of the Big River Management Area is either prime farmland or farmland of statewide importance. Since Governor Garrahy is putting new emphasis on preserving our state's agricultural lands, it would seem appropriate to address existing agriculture and the soils associated with agricultural production and what its future would be in the management area. The Important Farmlands maps and the Ag and Openlands maps of Rhode Island are available along with the soil survey for that area. These can be obtained from Robert E. Lee, P.O. Box 392, Robinson Street, Wakefield, RI 02880.

2) The report indicates recreational benefits to be derived from the project. This indicates a change from present Rhode Island policy, which clearly does not include multiple use of watershed management areas.

I thank you for the opportunity to review this proposal.

Donald M. McArthur
State Conservationist

cc: Gary A. Margheim, Environmental Coordinator, USDA, Soil Conservation Service, P.O. Box 2890, Washington, D.C. 20013

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. Box 1518
Concord, New Hampshire 03301

APR 1 1981

Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

Mr. Ignazio's letter of January 21, 1981, requested our comments on the combined Draft Interim Report, Draft Environmental Impact Statement and Section 404 Evaluation for the proposed Big River Reservoir Project, Coventry and West Greenwich, Rhode Island. Our comments are provided under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and the National Environmental Policy Act (PL91-190).

The primary emphasis of the Service's review is to determine the overall adequacy of these documents with respect to fish and wildlife and related resources and the impacts of the proposed action upon these resources.

We offer the following comments.

GENERAL COMMENTS ON MAIN REPORT, DRAFT EIS, SECTION 404 EVALUATION

We consider information presented in the above documents, for the most part, to be of a general nature with insufficient detail to predict and detect changes in environmental conditions. They lack sufficient depth and detail concerning environmental factors to afford a reasonable understanding of predicted impacts without constant reference to the Technical Appendices. We believe these documents should stand by themselves and contain sufficient information, albeit of a succinct nature, to allow an understanding of the project's overall impact upon fish and wildlife resources within the study area.

The ambiguities in the Main Report and DESI pertaining to mitigation measures for the tentatively recommended plan (Plan C) precludes identification of the most desirable plan (A, B, or C) from a fish and wildlife viewpoint. However, we note that all of these plans are deficient in addressing adequate measures to compensate for losses of fish and wildlife habitat and fall far short of offsetting habitat value losses.

Neither document seriously attempts to project fish and wildlife habitat values over the project life for without and with the project conditions. The only place where such projections occur are in our Fish and Wildlife

Coordination Act Report (Appendix H, Section 4) and these are largely ignored in both the Main Report and DEIS. In addition, neither document adequately addresses the secondary impacts of the project upon fish and wildlife resources within the study area.

DETAILED COMMENTS ON MAIN REPORT

Problem Identification

Page 9, para. 7 - States that "The forests in the Big River Reservoir study area are characterized by a predominance of oak, hickory and yellow poplar trees." The extensive areas of evergreen forest (white pine and pitch pine) are not mentioned. In addition, yellow poplar (Liriodendrom tulipifera) is not listed in Appendix H, Section 3, as one of the species of plants found in the Big River Study Area. Therefore, it should not be considered as a predominate species in the study area.

Page 9, para. 8 - We note that this is the only place in the Main Report where fish and wildlife resources are discussed under their own separate heading. Throughout the Main Report, fish and wildlife resources are discussed either under recreation or scattered under other headings. We believe that fish and wildlife resources are of sufficient interest and value to be accorded a separate heading for discussion, whenever appropriate, throughout the report. Sufficient information for such discussion, especially as pertains to Big River Reservoir, is contained in our Fish and Wildlife Coordination Act Report, September, 1979.

Page 10, para. 1 - Specifically classifies Big River as a warm-water fishery. While it is predominately a warm-water fishery, it should be noted the Rhode Island Department of Environmental Management lists Big River as a Class B trout fishing area, and it is annually stocked with about 2,000 trout by the Division of Fisheries and Wildlife. In addition, native brook trout are found in many of the tributaries.

Pages 16 and 17 - Concludes that, "... the 1975 population projections represent the most probable future condition as the basis for determining water resources development needs of the study area." We question the rational justifying the use of these 1975 population projections. It appears that the revised 1979 population projections would more accurately reflect population trends in the study area. When compared with preliminary Bureau of the Census data (November, 1980), the 1975 population projections exceed the study areas 1980 population by over 40,000 and the states population by nearly 55,000. However, the 1979 population projections are nearly in complete agreement with 1980 census data. We believe that a reanalysis of the most probable future condition is in order, inasmuch as the distribution of population within the study area and the State would have very direct effects on future water resource development plans that could adversely impact fish and wildlife resources.

Page 21, para. 4 - We question the validity of the following assumptions: "Population served was assumed to gradually increase until by 2030 the entire study area would be 100 percent served. Likewise, per capita consumption would increase over the entire study area, with rural area consumption growing by more than that of urbanized areas." Both of these assumptions inflate the need for water supply. From our perspective, it does not seem reasonable to assume that the population segment served by private wells will be forced to utilize a municipal water supply system. Based on the evidence presented, we fail to see the need for significantly increasing per capita consumption.

Page 26, para. 4 - States that, "Objectives associated with environmental needs were directed at preservation of existing stream conditions since no highly productive habitat exists in the Pawtuxet River Basin ..." What is the basis for this statement? We believe that data presented in Appendix H, Section 2, are indicative of a diverse and productive aquatic system within the area studied. The stated objective more clearly limits itself to existing downstream conditions (below Flat River Reservoir) and does not consider potential water quality improvements and subsequent increases in stream productivity. With improved water quality conditions, it is most likely that a productive warm-water fishery would prevail in the downstream area and the possibility of restoration of American shad and alewives to the Pawtuxet system could become a reality. Therefore, objectives associated with environmental needs should be directed at future stream conditions and appropriate changes should be made throughout the report.

Formulation of Preliminary Plans

Page 35, Ground Water - This section as well as Appendix B, pages 25-32, discusses the availability of ground water in various communities and points out that in many areas ground water is of unacceptable quality and would require extensive treatment. However, we find no detail or indepth analysis on the feasibility of such treatment. The cost of such treatment should not be of great concern since paragraph 6 states that "The price of water in the study area is so low that pricing policy changes would have little, if any, effect on use." Therefore, we suggest that the feasibility of utilizing ground water supplies be more fully explored.

Assessment and Evaluation of Detailed Plans

Page 50, para. 4 - The 8,300 acres referred to includes the entire Big River Management Area and not just the lands surrounding the reservoir.

Page 51, para. 1 - Recreation facilities proposed for Plan A are not shown on Plate 8 as indicated. This is also true of Plan C.

Page 51, para. 3 - Indicates that downstream flows into Flat River Reservoir would be reduced by 43 percent. However, this includes the entire drainage area of Flat River Reservoir. According to information contained in Appendix D, Hydrological Analysis, the average annual stream flow at the Big River dam site is about 60 cfs. With the project, this flow would be reduced to 6 cfs, a reduction of 90 percent. In addition, the project would reduce average annual stream flow below Flat River Reservoir by as much as 40 percent and as much as 15 percent in the main stem Pawtuxet. The potential impacts of these reduced flows on the aquatic biota of Flat River Reservoir and the downstream area has not been addressed in Plans A, B or C.

Page 51, para. 6 - The recreation activities allowed under all plans may not be compatible with wildlife management objectives and efforts to mitigate habitat losses. This should be addressed in Plans A, B and C.

Page 53, para. 2 and 3 - Discusses mitigation of adverse impacts of reduced downstream flows on riparian water uses. Potential aquatic resource losses or studies needed to determine such losses are not mentioned. We believe this should be addressed in Plans A, B and C.

Page 55, para. 6 and page 56, para. 6 - Indicates that Plan B includes additional mitigation measures, compared to Plan A, such as subimpoundments, stripping and grubbing of selected areas and reclaimation of strip mining areas. Yet on page 57, paragraph 5, it states that "For Plan B, mitigation of impacts will be identical to the requirements of Plan A." On page 60, paragraph 4, it states that mitigation requirements under Plan C would be the same as under Plan A. The Draft Environmental Impact Statement, pages 17-18, indicates that subimpoundments, stripping and grubbing and reclaimation of strip mining areas are included in the recommended plan, Plan C. We suggest that this entire section be clarified in order to more fully understand the extent of efforts undertaken to mitigate fish and wildlife resource losses under Plans A, B and C.

Page 57, para. 1 - Suggests that mitigation under Plan B would be of such an extent that negative fish and wildlife impacts would be minimal.

We do not agree with this statement since our Fish and Wildlife Coordination Act Report (contained in Appendix H, Section 4) indicates that while intensive management of the reservoir (subimpoundments) and surrounding state-owned land would mitigate about 68 percent of the total wildlife Habitat Unit losses, it would mitigate only about 20 percent of the wetland losses. Acquisition and management of an additional 5,800 acres of land would be required to compensate for all of the Habitat Unit losses. Additional studies would be needed to determine the magnitude of potential adverse impacts of reduced stream flow on the aquatic biota of Flat River Reservoir and the downstream area. The information contained in our Coordination Act Report has not been utilized in your assessment and evaluation of detailed plans, and we urge you to utilize this information to assure equal consideration of fish and wildlife resources in the planning process.

Comparison of Detailed Plans

Page 62, para. 5 - States that "Plan B includes more extensive measures to enhance environmental productivity, thus would produce more benefits to the local environment, particularly on fish and wildlife resources." We do not view measures taken under Plan B to enhance but rather to mitigate fish and wildlife resource losses, therefore, no benefits would occur over the existing situation. We suggest that this paragraph as well as others in the report that use the terms enhance, enhancement and benefits, be revised for context and appropriately rephrased. In addition, see our comments for page 57, paragraph 1.

Page 64, para. 6 - See our comments offered for pages 55-56, paragraph 6, page 57, paragraph 1; and page 62, paragraph 5.

DETAILED COMMENT ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

1.0 Summary

1.01, page 1, para 3 - We are not convinced that the figures shown represent the most probable demand estimates for water supply. Projected population growth is the most important element in developing a most probable future condition and we believe the projections utilized by the Corps are open to question. Therefore, we believe that a reanalysis of the most probable future condition is in order, inasmuch as the distribution of population within the study area and the State would have very direct effects on future water resources development plans that could adversely impact fish and wildlife resources. This issue should be addressed in the DEIS (see detailed comments on Main Report for pages 16-17 and page 21, paragraph 4).

AD-A105 362 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
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1.01, page 2, Plans A, B and C - There appears to be a discrepancy in these plans with regard to mitigation features. Plan C, as outlined in the Main Report, does not appear to include addition features such as subimpoundments and reclaimation of strip mining areas that is included in Plan B and shown on Plate 9 of the Main Report. Yet, these individual features appear on Figure 2 in Appendix H, Section 4, as basic mitigation features and are discussed as part of the recommended plan, Plan C, in the DEIS. Therefore, we question if the DEIS addresses the correct plan of development or if our confusion is due to the phrasology in the Main Report. (In addition, see detailed comments on Main Report for pages 55 and 56).

1.01, page 2, last para - States that, "Basic mitigation recommendations (Appendix H, Vol. IV) have been presented which would offset impacts to terrestrial and aquatic resources." We suggest that the basic differences between the Corps and the Service's mitigation plans be summarized in this section. In our opinion, the Corps' plan does provide for mitigation but fails to offset impacts by a substantial margin. The Service's plan would more completely offset impacts to terrestrial and aquatic resources.

3.0 Alternatives

3.01.6, page 10 - This section should address the feasibility of adequately treating groundwater supplies of unacceptable quality to provide potable water. (See detailed comments on Main Report for Page 35, Ground Water).

3.03 (5), page 17 - See detailed comments for 1.01, page 2, Plans A, B and C. In addition, this section is remiss in that potential adverse impacts to downstream aquatic biota, due to a reduced streamflow regime, is not recognized and mitigation measures that could reduce these impacts are not discussed.

3.03 (5), page 19, last para - States that, "The creation of subimpoundments would mitigate the loss of wetlands." We contend that while subimpoundments would mitigate some of the wetland losses, they fall woefully short of offsetting wetland losses. The subimpoundments as proposed by the Corps have been reviewed by the Service and checked on a map depicting four-foot contour intervals (Keyes Associates and Metcalf & Eddy, Inc., undated). Subimpoundments in the Congdon River and Tarbox Pond areas are relatively deep with maximum depths of over 20 and 12 feet, respectively, with the greater portion of each being over 8 feet in depth. The two smaller subimpoundments fair somewhat better but we do not consider either of them as providing first rate wetland areas. We feel that the Service has been generous in evaluating subimpoundments in its Fish and Wildlife Coordination Act Report (contained in Appendix H, Section 4). The value attributed to subimpoundment development reduced the area required for compensation of wetland losses by over 1,400 acres. An additional 4,500 acres of wetlands would still have to be acquired and managed in order to fully compensate for wetland losses. This should serve to rebutt the statement, contained in the Preface to Appendix H, Section 4, that the Service did not adequately consider the value of subimpoundments. We believe the above should be recognized and discussed in the DEIS.

4.0 <u>Affected Environment</u>

4.01, page 20 and 4.02, page 21 - We believe these sections should address the Flat River Reservoir and the South Branch and main stem Pawtuxet Rivers since a reduction in streamflow would obviously affect these areas. Neither section adequately addresses the significance of 570 acres of wetlands (National Wetland Inventory) that would be inundated by the project. While hunting use is noted, it is not mentioned that Big River Management Area is one of the largest areas of State-owned land in Rhode Island and hunters utilize the area to near capacity during the deer hunting season.

5.0 <u>Environmental Effects</u>

5.01.2, page 24, para 1 - The 5,326 acres for State-owned lands surrounding the reservoir site seems out-of-line with other figures quoted in the DEIS and Main Report. We believe that the heading as listed in the report (5.02.2) is incorrect.

5.01.2, page 24, para 2 and page 25, para 1 - The developments discussed in these paragraphs would have a significant secondary impact upon fish and wildlife resources of the area. These secondary impacts have not been adequately addressed in the DEIS.

5.01.5, page 28, para 4 - States that cultural mitigation could be accomplished by creating a "Historical Park" on a portion of the State-owned land surrounding the reservoir site. The extent of such a development and its impact on wildlife habitat has not been addressed.

5.01.6, page 29, para 1 - States that "Access to the reservoir and adjoining lands northeast of I-95 would not be allowed..." Exactly what this means in terms of opportunites lost to mitigate fish and wildlife habitat values has not been adequately addressed.

5.02.2, page 29, para 1 - See detailed comments on Main Report for page 62, paragraph 5.

5.02.2, page 29, para 2 - We do not view the Fish and Wildlife Coordination Act Report appended in Appendix H, Section 4, as a Planning Aid Report.

5.02.2, entire page 30 - The Corps rejects many of the recommendations contained in our Fish and Wildlife Coordination Act Report based on a lack of justification and spells out their rational for such rejection. We offer the following rebuttal:

We stand by our recommendation that the project not be constructed. An area of over 8,000 acres of State-owned lands in proximity to a large population center, utilized for hunting, fishing and other recreational pursuits, is a rare commodity in Rhode Island. Based on our analysis wildlife habitat in general is better than average quality and the 570 acres of wetlands are of significant value to a wide array of wildlife species. The area is not extensively managed for fish and wildlife resources and, in light of the unknown, we projected this to continue over the life of the project. However, this does not foreclose future options for such management if the project is not constructed. We believe that data presented in our Fish and Wildlife Coordination Act Report portray habitat values of sufficient magnitude to warrant the no construction recommendation. In addition, the questionable validity of population projections and the need for water supply as presented in the Main Report reinforces our recommendation that the project not be constructed.

The Corps claims that the Habitat Evaluation Procedures are not an established nor verified procedure. We refer you to the Federal Register, Vol. 46, No. 15, January 23, 1981, where it states on page 7659 (column 1, d) that "The Habitat Evaluation Procedures will be used by the Service as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation..."

The Corps claims that the wildlife benefits associated with acquisition and management of an additional 5,800 acres of land do not outweigh the social and economic impacts of such an acquisition. We do not view the acquisition and management of an additional 5,800 acres of land as a wildlife benefit but rather as mitigation to offset the loss of habitat values that would occur with development of the reservoir. This is consistent with the Service's Mitigation Policy as published in the aforementioned Federal Register. We classified wetlands of the project area in Resource Category 2, which is defined in the Federal Register (page 7657, column 3) as "Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section." The mitigation goal is "No net loss of in-kind habitat value." Uplands of the project area are classified in Resource Category 3 (page 7658, column 1) which is defined as "Habitat to be impacted is of high to medium value for evaluation species and is relatively abundant on a national basis." The mitigation goal is "No net loss of habitat value while minimizing loss of in-kind habitat value." Therefore, we believe that our Coordination Act Report adhears to existing policy and that the recommendation for acquisition and management of an additional 5,800 acres of land to compensate for habitat value losses represents a legitimate effort to protect and preserve fish and wildlife resource values.

The Corps claims that benefits for increasing downstream flows from 6 cfs to 18 cfs have not been justified. We are not claiming benefits for reducing average annual streamflow at the Big River dam site from 60 cfs to 18 cfs, a reduction of 70 percent. Rather, we are trying to establish an aquatic base flow in order to sustain most requisite life cycle needs for the endemic aquatic organisms downstream of the project area. We have recommended that additional studies be conducted of the downstream flow regimen utilizing a flow of 18 cfs from Big River Reservoir (Coordination Act Report, page 15). This information would be used to determine the impact of changed streamflow regimen upon the environmental characteristics of Flat River Reservoir, the South Branch and main stem Pawtuxet.

The Corps claims that fishery studies that have been conducted (Appendix H) are adequate to explain the effects of the impoundment on the fishery resources of the area. We find that these studies do not adequately define standing crop or productivity for either existing or future conditions. The impact of reduced downstream flows has not been adequately addressed. The amount and extent of organic material which would have to be removed from the pool area inorder to establish a cold-water fishery has not been clearly defined. Therefore, we believe that the additional studies recommended in our Fish and Wildlife Coordination Act Report are germane in that they would more clearly define the impacts of Big River Reservoir on the aquatic biota of the area.

5.02.2, page 30, last para - We agree with this paragraph in that mitigation measures for recreation, cultural resources, etc., could have a significant adverse impact upon management opportunities to increase wildlife habitat values. However, we encourage multiple use insofar as it does not unduly interfer with the basic purpose of mitigating wildlife habitat values. Impacts above this level would necessitate additional measures to compensate for wildlife habitat losses due to noncompatible use.

5.02.2, page 31, para 3 - The meaning of this paragraph is not clear and we suggest that it be rephrased to indicate what clearing operations are actually being addressed.

5.02.2, page 31, last para - See detailed comments on DEIS for 3.03 (5), page 19.

5.02.3, page 38, para 4 - States that "No significant effects on downstream (Flat River Reservoir or Pawtuxet River) aquatic biota are expected." What is the basis for this statement? We can find no scientific data in the Main Report, DEIS or Appendices that are revelant enough to support this statement. Therefore, we suggest that additional studies be conducted in order to adequately address this issue as recommended in our Fish and Wildlife Coordination Act Report.

5.02.4, page 35, para 1 - States that "Impacts on avifauna would be minimal ..." We find this statement erroneous in that over 3,000 acres of nesting habitat would be destroyed resulting in a reduction of the total bird population in the area.

5.02.4, page 35, para 3 - States that "The open reservoir would result in a greater environmental diversity..." We cannot logically follow the reasoning that a 3,240-acre body of water inundating wetlands, open field, forestland, shrubland and small streams and ponds would result in a greater environmental diversity.

DETAILED COMMENTS ON SECTION 404 EVALUATION

Evaluation Summary

Page 4, para 1 - Based on National Wetland Inventory data, there are 570 acres of wetlands within the Big River Reservoir site, not 524.

Page 4, para 2 - States that "Proper management of these adjacent regions would significantly ameliorate this impact..." We believe the extent of mitigation should be addressed. See detailed comments on Main Report for page 57, paragraph 1.

Page 4, para 3 - States that the Corps' plan emphasized mitigation of wetland losses. We do not believe that the Corps' plan adequately addresses mitigation of wetland losses. The subimpoundments proposed as mitigation for wetland losses are relatively deep and are not conducive to intensive wetland management. See detailed comments on DEIS for Section 3.03 (5), page 19, last paragraph.

Page 5, para 1 - States that streams and ponds of the project area are of low productivity and unable to sustain a significant fishery. We do not believe that the aquatic biota analysis contained in Appendix H, Section 2, indicates that streams and ponds of the project area are of low productivity. In addition, Flat River Reservoir which would be impacted by the project sustains a significant fishery.

Page 5, last para - States that efforts would be made to minimize undesirable degradation in the downstream area where possible. Since the Corps has rejected our recommendation for further studies in the downstream area to assess the extent of undesirable impacts (DEIS, Section 502.2, page 30), how can the impacts be minimized until the extent of the impacts are known. See our detailed comments on DEIS for Section 502.2, page 30.

<u>Ecological Evaluation</u>

230.4-1 (A-1), page 6 - This section implies that the loss of wetland habitat values will be substantially mitigated through appropriate project modification, i.e., stabilization structures in shallow coves. The degree or extent of such mitigation is not addressed. We contend that only 20 percent of the wetland losses will be mitigated by the Corps' proposed mitigation measures. See our detailed comments on DEIS for Section 3.03 (5), page 19.

<u>Chemical-Biological Interactive Effects</u>

230.4-1 (B-2), page 8 and 9 - This section implies that Big River Reservoir would be similar to Scituate Reservior and support a productive fishery. Yet, it acknowledges that "..no data on aquatic life in Scituate Reservoir is available.." This section also acknowledges that potential impacts on downstream aquatic biota is as yet unpredictable. However, we note no mention for additional studies (as recommended in our Fish and Wildlife Coordination Report) to determine potential standing crop and productivity of Big River Reservoir (relate to Scituate Reservoir) or to determine the potential impacts of a reduced streamflow regimen on downstream aquatic biota. We believe that the need for additional studies should be addressed.

<u>Conclusion</u>, page 20

We do not agree that "Every attempt has been made to provide for ... reasonable minimization and/or mitigation for adverse environmental impacts." The recommended studies contained in our Fish and Wildlife Coordination Act Report to more clearly define many of the potential adverse impacts have been rejected by the Corps. Only 20 percent of the wetland habitat value losses would be mitigated if the Corps' proposed mitigation plan is adopted.

Therefore, based on all of the above, we stand by the recommendations contained in our Fish and Wildlife Coordination Act Report (Appendix H, Section 4) and reiterate that our main recommendation is that the project not be constructed.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

Advisory Council On Historic Preservation

1522 K Street, NW
Washington, DC 20005

March 18, 1981

Mr. Joseph L. Ignazio
Chief, Planning Division
U.S. Army Corps of Engineers
422 Trapelo Road
Waltham, MA 02254

Dear Mr. Ignazio:

We have received your request for comments (you reference NEDPL-BU) on the draft environmental impact statement for the proposed construction of the Big River Reservoir in Coventry and West Greenwich, Rhode Island, pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969. The Council has determined that your draft environmental statement entions properties of cultural and/or historical significance, but we need more information on the effects of the undertaking on these resources. Please furnish documentation that you have fulfilled the requirements set forth in 36 CFR Sec. 800.4(b) of the Council's regulations "Protection of Historic and Cultural Properties" (enclosed). Specifically, the study conducted in 1978 by the Big River Cultural Resource Reconnaissance was not included in your draft interim report of July 1980 (Appendix I). This study mentions 12 possibly significant historic features within the impoundment area. A determination of these properties' eligibility for the National Register and an analysis of steps to mitigate any adverse effects of construction or inundation of these properties must be fully addressed in your report.

Please remember that compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470f, as amended, 90 Stat. 1320), the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800), and Executive Order 11593 (May 13, 1971) are independent requirements of law that must be fulfilled unless it has been determined in accordance with 36 CFR Section 800.4(a) of the Council's regulations that no properties that are included in or that would be eligible for inclusion in the National Register of Historic Places are located within the area of the undertaking's potential environmental impact and this finding is clearly set forth in the draft environmental impact statement. Accordingly, you should coordinate NEPA compliance with these separate responsibilities as provided for in 36 CFR Section 800.9 of the Council's regulations and the final environmental impact statement should contain the comments of the Council obtained pursuant to 36 Sec. 800.6 or 800.8 of the Council's regulations.

Should you have any questions or need assistance please call Joseph Hough at FTS 254-3495.

Sincerely,

Jordan E. Tannenbaum

Jordan E. Tannenbaum
Chief, Eastern Division of
Project Review

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

April 3, 1981

Colonel C.E. Edgar III
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02154

RE: D-COE-B36022-RI

Dear Colonel Edgar:

In accordance with Section 309 of the Clean Air Act, the National Environmental Policy Act and Section 404 of the Clean Water Act, we have completed our review of the Draft Environmental Impact Statement (DEIS) for the proposed Big River Reservoir Project in Coventry and West Greenwich, Rhode Island.

According to the DEIS, this project has as its goals water supply, flood protection and recreation resources in the study areas. The plan proposes the construction of the Big River Dam to be located at the confluence of Big River and the Flat River Reservoir in Coventry, Rhode Island. The approximately 70-foot high dam would have a top elevation of 312 feet msl, 9 feet above the maximum regulated pool level (spillway crest) at elevation 303 feet msl. At spillway crest, the reservoir would have a total lake area of about 3,400 acres and a total regulated storage capacity of 95,400 acre-feet. The upper 3 feet of storage between elevations 300 and 303 feet msl would be reserved for flood control storage, providing 9,500 acre-feet of storage equivalent to 6 inches of runoff from the 29.7-square mile watershed. The 73,600 acre-feet of storage between elevations 300 and 267 feet msl would be useable water supply storage and the remaining 12,300 acre-feet of storage below elevation 267 feet msl would be for conservation storage. The proposed plan also calls for the development of groundwater resources for the Bristol County area, and facilities to deliver water from the Providence water system to meet future demands of the Bristol County Water Company system.

From the standpoint of EPA's areas of jurisdiction and expertise, we believe the project could have significant adverse impacts. In addition, we believe the DEIS does not provide sufficient information on:

- impacts on the water supply of highway runoff, chemical spills, and secondary development, and methods to be used to mitigate these impacts;

- the impact of reduced streamflows on the water quality of the Flat River Reservoir and the South Branch of the Pawtuxet River;
- mitigation measures to minimize adverse impact on wildlife and wildlife habitat (while several conceptual measures are described none are detailed or endorsed);
- potential water quality impacts related to multiple-use and recreational activities;
- impacts associated with construction of the pipeline across Narragansett Bay;
- impacts resulting from development of groundwater resources in Bristol County, Rhode Island;
- actual flood protection benefits associated with Big River Reservoir.

Our detailed comments follow.

Water Quality

In our view, two critical issues associated with this project are the threat that I-95 will pose to the quality of the drinking water, and the impact of reduced flows on the already degraded quality of the lower stretch of the Pawtuxet River.

1. As you know, our concerns about the effect of locating an interstate highway across a surface drinking water supply were developed in detail in our position on the Interstate 84 project, proposed to cross Scituate Reservoir. We believe Interstate 95 could similarly degrade Big River Reservoir through spills of hazardous materials, road runoff, and development in connection with the highway and its interchanges. Clearly, these impacts could never be completely mitigated or prevented, but we believe it should be of highest priority to apply the most stringent mitigation measures. In this regard, the importance of a comprehensive watershed management plan cannot be overemphasized.

The EIS does not contain sufficient information on the impacts of I-95 and other roads in the watershed, and on potential mitigation measures. Based on the maps provided, it is difficult to identify the roads which will remain within the watershed after the proposed reservoir is built; this pertains both to roads which will cross the reservoir (i.e. Interstate 95 and Nooseneck Hill Road/Route 3) and to those which will lie within the area draining into it. In addition to an identification of all roads expected to remain, a detailed discussion of the mitigation measures planned to prevent both highway deicing compound and toxic materials runoff from entering the reservoir should be presented in the Final EIS.

We request the opportunity to work with you and the State to develop highway mitigation measures. These might include closed drainage systems throughout the watershed, barriers to prevent vehicles from entering the water supply, and other measures.

2. The proposed Big River Reservoir will have a negative impact on the water quality on the Pawtuxet River. This negative impact will occur not only at low flow but during all flow regimes of the Pawtuxet River. The lower stretch of the Pawtuxet River is currently in nuisance condition and much of the remainder of the River is not meeting its proposed Class C classification. The major sources of pollution on the River are the Cranston, Warwick, West Warwick, Ciba-Geigy and American Hoechst wastewater treatment plants. Over the next several years, more than $58 million in Federal and State grants will be needed to bring the Pawtuxet River up to the proposed Class C classification. The impact on downstream water quality was not addressed in the interim Report of the Big River Reservoir Project. The EIS should assess the project impact for all flow regimes on downstream water quality, wetlands, potential fisheries, wildlife, recreational resources, industrial riparian rights (i.e. American Hoechst) and other aquatic resources. This evaluation should take into consideration the possibility that due to budget cutbacks, Cranston, Warwick and West Warwick might not be able to provide advanced treatment. Also, the EIS should note that the water flow could affect seven hydroelectric projects on the South Branch of the Pawtuxet River which have initiated permit processing procedures with the Federal Energy Regulatory Commission. Finally, the EIS should identify alternative minimum flow releases and assess how they would affect the project and how they would minimize downstream water quality degradation.

3. According to the EIS, water quality analyses have indicated the presence of mercury in the waterways which will feed the proposed reservoir. We believe this finding warrants an investigation into the probable source of the mercury and a prediction of levels expected in the future.

4. The report indicates that swimming will be prohibited in the Big River Reservoir. In addition, the types of recreational activities which may be deemed permissible are discussed to a limited extent. We believe it might be advantageous to utilize existing water quality information from other reservoir systems where similar recreational activities are permitted (e.g., the New York City system). Perhaps the experience from other reservoir systems can be used as the basis upon which the appropriate level of permissible recreation can be determined.

<u>Projection of Water Demand</u>

It appears that the per capita water supply consumption rates provided in the report represent equivalent rates based on an averaging of domestic, commercial and industrial demands. Utilizing this projected damand rate, the future water supply demand was calculated based on population projections. Although water conservation measures were incorporated into the projected demand estimates, it appears that reductions from industrial recycling were not.

The EIS acknowledges that there is some dispute as to which population projection most closely represents future growth patterns. In our view, many of the assumptions that the Corps used in predicting future water demand that are found in Appendix A are invalid especially those relating to population projections and future industrial water use:

1. The Corps has used Rhode Island SPP 1975 population projections which were basically in agreement with the 1972 CBERS projections. Since that time the Bureau of Economic Analysis (BEA) of the Department of Commerce (in 1977) and RISPP (in 1979) have revised downward the population with the 1980 census. EPA's Regional Administrator approved the RISPP 1979 population projections and they are the projections currently used for all of our construction grants, water quality planning and air quality planning. In determining future water demands, we believe the Corps should use RISPP 1979 projections.

2. The Corps, on plate 7 of the Main Report, estimates that per capita consumption will increase by 60% between 1975 and 2020 even if strong conservation practices are adopted in Rhode Island. We question the validity of this estimate, and believe justification of the projected increase in per capita consumption should be provided in the EIS.

3. The Corps notes that the demand for future industrial water use was based on a theoretical model utilizing a growth factor based on economic and technological parameters. We question the use of this model for Rhode Island's situation. Each of the communities in the Providence and Bristol water supply district have NPDES requirements to develop a pretreatment program for their industries. A recent study for the metal plating industries in Rhode Island has estimated that they could reduce water use by 70% if pretreatment requirements are placed on them. Pretreatment requirements on other industries could have a similar benefit for decreased water use. This appears to be the trend. According to the U.S Department of Commerce and the Water Resources Council's second national assessment, industrial withdrawals are expected to drop nationally from 50.8 billion gallons a day to 19.4 bgd by the year 2000. This information should be taken into account in calculating water demand.

Flood Protection Benefits

As the watershed controlled by Big River only represents about 12 percent of the total Pawtuxet River watershed, the resulting downstream flood reductions on the main stem Pawtuxet River would appear to be quite limited. The flood benefits should be more clearly stated in the Final EIS.

The report claims benefits for flood damage reduction to three municipal treatment plants along the Pawtuxet River. The EIS should note that all three treatment plants are presently undertaking protection measures to mitigate flood impacts. In addition, if the proposed Warwick local protection project is built, involving the construction of dikes and walls along the Pawtuxet River, then some of the flood control benefit claimed by the Big River Reservoir would be negated.

Mitigation and Management Plans

We believe mitigation is a very important element of this project. Page 29 of the DEIS states that "refined specifications for implementation of the plans [fish and wildlife management plans] would be developed should the project be authorized for further study". We believe these mitigation measures to minimize the adverse impacts of the project should be identified in the EIS, described in detail, associated with responsible agencies or parties that can implement and manage the mitigation plans, and finally be connected with sources of initial and continual funding resources. Mitigation costs for both highway impacts and fish and wildlife impacts are likely to be very substantial, and should be included in the benefit/cost analysis.

Finally, we wish to comment on the concerns raised at your public hearing regarding the potential impact on the Big River Reservoir of the Picillo hazardous waste site in Coventry. We have investigated the matter and have determined that Picillo waste site is not within the watershed of the Reservoir. Examinations to date at the Picillo site do not indicate an eastward component of groundwater movement, nor does it appear at this time that contamination exists in or is migrating toward the Quidnick Reservoir. Additional bedrock wells are planned to be installed in the immediate future to confirm this premise. We will keep you apprised of the situation as more information becomes available.

Based on the concerns described above, we have rated this project ER-2 in accordance with our national rating system (see enclosed explanation).

We appreciate the opportunity to comment on this project. Please contact Don Cooke or Betsy Higgins of my staff at 617/223-4635 at your earliest convenience so that we may assist you in the development of highway mitigation measures, and in any other way you feel is appropriate.

Sincerely,

Richard R. Keppler

Richard R. Keppler, Acting Director
Environmental Impact Office

Enclosure

cc: Victor Bell, RI DEM
Wiley Archer, Providence Water Department

EXPLANATION OF EPA RATING

Environmental Impact of the Action

LO -- Lack of Objections

EPA has no objections to the proposed action as described in the draft environmental impact statement; or suggests only minor changes in the proposed action.

ER -- Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating federal agency to reassess these aspects.

EU -- Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1 -- Adequate

The draft environmental impact statement sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2 -- Insufficient Information

EPA believes that the draft environmental impact statement does not contain sufficient information to assess fully, the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft environmental impact statement.

Category 3 -- Inadequate

EPA believes that the draft environmental impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

If a draft environmental impact statement is assigned a Category 3, no rating will be made of the project or action; since a basis does not generally exist on which to make such a determination.

U.S. Department of Labor

Employment and Training Administration
John F. Kennedy Federal Building
Boston, Massachusetts 02203

Reply to the Attention of: 1TGBF

MAR 2 5 1981

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Sir:

This office can offer no input for the proposed Big River Reservoir Project, Coventry and West Greenwich, Rhode Island.

It is appreciated, however, that the Employment & Training Administration is being kept informed of the proposed projects being undertaken by the Corps of Enginners.

Sincerely,

Timothy M. Barnicle

Timothy M. Barnicle
Regional Administrator
for Employment & Training

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Administration
STATEWIDE PLANNING PROGRAM
265 Melrose Street
Providence, Rhode Island 02907

March 25, 1981

C.E. Edgar III
Colonel, Corps of Engineers
Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Col. Edgar:

This office, in its capacity of clearinghouse designate under OMB Circular No. A-95, Part II has reviewed the Big River Reservoir Draft Interim Report.

The Technical Committee of the Statewide Planning Program was presented the staff findings as a result of the review at its meeting of March 6, 1981. The Technical Committee recommendation is as follows:

1. The tentative selection of Plan C (pp. 64-65) appears to be the logical action based on the material presented in this study. Plan C is generally consistent with the applicable elements of the State Guide Plan. In carrying this study beyond the interim report, two subalternatives should be evaluated in conjunction with Plan C: Recreation Options II and III.

2. Aquidneck Island and North Kingstown should be added to the study area. Use of the Big River Reservoir to get future water needs for these areas may be the best solution for this problem. This addition might also change the timing recommendation for construction of the Reservoir. This variation is reinforced by the discussion of the current State Comprehensive Water Resources Development Plan (prepared in 1967) on page 37. (not attached)

3. The discussion of the 1975 and 1979 population projection by RISPP on pp. 16-19 presents a dilemma which cannot be fully resolved at this time. The study utilizes the 1975 projections primarily because these are closer to the OBERS Series E projection. However, the OBERS Series E projection was made in 1972, prior to Navy base closings, and appears to be much too high. On the other hand, the RISPP 1979 projection for 1980 is below the census count for the same year.

The importance of this issue is demonstrated on page 67 of Volume I, the Main Report. The study points out that the 1979 projections, combined with demand modification techniques, would move the date to which Big River Reservoir's need for water supply purposes from 1995 to 2025. The report also points out that this would not delay the need for flood damage reduction.

If possible, a conclusion as to "the best" population projection to use should be deferred until a new projection can be made incorporating the results of the 1980 census and other information concerning recent changes in water demand conditions, such as the contamination of groundwater supplies by chemicals, and increased industrial activity. In the interim, the 1975 and 1979 RISPP projections should be considered to establish a range of probable future projections for each target year.

4. The report develops three complimentary needs to be met by the plan eventually selected. These are water supply, flood control, and recreation. The discussion of flood damage reduction on pages 23-24 emphasizes necessity to incorporate flood protection in the design and construction of the Big River Reservoir. There are no other feasible and acceptable methods for reduction of downstream flooding on the main stem of the Pawtuxet River. Incorporation of flood control in the Big River Reservoir project is reinforced by the fact that this aspect of the project would have a higher benefit-cost ratio than the water supply or recreation components (p. 69).

5. The study finds, on page 34, that development of a reservoir on the Wood River is not justified by the yield available and the resulting environmental impacts. This is an important conclusion of this study which should be reflected in all related planning.

6. The report discusses the possibility of meeting needs of Foster and Glocester by development of local groundwater sources (p. 35). State and local plans and land use controls should attempt to avoid the need for public water systems in these two communities, except, possibly, for Chepachet.

7. The conclusion that pricing policy changes would have little effect on water use because of present low prices (p. 35) requires further consideration. A substantial price increase of a low-base price might be effective in modifying usage.

8. The report makes reference to the findings of the "208" project concerning the effect of the Big River Reservoir on downstream water quality and users. The specific minimum release recommendations of the "208" study for maintenance of low flows for both the Big River and Flat River watersheds were transmitted to the

Corps of Engineers on July 12. The current study should state in Volume I whether or not these recommendations would be followed.

9. The Corps of Engineers should investigate downstream hydropower because the proposed hydroprojects on the downstream portion of the main stem of the Pawtuxet may be affected by this project.

10. Recreational use.

The 1976 SCORP commits the state to a policy of "Making multiple use of water bodies and considering the multiple use potential of all water resource development projects for recreation and other purposes wherever possible." Part 5-4-3 of the SCORP provides information concerning recreational use of reservoirs in Rhode Island and nationwide. It recommends that an assessment of the water quality impact of recreational uses be accomplished.

The Corps of Engineers should do a more extensive assessment of the impacts on water quality be done for the different recreation options to determine how to limit adverse impacts in the quality of the reservoir water. Secondary implications of opening the area for recreation, such as the need for added enforcement and the increased possibility of others seeking to illegally dump, cut wood, etc., should be also assessed. The final decision about recreational use of the Big River Reservoir area will be decided by the Rhode Island General Assembly who will need as much information as possible to try to carry out the policy stated in the 1976 SCORP concerning the multiple use of reservoirs (p. 02-01.2).

Attachment #1 is a copy of a comment from the Coastal Resources Management Council. Attachments #2 and 3 are information for the Corps of Engineers concerning Recreation (2) and Air Pollution (3) is also attached.

We thank you for the opportunity to review this proposal.

Yours very truly,

Rene' J. Fontaine
A-95 Clearinghouse
Coordinator

RJF/KFR/sjc

Attachments (3)

Reference File EIS-81-03

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

INTER-OFFICE MEMO Attachment #1

TO : Daniel W. Varin, Chief DATE: February 12, 1981

DEPT : Statewide Planning Program

FROM : John A. Lyons, Chairman JAL.

DEPT : Coastal Resources Management Council

SUBJECT: EIS - 81-03 Big River Reservoir Feasibility Study

The Coastal Resources Management Council endorses the proposed Big River Reservoir development project. The present drought conditions and localized water shortages are evidence of the need for additional water supplies to serve the state. However, the proposed Big River Reservor will not begin production for an estimated 8 to 10 years. This time lag, when combined with the present supply situation, lends strong support to water conservation programs. Per capita water consumption apparently is on the increase, and such conservation programs as are now underway will hopefully create a measureable decrease in per capita water use.

The Coastal Resources Management Council urges that conservation of water resources be given the highest resource management priority over the next decade and beyond, not only because water is critical to the state's economy and life style, but because the development of additional sources is costly and can compete for scarce shoreline land and other coastal resources, as in the instances of aqueducts, desalination plants, and new or expanded sewer treatment plants.

The Coastal Resources Management Council is aware of the plan to construct an aqueduct from Comminicut Point in Warwick to Nyatt Point in Barrington to serve Bristol County and perhaps even Aquidneck Island. This project will require a CRMC permit, and to expedite the review process, early project level coordination with the Council and its staff is requested.

JAL/LRW/lmc

FEB

Attachment #2

Memorandum

TO: Rene Fontaine, A-95 Coordinator

FROM: George Johnson, Senior Planner GJ

SUBJ.: Review of Draft Interim Report: Big River Reservoir Project

At Dan Varin's request, I have looked over the portions of the subject report which deal with recreational aspects of the Big River proposal and offer the following comments for consideration by the Technical Committee in formulating our response to the Corps:

1. Main Report: p. 24 Recreation

Comment: Paragraph 2 under this section states that projections for the years 1995 and 2020 "show that the most significant needs on a statewide basis are for boating, camping, golfing, hunting, picnicking and swimming facilities." (emphasis added) This statement is largely consistent with the findings of the 1976 SCORP, however the following considerations and qualifications should be noted:

a) the 1976 SCORP projected demand only to the year 2000. Since details of the model used to extend the SCORP data to the year 2020 are not provided, we make no assessment of the validity of this expansion.

b) The 1976 SCORP's projections of statewide deficits in the year 2000 indicate the greatest needs (in order of magnitude) will be for: fresh water swimming; picnicking; tennis; boating; and camping. Of these, the forecasted deficits for fresh water swimming and picnicking are the most severe in terms of unmet design day demand. Both activities show deficits in excess of 20,000 activity occasions on the year 2000 design day.

c) Our projections for golfing indicate only a relatively modest facility shortage by the year 2000. A capacity deficit of approximately 1,100 activity occasions is forecasted for the year 2000 design day. (approximately 9% of total design day demand.)

d) The 1976 SCORP did not estimate supply capacities for several activities including hunting and sightseeing, thus precluding the forecasting of future supply/demand relationships. It should be noted however that total year 2000 demand for hunting is projected to be relatively modest in comparison to most other activities (forecast to be the next to least popular activity with a design day estimate of 5,030). In-state demand for sightseeing, on the other hand is projected to be quite significant (42,890) ranking 5th (out of 18) activities.

e) The 1976 SCORP did not measure or project demand for recreational off-road vehicle (ORV) usage. However, the most recent nationwide demand survey found this activity to be fairly popular nationally, with 20 percent of the population participating on 5 or more occasions per

#2 cont

year. (It is not known if this figure is representative for R.I.). However quite intensive recreational ORV usage is currently occurring in portions of the Big River site which have characteristics deemed by enthusiasts to be quite rare in southern New England. The displacement of this demand by the reservoir development has the potential for creating conditions of overuse and multiuse conflicts at other areas proximate to the site (particularly within the Arcadia Management Area).

2. Appendix H, Part I, E.

Given the fact that the Interim Draft Report recommends incorporation of recreational activities within the watershed and is in this respect a radical departure from previous thinking in the state concerning the compatibility of recreational usage and water supply, a review of the SCORP's position on recreation and reservoirs should be incororated into this discussion of agency policy. The SCORP commits the State to a policy of "Making multiple use of water bodies and considering the multiple use potential of all water resource development projects for recreation and other purposes wherever possible." While this policy is, quite appropriately, constrained by parallel goals and policies for preservation of water quality, it nevertheless represents a recognition that simultaneous achievement of recreation and water quality objectives with regard to a specific water body or development project can be both feasible and desirable from the standpoint of resource use efficiency. Part 5-4-3 of the SCORP provides extensive information on agency policy and experience concerning recreational usage of reservoirs both in Rhode Island and nationwide and includes a specific recommendation that an empirical assessment of the water quality impacts of recreational usage be accomplished.

3. Main Report p. 47 - 48

Recreation Options and Conclusions - Option III, representing the maximum development plan for recreation, is most desirable from the sole standpoint of expansion of recreational oportunities. The plan provides for replacement of most opportunities lost through development of the reservoir and includes additional increments of supply capacity for several activities needed to met forecasted statewide deficits. Because this option is most extensive and because of its inclusion of water contact activities, it also raises the greatest concern over the possibility of adverse water quality impacts.

As Option III is carried forth in further development of the water resources management plan, a goal of providing the maximum recreational experience while incorporating appropriate water quality safeguards should be adhered to. Specifically, as the Option is advanced beyond the conceptional stage, the following modifications to it should be considered:

a) restriction on the use of gasoline-powered boats in the primary and secondary reservoirs;

b) careful siting and design of trails, separation of motorized and non-motorized trail users and establishment of an on-going trails monitoring and maintenance program to minimize erosion and sedimentation problems;

d) cont.

c) basing the siting and design of the sanitary facilities on a careful analysis of soils, water table, groundwater flow and other site-specific conditions;

d) determination of a (numerical) maximum recreational use density for various facilities or portions of the watershed;

e) enforcement of these density levels via restricted access points and a permit and registration system which identifies who is in the watershed and for what purpose;

f) institution of a user fee schedule in connection with the permit system with proceeds going for enforcement and maintenance;

g) development and adoption of specific rules and regulations for recreational activities designed to minimize potential conflicts with water quality objectives;

h) inclusion of a visitors' center oriented to meeting demands for the sightseeing activity. The center could provide information and education on water quality, supply and conservation in general and the Big River Project in particular.

With inclusion of safeguards and planning considerations such as those presented above, a modified version of Option III should be capable of optimizing both recreational and water quality objectives of the Big River Project.

ATTACHMENT #3

Air Pollution

Page 9 in the Draft Main Report should be more specific in discussing different pollutants. More recent air quality sampling data is available (1979) from the R.I. Division of Air and Hazardous Materials.

For CO and TSP, only Providence is non-attainment (in 1979, CO standard was violated on nine days.)

For ozone, the entire state is non-attainment (in 1979, ozone was violated on no days in Providence and nine days in West Greenwich).

See attached tables.

TABLE 691-3(1)

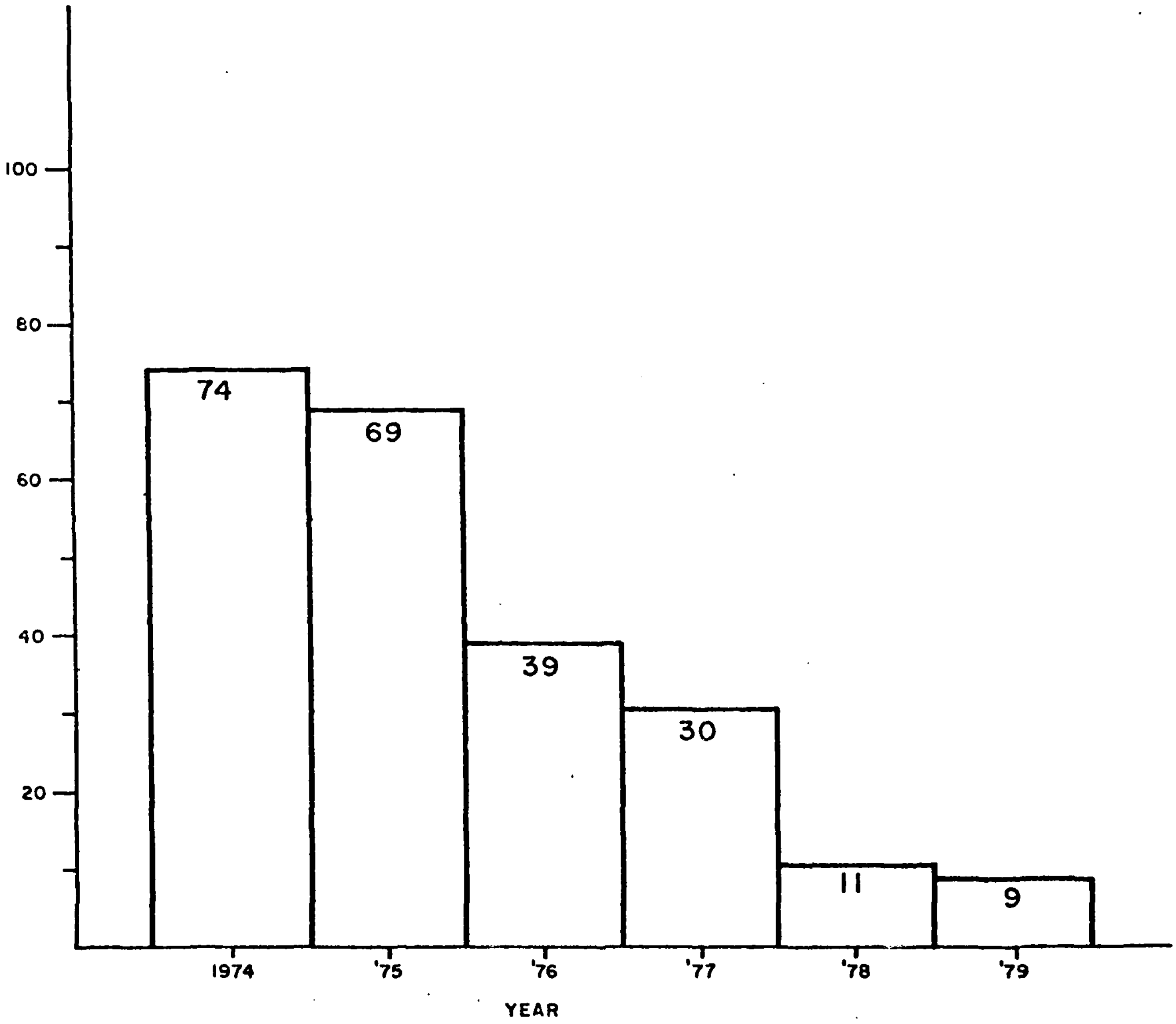
ATTAINMENT STATUS DESIGNATIONS FOR STATE OF RHODE ISLAND

Pollutant and Designated Area	Does Not Meet Primary Stds	Does Not Meet Secondary Stds	Cannot Be Classified	Cannot Be Classified or Better Than National Stds	Better Than National Stds
TOTAL SUSPENDED PARTICULATES					
Providence	x				
East Providence, Cranston, Warwick, North Providence, Pawtucket, and Central Falls			x		
Remainder of State					x
SULFUR DIOXIDE					
Statewide					x
CARBON MONOXIDE					
Providence	x				
Remainder of State				x	
OZONE					
Statewide	x				
NITROGEN DIOXIDE					
Statewide				x	

SOURCE: R.I. Department of Environmental Management

11.3 cont

CARBON MONOXIDE
NO. OF DAYS WITH VIOLATIONS OF THE 8-HR NAAQS
(DORRANCE STREET)

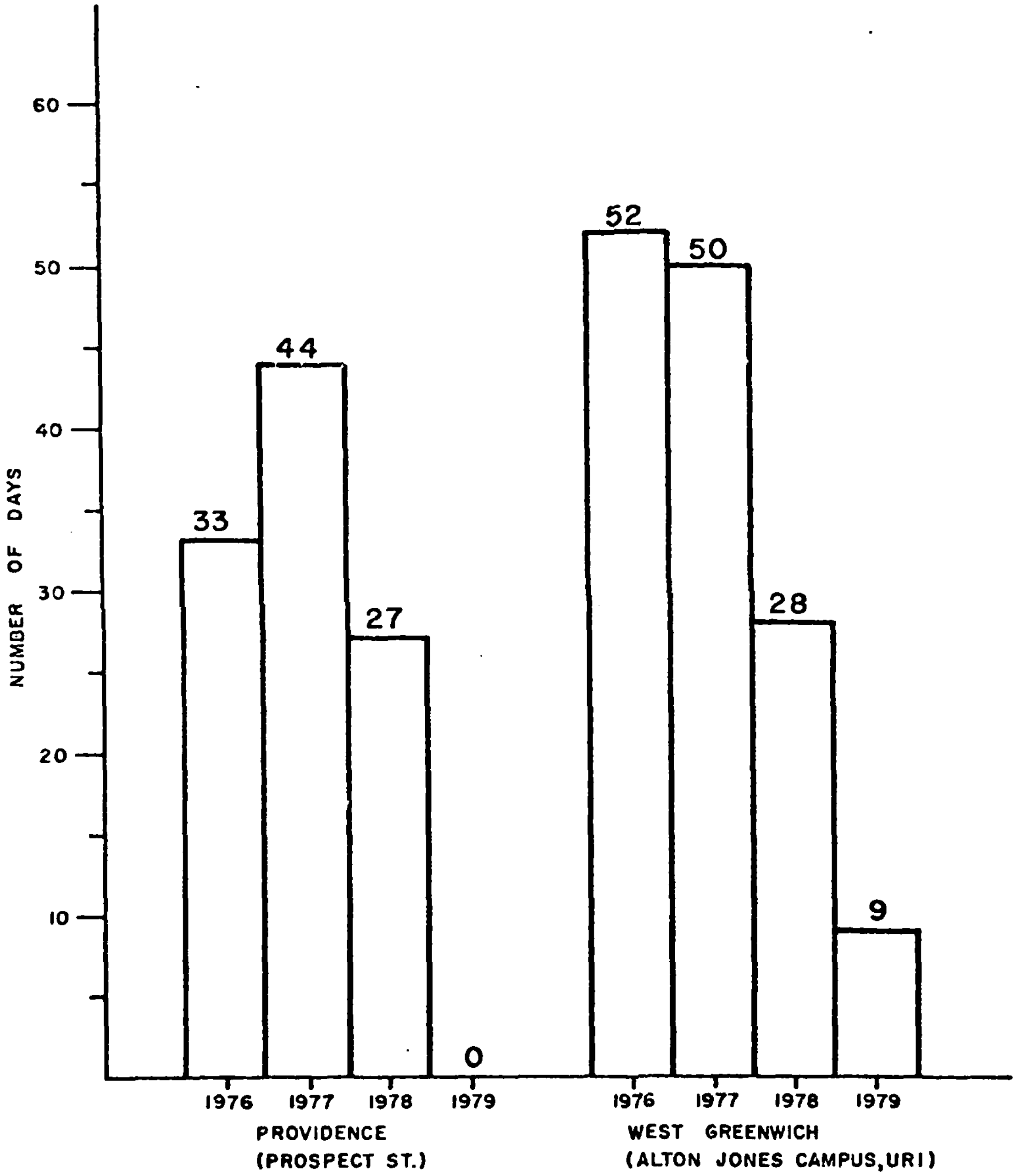


SOURCE: R.I. Department of Environmental Management

FIGURE 691-3(4)

PHOTOCHEMICAL OXIDANTS (O_3)

NUMBER OF DAYS WITH VIOLATION OF ONE HOUR NAAQS, 160ug/m^3*



*The new standard of 235 ug/m^3 is used in 1979

SOURCE: R.I. Department of Environmental Management

OFFICE OF STATE PLANNING

RHODE ISLAND STATEWIDE PLANNING PROGRAM

265 Melrose Street
Providence, Rhode Island 02907
(401) 277-2656

MEMORANDUM

To: Division Engineer, U.S. Army Corps of Engineers

Subject: Comments on Draft Interim Report--Big River Reservoir Project

Date: April 3, 1981

1. Choice of Plans and Options.

The Report's findings support the tentative selection of Plan C (pp. 64-65). Plan C is generally consistent with applicable elements of the State Guide Plan. We would urge, however, that the Corps consider amending Plan C as follows:

A. Add Aquidneck Island to the study area. Big River Reservoir may be the best solution for Aquidneck Island's water supply problems. Addition of Aquidneck Island to the study area may warrant greater priority for the project than our analysis of the Report in its current form indicates below.

B. Change the recreation option incorporated in Plan C from Option III to Option II. The latter would provide recreation opportunities roughly equivalent to those currently available. Prohibition of off-road vehicles, which is entirely consistent with prevalent attitudes toward recreational use of drinking-water reservoir watershed areas, may cause undesirable impacts on nearby private lands and on the Arcadia Management Area. We suggest that consideration of these impacts be weighed against the possibility of allowing off-road vehicle use in watershed areas where water quality impacts of such vehicles can be mitigated or prevented.

2. Population Projections - Water Needs of Study Area.

We believe that the Report's greatest shortcoming lies in its analysis, or lack of analysis, concerning the population growth and the water needs of the study area. The Corps' efforts in this regard are the subject of some fairly exhaustive regulation, which contemplates a more thorough analysis than that provided in the Interim Report. Part of this regulation, which controls the Corps' evaluation of water needs, stipulates:

> Considerable attention must be given to examining the relationship of the traditional water resources 'needs' categories to the overall study effort. It is mandatory to update or confirm the authenticity of the 'needs' in light of differing public perceptions and interim public actions that may have been undertaken. 33 CFR 292.6

In our judgment, the Report fails to update or confirm satisfactorily the findings of the 1967 Metcalf and Eddy Report, which findings rely on demographic and water-supply data from the mid 1960's and earlier. After acknowledging the fallibility and the proven inaccuracy of the OBERS Series E population projections and the 1975 projections issued by this Office, the Report goes on to justify their use by reason of convenience. It should be noted that the Corps, prior to completing and issuing the Report, had available to it this Office's 1979 population projections, which have proved remarkably accurate with respect to the 1980 census. By contrast, both the OBERS Series E projections, which were made in 1972 and do not account for the Navy base closure, and the 1975 projections have proved to be inaccurate overestimations of population growth in Rhode Island. While the Report recognizes the disparity between these projections, it does account for or attempt to incorporate the more recent and reliable projections in its estimation of future conditions.

We recommend that the Corps update its demographic data before drafting its final specification of future conditions. Use of more reliable demographic data may serve to clarify the issue whether and when the Big River project is needed. The Corps' impact statement preparation regulation suggests the use of more timely and accurate data when the OBERS data are insufficient:

> Specification of future conditions should reflect projections currently used by federal, state and local planning agencies. OBERS Series E Prime projections will be used as a basis for most studies. In certain instances, because of conditions unique to the study area or the limited size of the study area, OBERS may not be totally satisfactory... When the study area is very small in size, other projections will be neede d to provide sufficiently detailed projections of those conditions which affect the definitions of planning objectives over time. 33 CFR 292.9(b).

Such updating is necessary to insure that the enormous capital investment and environmental costs the project involves are warranted. The OBERS Series E projections and the 1975 projections have little more validity today than do the grossly inaccurate predictions for population growth and water need which spawned and have been used to justify the original Metcalf and Eddy 1967 Report and Water Supply Plan.

3. Flood Reduction.

We concur with the Report's emphasis on the necessity of incorporating flood protection in the design and construction of the proposed reservoir. There are no other feasible and environmentally acceptable methods to reduce downstream flooding on the main stem of the Pawtuxet River. Furthermore, the flood-control aspect of the proposed reservoir would appear to have a higher benefit-cost ratio than the water supply or recreation components.

4. Wood River Reservoir.

The Report finds (p. 34) that development of a reservoir on the Wood River is not justified by the potential yield and would entail undesirable environmental and recreational impacts. We support this conclusion and recommend that no additional state or federal funds be devoted to planning for the construction of a reservoir on the Wood River.

5. Groundwater Development in Foster-Glocester.

If the Corps wishes to maintain the option of developing local groundwater resources to meet the drinking water needs of Foster-Glocester, state action should be taken to encourage or effect the implementation of land use controls to maintain groundwater quality. Commensurately, state and local planning efforts should guide development so as to maintain groundwater quality in the Foster-Glocester area.

6. Water Demand Modification.

The Report concludes (p. 35) that price changes would have little effect on current water use in the study area because of current low prices. This conclusion appears to be at variance with basic business logic and common sense and deserves reconsideration. Comments from this office regarding a similar instance of illogic in the draft version of the 1979 PNB Study are also relevant here:

> The discussion of consumption-price sensitivity could be improved on several accounts. Given the importance of this topic and the large quantity of research material available, the superficial discussion of the professional literature is disappointing. Although the bibliography contains a number of citations which appear relevant to a discussion of demand elasticity, only two studies were referenced in the text and neither of these were given more than cursory analysis.
>
> The final rationale presented for diminishing the potential for consumption reduction through pricing policy changes is that, given the current low average daily cost for water use within the study area ($0.16) the typical customer would not significantly alter present water use habits even if the cost doubled or tripled. While it may be true that a three-fold increase in the cost of water computed on a daily basis could be perceived as of insufficient consequence to motivate conservation; when realistically viewed in the context of the annual billing cycle, the corresponding rise from $58.40 to $175.20 may be a sufficient inducement.
>
> In consideration of the above points we feel that a reassessment of the consumption - price sensitivity assumptions applied in the study may be in order.

The PNB Study failed to resolve the price elasticity issue. We request that further consideration be given to this important, nonstructural measure before the Report is issued in final form.

7. Maintenance of Low Flows.

We would like clarification regarding the Corps' intent to implement the 208 Study's specific minimum release requirements to maintain low flow levels for the Big River and Flat River Watersheds.

Daniel W. Varin
Chief

Charles F. Gauvin
Institutional Analysist

DWV:CFG:cac

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Environmental Management
OFFICE OF THE DIRECTOR
83 Park Street
Providence, R. I. 02903

April 1, 1981

Colonel C.E. Edgar, III
Division Engineer
New England Division
US Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Re: Interim Report - Big River Reservoir Project

Dear Colonel Edgar:

The Department of Environmental Management has completed review of the above referenced report. The Department's comments relate mainly to the scope and size of the study area, the need assessment and its relationship to the timing of the Project, support for the limited multiple-use concept and concern over the project impact to water quality, and terrestrial and aquatic resources.

In reviewing the interim report it became readily apparent that the updated report does not reflect comments previously directed to the Corps in reference to the "preliminary draft" report. Comments expressed in our letter of 7/10/79 remain valid, and at the risk of being redundant, the enclosed remarks encompass or reiterate those concerns.

While the Department basically supports the development of the Big River Reservoir as a future water supply, the interim report leaves numerous unanswered questions as to the future demand for water in the study area, and the potential for water conservation efforts to reduce these needs.

In addition, the effects of reservoir development on water quality and fish and wildlife has not been satisfactorily addressed. Further study is recommended to determine adverse effects and to formulate acceptable mitigation measures, as detailed in the attached comments.

Thank you for this opportunity to contribute to the environmental review process. The Department has extensive field experience in the Big River area and would like to offer our assistance in setting up field studies to augment existing baseline information and evaluate impacts to terrestrial and aquatic ecosystems. The Department would also like to request that formulation of a comprehensive mitigation program be conducted in close cooperation with DEM staff.

If you have any questions please call Victor Bell at 277-2777.

Sincerely yours,

W. Edward Wood
Director

LJ:fh

RI Department of Environmental Management

Interim Report - Big River Reservoir Project

Scope of Work

An economic feasibility study for the construction of a water supply transmission line to Bristol County and Aquidneck Island from supplies maintained by the Providence Water Supply Board was recently completed as a possible solution to meeting the area's projected water needs. Construction of a water supply transmission line to Bristol County with development of the Big River Reservoir considerably increases the feasibility of extending water mains to Aquidneck Island to meet the existing water supply system. Given the possibility that Aquidneck Island may eventually be included in the service area of the Scituate and Big River Reservoirs, the scope of the EIS should be expanded to include Aquidneck Island.

Need Assessment

Accurate estimation of future water demand is essential not only in determining the need for the Big River Reservoir but also in establishing a time frame for use of the Big River Reservoir water supply and in measuring the capacity of the Reservoir to satisfy future water needs. The projected need for water in the study area will therefore be a major factor in assessment of the time available to fill the reservoir, in calculation of optimum release rates, and in planning for development of additional water supplies. Specific concerns regarding the adequacy of the need assessment for the project include the following:

A) The reasonably attainable reduction in water use through water demand modification was determined to be 10% by the year 2030. This figure was derived without taking into account much more optimistic results of recent programs. Most importantly, the effect of pricing policies on water demand warrants serious consideration and should not have been excluded from in depth review. Conclusions that pricing policies would have little effect due to the currently low cost of water is unfounded, and inconsistent with the preceding statement that "the price charged for water is generally considered to offer the greatest potential as a demand modification technique"(p.B-20). Residential water demand is considered to be relatively inelastic, however, no evidence is offered to support this conclusion. The effect of pricing policies on commercial and industrial use also appears to have been under estimated and further study of both residential and non-residential water demand modification potential is justified.

Other water conservation methods discounted as impracticable may become more attractive when used in conjunction with other techniques. For example, direct waste water reuse may be feasible with elimination of declining block rates.

Establishment of a state water policy is primary to efficient management of existing water supplies and should have been considered a central issue in assessment of water supply strategies. A comprehensive water policy will help to guide water supply use and development, putting into perspective construction of the Big River Reservoir in the scheme of water supply alternatives.

B) Population and economic growth projections on which future water demand estimates are based do not clearly reflect actual trends. Recent population projections made by the RI Statewide Planning Program (technical paper #83, 1979) show stabilizing population levels, rather than the steady growth projected by the older estimates (RI Statewide Planning, Technical Paper #25, 1975) used by the Corps.

The validity of 1972 economic growth projections is also questionable given the shift in population trends and increases in energy costs that have occured since that time and in light of recent studies that predict a decline in economic vitality for the Northeast region.

Projections for population to be served by public water in the study area are based on 1975 information and also require updating.

C) p EIS-4. DEM is incorrectly recorded as having no expressed concern regarding Need for Reservoir Alternative Assessment, when in fact, one of the major concerns in review of the preliminary draft report concerned the need for the project and the assumption of increased per capita water consumption. Also, Table 1 fails to address DEM's concern for water quality under Environmental Consideration. These concerns are addressed below and in our 7/10/79 letter to the Corps.

Recreation

DEM supports multiple use of the reservoir and endorses the proposed recreation plan. The Department's position is that committment of such a large tract of land to a single purpose is not in the best interest of the State and that recreational use will provide some compensation for loss of existing recreation area. The use of a permit system to oversee activity in the reservoir area and to generate fees to cover the cost of management and enforcement is also recommended.

Water Quality

A) The Department is seriously concerned about the extremely low release rate of 6 CFS proposed by the Corps. Minimum release from the Big River Reservoir should not be less than 7.7 CFS (5.0 MGD) average flow for a 24-hour period. This figure is based on the unit 7Q10 flow of 0.26 CFSM at the Washington Gage. The use of the 0.2 CFSM figure based upon Scituate Reservoir release (Appendix D-p.27-28) has no relevance to conditions in the South Branch of the Pawtuxet River. Maintenance of this flow should occur during reservoir filling as as normal operation.

A corresponding requirement should be placed upon the regulation of the Flat River Reservoir to release no less than 14.8 CFS (9.5 MGD) average flow in a 24-hour period.

It must be stressed however, that 7.7 CFS is the absolute minimum flow considered necessary to maintain adequate waste assimilation levels. As this low flow normally occurs for only very brief periods during drought conditions, additional studies are needed to assess the effect of sustained low flows on downstream water quality. As previously discussed, more accurate projection of water needs in the study area is needed to determine if greater flows can be released without jeopardizing availability of the Big River Water supply when required.

B) The effect of runoff from existing roads in the watershed, particularly I-95, on water quality has not been properly addressed. An assessment of highway runoff, with evaluation of the cost and effectiveness of suitable control measures, should be included in the discussion of environmental impacts and mitigation measures. The cost of runoff mitigation should be included in estimation of a cost-benefit ratio for the reservoir.

Extremely hazardous waste transporters are barred from traveling routes where spills would be especially harmful. This route prohibition of the Hazardous Waste Management Act would apply in the Big River area as well and application would have to be made by extremely hazardous waste transporters to use I-95 in the watershed area.

Terrestial and Aquatic Resources

A) DEM strongly favors implementation of a fish and wildlife mitigation plan without which there would be no compensation for extensive loss of upland habitat, stream fisheries, and wetlands diversity.

Rejection of the US Fish and Wildlife Service mitigation plan (EIS-30(2)), which is based on the Habitat Evaluation Procedure (HEP) is not justified, particularly without an alternative mitigation proposal. The HEP program is based on the most current knowledge of wildlife habitat, and the plan should not have been dismissed without serious consideration of at least partial, if not total implementation of the proposal.

While the mitigation plan developed by the Corps appears to offer some degree of compensation for this loss, questions concerning the adequacy of mitigation, and possible negative effects of the plan, point out the need for further study of possible mitigation measures, and their effects, both positive and negative, on fish and wildlife. Adverse impacts of the mitigation plan include potential interference with migration of aquatic organisms and negative recreational impacts with subimpoundments. In addition, upland wildlife habitat management may decrease overall species diversity through loss or reduction of species intolerant of human intervention.

The Department of Environmental Management has conducted extensive field studies in the Big River area and should be consulted in development of a fish and wildlife mitigation plan.

B) Minimum low flows established by DEM as previously discussed, are minimum standards for waste assimilation, and are not based on biological demands. The Department recommends that studies be completed to determine the effects of reduced flow to downstream fisheries as proposed by the Fish and Wildlife Service. Little is known about the impacts of low flows to aquatic life and further study will help to identify these effects and provide a reference point for development of mitigation measures.

C) There is serious concern over the validity of the terrestrial and aquatic ecosystem analysis. Sampling techniques used and the short duration of field studies has resulted in numerous generalizations and inaccurate conclusions.

Comments submitted in our letter of 7/10/79 relating to analysis of terrestrial and aquatic resources have not been addressed in the interim report. These concerns remain pertinent and your attention is directed to them.

Several of the conclusions presented in the draft report are addressed briefly, as follows. These concerns and those previously identified demonstrate the necessity for establishment of more accurate baseline data. The Department recommends that additional field studies be conducted in the Big River area to determine more accurately the actual impacts to the terrestrial and aquatic systems of the site. This field work should not only include random, baseline studies, but careful assessments of identified unique habitats should also be made. In addition, area biologists, more familiar with the ecology of Rhode Island, should be contacted to attain accurate data of these ecosystems.

Page EIS-22

"*Vegetation surveys and wildlife habitat evaluations were conducted within the proposed Big River Reservoir Site.*"

Again, we must reitierate that an inadequate amount of field work (1 week) was used to assess the flora and fauna of the area. So short a period of in-field analysis can not properly assess the effects of a project of this magnitude.

Page EIS-35

Regarding avifauna, the data presented in Appendix H, and the conclusions drawn, are highly speculative. In Table 6 of Appendix H, birds are listed as being observed on the site, and the conclusion presented that these species probably breed in the area. Two of the species listed (Alder Flycatcher and Nashville Warbler) have been recorded as nesting in Rhode Island only once, and two additional species (Wilson's Warbler and Tennessee Warbler) have <u>never</u> been recorded breeding in this state. If indeed these 4 species were nesting, the significance of the Big River area, as habitat for unique species, is highly increased. This criticism is used as an example of the type of inaccuracies found repeatedly in the assessment.

It is also stated that the reservoir would provide suitable habitat for several species of diving ducks. This statement must be qualified to read resting or feeding habitat, and should not imply nesting areas, since these species do not breed in Rhode Island. Counts of migrating waterfowl at the Scituate Reservoir are generally insignificant, when compared to coastal localities, and the creation of a new inland water body will not greatly benefit populations of diving ducks in this region.

data
Inadequate date has been presented to support the statement that "the open reservoir would result in a greater environmental diversity by the creation of different types of habitat in the region which would support a higher diversity of species." Suitable open water habitats exist in other sections of the state, and the removal of particular terrestrial and aquatic (especially bogs) habitats would probably decrease natural plant diversity. Examples include some rarer plants, as identified by the DEM Heritage Program, as well as other species which would be lost from the area.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Environmental Management
OFFICE OF THE DIRECTOR
83 Park Street
Providence, R. I. 02903

July 10, 1979

Mr. John Craig
Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Mr. Craig:

BIG RIVER RESERVOIR

I would like to thank you for coming down on Tuesday, June 26, to discuss with our staff the Big River Reservoir Project.

Since that time our staff has reviewed the preliminary draft reports. Our comments are mainly concerned with four subject areas.

- The Proposed Recreation Plan
- Water Quality
- The Analysis of Terrestrial and Aquatic Ecosystem
- The Assessment of Need

Following is a general discussion of these areas and attached are the specific comments related to these and other areas.

RECREATION PLAN

The Department of Environmental Management generally endorses the Option 3 Recreation Plan as presented on pages 95-97 of the preliminary draft report. The Department's position is that the commitment of such a large tract of land to a single purpose use is not in the best interest of the population; and therefore, a multi-purpose management area as described in the attached comments should be proposed.

DOWNSTREAM WATER QUALITY IMPACTS

The Department is highly concerned with a number of downstream water quality impacts including sufficient downstream flow to meet water quality standards, the control of the release of the Flat River Reservoir, the effect on the river during the filling of the reservoir, and water temperature effects on the reservoir itself.

TERRESTRIAL AND AQUATIC ECOSYSTEM

The Department has many questions regarding the analysis performed on terrestrial and aquatic ecosystems. These our mainly related to simple techniques, the assessment of environmental impacts, and the duration and period of the studies.

NEED

There is general concern with the assessment of major increases in per capita consumption of water for the study years.

Attached please find detailed comments in these areas and a list of the attendance at the June 26 meeting.

I would like to thank you for this opportunity to express our Department's position on this important matter and hope that these comments will be helpful in preparing the draft reports.

If our Department can be of any further assistance to you, please do not hesitate to contact me.

Sincerely yours,

W. Edward Wood
Director

VB:lmd

Enclosure

COMMENTS

RECREATION PLAN

The Department of Environmental Management generally endorses the Option III Recreation Plan proposed in the Big River Reservoir's EIS (preliminary draft) 95-97. DEM's position is that the commitment of such a large tract of land to a single purpose use is not in the best interests of the population. The construction of a reservoir offers unique opportunities to provide water-related or water-enhanced recreational experiences. Furthermore, with proper management, recreational experiences in the watershed can be provided without compromising water quality. This contention has been well examined and substantiated in research done by Statewide Planning (see Technical Paper #47, RI Statewide Planning).

Specifically, the following activities should be permitted in the Big River Watershed Area under the following conditions:

A. Boating - Boating should be limited to boats powered by electric motors, sailboats, and row boats.

B. Fishing - Fishing activity would be heavily controlled by the Division of Fish & Wildlife so as to establish and maintain a strong fish population during the early life of the reservoir.

C. Swimming - Swimming and water skiing would not be allowed in the reservoir. However, swimming would be allowed at Carr's Pond and Phelph's Pond.

D. Trail Bikes - The Big River Area is presently one of the most popular areas for this activity. Although it is presently unregulated and uncontrolled, a well defined and planned trail system must be implemented in order for this activity to continue. This can be accomplished through coordinating efforts between the DEM Planning Division, the trail riding organizations, and the Trail Advisory Committee.

E. Camping - This activity is to be permitted under highly controlled conditions and only outside the watershed.

Other recreational activities such as picnicking, horseback riding, hiking, cross-country skiing, ice skating, and hunting should also be permitted but conditions need not be as restrictive as the above mentioned. Although less restrictive, these activities would be regulated under a permit system.

A controlled permit system for the users in the watershed and reservoir areas should be instituted. In this way, changes in water quality relative to density in use can be researched. A permit system would also supply the permitter with a record of who is and has been on the land and also acknowledge their responsibility and the conditions whereby permission to use is granted. It is also proposed that fees collected for the permits be used to finance the additional personnel needed to enforce and manage the use regulations.

No recreation would be permitted in the northern arm of the reservoir, which is the point of treatment and distribution.

A flora and fauna management plan for the reservoir and watershed should be developed jointly by the Fish & Wildlife Division, the Forest Environment Division, and the Water Resources Division.

This policy will be expanded and incorporated in the upcoming update of SCORP.

WATER QUALITY

A. The Corps has stated that based upon the 208 modeling work on the Pawtuxet River, 6 cfs as a release from the reservoir should suffice in meeting downstream water quality standards. A general comparison of drainage areas impacted by the project and seasonal low flow conditions would indicate that at least a 9 cfs release is necessary. At our meeting on June 26, 1979, Mr. Brueckner indicated that the 208 modeling should be further reviewed in developing an impact assessment for the project.

B. As the release from the Flat River Reservoir is controlled by private industry, what mitigation methods could be recommended to obtain a desired low flow condition release from the reservoir?

C. What will be the release and impacts to the river during the three year filling of the reservoir?

D. A change in water temperature may occur upon completion of the reservoir. What impact will this have on dissolved oxygen and will the increased temperature lead to nuisance conditions; i.e. stimulation of bluegreen algae, in Flat River Reservoir?

E. To the best of our knowledge, the Corps of Engineers has not involved the Division of Water Resources in this project prior to the release of this preliminary draft.

TERRESTRIAL AND AQUATIC ECOSYSTEMS

These comments are directed primarily to Appendix H, Volumes II and III (Terrestrial Ecosystem Assessment Report and Aquatic Ecosystem Assessment Report, both prepared by Normandeau Associates, Inc., 1979). The most serious problem with the report is that only one week of field work was utilized to assess the flora and fauna of an 8000-acre area. Many of the following comments reflect this lack of field work which has resulted in generalized and inaccurate conclusions.

Specific Comments:

A. There are many unanswered questions regarding the sampling techniques used to assess the flora and fauna of the study area. The methods used to select stands for vegetation surveys and transects for bird surveys are not described. In addition, the schemes used to sample vegetation of the selected stands have not been described.

B. In Section 3.1.2.4 is a discussion of the aquatic vegetation of two ponds in the study area, (Capwell Mill and Tarbox Ponds). Other ponds in the study area should also be assessed in this manner. Also, the accompanying figures (Numbers 5 and 6) in this section have not been updated with 1970 and 1975 photo-revisions present on current U.S.G.S. topographic maps.

C. The Vegetation Cover Map (Figure 7 - Section 3.1.2.6) is inadequate in assessing environmental impact to the area. A more accurate map deliniating wetland types and forest community types would be valuable. Also, this figure, as well as figure 14 (waterfowl breeding habitat) are not scaled and contain no orientation symbols.

D. The data for birds presented in Section 3.2.1.1 does not reflect the breeding population of the study area in that field work was conducted in late summer. Four species in Table 1, (Alder Flycatcher, Tennessee Warbler, Nashville Warbler, and Wilson's Warbler), have not been recorded as nesting in the State of Rhode Island. Also, it is likely that some species not listed are nesters in the study area.

E. Data for mammals was compiled only through direct observations over a one-week period; therefore results presented for this animal group are not reflective of the mammal populations present in the area.

F. In Section 3.2.1.5, data is presented on the carrying capacities of nine selected animal species. Many questions are raised in this section. Why were these nine, and only nine, species selected for analysis? Of what value is using data collected in Denmark and Great Britian without stating the habitat parameters of these other study areas? In our opinion, the data presented in this section is of little value in evaluating the caliber of the habitat in the Big River study area.

G. In Section 5.3 (Beneficial Effects of the Project on the Terrestrial Ecosystem), a statement is presented in the first paragraph that "Presence of a large open water body would result in greater environmental diversity of the region." It is doubtful that the addition of a large open body of water would result in greater diversity for the region due to the presence of other aquatic systems nearby; i.e., Scituate Reservoir, Flat River Reservoir, Stump Pond, and Quidneck Reservoir. The benefits of this addition are also doubtful. It is true an additional "landscape component" would be added to the area ecosystem but it would occur at the expense of existing stream ecosystems and adjoining uplands. The net effect may be a loss in total landscape components.

Also, the conclusion is drawn "... this water body will provide suitable habitat for such waterfowl species as scaup, common goldeneyes, buffleheads, and other diving ducks which prefer large bodies of water." Although the species mentioned might use the open water during migration, these birds do not breed in Rhode Island and probably would not benefit greatly from the creation of the reservoir.

H. In considering the adverse effects of the project, an assessment should be made concerning the impacts of the proposed increase of recreation on the flora and fauna of the area.

I. The techniques described in Section 6.0 (Mitigation Techniques) may increase productivity and diversity in certain areas but, on the whole, the net result would be to increase man's influence beyond the area directly affected by the creation of the reservoir. Establishment and periodic maintenance of openings and plantings creates an unnatural environment for wildlife species. Certain animals, particularly game species, are able to respond to this form of management; however, certain other, more sensitive species will be greatly reduced or eliminated, thus decreasing overall natural diversity. The goal, in attempting to mitigate the effects of creating the reservoir, should be in maintenance of total natural diversity now present in the Big River area. Suggested methods should simulate, as closely as possible, natural disturbances (windthrow, fire, etc.) rather than the creation of an artificial habitat.

J. In Section 2.3.1 (p. 12) it is stated that "contact was made with the RI Department of Conservation, the US Fish & Wildlife Service, the Audubon Society of Rhode Island, and the University of Rhode Island to obtain information on rare and endangered wildlife, critical habitats and wildlife populations." It would be advantageous for reviewers of the statement to know which individuals of these groups were contacted and what literature or information was obtained. Correspondence from qualified individuals should be published along with the assessment.

K. Appendix - Table 4: Species and seasonal status of birds occurring in the area should be listed according to a local publication; i.e., The Rhode Island Ornithological Club Checklist of Rhode Island Birds - 1973. The list presented in Table 4 contains many mistakes in status and habitat of some species and some species which might be present have been omitted.

Appendix - Table 5: The data presented on winter birds is of questionable value in that the data was obtained from Christmas Counts conducted in Newport and Washington Counties, and not in Kent or Providence Counties where the reservoir would be located. Proper winter resident bird surveys should be conducted to improve on this data.

Appendix - Table 6: More recent information, preferably field surveys conducted at the site, should be utilized in determining mammal populations.

L. In considering alternate sites (Wood River, Moosup River, and Bucks Horn Brook) very few sites were visited. These areas were inventoried in a general manner by using USGS topographic maps in combination with visits to sites representative of the major vegetative categories. USGS topographic maps are not intended to provide floral or faunal information and the number of sites visited is inadequate to make serious determinations.

M. Throughout the report literature is seldom cited making evaluation of methods and results difficult. Since this preliminary report is based in large part on literature review and limited field study, it is imperative that all citations be identified so that the literature used to draw conclusions may be evaluated.

O. Aquatic Section (Appendix H - Volume III): In this section the same inadequacies exist as with the terrestrial studies. Populations of aquatic species are extremely variable and each group must be sampled extensively on a seasonal basis. Results obtained are also dependent on the time of day of sampling. For example, electroshocking for fish, although an adequate means for sampling, should be performed diurnally and nocturnally to account for the habits of various species.

The list of reptiles and amphibians (Table 7.2-1) contains inaccuracies. For example, the Diamondback Terrapin is a turtel species of brackish waters and would undoubtedly not be found in the study area. More recent literature and field studies should be used to evaluate these species.

Whereas only one week was utilized to collect field data, the results do not adequately represent the status of the flora and fauna of the Big River Reservoir Area. It is recommended that additional year 'round field studies be conducted utilizing established sampling techniques. Vegetation should be sampled throughout the year on permanently established sampling plots. A field program for wildlife assessment should follow a similar program suggested by Dressler (1976[1]).

1 Dressler, Richard L. 1976. Wildlife resource assessment for environmental impact statements. Trans. Northeast Fish & Wildlife Conference. 33:133-136.

Under this system small mammals are surveyed through mark-recapture on permanent grids during each season. Larger mammals can be surveyed through direct observations supplemented by appropriate sampling schemes for individual species. Birds should be analyzed throughout the year utilizing the appropriate survey for the given season (Breeding Bird Survey: April-July; Winter Resident Survey: December-February; Spring and Fall Migratory Surveys). These surveys should be conducted in every major vegetative community. Reptiles and amphibians should also be evaluated using appropriate schemes.

More knowledgeable individuals should be contacted in determining the presence of rare and endangered species. The Rhode Island Heritage Program is presently compiling data on the locations and status of rare and endangered plants and animals in Rhode Island and, therefore, has become involved in the review process for the Big River Reservoir. Other people to contact should also include George Seavey, Coordinator of the New England Natural Areas Survey of 1971 in Rhode Island; Richard Champlin, well-known Rhode Island botanist; Al Hawkes, Director of the Audubon Society of Rhode Island; James Myers, Wildlife Biologist for the Department of Environmental Management's Division of Fish & Wildlife; and authorities at the University of Rhode Island including Dr. Robert Shoop, Dr. Frank Golet, and Dr. Robert Chipman.

It is evident that rare and endangered species of plants and animals have not been properly evaluated. Information obtained by the Rhode Island Heritage Program shows that three species of plants, rare in Rhode Island, occur at the Big River Area. These are: Northern Fly-honeysuckle (Lonicera villosa), Northern Prickly-Ash (Xanthoxylum americanum), and Lily-leaved Twayblade (Liparis lilifolia). Also, no mention is made in the report of individuals contacted in determining the presence of rare animals at the site. It is imperative that knowledgeable individuals, specifically the persons named above, be contacted to obtain accurate information regarding rare and endangered species.

NEED

In analyzing the preliminary draft report, one of the major concerns was the need for the project. The assessment of water quantity need was based primarily on increased per capita consumption of water. While we realize that you have studied the possible impacts of water conservation on water demand, it does not appear that conservation reductions are sufficiently taken into account in computing total demand. While conservation would not remove the need for the Big River Project, it might reduce the need for subsequent water resource development.

CULTURAL RESOURCE

The study has two components, the first being an evaluation of archaeological resources prepared by the Public Archaeology Laboratory at Brown University. The approach to prehistoric research questions and techniques appears to be thorough and includes a good use of information gathered from local collections, previous research, and informants.

The only question arises in the discussion of expected prehistoric sensitivities (p. 31-33), which can be more appropriately answered by the archaeological staff at the Rhode Island Historical Preservation Commission in their review of this study.

There are good suggestions in the section on historic archaeology for the use of primary sources and oral history techniques. However, I do question the claim that no time was available for thesis location (p. 35).

The second component of the study is a report on the historical and cultural resources within the project area prepared by the Rhode Island Historical Preservation Commission. The historical background provided by the report is certainly sufficient for an understanding of the economic and social rise and fall of the area. Tables I and II (p. 35-38) are especially useful in showing the relationship between the cultural resources and, more significantly, their relationship to the projected reservoir.

Each resource is assigned a level of significance which is helpful in ascertaining its historical value. These levels range from "National Register potential" to "important" to "contributing." All assignments seem valid with the possible exception of (S)-IND-10, the Hopkins Mill site, a former National Register property which is listed as only "contributing." This may be a result of its removal from the Register following its destruction in 1978 (p. 96).

Editorial corrections in this report include:

P. 50 - CEM-6 "Door War" should read "Dorr War."

P. 132-137, misnumbering of features in the Transportation section:

TRN-5 should be New London Turnpike.
(S)-TRN-6 should be site of Webster Gate.
TRN-7 should be Nooseneck Hill Road.
TRN-8 should be Big River Bridge, #34.
TRN-9 should be Nooseneck River Bridge, #36.
TRN-10 should be Interstate 95.

In general, both studies clearly indicate the presence and potential presence of prehistoric and historic cultural resources in the project area and thereby satisfy their intended goals. They serve as useful tools for the location and evaluation of these resources. However, they fail to indicate either the time necessary or the type of further study which will presumably include recommendations for mitigation of any National Register properties adversely affected by the reservoir project.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Transportation
PLANNING DIVISION
State Office Building
Providence, R. I. 02903

March 23, 1981

Division Engineer
New England Division
U. S. Army Corps
424 Trapelo Road
Waltham, MA 02254

Subject: Big River Reservoir
Draft Feasibility

We have reviewed the Draft report and offer the following comments:

1) Many roadways will be eliminated by the building of the reservoir.

a) how will these increase travel time and total VMT?

b) how will this impact energy consumption?

c) what effects will this have on Public Safety - Police, Fire, rescue, etc. response time?

d) what impact will this have on school districts? increased bus transportation, etc.

2) The EIS (pg. ES-26) states that Nooseneck Hill Road will be relocated along I-95 where it presently crosses the Big River. What provision has been made for where it crosses Nooseneck River?

3) The document states that if sub-impoundment dikes are not built for Hopkins Hill and Congdon Mill roads it would not be feasible either economically or environmentally to relocate these roadways. These roadways are important to the area's traffic network and special consideration should be given to them.

4) Surrounding roadways will be forced to carry a heavier burden because of the elimination of roads through the reservoir. This raises the following questions:

   a) what improvements, if any, will be made to these roadways to protect the reservoir from roadway drainage, hazardous spills, etc?

   b) what improvements to these roadways will be made to make them safe for the increased traffic?

   c) will these improvements be paid for under the Reservoir Project Contract? with Reservoir Project funding?

5) Your report states that this area will have an increase in recreational usage. This will cause an increase in the traffic on roadways surrounding the reservoir.

   a) what effect will this have on air quality? CO microscale and a NMHC meso scale analysis desired.

   b) what effect will this have on existing noise levels?

6) What temporary impacts will the construction equipment have on the project area? noise and air pollution emissions, roadway deterioration, etc?

These comments are significant and should be addressed in the Environmental Impact Statement.

Thank you for your consideration.

Sincerely,

Robert Brown

Robert S. Brown, Assistant Chief
Planning Division
for Joseph F. Arruda, Chief
Planning Division

RSB/SMC/ea
cc: Mr. Flanders
Mr. Kirby
Mr. Winiarski
Mr. Varin
Mr. Russ

The Conservation Law Foundation of Rhode Island
3 STEEPLE STREET
PROVIDENCE, RHODE ISLAND 02903
(401) 861-7550

S. Arlene Violet,
Counsel

April 2, 1981

Ms. Susan E. Brown
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Ms. Brown:

I'd like to submit the following comments concerning the Draft Interim Report for the Big River Reservoir Project in Rhode Island, prepared by the U.S. Army Corps of Engineers.

The Conservation Law Foundation of Rhode Island would hope that the primary goal of the Big River EIS would be to determine whether or not the Big River Reservoir is a necessary component of a broader comprehensive water resources plan for Rhode Island. This would be consistent with NEPA's policy of requiring full analysis of the alternatives and impacts of a proposed project.

The conclusion that the EIS reaches will depend in part on how well it analyses what our future water needs will be. The specific calculations which are used to determine this will go a long way toward wither showing the need or lack of need for the reservoir. In the Draft EIS, several factors are taken into account in calculating this. The first factor is what our future population will be. The Rhode Island Statewide Planning Program developed such figures in 1975 and then again in 1979. The 1979 figures reflect trends, such as declining regional birth rates, which could not be foreseen in 1975, and which show a gradual drop in the Rhode Island growth rate. We believe the Corps should use these more accurate figures throughout its calculations in the final EIS. That the 1975 figures are more consistent with the State Guide Plan (which was also developed in 1975) does not seem to be a valid rationale for using these figures. This assumption alone increases the projected water needs for the study area in the year 2030 by over 30% according to Table 15 and 16 in the report.

The methodology used in the EIS to calculate future water needs is based, secondly, on what percentage of the population will be served by a municipal water system in the year 2030. We question the Corps's assumption on page A-46 that the study area, which includes the towns of Foster, Glocester, Smithfield, Coventry, Scituate, and West Greenwich, will be 100% served by a municipal system in the year 2030. There has been no indication from our rural towns that they are planning this sort of urbanization, that they will allow development trends to continue if it begins to change the character of these towns, or that they are interested in giving up their private systems for conveniences of an urban system.

Thirdly, projected water needs are based on future per capita water demands. Again, the EIS seems to rely on outdated information. In this case it is on a "Feasibility Report" done in 1969 by the Corps of Engineers, according to page A-49 of the Draft. The report works from a graph which extrapolates future needs based on rates of demand between 1950 and 1965. This method predicts an increase in water demand per person over the next 50 years of approximately 90 mgd, up from the present 60 mgd. On page A-46, the EIS states that "in making estimates of future water use no direct allowance was made for the impact of changed policies on water consumption". We do not believe it is valid to assume that conservation-oriented policies will have no effect in the future, that the wasteful water practices of the 1950s and 1960s will continue into the distant future, or that appliances which use major amounts of water will come into demand. More realistically, a conscientious water conservation program would lower the amount of water demanded per person -- it should be able to go below 60 mgd. This aspect of water demand projection would be clearer in the EIS if assumptions regarding per capita needs were explained in more detail.

Fourth, predictions of industrial water demand are figured into the calculations. The Corps makes use of a mathematical model developed in 1971 (a period of rapid industrial growth) to predict this. We would request that the final EIS state the actual gpd increase which it calculates would result from this formula, and how parameters of the formula, such as "E", "D", "R", and "T", were chosen. This would allow the figures to be judged; readers would have more to go on than that results were figured into the overall demand calculations.

We concur with the EIS on page A-43 that "the economy of the state has changed significantly in recent years, showing decline in the manufacturing sector and increase in the services sector." Does this throw into question the assumption that industrial demand will increase at all over these years, since the services sector is much less water-demanding than the manufacturing sector?

Just as in the area of energy use, another important influence on how much additional water will be needed in the future is the degree to which conservation measures are encouraged. While most of the nation has very much approved of conservation measures (which don't lower the quality of life) in energy as sound and efficinet, the Corps has hardly acknowledged the relevance of this outlook in the EIS with respect to water. Water is quickly becoming a scarce and precious resource, and Rhode Island will want to steward it more carefully in years to come. A good deal of attention was paid to the concept of demand modification in a study prepared by the Corps just two years ago, entitled "Water Supply Alternatives for the Pawcatuck River and Narragansett Bay Drainage Basins". It concludes that use in old and new homes of low-flushing devices (such as toilets, showers, dish washers, and washing machines) to replace the less efficient ones, only in cases where it would be cost-effective, would save a minimum of 30% of water demand by the year 2030. An aggressive educational program to encourage voluntary conservation would save an additional 5%, according to the report. Overall, a conservative estimate of the water which could be saved by conservation measures would amount to 35% of demand. If this figure is used together with the 1979 population projections of Statewide Planning, according to Table 16 of the EIS we'd have a water surplus of 5 mgd in the study area by 2030. So a thorough consideration of the amount of water which could be saved through "demand modification" seems worth careful study.

The 1979 report goes as far as to say that, based on all studies available, we could theoretically save up to 70% of our water demand through these measures. In light of these figures (35% - 70%), it is not at all clear why the Big River EIS concludes that only 9% can be saved by the year 1995 and 11% by the year 2030. We believe that these figures are not consistent with recent studies such as the Corps own report of two years ago. Should the Draft's original figures be used in the final EIS, an explanation of what the reasoning was based on would be important.

Questions remain about the potential of other conservation measures also. To our knowledge, no Rhode Island study has estimated the impact which could result from price restructuring in the industrial sector, which consumes about 50% of our total water, and especially the impact of wastewater recycling in this sector, should pricing structures by changed to encourage it. Also, no studies that we know of have analysed the responsiveness of the different sectors -- residential, commercial, industrial -- to conservation measures in general. Until these studies are done, we don't believe that the true possibilities of demand reduction in R.I. can be known.

We also have several questions concerning reservoir impact. The Public Participation Program conducted by the University of Rhode Island for the Corps of Engineers in 1978-79 identified several key topics that it determined would be desirable for the EIS to answer. Several important ones don't seem to have been discussed in the EIS.

First is the question of how water quality would be affected downstream from the Reservoir due to reduced flow. Although the Corps may consider actual study of this to be outside of its jurisdiction, we don't believe the final EIS can be complete without having resolved this potentially significant impact. It would be desirable for the EIS to address the effects of concentrated pollutants in the rivers (especially of community health downstream), the combined effects of reduced flow in the Pawtuxet River from Big River plus the Scituate Reservoir, siltation effects, and of how present and potential uses of the river will be altered due to the new flow conditions. Perhaps the EIS could draw from recent workshops and studies of the New England River Basins Commission.

Secondly, numerous costs of building the reservoir could stand further analysis. The Corps concentrates throughout its study only on direct costs of the reservoir, such as for building transmission facilities, the cost of obtaining real estate for the Reservoir, engineering and design expenses, and so on. Inclusion of all these factors results in the tenuous cost/benefit ratio for the reservoir of 1.16/1. How much would this figure change if all indirect costs were included, such as taxes lost to the state and local communities due to state ownership of the reservoir land; the additional expenses of upgrading community sewage treatment plants to handle the additional water supply created by the reservoir, or, assuming that local communities will not have the money to do this, of the additional costs of polluting Narragansett Bay because of insufficient sewage capacity; the costs of losing sand and gravel resources which would be flooded over by the reservoir; health effects of concentrated pollutants downstream due to reduced flow, or alternatively of the additional costs which industries will have to pay to maintain downstream water quality at its present level when flow is reduced; and so on. Federal regulations (40 CFR 1502.22 and 23) require that "if information relevant to adverse impacts (such as reservoir costs) is essential to a reasoned choice among alternatives and is not known ... the agency shall include the information in the EIS. Furthermore, "... the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities." -- in other words, all indirect costs.

Third, barely any mention is made in the EIS of how satisfactorily runoff from I-95, which passes right through the reservoir, can be controlled. Only on page EIS-26 is mention made of this, to the effect that runoff control and stilling basin facilities would be desirable. The final EIS should analyse the probability of accidents occuring along this stretch -- an EPA survey of highway spills in New England lists 109 spills and 14 hazardous chemical spills involving surface water areas since 1972, some of which were in reservoir watersheds. The state of the art in highway runoff control technology is so poor that EPA ruled against the I-84 proposal in western Rhode Island partly on these grounds. The agency cited the unreliability of such technology. An engineer with EPA's Boston office stated in a September 30, 1979 Providence Journal article ("Roads and Reservoirs Can't Coexist Despite Best in Planning, EPA says") that settling basins and drainage pipelines are little more than theory: "We really don't know how well any of this is going to work in practice ... The truth is there are no proven techniques." One serious hazardous waste spill could contaminate the reservoir indefinitely. The Big River EIS needs to go into this in more than just a paragraph.

We believe that other areas of the EIS need clarification also:

1) What will be the environmental effect of a proposed trans-Narragansett Bay pipeline for carrying drinking water to the East Bay? This is part of the proposed project under Alternative C and must be considered in the Adverse Environmental Impacts section of the EIS.

2) What is the legal and political basis of the statement on page 64 that importing water from Rehobeth, Massachusetts would not be feasible because of interstate institutional restraints, which thereby would necessitate the pipeline. Are institutional constraints so costly as to warrant the extra 3 million dollars plus the environmental disruption of the pipeline?

3) Groundwater is identified in the EIS as generally being the most economical and least environmentally disruptive way of increasing municipal water supplies. Yet throughout the EIS, groundwater development is routinely dismissed as either too expensive or too impractical. On page 35, for instance, the EIS says "transmission costs from the Pawcatuck Basin to the rest of the study area would be excessive due to long distances involved. Development of groundwater in southern Rhode Island was thus ruled out .... We would like to see a full analysis in the "Alternatives" section of Rhode Island's groundwater reserves. Figures cited in the EIS, for instance, indicate a large aquifer of drinkable water in the Pawcatuck Basin and surpluses elsewhere around the state. What are the actual economic costs and environmental consequences of developing them (the amounts which are

available is partly addressed in the Draft; but these figures apparently combine values of what is theoretically available with a judgement of how much is socially and environmentall acceptable to use. We would like to see all figures spelled out in much more detail).

4) The EIS also describes large reserves of groundwater in Providence, Cranston, Lincoln, and elsewhere which are of poorer quality. This water appears suitable for industrial purposes (which demand over 50% of the state's water at present), yet there is no discussion of the feasibility of using these supplies in the future for these purposes.

We believe that a discussion of water resource needs in our state is most timely right now, and applaud the Corps of Engineers for undertaking these studies. We are not opposed to expansion of water supplies in Rhode Island if they are needed, but believe that whether or not supplies such as the Big River Reservoir are really needed now has not yet been shown. Too many questions about the future need for water and the desirability and potential of alternatives remain to be answered before determining this. We hope the Corps continues to stay involved in the analysis of these questions.

Thank you very much.

Yours truly,

John Jewett

John Jewett

River Conservation Committee
Rhode Island Canoe Association
20 Knowles St.
Lincoln, R.I. 02865
March [illegible], 1981

Division Engineer
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Rd.
Waltham, Ma. 02254

Dear Sir:

We are writing in regard to the Big River Reservoir Project in Rhode Island. The River Conservation Committee would like to formally express the views of the Rhode Island Canoe Association on the draft Feasibility Report and draft Environmental Impact Statement for the proposed reservoir project.

Our main interest, as canoeists, in this project relates to the recreation plan. Our 150 member organization presently uses the Big River Area for recreational canoe trips during the warm weather months. In a sense, we would prefer to canoe on a relatively small stream, rather than on a large, sometimes windy reservoir. But if the stream is taken for the reservoir project, we strongly urge that canoeing be permitted. From the research I have done on plan C of this feasibility study, it appears that developing the recreational potential of the reservoir area is an important aspect of the total plan. If canoeing is not included in the reservoir recreation plan, we as a special interest recreation group would obviously suffer by not having canoe access to the reservoir. But it should also be realized that canoeists will be affected in a more profound sense than other recreation groups, because once the reservoir is built we would no longer be able to use the Big River itself for canoeing.

We would like our opinions to be considered in this study and we also request that this letter be considered as part of the review process.

Sincerely,

Carolyn A. Stefanik

(Ms.) Carolyn A. Stefanik
Chairperson, River Conservation Committee
Rhode Island Canoe Association

STANLEY BERNSTEIN
DIRECTOR

VINCENT A. CIANCI, JR.
MAYOR

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

40 FOUNTAIN ST., · PROVIDENCE, R. I. 02903 · TEL. 401-831-6550

April 2, 1981

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Sir:

We have the following comments to make on the Draft Report for the proposed Big River Reservoir Project after our review of its contents. Some of these points were briefly summarized in oral remarks presented at the public meeting on 26 March 1981.

At the outset we acknowledge the probability, but as a likelihood rather than as a certainty, that construction of the Big River Reservoir will become necessary to serve a larger geographic area of water users than are served by the Scituate Reservoir currently. However, we feel now that the need is developing later than trends indicated a decade ago, and that construction should be scheduled at least five to ten years later in order to avoid an expensive prematurity of capital investment due to excess capacity during the interim. At the same time we continue to appreciate the wisdom with which, some decades ago, the State of Rhode Island acquired the entire site in order to prevent further accumulation of private investment and needlessly increasing acquisition, site clearance and other expense.

Two factors have deferred demand for the water supply, including our interrupted population growth in the potential and prospective water service area, as well as a sharply diminishing per capita rate of increase in demand. The first of these factors is less debatable than the second, and was revealed two years ago this month in the 1979 population projections of the Statewide Planning Program, which for good and sufficient reasons superseded their own 1975 projections. Both of these projections were fully competent and properly responsive to trends discernable at each epoch, but the 1975 work became obsolete by reason of the sharply dropping birth rate and the closing of the Quonset naval base. For similar reasons the 1972 projections of the Office of Business Economics / Economic Research Service ("OBERS") were additionally obsolete despite their competency at that date, and should not have been used to justify a "choice" between two apparently conflicting state projections.

On the basis of the 1979 projection, for the design year 2030, the population in the service area was in 1975 overprojected by 37.7% (833,400 vs. 605,300), and for the year 2040, by 41.5% (850,100 vs. 600,600). Both projections were done by the same Principal Research Technician, Mr. Chester J. Symanski, with supporting staff in the Rhode Island Statewide Planning Program, who have the respect of the Population Advisory Committee of the State Planning Council as well as of the U. S. Bureau of the Census. Aside from the advantage held by the 1979 projection by virtue of four more years of development in actual data trends, there were four more years of professional experience by staff. The 1980 population counts were close to those projected in 1979 for the Rhode Island municipalities.

Increasing public awareness of the need for conserving all resources including water and energy can be reasonably expected to put some damper upon the rise in per capita consumption, more effectively than could be anticipated as long ago as 1969 and 1975, the base years mentioned on Page A-49 in the discussion, unsupported by data presentation, of per capita consumption. The assumptions made appear in need of re-evaluation and updating.

Consideration of these demand factors may help to prevent any mis-timing or mis-sizing of water supply development, and to support public credulity for the Corps' analyses of needs.

Our second major comment on the Draft Report relates to the omission of an electric power generation facility at the proposed Big River dam. At the March 26, public meeting it was stated by John C. Craig, study manager, that "hydro power at Big River is not considered feasible at this time". However, since the report preparation was completed as of July 1980, the Federal Energy Regulatory Commission has commenced effectuation of the Public Utility Regulatory Policies Act of 1978 which requires encouraging cogeneration and small power production at facilities such as this. The Rhode Island Public Utilities Commission on March 20, 1981, issued its decision and order regulating sales and purchases of electricity between electric utilities and small power production facilities, and established the formula by which the energy cost avoided by Narragansett Electric Company's wholesale supplier, New England Power Company, must be determined for on-peak and off-peak periods and adjusted for line losses, and used as the basis for rates to be paid for cogenerated power. By April 9, 1981, tariffs must be filed including the calculated rates. We expect that the rates will at times vary in the range of about $0.075 to $0.080 per kilowatt hour, or about 14 to 15 times the rates currently paid to the Providence Water Supply Board for cogenerated power sold to Narragansett Electric Company at the Scituate Reservoir dam. These developments affect substantially the picture of economic feasibility for the proposed Big River dam, and we therefore call upon the Corps to make a careful evaluation of power co-generation under these new conditions.

Our third major comment concerns the extensive discussion given in several of the report volumes to justifying the abandoned proposal for the Natick Diversion tunnel project and refuting points of official and public objections against it. In Volume VII, Appendix 3 entitled "Public Views & Responses" contains a section presenting "Correspondence from 1976 Public Meeting" beginning on Page 3-26, in which eight letters appear. Omitted from this section is a letter constituting the official response of the City of Providence to the proposal, dated October 14, 1976, presented with the approval of the Mayor and the Director of the Department of Planning and Urban Development at the late stage public meeting on that date. Although the official status of that communication was acknowledged on Page 3-23 in the summary of that meeting, the contents are withheld from the present volume.

The importance of that omission arises from the manner in which the comments in that letter were summarized by the Corps so selectively on Pages 10-7 and 10-8 as to omit vital portions of those comments. For example, we did recognize the advisability of providing some simplified backflow prevention device to check abnormal (but not normal) tides from inundating most of the Warwick and Cranston flood plain areas along the Pawtuxet River's main stem. Also, in re-wording our comments the Corps omitted our suggestion that, if found safe after engineering analysis, the simple use of a few additional stop logs in the existing slots at the top of the Scituate Reservoir spillway would accomplish a modest utilization of the effective height of the dam, according to its original design, for brief periods during and following flash floods. By this omission the Corps made room for objecting to "a costly procedure to outfit the dam with new appurtenant flood control facilities, and therefore, is not considered feasible".

Comment 4-1 regarding the Broad Street Dam, the concrete wall jutting across its spillway, and the sediments, rubble, and obsolete foundations of old weirs and bridges, was so summarized by the Corps as to exclude our description of the elevation of the natural riverbed which, before construction of the earliest dam at Broad Street, was several feet lower for several miles than the present silted-in river bottom. The Corps' response again discounts almost completely the value of restoring the original cross-section and gradient of the Pawtuxet River's main stem, without justifying that discounting, with the unsubstantiated statement that "the removal of such objects would only have a minor effect on <u>riverine</u> flooding."

Comment 4-3 was similarly re-worded by the Corps to imply that we had grossly over-estimated the storage volumes behind existing dams along the Pawtuxet River. The response by the Corps pointed to "insufficient storage capacity to be an effective element in a flood control system", but did not indicate what that total of capacity would be assuming the routine draw-down of the whole series of dams that are not needed as reservoirs, as a portion to be added to whatever flood storage volumes might be available at Scituate, Flat River and Big River reservoirs. We merely sought to indicate that "every little bit helps", especially in non-structural solutions costing very little, and we did not miscalculate those capacities as being unrealistically large.

In our view the Corps has not justified its preference for leaving in place the obstructions and sediments which can only add to the hazards menacing all the flood plain investments surrounding the river's main stem. Respectfully we suggest the presentation of our letter of October 14, 1976, as written, and that the Corps re-work its responses to handle our comments more directly, in the final project report.

On other issues, we have these recommendations to make:

1. That decisions about allowing recreational use of the reservoir water areas and surrounding forest management areas are policy issues to be resolved by the water supply management agency under Rhode Island law according to their experience with water quality requirements.

2. That the final report detail methods and costs for insulating Route I-95 drainage and hazardous spills from the Big River watershed according to standards applicable to newly constructed interstate routes.

3. That the final report provide that materials to be excavated for use in constructing the dam and dikes and relocated highways be taken only between the elevations 267' and 300' NGVD unless impervious fill material is in short supply within that interval, so as to contribute to the water supply volume exclusively.

We appreciate the opportunity at this stage of the planning process for contributing the above comments on your Draft Project Report.

Sincerely yours,

John R. Kellam

John R. Kellam
Supervisor of Long Range Planning

Copies:
Mayor Cianci
Water Supply Board
R. I. Statewide Planning Program

QUIDNICK RESERVOIR COMPANY
1180 NARRAGANSETT BOULEVARD
APARTMENT C-2
CRANSTON, RHODE ISLAND, 02910

March 25, 1981

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Attention: N.E.D.P.L. - B.U.
c/o C.E. Edgar, III
Colonel, Corps of Engineers
Division Engineer

Re: Big River Reservoir Project
Public Comment Period
Response to Public Meeting Announcement
U.S.A.C. Correspondance Dated February 26, 1981

New England Division, Corps of Engineers

The Quidnick Reservoir Company is a Rhode Island Corporation that was granted its charter by the State Legislature in May of 1846, to construct dams along the South Branch of the Pawtuxet River, to control the flow. Recently, the mill owners that form the Corporation, applied to the U.S. Department of Energy for a low interest loan to fund an engineering feasibility study to determine the viability of redeveloping hydropower at eight of their dam sites. On May 21st of 1979, the Quidnick Reservoir Company held a meeting to discuss their plans for redeveloping hydroelectric power along the Pawtuxet River. That meeting was held at the Rhode Island Governor's Energy Office and was attended by the office's Director, by the Rhode Island Water Resource Board, by the Rhode Island Public Utilities Commission, by the Rhode Island Port Authority, by the Rhode Island Department of Environmental Management, and by the members of Quidnick Reservoir Company accompanied by their engineering consultants, Halliwell Associates, Inc. The details of that meeting and of those persons in attendance are included within this correspondance as Exhibit A.

However, the importance of that meeting as it relates to the proposed Big River Reservoir is, that it was established that the Quidnick Reservoir Company was undertaking a large financial commitment to study the feasibility of re-establishing hydroelectric power at 8 of its dam sites. It was also established that a possible conflict over the use of the water could arise between Quidnick's desire to produce hydropower, and the State's desire to utilize the water to operate the proposed reservoir. Quidnick was assured by the Water Resources Board that both interests could be served by the Reservoir Project, and that the flow control at the dam would actually improve the hydroplant's power production capabilities during low flow periods by providing guaranteed minimum releases. The meeting was adjourned with an optimistic attitude on the part of all parties that cooperation would allow both projects to survive.

In May of 1980 the Quidnick Reservoir Company received approval from the Department of Energy for a $147,600 loan to conduct the hydroelectric feasibility study, and the project began. In June of 1980, the Quidnick Reservoir Company also received 8 preliminary permits from the Federal Energy Regulatory Commission to establish priority in developing their hydroplants.

On January 23, 1981, an announcement was made by the New England Division of U.S.A.C. that the Draft Report for the Big River Reservoir was completed and available for public review. The engineering consultants for the Quidnick Reservoir Company have reviewed the Draft Report and their findings have caused great concern among the members of the Quidnick Reservoir Company.

In particular, there are 4 areas that the members of the Quidnick Company have expressed great concern:

1. <u>Non-Recognition of the Quidnick Reservoir Company in the Draft Report</u>

Despite the nearly 2,200 pages of text, tabulated information, and 2½ years of research, the Draft Report does not address the Quidnick Reservoir Company, its water rights, or its plans to redevelop hydroelectric power along the South Branch of the Pawtuxet River. This proposed redevelopment of hydropower is an obvious competing use of the water, which was not resolved in the study, nor was it even considered.

Further, despite the efforts of Quidnick to maintain a high profile for their hydroelectric development plans, and their numerous meeting with State agencies regarding the conflict of water use, the Draft Report has for all intents and purposes, ignored them.

2. <u>Competing Water Uses</u>

The Hydroelectric Feasibility Study reached its half-way mark this fall, and on October 23, 1980, a Mid Study Report was filed with the Department of Energy for approval. Approval of that report was received by D.O.E., and the balance of the loan monies to complete the study were released.

Contained within the Mid Study Report were computer printouts of the U.S. Geological Survey's Program of river flow data as measured along the South Branch of the Pawtuxet. Based upon the data generated from that program, a flow duration curve was developed for each site, indicating a design flow for the 8 hydrostation's of 180 cfs, ($Q_{25\%}$). Using that flow of 180 cfs, along with the available net head at each site, powerhouse capacities were developed and equipment selected. Annual kilowatt hour production for each site was then calculated, and estimated revenues were compared with estimated costs.

The results of those analyses indicated that based upon those historic flows, the given heads, and costs, the projects were all technically and economically feasible.

The Final Draft Report for the Big River Reservoir proposes to reduce the contributing drainage area of the South Branch of the Pawtuxet River at the Washington Gauging Station from 63.8 square miles to 34.1 square miles.

This in effect will reduce the average flows at the Washington Gauging Station from 128 cfs, to 79.7 cfs, a 37.7% reduction in flow. By impounding this amount of the flowage from the contributing Big River, all of the proposed hydroelectric plants along the South Branch of the Pawtuxet River will be rendered economically infeasible. Because of the relatively low heads at each of the dam sites (14 to 30 feet), and the already modest flows of the Pawtuxet River, (Q @ 128 cfs), none of these proposed hydroelectric projects could sustain a 38% reduction in flows, and be expected to amortize itself.

3. Water Quality

The Quidnick Reservoir Company owns the riparian rights to the Flat River Reservoir and they operate the gates controlling the flow to the South Branch. The miminum 7Q10 flow of 23 cfs must be released from the reservoir gates at all times to assure adequate flow to mix with the American Hoechst discharge. The R.I.D.E.M. expressed concern that the development of the proposed Big River Reservoir would further compound the dissolved oxygen problems of the South Branch. By considerably reducing the flows into the Flat River Reservoir, the average annual flows of the South Branch will be reduced by approximately 40 percent with the minimum downstream release capabilities of the Flat River Reservoir also adversly effected, thereby reducing the overall assimilative capacity of the river. While the Army Corps of Engineer's Preliminary Feasibility Analysis of the Big River Reservoir Project has discussed the reduction of flows, the effect this project would have on the dissolved oxygen levels in the South Branch must be analyzed in much greater detail in the final report. It would appear that the dissolved oxygen water quality standard of 5 mg/l may be violated by the proposed Big River Reservoir Project.

4. Ownership of Flowage Rights

Quidnick Reservoir Company and its membership maintain a threefold right of ownership and usage of the water flowage rights. Quidnick Reservoir Company itself maintains two major forms of ownership and each member of the Company maintains rights separate and apart from Quidnick but arising from its ownership of land.

Quidnick's twofold rights refer to its outright ownership of land and also its ownership of flowage rights. Both forms of ownership are documented by deeds recorded in the land evidence records in the various towns involved which deeds were recorded in the period of approximately 1865-1878.

The outright ownership of land is ownership in "fee simple absolute" and ownership of flowage rights is the right to flow waters over land owned by others. These two forms together when read together give Quidnick the right to create a reservoir of water in the West Warwick and Coventry area where the ownership exists. It is these rights which Quidnick has owned continuously from the time they first obtained them, some 100 - 120 years ago, and still owns them today. This ownership has never been diminished by any condemnation, purchase or easement by any person, corporate body or municipal government.

The area created by Quidnick Reservoir Company is approximately 938 acres. Many of the exact bounds may be difficult to locate due to the meandering and flowing of the Big River over the past 100 years, but the land and flowage rights exists and are owned by Quidnick Reservoir Company.

The ownership of the lands and flowage rights to the south of the proposed Big River Reservoir is set forth in the map in the attached Exhibit B and the deeds creating this ownership are as follows:

#	Grantor	Grantee	Town	Book/Page	Date
1	David Howard	QRC	W.G.	Bk13 Pg.543	May 26, 1873
2	Sara Matteson	QRC	W.G.	Bk13 Pg.544	May 30, 1873
3	Wm. B.Whitford	QRC	W.G.	Bk12 Pg.404	Oct. 15, 1875
4	John W. Howard	QRC	W.G.	Bk12 Pg.346	May 28, 1874
5	Spencer Greene	QRC	W.G.	Bk12 Pg.394	Aug. 19, 1875
6	Thurston Hall and Wife	QRC	W.G.	Bk12 Pg.399	Sept. 6, 1875
10	Moria Wickes	QRC	W.G.	Bk14 Pg.143	May 28, 1878
7	Amos Sweet	QRC	W.G.	Bk12 Pg.418	Aug. 7, 1876
8	Searles Capwell	QRC	W.G.	Bk12 Pg.332	Feb. 24, 1874
9	Dexter M. Johnson	QRC	W.G.	Bk12 Pg.313	Mar. 12, 1873
11	Phillip A. Sweet	QRC	Coventry	Bk28 Pg.160	Sept 22, 1870
	Benedict Lapham	QRC	Coventry	Bk28 Pg.307	Oct. 23, 1872
12	Phillip Sweet	QRC	Coventry	Bk28 Pg.159	Sept 22, 1870
13	Richard T.Mitchell	QRC	Coventry	Bk27 Pg.267	Sept 19, 1868
14	Phillip Sweet	QRC	Coventry	Bk28 Pg.160	Sept 22, 1870
15	Benedict Lapham	QRC	Coventry	Bk28 Pg.307	Oct. 23, 1872
16	Stephen Andrew,Jr.	QRC	Coventry	Bk26 Pg.614	Aug. 8, 1867

The third fold of ownership arises through the individual members of Quidnick. Each member of Quidnick also owns land on the bank of the River and as such has certain riparian rights. These rights give each owner the right to have the water flow past its property undiminished in quantity and quality as well as the right to put the water to reasonable and beneficial use.

Each member and land owner has use for the water flowing by its property. Some use the water for cooling purposes while others use the water as an intergral part of the business. Any interuption in the quantity, quality or their use of water would greatly effect their business operations. The Army Corps report does not acknowledge the real effect the Reservoir will have on these downstream users nor does it acknowledge the magnitude of the damage to these business and to the jobs, taxes and other economic issues of the towns and the people if these businesses are forced to relocate due to changes in their water quality or quantity.

CONCLUSION

In summary, the Quidnick Reservoir Company contends the following:

1. That despite their continued efforts with numerous State and Federal agencies to be recognized, the Draft Report does not acknowledge their existance or intentions to develop hydropower.

2. That the Draft Report's recommendations on flowage impoundment are not compatible in their present form, with the proposed hydropower developments.

3. That the dissolved oxygen water quality standard of 5 mg/l for the South Branch of the Pawtuxet River may be violated by the proposed Big River Reservoir Project.

4. That the State does not hold the riparian rights to the Big River flowage, but instead that is held by the Quidnick Reservoir Company and its members.

Because of the aforementioned facts, the Quidnick Reservoir Company strongly recommends that the Draft Report in its present form, be either rejected in its entirety, or be amended to rectify its deficiencies and become compatible with the plans of the Quidnick Reservoir Company.

Joel Westerman, President
Quidnick Reservoir Company

cc: Gordon & Levitt, Atty.
Pontiac Mills
Original Bradford Soap Corp.
Concordia Manufacturing
Garland Industries
Coventry Realty Co.
American Hoechst
Westerman Realty Co.
Natco Products Corp.
Saybrooke Manufacturing
Halliwell Associates, Inc.

EXHIBIT A

ACTIONS AND INTERACTIONS BETWEEN THE QUIDNICK RESERVOIR COMPANY AND GOVERNMENT AGENCIES PARTY TO THE PROPOSED BIG RIVER RESERVOIR DEVELOPMENT

1. May 21, 1979

Meeting before the R.I. Governor's Energy Office to officially introduce the proposed hydroelectric development along the South Branch of the Pawtuxet River.

ATTENDANCE:

NAME	ADDRESS & ORGANIZATION	PHONE
Emile Benoit	Governor's Energy Office	277-3374
Dante Ionata	Governor's Energy Office	277-3374
Peter Calise	Water Resource Board	277-2217
Jeff Kosciusko	Garland Industries	821-1450
Louis Lanoie	Garland Industries	821-1450
Earle F. Prout, Jr.	D.E.M. - Dams Section	277-6820
Douglas W. Hartley	P.U.C.	277-2442
Michael A. Silvester	Bradford Dying Assoc.	274-6300
Attorney at Law	Westerly, R.I.	
	(1122 Ind. Bank Bldg.)	
John W. Grifalconi	Aalto House, Box 9, Kingston	789-1233
Joel Westerman	Westerman Realty Co.	821-3880
Everett W. Kenedy	American Hoechst Corp, Cov.	823-2118
William M. Donahue	American Hoechst Corp	823-2495
Jay Ryder	Halliwell Associates	438-5020
Dennis Leahy	Natco Products Corp.	828-0300
Robert Galkin	Quidnick/Natco	828-0300
Jack Halliwell	Halliwell Associates	438-5020
Bill Foster	Governor's Energy Office	277-3374
Jim Skeffington	Edwards & Angell-Bond Counsel	274-9200

At the conference Mr. Peter Calise of the Rhode Island Water Resources Board told the members of the Quidnick Reservoir Company that if they were to proceed with their hydro development, that the Board would act as a development agency for Quidnick. He noted that the Big River Reservoir would have a "favorable" impact upon the hydroelectric development because there would be guaranteed releases during low flow periods (3 to 4 million gallons per day). He pointed out that at that time there were some matters to be resolved such as whether the actual reservoir storage would take place in the Flat River or in the Big River. Finally, Mr. Calise indicated that the Water Resource Board realized the need for coordination between the state's potable water requirements and power generation, but that through working together, both the Board and Quidnick can "come out winners".

Mr. Joel Westerman, President of Quidnick Reservoir Company, responded that the Big River represented approximately one half of the South Branch's watershed, and that 3 to 4 mgd during low flow periods was inadequate. He pointed out that for pollution control measures alone, the river required a minimum of 9 to 12 mgd during those low flow periods.

In his closing remarks, Mr. Westerman noted to the attendees of the meeting, that of all those present, the key group in this development was the Water Resources Board. He then requested from the Water Resources Board, written confirmation of the historic flow data of the South Branch, and the projected flows that the Board anticipated after the reservoir was constructed.

To date, that correspondance has not been received.

2. December 6, 1979

The Quidnick Reservoir Company filed 8 applications to the Federal Energy Regulatory Commission for Preliminary Permits to secure the right to study the development of hydroelectric power at the 8 dams.

Notice of the application was published in the Rhode Island newspapers in accordance with Section 4(f) of the Federal Power Act. No protests were filed. Federal, state, and local agencies that received the notice were requested to provide comments on the application. The Rhode Island Department of Environmental Management, the U.S. Environmental Protection Agency, the U.S. Department of the Interior, and Mr. Brian H. Manning of Coventry, Rhode Island, commented on the application and had no objection to the issuance of the permits.

3. December 21, 1979

The Quidnick Reservoir Company files application to the U.S. Department of Energy's Title IV Program for a $147,600 loan to fund the 8 hydroelectric feasibility studies.

4. May 7, 1980

The Quidnick Reservoir Company receives approval of its loan request from the Department of Energy to study the feasibility of redeveloping hydroelectric power at 8 sites. The contract is signed, returned to D.O.E., and the study begins.

5. June 25 - 27, 1980

The members of the Association receive their preliminary permits on each of the 8 sites from the Federal Energy Regulatory Commission.

6. October 27, 1980

At the Governor's Statewide Conference on Hydropower, representatives of the Water Resources Board address the attendees from the audience. He solicits a favorable vote on the upcoming referenda for the Big River Reservoir, and promises to the Quidnick Reservoir Company, that they will be assured an adequate flow of water to operate their proposed hydroelectric plants.

7. January 23, 1981

The Army Corps of Engineers completes its draft report for the Big River Reservoir Project, and makes it available for public review. The notice sent by the army corps noted the following:

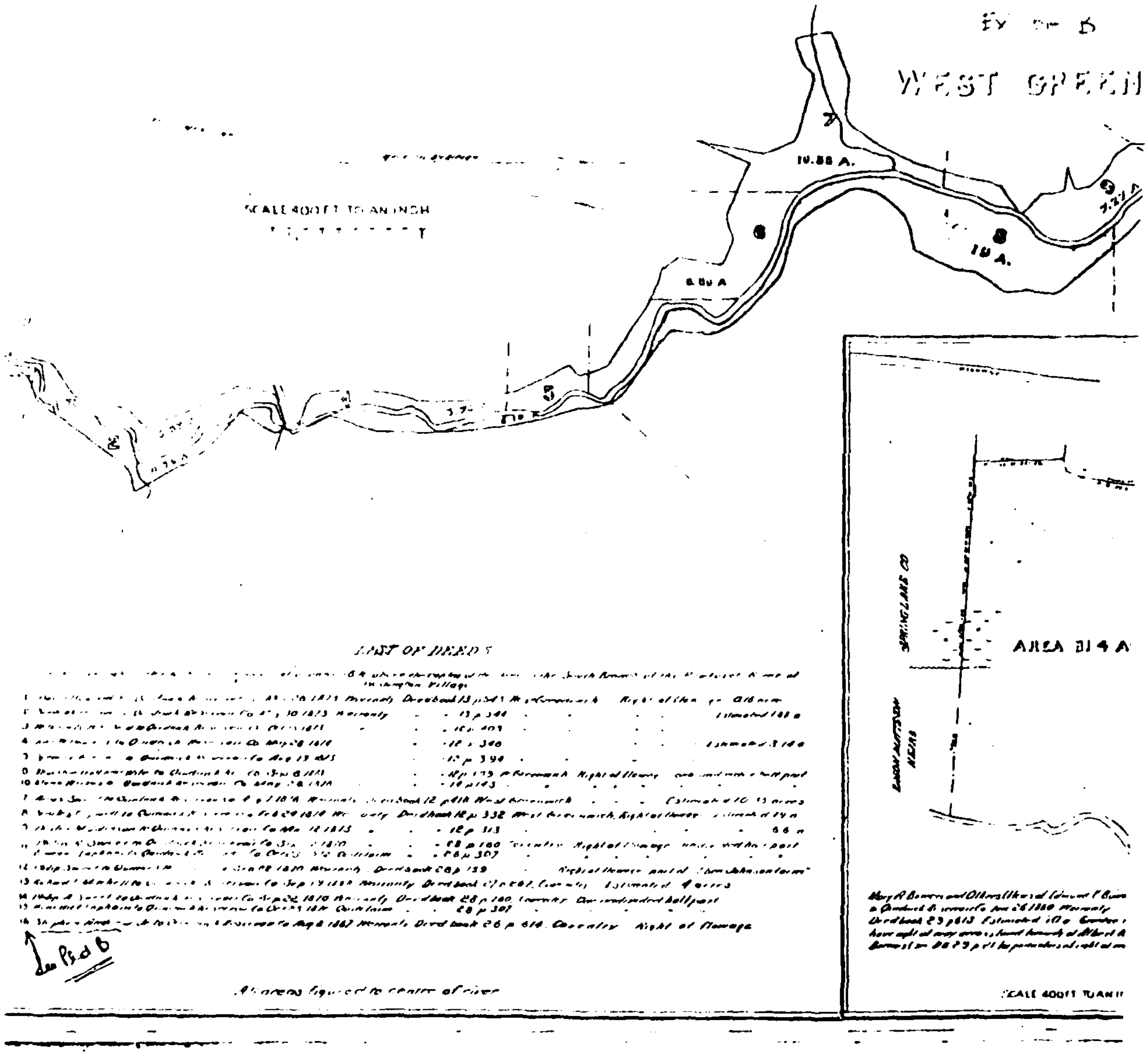
> "the report presents the results of studies undertaken as part of the Pawcatuck River and Narragansett Bay Drainage Basins Water and Related Land Resources Study, to determine the feasibility of the proposed reservoir project for purposes of flood damage reduction, municipal and industrial water supply, and recreation. Results of the 2½ year feasibility study are incorporated into a seven volume report consisting of nearly 2,200 pages of text, tabulated information, and graphical presentation."

However, there is no mention of the Quidnick Reservoir Company's ownership of the Big River Reservoir water rights within the report. There is also no mention of the fact that Quidnick is in the middle of a hydroelectric feasibility study, also funded by the federal government.

The notice sent by the Corps went on to note:

> "Due to the extent of the technical information presented in the report and the resulting cost of reproduction, the number of copies available for general distribution is limited. However, the report is being distributed to other federal, state and local governmental agencies, special groups and interested parties, having responsibilities associated with the proposed project. In addition, copies are being placed in repositories throughout the study area in order that the report be available to all other interested parties, both public and private. All report recipients are shown on the attached list."

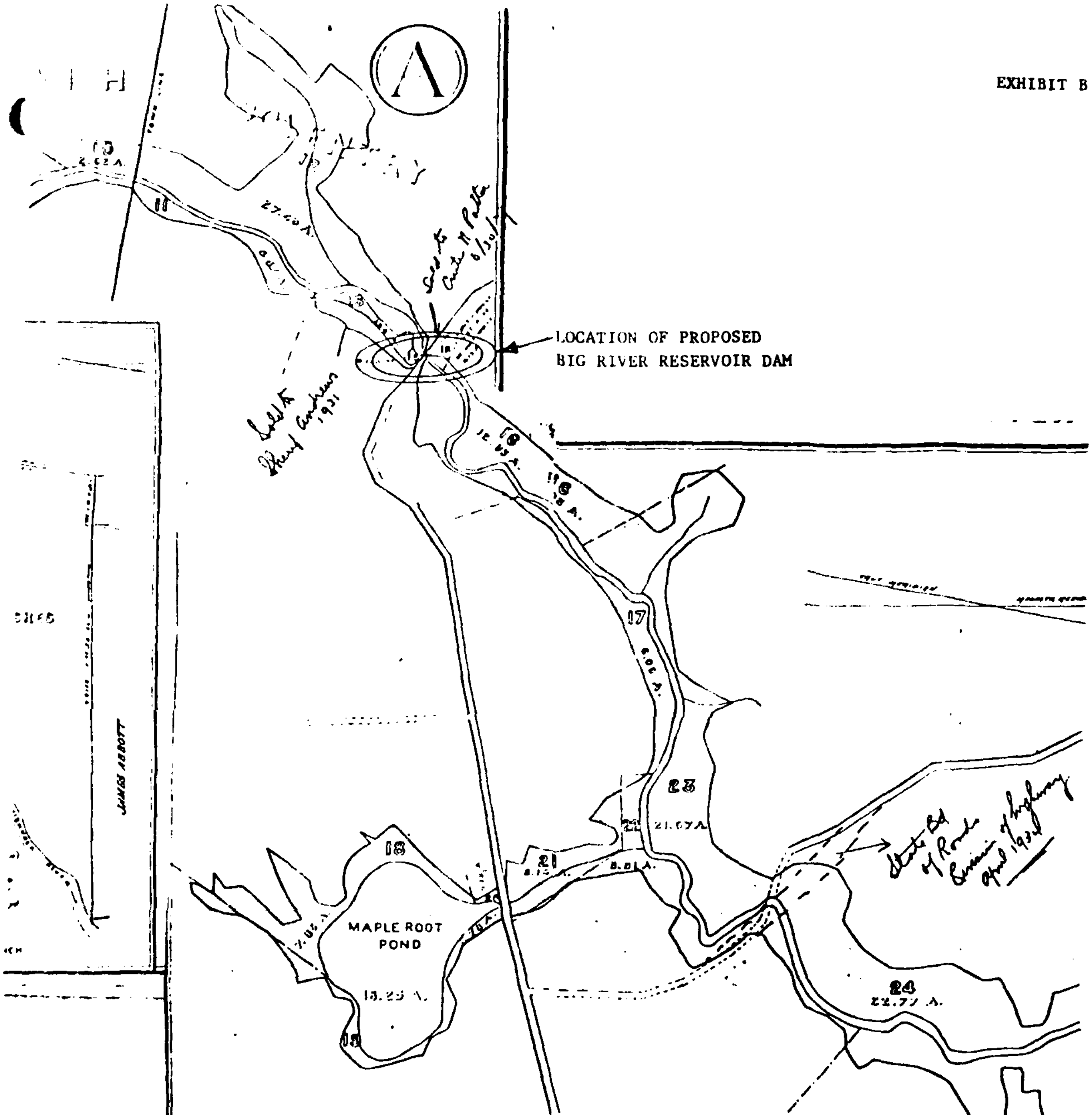
The Quidnick Reservoir Company, however, was not on the Army Corp's list as a "special interest group", or an "interested party", and they therefore did not receive a copy of the report.



QUIDNICK RESERVOIR COMPANY'S OWNERSHIP OF LANDS AND FLOWAGE RIGHTS

IN THE VICINITY OF THE PROPOSED BIG RIVER RESERVOIR

EXHIBIT B



LIST OF DEEDS

[illegible]

16 [illegible] to Quidnick Reservoir Co [illegible] Deed book [illegible] Warranty Right of Flowage
17 [illegible] to Quidnick Reservoir Co June 15 1880, Deed book 30 p 217 [illegible]
21 [illegible]
18 [illegible] to Quidnick Reservoir Co [illegible] Warranty. Right of Flowage
19 [illegible] to Quidnick Reservoir Co [illegible] Warranty Right of Flowage. [illegible]
20 [illegible] to Quidnick Reservoir Co July [illegible] Warranty Right of Flowage
21 [illegible] to Quidnick Reservoir Co April [illegible] 1880 Deed book 30 p 193 Warranty Right of Flowage [illegible]
23 [illegible] to Quidnick Reservoir Co [illegible] Warranty Right of Flowage part of [illegible]
24 [illegible] to Quidnick Reservoir Co May 12 1873 [illegible] Quitclaim. Right of Flowage
25 [illegible] to Quidnick Reservoir Co April [illegible] Warranty Right of Flowage Estimated [illegible] acres
26 [illegible]
26 [illegible] to Quidnick Reservoir Co May [illegible] 1873, Deed book [illegible] Quitclaim Land Flowed — See Plat D
27 [illegible] to Quidnick Reservoir Co June [illegible] Warranty Right of Flowage
28 [illegible] to Quidnick Reservoir Co Nov [illegible] Deed book 29, p 133 Warranty Right of Flowage. Estimated [illegible] acres

All areas figured to centre of river

SECTION 3

COMMENTS AND RESPONSES - OTHER LETTERS RECEIVED

TABLE OF CONTENTS

SECTION 3

COMMENTS AND RESPONSES - OTHER LETTERS RECEIVED

COMMENTS AND RESPONSES

City of Cranston

COMMENT 1: The contruction of this project will not be in the City of Cranston, however, I wish to give my full support in this matter to provide flood damage reduction in the Pawtuxet River, but most importantly to provide ample municipal and industrial water to the cities and towns to be served by this project.

RESPONSE: Your comment is acknowledged and included in the record.

Coventry Rod & Boat Club 9 February 1981

COMMENT 1: Given the current proposals to develop hydro-electric power on the far-lesser dams on the Pawtuxet River, I find puzzling the omission of any such provisions in the Big River dam project.

RESPONSE: Hydroelectric power generation was studied for its feasibility as a project purpose, and was not included at this time. The limited studies performed could not definitely show hydropower generation to be cost-effective, and projected it to be only a small part of the overall facilities, so it was not considered to be a formal project purpose. Further engineering investigations during advanced design stages will address the question of hydropower generation in greater detail, when more information should be available on operational modes of the dam, especially on the period before full water supply yield is needed.

See also response to Comment 1, U.S. Dept. of Energy.

COMMENT 2: The miniscule brook near the scrap yard at old Route 3, and the slow-moving current and relatively narrow width of the stream at Zeke's bridge (Harkney Hill Road) lead me to conclude that such previously published stats as "27 MGD" at the bridge or "42 MGD safe daily yield" from ground and surface water are far too optimistic. I seriously doubt the ability of the site to produce such yields for system projections alone, much less provide the added requirements for maintaining the level of the Flat River Reservoir (Johnson's Pond) plus the needs of downstream industries.

RESPONSE: Hydrologic analyses of the Big River watershed have shown that the safe yield of the reservoir would be approximately 32 MGD if operated independently, based on downstream releases of 6 cfs (3.8 MGD). If operated in a system with Scituate Reservoir, the characteristics of the two watersheds could be taken advantage of to raise the Big River safe yield to approximately 36 MGD. These yields are based on historical rainfall and streamflow records from the Pawtuxet basin. The slow-moving nature of the Big River has resulted in a long cycle of drawdown and refill for the reservoir, but the large storage capacity allows the safe yield to be attained.

Original Bradford Soap Works, Inc. 18 March 1981

COMMENT 1: Our plant has been located on the Pawtuxet River since 1869 and has used the water flowing in the river continually. We presently use the water for cooling various process of our production.

We are concerned that the proposed Big River Reservoir project might effect the watershed of Quidnick Reservoir Company (of which we are a part owner) and ultimately the quantity and quality of the water flowing in the Pawtuxet River. If this should happen it would effect our operation and possibly make the proposed hydro electric power project not feasible.

RESPONSE: See response to Comment 1, Quidnick Reservoir Company.

Concordia Manufacturing Company 20 March 1981

COMMENT 1: After reviewing the "Public Information Pamphlet" prepared by the Army Corps of Engineers regarding the proposed Big River Reservoir, we, as property owners along the river, are concerned about the quantity and quality of the flow remaining for our use.

We currently meet EPA pollutant discharge standards, and we are concerned, should our process change, we might have a problem with this, where none exists currently. Furthermore, we had hopes to develop our dam for its hydro potential. That will be diminished. Our property, currently suitable for rental, sale or expansion, will be reduced in value if our riparian rights are disregarded. I'm told the river classification will drop from C to D, and the 128 CFS flow will be cut in half. It is my understanding that riparian rights are recognized in Rhode Island law, and therefore, anything that impedes our flow infringes on our legally enforceable rights.

RESPONSE: See response to Comments 1, 4 of Quidnick Reservoir Company.

Arctic Development Corporation 23 March 1981

COMMENT 1: Riparian Rights; as owners of riparian rights, we are concerned that the water will become diminished in quality and quantity as a result of your reservoir project. Under the common law doctrine of riparian rights, which is recognized in the State of Rhode Island, we, as riparian owners, have the right to have the water flow past our land undiminished in quality and quantity. Your public information pamphlet did not recognize our riparian rights. We believe serious reductions in river flow past our dam site are not within the bounds of Rhode Island riparian law, and, if your project is implemented, it would have a serious effect on the market value of our industrial property.

RESPONSE: See response to Comment 5, Quidnick Reservoir Company.

COMMENT 2: Industrial Uses; as we own a large industrial complex on the site of the Arctic Dam, the reduced quality and quantity of flow past our site could have serious consequences to present or future use of the industrial permises that we may now, or in the future, lease to manufacturing users in that we would be unable to meet future E.P.A. effluent discharge and temperature requirements that may be required by us or future tenants. The reduction in flow could also result in a change in classification of the river as it passes our dam site from a Class C to a Class D. This could limit the use of water for certain industrial processes. We, as landlords, are fearful that present tenants might consider vacating if water is not available to them and that future tenants would be more difficult to procure having a negative effect on our rental income and property value.

RESPONSE: See response to Comment 4, Quidnick Reservoir Company.

COMMENT 3: Hydroelectric Use; implementation of the Big River Reservoir Project could render our proposed hydroelectric plant, at the Arctic Dam site, economically infeasible. A hydroelectric feasibility study, under the auspices of the D.O.E., is now approximately 75% complete and indicates our site as being feasible for the generation of electric power based on the past average river flows (128 cfs). It appears that your project would only provide us with half as much flow. We had counted on the development of this hydroelectric facility to allow our own operating company and those of our tenants to become more competitive with other manufacturing facilities, particularly those in the south, who do not have the high costs of providing heat and electricity to their plants. Without question, your restriction of the river flows, that we had counted on, would mean that we would be unable to develop hydro power and would worsen our competitive position, all at great expense.

RESPONSE: See response to Comment 1, Quidnick Reservoir Company.

Valley Industries, Inc. 24 March 1981

COMMENT 1: We are owners of an industrial mill complex and a dam site on the Pawtuxet River in West Warwick, Rhode Island, known as the Centreville Mill and Centreville Dam, respectively, that carry riparian rights which we feel will be infringed upon by the proposed Big River Reservoir Project. As we understand the law in Rhode Island concerning riparian rights, we have the right to the continued flow of water over our dam undiminished in quantity and quality. To reduce this quality or quantity, is to reduce the value of our property on the river.

RESPONSE: See response to Comment 5, Quidnick Reservoir Company.

COMMENT 2: A study is being conducted to determine the feasibility of generating hydroelectric power at our dam site. This study, which is sponsored by the Department of Energy, and is approximately 75% complete, indicates that our dam site is feasible for the generation of electric power, If we understand your proposed project correctly, you will be reducing the average flow by about 50%. This would render our proposed hydro plant economically infeasible at a significant loss of future profits. We had also counted on this power to allow us and other tenants in our industrial complex to be more competitive with southern manufacturers who have relatively low cost electric power.

RESPONSE: See response to Comment 1, Quidnick Reservoir Company.

COMMENT 3: Furthermore, a reduction in the quantity or quality of the flow at our site would make it difficult, if not impossible, to meet future effluent discharge and temperature requirements that may be required by present or future tenants. It could also limit the use of water for certain industrial processes. We therefore run the risk of losing some of these valued tenants if the water is not available to them and would make it more difficult for us to obtain new tenants in the future, all having a serious effect on our future income and property value.

RESPONSE: See response to Comment 4, Quidnick Reservoir Company.

Westerman Realty Company 26 March 1981

COMMENT 1: We have read your Public Information pamphlet with great interest. We find the reduction in flow of the Pawtuxet River South Branch will cause severe damage to our company, as a multi-tenanted landlord. Our current two tenants (Hope Valley Dyeing Corp. and Warwick Dyeing Corp.) will have a large reduction in the quality of the water they currently use for dyeing. This is because the reduced flows will reduce the dilution of the American Hoechst effluent. This comes down stream to us in a "weak tea" color. With half the flow, the color will be twice as dark and this will make the river water useless for light shades of dyeing. Hope Valley Dyeing Corp. currently uses 30,000 gal./day of municipal water and 32,000 gal./day of river water. This would shift to almost 100% municipal water.

RESPONSE: See response to Comment 3, Quidnick Reservoir Company.

COMMENT 2: As a landlord of river front industrial property, our future tenants would have great trouble meeting EPA discharge requirements. Our reparian rights to the quality and quantity of the water has been severely reduced by this reservoir.

RESPONSE: See response to Comments 2, 5 of Quidnick Reservoir Company.

COMMENT 3: In addition, we are in the middle of a D.O.E. hydro-electric feasibility study of two dam sites for retrofitting. By cutting the flow in half, our two old hydroelectric sites will not be able to make electricity economically.

RESPONSE: See response to Comment 1, Quidnick Reservoir Company.

City of Cranston 2 April 1981

COMMENT 1: The City of Cranston and its various agencies have long been in favor of water resource planning in order to continue the fine tradition of drinking water that the residents of Cranston have traditionally enjoyed.

As noted in your public announcement of February 26, 1981, the Big River Reservoir Project is a multi-purpose proposal including a comprehensive water resources management plan for flood damage reduction, a municipal and industrial water supply, and public recreation. The City favors objectives in all of these areas.

RESPONSE: Your comment is acknowledged and included in the record.

COMMENT 2: Flood damage in areas on the lower Pawtuxet River in Cranston, Warwick and West Warwick have caused increasing problems recently. Efforts to mitigate the flood damages are thus welcomed. However, the City wishes to point out that reduction of flows will result in other impacts on the Pawtuxet River most notably in water quality. A recent study conducted for the City noted that the effect of the proposed Big River Reservoir will be a natural flow reduction of 15% on the main stem of the Pawtuxet River. This would cause an increase of 9% in the percentage of wastewater in the river, e.g. from 9% to 18%. Any future flood reduction policy and programs from the Big River Reservoir Project should carefully consider impacts on water quality.

RESPONSE: See response to Comment 3, U.S. EPA.

COMMENT 3: Minimum flows in the Pawtuxet River are vital to maintain the river's integrity as well as to protect the Upper Bay. In planning for future flow control, it appears essential that management of both the Scituate Reservoir and the Big River Reservoir is coordinated so that adequate minimum flows in the Pawtuxet are assured.

RESPONSE: See response to Comment 3, U.S. EPA.

Town of West Warwick 7 April 1981

COMMENT 1: Be advised that the wasteload allocation for the Town of West Warwick Treatment Plant has been calculated on 6 cfs (3.8 mgd) seven day low flow. This does not include seepage. This is of particular concern to the Town during the construction and filling of the Reservoir. The effect on treatment facilities should be assessed.

RESPONSE: Calculations of downstream releases done by the Corps had produced a 6 cfs minimum release, which would satisfy the West Warwick Treatment Plant requirements. This minimum release would be maintained throughout the construction and filling period. This release is subject to upward revision on further analysis; see response to Comment 8, U.S. EPA letter. Thus, there should be no adverse affect on the downstream treatment facilities.

COMMENT 2: The downstream riparian rights should be assessed in relation to the minimum downstream release during construction and filling of the Reservoir.

RESPONSE: See response to Comment 5, Quidnick Reservoir Company.

COMMENT 3: It is noted, finally, that one alternative transmission line would be going down Washington Street in West Warwick, During construction of this line, would the Corps be responsible for the replacement of destroyed or damaged sewer lines?

RESPONSE: The transmission main from the treatment plant to the connection with the Providence Water Supply Board System would be a non-Federal responsibility. Damages due to construction of the transmission line would also be the responsibility of the non-Federal sponsor. It should be noted, however, that engineering studies done for the feasibility study have shown the tunnel to be the best alternative transmission method. Should advanced design studies bear out this conclusion, no sewer lines would be disrupted by tunnel construction.

Coalition of Coastal Communities 8 April 1981

COMMENT 1: Although the municipalities of Newport, North Kingstown, Narragansett, Jamestown and other South County towns are not included in the project's study area, the water supply needs of these coastal communities must be addressed in the plans for the proposed reservoir. The magnitude of the communities needs has been shown by the recent severe water shortages in the areas.

RESPONSE: See response to Comment 2, RI Statewide Planning Program, A-95 Coordinator.

COMMENT 2: The Army Corps choice of the 1975 statewide planning program's population projections as opposed to their 1979 figures is not an acceptable basis to plan R.I.'s future water supply needs. This is supported by preliminary figures from the 1980 census which suggest that the 1979 projection is more accurate.

RESPONSE: See response to Comment 8, U.S. Fish and Wildlife Service letter.

COMMENT 3: Possible reductions in the water quality of the Pawtuxet River resulting from a 15% reduction in the lower river flow was not sufficiently discussed in the Environmental Impact Statement (eg. section 5.02.3 (1) and (2). The Coalition has estimated that the volume of sewerage treatment plant wastewater in the lower Pawtuxet will increase from the present 9% to 18% of the average natural flow when the Big River Reservoir and the expansion of sewerage treatment plants on the river are complete. (Coalition of Coastal Communities, "Cranston Environmental Audit," 1980). Furthermore, the percentage of the wastewater in the river during low flow conditions will increase from 50% to over 65% after the completion of the reservoir. We feel that these hydrological modifications will constitute an alternation of the river's water quality and therefore should be fully described in the report.

RESPONSE: See response to Comment 3, U.S. EPA.

Arthur W. Erickson 10 April 1981

COMMENT 1: I am troubled with the proximity of the Picillo chemical dump site leaching its large quantity of poisonous chemicals directly into this proposed Big River Reservoir. This dump and all the lakes and groundwater around it is approximately 250 to 330 feet higher in elevation than this new reservoir. It is less than 2½ miles from the reservoir itself. I should think your engineers would be highly concerned with this problem. The proposed dam at Zeke's Bridge is approximately 4.5 miles from the dump and approximately 330 feet lower.

What I would like to have done is to rid this dump of its chemicals before the reservoir site is started at all. This dump is one of the 3 most explosive and dangerous dumps in New England and the country. The EPA and DEM have been involved with this dump since 1977 and the method of dumping these chemicals and condition of same has deteriorated to such a state that if they are not taken care of immediately, they will be with us for years to come. The sooner done, the better and chances of these chemicals leaching down from a height of 330 feet to Zeke's Bridge will be eliminated.

RESPONSE: See response to Comment 3, U.S. Dept. of Housing and Urban Development letter. The cleanup of such a site is not within the Corps' authority, so any efforts to remedy the Picillo situation must be undertaken by other Federal or State agencies.

Coventry Republican Town Committee 13 April 1981

COMMENT 1: What affect will the close proximity of the Piccillo dump, one of the worst toxic dump sites in New England, have on its' water reserve quality?

RESPONSE: See response to Comment 3, U.S. Dept. of Housing and Urban Development.

COMMENT 2: What effect will the admitted 50% reduction in water flow into Johnson's Pond have?

A.) Will level of water be reduced, thus effecting recreation and/ or waterfront property values?

B.) If flow is reduced by that amount, will it turn into a large sewage system, do to stagnant water?

RESPONSE: More frequent and longer duration drawdowns of Flat River Reservoir will occur as a result of the reduced flows from Big River. A system simulation of the effect of Big River Reservoir on Flat River Reservoir was done for the Big River feasibility study, and shows that average

Monthly Flat River pool levels will be reduced by as much as 1.3 feet during November. However, during April and May, pool levels will be reduced by only about 0.1 feet on the average.

TOWN OF COVENTRY
Town Hall, 670 Flat River Road, Coventry, R.I. 02816 • Tel. 821-6400

April 15, 1981

C. E. Edgar III
Colonel, Corps of Engineers
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Ma 02254

Dear Colonel Edgar:

Enclosed please find copy of resolution passed and adopted by the Town Council at its regular meeting held on April 13, 1981.

Very truly yours,

Monique Capwell CMC

Monique Capwell CMC
Town Clerk

Enc.

TOWN OF COVENTRY

RESOLUTION

OF THE

TOWN COUNCIL

NO. ____________

RESOLVED:

That the Coventry Town Council be on record as opposed to the building of the Big River Reservoir for the following reasons:

1. The diversion of approximately 50% of the water entering the Flat River Reservoir, also known as Johnson's Pond. This is Coventry's largest water recreational resource, and is enjoyed by people from all over the State of Rhode Island. Johnson's Pond is also important to the town's industry located along the river, i.e. America Hoescht Co.

2. All of the recreation that will be allowed in the proposed reservoir will be in the town of West Greenwich and none in the Town of Coventry.

3. The possible effects of the chemicals at the Piccilo Dump site and the possibility that in the many years to come may render the reservoir useless.

PASSED AND ADOPTED this ____ day of ____________ 1981.

APPROVED ______________________
President

ATTEST: ______________________
Town Clerk

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
WASHINGTON, D.C. 20510

April 6, 1981

Colonel C.E. Edgar, III
New England Division Engineer
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Edgar:

Thank you for contacting me with regard to the draft Feasibility Report and draft Environmental Impact Statement currently being compiled for the Big River Reservoir Project in Coventry and West Greenwich Rhode Island.

I am pleased to know that plans for the project are continuing to progress, since the Big River Reservoir will play a crucial role in fulfilling the future drinking water needs of the state of Rhode Island. I am particularly concerned that every possible environmental precaution be taken to insure the long term integrity of the planned reservoir.

As you may know, the discharge of bulk chemicals into the ground and the burial of drums containing hazardous chemicals at the Picillo property located in Coventry, Rhode Island has created a significant contamination problem which is being addressed by state and federal officials. Since the Picillo property is located within several miles of the site of the planned Big River Reservoir, it is especially important that all potential effects of this contamination be studied to insure that no threat exists to the project area.

It is my understanding that chemical contaminants from the Picillo site have been found to be leeching into an adjacent wetlands area. The proximity of this area to the Flat River and Quidnick Reservoirs is of understandable concern to many area residents, and the eventual migration of the leachate to the Big River watershed area is a question which certainly merits a thorough examination. I ask that the Army

Corps of Engineers avail itself of all pertinent data compiled by the federal Environmental Protection Agency and the Rhode Island Department of Environmental Management and to conduct any other studies which might be necessary in order to address in the draft Environmental Impact Statement all the potential effects of contamination emanating from the Picillo chemical dumpsite on the Big River Reservoir Project.

Thank you for your kind cooperation. Please include this letter with the other comments received at the public meeting conducted by the Corps in Coventry, Rhode Island on March 26, 1981.

With best wishes.

Sincerely,

John H. Chafee

John H. Chafee
United States Senator

JHC:dg

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDPL-BU

21 April 1981

Honorable John H. Chafee
United States Senate
Washington, D.C. 20510

Dear Senator Chafee:

I have your letter of 6 April 1981 regarding the hazardous waste dump at the Picillo property in Coventry, Rhode Island, and the possibility of contamination of the Big River watershed.

Members of my staff have met with members of the staff of the office of Uncontrolled Hazardous Waste Sites, U.S. Environmental Protection Agency, Region 1, to discuss the magnitude of the problem and its relation to the Big River Reservoir study. The EPA has made investigations of the site in cooperation with the Rhode Island Department of Environmental Management, and has recently published two reports, "Evaluation of Abatement Alternatives: Picillo Property, Coventry, Rhode Island," (January 1981), and "Use of Remote Sensing Techniques in a Systematic Investigation of an Uncontrolled Hazardous Waste Site," (February 1981).

Study efforts to date by EPA have identified the scope of the contamination problem, and several possible solutions, along with recommendations for further study to further define the problem. Among the findings of the EPA studies are that approximately 10,000 gals/day of contaminated groundwater are flowing away from the Picillo site and into the nearby swamp.

Observation well tests have shown the groundwater flow to be in a northwesterly direction, away from both Quidnick Reservoir and the Big River watershed. Surface runoff into either watershed is also contraindicated by the topography of the area, and testing of Quidnick Reservoir has shown no signs of contamination to date. EPA has indicated that further monitoring wells will be installed to confirm that no contaminated groundwater flows in an easterly direction.

In conclusion, although the Picillo waste dump does not appear to pose any hazard to the Big River Reservoir development, we will continue our efforts to remain abreast of additional information as it becomes available, both from EPA and other sources.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Copy Furnished:
Honorable John H. Chafee
United States Senator
301 Pastore Federal Building
Providence, Rhode Island 02903

EXECUTIVE CHAMBER

CITY OF CRANSTON — RHODE ISLAND

EDWARD D DIPRETE
MAYOR

February 3, 1981

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Att: Col. William E. Hodgson, Jr.
Acting Division Engineer

Re: Big River Reservoir Project

Dear Col. Hodgson:

The construction of this project will not be in the City of Cranston, however, I wish to give my full support in this matter to provide flood damage reduction in the Pawtuxet River, but most importantly to provide ample municipal and industrial water to the cities and towns to be served by this project.

I am fully aware of the potential serious problem in water supply if this project does not proceed with expediency.

Sincerely,

Edward D. DiPrete

Edward D. DiPrete
Mayor

cc: Stanton M. Latham

Col. C.E. Edgar III
Corps of Engineers
New England Division

78 Columbia ave
Coventry, R.I. 02816
9 February 1981

Subject: Big River Reservoir Project, announcement of Public meeting, Request for further information.

1. Given the current proposals to develop hydro-electric power on the far-lesser dams on the Pawtuxet River, I find puzzling the omission of any such provisions in the Big River dam project.

Surely, a 70 foot head of water would drive turbines of considerable magnitude, and surely, our vaunted American technology can devise a method of utilizing this head for hydro-power and still provide for efficient transmission to the ultimate consumer and/or water supply system.

Given our current and on-going energy crisis, I can only consider this omission inexcusable at best.
I solicit your rationale on this point.

2. Having hiked, fished and boated the proposed impoundment area for the past 30 years, I have an intimate familiarity with the site and especially the water flow.
The miniscule brook near the scrap yard at old Route 3, and the slow-moving current and relatively narrow width of the stream at Lake's bridge (Harkney Hill Road) lead me

to conclude that such previously published statements "37 MGD" at the bridge or "42 MGD safe daily yield" from ground and surface water are far too optimistic. I seriously doubt the ability of the site to produce such yields for system projections alone, much less provide the added requirements for maintaining the level of the Flat River Reservoir (Johnson's Pond) plus the needs of downstream industries.

Let me expand that point: Johnson's Pond receives the entire flow of the Big River PLUS Turkey Meadow Brook and a dozen other minor tributaries (which are not available to you, or rather, to the Big River Project). Yet despite the additional flow into Johnson's Pond, over and above Big River, there have been numerous occasions in past years wherein Johnson's Pond had to be drained down below accepted recreational levels in order to satisfy the needs of downstream industries. On this basis, I submit that to fill the reservoir, to export 42 MGD out of the county, to maintain the Johnson's Pond level and to satisfy downstream requirements, all simultaneously, is beyond the capacity of the watershed, despite the voluminous data presented in the comprehensive report.

Since a previously scheduled R.I. Militia meeting will preclude my attendance at your 26 March meeting, I would appreciate your comments by mail.

Sincerely,

Warren F. Dietzel
Director, Coventry Rod + Boat Club

BRADFORD

Original Bradford Soap Works, Inc.

Special Chemical Products WEST WARWICK, R. I. 02893 · 401 821-2141

March 13,1981

Department [illegible] the [illegible]
[illegible] Division,
Corps of Engineers
424 Trapelo Road
Waltham, [illegible] 02254
Attn: [illegible]
[illegible] E. Edgar, III
Colonel, Corps of Engineers
Division Engineer

[illegible] RESERVOIR [illegible]
[illegible] REPORT
[illegible] PUBLIC [illegible] ANNOUNCEMENT
[illegible] SPONSORED [illegible] /81

Gentlemen:

Our plant has been located on the Pawtuxet River since 1869 and has used the water from the river continually. We presently use the water for cooling various [illegible] of our production.

We are concerned that the proposed [illegible] River Reservoir project [illegible] Reservoir Company (of which we are [illegible] owner) and ultimately [illegible] quantity and quality of the water flowing in the Pawtuxet River. If this should happen it would affect our operation and possibly [illegible] the proposed hydro electric power project not feasible.

BRADFORD

Original Bradford Soap Works, Inc.

Special Chemical Products

WEST WARWICK, R. I. 02893 · 401 821-2141

We are concerned that the "Public Information Pamphlet" did not address the riparian rights of the Quidnick Reservoir Company and trust that you will rectify that situation and advise us of your thoughts on this matter.

Very truly yours,

ORIGINAL BRADFORD SOAP WORKS, INC.

Allen [illegible]. Howland
Chairman of the Board

[illegible]/dr

Concordia

March 20, 1981

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Attention: N.E.D.P.L.-B.U.
c/o C. E. Edgar, III
Colonel, Corps of Engineers
Division Engineer

Re: Big River Reservoir Project
Public Comment Period
Response to Public Meeting Announcement
U.S.A.C. Correspondence of 2/26/81

New England Division, Corps of Engineers

Gentlemen:

After reviewing the "Public Information Pamphlet" prepared by the Army Corps of Engineers regarding the proposed Big River Reservoir, we, as property owners along the river, are concerned about the quantity and quality of the flow remaining for our use.

We currently meet EPA pollutant discharge standards, and we are concerned, should our process change, we might have a problem with this, where none exists currently. Furthermore, we had hopes to develop our Dam for its hydro potential. That will be diminished. Our property, currently suitable for rental, sale or expansion, will be reduced in value if our riparian rights are disregarded. I'm told the river classification will drop from C to D, and the 128 CFS flow will be cut in half. It is my understanding that riparian rights are recognized in Rhode Island law, and therefore, anything that impedes our flow infringes on our legally enforceable rights.

Sincerely,

Paul Boghossian

Paul Boghossian
President

rmm

CONCORDIA MANUFACTURING COMPANY · COVENTRY RHODE ISLAND · 401 828 1100
POST OFFICE BOX 151 WEST WARWICK RHODE ISLAND 02893

ARCTIC DEVELOPMENT CORPORATION

33 Factory Street
West Warwick, Rhode Island

March 23, 1981

The Army Corps of Engineers
New England Division
424 Trapelo Rd.
Waltham, Ma. 02254

Att: Col. C. E. Edgar III, Division Engineer
N.P.E.D.P.L.-B.U.

Re: Big River Reservoir Project

Gentlemen:

With reference to your Public Meeting Announcement covered by your correspondence of February 26, 1981 concerning the above-referenced project, please be advised that we have read your public information pamphlet and would like to make the following comments regarding:

#1) RIPARIAN RIGHTS: as owners of riparian rights, we are concerned that the water will become diminished in quality and quantity as a result of your reservoir project. Under the common law doctrine of riparian rights, which is recognized in the State of Rhode Island, we, as riparian owners, have the right to have the water flow past our land undiminished in quality and quantity. Your public information pamphlet did not recognize our riparian rights We believe serious reductions in river flow past our dam site are not within the bounds of Rhode Island riparian law, and, if your project is implemented, it would have a serious effect on the market value of our industrial property

#2) INDUSTRIAL USES; as we own a large industrial complex on the site of the Arctic Dam, the reduced quality and quantity of flow past our site could have serious consequences to present or future use of the industrial premises that we may now, or in the future, lease to manufacturing users in that we would be unable to meet future E.P.A. effluent discharge and temperature requirements that may be required by us or future tenants. The reduction in flow could also result in a change in classification of the river as it passes our dam site from a Class C to a Class D. This could limit the use of water for certain industrial processes. We, as landlords, are fearful that present tenants might consider vacating if water is not available to them and that future tenants would be more difficult to procure having a negative effect on our rental income and property value.

#3) HYDROELECTRIC USE; implementation of the Big River Reservoir Project could render our proposed hydroelectric plant, at the Arctic Dam site, economically infeasible. A hydroelectric feasibility study, under the auspices of the D.O.E., is now approximately 75% complete and indicates our site as being feasible for the generation of electric power based on the past

continued...

ARCTIC DEVELOPMENT CORPORATION

average river flows (128 cfs). It appears that your project would only provide us with half as much flow. We had counted on the development of this hydroelectric facility to allow our own operating company and those of our tenants to become more competitive with other manufacturing facilities, particularly those in the south, who do not have the high costs of providing heat and electricity to their plants. Without question, your restriction of the river flows, that we had counted on, would mean that we would be unable to develop hydro power and would worsen our competitive position, all at great expense.

It is disturbing to us that this project has proceeded without having given consideration to our rights and, as far as we know, the rights of other property owners on the Pawtuxet River who are fellow members of the Quidnick Reservoir Company. Nor, as parties, have we received any communications, addressed to us, from the Army Corps or the State's Water Resources Board concerning our rights or even recognized our existence. It was only by chance that we became aware of your P.M.A. and your P.I.P.

As you have not addressed any of the above three points in your pronouncements may we have your position regarding them. Thank you.

In the meantime, we must make strong objections to your plans for the Big River Reservoir Project as we now understand them.

Very truly yours,

ARCTIC DEVELOPMENT CORPORATION

ROBERT T. GALKIN, President
RTG:jll
cc:Saul Hodosh, Esq.
Halliwell Assoc., Inc.
Quidnick Reservoir Co.

Valley Industries, Inc.

33 FACTORY STREET
WEST WARWICK, RHODE ISLAND

March 24, 1981

Col. C. E. Edgar III, Division Engineer
N.P.E.D.P.L.-B.U.
The Army Corps of Engineers
New England Division
424 Trapelo Rd.
Waltham, MA 02254

Dear Col. Edgar:

A public information pamphlet issued by the Army Corps of Engineers concerning the Big River Reservoir Project in Rhode Island was recently brought to our attention by another party who also advised us of your public meeting announcement of February 26, 1981. Needless to say, we were annoyed in receiving this information in the way we did since, as outlined below, we are parties with vital interests who should have received direct communication.

We are owners of an industrial mill complex and a dam site on the Pawtuxet River in West Warwick, Rhode Island, known as the Centreville Mill and Centreville Dam, respectively, that carry riparian rights which we feel will be infringed upon by the proposed Big River Reservoir Project. As we understand the law in Rhode Island concerning riparian rights, we have the right to the continued flow of water over our dam undiminshed in quantity and quality. To reduce this quality or quantity, is to reduce the value of our property on the river.

A study is being conducted to determine the feasibility of generating hydroelectric power at our dam site. This study, which is sponsored by the Department of Energy, and is approximately 75% complete, indicates that our dam site is feasible for the generation of electric power. If we understand your proposed project correctly, you will be reducing the average flow by about 50%. This would render our proposed hydro plant economically infeasible at a significant loss of future profits. We had also counted on this power to allow us and other tenants in our industrial complex to be more competitive with southern manufacturers who have relatively low cost electric power.

AD-A105 362 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS WATER AND --ETC(U)
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Furthermore, a reduction in the quantity or quality of the flow at our site would make it difficult, if not impossible, to meet future effluent discharge and temperature requirements that may be required by present or future tenants. It could also limit the use of water for certain industrial processes. We therefore run the risk of losing some of these valued tenants if the water is not available to them and would make it more difficult for us to obtain new tenants in the future, all having a serious effect on our future income and property value.

As the Army Corps nor the Rhode Island Water Resources Board has not given any consideration to our rights, nor have they communicated with us in any way, we must take exception to the Big River Reservoir Project and voice our objections to it. May we please hear from you on these points as soon as possible.

Very truly yours,

VALLEY INDUSTRIES, INC.

Denis J. Leahy
Vice President

DL:ss

cc: Halliwell Associates
Hodosh, Spinella & Angelone, attorneys
Quidnick Reservoir Company

WESTERMAN REALTY COMPANY
20 REMINGTON STREET
WEST WARWICK, R. I. 02893
◆
AREA CODE 401
TELEPHONE: 821-3880

March 26, 1981

Department of the Army
N. E. Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Attn: N.E.D.P.L.-B.U.
c/o C. E. Edgar, III
Colonel, Corps of Engineers
Division Engineer

Re: Big River Reservoir Project
Public Comment Period
Response to Public Meeting Announcement
U.S.A.C. Correspondence of 2/26/81

Gentlemen:

We have read your Public Information pamphlet with great interest. We find the reduction in flow of the Pawtuxet River South Branch will cause severe damage to our company, as a multi-tenanted landlord. Our current two tenants (Hope Valley Dyeing Corp. and Warwick Dyeing Corp.) will have a large reduction in the quality of the water they currently use for dyeing. This is because the reduced flows will reduce the dilution of the American Hoechst effluent. This comes down stream to us in a "weak tea" color. With half the flow, the color will be twice as dark and this will make the river water useless for light shades of dyeing. Hope Valley Dyeing Corp. currently uses 30,000 gal./day of municipal water and 32,000 gal./day of river water. This would shift to almost 100% municipal water.

As a landlord of river front industrial property, our future tenants would have great trouble meeting EPA discharge requirements. Our riparian rights to the quality and quantity of the water has been severely reduced by this reservoir.

In addition, we are in the middle of a D.O.E. hydroelectric feasibility study of two dam sites for retrofitting. By cutting the flow in half, our two old hydroelectric sites will not be able to make electricity economically.

In summary, we believe you have not addressed our riparian rights in relation to the R. I. Riparian Law and therefore, we do not want this reservoir project implemented. If public policy demands the project continues, then the Westerman Realty Company demands just compensation.

Very truly yours,

WESTERMAN REALTY COMPANY

Joel Westerman

Joel Westerman, Vice-Pres.

JW:jl

EXECUTIVE CHAMBER

CITY OF CRANSTON — RHODE ISLAND

EDWARD D. DiPRETE
MAYOR

April 2, 1981

Colonel C.E. Edgar, III
Division Engineer
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Re: Big River Reservoir Project

Dear Colonel Edgar:

Regretfully, the City of Cranston was not able to send a representative to the hearing on March 26, 1981, regarding the Big River Reservoir Project as sponsored by your agency.

The City of Cranston and its various agencies have long been in favor of water resource planning in order to continue the fine tradition of drinking water that the residents of Cranston have traditionally enjoyed.

As noted in your public announcement of February 26, 1981, the Big River Reservoir Project is a multi-purpose proposal including a comprehensive water resources management plan for flood damage reduction, a municipal and industrial water supply, and public recreation. The City favors objectives in all of these areas.

Flood damage in areas on the lower Pawtuxet River in Cranston, Warwick and West Warwick have caused increasing problems recently. Efforts to mitigate the flood damages are thus welcomed. However, the City wishes to point out that reduction of flows will result in other impacts on the Pawtuxet River most notably in water quality. A recent study conducted for the City noted that the effect of the proposed Big River Reservoir will be a natural flow reduction of 15% on the main stem of the Pawtuxet River. This would cause an increase of 9% in the percentage of wastewater in the river, e.g. from 9% to 18%. Any future flood reduction policy and programs from the Big River Reservoir Project should carefully consider impacts on water quality.

Minimum flows in the Pawtuxet River are vital to maintain the river's integrity as well as to protect the Upper Bay. In planning for future flow control, it appears essential that

Colonel C.E. Edgar, III
April 2, 1981
Page 2

management of both the Scituate Reservoir and the Big River Reservoir is coordinated so that adequate minimum flows in the Pawtuxet are assured.

Thank you for the opportunity to comment on this important proposal.

Sincerely,

Edward D. DiPrete

Edward D. DiPrete
Mayor

EDD:mlb

MEMBERS OF TOWN COUNCIL
JOYCE G. BULGER
President
GEORGE J. McKANNA
Vice-President
ALBERT D. RUZZO, JR.
~~G. RAYMOND COUTU~~
RICHARD S. HUGHES, JR
Council Clerk
ANNA C. QUARTO C.M.C

State of Rhode Island and Providence Plantations
Town of West Warwick
TOWN CLERK'S OFFICE
TOWN HALL
1170 MAIN STREET, WEST WARWICK, R.I. 02893

April 7, 1981

Division Engineer
New England Division
U.S. Army Corps of Engineer
424 Trapelo Road
Waltham, Mass. 02254

RE: BIG RIVER RESERVOIR

The Town of West Warwick would like to make the following comments for the record, concerning the above reference project:

1. Be advised that the wasteload allocation for the Town of West Warwick Treatment Plant has been calculated on 6 cfs (3.8 mgd) seven day low flow. This does not include seepage. This is of particular concern to the Town during the construction and filling of the Reservoir. The effect on treatment facilities should be assessed.

2. The downstream riparian rights should be assessed in relation to the minimum downstream release during construction and filling of the Reservoir.

3. It is noted, finally, that one alternative transmission line would be going down Washington Street in West Warwick. During construction of this line, would the Corps be responsible for the replacement of destroyed or damaged sewer lines?

The Town requests that a copy of the responsiveness summary be forwarded to us, when it is available.

Very truly yours,

Joyce G. Bulger

Joyce G. Bulger
Council President

JGB:nap

COALITION of COASTAL COMMUNITIES

Washington County Government Center
Tower Hill Rd., Wakefield, R.I. 02879

COUNCILMAN JOHN DOYLE, *President*
MAYOR EDWARD DIPRETE, *Vice President*
COUNCILMAN EDWARD SMITH, *Secretary*
PETER DEANGELIS, *Treasurer*

DAVID STROUSS, *Executive Director*

401-789-9917

April 8, 1981

C. E. Edgar, III
Colonel, Corps of Engineers
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Edgar, III:

The Coalition of Coastal Communities submits the following comments on the U.S. Army Corps of Engineer's plans for the Big River Reservoir project in response to the March 26 announcement.

(1) Although the municipalities of Newport, North Kingstown, Narragansett, Jamestown and other South County towns are not included in the project's study area, the water supply needs of these coastal communities must be addressed in the plans for the proposed reservoir. The magnitude of the communities needs has been shown by the recent severe water shortages in the areas.

(2) The Army Corps choice of the 1975 statewide planning program's population projections as opposed to their 1979 figures is not an acceptable basis to plan R.I.'s future water supply needs. This is supported by preliminary figures from the 1980 census which suggest that the 1979 projection is more accurate.

(3) Possible reductions in the water quality of the Pawtuxet River resulting from a 15% reduction in the lower river flow was not sufficiently discussed in the Environmental Impact Statement (eg. section 5.02.3 (1) and (2). The Coalition has estimated that the volume of sewerage treatment plant wastewater in the lower Pawtuxet will increase from the present 9% to 18% of the average natural flow when the Big River Reservoir and the expansion of sewerage treatment plants on the river are complete.

(Coalition of Coastal Communities, "Cranston Environmental Audit," 1980). Furthermore, the percentage of the wastewater in the river during low flow conditions will increase from 50% to over 65% after the completion of the reservoir. We feel that these hydrological modifications will constitute an alternation of the river's water quality and therefore should be fully described in the report.

These issues are of major concern to the coastal communities we represent, and we sincerely request that they be addressed in your plan.

Sincerely yours,

David Strouss,
Executive Director

DS:JM

April 10, 1981

14 Apr
Rec

Department of the Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Mass. 02154

Attn:Lawrence S. Grossman,Public Information Specialist
" Mark DeSouza X503

Gentlemen:

In regard to the "Big River Reservoir", Coventry and West Greenwich, R. I. and the public hearing recently held in the Coventry High School, I would like to add a few comments.

Speaking for myself, although also as a member of S.O.W.(Save Our Water), I am 100% in favor of the proposed reservoir, BUT:

I am troubled with the proximity of the Picillo chemical dump site leaching its large quantity of poisonous chemicals directly into this proposed Big River Reservoir. This dump and all the lakes and ground water around it is approximately 250 to 330 feet higher in elevation than this new reservoir. It is less than 2½ miles from the reservoir itself. I should think your engineers would be highly concerned with this problem. The proposed dam at Zeke's Bridge is approximately 4.5 miles from the dump and approximately 330 feet lower.

What I would like to have done is to rid this dump of its chemicals before the reservoir site is started at all. This dump is one of the 3 most explosive and dangerous dumps in New England and the country. The EPA and DEM have been involved with this dump since 1977 and the method of dumping these chemicals and condition of same has deteriorated to such a state that if they are not taken care of immediately, they will be with us for years to come. The sooner done, the better and chances of these chemicals leaching down from a height of 330 feet to Zeke's Bridge will be eliminated.

Bucks Horn Reservoir was mentioned at the Hearing. I'm enclosing a map of same for your records if you don't have same. Bucks Horn could conceivably be worked into Big River, being 200 to 300 feet above same.

Sincerely,

Arthur W. Erickson

Arthur W. Erickson

Perry Hill Road
R.R.2, Box 1175
Coventry, R.I. 02816

Coventry Republican Town Committee

April 13, 1981

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

Dear Sir:

The Coventry Republican Town Committee would like to express their concern on the proposed Big River Reservoir project in the Coventry-West Greenwich, R.I. area.

There are some unanswered questions that we feel should be thoroughly investigated prior to proceeding any further.

1.) What affect will the close proximity of the Picillo dump, one of the worst toxic dump sites in New England, have on its' water reserve quality?

2.) What will the admitted 50% reduction in water flow into Johnson's Pond have?

   A.) Will level of water be reduced, thus effecting recreation and/or waterfront property values?

   B.) If flow is reduced by that amount, will it turn into a large sewage system, do to stagnant water?

These questions are very important to local residents and deserve a sincere answer.

Please direct all replies to my attention, and thank you for your attention to this matter.

Sincerely,

Raymond A. Byrnes
Chairman, Coventry
Republican Committee
4 Plum Tree Lane
Coventry, R.I. 02816

RICHARD A. CARROLL
Chairman
ALFRED T. CICCONE
Member
JOHN A. DOHERTY
Member
ROBERT F. HOWARD
Member
VINCENT J. CIRELLI
Councilman
LAURENCE K. FLYNN
Councilman
JAMES R. BERNARDO
Ex-Officio

WATER SUPPLY BOARD

CITY OF PROVIDENCE

WILEY J. ARCHER
P.E., Acting Chief Engineer
WILLIAM J. McGAIR
Legal Advisor
JAMES A. LOMBARDI
Secretary

May 6, 1981

Colonel C. E. Edgar III
Division Engineer
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Edgar:

The Water Supply Board offers the following comments in response to the Draft Report on the Big River Reservoir Project as prepared by the U. S. Army Corps of Engineers. The department recognizes an immediate need to initiate preliminary design and engineering work and supports action taken in this direction.

The present shortfall in precipitation and resulting water shortages in Rhode Island communities emphasize the need for prompt action in the construction of Big River Reservoir. Furthermore, urgency for the project is reinforced by the degradation of ground water supplies throughout the industrialized Northeast. Communities are already looking to protected surface water supplies for potable water when ground water supplies cannot meet demand or are contaminated.

The argument that the Big River Reservoir will not be needed in the near future based strictly on population projections does not allow for the future demands on the Providence system created by expansion of the service area for any of numerous reasons, not the least of which is contamination of ground water supplies. In addition, after construction of the reservoir, a period of time which will allow for aging and self purification will assist in maintaining water quality; and this time should be utilized since the facility will ultimately be required.

The Corps report outlines an estimated safe yield of 77 M.G.D. in Table 12 of Volume II and indicates that the safe yield is increased to this number based on Corps analysis. Data to support the revised safe yield figure could not be found in the report.

The department recommends that extra planning be devoted to develop adequate safeguards to prevent contamination of the reservoir from spills of hazardous materials and highway runoff. The location of Interstate 95 is critical to the watershed and mitigation procedures should be considered in detail.

552 ACADEMY AVENUE • PROVIDENCE, RHODE ISLAND • 02908 • 401-521-6300

The watershed source of Big River Reservoir in relation to the total Pawtuxet River watershed suggests limited flood protection benefits. However, single-agency operation of both the Scituate and Big River Reservoirs would provide for efficient coordinated management of water production, hydro power, and flood protection. Until water supply demand dictates otherwise, the availability of Big River Reservoir storage will offer the water purveyor with flexibility in contingency planning during periods of heavy runoff.

The primary impetus in planning for the Big River Reservoir is water supply. The significant volumes of study dedicated to recreational uses seem out-of-proportion to what should be the main thrust of the project. The Federal Safe Drinking Water Act, the maintaining of compatibility with high-quality Scituate Reservoir raw water, and other water quality requirements gives us reason to question the validity of such strong emphasis on recreational uses.

The Corps report dwells at length on these recreational uses but does not adequately address the cost of operation of such uses upon completion of the project. Costs may not match the recreationists' ability to pay or the purveyors' to fund. The Water Supply Board stands by its policy of no recreational use on terminal reservoirs.

Very truly yours,

Wiley J. Archer, P.E.
Chief Engineer

ms

cc: Mr. Hans Bergey
Land Management Specialist, WSB

Mr. John Kellam
Dept. of Urban Development

STATE OF RHODE ISI AND AND PROVIDENCE PLANTATIONS

Department of Environmental Management
OFFICE OF THE DIRECTOR
83 Park Street
Providence, R. I. 02903

May 7, 1981

Colonel C. E. Edgar, III
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Edgar:

SUBJECT: Interim Report and Environmental Impact Statement for the Big River Reservoir Project-Fish and Wildlife Mitigation Plan

We would like to thank Project Manager John Craig, Bud Barrett of the Impact Analysis Branch, and other staff members for coming down to discuss our comments concerning the above referenced report. Unfortunately, we are unable to provide answers to all the Corps' questions regarding the state's role in project development and sponsorship. The following comments are limited to Fish and Wildlife impact mitigation, and are divided into two categories: (1) on-site mitigation measures, and (2) off-site mitigation or land acquisition. In considering the levels of habitat enchancement and acquisition necessary to compensate for loss of habitat, it will be assumed that the Big River area would remain in state ownership, and the primary land use would be wildlife management, as is presently the situation.

On-Site Habitat Improvement

The DEM Division of Fish and Wildlife participated in the Habitat Evaluation Procedure (HEP) of the Reservoir area to assess wildlife values, estimate impacts, and establish the type and extent of mitigation necessary to compensate for loss of habitat. However, DEM was not consulted, and was not involved in development of the mitigation plan formulated by the Corps in conjunction with Normandeau Associates, Inc., nor that proposed by the Fish and Wildlife Service.

The Department supports the concepts of the on-site mitigation plan developed by the Corps, with emphasis on wetlands and cold water fisheries. Management efforts should be focused on these areas for two reasons. The greater need for mitigation of wetland habitat loss over loss of upland area has been documented by the Fish & Wildlife Service as part of the HEP. Secondly, the upland habitat management techniques recommended certainly have some value, but the expense of such labor intensive management methods may not be justified by the level of habitat improvement that can be expected. In addition, species most in need of protection--those intolerant of human intervention--would benefit the least from management. Some habitat improvement (for game species, primarily) would occur as a result of activities on the site, such as clearing of fire routes.

Methods designed to create additional wetlands and establish cold water fisheries are outlined in the draft report. These include use of subimpoundments to form wetlands, and stripping of organic matter to promote establishment of cold water fisheries. As discussed in our letter of April 1, 1981, further articulation of these features is necessary in the engineering and design work for the project. The feasibility of constructing impoundments must be determined, as well as the location of dikes, the design of water control structures, and optimum water levels to be maintained. The hydrologic and biological effects of subimpoundment must also be assessed. In the event that wetland creation by subimpoundment is shown to be impracticable, other wetland mitigation measures should be considered.

Design details of cold water fisheries establishment must also be addressed in the engineering and design phase of the project. However, fisheries enchancement would serve no practical purpose if the resource could not be enjoyed by the public. The eventual use of the reservoir, whether multiple use or strictly for water supply and flood control, greatly affects the need for mitigation of lost recreational opportunities.

Off-Site Mitigation

The mitigation plan developed by the Corps deals mainly with management of the Big River site and inappropriately excludes land acquisition as a means of compensation. In our comments of April 1, 1981, we recognized the difficulty in acquiring the amount of land deemed necessary to fully compensate for habitat loss. The cost of purchasing 5,800 acres, the area needed for 100% mitigation, would be very high and it is unlikely that this aspect of the mitigation plan would be supported by the state project sponsor if the cost is considered unreasonable. However, mitigation of adverse impacts is an essential aspect of the project which cannot be considered dispensible, and the Department strongly supports development of an intermediate land acquisition plan. In considering both the economic realities of acquisition and the need to compensate for loss of habitat, the Department finds that purchase of 1,500 to 2,500 acres of high value wildlife habitat would strike an acceptable balance.

DEM has conducted a preliminary investigation of open areas throughout the state, taking into consideration the value of the habitat, in comparison to that lost, the availability of the land, and its vulnerability to development. This initial study indicates that acquisition of land in the watershed of the Pawcatuck River would result in the highest level of mitigation in terms of wildlife and fisheries, recreation, and preservation of scenic and visual character.

Of the total land acquisition recommended by the Fish and Wildlife Service, it was specified that 4,450 acres of 5,800 acres consist of wetland habitat to compensate for actual wetland loss. Based on the quality of habitat proposed for acquisition in the Pawcatuck watershed, the purchase of approximately 2,000 acres of fisheries and wildlife habitat, much of it wetlands, may approach more complete mitigation than suggested by the total acreage.

As required by the Fish & Wildlife Service, DEM is prepared to participate in a habitat evaluation of the sites to be purchased. A list of areas under consideration at this time follows.

1)	West Greenwich	- The upper reaches of Breakheart Brook and nearby wooded swamp.
2)	West Greenwich	- The upper reaches of the Falls River and upland habitat. Formerly the Pine Top Ski area.
3)	Hopkinton, Exeter, Richmond	- Land bordered on either side by the Arcadia Management Area and where the confluence of several streams forms the Wood River.
4)	Hopkinton	- Land adjacent to Blue and Ashville Ponds, including a tributary of the Wood River.
5)	Hopkinton, Richmond	- Shoreline and upland areas along Wood River from roughly I-95 in Hope Valley, south to Woodville.
6)	Hopkinton, Charlestown	- Shoreline and adjacent areas along the Wood River from Wood River Junction south to the Burlingame Management Area.
7)	Westerly	- Large marsh bordering, and including Chapman Pond and a section of the Wood River.

Each site is located in the watershed of the Pawcatuck River and consists of wetland and upland habitat in the upper reaches of the watershed, and along the Wood River, as well as interconnected wetlands. The combined land area totals roughly 2,000 acres, with land values generally between $800 and $2,500 per acre.

It is DEM's position that on-site habitat enhancement and land acquisition as discussed above is necessary to provide an acceptable level of mitigation for irreversible, adverse impacts of reservoir development.

The Department is most willing to assist in refining the mitigation plan for inclusion int the final environmental impact statement, and in detailed development of the mitigation methods during design and engineering. Please contact Victor Bell of the Division of Planning and Development if you have any questions or would like to discuss this matter further.

Very truly yours,

W. Edward Wood
Director

WEW:mc

cc: John Craig
William McCarthy
Robert Bendick
John Cronan
Robert Russ
Malcolm Grant

STANLEY BERNSTEIN
DIRECTOR

VINCENT A. CIANCI, JR.
MAYOR

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT
40 FOUNTAIN ST., - PROVIDENCE, R. I. 02903 - TEL. 401-831-6550

May 11, 1981

Colonel C. E. Edgar III
Division Engineer
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Edgar:

From Mr. Wiley J . Archer, P.E., Chief Engineer of the Providence Water Supply Board, I have received a copy of his letter to you dated May 6, 1981. Although my comments by letter of April 2, 1981, regarding the population and conservation components of demand for Big River Reservoir water are not affected, I wish to state my agreement that any service area expansions beyond those tabulated on page A-47 of Volume II, the increase in those additonal areas of ground water contamination if permitted or uncontrollable, the process of reservoir self-purification by aging, and the question of Scituate dependable yield, none of which were involved in my April 2nd comments, are valid factors to be considered. Mr. Archer's other views regarding recreational uses of terminal reservoirs, have had our complete support as you know.

We note your presentation on pages D-22 through D-27 in Volume III regarding combined two-reservoir system yields, which evidently are not sufficiently detailed to justify for Mr. Archer your addition of 5 MGD to the Scituate Reservoir's dependable yield. Assuming that by the addition of Big River, Scituate's yield increases from 72 to 77 MGD, and likewise Big River's yield increases from 31.9 to 36 MGD, the total system increment due to such combining appears to be 9.1 MGD, raising the combined yield to 113 MGD. Perhaps it would be useful in the final report to present the Scituate storage-yield curve alongside the Big River storage-yield curve shown in Plate D-12. Also, would it be possible to let Mr. Archer and me have a look at the computer simulation using the HEC-3 program referred to on Page D-25? Probably we would find it satisfactory, and if so the only need is for our understanding of the assumptions built into the program, since the graphics alone do not yield such an understanding.

Incidentally, in Volume III, Plate D-2 shows, in addition to the Washington, R.I. long-term guaging station (01116000), two short-term stations at Nooseneck, R.I., (01115630) and Carr River near Nooseneck (01115770), but in the text on Page D-5, four short-term stations are said to be located on small tributaries in this South Branch basin. The other two short-term stations should be shown on Plate D-2 in the final report. Also, it would be useful if Plate D-1 could have an improved registration of the blue overlay. Plates D-10 and D-13 do not agree as to the total storage (83,500 vs. 84,500 AC.-FT.) and the conservation storage (11,400 vs. 12,280 AC.-FT.) for Big River.

In all other respects our comments of April 2, 1981, stand as submitted.

Sincerely yours,

John R. Kellam

John R. Kellam
Supervisor of Long Range Planning

Copy: Wiley J. Archer, P.E.
Chief Engineer, WSB

Coventry Republican Town Committee

June 4, 1981

Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Mass. 02254

Att: Colonel C. E. Edgar, III

Dear Colonel Edgar:

As a follow up to my letter dated April 13, 1981, which neither you nor the Corps acknowledged receiving, I am enclosing a water flow rate study done by Mr. Warren F. Dietzel. Mr. Dietzel, a member of the Republican Town Committee and a highly respected Coventry resident, has worked long and hard to prepare this report. It very graphically points out wide differences between your flow rate figures of 42 million gallons per day and his figures of 29.6 million gallons per day. His study was done under optimum conditions, one day following a rainfall of 0.65", May 13, 1981. Keeping in mind that we have been experiencing drought conditions for some time, his flow rate is much higher than indicated during previous flow rate studies. These other calculations are also indicated in his attached report.

Other concerns are the loss of massive amounts of recreational areas. The Providence Water Supply Board has already indicated that, if they have control, no public recreation will be permitted. They did the same thing at the Scituate Reservoir, by fencing the entire area. This would be a tremendous loss to the people of Rhode Island, if such an attitude prevailed. Certain areas should definitely be left for recreation and maintained as such, through the years. We cannot afford to relinquish such a valuable resource to narrow minded people wishing to cut off the outside world. The Providence Water Supply Board should definetly not be allowed to control this potential water resource.

Another concern is the close proximity of the Piccillo dump and its potential toxic effect on the reservoir and its water quality.

You claim the water from that area drains into the Moosup River [illegible], but how do you substantiate that all the surface water or other smaller tributaries will flow away from the area. This is a very serious problem that must be addressed further before any construction begins.

I wish to emphasize that the Coventry Republican Town Committee is not against the building of the reservoir. We are concerned, however, with the many unanswered questions we have, and the overall welfare of our community and its residents. If these questions cannot be satisfactorily answered, then and only then, would we be forced to lead a fight against the reservoir construction.

In conclusion, we request specific answers to the following:

1.) Why is there such a wide variance between your flow rate figures and Mr. Dietzel's?

2.) If our flow rate figures are accurate, how long would it take to fill the reservoir?

  A.) Our estimates are at least 10 years

3.) How are you going to export water to other communities, if you do not have enough volume to fill the reservoir.

4.) What effect will the reduced water flow (at least 50%) have on Johnson's Pond?

  A.) Will it [illegible]?
  B.) Will it ruin abutting property values?
  C.) How will it effect business concerns downstream that rely on this water to operate their establishments?
  D.) Will it eliminate recreation on Johnson's Pond?

5.) Will the Providence Water Supply Board control the reservoir?

6.) Will recreation be guaranteed to Rhode Island residents?

7.) What forms of recreation will be allowed?

  A.) Boating?
  B.) Fishing?
  C.) Swimming?
  D.) Picnicing?

8.) How large an area will be set aside for this Purpose?

9.) What effect does the [illegible] have on future water quality?

10.) What studies have been done to insure no effect?

11.) Will an earthen dam, as this is going to be, be guaranteed to hold up over the long term?

  A.) Earthern dams have been known to let go in the past.

.) We already are experiencing a leak at a smaller earthern dam on Johnson's Pond.

The above letter and enclosures are being forwarded to:

John H. Chafee
Member of Senate

Claudine Schneider
Member of Congress

Providence Journal Bulletin
1167 Main Street
West Warwick, R.I. 02893
Mr. William Pugh

Pawtuxet Valley Daily Times
1353 Main Street
West Warwick, R.I. 02893
Mr. Ted Holmberg

I appreciate your concern on this matter, and will be looking forward to your prompt response.

Sincerely,

Raymond A. Byrnes

Raymond A. Byrnes
Chairman
Coventry Republican Committee
1 Plum Tree Lane
Coventry, R.I. 02816

Enclosures:

1.) Flow rate study prepared by Mr. Warren J. Dietzel

2.) Copy of previous letter dated April 13, 1981

NFD# 945-581

20 May 1981

BIG RIVER FLOW-ANALYSIS-SURVEY REPORT

A. The following study was conducted in response to specific data contained in the Big River Reservoir Project Feasibility Report distributed January 30 1981. This writer, having had some 25 years of boating , hiking and fishing experience throughout the proposed impoundment area, as well as the lower Big River and Johnson's Pond water bodies, felt serious reservations as to the capability of Big River to produce the projected yield of MGD noted in the Report.

B. An initial simplified test survey was conducted on 12 March 1981 to determine whether the flow rate was sufficiently low enough to substantiate the original doubts and thereby justify a more thorough analysis.

1. A rate-of-flow calculated to be 4.5 MGD was measured at the junction of R.I.Route 3 and Big River in west Greenwich to the south of Division Road.

2. A second similar calculation was made at the point of impoundment at the junction of Harkney Hill Road and Big River commonly known as Zeke's Bridge. A rate-of-flow of some 9.5 MGD was indicated at this point, which is the maximum flow point for the filling of the proposed reservoir.

3. The 12 March analysis was conducted under admittedly dry conditions, there having been no precipitation for some seven full days and very little in the preceding two weeks, and an absence of snow cover for the prior month. However, it must be noted that said lack of precipitation is all too often common during the warmer seasons of the year.

4. Despite the drought conditions of the above test, it was felt that the extremely low flow rate warranted the implementation of a more comprehensive series of tests. Consequently these tests were conducted on 13 May 1981, the day following a 0.65" rainfall.

TEST PROCEDURES

A. The initial requirement to establish MGD was to determine the rate of flow in FPS (feet per second) through a given aperture over a fixed distance. The abutments of Zeke's bridge provided near perfect parameters for this task.

The bridge flooring itself provided the ideal suspension points, utilizing the upstream and downstream edges,for the plum bobs which define the fixed distance and serve as control points to measure the traverse time of the drift floats, or rods.

The traverse span of the plum bobs was measured at 24.5 linear feet.

The drift rods were constructed of 5/16" square fir in both 24" and 36" lengths, weighted with approximately ½ ounce of lead, plus/minus the required variable,to insure full vertical positioning of the rod during the drift. The rods were set to provide 1" of surface extension for visibility and to cancel or minimize any wind effect. (No appreciable difference was detected in FPS between the 24" and 36" rods)

The drift rods were introduced into the stream at a point approximately 30 feet above the control points to insure achieving the full flow speed of the stream.

The drift rods were positioned into the stream in five different points accross the width of the river to establish any variance in flow differentials. See diagram in Table #1.

Traverse times from the upper to the lower control points were measured with a Meylan 208A stopwatch. All readings noted in Table #1 are expressed in .01 minutes.

B. The second requirement in developing MGD was the determination of the flow-front in square feet, to be converted to CFS (cubic feet /second). This was accomplished by measuring the stream depth at six given points across the span of the stream between abutments to develop a contour profile. See Table #2.

TEST PROCEDURES (cont.)

The six depth readings provide the extremes with which to develop five cross-sectional areas, "A" through "E" as illustrated in Table #2, the totals of which project the mean flow front in square feet.

C. Due to the difficulty of achieving an unimpeded drift of the flow rods through Section "C" (Table#2) because of the bridge center pilings, the mean average of the flow rates of Sections "B" and "D" has been utilized. The eddy currents present in this area obviously cause a restricted flow; therefore the use of a mean average is biased in favor of those who claim a higher MGD rate.

COMPUTATIONS

Cross-sectional areas:

Section A flow front:
4.5'+5.8' ÷2x 8' = 41.2 sq.ft.

Section B
5.8'+6.1' ÷2x 8' = 47.6 " "

Section C
6.1'+6.2' ÷2x 8' = 49.2 " "

Section D
6.2'+5.8' ÷2x 8' = 48.0 " "

Section E
5.8'+4.2' ÷2x 8' = 40.0 " "

****

Rates-of-flow by section:

Section A
24.5'@ 2.68 min. = 9.14 feet per minute

Section B
24.5'@ 2.28 min. = 10.75 " " "

Section C
24.5'@ 2.04 min. = 12.01 " " "

Section D
24.5'@ 1.81 min = 13.54 " " "

Section E
24.5'@ 1.57 min. = 15.60 " " "

****

Cubic feet per minute (CFM) by section:

Section A	B	C
41.2 sq.ft.	47.6	49.2
x 9.14FPM	x10.75	x12.01
376.57 CFM	511.70 CFM	590.89 CFM

COMPUTATIONS(cont.)

Section

D	E
48.0	40.0
x13.54	x15.60
649.92 CFM	624.00 CFM

****

Total flow in CFM:

376.57	
511.70	
590.89	
649.92	
624.00	
2753.08	total CFM
x60.	min.
165,184.8	CF/hr.
x24.	
3,964,435.2	CF/day

****

3,964,435.2 CFD
x 7.48 gals/cu.ft.

29,653,975 gallons per day.

SUMMARY

****

The Feasibility Report prepared by the U.S.Army Corps of Engineers projects a "safe yield of 42 million gallons per day" combined surface and groundwater supplies.

Since the enclosed study, made under optimum flow conditions, indicates a flow of only 29.6 MGD, serious questions arise as to the capacity of Big River to simultaneously provide for the groundwater (shallow-well) requirements of the area, maintain the recreational level of Johnson's Pond, fulfill the water needs of downstream industries, while at the same time attempt to fill a 95,000 acre-foot reservoir and still "export" a major portion (or a quantity in excess) of the stream flow, out of Kent County.

The above should be considered a prohibitive requirement under conditions of normal precipitation and/or normal stream flow.

The Big River itself provides in excess of 75-80% of the water required to maintain the level of Johnson's Pond; on numerous past occasions the level of said Pond has had to be lowered to satisfy the needs of downstream industries and to provide the normal flushing requirements. It may well be anticipated that the exporting and filling requirements of the Big River Reservoir Project could totally decimate the recreational and residential value of all the homes on Johnson's Pond.

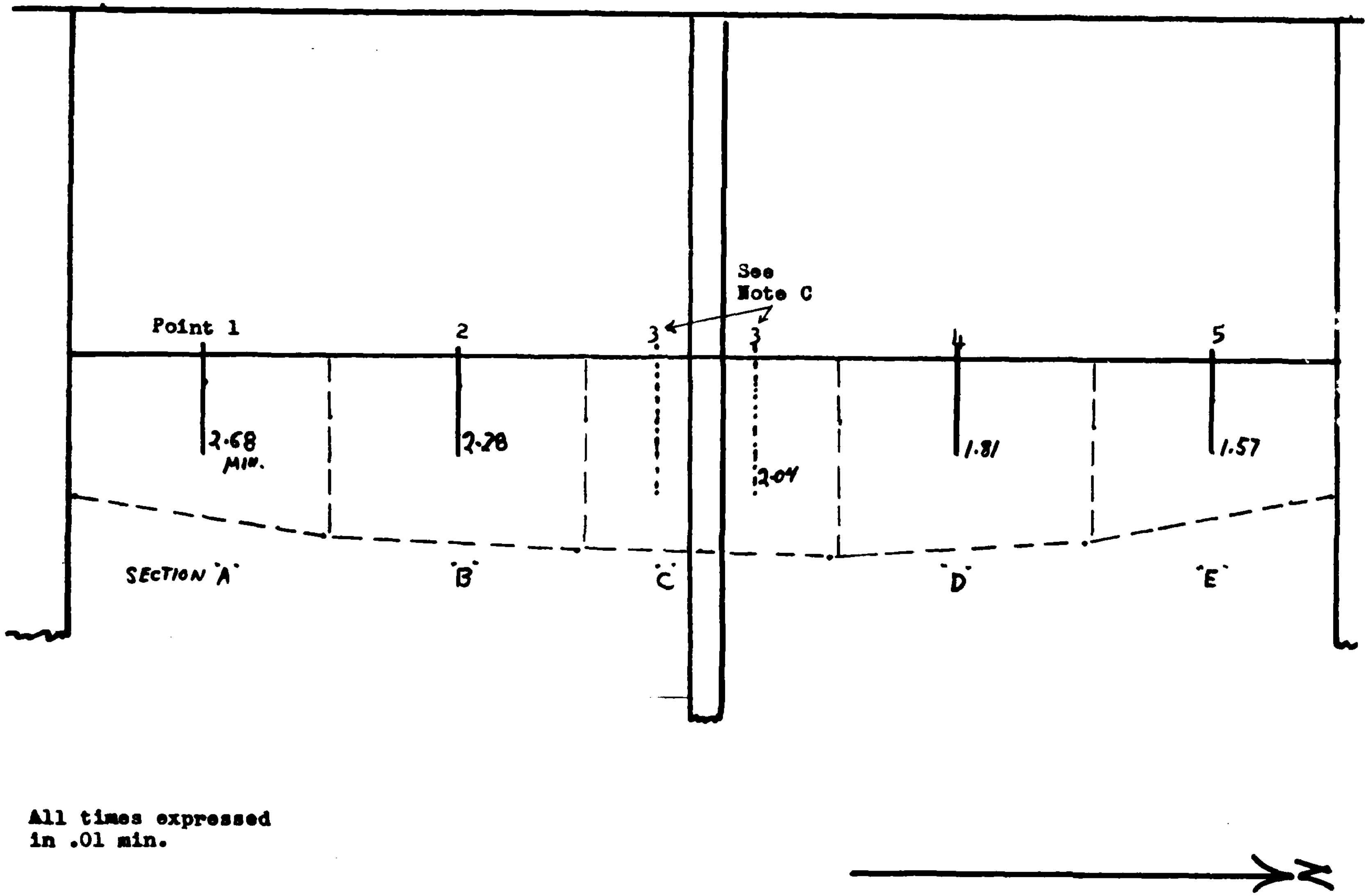
Additional considerations include the safety factors of the earthen-type dam proposed for this project and the unconscionable lack of any projection to utilize the 70-foot head of water for the developnent of hydro-electric power in this energy-hungry area.

Warren F. Dietzel

Warren F.Dietzel, I.E.

AVERAGE TRAVERSE READINGS THROUGH SECTIONS "A" THROUGH "E" BY CENTER POINT.

TABLE # 1

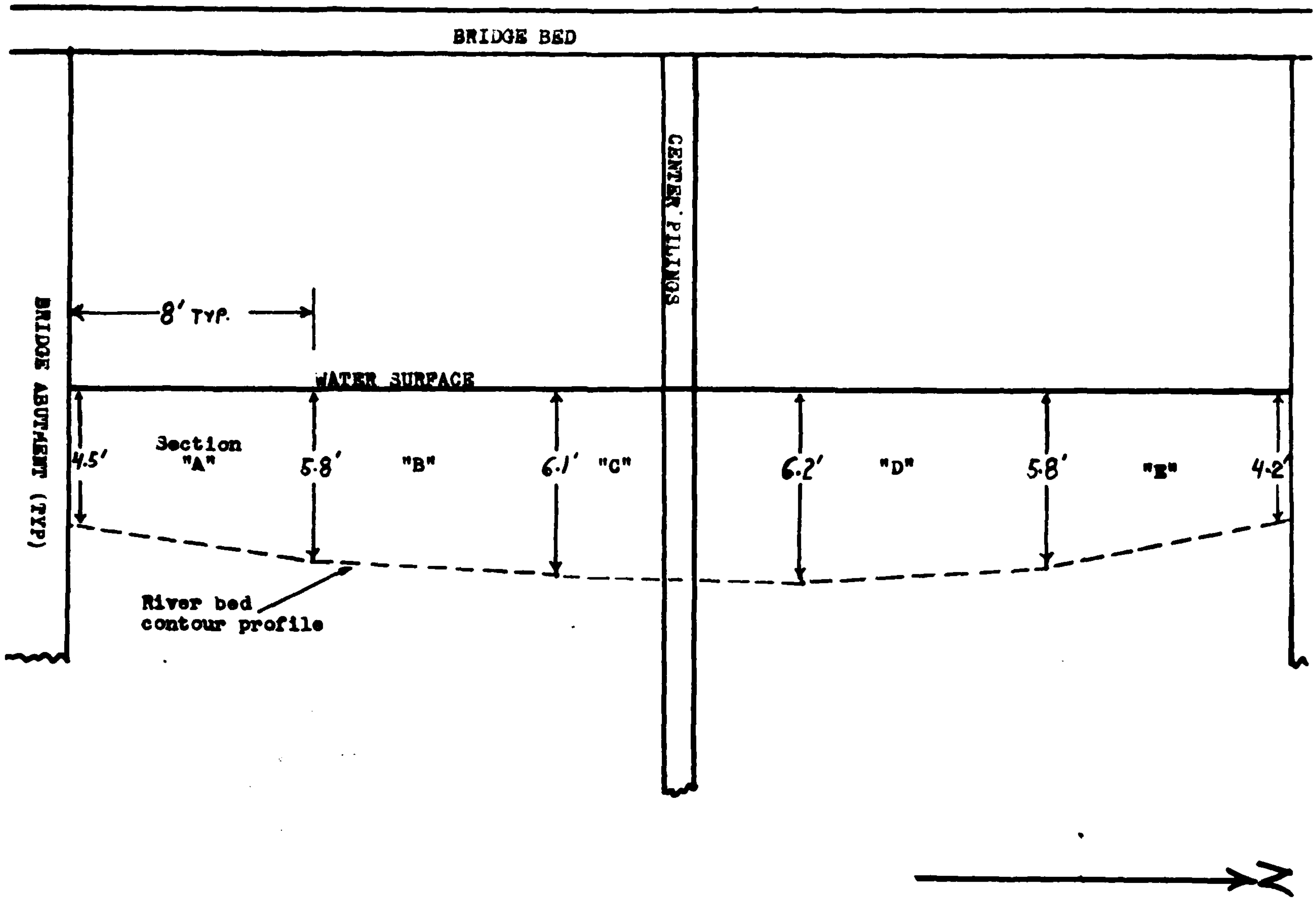


All times expressed
in .01 min.

ō

2f. RD.

TABLE # 2



BRIDGE BED
CENTER PILINGS
BRIDGE ABUTMENT (TYP)
8' TYP.
WATER SURFACE
4.5'
Section "A"
5.8'
"B"
6.1'
"C"
6.2'
"D"
5.8'
"E"
4.2'
River bed contour profile
N

5/13/81

VERTICAL TABULATION SHEET
(ID-GEN-323 (Rev 6-57)

FLOW READINGS BY SECTION (24.5' TRAVERSE)

	Elapsed times in .01 min.	Point 1		2		3		4		5			
1	Test #1	2.64		2.27		See note "C" test procedure.		1.75		1.56			
2													
3	#2	2.73		2.34				1.81		1.62			
4													
5	#3	2.68		2.22				1.86		1.53			
6													
	Average:	2.68		2.28		2.04		1.81		1.57			
8													
9													
10													
11													
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STATE OF RHODE ISLAND & PROVIDENCE PLANTATIONS

EXECUTIVE CHAMBER

PROVIDENCE

J. JOSEPH GARRAHY
GOVERNOR

June 6, 1981

Mr. Joseph L. Ignazio, Chief
Planning Division
New England Division, Corps of
Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Mr. Ignazio:

Re: Your Letter of May 1, 1981 on Big River Reservoir Project

I have discussed the questions you raised in the above referenced letter at length with representatives of the Department of Environmental Management, the Water Resources Board, and the Office of State Planning. The following responses may, therefore, be construed as representative of the State of Rhode Island's position on the issues discussed.

1. Water Supply Needs/Population Projections: While we believe the 1979 population data to be more accurate than that from 1975, we do not believe that the need for the Big River Reservoir can be determined on the basis of population projections alone. Indeed, a wide range of other factors must be considered and, until they are, the point at which time the capacity of the new reservoir will be needed must remain largely conjectural. Among the factors which we believe the Corps should consider in making its projections are the size and population of the potential service area, both of which may increase significantly in the future; evolving consumption rates and patterns within that service area; impacts on industrial consumption caused by implementation of the Clean Water Act Amendments and the Resource Conservation and Recovery Act; supplementation and/or replacement requirements of other water systems in the State affected by diminishing water supplies and contamination of sources; and finally, the safe yield of the Scituate Reservoir system (70 m.g.p.d. rather than the 77 m.g.p.d. figure used by the Corps).

2. Flood Hazards and Damage: We feel that the nonstructural control measures being studied by the Corps under Section 205 of the 1948 Flood Control Act represent a promising permanent solution certain of the Pawtuxet's chronic flooding problems, certainly flooding of residential areas. I refer to Colonel Hodgson's letter of May 27, 1981. We urge the Corps to press forward with these studies and to initiate corrective action as soon as possible. If prompt action is taken, the date by which the Big River dam is needed, which as we note is difficult to establish at this point, becomes considerably less of a flood control concern than it is otherwise.

3. Social Acceptability of Continued Retention of the Reservoir Site: The State of Rhode Island intends to retain ownership of the Big River Reservoir site indefinitely. That commitment is not conditional on an early construction timetable for the reservoir.

4. Fish and Wildlife Mitigation Requirements: The Rhode Island Department of Environmental Management, by letter of May 7, 1981 to Colonel Edgar, has determined that acquisition of 1500 - 2000 acres of land in the Wood River watershed at a cost of approximately $2.3 million would be adequate to replace natural habitat lost to flooding of the reservoir site. This is considerably less than the 5,000 acres proposed by the Fish and Wildlife Service and is conditional on implementation of the on-site habitat improvement measures proposed by the Corps.

5. Impacts of Downstream Flow: The critical downstream release must be based on water quality related to the assimilation of waste at downstream sewage treatment plants, whereas we do not believe that restoration of a viable fishery in the river is a realistic objective or concern. Therefore, the minimum release should be based primarily on that necessary for proper operation of downstream sewer disposal plants in relationship to their NPDES permits. As to the question of riparian impacts and liability for their mitigation, we believe that a number of complex and thorny legal issues come into play. Because these issues have not been discussed by or between State and Federal officials, we cannot comment on your contention that mitigation is a non-federal responsibility except to say that, until such discussions are held, we cannot accept that contention as fact.

Mr. Joseph L. Ignazio
Page Three
June 5, 1981

6. Recreational Use: We support maximum recreational access to and use of the reservoir site consistent with public health and environmental quality considerations and State law. As you may know, that law presently prohibits water contact activities in a public water supply. Amendment of this law will be considered if necessary in order to permit the reservoir project to proceed.

7. Cost Sharing/Financial Commitment: As you know, the funding formulas referenced in the Corps report are being reconsidered by the Reagan Administration. Consequently, while we enthusiastically support Corps efforts to obtain Congressional authorization for the Big River Reservoir project, it is not possible for us to make a matching dollar commitment at this time. You may be assured, however, that the State supports the project and that we stand ready to discuss a financial commitment when it becomes clearer what such a commitment entails.

I hope the above answers adequately address the questions raised in your May 1, 1981 letter. If supplemental information of clarification is desired, please call me at 277-2074. In the meantime, we look forward to continued cooperation with the Corps as we pursue our own engineering and design studies.

Sincerely,

Malcolm J. Grant

Malcolm J. Grant
Policy Associate

MJG:jmd

State of Rhode Island and Providence Plantations

EXECUTIVE CHAMBER, PROVIDENCE

J. Joseph Garrahy
Governor

June 9, 1981

Colonel C. E. Edgar III
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Edgar:

Re: Corps of Engineers Big River Reservoir Project

This is to indicate the State of Rhode Island's strong support for Corps efforts to obtain Congressional authorization for the Big River Reservoir project. We have reviewed your preliminary studies carefully and believe authorization of the project to be in the best interests of the citizens of this State.

As you know, the funding formulas referenced in the Corps report are being reconsidered by the Reagan Administration, and it is consequently not possible for us to make a matching dollar commitment at this time. You may be assured, however, that the State supports the project enthusiastically and that we stand ready to discuss a financial commitment when it becomes clearer what specifically this entails.

We will look forward to continued close cooperation with the Corps on this vital project.

Sincerely,

J. Joseph Garrahy
GOVERNOR

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION. CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDPL-BU

18 June 1981

Mr. Raymond A. Byrnes, Chairman
Coventry Republican Committee
Four Plum Tree Lane
Coventry, Rhode Island 02816

Dear Mr. Byrnes:

I have your 4 June 1981 letter, addressed to Colonel C. E. Edgar, III, regarding the Corps' Big River Study and Draft Report. The 13 April letter that you wrote has been included in the report along with answers to the questions that you raised. Your response did not reach this office by the 10 April deadline that was established for review comments, however, the final report preparation was still at a stage where the letter could be included when we did receive it. The report is currently under preparation and I will send it to you when reproduction is completed later this summer.

Our hydrologic studies and the resultant dependable flows are based on a 40-year record at gages maintained by the United States Geological Survey. The methodologies that we used are tried and proven. Report Appendix D, Hydrologic Analysis, explains the methodology in detail.

The report states that project lands consist of 8,300 acres of which 3,400 acres are subject to inundation by the Big River Reservoir. The 4,900 acres of land area will provide for considerably more recreation opportunity than presently exist for two reasons. First, a large attractive body of water, Big River Reservoir, will be added and second, the land area will be managed. The area presently is unmanaged.

The State of Rhode Island has provided the Corps with assurances of local cooperation not the Providence Water Supply Board. The State has accepted a plan which includes a recreation function.

The Piccillo dump question was raised at the 26 March 1981 Public Meeting. Subsequent to that meeting we discussed the matter with the Environmental Protection Agency (EPA). The dump site is outside the surface drainage area of the Big River Watershed and an analysis of the groundwater flow indicates that the leachate is traveling west or away from the Big River watershed. New observation wells are being installed, however, the re-examination of groundwater travel will be of top priority if the Corps enters into the engineering phase of the Big River Project.

NEDPL-BU 18 June 1981

Mr. Raymond A. Byrnes, Chairman

You have listed 11 questions on the second page of your letter. Most of them are adequately addressed in the report, however, I will go over them briefly here. The answers are keyed to the numbers on your questions.

1. The hydrologic methodologies that we have employed are proven and are accepted engineering procedures. The methodology is explained in the report.

2. The flow rates that you present are not valid, as noted on page one.

3. As our figures indicate, the Big River Reservoir together with Scituate Reservoir would have sufficient yield to service the areas indicated in the report.

4. The reservoir would provide at least a minimum release equal to the seven-day/ten-year low flow requirements under natural conditions. This flow is defined as the minimum flow that would occur on seven consecutive days with an expected frequency of once in ten years. It is generally accepted as minimum flow necessary to maintain satisfactory water quality conditions in a river.

5. As mentioned previously, the State, not the Providence Water Supply Board, provided the Corps with local assurances.

6. The plan as presented in the report would indeed provide for public recreation.

7. All four recreational pursuits mentioned are included in the recommended project.

8. 8300 acres (4900 acres of land plus 3400 acres of water surface).

9. There is no reason to believe that the Piccillo dump will have any effect on the water quality of the Big River Reservoir.

10. To assure that Piccillo dump would not contaminate water in Big River Reservoir, data relating to surface and groundwater flow were examined. EPA was consulted and plans were made to continue monitoring of groundwater if preconstruction engineering work is conducted by the Corps.

11. A well designed earthen dam will "hold up" indefinitely. Most Corps dams are of earth embankment and no Corps of Engineers dam has ever failed.

I trust this information is useful to you.

Sincerely,

JOSEPH L. IGNAZIO
Chief, Planning Division

ADDENDA AND ERRATA TO
Appendix D, "Hydrologic Analysis"

1. p. D-18, second paragraph: reference to "Plate D-6" should read "Plate D-7"

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX D

HYDROLOGIC ANALYSIS

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX D

HYDROLOGIC ANALYSIS

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1. PURPOSE

This report presents hydrologic analysis pertinent to feasibility studies of the proposed Big River Reservoir in West Greenwich, Rhode Island. Included are sections on watershed description, climatology, reservoir characteristics, water supply yields, flood control and system simulations.

2. OTHER REPORTS

The following two reports contain hydrologic analysis and information, by others, relative to the Big River Reservoir project:

> "Report to the Water Resources Coordinating Board, State of Rhode Island, on a Development Plan for the Water Supply Resources of Rhode Island." Metcalf and Eddy, Inc., Engrs. June 30, 1967.
>
> "Appendices for Summary Report, Recommended Program for the Development of the Big and Wood River Reservoirs and Waterworks Improvements for the Providence Water Service Area." Charles A. Maguire & Associates, March 1968.

3. WATERSHED DESCRIPTION

a. General. The Big River Reservoir Project would be located in West Greenwich, Rhode Island at the mouth of the Big River, a tributary stream to the Pawtuxet River. The Pawtuxet River basin, shown on plate D-1, lies entirely within the State of Rhode Island and covers a total area of 230 square miles. Drainage is generally to the east with the Pawtuxet River discharging to the ocean at the Cranston-Warwick town line. The parent basin is triangular in shape with a north-south base of 23 miles and an east-west length of about 18 miles. The westerly headwater region of the Pawtuxet watershed is quite hilly with little urban development, whereas the lower easterly portion is very flat and quite highly urbanized. The headwater region of the basin is drained by the North and South Branches of the Pawtuxet, with drainage areas of 106 and 73 square miles, respectively. Water resources of the westerly headwater region have been extensively developed for water supply, particularly the North Branch, where 92.8 square miles or 87 percent of its watershed is controlled by Scituate Reservoir, the principal water supply source for the region.

The South Branch originates at Flat River Reservoir which has a drainage area of 56.7 square miles, equal to 77 percent of the total South Branch watershed. Pertinent data on Scituate and Flat River Reservoirs are listed in table 1.

TABLE 1

SCITUATE AND FLAT RIVER RESERVOIRS

PERTINENT DATA

	Scituate	Flat River
Drainage Area (sq. mi.)	92.8	56.7
Spillway Length (feet)	412	169
Spillway Elevation (ft. msl)	284	248
Top of Flashboards (ft. msl)	285.5	N.A.*
Storage Capacity		
Spillway Crest (acre-feet)	113,600	5,150
Spillway Crest (inches)	23	1.7
Top of Flashboards (acre-feet)	118,500	N.A.*
Top of Flashboards (inches)	24	--
Surface Area at Spillway Crest (acres)	3,400	850
Top of Dam Elevation (ft. msl)	298	256

*Not Applicable

The main stem Pawtuxet River, originating at the confluence of the North and South Branches at River Point in West Warwick, flows northeasterly between low banks for 10.9 miles to its mouth in Pawtuxet Cove. The river averages about 100 feet in width and about 4 feet in depth throughout its length and has an average slope, excluding drops at three existing run-of-river dams, of approximately 2.6 feet per mile. From its origin to the mouth the river has a total fall of about 50 feet. Originally, approximately 3 miles of the lower reach of the river was a tidal estuary until the construction of the Pawtuxet dam near the mouth of the river in 1870 to prevent salt water intrusion. In the lower reach, the main river is joined by two other tributaries from the north, Meshanticut Brook and Pocasset River, at river miles 9.0 and 3.8, respectively. Pertinent data on the Pawtuxet River and its tributaries are listed in table 2.

TABLE 2

PAWTUXET RIVER PERTINENT DATA

Name of Stream	Distance Above Pawtuxet Dam (river miles)	Total Drainage Area (sq. mi.)	Length (miles)
Pawtuxet River	0.0	230.4	10.9
Pocasset River	3.8	20.8	11.6
USGS Gage	4.5	200.0	-
Meshanticut Brook	9.0	15.0	6.5
North and South Branch Confluence	10.9	179.0	-
North Branch	10.9	106.0	6.8
Gainer Dam (Scituate Reservoir)	17.7	92.8	-
South Branch	10.9	73.0	9.0
Flat River Reservoir	19.9	56.7	-
Big River	23.0	29.7	-

b. Big River Basin. The Big River dam would be at the mouth of the Big River, a tributary to the Flat River Reservoir near the West Greenwich-Coventry, Rhode Island town line. The watershed lies almost entirely in the town of West Greenwich covering an area of 29.7 square miles. Drainage patterns in the watershed are quite irregular and principal tributaries to the Big River are Nooseneck, Congdan, and Carr Rivers.

The watershed has rolling hills intertwined by relatively flat gradient streams containing small ponds and swamps. Elevations in the watershed generally range from 250 to 600 feet above mean sea level. The area is relatively undeveloped and quite wooded. A map of the Big River watershed is shown as plate D-2.

4. CLIMATOLOGY

The Big River site, in the State of Rhode Island, is near 41°40'N latitude in the northeast continental United States. At this latitude the climate can best be characterized as moderately cool and humid. The average annual temperature is about 50 degrees Fahrenheit, with monthly averages varying from a high of 73 degrees in July to a low of about 29 degrees in January. Extremes in temperature vary from 104 to -17 degrees Fahrenheit. The average growing season between killing frosts is about 190 days, extending from mid-April to mid to late October. The mean, maximum, and minimum temperatures recorded at Providence are listed in table 3.

TABLE 3

MONTHLY TEMPERATURES
AT
PROVIDENCE, RHODE ISLAND

Month	Mean	Maximum*	Minimum*
January	29.2	68	-13
February	29.3	69	-17
March	37.6	90	1
April	47.6	98	11
May	53.7	95	29
June	67.0	101	39
July	72.7	101	46
August	71.0	104	40
September	63.8	99	32
October	53.9	90	20
November	43.3	82	9
December	32.6	69	-12
ANNUAL	50.1	104	-17

*Based on 74 Years of Record through 1978

The average annual precipitation over the Pawtuxet River basin varies from about 43 inches in the lower coastal areas to about 48 inches in the uplands in the vicinity of Big River. Distribution of the precipitation is quite uniform throughout the year, however, extremes in monthly values range from a high of more than 12 inches to less than 0.20 inch on several occasions. Also, some of the precipitation during winter months occurs as snowfall with the average annual snowfall over the basin about 40 inches. Water content of the snow cover usually reaches a maximum about the first of March but rarely exceeds 2 to 3 inches due to the moderating effect of Narragansett Bay. Table 4 lists monthly rainfall recorded at Providence for the period 1832 to 1977. Table 5 is a summary of monthly snowfall.

The prevailing wind in the area is from the southwest with a mean annual speed of about 11 miles per hour. The fastest wind at Providence was 95 miles per hour from the southeast and occurred during the hurricane of September 1938. The mean relative humidity in the area is about 70 percent.

5. STREAMFLOW

a. General. The average annual runoff from the Pawtuxet River basin is about 27 inches or approximately 60 percent of average annual precipitation. This produces an average annual streamflow of approximately 1.9 cubic feet per second per square mile (csm) of watershed. The South Branch has an average flow of about 2.0 csm, representing a flow of about 60 cfs, at Big River (D.A. = 29.7), and the mean is about 146 cfs for the Branch (D.A. = 73 square miles). Average flow of the Pawtuxet River is about 390 cfs. In recent years the average annual diversion at Scituate Reservoir for domestic water supply has been in the order of 90 cfs. Though precipitation is distributed quite uniformly throughout the year, there are variations in runoff due to the accumulation and melting of winter snows and the seasonal variations of evapotranspiration from the watershed. As a result, approximately 75 percent of the annual runoff occurs during the 6-month period December through May, with only 25 percent occurring during June through November.

b. Streamflow Data. The U.S. Geological Survey has recorded streamflow on the South Branch at Washington, Rhode Island (D.A. = 63.8 square miles) and on the mainstream Pawtuxet River at Cranston, Rhode Island (D.A. = 200 square miles) since about 1940. Four other short-duration USGS gaging stations are located on small tributaries in the basin. Average streamflow at the two long-term stations, for the period of record, is 128 and 338 cfs, respectively. Mean, maximum and minimum monthly runoff on the South Branch and main stem Pawtuxet, after adjustment for change in storage and diversions from upstream reservoirs, are listed in table 6. Monthly streamflow on the South Branch in cfs, both as experienced and as adjusted for upstream regulation is listed

TABLE 4

MONTHLY PRECIPITATION IN INCHES
AT PROVIDENCE, RHODE ISLAND

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1832	3.87	4.25	3.20	3.33	4.14	0.33	1.82	3.92	3.50	2.01	3.46	5.63	39.46
1833	1.71	1.55	1.97	3.17	0.99	4.81	1.11	2.15	1.53	5.98	4.50	4.67	34.14
1834	1.57	1.13	1.43	3.13	5.61	5.10	7.58	1.15	3.81	4.64	3.80	2.97	41.92
1835	3.50	1.20	4.60	4.06	1.50	1.95	2.84	2.25	0.83	3.26	1.72	3.25	30.96
1836	5.63	3.45	5.00	2.30	2.51	3.25	1.53	0.72	1.03	2.35	5.25	4.85	37.87
1837	1.40	2.65	3.17	4.65	7.28	2.82	1.38	2.00	0.48	1.29	1.95	2.55	31.62
1838	2.70	2.32	2.70	2.70	3.88	3.30	0.63	3.55	6.76	4.61	3.65	1.08	37.88
1839	0.76	1.50	1.50	3.63	3.79	2.31	5.26	5.00	1.83	3.75	2.30	5.12	36.75
1840	2.80	2.05	3.50	3.45	3.35	2.89	3.38	3.20	2.95	5.17	5.35	3.10	41.19
1841	6.45	1.50	2.86	7.78	2.18	0.98	5.13	5.12	2.35	3.20	4.45	5.86	47.86
1842	1.30	4.05	2.07	2.10	3.40	9.65	1.48	3.35	1.40	1.16	3.82	3.93	37.71
1843	0.60	5.27	5.58	4.34	3.50	2.12	1.83	6.23	2.20	6.45	1.35	3.03	42.50
1844	4.32	1.95	4.75	0.67	1.95	1.15	4.42	1.11	2.83	5.80	3.30	2.75	35.00
1845	3.20	2.70	3.53	2.34	2.75	2.32	3.10	5.63	1.63	3.40	9.08	3.48	43.16
1846	1.82	2.08	2.86	1.75	4.58	1.30	1.44	2.73	2.33	1.85	4.62	3.15	30.51
1847	2.13	2.71	3.17	1.72	2.02	6.98	2.28	5.50	8.35	1.95	5.72	5.97	48.50
1848	4.82	3.80	2.40	0.95	5.00	3.80	1.85	3.73	2.45	4.05	3.80	3.83	40.48
1849	0.80	0.60	5.99	1.62	3.43	1.23	2.00	3.39	3.14	6.55	2.42	3.52	34.69
1850	5.60	3.38	5.19	4.67	5.00	2.60	2.35	7.65	5.00	2.10	2.10	5.85	51.49
1851	1.93	3.87	2.00	7.80	3.58	1.90	5.19	3.77	2.47	3.20	5.05	2.62	43.38
1852	2.70	2.00	3.55	6.65	2.00	1.00	1.68	8.00	1.40	1.30	4.60	3.70	38.58
1853	4.27	5.75	1.35	5.05	4.95	0.90	6.37	8.38	3.80	4.15	4.40	3.90	53.27
1854	1.80	4.85	2.85	6.30	3.60	3.60	2.45	0.30	6.10	1.90	9.15	3.35	46.25
1855	6.45	4.05	0.85	2.50	2.55	1.95	3.25	2.02	0.25	5.33	3.75	6.10	39.05
1856	5.25	0.80	1.55	2.80	4.10	2.47	4.20	5.75	5.10	1.15	2.00	5.80	40.97
1857	5.50	2.36	3.35	6.29	4.33	1.90	3.45	4.80	2.27	2.90	2.40	5.20	44.75
1858	3.33	2.80	2.05	3.63	2.35	5.55	4.90	8.20	3.05	2.80	2.40	3.45	44.51
1859	5.75	1.85	8.00	2.28	3.40	7.06	1.14	3.69	3.65	2.62	2.27	3.45	45.16
1860	1.00	3.54	1.80	1.55	1.65	4.02	3.09	5.70	5.38	2.10	3.95	4.66	38.44
1861	4.87	2.95	4.62	7.75	3.22	4.61	2.21	4.50	2.75	2.17	3.20	1.40	44.25
1862	6.06	3.15	4.12	1.60	2.60	6.75	3.52	1.47	7.35	4.77	6.85	2.10	50.34
1863	4.61	4.04	4.88	5.52	2.33	1.90	9.42	4.59	1.74	2.97	7.51	5.66	55.17
1864	4.66	1.53	4.74	2.46	3.15	1.22	1.46	4.05	2.36	2.85	3.42	4.95	36.85
1865	5.29	5.45	5.56	2.98	6.23	1.56	3.91	0.74	0.27	4.60	4.03	4.08	44.70
1866	2.35	5.64	4.29	2.02	5.29	4.43	2.03	3.54	5.75	2.78	3.97	3.96	46.05
1867	5.72	6.80	5.32	2.24	3.94	1.56	3.15	8.23	0.62	4.07	2.59	2.80	47.04
1868	4.56	1.71	4.63	7.02	10.57	4.42	2.09	4.55	5.95	1.23	4.39	2.40	53.52
1869	3.92	5.19	6.34	2.07	5.20	5.63	0.88	1.58	5.08	5.92	2.19	4.70	48.70
1870	6.22	3.34	5.47	5.50	2.55	8.22	2.48	1.71	2.11	5.62	2.83	2.97	49.02
1871	2.35	3.80	5.25	3.81	3.80	5.57	3.63	5.73	1.00	6.68	3.35	2.94	47.91
1872	2.45	1.56	5.02	2.35	3.64	3.03	5.31	6.12	6.18	5.34	4.95	2.76	48.71
1873	5.56	4.60	3.67	3.57	4.62	2.74	2.89	7.89	2.17	4.80	5.16	4.99	52.66
1874	3.62	4.40	2.00	8.54	3.04	3.21	2.58	7.71	2.20	0.92	2.66	2.51	43.39
1875	3.54	3.76	4.57	5.02	3.44	7.27	3.56	8.85	2.05	4.07	5.12	0.97	52.22
1876	1.28	4.42	9.75	4.24	3.23	1.40	4.14	1.82	5.73	2.15	6.95	5.25	50.36
1877	4.55	0.33	7.99	2.40	4.40	4.60	3.60	6.41	0.90	5.81	6.41	1.40	48.80
1878	3.53	5.70	3.86	5.42	2.00	4.59	2.31	3.88	1.25	4.57	8.81	6.56	52.48
1879	2.91	4.32	5.59	4.67	1.27	3.10	4.10	5.03	2.42	1.00	2.53	3.65	40.59
1880	2.88	5.53	4.59	3.25	0.83	1.05	6.07	5.19	2.09	3.06	3.14	3.61	41.29
1881	6.17	6.30	5.30	1.56	2.26	6.10	4.09	0.49	2.02	2.46	4.65	3.39	44.79
1882	7.99	4.90	3.50	2.81	3.83	2.32	1.93	1.53	7.83	2.78	2.29	3.25	44.96
1883	5.97	4.50	2.58	2.04	4.33	1.26	3.18	0.83	2.50	5.23	2.59	4.53	39.54
1884	4.96	6.46	4.58	4.35	3.20	3.87	3.07	4.03	1.23	2.74	3.55	6.72	48.76
1885	6.03	4.13	1.50	2.85	3.53	2.07	2.20	4.78	0.80	5.51	3.50	2.71	39.61
1886	7.10	11.31	3.28	2.87	3.86	1.31	1.99	4.22	2.77	3.53	3.86	5.92	52.02
1887	6.61	5.87	4.74	4.40	2.23	4.24	6.09	5.87	1.58	2.99	2.16	4.20	50.98
1888	4.63	4.29	6.65	2.81	5.65	1.07	2.55	7.84	9.19	5.37	9.02	4.37	63.44
1889	5.62	2.55	1.98	4.07	4.71	2.90	9.49	5.83	5.23	4.52	6.39	2.62	55.91
1890	2.79	3.35	8.27	3.59	5.47	2.68	1.81	2.61	4.82	9.19	0.74	5.28	50.60
1891	8.14	6.00	5.55	3.58	2.29	3.50	3.31	6.26	2.77	4.70	2.84	4.25	53.19
1892	5.15	1.72	4.45	1.39	6.07	2.89	1.86	3.07	1.81	1.36	6.12	1.50	37.39
1893	3.47	7.88	5.59	4.51	6.24	3.59	1.10	4.24	2.27	4.25	2.72	5.42	51.28
1894	4.14	4.55	1.33	3.72	5.04	0.56	0.77	2.14	3.09	6.79	3.52	5.62	42.27
1895	5.74	1.90	3.31	6.25	3.88	2.66	4.64	2.71	2.20	8.08	6.66	2.78	50.81
1896	3.52	6.62	6.14	1.22	3.13	3.90	1.34	2.56	8.53	2.71	3.37	2.87	45.91
1897	6.24	3.00	2.95	3.30	4.46	3.31	5.56	4.47	1.77	0.49	7.09	4.99	47.63
1898	6.01	6.45	2.95	6.08	4.07	1.16	10.26	6.00	2.26	8.43	7.29	2.54	63.50
1899	5.18	6.00	8.38	2.12	2.60	3.62	4.69	1.56	9.16	1.68	2.37	1.88	49.24
1900	4.20	8.17	5.67	1.90	6.24	2.19	2.04	3.13	4.05	2.86	4.54	2.79	47.78
1901	1.93	1.00	8.10	8.90	6.85	1.00	2.93	2.56	4.17	2.98	2.24	9.40	52.06
1902	2.06	6.97	5.71	3.09	1.20	4.17	3.41	2.39	6.55	4.57	1.80	6.40	48.32
1903	4.98	5.64	8.17	4.01	0.58	6.64	4.75	3.92	1.00	2.89	1.77	3.56	47.91
1904	6.45	3.38	3.92	9.45	2.37	2.46	1.06	5.12	5.34	2.11	1.95	4.31	47.92
1905	2.45	1.18	1.98	3.09	1.62	5.63	2.64	3.00	5.70	1.88	1.57	3.92	34.66
1906	2.59	2.88	4.29	2.07	4.51	3.40	5.29	2.51	3.18	4.91	1.90	3.81	41.34
1907	2.63	2.36	1.78	4.24	3 72	2.22	1.06	0.88	8.66	3.44	4.60	4.96	40.55
1908	2.93	4.00	3.42	1.77	4.18	2.01	4.33	5.16	0.88	3.37	0.92	3.12	36.09
1909	3.06	5.80	2.86	5.07	2.09	1.61	0.58	2.50	3.28	1.25	2.95	2.70	33.75
1910	4.85	3.86	1.32	1.64	2.90	3.98	2.86	2.62	2.68	1.60	3.37	2.53	34.21

TABLE 4 (Cont'd)

MONTHLY PRECIPITATION IN INCHES
AT PROVIDENCE, RHODE ISLAND

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1911	2.71	[illegible]	[illegible]	3.14	2.01	1.86	3.23	4.86	2.01	2.79	5.61	3.01	36.80
1912	4.39	2.65	[illegible]	3.61	3.99	0.63	1.76	2.90	1.87	2.37	2.81	5.61	38.65
1913	2.90	2.97	[illegible]	5.32	1.84	1.19	2.29	2.36	2.90	5.45	1.96	3.46	36.94
1914	3.56	2.90	[illegible]	3.94	1.88	0.58	2.81	2.02	0.48	2.97	1.96	2.93	29.50
1915	6.86	[illegible]	[illegible]	1.58	1.82	1.29	6.35	4.48	0.88	1.86	1.67	3.80	33.96
1916	1.35	[illegible]	[illegible]	2.89	3.85	4.20	6.37	0.78	0.86	2.39	1.92	3.03	34.44
1917	3.01	2.97	[illegible]	2.62	3.39	4.33	1.09	5.90	2.28	5.02	0.31	2.10	36.16
1918	3.11	2.87	[illegible]	3.74	2.07	3.12	4.44	2.41	8.04	0.65	2.01	3.14	37.37
1919	[illegible]	3.00	[illegible]	3.32	3.79	3.32	3.68	5.14	5.80	1.49	3.79	2.11	44.09
1920	2.62	4.56	3.66	4.70	4.92	6.80	3.00	3.17	2.11	1.44	3.69	3.91	44.56
1921	3.32	2.23	[illegible]	4.21	2.60	3.35	5.35	1.88	1.33	1.23	6.35	2.43	36.78
1922	1.36	2.42	4.67	2.18	4.24	6.56	6.88	6.96	3.28	2.66	1.09	2.58	44.90
1923	6.55	1.97	3.14	4.75	1.19	4.31	3.09	1.48	1.52	4.09	3.62	5.13	40.84
1924	4.13	3.67	1.34	3.77	2.71	1.05	1.12	5.39	6.71	0.15	1.48	1.96	33.48
1925	3.21	2.06	3.70	1.95	1.92	1.73	3.56	1.88	2.58	3.53	4.11	3.28	33.62
1926	2.69	3.82	3.14	2.12	2.48	1.52	2.88	4.20	1.58	4.62	5.30	2.75	37.10
1927	2.60	2.02	[illegible]	1.88	2.76	3.04	4.16	10.88	2.48	4.18	3.11	4.69	43.36
1928	2.27	2.85	2.64	3.69	1.18	3.70	5.00	4.03	3.25	3.63	2.13	2.87	37.24
1929	4.49	3.04	3.17	5.94	3.45	0.96	1.41	2.44	2.27	2.70	2.47	3.94	36.18
1930	2.62	2.57	3.02	1.08	2.21	2.71	3.80	2.14	1.23	3.60	3.32	2.67	30.97
1931	3.42	1.98	4.14	2.68	4.07	4.95	3.03	4.99	1.37	2.40	0.83	3.20	37.06
1932	4.45	1.76	4.69	1.98	2.51	2.44	2.83	4.86	8.48	4.49	4.49	1.66	44.64
1933	2.02	3.15	[illegible]	5.33	4.10	2.85	2.24	2.68	6.20	2.59	1.35	2.96	41.17
1934	3.80	3.38	[illegible]	4.00	3.50	3.33	0.82	2.34	4.13	2.26	3.88	3.10	38.36
1935	6.02	2.64	1.67	3.37	1.51	4.53	2.72	1.14	2.95	0.76	4.29	1.05	32.58
1936	6.84	3.27	[illegible]	3.79	1.68	2.92	2.34	3.00	5.29	2.49	1.05	9.44	49.39
1937	[illegible]	1.75	3.82	5.27	2.54	3.14	1.16	4.13	3.01	4.06	5.42	3.22	42.13
1938	4.37	2.34	2.39	2.22	4.49	7.21	6.92	2.21	5.16	3.01	3.40	3.31	47.03
1939	2.30	4.09	4.62	4.33	0.57	2.70	1.07	4.08	2.39	4.31	0.76	3.12	34.34
1940	2.50	3.13	3.69	5.30	5.01	2.22	3.24	0.99	2.57	1.86	6.38	2.15	39.04
1941	3.57	2.34	3.54	1.53	3.10	4.01	5.68	2.45	1.03	1.07	2.79	3.37	34.48
1942	3.98	3.84	7.98	0.72	1.77	3.44	4.56	4.54	1.68	3.09	5.03	6.39	47.02
1943	4.07	1.61	3.74	3.72	3.34	1.88	1.97	0.82	1.24	4.39	2.32	1.15	30.25
1944	2.58	2.52	5.00	3.82	0.86	4.16	0.96	1.34	9.74	3.33	7.52	3.42	45.25
1945	4.08	4.26	2.21	2.57	4.25	3.97	1.98	2.63	1.87	2.29	8.50	7.82	46.43
1946	3.63	3.55	1.49	2.25	3.99	2.91	1.25	12.24	1.70	0.16	0.67	3.84	37.68
1947	2.85	1.83	3.36	4.91	3.73	3.93	4.71	2.01	2.96	2.27	5.42	3.73	41.71
1948	6.15	2.34	3.73	3.71	9.25	3.50	5.13	2.15	2.36	4.85	5.00	2.30	50.47
1949	4.23	3.66	2.32	5.17	3.47	0.04	0.96	3.23	3.42	1.98	3.27	1.86	33.61
1950	3.73	4.44	3.84	2.88	2.15	1.97	0.98	5.66	1.88	2.77	6.89	4.27	41.46
1951	4.63	3.90	5.58	3.93	4.60	1.52	2.38	3.66	1.70	3.52	8.10	5.50	49.02
1952	4.41	4.57	4.41	4.15	3.73	2.70	0.24	7.06	1.68	2.75	2.73	3.40	41.83
1953	7.12	4.51	8.31	6.70	3.25	0.55	4.43	3.99	2.99	4.71	6.59	5.42	58.57
1954	2.84	2.68	3.53	4.91	5.92	1.31	2.56	8.30	6.04	2.79	4.92	5.73	51.53
1955	[illegible]	4.97	5.35	3.61	2.37	3.72	3.34	11.12	3.27	7.00	5.60	0.58	51.71
1956	4.92	4.60	5.51	3.08	1.43	1.57	4.92	0.91	3.10	3.74	3.62	5.27	42.67
1957	2.17	1.68	3.29	4.46	0.93	0.39	1.41	2.51	0.87	2.52	3.99	5.86	30.08
1958	2.12	2.95	3.45	7.21	4.05	3.15	6.29	5.15	5.02	3.08	2.58	1.49	51.54
1959	2.27	3.67	6.04	3.83	1.46	4.83	4.01	3.53	0.77	4.71	3.85	4.17	43.14
1960	3.02	5.63	2.48	2.94	3.79	1.26	4.61	1.06	5.98	2.24	2.77	4.30	40.08
1961	3.52	4.68	4.16	7.32	5.21	1.48	2.76	3.86	7.92	2.39	3.10	3.16	49.56
1962	4.70	5.16	1.93	3.85	2.14	5.52	1.62	2.73	3.67	11.89	4.49	2.63	50.33
1963	3.40	3.15	3.78	1.62	4.69	3.54	3.35	1.56	4.10	1.63	6.53	2.15	39.50
1964	5.65	3.15	2.26	5.34	0.71	2.34	2.63	2.38	3.95	2.11	2.43	5.46	38.41
1965	3.46	3.77	1.72	2.43	1.08	1.91	1.28	1.90	1.64	2.75	2.08	1.42	25.44
1966	3.40	4.30	2.40	1.48	3.85	2.31	2.77	3.37	5.23	2.60	3.93	3.04	38.68
1967	1.60	2.51	5.49	4.19	7.27	2.72	3.95	3.24	3.17	2.25	2.75	7.36	46.50
1968	3.50	1.31	7.83	1.49	3.54	4.74	1.49	1.61	1.14	1.79	6.22	6.70	41.36
1969	2.23	4.30	3.10	3.95	2.41	1.23	2.98	2.58	3.09	1.62	6.35	10.75	44.59
1970	0.50	5.34	4.75	3.91	3.03	4.25	1.00	6.59	1.79	4.41	5.31	4.54	45.42
1971	2.01	5.36	3.81	2.31	3.83	1.64	3.48	3.03	2.54	2.88	5.16	2.37	38.42
1972	1.85	5.19	6.70	3.71	5.73	6.83	4.25	2.98	7.31	4.36	[illegible]	7.70	65.06
1973	3.06	3.55	2.78	7.16	3.99	3.48	2.92	5.17	3.04	3.17	2.29	7.63	48.24
1974	4.45	3.04	4.51	2.86	2.74	3.28	1.64	3.10	6.15	2.79	1.56	4.54	40.66
1975	6.78	3.29	3.07	2.99	2.06	4.73	3.51	2.19	6.15	4.66	6.29	5.11	50.83
1976	6.38	2.91	3.44	2.00	2.53	1.60	8.08	7.01	1.57	6.52	0.81	3.47	46.32
1977	3.90	2.87	5.62	3.35	3.43	3.92	2.04	2.12	5.60	6.90	3.24	5.85	48.84
TOTAL	563.98	546.53	581.84	561.42	498.20	453.72	469.15	563.23	487.69	499.74	564.27	571.18	
NO. YEARS	146	146	146	146	146	146	146	146	146	146	146	146	
MEAN	3.86	3.74	3.99	3.85	3.41	3.11	3.21	3.86	3.34	3.42	3.86	3.91	43.56
MAXIMUM	8.14	11.31	9.75	9.45	10.57	9.65	10.26	12.24	9.74	11.89	9.15	10.75	65.06
MINIMUM	0.50	0.33	0.07	0.67	0.57	0.33	0.24	0.30	0.25	0.15	0.31	0.58	25.44

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TABLE 5

MEAN MONTHLY SNOWFALL
AT
PROVIDENCE, RHODE ISLAND

Elevation 51 Feet MSL
73 Years of Record
(Depth in Inches)

Month	Snowfall
January	9.6
February	10.2
March	6.7
April	0.9
May	0.1
June	0
July	0
August	0
September	0
October	T
November	1.0
December	6.6

Annual Average 35.10 Inches

TABLE 6

MONTHLY RUNOFF
(In Inches)

Month	Pawtuxet River at Cranston Rhode Island (D.A. = 200 square miles)			South Branch Pawtuxet River at Washington, Rhode Island (D.A. = 63.8 square miles)		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	3.11	6.56	0.78	2.89	5.84	0.69
February	3.25	7.38	1.34	3.07	4.58	1.33
March	4.66	8.96	2.56	4.29	7.26	2.66
April	3.86	7.01	1.24	3.79	6.49	1.22
May	2.70	5.38	1.34	2.83	5.61	1.24
June	1.45	3.96	0.24	1.67	4.37	0.49
July	0.83	2.52	0.002	1.00	2.33	0.28
August	0.79	3.43	0.06	0.86	2.81	0.29
September	0.90	4.96	0.11	0.91	4.16	0.28
October	1.11	6.48	0.20	1.20	5.81	0.45
November	2.09	6.93	0.43	2.00	5.85	0.50
December	3.06	8.31	0.67	2.91	6.96	0.66
ANNUAL	27.81	46.23	12.75	27.42	42.39	12.64

in table 7. Experienced flow duration curves for the period of record at both the South Branch and Pawtuxet River gages are shown on plate D-14.

6. FLOODS

a. General. Floods can occur in the Pawtuxet basin any season of the year as a result of intense rainfall or in the winter and spring as a result of rainfall in combination with snowmelt. Ocean flooding also occurs on the lower main stem Pawtuxet during abnormal storm tides in Narragansett Bay. Flood damage potential is generally concentrated along the main stem Pawtuxet River in the lower more developed area of the basin. Approximate limits of the lower basin flood plain are shown on plate D-3.

Freshwater floods in the basin have been modified considerably by Scituate Reservoir since its construction in 1926, and to a lesser degree by Flat River Reservoir. Pertinent data on Scituate and Flat River Reservoirs is listed in table 1. The magnitude of freshwater floods on the lower more developed reaches of the Pawtuxet River are a function of: (1) storm rainfall and resulting runoff from the 80.9 square miles of watershed downstream of the reservoirs, and (2) the initial storage capacity in the reservoirs and the resulting magnitude and timing of discharges from the reservoirs. Following are discussions of some of the more notable floods that have occurred in the 19th and 20th centuries.

b. Historic Floods.

(1) 22-23 September 1815. An abornmally high tide of 14.2 feet above msl in the Providence area resulted in extensive coastal flooding. It is reported that vessels were driven from their moorings and many wharves, stores, houses and barns were destroyed. There was apparently a relatively insignificant amount of coincident rainfall-runoff associated with this storm. Though flooding was undoubtedly extensive in the lower Pawtuxet River, destruction was minimized by the lack of development in the flood plain at this date.

(2) 11-14 February 1886. This flood was the greatest ever known on the main stem Pawtuxet River, resulting from 7 to 8 inches of rainfall over the basin augmented by snowmelt with an estimated water equivalent of 2 inches. Experienced flood levels were 6 to 7 feet higher than any other known flood before or since this event. There were no record of flows on the main stem but previous studies by the Corps estimated the discharge of the river was about 14,000 cfs in the vicinity of the present USGS gage site in Cranston.

Scituate Reservoir was not in existence at the time of this flood. If it had been built and initially filled, it is estimated the resulting flood at Cranston would have been modified to about 11,000 cfs. A recurrence of such a flood today, with present levels of development in the lower basin would result in a catastrophic type disaster.

TABLE 7
MONTHLY DISCHARGES
SOUTH BRANCH PAWTUXET RIVER AT WASHINGTON, RI
D.A. = 63.8 SQ MI
Period of Record 1941-1975

Year		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1941	Observed	107	171	134	114	90.6	109	77.7	63.8	50.8	28.5	40.7	49.6	86.[illegible]
	(Natural)	(112)	(170)	(147)	(117)	(112)	(99)	(58.5)	(41.2)	(24.8)	(28.1)	(43.2)	(67.0)	(85)
1942		63.2	110	278	155	83.9	81.5	80.1	71.7	64.7	57.7	62.2	135	103.6
		(87.5)	(147)	(296)	(142)	(85.2)	(60.1)	(65.9)	(72.8)	(40.2)	(49.2)	(99.7)	(184)	(110.8)
1943		192	187	231	158	178	112	49.8	42.1	36.1	36.6	64.7	63.5	112.6
		(171)	(208)	(224)	(159)	(181)	(81.4)	(35.4)	(28.9)	(20.0)	(51.8)	(75.6)	(45.3)	(106.8)
1944		54.6	62.9	106	181	122	83.4	54.2	42.1	50.2	69.6	127	227	98.3
		(58.9)	(78.8)	(158)	(192)	(113)	(68.4)	(27.9)	(16.6)	(105)	(62.3)	(171)	(218)	(105.8)
1945		225	174	272	134	182	113	89.7	64.3	36.1	36.9	49.7	229	133.8
		(188)	(182)	(294)	(144)	(177)	(101)	(62.8)	(36.1)	(29.6)	(35.0)	(105)	(260)	(134.5)
1946		249	186	182	117	112	146	48.5	122	96.5	81.9	62.4	60.3	122.[illegible]
		(225)	(185)	(205)	(109)	(126)	(116)	(44.0)	(155)	(58.6)	(60.6)	(59.1)	(70.5)	(117.[illegible])
1947		74.8	86.1	187	206	197	108	86.1	63.7	54.7	46.1	72.8	119	107.[illegible]
		(105)	(102)	(210)	(210)	(194)	(103)	(66.5)	(40.9)	(32.3)	(40.1)	(149)	(85.6)	(111.5)
1948		129	126	328	282	294	262	98.2	78.3	46.2	44.7	59.0	111	154.9
		(96.1)	(184)	(354)	(272)	(311)	(250)	(82.5)	(51.0)	(29.6)	(48.5)	(99.6)	(98.3)	(156.4)
1949		134	197	192	214	133	79.4	43.0	48.7	39.6	31.1	37.0	43.5	99.4
		(170)	(195)	(185)	(221)	(136)	(48.5)	(32.1)	(25.5)	(24.5)	(29.0)	(49.4)	(60.7)	(98.1)
1950		52.3	124	177	180	134	122	66.7	50.8	42.4	45.3	51.2	107	96.1
		(83.9)	(152)	(189)	(182)	(134)	(104)	(40.6)	(37.7)	(37.2)	(32.1)	(99.4)	(146)	(103.2)
1951		166	250	225	254	147	117	60.9	59.1	47.4	51.7	138	212	144.0
		(164)	(252)	(230)	(250)	(148)	(118)	(36.8)	(37.2)	(31.1)	(44.8)	(211)	(215)	(144.8)
1952		244	246	278	161	159	96	64.0	70.1	59.3	53.4	41.3	54.5	127.2
		(243)	(242)	(285)	(167)	(155)	(83.7)	(34.0)	(71.1)	(31.9)	(35.2)	(49.4)	(85.9)	(123.6)
1953		137	251	361	375	203	76.4	61.9	56.2	53.5	54.2	71.8	250	162.6
		(193)	(251)	(367)	(371)	(201)	(68.3)	(42.7)	(37.3)	(32.2)	(55.6)	(143)	(252)	(167.5)
1954		144	160	201	228	234	92.5	49.2	68.3	240	123	204	300	170.3
		(146)	(166)	(195)	(231)	(233)	(77.3)	(51.3)	(87.8)	(238)	(111)	(215)	(311)	(171.9)
1955		230	211	236	166	135	62.8	67.3	135	146	216	354	153	176.0
		(187)	(245)	(227)	(188)	(128)	(85.3)	(51.7)	(128)	(77.3)	(321)	(335)	(136)	(175.8)
1956		203	262	260	338	149	133	61.2	59.2	52.1	75.5	62.4	121	148.0
		(198)	(258)	(274)	(341)	(166)	(98.6)	(79.5)	(32.1)	(51.9)	(65.5)	(79.9)	(153)	(149.8)
1957		147	161	163	220	75.3	39.2	34.1	39.4	29.1	29.2	30.9	102	89.2
		(142)	(144)	(169)	(245)	(79.1)	(28.3)	(15.7)	(18.7)	(16.1)	(24.9)	(45.7)	(137)	(88.8)
1958		306	218	299	349	271	117	75.7	118	93.2	148	133	136	188.7
		(323)	(199)	(309)	(365)	(271)	(117)	(72.6)	(110)	(90.2)	(138)	(132)	(118)	(187.1)
1959		99.7	132	259	256	120	107	130	62.5	54.9	59.7	89.8	223	132.8
		(111)	(143)	(281)	(260)	(126)	(111)	(127)	(40.2)	(31.0)	(78.3)	(102)	(208)	(134.9)
1960		202	223	200	210	124	69	68.6	53.2	72.5	67.1	99.7	128	126.4
		(191)	(268)	(169)	(239)	(136)	(49.0)	(59.8)	(31.7)	(85.9)	(70.7)	(100)	(134)	(127.8)
1961		147	149	277	311	218	131	77.9	49.1	122	133	106	128	154.1
		(137)	(193)	(258)	(326)	(232)	(110)	(59.6)	(44.9)	(147)	(127)	(100)	(124)	(154.0)
1962		238	167	256	261	117	91.5	48.1	61.2	44.0	146	223	214	155.6
		(250)	(143)	(296)	(281)	(120)	(91.0)	(39.5)	(33.3)	(39.4)	(151)	(220)	(211)	(156.3)
1963		116	190	206	141	155	92.1	47.0	48.6	48.0	47.3	40.3	92.0	101.9
		(129)	(205)	(209)	(145)	(159)	(95.9)	(45.9)	(27.3)	(39.8)	(33.5)	(82.7)	(114)	(107.2)
1964		221	196	212	293	72.0	43.3	41.5	33.5	60.4	36.0	38.0	94.5	111.8
		(215)	(203)	(215)	(293)	(68.9)	(43.5)	(38.9)	(16.2)	(30.4)	(41.3)	(41.2)	(98.5)	(109.4)
1965		130	159	186	109	81.1	58.0	35.5	39.9	44.3	36.6	28.7	34.5	78.6
		(118)	(201)	(175)	(124)	(88.4)	(53.5)	(21.5)	(20.8)	(22.8)	(28.3)	(28.6)	(36.4)	(76.5)
1966		35.9	45.7	136	68.2	100	76.6	38.3	38.1	42.4	39.7	75.5	87.2	65.3
		(38.1)	(105)	(153)	(70.0)	(103)	(61.2)	(29.8)	(24.4)	(38.1)	(50.1)	(108)	(91.9)	(72.7)
1967		120	95.7	213	228	252	147	101	84.7	64.7	81.9	79.0	193	138.3
		(108)	(100)	(221)	(228)	(252)	(150)	(98.4)	(77.4)	(56.0)	(70.9)	(86.8)	(201)	(137.5)
1968		202	185	334	141	127	121	64.2	42.8	42.6	47.4	53.8	148	125.7
		(193)	(173)	(364)	(149)	(129)	(120)	(50.8)	(28.4)	(22.9)	(29.0)	(93.3)	(167)	(126.6)
1969		129	123	186	272	168	79.5	55.2	73.3	63.7	58.7	120	200	127.4
		(126)	(96.9)	(231)	(269)	(176)	(70.0)	(52.8)	(51.8)	(48.3)	(49.0)	(134)	(247)	(129.3)
1970		181	327	147	271	121	95.4	56.9	48.1	41.2	37.9	53.5	119	124.9
		(177)	(315)	(165)	(273)	(124)	(95.3)	(42.1)	(30.7)	(24.3)	(36.8)	(102)	(112)	(124.8)
1971		108	141	236	155	148	71.2	44.1	42.8	37.0	35.3	41.5	64.3	93.7
		(70.6)	(200)	(244)	(158)	(148)	(61.4)	(38.0)	(20.9)	(17.4)	(41.5)	(51.0)	(91.1)	(95.2)
1972		120	130	401	191	237	250	129	74.9	100	112	273	409	202.2
		(121)	(148)	(402)	(196)	(237)	(247)	(129)	(54.2)	(77.6)	(104)	(325)	(385)	(202.2)
1973		266	282	176	260	218	91.3	117	91.3	134	47.5	47.2	274	167.0
		(251)	(280)	(176)	(273)	(221)	(103)	(116)	(91.3)	(69.7)	(68.2)	(77.5)	(280)	(167.2)
1974		250	223	249	223	107	74.4	41.4	23.6	42.2	66.2	61.8	166	127.3
		(246)	(226)	(242)	(226)	(122)	(75.7)	(38.8)	(18.9)	(41.0)	(60.4)	(65.4)	(167)	(127.4)
1975		230	178	193	160	84.2	105	50.5	39.5	74.4	119	185	200	134.9
		(227)	(175)	(192)	(174)	(98.4)	(103)	(47.8)	(29.4)	(54.5)	(119)	(185)	(200)	(133.8)
MEAN		162	175	228	211	153	104	66.1	61.7	66.5	68.6	93.7	150	128.2
		(160)	(187)	(238)	(217)	(157)	(95.7)	(55.3)	(47.7)	(52.1)	(68.3)	(116)	(158)	(129.2)
MAXIMUM		306	327	401	375	294	262	130	135	240	216	354	409	202
		(323)	(315)	(402)	(371)	(311)	(250)	(129)	(155)	(238)	(321)	(335)	(385)	(202)
MINIMUM		35.9	45.7	106	68.2	72.0	39.2	34.1	23.6	29.1	28.5	28.7	34.5	65.3
		(38.1)	(78.3)	(147)	(70.0)	(68.9)	(43.5)	(15.7)	(16.2)	(16.1)	(24.9)	(28.6)	(36.4)	(72.7)

(3) 2-4 November 1927. The heaviest rainfall associated with this major storm system occurred outside the Pawtuxet basin. Rainfall amounts varying from 2 to 7 inches were reported within the watershed. Scituate Reservoir stored 100 percent of the runoff from its watershed and only a minor flood freshet developed in the lower basin.

(4) 9-21 March 1936. New England floods resulting from this storm were caused by a combination of heavy rainfall, deep snow cover, and unusually high temperature for the season. Rainfall in the Pawtuxet basin was about 3.4 inches for the period 9-12 March and 3.1 inches for the period 18-22 March. Water equivalent of the snow cover, which was depleted during the period, was estimated at about 1 inch.

The flood was significantly modified by storage capacity initially available in the upstream reservoirs and the resulting peak flow of the Pawtuxet River in the vicinity of the present USGS gage in Cranston was estimated at about 5,300 cfs.

(5) 18-24 July 1938. This flood was the greatest experienced on the main stem Pawtuxet since the construction of Scituate Reservoir in 1926. It was the result of a coastal storm producing an average of 7 inches of rainfall over the Pawtuxet basin. This event occurred at a time when both Flat River and Scituate Reservoirs were initially almost full; therefore, the only modifying effect was that due to surcharge storage. The resulting peak discharge at Cranston has been estimated at about 6,300 cfs. The flow components making up the July 1938 flood hydrograph at Cranston are graphically presented on plate 5.

(6) 17-22 September 1938. The hurricane of September 1938 produced an abnormal tide level in Narragansett Bay of 15.7 feet above msl in the vicinity of the mouth of the Pawtuxet River. This tide was 10.2 feet above the crest of the Pawtuxet dam and resulted in extensive tidal flooding in the lower reaches of the Pawtuxet River. The rainfall of the preceding 4 days averaged 5 inches over the Pawtuxet watershed, but upstream reservoir levels were low and Pawtuxet River flows were not considered a major contributor to experienced floods.

(7) 31 August 1954. Hurricane "Carol" passed over the western portion of the basin creating abnormally high tides to elevation 14.7 feet above msl in Narragansett Bay near the mouth of the Pawtuxet River. The overtopping of Pawtuxet dam resulted in flood stages to approximately 12.5 feet msl upstream of the dam. Wind gusts of about 100 mph were recorded at Providence during this hurricane. Precipitation associated with this storm was only about 3 inches over the basin and freshwater flooding was not a major factor.

(8) 17-18 March 1968. The 1968 event was produced by 4 to 7 inches of rainfall occurring in a 48-hour period. A preceding storm on the 12th and 13th of the month plus some snowmelt provided high antecedent runoff conditions. The resulting peak discharge at the USGS gage in Cranston was 3,110 cfs. Though flood damages were not major, the event occurred following a period of very intensive development in the lower basin, and brought attention to the great flood damage potential to which most of this development was exposed. The 1968 flood discharge on the main stem Pawtuxet River was significantly modified by storage capacity initially available at Scituate Reservoir. Had this reservoir been initially filled, it is estimated the peak flow at Cranston would have been about 6,500 cfs or comparable to the experienced July 1938 flood when reservoirs were initially full.

Detailed analysis of the development of the March 1968 flood is graphically presented on plate D-4. Pertinent data on the effects of Scituate and Flat River Reservoirs on historic floods is summarized in tables 8 and 9.

(9) 25-26 January 1979. During the preparation of this report, the Pawtuxet River experienced the greatest floodflow since 1938. All data is not as yet in and a detailed analysis of this event has not been completed, but the peak flow on the Pawtuxet, recorded at the Cranston USGS gage, was 4,100 cfs. This flood event was the result of about 3 inches of rain on the 21st and 22nd of January, which produced considerable filling of available reservoir storage, and was followed by about 5 inches of rain on the 25th of January.

c. Flood Frequencies

(1) General. Flood frequencies for the Pawtuxet River were derived through analysis of historical flood discharge data within the basin, both recorded and computed, as well as by comparison with long-term discharge records of streams outside the basin but in the general region. Peak discharge frequency curves were developed for (a) the Pawtuxet River at Cranston, (b) the South Branch at Washington, (c) the uncontrolled 50.5 square mile local area downstream of the Flat River and Scituate Reservoirs to the Cranston gage, and (d) the 30.4 local from the gage to the mouth of the river.

(2) Pawtuxet River. Due to the complexity of the effect of upstream reservoirs on floodflows on the main stem Pawtuxet, conventional statistical flood frequency analysis of the data was not considered applicable. Instead, recorded annual peak flows and historical flood peaks were plotted using "Beard's" plotting positions and a composite frequency curve was fitted to the plotted data as shown on plate D-6.

TABLE 8

FLOOD STORAGE BY UPSTREAM RESERVOIRS

	Scituate Reservoir (D.A. = 92.8 sq.mi.)				Flat River Reservoir (D.A. = 56.7 sq.mi.)			
	Initial Storage Capacity		Surcharge Storage		Initial Storage Capacity		Surcharge Storage	
	Inches	% Runoff	Inches	% Runoff	Inches	% Runoff	Inches	% Runoff
February 1886	Before Construction				0.48	10	1.51	30
November 1927	3.72	100	0	0	1.06	30	0.27	7
March 1936	3.21	60	1.47	28	0	0	0.76	14
July 1938	0	0	1.30	37	0.11	5	0.43	19
March 1968	2.24	100	negligible	negligible	0	0	.81	38

TABLE 9

ESTIMATED EFFECT OF UPSTREAM RESERVOIRS ON PEAK FLOWS AT CRANSTON, RHODE ISLAND

Flood	Flat River & Scituate Initially Filled To Spillway Crest (cfs)	With Complete Storage In Flat River And Scituate (cfs)	Experienced Discharge (cfs)
February 1886	11,000	7,000	14,000*
July 1938	6,300	3,300	6,300
March 1968	6,800	2,700	3,110
SPF	19,000	13,000	-

*Scituate Reservoir not in existence

(3) South Branch. A discharge frequency curve for the South Branch at Washington, Rhode Island was developed by statistical analysis using the annual peak flows for 39 years of record, plus the addition of the estimated peak flows for the 1936 through 1938 water years. Thus the analysis was made using 44 annual peak flows. A Log Pearson type analysis was made in accordance with procedures presented in "Statistical Methods in Hydrology" by L. Beard dated January 1962. The basic statistical data is listed in table 10. Peak discharge data for both the South Branch and Pawtuxet are listed in table 11.

(4) Locals. The peak discharge frequency curves for the unmodified 50.5 square mile local downstream of Flat River and Scituate Reservoirs and the 30.4 square mile local downstream of the gage were developed by relating the computed 1968 flood contributions from the areas with similar gaged watersheds, namely Kettle Brook and Branch River in the neighboring Blackstone River basin. Statistical data developed for the gaged streams and that adopted for the local watersheds are listed in table 10. The adopted discharge frequency curve for the Pawtuxet River at Cranston is shown on plate D-6.

(5) Flood stage frequencies. Flood stage-frequency curves, for use in damage-benefit analyses, were developed at various index stations using the discharge frequency information just discussed in conjunction with developed stage-discharge rating curves. The rating curves were developed from backwater studies, which are discussed in paragraph 6, entitled: "Flood Profiles". In the reach of the river affected by flood tides, composite stage frequency curves were developed reflecting tide and freshwater flooding. For example, if a given flood level was expected to be reached 10 times in 100 years by freshwater flooding and 5 times per 100 years by flood tides then the composite curve would indicate flooding to this level 15 times per 100 years.

Modified stage frequency curves for various plans of improvement were similarly developed using the modified discharge frequencies and appropriate rating curves.

d. Standard Project Flood

(1) General. The standard project flood (SPF) represents the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonable characteristic of the region, excluding extremely rare combinations. The SPF represents a "standard" against which the flood potential of a river can be judged, as contrasted to an analysis of flood records which may be misleading due to abnormal

TABLE 10

DISCHARGE FREQUENCY DATA

	South Branch Pawtuxet River Washington, R.I.	Branch River Blackstone Basin Forestdale, R.I.	Kettle Brook Blackstone Basin Worcester, Mass.	Adopted for Local To Cranston Gage	Adopted for Local Below Cranston
Drainage Area (sq. mi.)	63.8	91.2	31.3	50.5	30.4
Log of Mean	2.83	3.19	2.65	3.05	2.85
Standard Deviation	0.218	0.220	0.325	0.270	0.250
Adopted Skew	+0.5	+0.5	+0.5	+0.50	+0.50
100-Year Frequency (Q in cfs)	2,640	6,600	3,620	6,000	3,000
50-Year Frequency "	2,190	5,300	2,690	4,600	2,500
20-Year Frequency "	1,600	3,950	1,790	3,300	1,800
10-Year Frequency "	1,300	3,100	1,270	2,500	1,400
5-Year Frequency "	950	2,400	850	1,800	1,050
2-Year Frequency "	650	1,480	420	1,100	640

TABLE 11

PEAK DISCHARGE DATA

	South Branch Pawtuxet River at Washington, RI (D.A. = 63.8 sq. mi) Q (cfs)	Pawtuxet River at Cranston, RI (D.A. = 200 sq. mi) Q (cfs)
1936	1810	
1940	-	1960
1941	299	1960
1942	665	1430
1943	507	1450
1944	499	1620
1945	731	1640
1946	494	1510
1947	620	1320
1948	959	1910
1949	353	1170
1950	616	1140
1951	642	1430
1952	746	1600
1953	898	1830
1954	1320	2010
1955	658	1490
1956	942	2090
1957	421	1080
1958	752	1770
1959	602	1770
1960	382	1520
1961	682	1800
1962	822	1950
1963	313	1960
1964	660	1530
1965	310	1820
1966	269	695
1967	902	2480
1968	1860	3110
1969	704	2050
1970	1530	2710
1971	337	1190
1972	938	2080
1973	902	2730
1974	590	2320
1975	345	1630
1976	651	2070
1977	910	1820
1978	1420	3040
1979	1740	4100

sequences of events during the period of record. The SPF for the Pawtuxet River was developed using standard project storm rainfall, as described in EM 1110-2-1411, and unit hydrographs derived from analysis of recorded floods in the basin.

(2) Rainfall. The standard project storm was oriented over the Pawtuxet watershed with its center near the junction of the two branches with its long axis running in a southwest to northeast direction. The storm pattern is shown on plate D-6.

The standard project storm index rainfall for 24 hours over a 200 square mile area is 11 inches. A summary of the adopted standard project storm contribution for a drainage area of 200 square miles is as follows:

	Inches
SPS Rainfall (24 hours)	11.0
Losses	2.3
Rainfall Excess	8.7
Maximum 3-Hour Rainfall Excess	5.3

Losses were assumed at the rate of 0.1 inch per hour which is consistent with minimum losses determined in previous Corps of Engineers studies for the New England Area. The rainfall over each tributary and local area was obtained by planimetering between the isohyets and respective watershed divides.

(3) Unit hydrographs. Unit hydrographs were derived, through analysis of the March 1968 flood, for the watersheds of (a) Flat River Reservoir, (b) Scituate Reservoir, and (c) the two downstream local areas. The peaks of all developed unit hydrographs were increased 25 percent, in accordance with EM 1110-2-1405, to reflect the increased runoff rates expected under standard project storm conditions. A typical unit hydrograph development is shown on plate D-5.

(4) Standard project flood. Rainfall excess was computed for each subwatershed and applied to the adopted unit hydrographs. The resulting hydrographs for Flat River and Scituate Reservoirs were routed through surcharge storage assuming the reservoirs initially filled to spillway crest. The resulting outflow hydrographs were then routed downstream and combined with the component hydrographs from the local areas. The development of the SPF for the Pawtuxet basin is graphically illustrated on plates D-7 and D-7A.

e. Flood Profiles

Flood profiles for the main stem of the Pawtuxet River are shown on plate 8. Profiles were computed by standard backwater procedures using a minimum of surveyed cross sections of the river and the computer program, HEC-2, developed by the Hydrologic Engineering Center in Davis, California. The computer model was calibrated, to the extent possible, against historic flood elevations. In many instances the computed profile for a historic flood discharge was somewhat higher than observed and this was attributed largely to reduced hydraulic capacity of the river due to accelerated development. Backwater computations were made for a range of both natural and modified floods using a Manning's n of 0.05 for channel and 0.08 for overbank. Assumed contraction and expansion loss coefficients were 0.3 and 0.5, respectively.

7. DROUGHTS

The Pawtuxet River basin, in southeastern New England, is a semi-humid region with an average annual rainfall of about 43 inches, with a minimum of record at Providence of 25.4 inches in 1965. However, the long-term normal rainfall of approximately 43 inches is the average of many highs and lows. When rainfall is below average for a period of time, the area experiences what is referred to as a drought. In this case, a drought is defined as a prolonged period of precipitation deficiency which seriously affects both riverflow and groundwater supplies. The recent drought of the 1960's in southeastern New England was one of the greatest ever experienced in the area, at least since the beginning of systematic streamflow records near the turn of the 20th century. An analysis of rainfall records at Providence dating back to 1832 indicates there was a drought comparable to the "sixties" drought in 1914-1916. Monthly rainfall values recorded at Providence since 1832 are listed in table 4.

The 1960's drought followed a period of above normal rainfall during the 1950's resulting in complacency on the part of cities and towns during a period of rapidly increasing water demand. This drought was particularly severe, because it was the result of two years in succession, 1965 and 1966, of near record lows in annual precipitation. The average flow of the South Branch, Pawtuxet River was about 57 percent of normal for the period May 1964 to October 1966, equivalent to a runoff deficiency of more than 25 inches. Assigning a frequency of occurrence to such an event is quite conjectural, however, based on statistical analyses of hydrologic records in the region, the annual probability of a 1960's magnitude drought is not considered to be more than 1 to 2 percent. Normally, only in the analysis of the shorter term hydrologic records is there sometimes an indication of the sixties drought being more frequent than

2 percent. In other words, the maximum yield of a water supply system under conditions of a 1960's drought, could be considered the system's 98 to 99 percent dependable yield.

Minimum rainfall frequency curves computed from Providence rainfall records and minimum runoff frequency curves computed using shorter term records of the South Branch and North Branch at Scituate Reservoir are shown on plate D-9. The curves were developed using annual data in a "Pearson" distribution. The minimum values of record are also shown on the curves to illustrate relative positioning.

8. BIG RIVER RESERVOIR

a. General. The Big River Reservoir would be created by the construction of an approximately 70-foot high dam across the Big River near the Coventry-West Greenwich town line, the dam site being at approximately 41°39'55" North Latitude and 71°37'15" West Longitude. The dam would have a top elevation of 312 feet msl, 9 feet above the maximum regulated pool level (spillway crest) at elevation 303 feet msl. At spillway crest, the reservoir would have a total lake area of about 3,400 acres and a total regulated storage capacity of 95,400 acre-feet. The upper 3 feet of storage between elevations 300 and 303 feet msl would be reserved for flood control storage, providing 9,500 acre-feet of storage equivalent to 6 inches of runoff from the 29.7-square mile watershed. The flood control aspect of the project is discussed further in paragraph 9 - "Flood Control".

The 73,600 acre-feet of storage between elevations 300 and 267 feet msl would be useable water supply storage and the remaining 12,300 acre-feet of storage below elevation 267 feet msl would be termed "conservation" storage. This conservation storage, equivalent to about 15 percent of total storage would provide for sediment accumulation, fish maintenance, and esthetics, however, such storage could possibly be partially used for water supply under unforeseen emergency conditions. Storage requirements for water supply are discussed further in paragraph 10 - "Water Supply Yields". The site of the Big River dam and reservoir is shown on plate D-2. Elevation versus lake area and storage capacity curves are shown on plate D-10.

b. Evaporation Losses. The construction of Big River Reservoir would replace approximately 3,200 acres of present land area with lake area. The net loss in watershed yield due to evaporation from such a lake surface would be the difference between lake evaporation and evapotranspiration from vegetated land area. Average annual evapotranspiration and other losses from land area is the difference between mean annual rainfall and mean annual stream runoff. Mean annual precipitation as recorded at Providence is 43 inches and runoff is about 27 inches, therefore, mean annual evapotranspiration is in the order of 16 inches. Mean annual lake evaporation in the region is 27 inches, according to "Climatic Atlas of the United States", ESSA, June 1968.

The net loss from lake evaporation would be 27 inches minus 16 or 11 inches over the lake area of 3,200 acres; equivalent to an average annual net loss in watershed yield of 4 cfs. In analyzing Big River Reservoir, an average annual net loss of 5 cfs was allowed for lake evaporation losses.

c. Spillway Design Flood. The Big River Dam and Reservoir would be equipped with an ungated emergency overflow spillway capable of discharging the maximum probable storm runoff with the reservoir initially filled to spillway crest elevation, 303 feet msl, as a result of antecedent flood runoff. The maximum probable inflow hydrograph was determined by applying the 24-hour rainfall of 23.4 inches to an adopted unit hydrograph. The unit hydrograph was selected based on analysis of the March 1968 flood in the basin. The computed unit graph was peaked 25 percent to reflect the increased rate of runoff expected under intense rainfall and with the shortened flow distances with the presence of the large lake area. Snyder's coefficients, T_p and Q_p for the adopted unit graph were 5.5 hours and 54 cfs per square mile, respectively. The computed peak inflow to the reservoir was 28,600 cfs and the peak outflow, with a 400-foot long spillway, would be 12,000 cfs with surcharge storage in the reservoir rising 4 feet to elevation 307 feet msl. Spillway capacity was computed by conventional weir formula using an average discharge coefficient of 3.8. It is noted that the relatively large amount of surcharge storage at this project provides significant modification of the spillway design flood. Four feet of surcharge storage is equivalent to about 10 inches of runoff from the watershed which is almost 50 percent of the spillway design storm runoff.

The spillway design flood development is graphically shown on plate D-11. Included is a surcharge height versus spillway length curve.

d. Design Elevation of Dam. The effective full pool fetch distance at the Big River dam would be 0.76 mile and with a 58 mile per hour wind speed in accordance with ETL 1110-2-221, the wave runup on a 1:4 slope and wind setup would be 2.6 and 0.5 feet, respectively. Since the sum of these two is less than 5 feet, a minimum freeboard of 5 feet above design surcharge was adopted for determining the top elevation of the dam. Thus the design top elevation of the dam, with a 400-foot long emergency spillway, would be 312 feet msl.

9. FLOOD CONTROL

Based on the operation of flood control reservoirs in New England and the analysis of major hurricane storm runoff, standard project floods, and large volume snowmelt rainfall runoff, it has been determined that flood control storage equivalent to 6 to 8 inches of runoff from the contributing watershed is desirable at flood control reservoirs for effective operation. Providing 9,500 acre-feet of flood control storage at Big River, 3 feet of depth above the full water supply level, would be equivalent to 6 inches of runoff from the 29.7 square mile watershed.

The watershed controlled by Big River represents only about 12 percent of the total Pawtuxet River watershed, therefore, resulting downstream flood reductions on the main stem Pawtuxet River would be quite limited. The potential reduction would vary depending on the type of flood development, antecedent conditions and the storm orientation over the basin. In a repeat of floods such as experienced in March 1968 and July 1938, it has been judged that the Big River Project would reduce flood levels on the South Branch and upper Pawtuxet River, in the vicinity of the Cranston gage, on the order of 1.5 to 2 feet. In the lower main stem Pawtuxet, in the vicinity of the Warwick Industrial Park, the reductions would be on the order 0.5 foot. Table 12 lists representative percent reductions in floodflows provided by Big River at selected index stations on the South Branch and main stem Pawtuxet River. Reductions in the March 1968, July 1938 and standard project flood by Big River Reservoir are presented in table 13. Development of the March 1968 flood and the standard project flood are shown on plates D-4 and D-7, respectively. Profiles of the main stem Pawtuxet River showing the effects of Big River Reservoir are illustrated on plate D-8. If the proposed Warwick local protection project is built, involving the construction of dikes and walls along the Pawtuxet River, then some of the reduction by Big River Reservoir would be negated as shown on plate D-8.

10. WATER SUPPLY YIELDS

a. General. The "dependable" or "safe" yield of a surface water system varies with the degree of dependability sought. There is no way of reliably determining the severest possible drought, and if there were, it probably would not be practical to design for such a condition but rather accept some degree of risk.

Safe yields are often based on the yield that can be provided continuously during: (1) the severest drought of record, or (2) the 1 or 2 percent annual chance drought based on statistical projections, or (3) that yield that can be provided during a 20-year frequency drought without exhausting more than say 75 percent of total usable system storage. As a comparison, it has been determined that in a 1960's drought, the existing Scituate Reservoir system could supply a continuous yield, after downstream minimum releases of 68 MGD without exhausting more than 80 percent storage, 72 MGD with 88 percent storage and 77 MGD with 100 percent storage. For purposes of this feasibility study, "safe yield" was taken as that yield that could be provided during a 1960's drought utilizing usable storage. This was considered a liberal "safe yield" determination but not unrealistic. The 1960's drought is considered in the 1 to 2 percent chance range based on 146 years of rainfall records and 59 years of flow records. Using the sixties drought as the design yield, it is considered that not more than 75 percent of storage would be used in the 20-year frequency drought and it would be expected that conservation measures could be taken to reduce demand somewhat during droughts less frequent than 20 years.

TABLE 12

TYPICAL PERCENT REDUCTIONS IN FLOODFLOWS BY BIG RIVER RESERVOIR

Location	Drainage Area (sq.mi.)	Percent Reduction
South Branch at Washington Gage	63.8	50
Natick Dam	180	25
Cranston USGS gage	200	20
Warwick Avenue	228	10

b. System Yield. Big River Reservoir, with 24,000 MG of usable water supply storage, would provide a dependable yield approximately equal to the long-term average annual runoff from the watershed less net evaporation loss and downstream releases. With an average annual runoff of about 38.8 MGD (60 cfs) and evaporation losses and downstream releases of 3.1 (5 cfs) and 3.8 MGD (6 cfs), respectively, the net yield would be about 31.9 MGD (49 cfs). A Big River mass curve analysis and storage versus yield curve is shown on plate D-12. However, these yields would be that of Big River Reservoir operating as an independent source. Whereas, with Big River operating as part of a system with Scituate, there would be an opportunity to realize an added increment of yield over and above the sum of the independent yields of the two projects. With the two

TABLE 13

FLOOD CONTROL
EFFECTS OF BIG RIVER RESERVOIR

Location	Drainage Area (sq mi)	March 1968 Flood Natural Q (cfs)	March 1968 Flood Natural Elevation (ft msl)	March 1968 Flood Modified Q (cfs)	March 1968 Flood Modified Elevation (ft msl)	July 1938 Flood Natural Q (cfs)	July 1938 Flood Natural Elevation (ft msl)	July 1938 Flood Modified Q (cfs)	July 1938 Flood Modified Elevation (ft msl)
South Branch at Washington Gage	63.8	1,870	224.0	900	222.5	-	-	-	-
At Natick Dam	180	2,600	33.4	1,550	31.5	5,800	37.6	4,900	36.6
At Cranston USGS Gage	200	3,110	19.7	2,340	18.2	6,300	22.7	5,350	21.9
At Warwick Avenue	228	3,900	12.0	3,500	11.6	7,000	14.4	6,100	13.8

Location	Drainage Area (sq mi)	100-Year Frequency Flood Natural Q (cfs)	100-Year Frequency Flood Natural Elevation (ft msl)	100-Year Frequency Flood Modified Q (cfs)	100-Year Frequency Flood Modified Elevation (ft msl)	Standard Project Flood Natural Q (cfs)	Standard Project Flood Natural Elevation (ft msl)	Standard Project Flood Modified Q (cfs)	Standard Project Flood Modified Elevation (ft msl)
South Branch at Washington Gage	63.8	2,750	225.0	1,470	223.4	7,900	228.7	4,250	226.3
At Natick Dam	180	5,500	37.4	4,100	35.6	17,000	46.9	13,600	44.2
At Cranston USGS Gage	200	6,600	23.0	5,300	21.8	19,600	32.8	16,200	30.5
At Warwick Avenue	228	8,200	15.2	6,900	14.4	23,000	21.3	20,700	20.6

operating as a system, Scituate could provide a greater portion of the demand during high runoff periods, thereby, reducing spillage losses from its watershed, while at the same time reducing the demand on Big River Reservoir, allowing for the refill of its relatively large amount of storage. It is presently estimated that such operation could realize an added increment of system safe yield of about 4 MGD. Therefore, the total added yield of the system by the addition of the Big River Reservoir Project would be approximately 36 MGD. Based on analysis of the sixties drought of record, whose frequency is considered less than 2 percent annually, the dependable yield of the existing Scituate Reservoir system, after downstream releases, would be approximately 77 MGD. Therefore, the resulting Big River-Scituate system yield would be about 113 MGD. A Scituate mass curve analysis is also shown on plate D-12. A tabulation of system yields for various amounts of usable storage at Big River are listed in table 14.

A computer simulation of the Big River-Scituate Reservoir system operation was made using the computer program HEC-3, "Reservoir Systems Analysis", with hydrologic data for the historic 35-year period 1941 through 1975. The reservoirs were operated as a system with a continuous water supply demand of 113 MGD (175 cfs), the minimum dependable yield based on the 1960's drought. A graphical summary of this simulation is shown on plate D-13. Shown on this plate are monthly storages, inflows-outflows from both reservoirs, the pool level at Big River and the proportional water supply yields from the two reservoirs.

c. Inter-Basin Diversions. In the past it has been suggested that if Big River Reservoir were built and at some time in the future additional water supply was required then it might be possible to increase inflows to Big River by intra-basin diversions. For this feasibility study such plans were hydrologically investigated only to the extent of establishing what increases in yield might be realized. One plan would consist of pumping from Flat River Reservoir back to Big River Reservoir and two other plans consisted of inter-basin diversions from Wood River in the Pawcatuck River basin and from Moosup River in the Thames River basin. The three plans were analyzed by daily computer simulation in which all flows in excess of minimum downstream flow were diverted to Big River up to maximum diversion capacity. For these studies, minimum downstream flow was assumed at 0.2 cfs per square mile of drainage area. Increased yield was based on analysis of the sixties drought and reregulating storage required at Big River for each operation was also established by analysis of the sixties drought. A typical mass curve of diversions to Big River by such an operation is shown on plate D-12. It is noted that the computer simulation program assumes 100 percent effective daily operation of the diversion system precisely according to the established operating plan. Such operation would be highly unlikely in

TABLE 14
BIG RIVER RESERVOIR SYSTEMS
1960 DROUGHT YIELDS

	Drainage Area (sq. mi.)	Usable Storage (MG)	Usable Storage (Ac-Ft)	Elevation (ft, msl)		Total Yield MGD	Total Yield CFS	Net Yield(5) MGD	Net Yield(5) CFS	System Yield MGD	System Yield CFS	Transfer Capacity MGD	Transfer Capacity CFS
1 Scituate	92.8	39,746(1)	121,976			89(6)	137	77	119	77	119	-	-
2 = 1 Plus Big River													
Scituate	92.8	39,746	121,976			89	137	77	119				
Big River	29.7	10,500	32,200	286(2)	(291)(3)	26(7)	45	25	39	102	158		
		15,000	46,000	292	(295)	33	51	29	45	106	164		
		19,800	60,700	297	(300)	37	57	33	51	110	170		
		24,000	73,600	300	(303)	40	62	36	56	113	175		
3 = 2 Plus Flat River Skimming													
Scituate	92.8	39,746	121,976			89	137	77	119				
Flat River	27 Net	(4,500)(4)				13	20	13	20			60	93
Big River	29.7	15,000	46,000	292	(295)	29	45	25	39	115	178		
		19,800	60,700	297	(300)	33	51	29	45	119	184		
		24,000	73,600	300	(303)	37	57	33	51	123	190		
4 = 3 Plus Wood River Skimming													
Scituate	92.8	39,746	121,976			89	137	77	119				
Wood River	36	(4,500)				18	29	18	29			50	77
Flat River	27 Net	(4,500)				13	20	13	20			60	93
Big River	29.7	19,800	60,700	297	(300)	29	45	25	39	133	205		
		24,000	73,600	300	(303)	33	51	29	45	137	212		
5 = 4 Plus Moosup Skimming													
Scituate	92.8	39,746	121,976			89	137	77	119				
Moosup	34.2	(4,200)				17	26	17	26			60	93
Wood River	36	(4,800)				18	29	18	29			50	77
Flat River	27 Net	(4,500)				13	20	13	20			60	93
Big River	29.7	24,000	73,600	300	(303)	29	45	25	39	150	233		

(1) Data from Providence Water Supply Board
(2) Pool level assuming 4,000 MG (12,300 acre-feet) dead storage
(3) Pool level with 9,500 acre-feet of flood control storage
(4) Big River storage allocation for skimming operation
(5) Net yield = total yield - downstream release (0.2 cfs/sq.mi.)
(6) Yield based on Scituate runoff data reported by Providence Water Supply Board
(7) Big River yield operated as part of system with Scituate

actual practice, therefore, the adopted yields were taken as about 80 percent of theoretical, thereby assuming an actual diversion of 80 percent of the theoretical maximum. The increased yields with selected diversion capacities for each of the plans are listed in table 14, together with the amount of Big River storage utilized for reregulation.

These inter-basin diversion yield values are presented for information purposes only, and the feasibility of any such plans for future augmentation of flows to Big River would require extensive study. An undesirable feature of such diversions, among many, is the fact that the diversions would have to be pumped and as droughts cannot be forecast, much unnecessary and costly pumping would be required to protect against the possible but unpredictable development of a serious drought.

11. DOWNSTREAM FLOW REGIME

a. Present Flow Regime. The average flow on the main stem Pawtuxet River at the USGS gage (D.A. = 200 square miles) is 340 cfs (1.7 csm), with average monthly flows ranging from 580 cfs in March to 170 cfs in August. Extremes in flow, during the period of record, (1939-1979), have ranged from 4,100 cfs in January 1979 to 22 cfs in September 1944. The mean annual 1 and 7 day low flows are about 46 cfs (0.23 csm) and 107 cfs (0.53 csm), respectively. Whereas, the 10-year frequency 1 and 7 day low flows are about 28 cfs (0.14 csm) and 74 cfs (0.37 csm), respectively.

Water supply for the city of Providence is drawn from the North Branch of the Pawtuxet River at Scituate Reservoir. The minimum release rate from the Scituate Reservoir during the week for downstream industrial users is 12 MGD (18.5 cfs) which is equivalent to 0.2 cfs per square mile (0.2 csm). Present withdrawal for water supply at Scituate is on the order of 90 cfs. Future demands will increase water supply withdrawals from Scituate which will further reduce average annual flows on the Pawtuxet, but should have little effect on minimum flows since they are presently made up mainly of the minimum releases from Scituate and Flat River Reservoirs plus treatment plant effluents. Average monthly flows of the Pawtuxet River at Cranston both natural and as modified by present reservoir operations and diversions are listed in table 16. Flow duration curves for the Pawtuxet and South Branch are shown on plate D-14.

The average annual flow of the South Branch of the Pawtuxet at the USGS gage (D.A. = 63.8 square miles) is 128 cfs, equivalent to 2 cfs per square mile. Extremes in flow during the period of record have varied from 1,860 cfs in 1968 to a low of 2.8 cfs (in August 1944). Average monthly flows vary from about 220 cfs in March to 60 cfs in

August. Flat River Reservoir has been operated in the past for downstream industrial water supply. This operation has generally consisted of maintaining a minimum week day flow of about 50 cfs with minimum releases of 8 to 12 cfs on weekends. The mean annual 1 and 7 day low flows on the South Branch are 8.3 cfs (0.13 csm) and 28.5 cfs (0.44 csm), respectively. Similarly, the 10-year frequency 1 and 7 day low flows are 4.5 cfs (0.07 csm) and 16 cfs (0.25 csm), respectively. Low flow frequencies were computed by applying a Log Pearson Type III distribution to minimum annual 1 and 7 day average flows. Average monthly flows of the South Branch, both natural and as modified by Flat River Reservoir operations are listed in table 15.

b. Flow Regime with Big River. The Big River Project, if constructed and operated as proposed, would have a minimum average downstream release of 6 cfs, equivalent to 0.2 cfs per square mile. This minimum release rate per unit drainage area would be comparable to the minimum release rate at Scituate Reservoir and would approximate the present mean annual 1 day low flow rate and 10 year frequency 7 day rate on the South Branch and main stem Pawtuxet Rivers.

Though Big River would provide a minimum downstream release, when operated for maximum dependable water supply, it would have a marked reducing effect on average flows of the South Branch. Maximum water supply demand at Big River would reduce average annual flows on the South Branch in the vicinity of the USGS gage by about 40 percent. The project could also affect the low flow regulating capability of Flat River Reservoir since it would control nearly 50 percent of its watershed. This effect is discussed further in the following section.

Big River would also have the potential of reducing average annual flow on the main stem Pawtuxet by as much as 15 percent. However, the effect of a water supply reservoir on downstream flows is dependent on whether the water is used outside the basin or not, and if used within the basin where it is returned to the river. Historically, industrial water use along a river has had little impact on streamflow, since the water was used and returned to the stream. However, when used water is piped to downstream treatment plants, it can have marked effect on streamflow maintenance. Flows on the Pawtuxet are already affected by Scituate and Flat River Reservoir operations and Scituate will have further effect as water supply demand grows, whether Big River is constructed or not. Tables 15 and 16 list comparative average monthly flows for the South Branch and Pawtuxet Rivers for three different conditions: (1) natural flows with no upstream reservoir regulation, (2) observed flow values with existing reservoir operation during the period 1941-1975, and (3) projected future flow conditions with Scituate and Big River operating as a system to provide a water supply yield of 175 cfs (113 MGD).

TABLE 15

AVERAGE MONTHLY FLOWS

South Branch Pawtuxet River
at Washington, RI
(D.A. = 63.8 sq mi)

Month	Natural (cfs)	Observed (cfs)	Projected Future* (cfs)
January	160	162	89.8
February	187	175	109
March	238	228	134
April	217	211	137
May	157	153	93.3
June	95.7	104	57.3
July	55.3	66.1	46.1
August	47.7	61.7	44.5
September	52.1	66.5	45.3
October	68.3	68.6	51.5
November	116	93.7	64.6
December	158	150	84.5
Annual	129	128	79.7

* with Big River and Scituate operating for 113 MGD (175 cfs) yield.

TABLE 16

AVERAGE MONTHLY FLOWS

Pawtuxet River at Cranston
Rhode Island
(D.A. = 200 sq mi)

Month	Natural (cfs)	Observed (cfs)	Projected Future* (cfs)
January	542	437	280
February	625	486	327
March	807	587	384
April	677	552	381
May	466	385	251
June	257	249	155
July	144	172	128
August	141	171	129
September	164	186	138
October	197	185	143
November	373	263	183
December	541	397	264
Annual	411	339	230

* with Big River and Scituate operating
for 113 MGD (175 cfs) yield.

12. BIG RIVER EFFECT ON FLAT RIVER RESERVOIR OPERATION

a. General. The Big River Dam and Reservoir would be located within the existing Flat River Reservoir watershed, intercepting the runoff from 29.7 square miles or 52 percent of the 56.7 square mile Flat River watershed. The existing Flat River Reservoir has a surface area of approximately 1.33 square miles and usable storage capacity of about 5,150 acre-feet (1,680 million gallons), equivalent to about 1.7 inches of runoff from its total watershed area. Historically, the seasonal regulation of storage at Flat River Reservoir has not been specific but for the most part the project has been operated to maintain low flows downstream for industrial use. This results in augmentation usually during late summer and sometimes again in mid-winter with refill occurring during the other times of the year. The operation has generally consisted of maintaining a minimum week day flow on the South Branch of about 50 cfs and cutting back on weekends 408 to 12 cfs, thus resulting in an average weekly regulated minimum flow of about 40 cfs. A simulation of the existing system indicated the Flat River Project to be capable of supplying this minimum flow with a relatively high dependability, i.e. 95± percent.

b. Downstream Flows. Superimposing the Big River Reservoir system operation into the basin obviously would have a marked effect on inflows to Flat River Reservoir, reducing the average inflow to the project by about 43 percent, from 115 to 65 cfs. The project's ability to maintain downstream flows would also be affected. With Big River operating for maximum water supply with a continuous minimum release of 6 cfs,it was determined that the minimum downstream capability of Flat River would be reduced from 40 to about 33 cfs. By modifying the release from Big River to zero in March, April, May, and June and 12 cfs in July, August, September and October, the impact was reduced by about 50 percent resulting in a minimum downstream release capability at Flat River of 37 cfs. Average monthly flows at the South Branch; natural, as regulated by Flat River, and as computed with ultimate Big River operation, are shown graphically on plate D-15. Monthly computed flows by simulation, for the hydrologic period 1941-1975, are also shown on plate D-15. It is noted that the computed flows shown on plate 15 are those resulting from system simulation with Flat River operating for minimum downstream flow and do not necessarily reflect precisely the actual historical operation of Flat River.

c. Flat River Reservoir Levels. As stated previously, the seasonal operation of storage at Flat River Reservoir has not been specific but in general the project is operated to maintain minimum average flows downstream of about 40 cfs, 50 cfs during the week, and 8 to 12 cfs on weekends. As a basis of comparison, simulations were made with the existing system operating for 40 cfs and the future system operating for a minimum downstream flow of 37 cfs. Minimum yearly releases from Big River were 6 cfs but were set at zero for March, April, May and June, and 12 cfs for July, August, September, October. The minimum was 6 cfs for the remaining months. The effect of the Big River operation was to cause more frequent drawdowns of Flat River and a slower refill. Comparative average monthly Flat River pool levels are shown on plate D-15. A plot of comparative pool levels for the simulation period 1941-1975 is also shown on plate D-15. As noted before, the existing system simulation is for an assumed operational plan and does not necessarily reflect the natural historical operation at Flat River.

13. RESERVOIR FILLING

The Big River Reservoir would have a total storage capacity, including dead storage and water supply of about 85,000 acre-feet, equivalent to over 53 inches of runoff from the 29.7 square mile watershed. Since the average annual runoff in the area is about 27 inches, maintaining only the minimum downstream release of 6 cfs with no water supply withdrawals, it would be expected that three years would be required to fill the reservoir, and any drought conditions could further extend the required filling time.

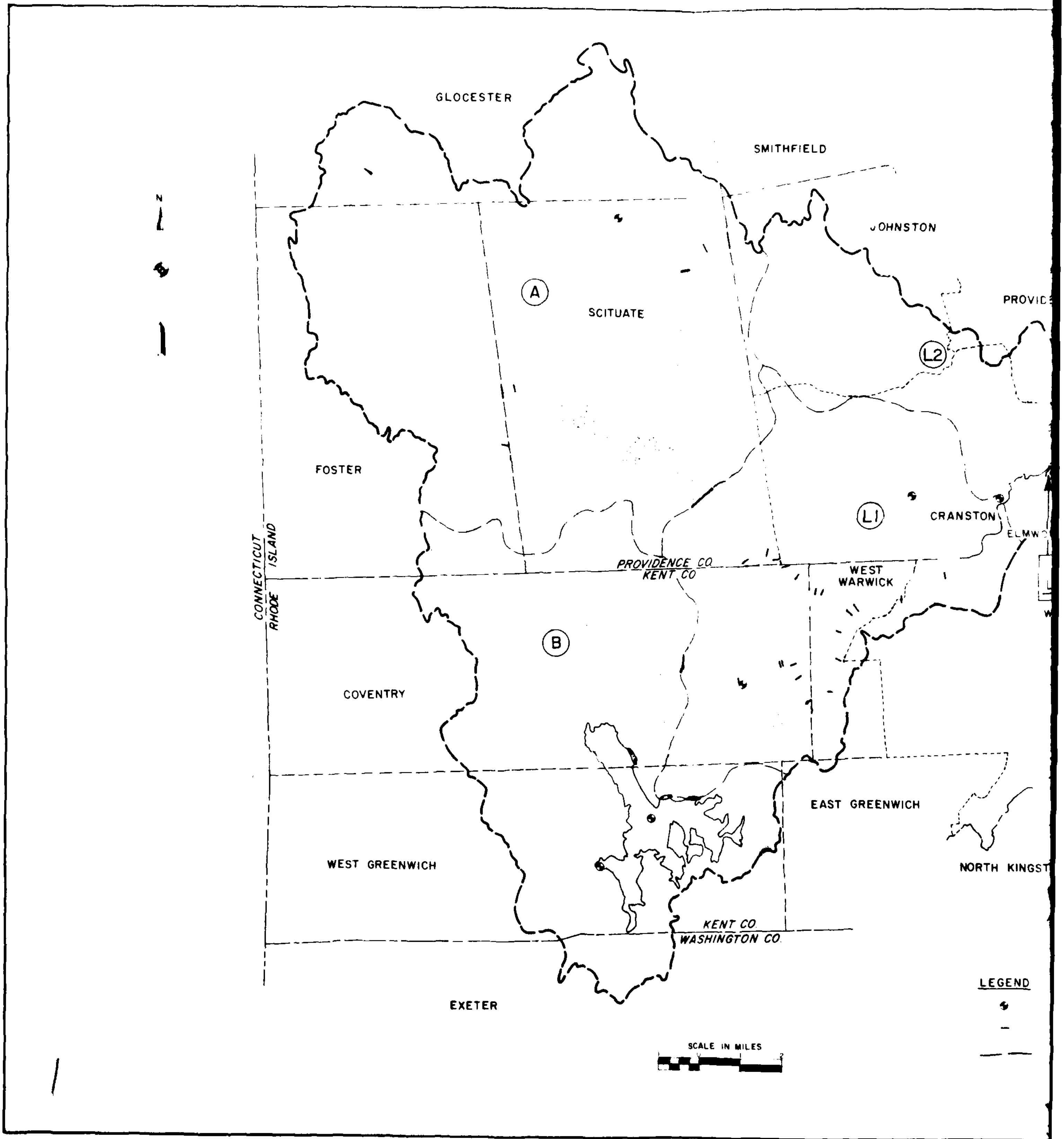
14. RESERVOIR REGULATION

The target lake level at Big River Reservoir would be elevation 300 feet msl. Storage above 300 up to 303 feet msl would only be used for the regulation of infrequent flood events and would be of short duration with the level lowered back to 300 feet msl as soon as downstream channel capacities permitted the safe release of impounded floodwaters. It would not be expected that the lake level would reach elevation 303 feet msl on an average more frequently than once in 50 years. With no inter-basin diversions into Big River Reservoir, and the project operated in system with Scituate, for maximum dependable water supply, the average annual lake fluctuations might be in the order of 3 to 6 feet with maximum annual fluctuations in the order of 15 to 20 feet. Normally, drawdowns would occur during the period July through October with the most pronounced refill period occurring during the spring period March through April. Normal drawdown of 3 to 6 feet would vary the lake area about 150 to 300 acres, respectively, with maximum fluctuations resulting in about 800 acres change in lake area. With no diversions to the reservoir, there would be a tendency for multi-year cyclic drawdowns with the lake level not returning to normal full pool each year and maximum drawdown approaching 33 feet, during very infrequent severe multi-year droughts. The simulation of the system operation for a 35-year hydrologic period, assuming maximum dependable water supply draft, resulted in the lake level variations shown graphically on plate D-13. Pertinent lake level information is listed in table 17. It is noted that the simulation was based on an operation for maximum

TABLE 17
BIG RIVER LAKE LEVELS

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1941	299.85	300.00	300.00	299.94	299.60	299.41	298.89	298.01	297.30	296.24	295.38	294.89
1942	294.83	295.20	297.22	297.60	297.33	296.80	296.29	296.56	294.64	293.99	293.86	295.03
1943	295.43	296.25	297.34	297.96	298.55	297.91	297.12	296.16	295.05	294.45	294.07	293.36
1944	292.75	292.46	292.98	293.76	293.70	293.12	291.56	289.63	288.25	286.24	286.25	288.84
1945	290.71	292.04	294.10	294.68	295.43	295.20	294.55	293.67	292.60	290.92	290.51	292.50
1946	293.70	294.50	295.57	295.47	295.69	295.68	294.79	295.07	294.54	293.95	293.22	292.75
1947	292.76	292.70	293.65	294.51	295.11	294.80	294.30	293.49	292.61	291.15	292.19	291.67
1948	291.30	292.41	295.15	296.41	298.01	298.92	298.23	297.57	296.65	295.81	295.79	295.78
1949	296.44	297.19	297.96	298.78	298.80	297.89	297.04	296.07	295.10	294.28	293.65	293.19
1950	293.06	293.45	294.38	295.23	295.41	295.07	294.31	293.47	292.49	290.74	290.18	290.84
1951	292.14	293.[illegible]	295.28	296.52	296.87	296.83	295.96	295.01	294.21	293.47	294.50	295.69
1952	296.92	297.90	299.50	300.00	300.00	299.61	298.60	297.95	297.14	296.18	295.31	294.97
1953	295.96	297.20	300.00	300.00	300.00	299.28	298.42	297.60	296.75	295.99	296.07	297.30
1954	297.52	297.86	298.67	299.80	300.00	299.35	298.48	298.05	299.15	299.01	299.88	300.00
1955	300.00	300.00	300.00	300.[illegible]	299.93	299.51	298.70	299.38	299.20	300.00	300.00	299.91
1956	300.00	300.00	300.00	300.[illegible]	300.00	299.64	299.06	297.98	297.34	296.68	296.20	296.56
1957	296.81	297.05	297.54	298.81	298.28	297.45	296.37	295.13	294.21	293.31	292.60	292.82
1958	295.12	295.72	297.66	300.00	300.00	299.63	299.16	298.83	298.49	298.62	298.69	298.67
1959	298.57	298.99	300.00	300.00	299.86	299.63	299.74	298.94	297.91	297.57	297.56	298.72
1960	299.58	300.[illegible]	300.00	300.[illegible]	300.00	299.29	298.62	297.68	297.45	297.05	297.00	297.25
1961	297.50	298.50	300.00	300.00	300.00	299.79	299.10	298.24	298.50	298.30	298.15	298.16
1962	299.41	299.46	300.00	300.00	299.88	299.51	298.61	297.69	296.96	297.17	297.73	297.93
1963	297.94	298.20	299.38	299.44	299.54	299.10	298.17	297.29	296.46	295.33	295.17	295.09
1964	296.20	296.96	297.86	299.33	298.86	297.99	297.23	296.21	295.20	294.47	293.76	293.71
1965	293.77	294.57	295.24	295.[illegible]	294.91	294.33	293.38	292.23	290.53	288.31	285.94	283.52
1966	281.21	280.24	279.95	278.3[illegible]	277.45	276.04	274.03	271.87	270.00	267.26	267.19	265.04
1967	266.64	265.88	269.46	271.8[illegible]	274.50	274.97	274.57	273.84	272.92	272.38	272.13	273.59
1968	275.[illegible]2	277.29	282.45	284.0[illegible]	285.48	286.72	287.08	286.42	284.03	281.88	280.72	281.08
1969	280.90	290.14	28[illegible].91	286.07	28[illegible].10	288.70	289.09	289.47	287.38	285.20	284.23	287.20
1970	289.25	291.91	293.07	295.[illegible]	2[illegible].50	295.24	294.49	293.61	292.63	291.14	290.49	289.89
1971	286.35	290.33	292.35	293.15	29[illegible].81	293.53	292.91	291.51	289.66	287.38	285.30	283.80
1972	282.[illegible]8	283.56	288.60	290.57	292.54	294.56	295.48	295.60	295.70	295.84	298.38	300.00
1973	300.00	300.00	300.00	300.00	300.00	299.80	299.43	299.06	298.47	297.94	297.62	299.83
1974	300.00	300.00	300.00	300.00	300.00	299.43	298.56	297.63	296.98	296.52	296.11	296.72
1975	298.30	298.80	299.80	300.00	299.72	299.34	298.47	297.62	297.07	297.15	298.40	299.64
MEAN	294.30	294.90	296.00	296.70	296.90	296.70	296.00	295.30	294.50	293.60	293.50	293.80
MAXIMUM	300.00	300.00	300.00	300.00	300.00	299.80	299.74	299.38	299.20	300.00	300.00	300.00
MINIMUM	266.64	265.88	269.46	271.87	274.50	274.97	274.03	271.8[illegible]	270.00	267.26	267.19	265.04
10 YR. FREQ HIGH	300.00	300.00	300.00	300.00	300.00	300.00	299.10	299.1[illegible]	298.90	298.50	298.90	299.50
10 YR. FREQ LOW	282.50	281.50	28[illegible].60	286.50	288.60	287.60	288.60	287.60	286.00	284.40	282.50	282.10
MAX MONTHLY CHANGE +	2.66	5.16	5.16	3.16	[illegible].63	2.00	.94	1.10	1.10	2.54	2.97	2.97
MAX MONTHLY CHANGE -	-2.31	-0.97	-1.60	-1.60	-1.41	-2.01	-2.16	-2.39	-2.74	-2.74	-2.42	-2.42

dependable water supply. Efforts to optimize the operation of the project for other purposes during wetter than average periods or prior to the need for maximum water supply would have to be made a part of continuing studies and based on periodic review of water resource needs.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JOHNSTON
PROVID
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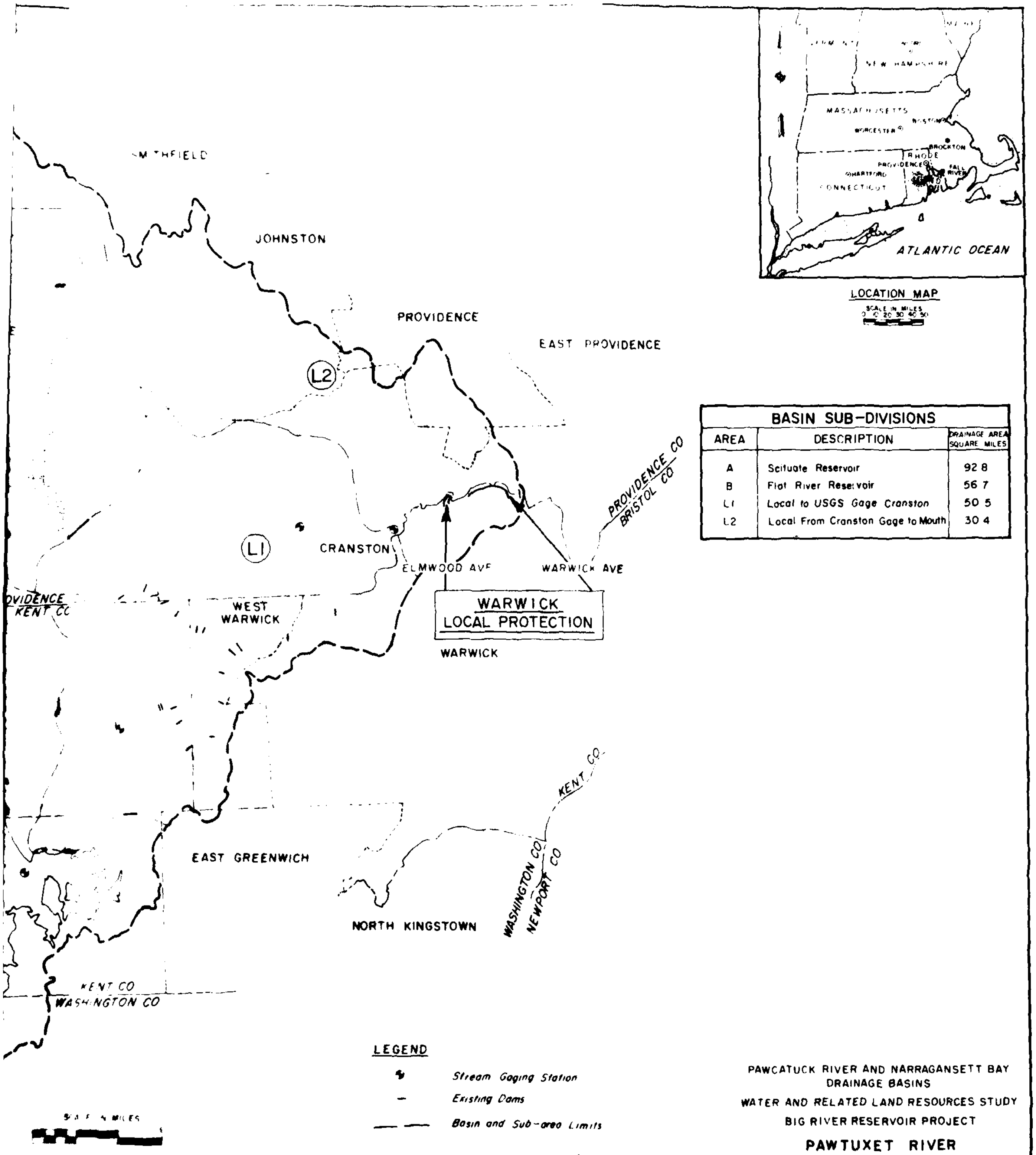
CRANSTON
ELMW
CONNECTICUT
RHODE ISLAND
PROVIDENCE CO.
KENT CO.
WEST WARWICK
B
COVENTRY
EAST GREENWICH
WEST GREENWICH
NORTH KINGST
KENT CO.
WASHINGTON CO.
EXETER
LEGEND
SCALE IN MILES



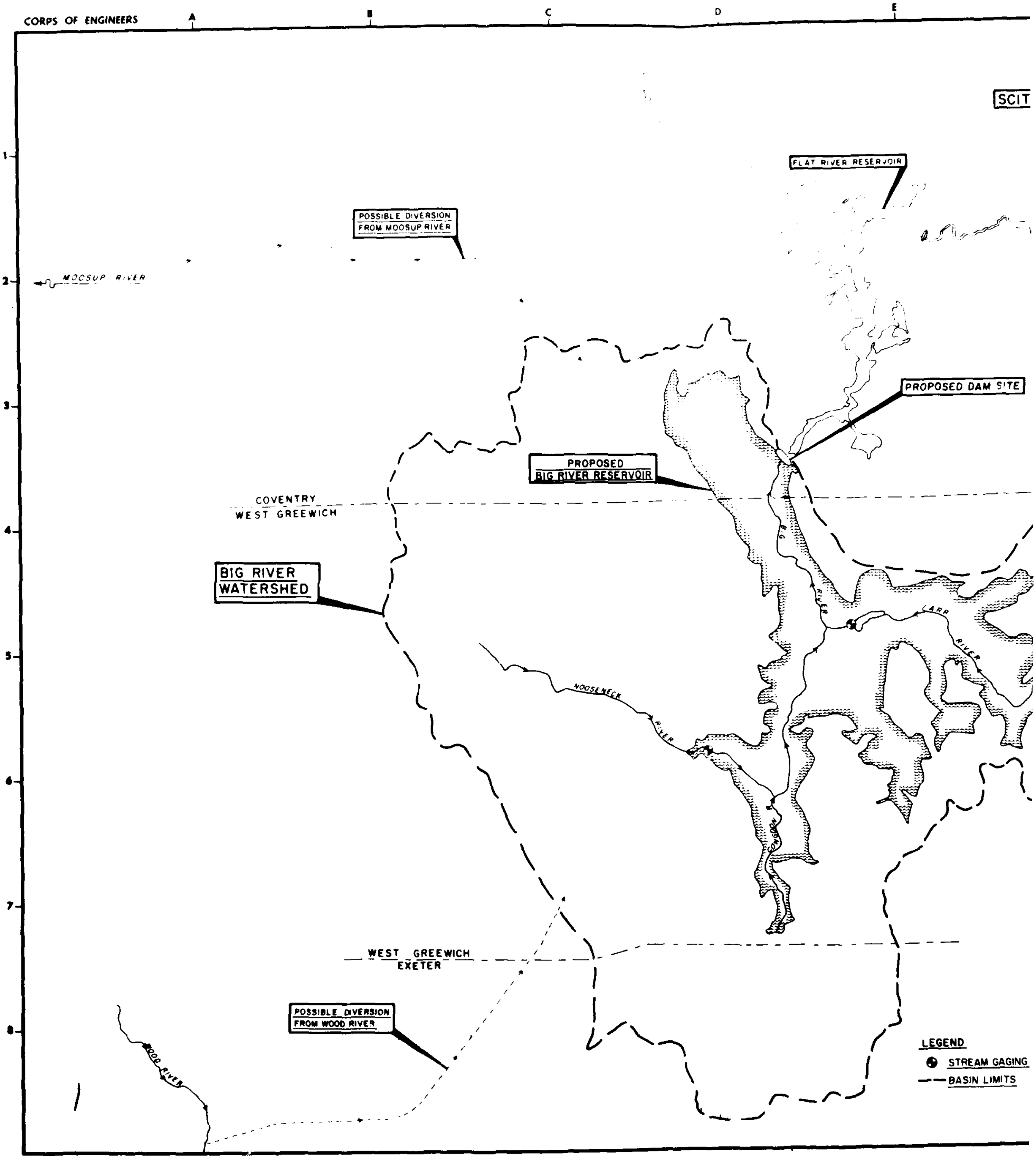
BASIN SUB-DIVISIONS		
AREA	DESCRIPTION	DRAINAGE AREA SQUARE MILES
A	Scituate Reservoir	92 8
B	Flat River Reservoir	56 7
L1	Local to USGS Gage Cranston	50 5
L2	Local From Cranston Gage to Mouth	30 4

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER
BASIN MAP

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE D-1


CORPS OF ENGINEERS
A
B
C
D
E
1
2
3
4
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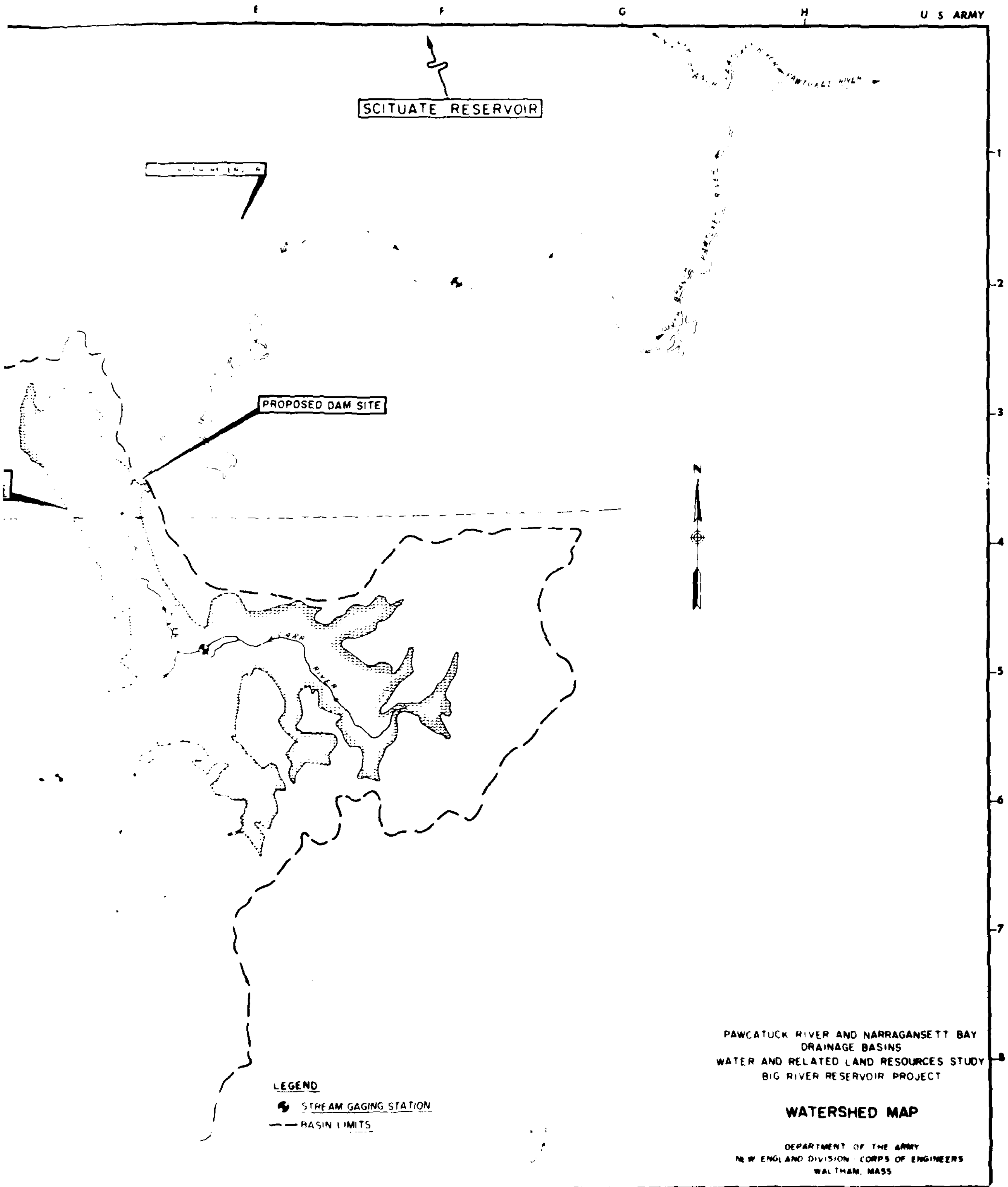
6
7
8
SCIT
FLAT RIVER RESERVOIR
POSSIBLE DIVERSION FROM MOOSUP RIVER
MOOSUP RIVER
PROPOSED DAM SITE
PROPOSED BIG RIVER RESERVOIR
COVENTRY
WEST GREEWICH
BIG RIVER WATERSHED
BIG RIVER
CARR RIVER
NOOSENECK RIVER
WEST GREEWICH
EXETER
POSSIBLE DIVERSION FROM WOOD RIVER
WOOD RIVER
LEGEND
STREAM GAGING
BASIN LIMITS



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F
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U S ARMY
SCITUATE RESERVOIR
PROPOSED DAM SITE
N
1
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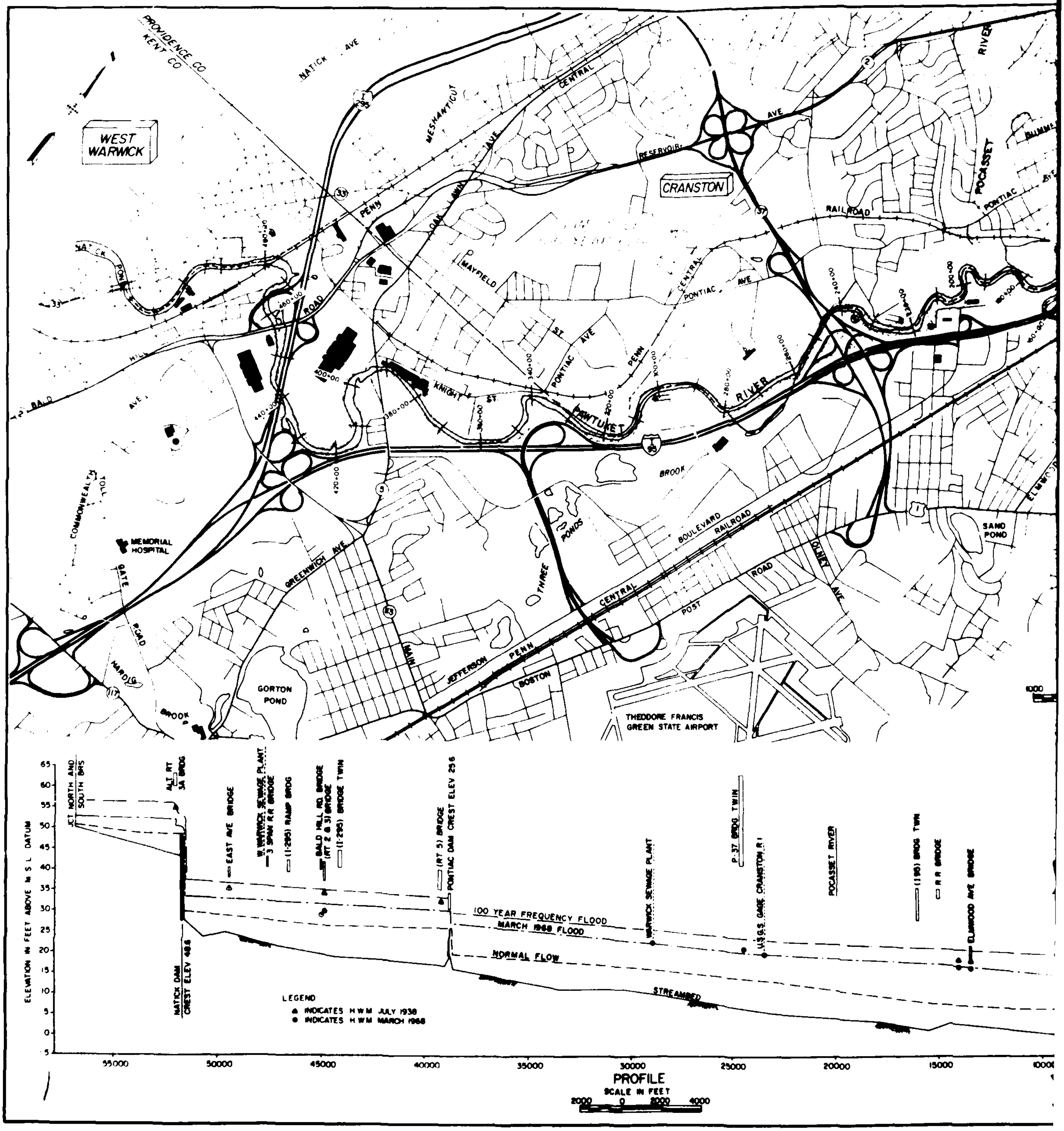
LEGEND
STREAM GAGING STATION
BASIN LIMITS
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT
WATERSHED MAP
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS

PLATE D-2



PROVIDENCE CO
KENT CO
NATICK AVE
WEST WARWICK
MESHANTICUT
CENTRAL
OAK LAWN AVE
PENN
RESERVOIR AVE
CRANSTON
RAILROAD
POCASSET
RIVER
PONTIAC AVE
MAYFIELD
KNIGHT ST
CENTRAL
PONTIAC AVE
PENN
PAWTUXET
RIVER
BALD HILL AVE
ROAD
BROOK
THREE PONDS
BOULEVARD
RAILROAD
CENTRAL
POST ROAD
OLNEY AVE
SAND POND
COMMONWEALTH TOLL
MEMORIAL HOSPITAL
GATE ROAD
GREENWICH AVE
HARDIG
BROOK
GORTON POND
MAIN
JEFFERSON
PENN
BOSTON
THEODORE FRANCIS GREEN STATE AIRPORT
ELEVATION IN FEET ABOVE M S L DATUM
JCT NORTH AND SOUTH BRS
ALT RT 3A BRDG
EAST AVE BRIDGE
W. WARWICK SEWAGE PLANT
3 SPAN R.R. BRIDGE
(I-295) RAMP BRDG
BALD HILL RD. BRIDGE (RT 2 & 3) BRIDGE
(I-295) BRIDGE TWIN
(RT 5) BRIDGE
PONTIAC DAM CREST ELEV 29.6
WARWICK SEWAGE PLANT
P-37 BRDG TWIN
U.S.G.S. GAGE CRANSTON, R.I.
POCASSET RIVER
(I-95) BRDG TWIN
R R BRIDGE
ELMWOOD AVE BRIDGE
NATICK DAM CREST ELEV 48.6
100 YEAR FREQUENCY FLOOD
MARCH 1968 FLOOD
NORMAL FLOW
STREAMBED
LEGEND
▲ INDICATES H W M JULY 1938
● INDICATES H W M MARCH 1968
PROFILE
SCALE IN FEET
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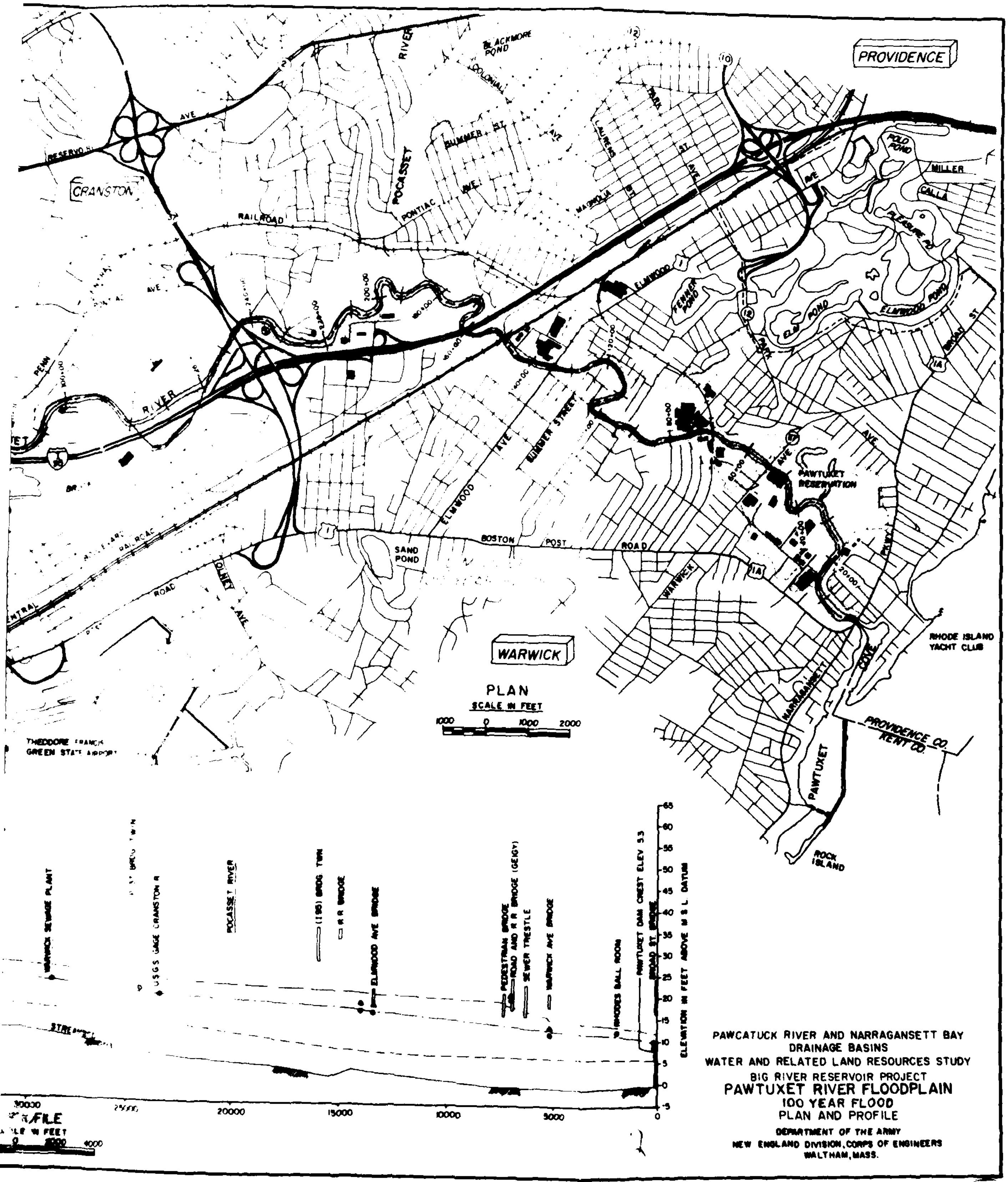
PROVIDENCE
CRANSTON
WARWICK
PLAN
SCALE IN FEET
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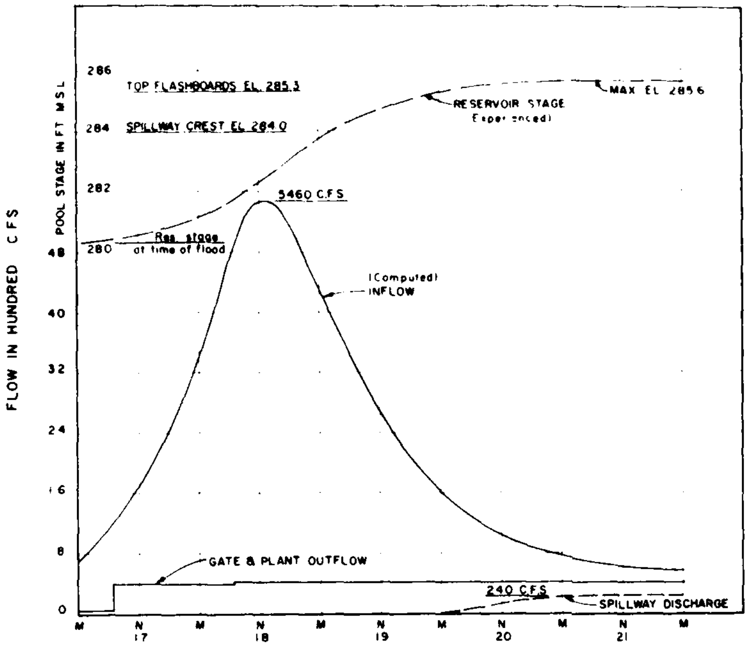
RHODE ISLAND YACHT CLUB
PROVIDENCE CO.
KENT CO.
ROCK ISLAND
SAND POND
BOSTON POST ROAD
ELMWOOD AVE
THEODORE FRANCIS GREEN STATE AIRPORT
WARWICK SEWAGE PLANT
POCASSET RIVER
ELMWOOD AVE BRIDGE
PEDESTRIAN BRIDGE
SEWER TRESTLE
WARWICK AVE BRIDGE
RHODES BALL ROOM
PAWTUXET DAM CREST ELEV 5.3
BROAD ST. BRIDGE
ELEVATION IN FEET ABOVE M.S.L. DATUM
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT
PAWTUXET RIVER FLOODPLAIN
100 YEAR FLOOD
PLAN AND PROFILE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

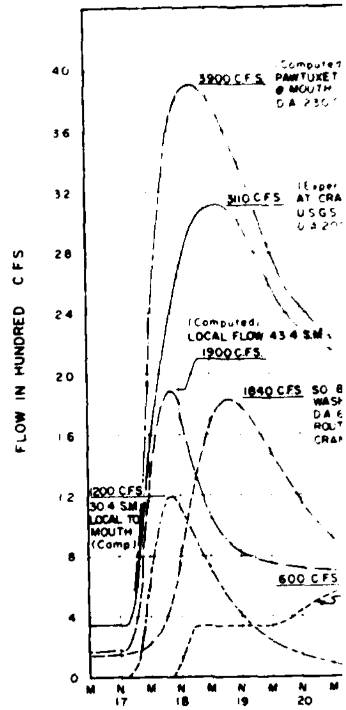
PLATE D-3

C D

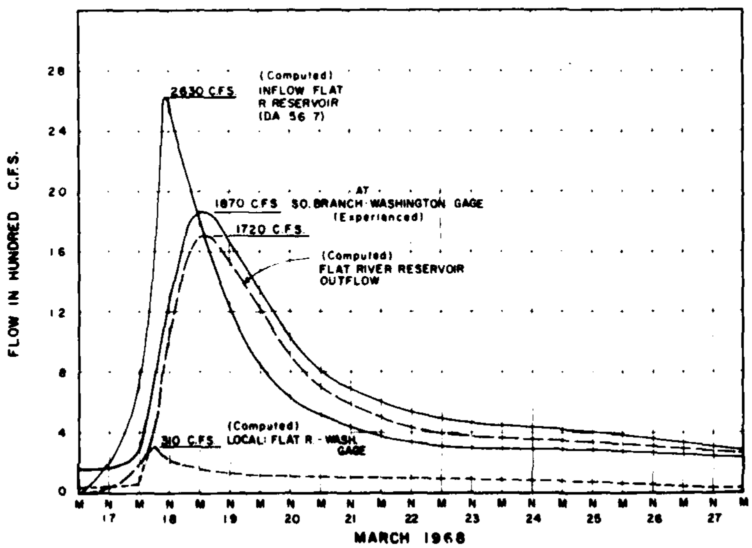


MARCH 1968

SCITUATE RESERVOIR
(DA 92 8 Sq. MI)

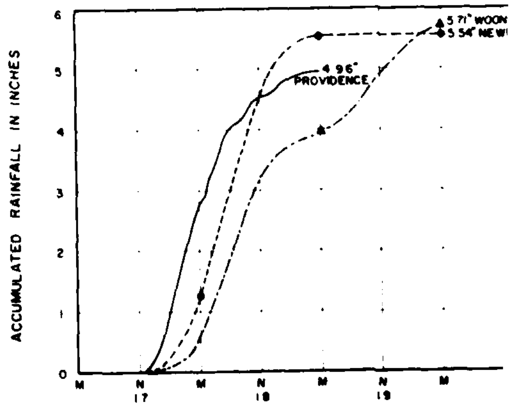


FLOOD COMPONENTS
MOUTH



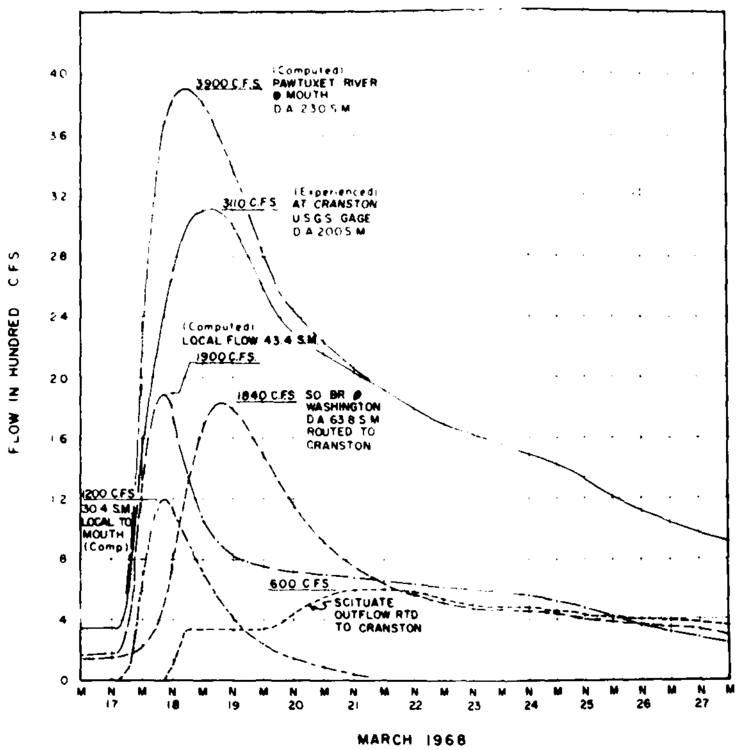
MARCH 1968

SOUTH BRANCH PAWTUXET RIVER
AT
WASHINGTON R.I. (DA 63 8 Sq MI)

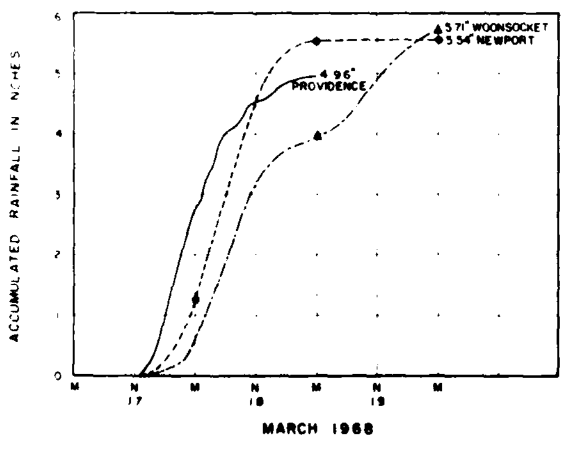


MARCH 1968

MASS. RAINFALL CURVES
(●, △ INDICATE OBSERVED RAINFALL VALUE)



FLOOD COMPONENTS AT CRANSTON USGS GAGE AND AT MOUTH OF PAWTUXET RIVER



MASS RAINFALL CURVES

(●, ▲ INDICATE OBSERVED RAINFALL VALUE)

PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS

WATER AND RELATED LAND RESOURCES STUDY

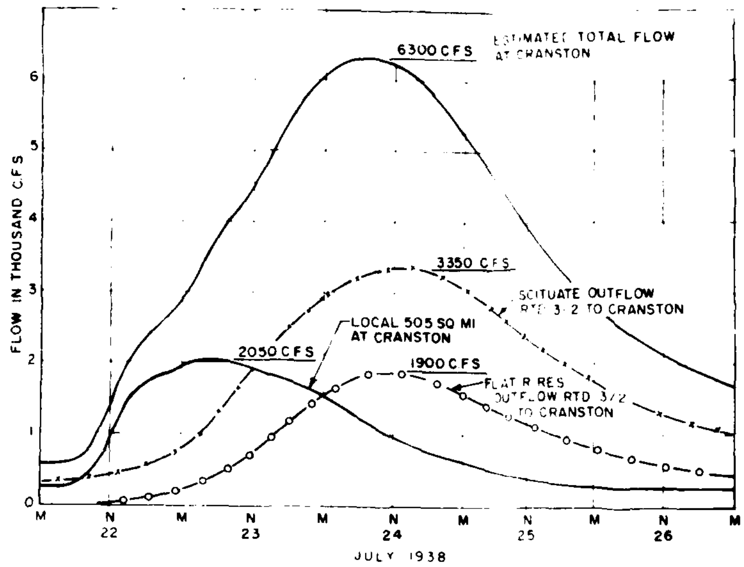
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER BASIN

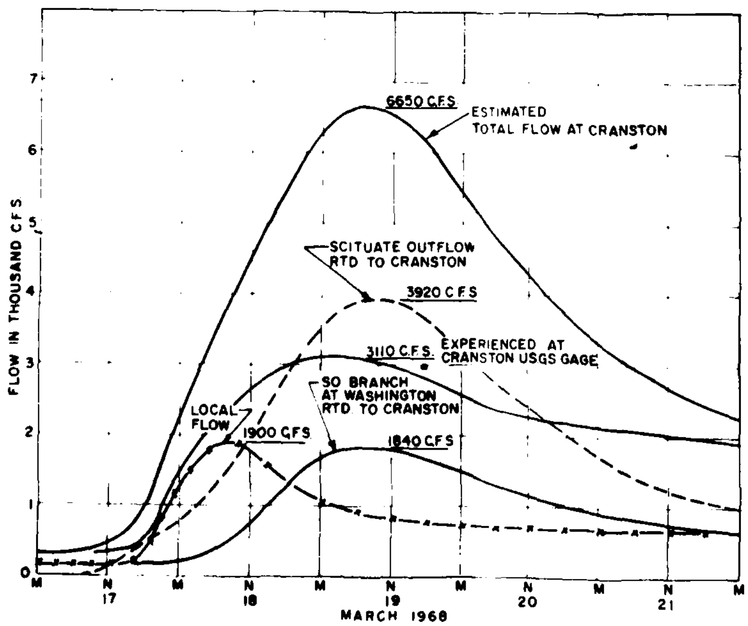
MARCH 1968 FLOOD ANALYSIS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

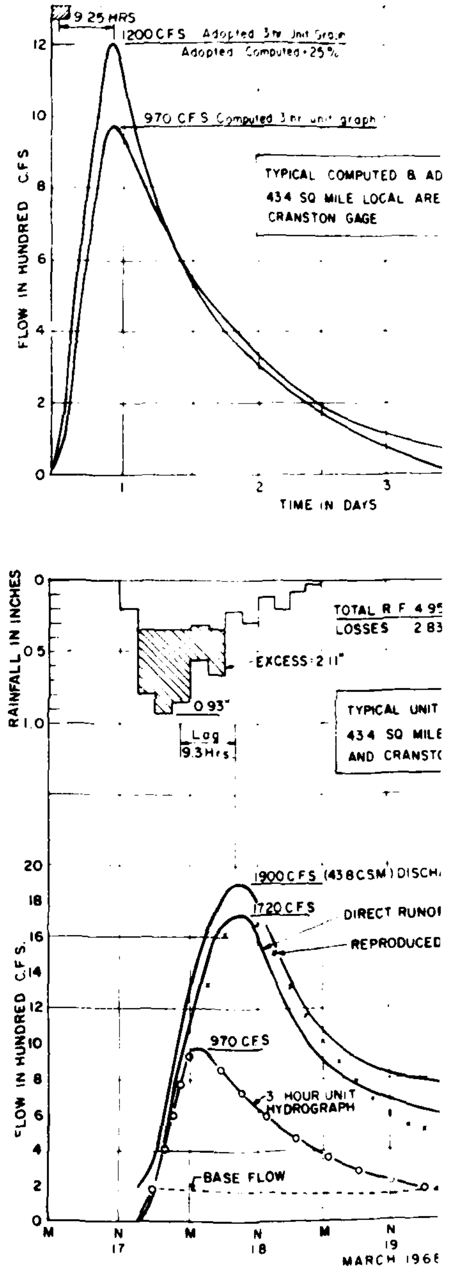
PLATE D-4



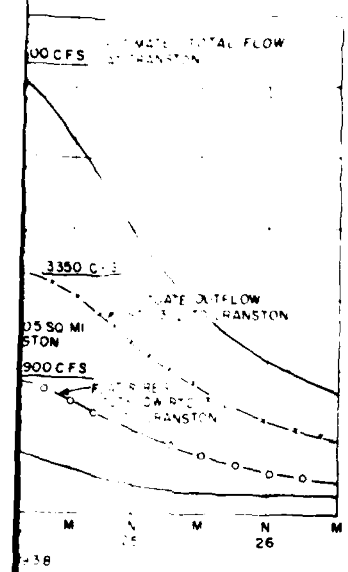
RECONSTRUCTED JULY 1938 FLOOD
AT CRANSTON R.I.



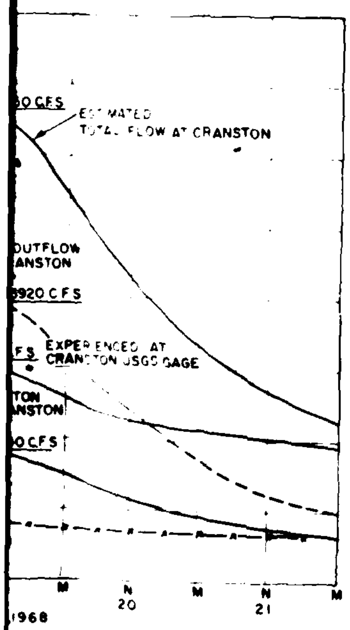
HYPOTHETICAL MARCH 1968 FLOOD
IF SCITUATE RESERVOIR WAS FULL AT START OF FLOOD



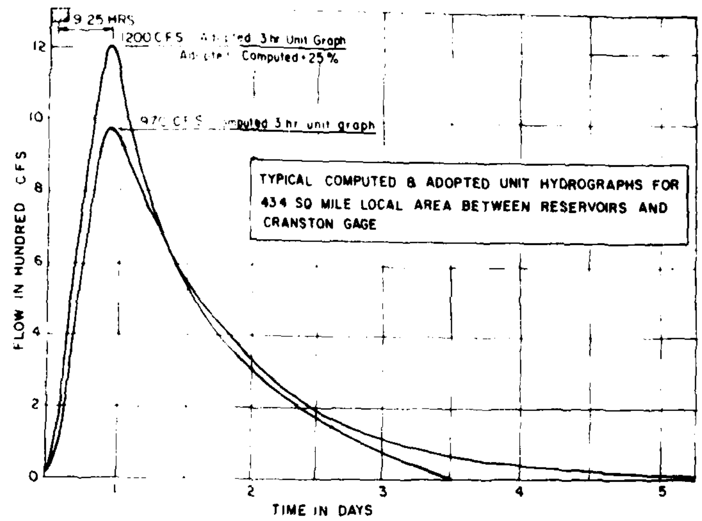
UNIT HYDROGRAPH

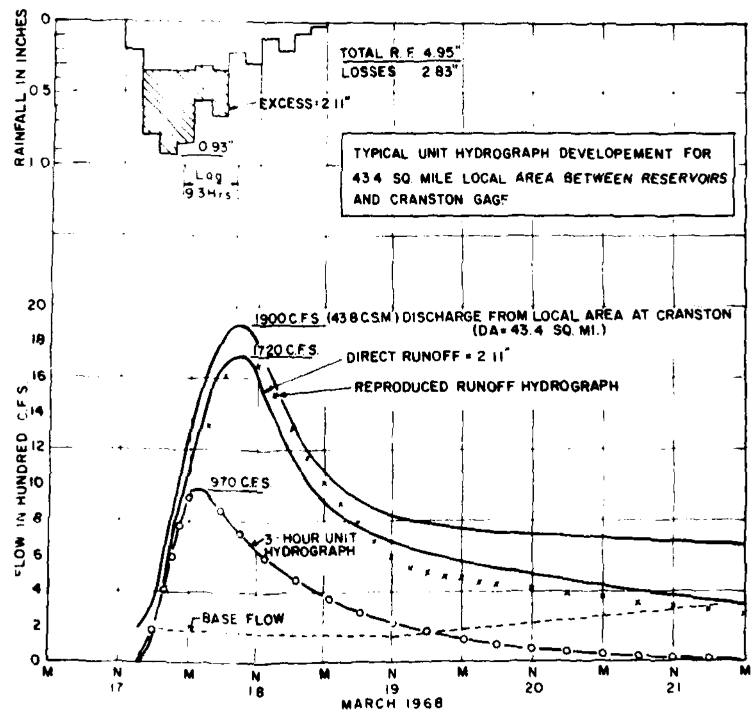


ULY 1938 FLOOD
ON R.I.



CH 1968 FLOOD
ULL AT START OF FLOOD





UNIT HYDROGRAPH ANALYSIS

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT
PAWTUXET RIVER BASIN
FLOOD COMPONENTS AND
UNIT HYDROGRAPH ANALYSIS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE D-5

2

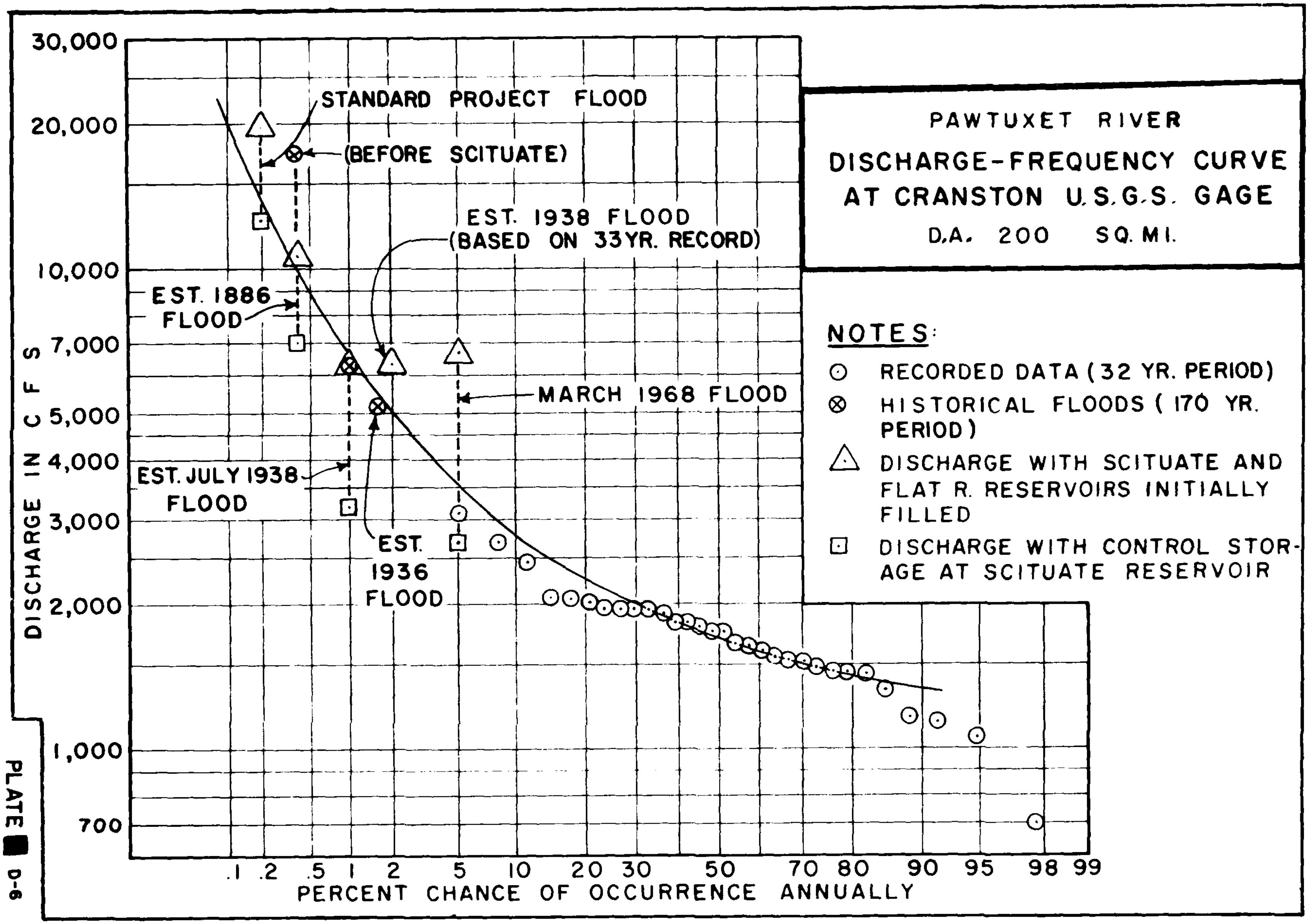
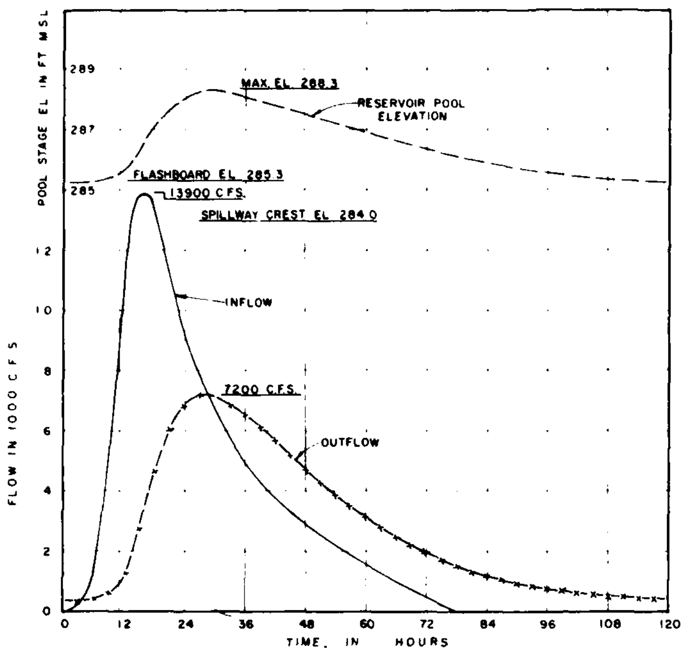
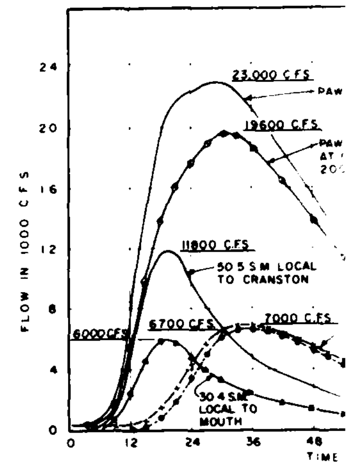

PAWTUXET RIVER
DISCHARGE-FREQUENCY CURVE
AT CRANSTON U.S.G.S. GAGE
D.A. 200 SQ. MI.
NOTES:
RECORDED DATA (32 YR. PERIOD)
HISTORICAL FLOODS (170 YR. PERIOD)
DISCHARGE WITH SCITUATE AND FLAT R. RESERVOIRS INITIALLY FILLED
DISCHARGE WITH CONTROL STORAGE AT SCITUATE RESERVOIR
STANDARD PROJECT FLOOD
(BEFORE SCITUATE)
EST. 1938 FLOOD
(BASED ON 33YR. RECORD)
EST. 1886 FLOOD
MARCH 1968 FLOOD
EST. JULY 1938 FLOOD
EST. 1936 FLOOD
DISCHARGE IN C F S
30,000
20,000
10,000
7,000
5,000
4,000
3,000
2,000
1,000
700
.1 .2 .5 1 2 5 10 20 30 50 70 80 90 95 98 99
PERCENT CHANCE OF OCCURRENCE ANNUALLY

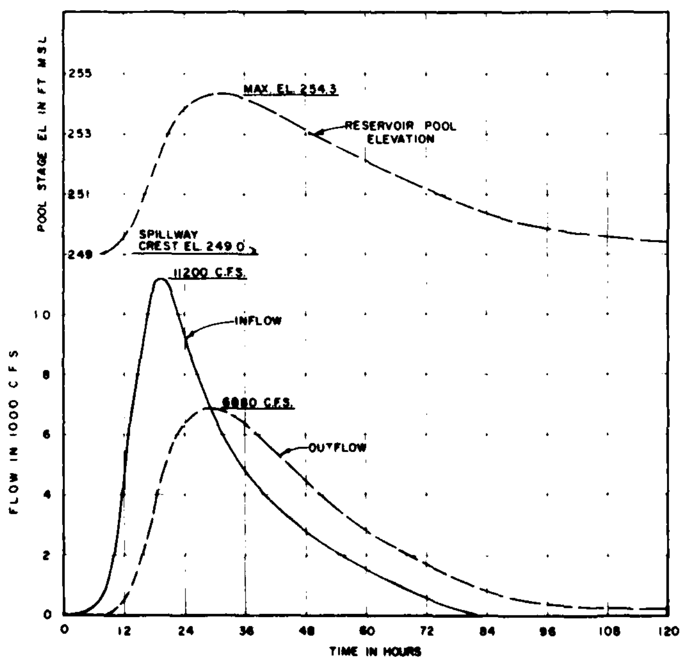
PLATE D-6



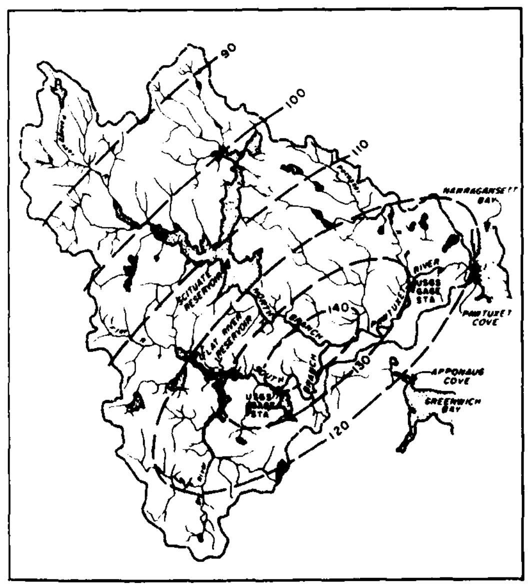
SCITUATE RESERVOIR



PAWTUX

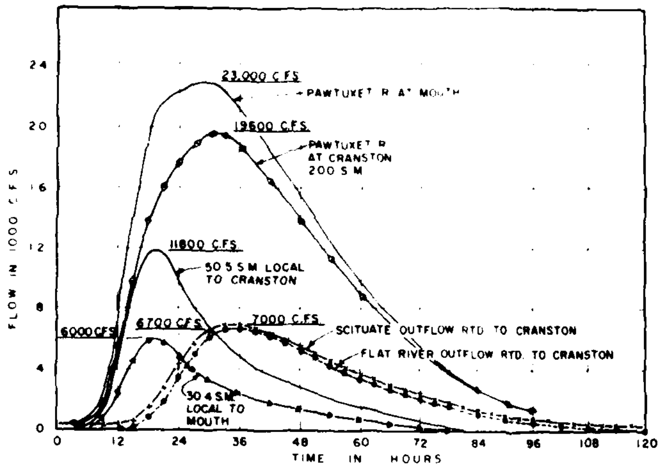


FLAT RIVER RESERVOIR

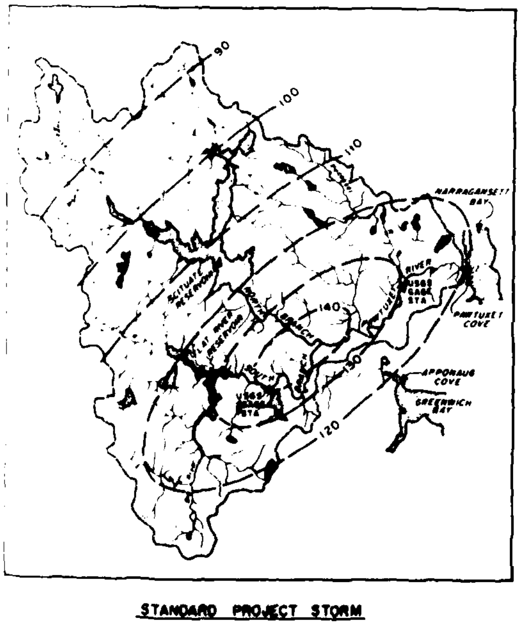


STANDARD PROJECT STORM

PATTERN IN PERCENT OF 96 HR-200 SQ. MILE INDEX RAINFALL



PAWTUXET RIVER BASIN



STANDARD PROJECT STORM

PATTERN IN PERCENT OF 96 HR-200 SQ. MILE INDEX RAINFALL

PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS

WATER AND RELATED LAND RESOURCES STUDY

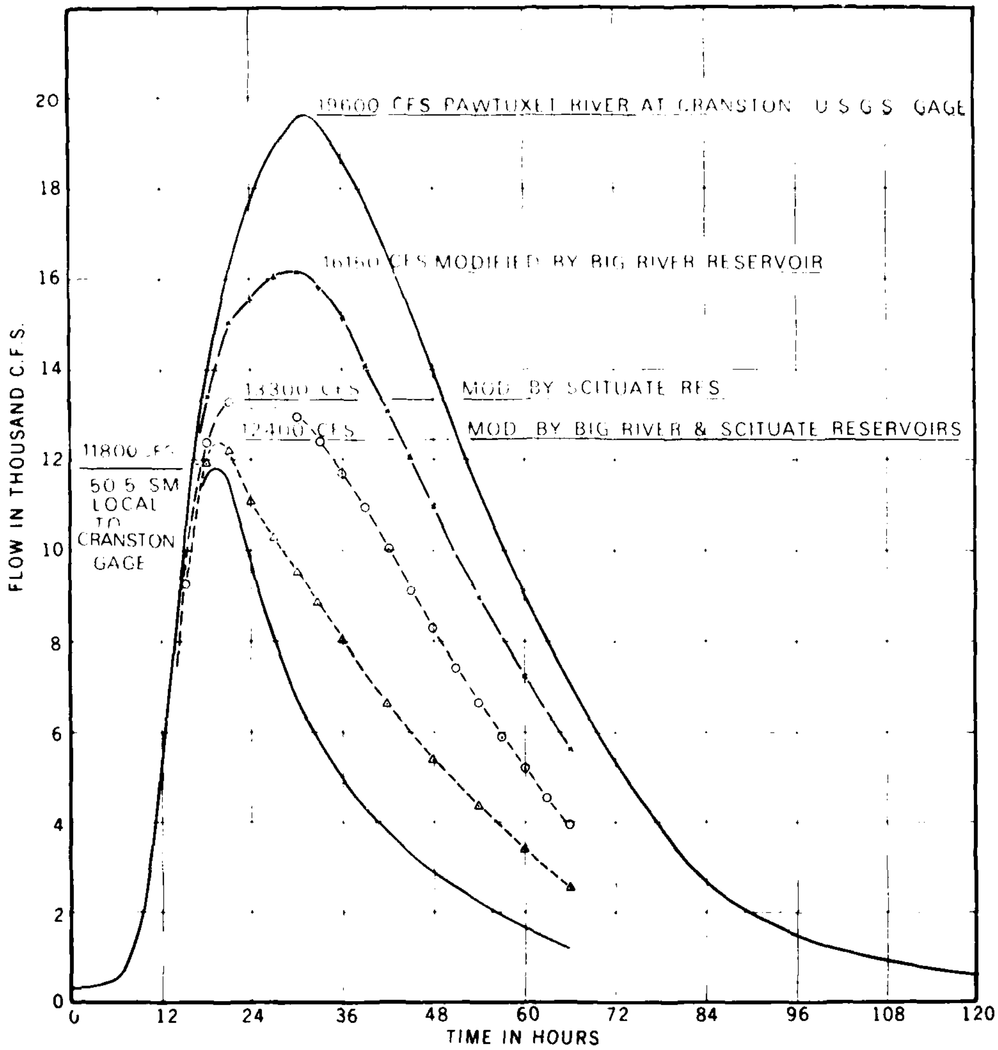
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER BASIN

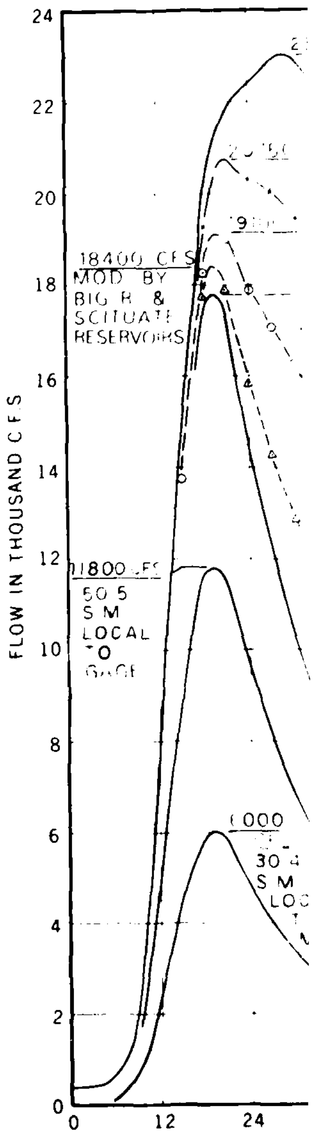
STANDARD PROJECT FLOOD

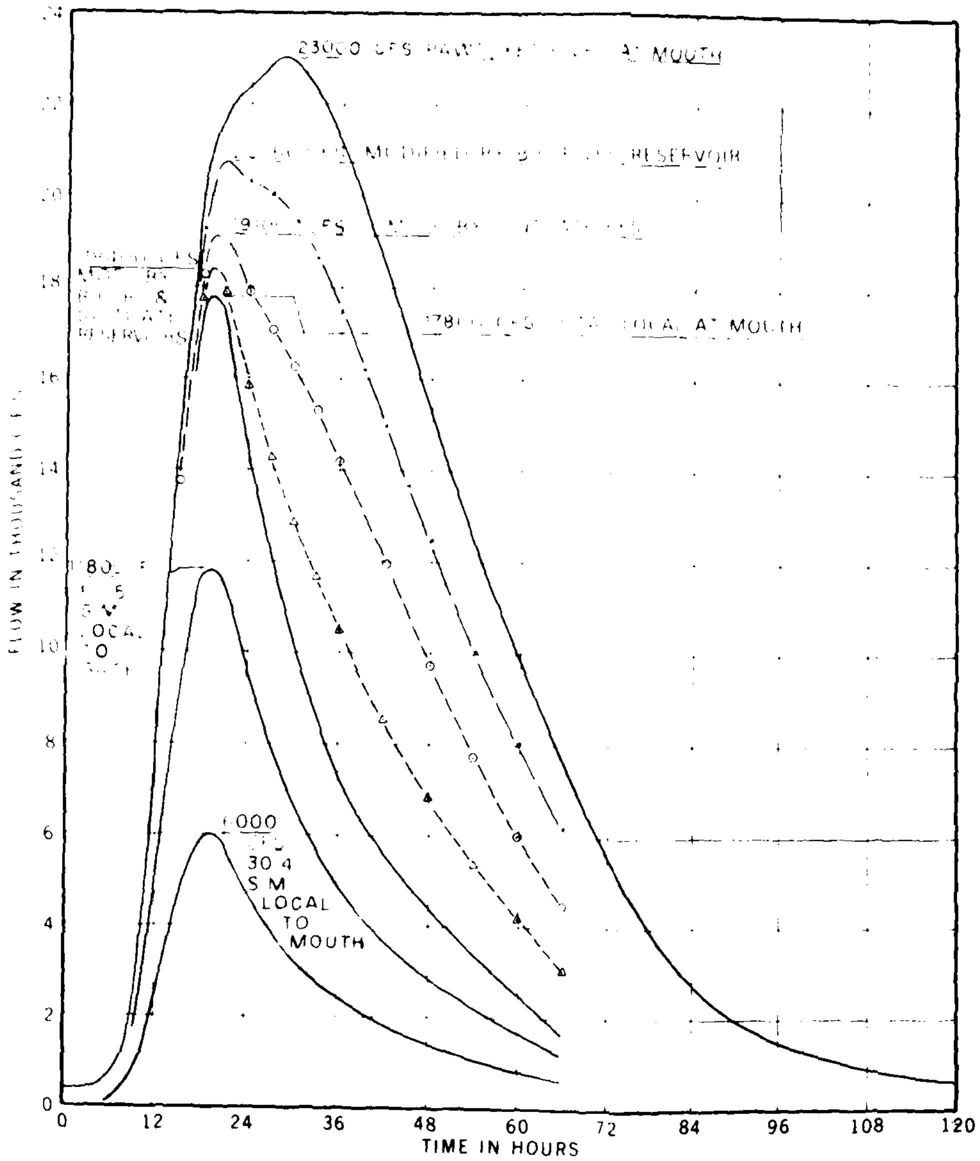
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE D-7



S.P.F. AT CRANSTON U.S.G.S. GAGE
(200.0 Sq. Mi.)





S.P.F. AT MOUTH
(230.4 Sq. Mi.)

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

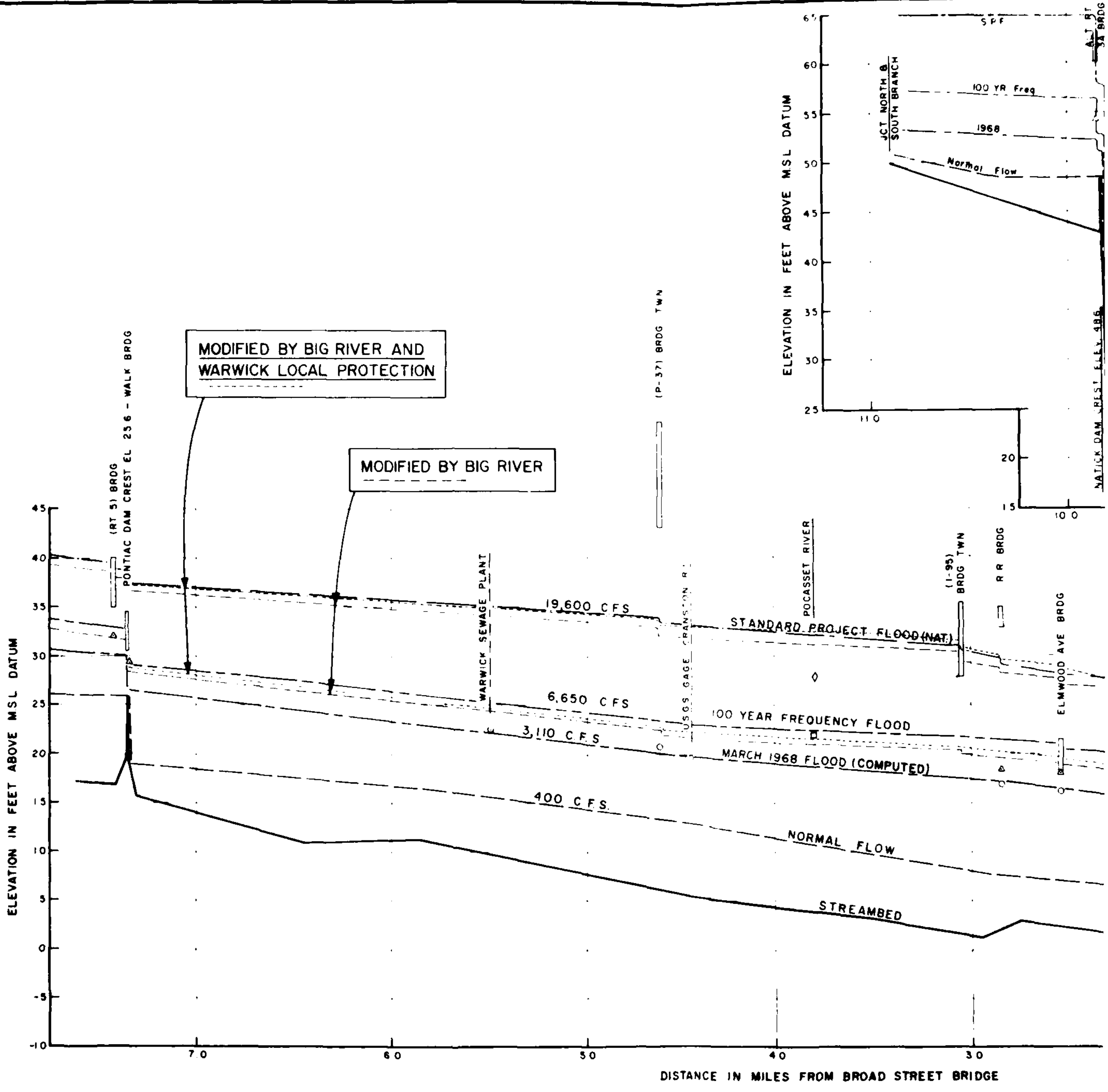
PAWTUXET RIVER BASIN

STANDARD PROJECT FLOOD COMPONENTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE D-7A

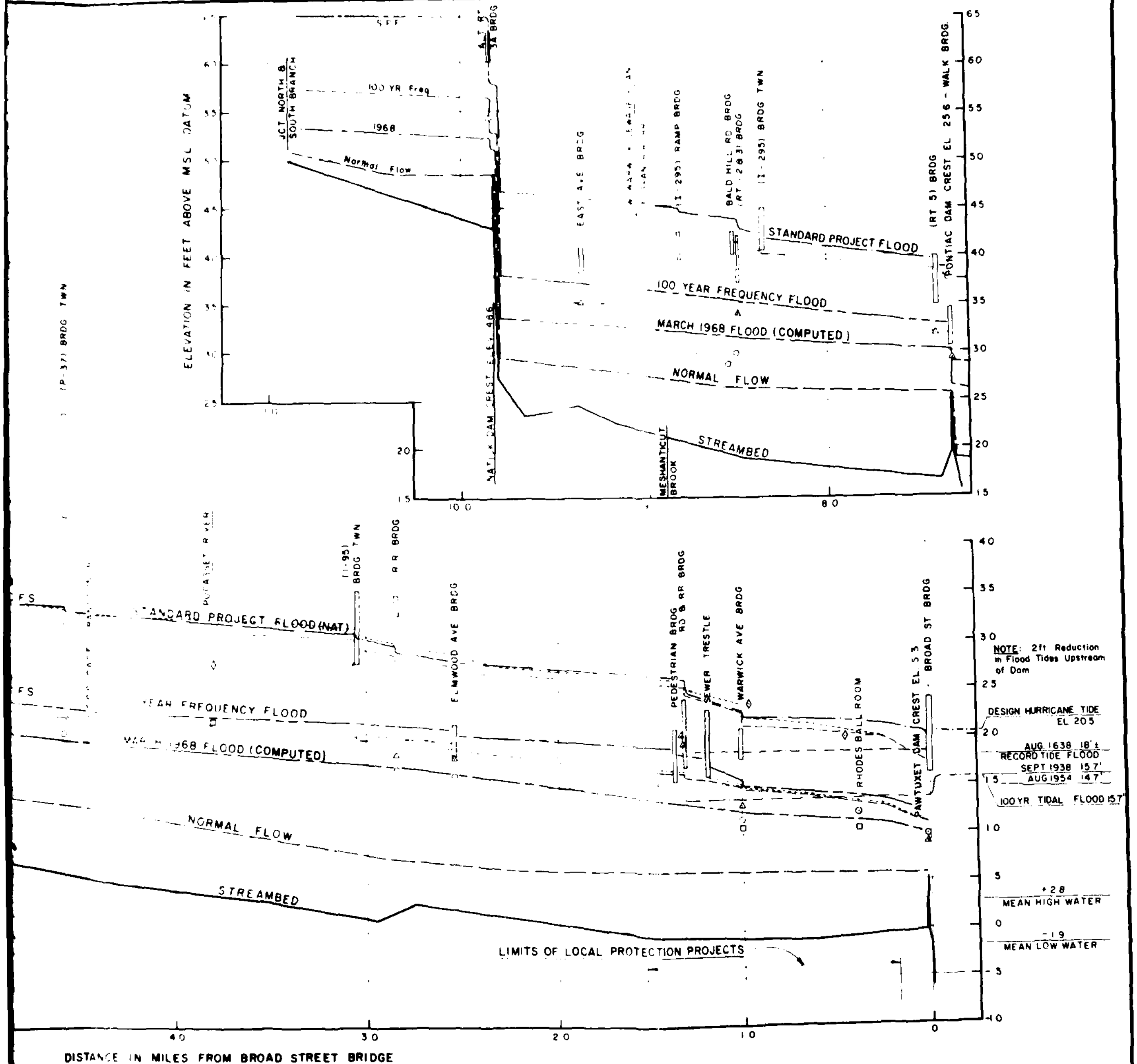
CORPS OF ENGINEERS



PAWTUXET RIVER PROFILE

LEGEND:

- △ INDICATES H.W.M. JULY 1938
- ⊙ INDICATES H.W.M. MARCH 1968
- ⊡ INDICATES H.W.M. MARCH 1936
- ◇ INDICATES H.W.M. FEB. 1886



PAWTUXET RIVER PROFILE

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER BASIN

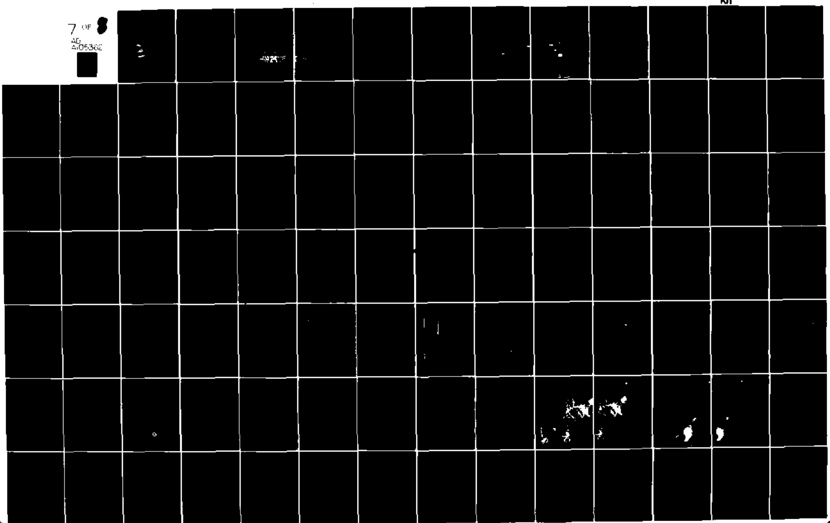
MAIN STEM FLOOD PROFILES
WITH EFFECTS OF BIG RIVER & L.P.P.

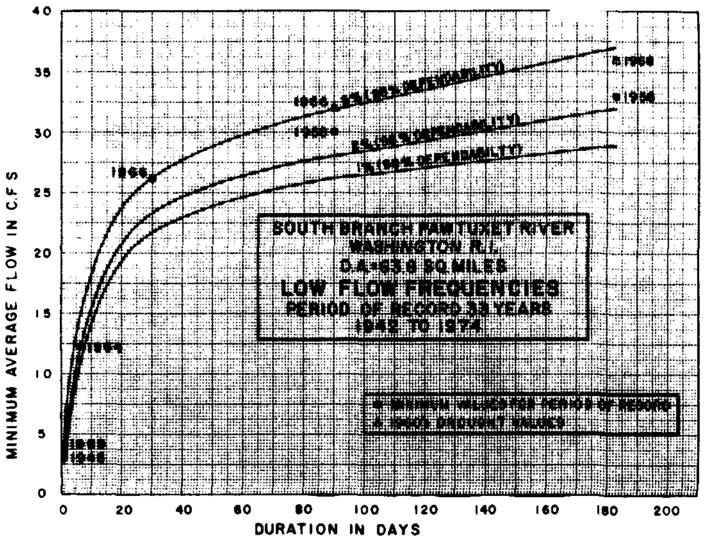
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

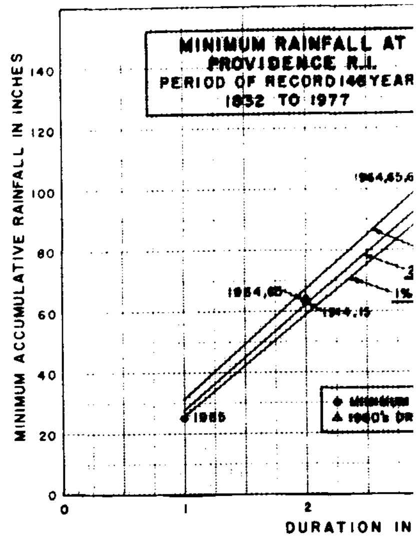
AD-A105 362 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS WATER AND --ETC(U)
JUL 81

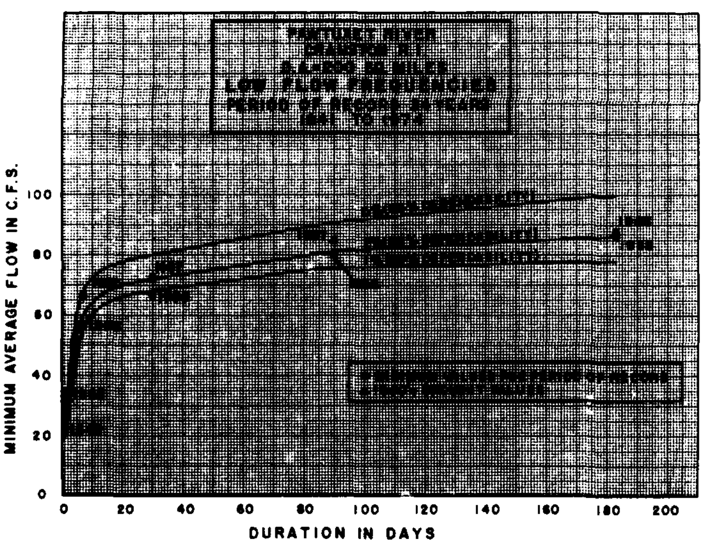
UNCLASSIFIED NL

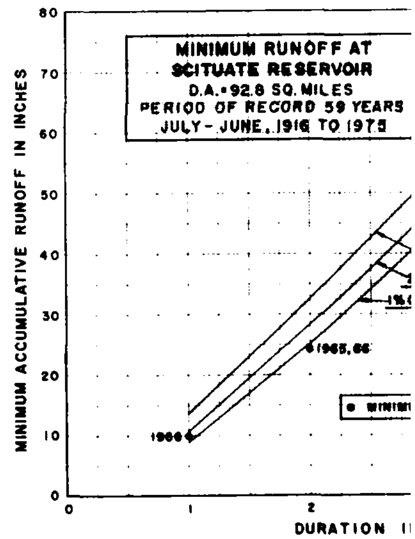
7 OF 8
AD
A105362

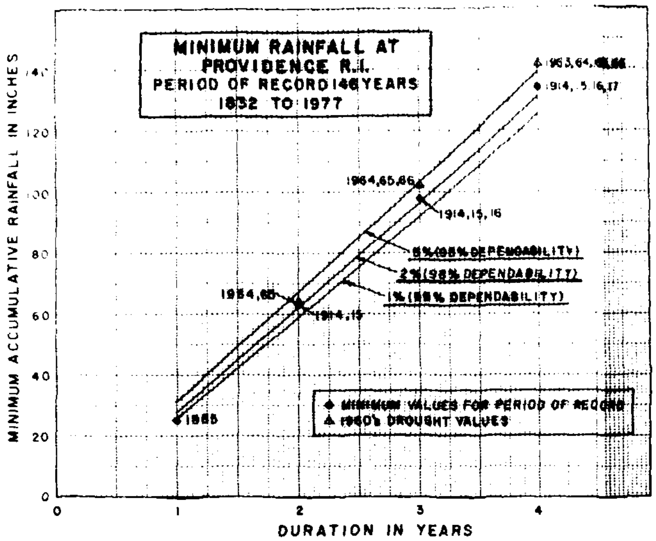


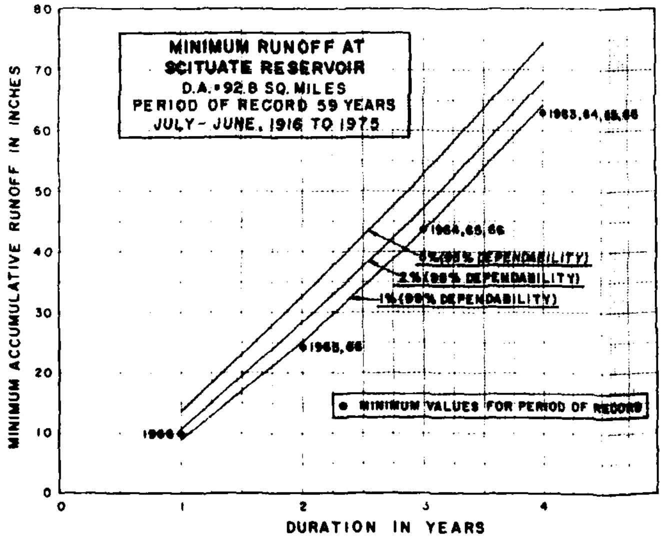

SOUTH BRANCH PAWTUXET RIVER
WASHINGTON R.I.
D.A.=63.0 SQ. MILES
LOW FLOW FREQUENCIES
PERIOD OF RECORD 33 YEARS
1942 TO 1974
MINIMUM AVERAGE FLOW IN C.F.S.
DURATION IN DAYS


MINIMUM RAINFALL AT
PROVIDENCE R.I.
PERIOD OF RECORD 146 YEAR
1832 TO 1977
MINIMUM ACCUMULATIVE RAINFALL IN INCHES
DURATION IN


LOW FLOW FREQUENCIES
MINIMUM AVERAGE FLOW IN C.F.S.
DURATION IN DAYS


MINIMUM RUNOFF AT
SCITUATE RESERVOIR
D.A.=92.8 SQ. MILES
PERIOD OF RECORD 59 YEARS
JULY - JUNE, 1916 TO 1975
MINIMUM ACCUMULATIVE RUNOFF IN INCHES
DURATION



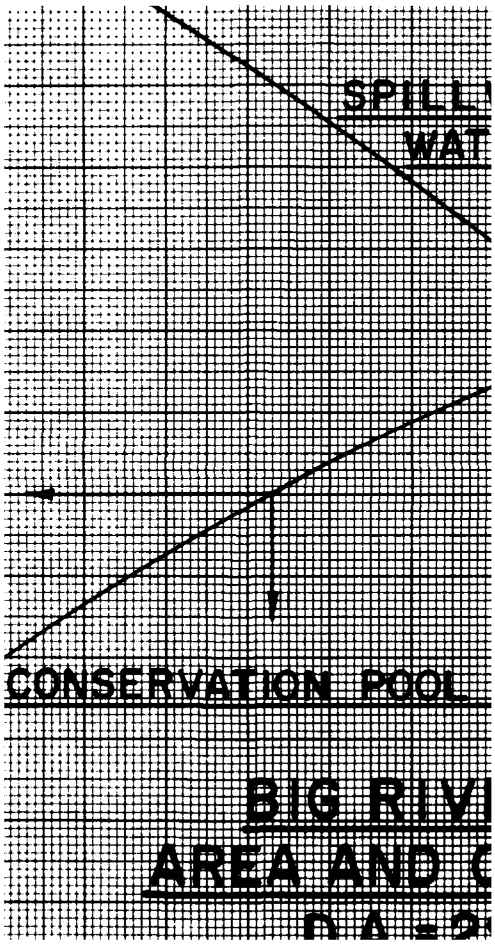


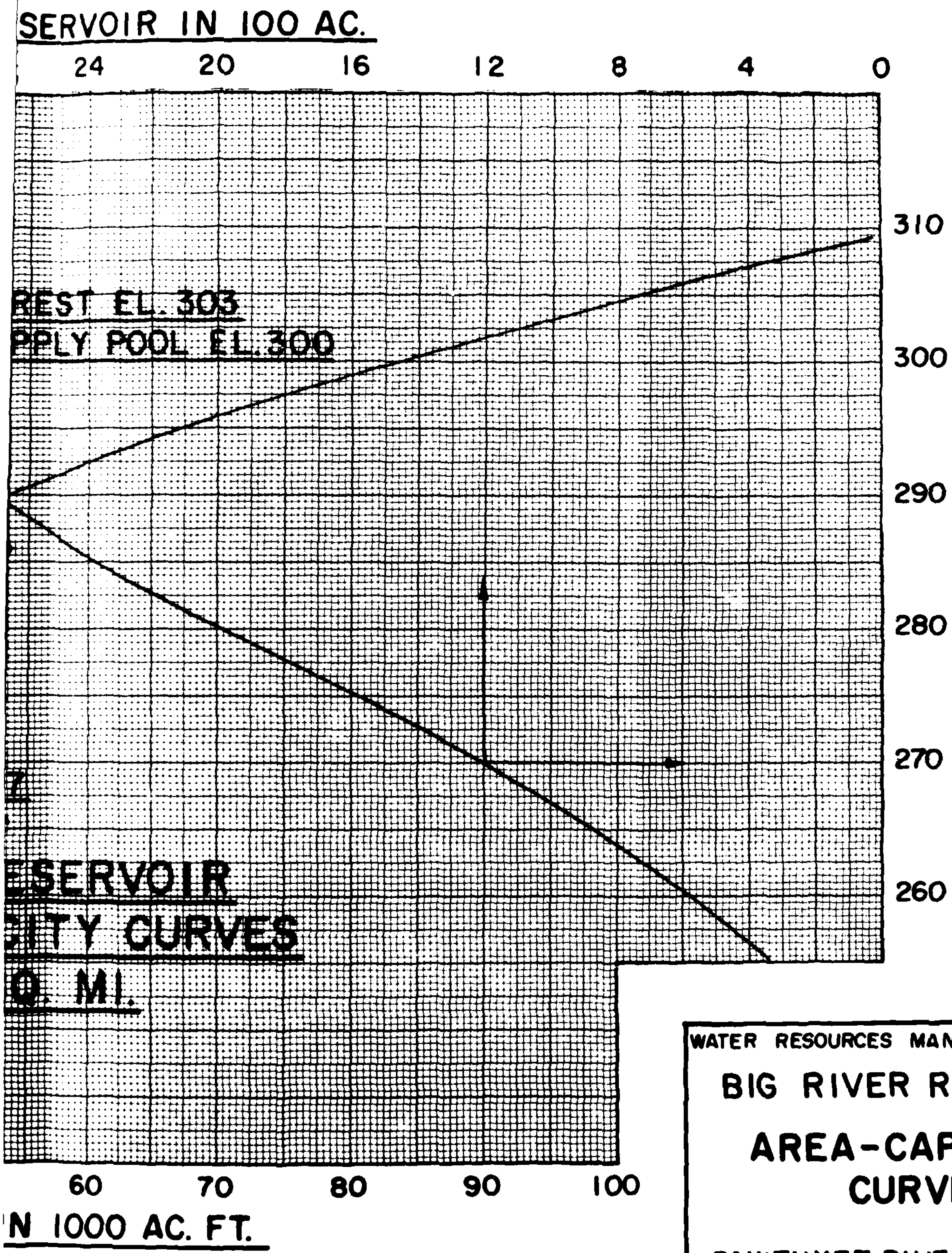
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

ANALYSIS OF DROUGHTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE D-9


SPILLW
WAT
CONSERVATION POOL
BIG RIVE
AREA AND C
D A = 2



WATER RESOURCES MANAGEMENT REPORT

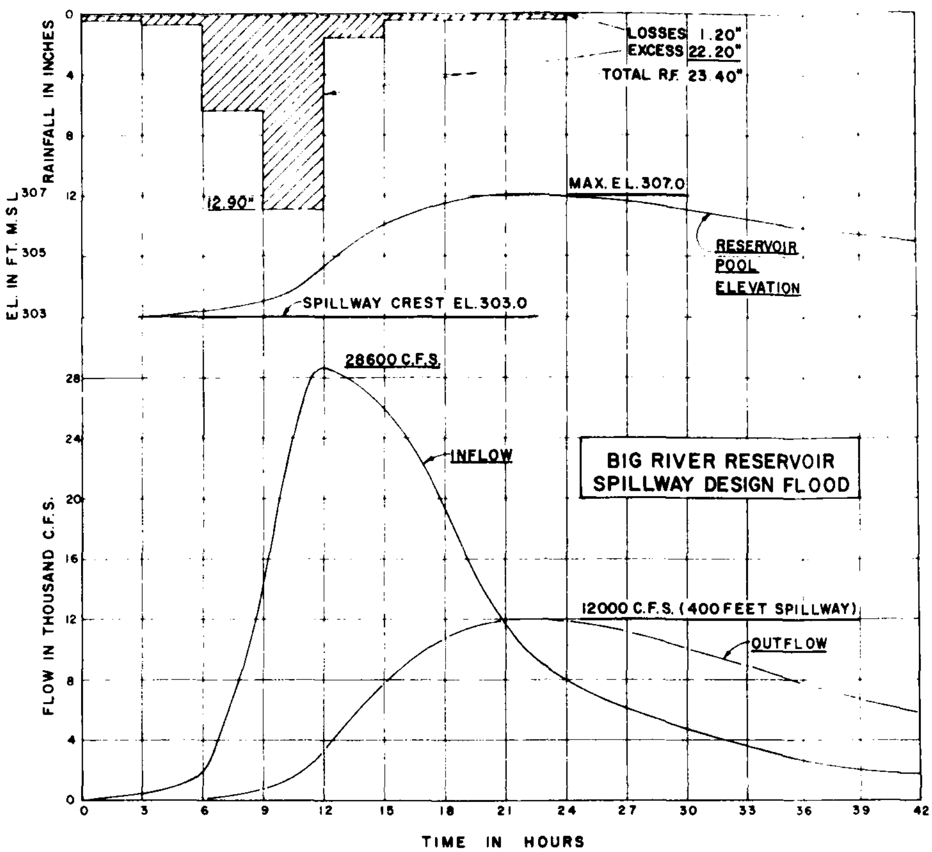
BIG RIVER RESERVOIR

AREA-CAPACITY CURVES

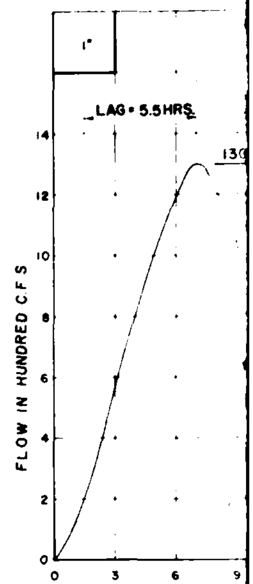
PAWTUXET RIVER BASIN, R.I.

PLATE D-10

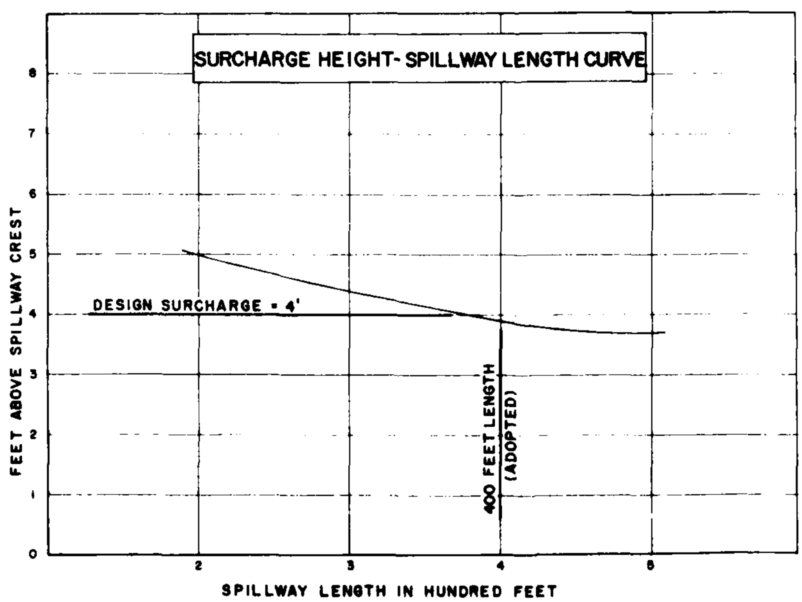
2



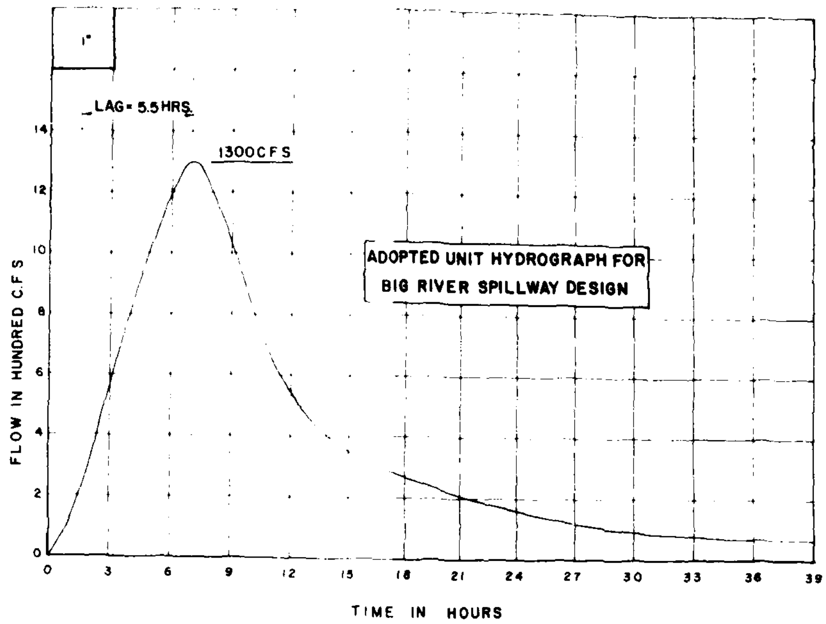
RAINFALL IN INCHES
EL. IN FT. M.S.L.
LOSSES 1.20"
EXCESS 22.20"
TOTAL R.F. 23.40"
12.90"
MAX. EL. 307.0
RESERVOIR POOL ELEVATION
SPILLWAY CREST EL. 303.0
28600 C.F.S.
INFLOW
BIG RIVER RESERVOIR SPILLWAY DESIGN FLOOD
12000 C.F.S. (400 FEET SPILLWAY)
OUTFLOW
FLOW IN THOUSAND C.F.S.
TIME IN HOURS



1"
LAG = 5.5 HRS.
FLOW IN HUNDRED C.F.S.



SURCHARGE HEIGHT- SPILLWAY LENGTH CURVE
DESIGN SURCHARGE = 4'
400 FEET LENGTH (ADOPTED)
FEET ABOVE SPILLWAY CREST
SPILLWAY LENGTH IN HUNDRED FEET

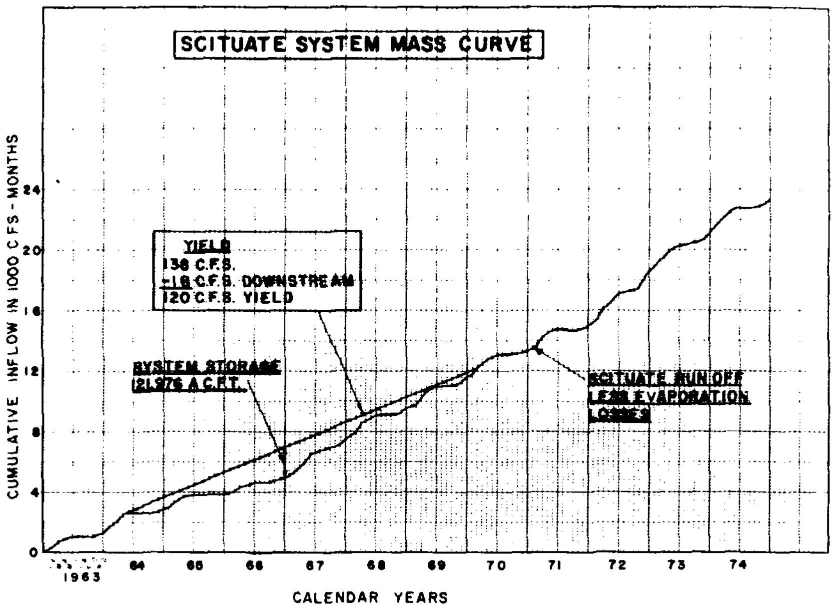


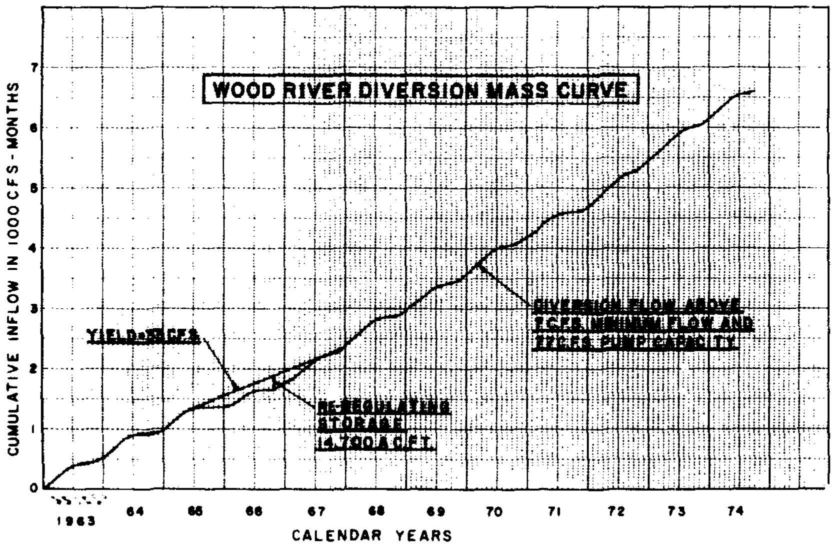
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

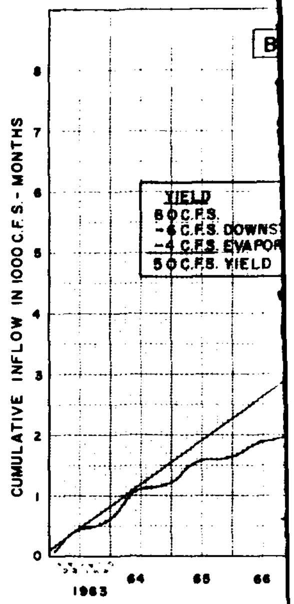
SPILLWAY DESIGN FLOOD

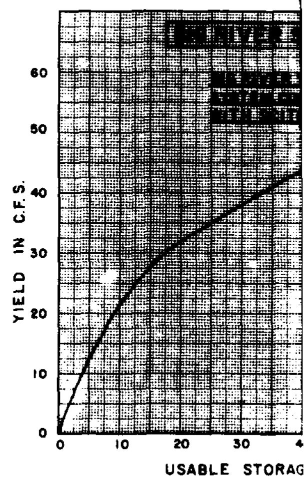
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

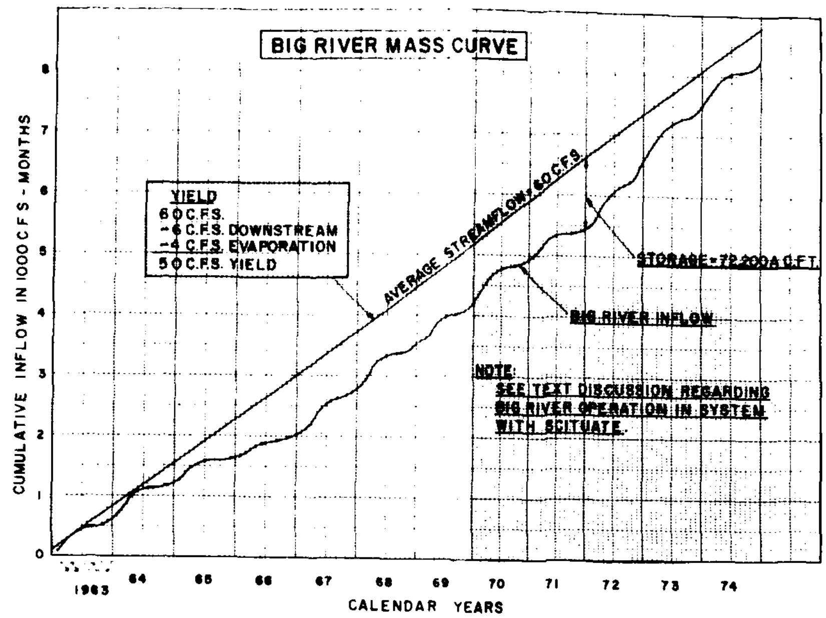
PLATE D-11

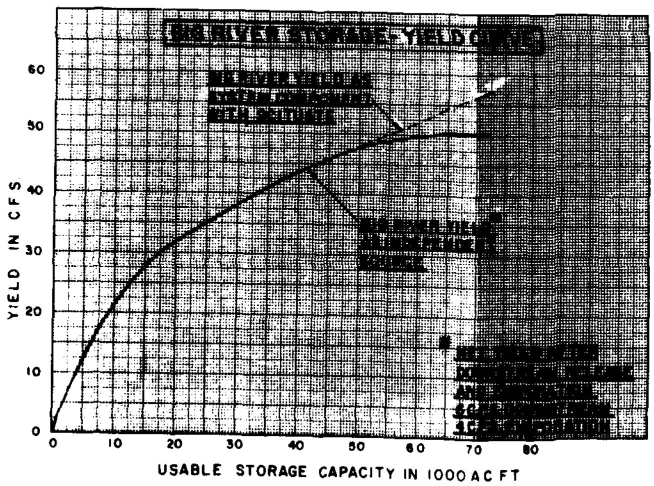

SCITUATE SYSTEM MASS CURVE
YIELD
136 C.F.S.
-16 C.F.S. DOWNSTREAM
120 C.F.S. YIELD
SYSTEM STORAGE
121,976 A.C.FT.
SCITUATE RUN OFF
LESS EVAPORATION
LOSSES
CUMULATIVE INFLOW IN 1000 C.F.S. - MONTHS
CALENDAR YEARS


WOOD RIVER DIVERSION MASS CURVE
DIVERSION FLOW ABOVE
7 C.F.S. MINIMUM FLOW AND
77 C.F.S. PUMP CAPACITY
RE-REGULATING
STORAGE
14,700 A.C.FT.
CUMULATIVE INFLOW IN 1000 C.F.S. - MONTHS
CALENDAR YEARS


YIELD
CUMULATIVE INFLOW IN 1000 C.F.S. - MONTHS


YIELD IN C.F.S.



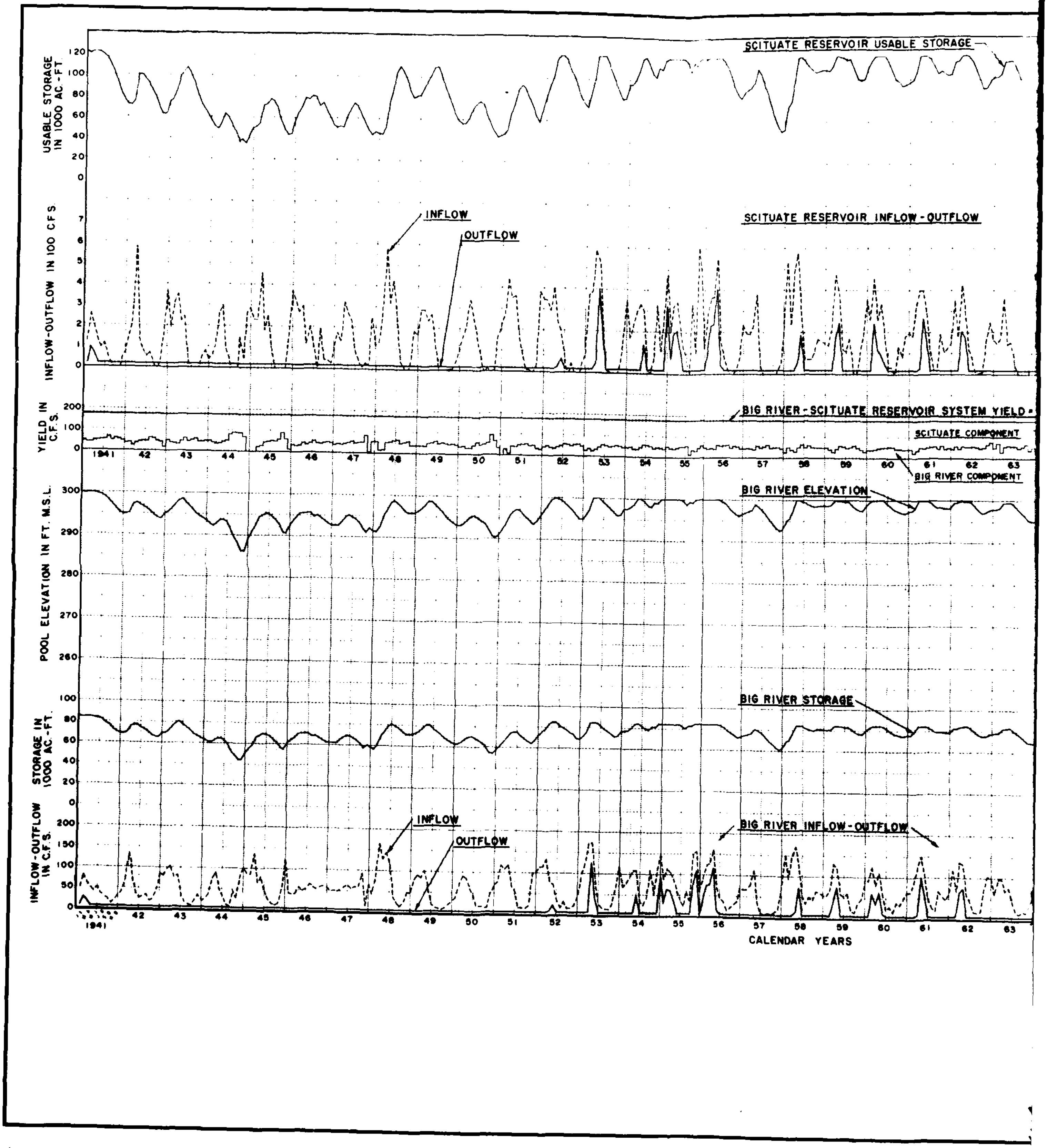


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

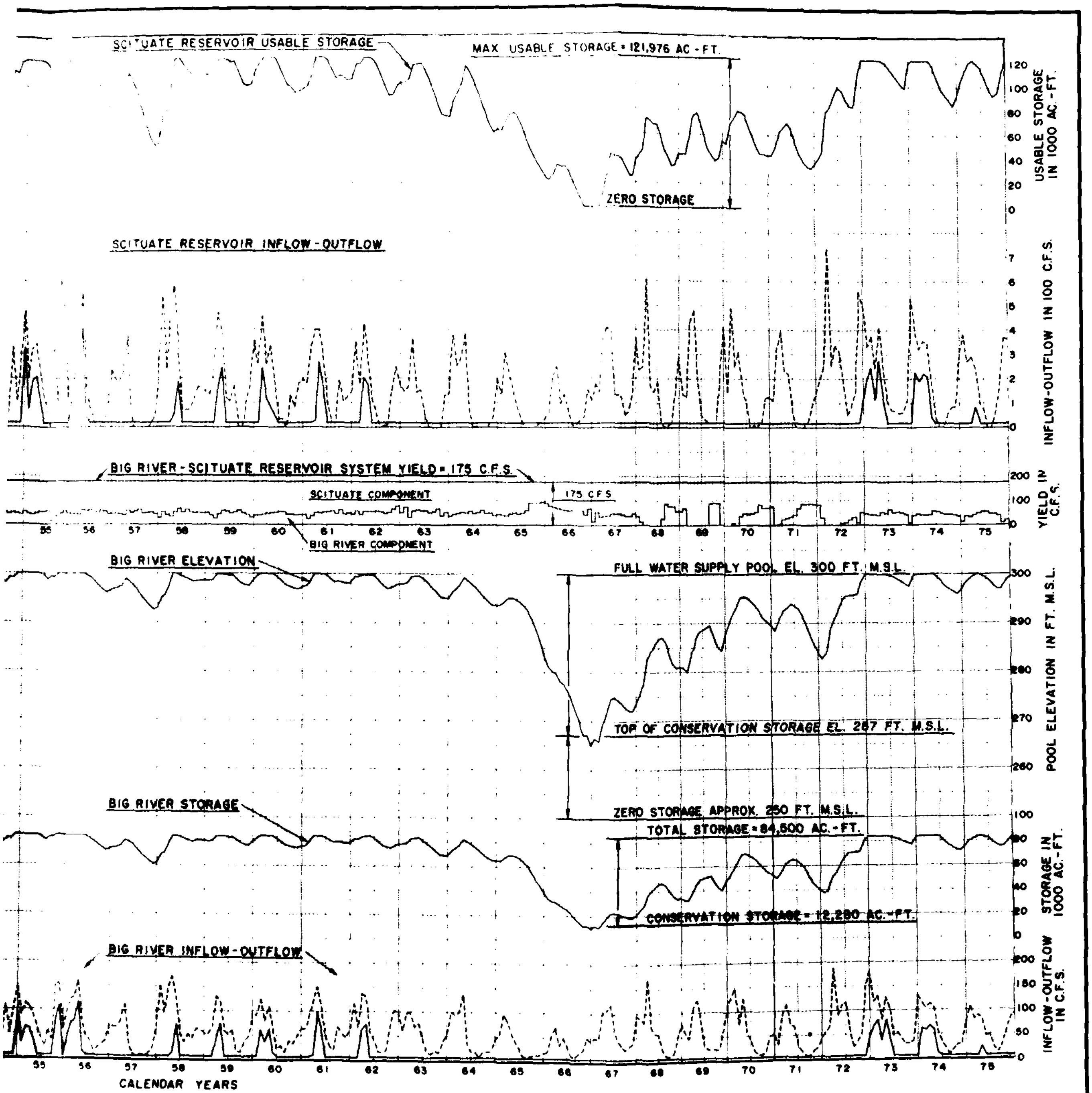
STREAMFLOW MASS CURVE ANALYSIS AND STORAGE YIELD CURVE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS

PLATE D-12



SCITUATE RESERVOIR USABLE STORAGE
USABLE STORAGE IN 1000 AC.-FT.
SCITUATE RESERVOIR INFLOW-OUTFLOW
INFLOW
OUTFLOW
INFLOW-OUTFLOW IN 100 CFS
BIG RIVER-SCITUATE RESERVOIR SYSTEM YIELD
SCITUATE COMPONENT
BIG RIVER COMPONENT
YIELD IN C.F.S.
BIG RIVER ELEVATION
POOL ELEVATION IN FT. M.S.L.
BIG RIVER STORAGE
STORAGE IN 1000 AC.-FT.
BIG RIVER INFLOW-OUTFLOW
INFLOW
OUTFLOW
INFLOW-OUTFLOW IN C.F.S.
1941 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
CALENDAR YEARS



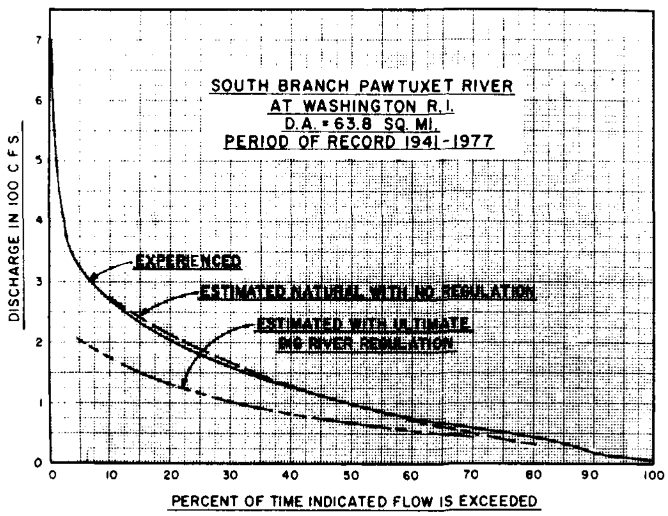
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

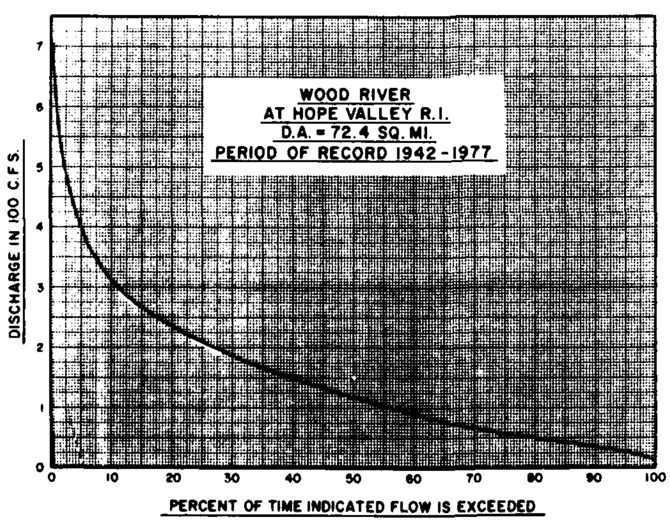
BIG RIVER RESERVOIR
AND SCITUATE RESERVOIR
MONTHLY SYSTEM SIMULATION

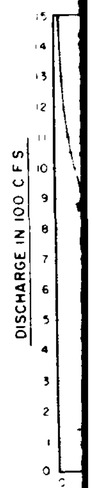
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

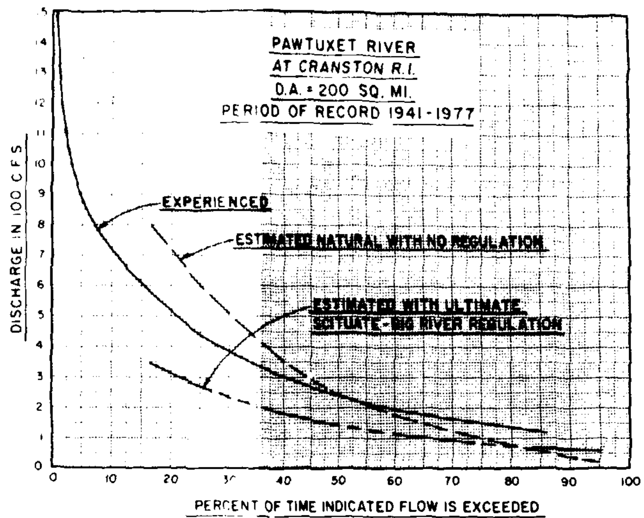
PLATE D-13

CORPS OF ENGINEERS







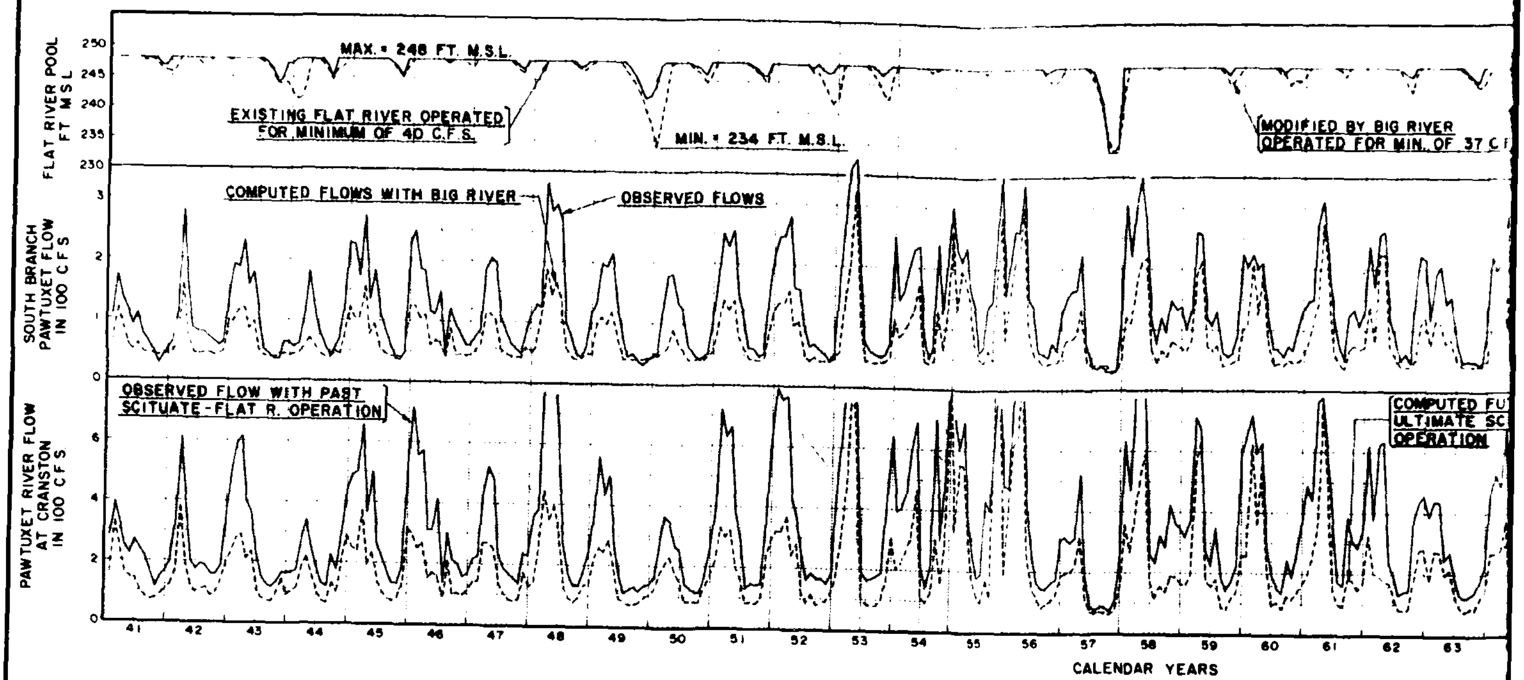


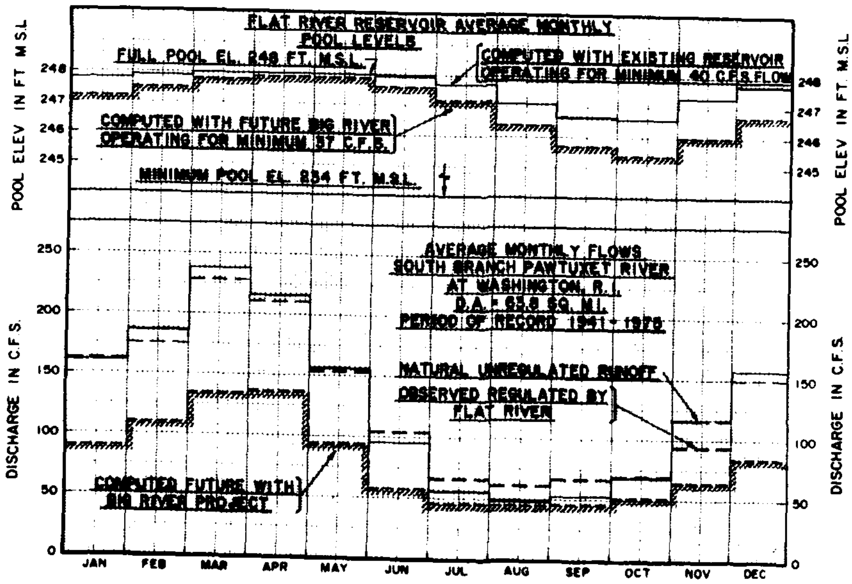
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY

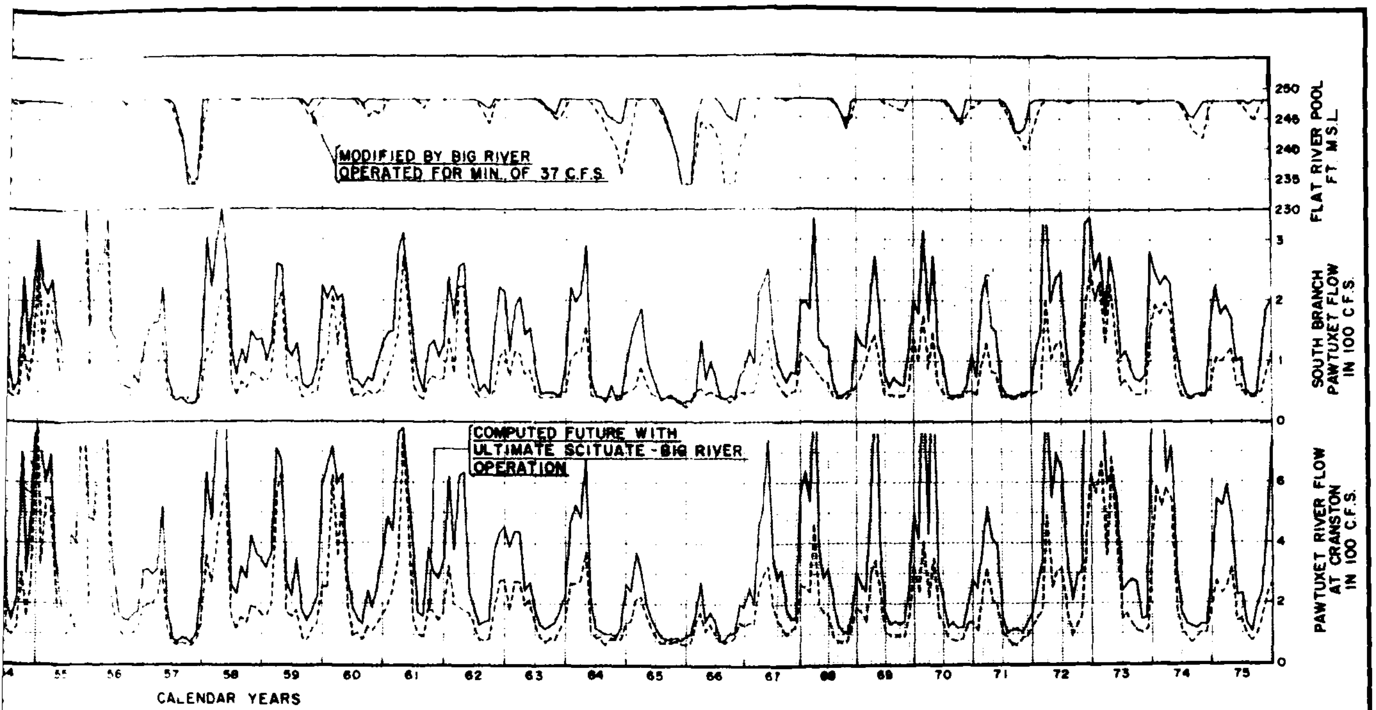
BIG RIVER RESERVOIR PROJECT

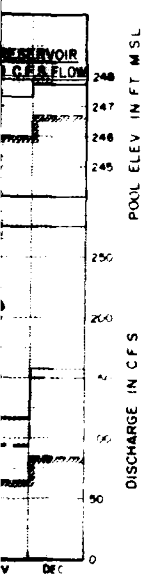
PAWTUXET RIVER AND SOUTH BRANCH
FLOW DURATION CURVES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS.


FLAT RIVER POOL FT M S L
MAX. = 248 FT. M.S.L.
EXISTING FLAT RIVER OPERATED FOR MINIMUM OF 40 C.F.S.
MIN. = 234 FT. M.S.L.
MODIFIED BY BIG RIVER OPERATED FOR MIN. OF 37 C.F
SOUTH BRANCH PAWTUXET FLOW IN 100 C F S
COMPUTED FLOWS WITH BIG RIVER
OBSERVED FLOWS
PAWTUXET RIVER FLOW AT CRANSTON IN 100 C F S
OBSERVED FLOW WITH PAST SCITUATE - FLAT R. OPERATION
COMPUTED FU ULTIMATE SC OPERATION
CALENDAR YEARS


FLAT RIVER RESERVOIR AVERAGE MONTHLY POOL LEVELS
FULL POOL EL. 248 FT. M.S.L.
COMPUTED WITH EXISTING RESERVOIR OPERATING FOR MINIMUM 40 C.F.S. FLOW
COMPUTED WITH FUTURE BIG RIVER OPERATING FOR MINIMUM 37 C.F.S.
MINIMUM POOL EL. 234 FT. M.S.L.
POOL ELEV IN FT M.S.L
AVERAGE MONTHLY FLOWS SOUTH BRANCH PAWTUXET RIVER AT WASHINGTON, R.I.
D.A. = 63.8 SQ. MI.
PERIOD OF RECORD 1941 - 1975
NATURAL UNREGULATED RUNOFF
OBSERVED REGULATED BY FLAT RIVER
COMPUTED FUTURE WITH BIG RIVER PROJECT
DISCHARGE IN C.F.S.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC





PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

BIG RIVER RESERVOIR
AND FLAT RIVER RESERVOIR
MONTHLY SYSTEM SIMULATION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE D-15

7

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX E

WATER QUALITY

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX E

WATER QUALITY

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UPBAN STUDY

BIG RIVER RESERVOIR PROJECT

WATER QUALITY

1. INTRODUCTION

Big River Reservoir is a proposed water supply impoundment on the Big River in Coventry, Rhode Island. The purposes of the study reported here are to define water quality conditions in the project's watershed, drawing upon data collected by five federal, state and private organizations, and to make predictions of possible future water quality conditions in the proposed reservoir. These predictions are based upon the existing watershed water quality data base and knowledge of general tendencies of water quality and hydrodynamics in man-made reservoirs. Also, to assist in the predictions, a comparative analysis with Scituate Reservoir, a nearby water supply reservoir with similar physical characteristics and a fairly extensive data base, was made.

The diversion of water from four surrounding sites has been proposed as a means to increase the yield of Big River Reservoir. These diversion sources are the Wood River, the Moosup River, Buckshorn Brook and Flat River Reservoir. Included in this study is an analysis of existing water quality conditions at the sites and qualitative statements concerning the impact of diversions on water quality in Big River Reservoir.

2. EXISTING WATER QUALITY CONDITIONS

a. Big River Watershed

(1) State Classification and Standards. - The waters of the Big River, Carr River, Nooseneck River, and their tributaries are rated Class A by the Rhode Island Division of Water Pollution Control. Class A waters are suitable for water supply and all other uses and are uniformly excellent in character. Water quality requirements for Class A waters include: dissolved oxygen (DO) levels at least 75 percent of saturation 16 hours a day and not less than 5 mg/l at any time; total coliform bacteria not to exceed a median of 100 per 100 ml nor more than 500 in more than 10 percent of samples collected; turbidity not to exceed 5 Jackson Turbidity Units (JTU); no chemical constituents in concentrations which would exceed the limits prescribed by the U. S. Environmental Protection Agency for public drinking waters; and no color, pH, taste, odor, or temperature increase except as naturally occurs. In addition, as a guideline pending further research, a fecal coliform criteria has been set for Class A waters of

of a median of 20 per 100 ml and not more than 200 per 100 ml in more than 10 percent of the samples collected.

(2) Data Collection. - Water quality conditions for the Big River watershed streams have been monitored since 1962 when the City of Providence Water Supply Board initiated a data collection program for two stations on the Big River: one at the Route 3 bridge and the other at the proposed dam site at Harkney Hill Road. Lesser amounts of data have also been collected by the U.S. Geological Survey (USGS) in 1963 and more recently by the Rhode Island Water Resources Board and Keyes Associates-Metcalf and Eddy, Inc. (KAME), both in 1976. The most comprehensive data collection program was initiated in August 1978 by the New England Division, Corps of Engineers. This program was necessary to fill in the gaps in the existing data base, particularly with regard to nutrient and heavy metals data and the in-situ measured parameters-temperature and dissolved oxygen. The locations of the Corps of Engineers sampling stations are shown on plate E-1 and described in table 1.

(3) Water Quality Assessment. - Evaluation of all available data indicates that the waters of the Big River Watershed fail to meet their Class A rating because levels of iron, manganese, total coliforms, color, turbidity and mercury exceed the standards. Otherwise, the water quality is high and meets the criteria set by the State of Rhode Island and the National Primary and Secondary Drinking Water Regulations.

(a) Iron and manganese. - The National Secondary Drinking Water Regulations (NSDWR) which deal with the aesthetic quality of drinking water, set limits of 300 ug/l on iron and 50 ug/l on manganese to protect public welfare. The mean levels of iron in the waters of the Big River watershed are about equal to the 300 ug/l limit set by the NSDWR. Daily peak concentrations of iron can be as high as 1,400 ug/l. Mean manganese concentrations in Big River watershed water are below the 50 ug/l limit set by the NSDWR. However, this limit is frequently exceeded by peak daily concentrations of up to 140 ug/l.

(b) Coliform bacteria. - The median total coliform count of 121 per 100 ml violates Rhode Island Class A standards which call for a median of not more than 100 per 100 ml. The requirements that not more than 10 percent of the total coliform counts be over 500 per 100 ml and the requirements of the state's guideline limits for fecal coliform counts are fully met, however.

(c) Turbidity and color. - There are no point source discharges in the Big River watershed and, consequently, the color and turbidity of the waters meet the "as naturally occurs" criteria set

TABLE 1

CORPS OF ENGINEERS

WATER QUALITY SAMPLING STATIONS

1 - Wood River at Ten Rod Road

2 - Nooseneck River at Route 3

3 - Big River above Carr River

4 - Carr River at Burnt Sawmill Road

5 - Big River at Harkney Hill Road (Dam Site)

6 - Bucks Horn Brook near Greene

7 - Moosup River at Oneco, Conn.

8 - Flat River Reservoir

by the Rhode Island Division of Water Pollution Control. The Rhode Island Class A standards further state that the turbidity should be less than 5 JTU. The mean turbidity level in the waters of the Big River watershed is about 1 JTU. Although peaks of up to 20 JTU have been recorded, it is very unusual for the daily turbidity to exceed 5 JTU.

The NSDWR limit for color is 15 Pt-Co units. This standard is thoroughly exceeded by the waters of Big River watershed, the mean color concentration of which is over 50 Pt-Co units. Peak color concentrations of up to 140 Pt-Co units have been measured and it is a rare event for the color level to be less than 15 Pt-Co units. The high color is thought to be of natural origin, probably originating from the many swamps in the watershed.

(d) Dissolved oxygen. - Dissolved oxygen measurements in the waters of the Big River watershed are always greater than 5 mg/l and usually greater than 75 percent of saturation thus meeting Rhode Island Class A requirements.

(e) Mercury and other heavy metals. - Measurements of mercury in Big River watershed water are usually below the 1 ug/l detectable limit for the analytical procedure employed. However, occasional high concentrations of up to 2.8 ug/l exceed the 2 ug/l limit set by the National Primary Drinking Water Regulations. Measurements of other heavy metals including arsenic, barium, cadmium, chromium, lead, and silver were all either below the criteria set by the National Primary Drinking Water Regulations or below the detectable level for the analytical method employed.

(f) Pesticides, herbicides and radioactivity. - Analyses for the pesticides chlordane, endrin, heptachlor, heptachlor epoxide, lindane, methoxychlor and toxaphene and the herbicides 2,4-D and 2,4,5-TP silvex were all below the detection limit for the analytical method employed. A high concentration of chloroform was found in a water sample collected by KAME and analyzed at a private laboratory. The reliability of this analysis was suspect, however, and additional tests were performed by the U. S. Environmental Protection Agency. These analyses found no chloroform.

Alpha and beta radioactivity analyses were all below the National Primary Drinking Water Regulations criteria.

(g) pH. - Mean pH in Big River watershed water is 6.3, which is on the acid side of neutral. The range in pH measurements was 4.7 to 7.9.

(h) Other parameters. - Other water quality parameters measured in the Big River watershed show that the waters are very soft with low alkalinity; nutrient concentrations are very low; dissolved solids concentrations are low; and suspended solids concentrations are very low.

b. Diversion Sites

(1) State classifications. - The proposed diversion sites are the Wood River, the Moosup River, Buckshorn Brook and Flat River Reservoir. The waters of the Wood River, the Moosup River and Buckshorn Brook are designated Class A by the Rhode Island Division of Water Pollution Control, while Flat River Reservoir is designated Class B. Class A waters are described in paragraph 2.a.(1). Class B waters are suitable for recreational purposes including bathing, agricultural and industrial uses and fish and wildlife habitat, have good aesthetic value and are suitable for public water supply with appropriate treatment, the latter being the intended use in this instance.

(2) Data collection. - Water quality data from stations at or near the diversion sites have been collected by the USGS, the Rhode Island Water Resources Board and KAME. Data collection was also initiated by the Corps of Engineers in August 1978 to develop a more comprehensive data base tailored to the Big River Reservoir water quality studies. Stations where Corps water quality data collection is in progress are listed in table 1 and shown on plate E-1.

(3) Water quality assessment. - The waters of the Wood River at the proposed diversion site are of high quality and fully meet Rhode Island Class A criteria for dissolved oxygen, total and fecal coliform bacteria, and turbidity. The waters of Buckshorn Brook and the Moosup River at the proposed diversion sites are of generally high quality but do not fully meet R.I. Class A criteria because of high levels of coliform bacteria. The waters of the Flat River Reservoir are of generally good quality and meet their Class B requirements except for low levels of DO.

Occasional high levels of iron at all sites and occasional high levels of manganese at the Wood River, Buckshorn Brook, and Flat River Reservoir exceed National Secondary Drinking Water Regulation limits. Other heavy metals concentrations and pesticide and herbicide concentrations at all sites are below National Primary and Secondary Drinking Water Regulations limits.

Other generalizations of the quality of the water that are true for all the diversion sites include: color levels are within EPA recommended limits for a public water supply source, but would have to be reduced before the water entered the actual distribution system; nutrient concentrations are very low; waters are soft with mean pH on the acid side of neutral; dissolved solids concentrations are low and suspended solids concentrations are very low.

c. Scituate Reservoir

Scituate Reservoir was created by the construction of Gainer Dam on the North Branch of the Pawtuxet River in 1926. It lies in the same river basin as the Big River, which is a tributary of the South Branch of the Pawtuxet River (see plate E-1). The dam, reservoir and 12,450 acres of watershed land (including the 3,600-acre lake) are owned and managed by the City of Providence Water Supply Board. Strict control of the Board-owned land is exercised with no unauthorized entrance allowed.

Preparation of the Scituate Reservoir site for inundation consisted of clearing and grubbing. All trees, buildings, masonry walls, chimneys and wood portions of bridges were removed, and cemeteries were relocated. Privies, stables and cesspools were cleaned out and then the areas were disinfected and covered with earth. All stumps and brush were removed or burned. Stripping of topsoil from the entire reservoir was not accomplished.

Scituate Reservoir has experienced a general increase in water quality conditions over its lifetime. Levels of color, turbidity and iron have decreased from relatively high values just after filling to acceptably low and fairly constant levels over the last 25 years. The period of stabilization of these parameters varied from 15 to 20 years.

The quality of water in Scituate Reservoir now is very good. The reservoir has no algae problems and low levels of nutrients; total inorganic nitrogen averages about 0.10 mg/l, which is well under the 0.30 mg/l level generally accepted as the threshold limit for algae bloom development. The water is soft with low alkalinity and the chloride levels are low. Color, turbidity, iron, and manganese levels are low although they increase in the lower depths of the reservoir during the summer stratification period. Other metals are either at less than detectable concentrations or at less than EPA recommended limits for drinking waters. Dissolved oxygen concentrations are high, generally above eighty percent of saturation, except in lower levels of the reservoir during stratification periods. The pH of the water is in the acid range and averages about 6.0. Pesticides and phenols have not been found in greater than EPA limits for drinking waters. Coliform counts are low, generally under 10 per 100 ml.

The City of Providence Water Supply Board collects water quality data at 22 locations throughout the Scituate Reservoir watershed on a monthly basis. Parameters monitored include color, turbidity, pH, iron, manganese, acidity, alkalinity and coliform bacteria. KAME, in a 1977 study prepared for the Rhode Island Water Resources Board, utilized the data for ten of these stations to compare inflow water quality to outflow water quality as measured at the raw water intake from Scituate Reservoir. Color, turbidity, iron and manganese data were used in the evaluation.

The results of the study demonstrated that color and iron in the outflow were considerably lower than in the inflow due to the storage effects of the reservoir. Over the period 1960 to 1974 the average annual percent reduction in color was 56 and, for iron, 63. Turbidity showed no reduction due to storage, primarily because the inflow levels were generally very low (less than 0.5 turbidity units). Manganese was observed to be higher in the outflow than in the inflow. This was attributed to the fact that water is withdrawn from the bottom of the reservoir where anaerobic conditions may exist or develop seasonally, thereby allowing manganese to solubilize. That the iron levels are not likewise higher may be due to the tendency of iron to precipitate out faster than manganese when reexposed to aerobic water.

3. FUTURE WATER QUALITY CONDITIONS - BIG RIVER RESERVOIR

a. General

The quality of water in the Big River Reservoir is expected to be very similar to that of Scituate Reservoir. This assumption is based on the following facts: both reservoirs are located in the same geographical region - central Rhode Island; both are in the Pawtuxet River Basin; the watersheds of both are relatively undeveloped and heavily wooded; the morphometric characteristics of both are similar; and water quality conditions in the feeder streams to both are similar. Available data and information concerning Scituate Reservoir will therefore be used to assist in the prediction of water quality conditions in Big River Reservoir.

b. Morphometry

Big River Reservoir will exhibit a dendritic shoreline somewhat in the shape of a four-pronged pitchfork. The four prongs correspond to arms of the reservoir south of the Route I-95 crossing formed by impoundment of the Big, Nooseneck and Congdon Rivers, the stream draining Sweet Pond, Mud Bottom Brook and the Carr River. North of the highway, the reservoir will be fairly rectangular in shape and will inundate the Big River and Bear Brook. The largest tributary to the reservoir will be the Nooseneck River with a drainage area of about 8 square miles. Other tributaries will be Rathbon and Carr Ponds and their watersheds and the streams tributary to Bear Brook.

The general morphometric characteristics of Big River Reservoir are summarized on table 2. At elevation 300 ft. msl, top of water supply pool, the reservoir will have a surface area, A, of 3,240 acres (1311 hectares) and volume, V, of 84,000 acre-feet (1.04×10^8 cubic meters). The mean depth, $\bar{Z} = V/A$, is 25.9 feet (7.9 meters); the maximum depth, Z_m, will occur at the dam site and will be 60 feet (18.3 meters); the maximum length along the surface will be approximately 6 miles (9.7 kilometers).

The shoreline of the reservoir at elevation 300, including the Route I-95 embankment but not including any islands, will be approximately 34 miles (54.7 kilometers). "Development of shoreline", a measure of the departure of the shape of a lake from that of a circle whose circumference is equal to the lake's shoreline length, is approximately 4.3 which is indicative of a dentritic shape. The ratio of mean depth to maximum depth ($\bar{Z} : Z_m$), a measure of the volume development of a lake, is 0.43. This ratio for most lakes falls between 0.33 and 0.5. Higher values indicate shallow lakes with flat bottoms or deep crater-type lakes and fjord lakes, among others. Lower values indicate lakes with highly localized deep holes.

As many as 24 islands could exist with the reservoir surface at elevation 300 ft. msl. Most would be very small with only a few reaching several acres in area. Four named ponds, Reynolds, Capwell Mill, Sweet and Tarbox, will be inundated along with from 5 to 10 smaller unnamed ponds.

Table 2

GENERAL MORPHOMETRY
BIG RIVER RESERVOIR EL. 300 FT. MSL

Area, A (acres)	3,240
Volume, V (acre-feet)	84,000
Mean Depth, $\bar{Z}=V/A$ (feet)	25.9
Maximum Depth, Z_m (feet)	60
Length (miles)	$\approx$6
Shoreline (miles)	$\approx$34
Development of Shoreline, $D_L = L/2\sqrt{\pi A}$	4.3
$\bar{Z} : Z_m$	0.43
No. of Islands	11 to 24
No. of Ponds Inundated	9 to 14

c. Reservoir Water Quality Predictions

(1) General. - Water quality conditions in Big River Reservoir will depend to a great extent on the type and amount of reservoir site preparation performed prior to filling. Site preparation options most commonly used are: clearing; clearing and grubbing; and clearing, grubbing and stripping. Clearing involves the cutting and removal of woody vegetation, generally all trees greater than 2 inches diameter. It leaves the greatest amount of organic materials in the reservoir area and will generally exert the most adverse impact on water quality. Grubbing, used in conjunction with clearing, involves the removal of stumps. Its relative impact on water quality will be somewhat less. Stripping is the removal of forest-floor organics and topsoil down to mineral soil and is performed after the site has been cleared and grubbed. Since this option removes the majority of organic materials from the reservoir, it will exert the least negative impact on water quality. A reservoir that is cleared, grubbed and stripped will achieve chemical stability faster than reservoirs that receive lesser degrees of site preparation.

Predictions of water quality conditions in Big River Reservoir are presented herein for two site preparation schemes: (a) extensive preparation with total clearing, grubbing and stripping and (b) limited preparation with total clearing and grubbing only. Lesser degrees of site preparation such as are recommended in Corps of Engineers policy and guidance will result in poorer water quality conditions for an indeterminable period following filling.

(2) Future Water Quality with extensive site preparation. -

(a) General. - If the reservoir site is thoroughly prepared by the clearing, grubbing and stripping of all organic material prior to inundation, the reservoir water quality would be very good. As explained earlier, the physical and chemical characteristics of Big River Reservoir are expected to be similar to those of Scituate Reservoir. However, if Big River Reservoir receives this extensive site preparation, its water quality may be even better than that of Scituate Reservoir.

(b) Dissolved oxygen. - The dissolved oxygen (DO) levels in the reservoir would be high. With high concentrations of DO in the inflowing streams, little organic material in the bottom of the reservoir, and the expected low productivity of the lake, there would not be anything to make significant demands on the oxygen resources of the water. The lowest DO would occur in the hypolimnion towards the end of the summer stratification period. At Scituate Reservoir, the mean monthly DO in the hypolimnion at this time of year has gone below 5 mg/l. However, this would not happen at Big River Reservoir if it is stripped of all organic material before filling. The DO in the hypolimnion is expected to be always above the 5 mg/l level required to preserve a cold water fishery.

(c) Nutrients. - Nutrient concentrations in the reservoir are expected to be very low and the reservoir will be oligotrophic. The streams in the Big River watershed contain inorganic nitrogen in concentrations less than 0.3 mg/l and inorganic phosphorus in concentrations less than 0.01 mg/l, the levels that are generally considered critical to the formation of algae blooms. With the reservoir bottom stripped there would be no other significant sources of nutrients. Thus, algae growth would be restricted by low levels of both nitrogen and phosphorus.

As a check on the predicted trophic status of the Big River Reservoir, the nutrient input-output model of Dillon and Rigler was used to compute phosphorus concentration, cholorophyll a concentration and Secchi disc transparency in the proposed impoundment. Using the sum of the natural and artificial loads of phosphorus to the reservoir and measures of the reservoirs morphometry and water budget, a phosphorus concentration during the spring overturn of 0.003 mg/l, a summer average chlorophyll a concentration of 0.4 ug/l and a Secchi disc transparency of greater than 10 meters were computed. Since a concentration of chlorophyll a of 2 mg/l and a Secchi disc transparency of 5 meters are considered characteristic of a very unproductive lake, Big River Reservoir is expected to be very oligotrophic.

(d) pH. - The pH in Big River Reservoir is expected to be essentially the same as that currently found in the watershed streams. Algae blooms, which could raise pH during the day and lower it at night, are not expected to occur in this lake. A lowering of the pH in the hypolimnion due to a buildup of dissolved carbon dioxide may occur during periods of stratification. Otherwise, the main effect on the impoundment would be to reduce the variations in pH. Using the pH values observed in the Big River watershed and at the raw water intake at Scituate Reservoir as guides, the mean pH in Big River Reservoir would be about 6.0 with values ranging from 5.5 to 6.5.

(e) Coliform bacteria. - Although the present water quality conditions in the Big River watershed violate the Rhode Island Class A standard criterion for total coliform bacteria, the expected coliform levels in the Big River Reservoir are much lower. There are two reasons for this: first, the dwellings currently within the reservoir area will be removed prior to impoundment thus eliminating the major sources of coliform bacteria; second, the reservoir will act as a sedimentation basin allowing bacteria to settle out and the increased detention time in the reservoir will allow more bacterial die off. The expected coliform counts in the raw water inlet at Big River Reservoir are similar to the coliform counts currently in the raw water intake at Scituate Reservoir. The median of the coliform counts measured there by the Providence Water Supply Board for the period January 1976 to March 1978 was 4 per 100 ml and less than 1 percent of the counts were over 500 per 100 ml.

(f) Color. - The color in Big River Reservoir water would be low, but not low enough to not require color removal treatment. At Scituate Reservoir the effect of impoundment on color is to decrease it to an average of 56 percent of inflow color. Applying this removal efficiency to Big River Reservoir would give a color concentration at the raw water intake of about 20 Pt-Co units. During the fall overturn, the color in the Scituate Reservoir can increase 60 percent. Applying this increase to Big River water would give a fall overturn color of 30 Pt-Co units. However, because of the expected higher DO in the hypolimnion at Big River Reservoir, it is likely that the increase in color during overturns will be relatively less at Big River than at Scituate Reservoir.

A limit of 75 Pt-Co units is recommended by the U. S. Environmental Protection Agency for waters to be used as a source of public water supply. The waters of Big River Reservoir would easily meet that criterion. However, the National Secondary Drinking Water Regulations set a 15 Pt-Co limit on drinking water. Therefore, color removal would be part of the required treatment for Big River Reservoir water.

Scituate Reservoir did not achieve its full color reduction potential until the reservoir had been in operation for 30 years. However, Big River Reservoir is expected to stabilize more quickly because of the complete removal of organic material from the site prior to impoundment.

(g) Turbidity. - If Big River Reservoir behaves in the same manner as Scituate Reservoir with the average turbidity in the raw water intake about equalling the average turbidity in the watershed, then the average turbidity in the raw water would be about 1 JTU with peaks of about 2 JTU during overturns. However, as the levels of turbidity at Scituate Reservoir seem to represent a "base" level which will not settle out, it is possible that the higher levels of turbidity in the Big River watershed would settle out to leave this lower "base" level in the reservoir. In this case, the yearly average turbidity in the Big River Reservoir would be about 0.2 JTU, but there would be highs of over 1 JTU during overturns.

(h) Iron. - Applying the same percentage removal of iron to Big River Reservoir as is occurring at Scituate Reservoir yields a predicted raw water iron concentration at the intake of 100 to 200 ug/l. These concentrations are below the 300 ug/l iron limit set by the National Secondary Drinking Water Regulations. However, Scituate Reservoir did not effect any iron removal during the first twenty years of its operation while the reservoir was stabilizing. Therefore, there may be high levels of iron in Big River Reservoir water during the initial years of its operation prior to stabilization. The absence of organic material on the bottom of Big River Reservoir should cause periods of anaerobic conditions in the hypolimnion to be shorter than at Scituate Reservoir, or possibly, non-existent. Since under anaerobic conditions the iron that has precipitated from the aerobic portions of the lake becomes redissolved, the iron removal capabilities of Big River Reservoir may be even greater than that of Scituate Reservoir.

A recommended limit for iron to protect aquatic life is 1000 ug/l. Since this level is rarely exceeded in the tributaries of Big River Reservoir and because the reservoir would have lower levels of iron than its tributaries, there is no reason to expect that iron would exist in concentrations that would be a problem for sensitive aquatic life.

(i) Manganese. - If manganese levels in Big River Reservoir follow the same patterns as in Scituate Reservoir where the raw water at the intake had concentrations 260 percent of the manganese in the tributary streams, then the intake water would be expected to have an average of 55 to 120 ug/l manganese. Both of these are greater than the 50 ug/l limit set by the National Secondary Drinking Water Regulations to protect public welfare. Thus, treatment to remove manganese will be required for Big River water if the reservoir behaves in this manner. However, if the manganese leaving the reservoir is at the same concentration as that entering it, or if the reservoir acts to remove manganese through oxidation and precipitation, then the average manganese concentrations at the intake would be less than the drinking water criterion.

(j) Other heavy metals. - The levels of other heavy metals in Big River Reservoir would be undectable or below National Primary and Secondary Drinking Water Regulations limits. The only metal found in excess of these standards in the watershed was mercury which was found in a few samples to be up to 140 percent of the drinking water criterion. However, most of the samples contained levels of mercury that were less than half of the criterion. Therefore, when the waters are mixed in the reservoir the final mercury concentration would be well below the drinking water criterion.

(k) Pesticides. - Pesticides and phenolic compounds which occur at levels less than detectable or less than drinking water criteria in the watershed streams, would have similar or lower concentrations in the reservoir.

(1) Other parameters. - Other water quality predictions include: the water would be soft with low alkalinity; chloride concentrations would be low although they have been showing a slowly increasing trend over the past years; conductivity would be low; and suspended solids levels would be very low.

(3) Future water quality with limited site preparation. -

(a) General. - For purposes of this analysis, it is assumed that Big River Reservoir would be prepared by clearing and grubbing only, which is the type of preparation Scitute Reservoir received. The expected water quality under these conditions would have significantly higher levels of color, iron, and, possibly, manganese and nutrients than in the case described above where all organic material was stripped after clearing and grubbing. Dissolved oxygen concentrations and pH levels would show greater variations. The effect of the limited site preparation on levels of coliforms, heavy metals, and pesticides would not be significant.

(b) Dissolved oxygen. - The manner in which the reservoir lands are prepared for inundation will not alter the high levels of DO and low levels of organics in the watershed streams and surface DO concentrations in the reservoir would be in excess of 80 percent of saturation, however, the decay of organic materials left at the lower levels of the reservoir would bring hypolimnion DO concentrations below 5 mg/l and possibly to anaerobic conditions during the summer stratification period.

(c) Nutrients. - The organic materials left on the reservoir lands would release nutrients to the overlying water especially during the low DO conditions expected in the hypolimnion during summer stratification. The effect of these nutrients would be to produce an oligotrophic/mesotrophic lake. Eventually the nutrients will be flushed out of the impoundment by the low-nutrient waters of the tributary streams, but for at least the first few years after filling, there will be occasional noticeable algae growths although algae blooms of the nuisance type would not occur.

There will be diurnal fluctuations in the DO of the surface waters if the nutrient conditions become high enough to support large growths of algae. It is unlikely, however, that algae growths would approach bloom conditions such that daytime DO concentrations would go much over saturation or nightime DO's below 6 mg/l.

(d) pH. - With limited site preparation, the mean pH values would be about the same as in the case of more extensive clearing, but there would be greater variations in the reservoir. During summer stratification, the decay of organic material on the reservoir bottom would cause a pH drop in the hypolimnion due to a buildup of dissolved carbon dioxide. During periods of rapid algae growth, the pH of the surface waters would rise due to a consumption of dissolved carbon dioxide. At night the pH would drop as algae respiration increases the carbon dioxide levels.

The pH would average about 6.0 standard units with most values being between 5.5 and 6.5. During the late summer, the hypolimnion pH could drop to 4.7 or less, and during conditions favoring large algae growths, the daytime pH could reach 8.0 or higher in the surface waters.

(e) Color. - The color of the reservoir water will follow patterns similar to those at Scituate Reservoir; however, it would be higher at Big River Reservoir because the color in the watershed streams is higher than in the Scituate Reservoir watershed. The color in the water immediately after filling would be about 60 Pt-Co units, and within 5 to 10 years later the color would be expected to reduce to 30 Pt-Co units. Over the next 25 years, the color would gradually reduce to a level of about 15 to 20 units. During the fall overturn each year, the color would increase to 30 or more Pt-Co units. These levels of color are less than the 75 Pt-Co units limit recommended by the U. S. Environmental Protection Agency for a public water supply source, but they do not meet the 15 Pt-Co unit color criterion of the National Secondary Drinking Water Regulations. Therefore, treatment to remove color will be necessary.

(f) Iron. - The total amount of iron entering the reservoir will be unaffected by the reservoir site preparation, however, the amount of iron in solution will be very much affected by the presence of organic materials on the bottom of the reservoir. The decay of these materials could cause anaerobic conditions in the lower levels of the reservoir especially during the summer stratification period. Under anaerobic conditions, precipitated iron is readily converted to a soluble form.

If the iron levels follow the same pattern at Big River Reservoir as they did at Scituate, with adjustments for the higher levels of iron in the streams of the Big River watershed, then during the first 20 years of reservoir operation the mean yearly concentrations of iron in the reservoir would be 300 to 600 ug/l. Concentrations of twice that or more would occur during the annual fall overturn.

It is expected that, after 20 years, the reservoir would remove iron from inflowing waters and the mean iron concentrations in the reservoir water would drop to 100 to 200 ug/l. During the fall overturn, the iron concentration would increase by a factor of up to 2. Since the National Secondary Drinking Water Regulations limit iron to 300 ug/l, iron removal treatment would be required.

(g) Manganese. - Manganese concentrations would be higher for the same reasons that iron concentrations would be higher. However, the expected manganese concentrations in Big River Reservoir are very hard to predict using Scituate Reservoir as a guide because of the anomaly in the amounts of manganese entering and leaving the latter reservoir. If manganese levels in Big River Reservoir follow the same patterns as those exhibited by the Scituate Reservoir data, that is where the raw water at the intake has 260 percent of the weighted average of the manganese in the tributary streams, then the intake water will have an average of 60 to 120 ug/l Mn. The National Secondary Drinking Water Regulations set a 50 ug/l limit on manganese, and treatment to remove it would be required.

It is possible that the reservoir will act to reduce manganese concentrations through oxidation and precipitation. In this case, the only prediction that can be made is that the removal of manganese would be less complete with lesser site preparation because the anaerobic conditions at the reservoir bottom would interfere with the oxidation and removal of manganese.

(h) Other parameters. - Other water quality parameters which would be affected little or not at all include turbidity, coliform bacteria, heavy metals, and pesticides. The turbidity will not increase, except possibly during overturns, because the reservoir would act as a settling tank regardless of the method of reservoir site preparation. Coliform counts would be low because the major sources within the watershed would be removed just as in the case of extensive site preparation. Heavy metals and pesticides would continue to be absent or exist in only trace concentrations in the watershed.

(4) Reservoir temperature regime. -

(a) General. - Preliminary investigations concerning the thermal regime of Big River Reservoir were conducted using the HEC Reservoir Temperature Stratification Model, which simulates the vertical temperature distribution of a lake by computing, on a monthly basis, the energy balance of the lake. Components of the energy balance that are considered are: evaporation, precipitation, solar radiation, surface conduction, inflow and outflow advection and internal diffusion. The model employs some relatively simple solution techniques for various aspects of the computations, which, along with the monthly time step, makes the model unsuited for design applications. However, it does lend itself to use in preliminary studies of proposed reservoirs, and the monthly operation simulation feature allows analysis of long historic periods. For this study, the model was used to provide an indication of possible temperature stratification patterns, to provide an indication of the need for a multi-level intake structure and to make a preliminary assessment of the number and location of withdrawal ports to meet downstream temperature objectives. Thirty-six years of hydrometeorological record spanning the period 1941-1976 were analyzed. Several elevations of withdrawal for water supply and downstream releases were tested.

(b) Downstream temperature objective. - A preliminary downstream temperature objective was developed from a regression analysis of 3-1/2 years of streamflow temperature data from the Hunt River near Davisville, R.I. (DA = 17.3 mi^2), an adjoining watershed to the east of Big River. The resulting objective temperature range is shown on plate E-2. The same regression equation was also used to synthesize the temperature regime of the Big River at the point of inflow to the reservoir.

(c) Thermal simulation. - The study results indicated that Big River Reservoir would experience moderate to strong stratification and that the elevation of the water supply withdrawal port(s) will greatly influence the thermal structure of the hypolimnion. Typical stratification patterns for March to October 1962 and 1971 are shown on plates E-3 and E-4. These two years represent high pool (wet year) and low pool (critical dry year) conditions, respectively. The temperature profiles are the result of withdrawing supply water from the bottom (el. 243 ft. msl) and downstream release water from el. 264 ft. msl. The impact of making water supply releases from a higher elevation is displayed on plates E-5 and E-6 for July and October of the same two study years. With water supply taken from minimum pool elevation 268 ft. msl and downstream releases taken from elevation 264 ft. msl, the hypolimnion zone is significantly cooler. Taking water supply from the bottom (el. 243 ft. msl) would deplete the cool water and could result in the inability to meet downstream temperature requirements in the late summer and fall when the cooling of the reservoir will lag the natural cooling of free-flowing streams, thus resulting in higher than natural discharge temperatures. Positive control of the temperature of water released downstream could be provided by using from 3 to 5 levels of intakes. The number and locations will be dependent in part on the location of the water supply intake.

Certain factors that could influence the ultimate outlet configuration and operation scheme, namely, use of Flat River Reservoir temperatures as the downstream objective and consideration of the effects on reservoir hydrodynamics of the Route I-95 embankment and culverts, were not considered in this preliminary study due, primarily, to a lack of data and analytical methods. Future design studies of this project must include thorough analyses of these factors.

(5) Effect of diversions. -

Water quality conditions in the Big River watershed and those at the possible diversion sites are basically similar in physical and chemical characteristics. The effect on water quality of diverting water to Big River Reservoir and, in particular, the effect on the quality of water withdrawn for water supply will depend more on where the diverted water enters the reservoir than which source is used.

If water diverted to Big River Reservoir is pumped the shortest possible distance, Wood River water would enter the reservoir on the east side of Route I-95, well away from the dam. These diverted waters would mix thoroughly with the waters of the reservoir. Sedimentation and oxidation would remove color, metals, and coliforms and the water at the intake works would be the same as if no diversions to the reservoir had been made.

However, if diversion is effected by pumping Moosup River, Buckshorn Brook, or Flat River Reservoir water the shortest possible distance to Big River Reservoir, the flows would enter the reservoir on the west side of Route I-95 at or near the dam. In this case, the partial barrier created by Route I-95 and possible short circuiting could greatly reduce the mixing, oxidation, and sedimentation in the reservoir. This would cause a markedly inferior quality water in terms of metals, color, turbidity, and DO concentrations to enter the raw water intake works.

4. WATER TREATMENT vs. DEGREE OF SITE PREPARATION

a. General

The prime consideration in formulating a recommended plan for reservoir site preparation is the benefits to be derived from the proposed action. In the case of a water supply reservoir, the benefits can be determined in terms of the cost savings of treating a higher quality water associated with an extensive site preparation plan. The following comparison of treatment costs for the two site preparation options outlined in paragraphs 3c(2) and 3c(3) is made to assist in the decision-making process.

b. Introduction

The basic assumption made in computing water treatment cost savings is that the same water treatment plant will be built to treat Big River Reservoir water regardless of the method of reservoir site preparation. Therefore, the water treatment cost savings attributable to stripping the reservoir of all organic material prior to filling would be due only to reduced chemical requirements and chemical handling costs.

To calculate the chemical costs associated with the case of the stripped reservoir, it was assumed that the reservoir water quality will stabilize immediately after filling at a level equivalent to that existing in Scituate Reservoir during the year ended 30 June 1977. Chemical dosages required to treat the water would, therefore, be the same as those used to treat Scituate Reservoir water in 1977. This year was chosen for analysis because it was more than 50 years after Scituate Reservoir was filled and represents well stabilized physicochemical conditions, and because it was the most recent for which data was available.

The chemical costs associated with the case of the unstripped reservoir (cleared only) were calculated from the results of jar tests of water samples collected from the Big River at the dam site presented in the 1977 report on Big River Reservoir by Keyes Associates - Metcalf & Eddy, Inc. These jar test data were assumed to be indicative of the chemical requirements for treatment of the Big River Reservoir water during the initial years after impoundment. In actuality, the river water samples used in the jar tests had lower iron and manganese concentrations than reservoir water is expected to have. However, no other jar test data was available, and the difference in water quality was accounted for by calculating chemical requirements in a very conservative manner.

c. Chemical and Chemical Handling Costs for Treating Water

(1) Extensive Site Preparation. - In 1977, Scituate Reservoir water was treated using ferri-floc, quicklime, chlorine, and fluoride. The same yearly average concentrations of these chemicals were applied to the 37 MGD net yield of Big River Reservoir. The cost for these chemicals, using 1977 prices, is $128,000 per year. Table 3 details how this cost was calculated. Chemical handling costs were computed using the ratio of labor costs associated with chemical handling to chemical costs at Scituate Reservoir. This gave a labor cost of $2,300 per year at the proposed Big River water treatment plant. Assuming that overhead costs associated with labor are twice the actual cost of the labor gave a total labor cost of $6,900 per year, and a total annual chemical and chemical handling cost of $134,900.

(2) Limited Site Preparation. - Chemical requirements for treating Big River Reservoir water for the unstripped case were very conservatively calculated from the results of the jar tests performed by Metcalf & Eddy, Inc. In these tests, 15-30 mg/l of ferric sulfate was

used with concentrations of 18-30 mg/l of lime and 5-15 mg/l of chlorine to obtain good flocs and filtrates. The required doses for this analysis were taken to be 30 mg/l of ferric sulfate, 30 mg/l of lime, and 5 mg/l of chlorine. In addition, to attain extra conservative estimates, it was assumed that the 5 mg/l of chlorine was only used in clarifying the water and that an additional 0.5 mg/l of chlorine was required for disinfection.

Under these conditions, the cost of chemicals, using 1977 prices, for treating 37 MGD of Big River Reservoir water is $329,000 per year. Table 4 details how this price was calculated. Labor costs for handling these chemicals are $6,000 per year and associated overhead costs are $12,000 per year, bringing the total annual chemical and chemical handling costs to $347,000. This figure is conservatively high because the doses of ferri-floc and lime are high, and because the experience at Scituate Reservoir was that it was cheaper to use alum during the initial years after reservoir filling.

d. Comparison of Water Treatment Alternatives

The savings in water treatment costs by stripping the reservoir of all organic material is $212,000 per year ($347,000 - $135,000) in 1977 prices. To be ultra-conservative, it was assumed that the reservoir would never stabilize and this yearly savings would continue forever. The present worth of these savings in 1977 at a 6-5/8 percent interest rate would be $3,200,000.

TABLE 3

Chemical and Chemical Handling Costs

With

Extensive Site Preparation

I Chemical Costs at Scituate Reservoir in 1977.

Chemical	Cost ($\$/10^6$ gallons water treated)
Ferri-floc	5.32
Quicklime	2.26
Chlorine	.46
Fluoride	1.45

II Chemical Handling Costs at Scituate Reservoir.

Total chemical costs = $219,644.73
Total labor costs for chemical handling = $3,988.80
Ratio of dollars labor cost per dollar chemical cost = 0.0182

III Costs for Treating 37 MGD (13,500 x 10^6 gal/yr) of Big River Reservoir Water.

Chemical Costs

Ferri-floc:	13,500 x 10^6 gal x 5.32 $\$/10^6$ gal	=	$ 71,800
Quicklime:	13,500 x 10^6 gal x 2.26 $\$/10^6$ gal	=	30,500
Chlorine:	13,500 x 10^6 gal x .46 $\$/10^6$ gal	=	6,200
Fluoride:	13,500 x 10^6 gal x 1.45 $\$/10^6$ gal	=	19,200
Total			$128,000

Chemical Handling Costs

Labor:	128,000 x 0.0182 $labor/$chem	=	$ 2,300
Overhead:	2,300 x 2	=	4,600
Total			$ 6,900
Total Chemical and Handling Costs			$135,000

TABLE 4

Chemical and Chemical Handling Costs

With

Limited Site Preparation

I Chemical Costs at Scituate Reservoir in 1977.

Chemical	Cost
Ferri-floc	.0493 \$/lb
Quicklime	.0219 \$/lb
Chlorine	.11 \$/lb
Fluoride	1.45 \$/10^6 gal water treated

II Costs for Treating 37 MGD (113,000 x 10^6 lb/yr) of Big River Reservoir Water.

Chemical Costs

Ferri-floc:	113 x 10^9 lb/yr x 30 ppm x 10^6 x .0493 \$/lb =	\$167,000
Quicklime:	113 x 10^9 lb/yr x 30 ppm x 10^6 x .0219 \$/lb =	74,000
Chlorine:	113 x 10^9 lb/yr x 5.503 ppm x 10^6 x .11 \$/lb =	68,000
Fluoride:	13,500 x 10^6 gal x 1.45/10^6 gal =	20,000
Total		\$329,000

Chemical Handling Costs

Labor:	329,000 x 0.0182 \$labor/\$chem	\$ 6,000
Overhead:	6,000 x 2	12,000
Total		\$ 18,000
Total Chemical and Handling Costs		\$347,000

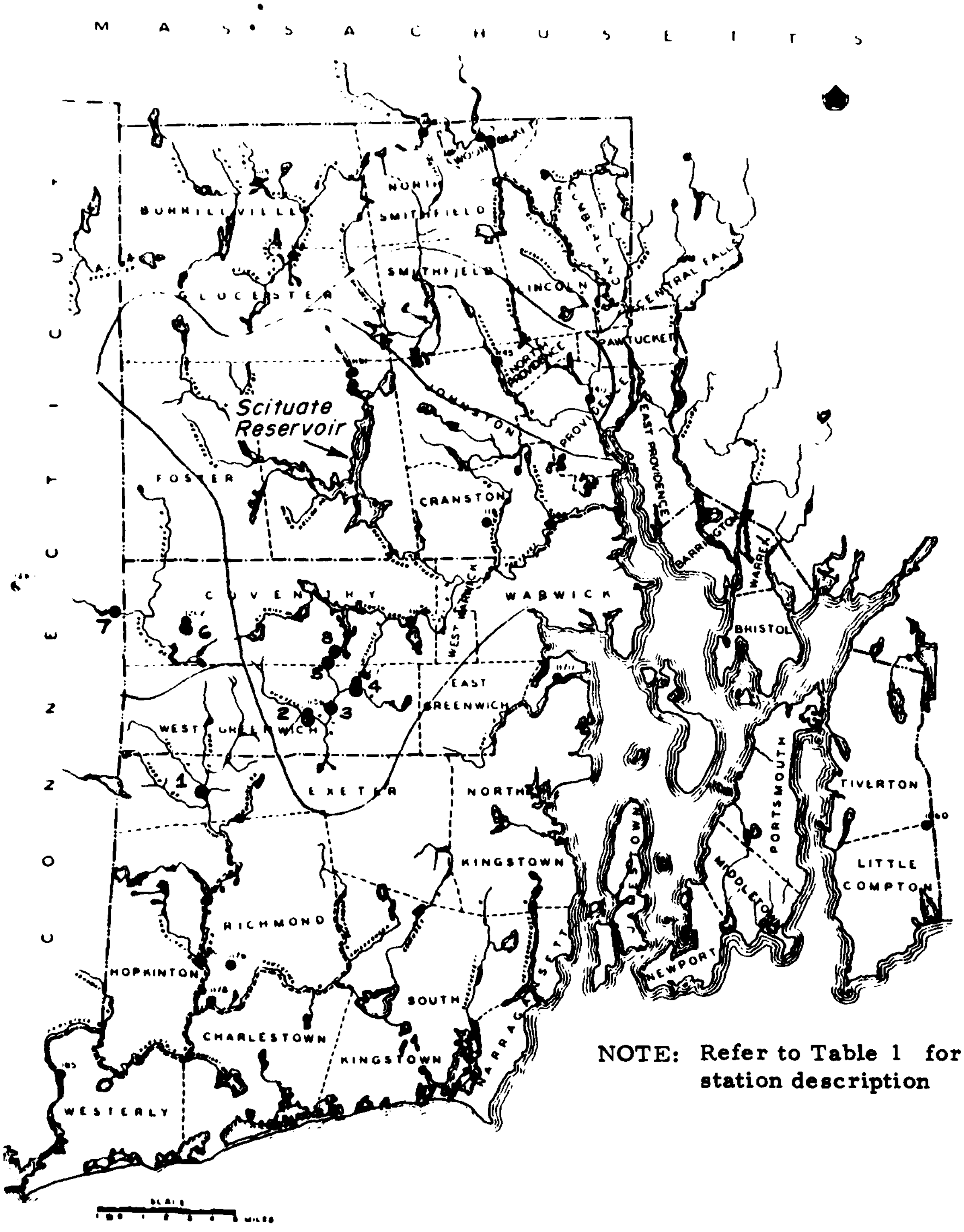
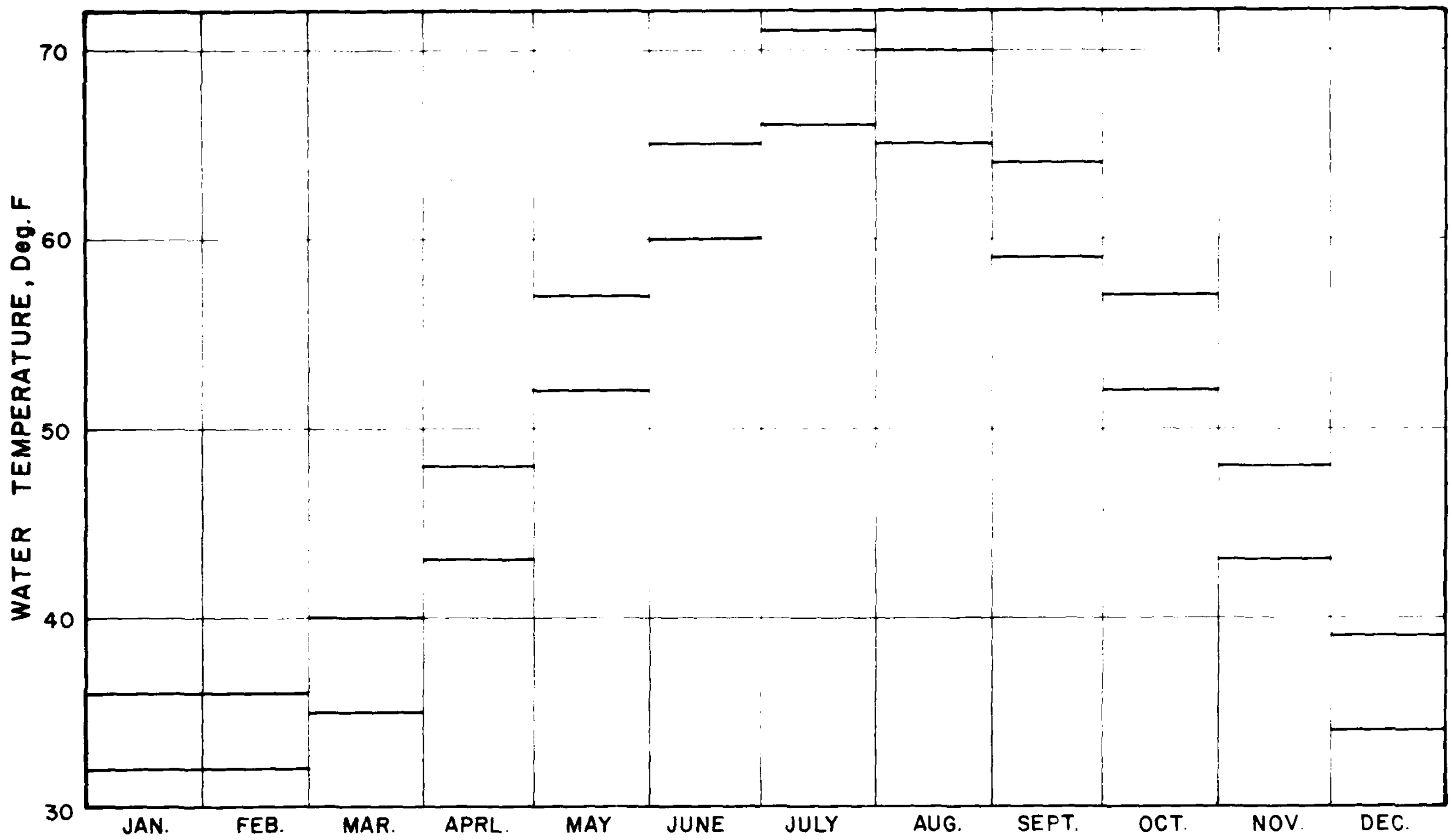


Plate E-1 - Water Quality Sampling Station Locations

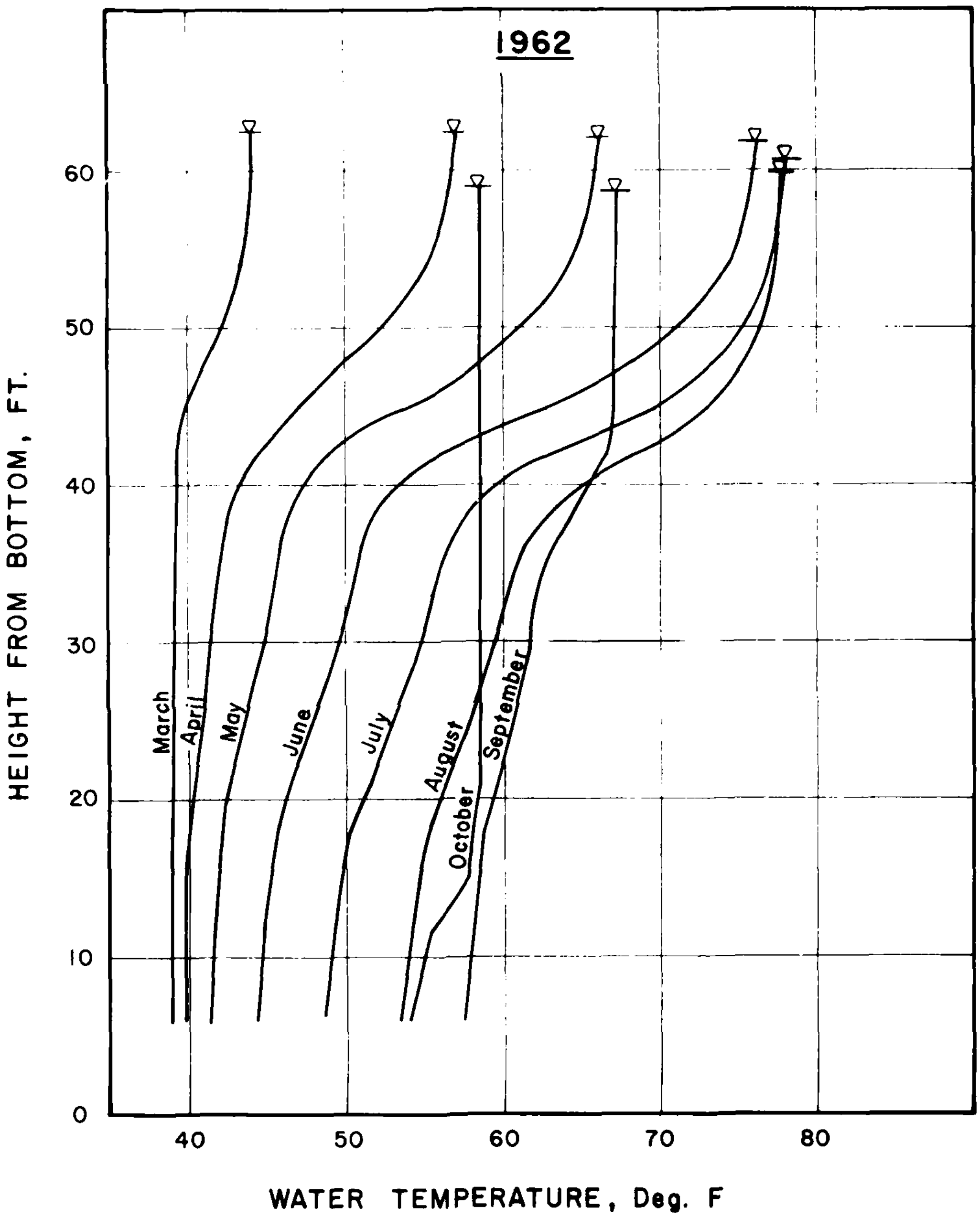


WATER RESOURCES DEVELOPMENT

BIG RIVER RESERVOIR PROJECT

MEAN MONTHLY OBJECTIVE RANGE

DOWNSTREAM RELEASE TEMPERATURE



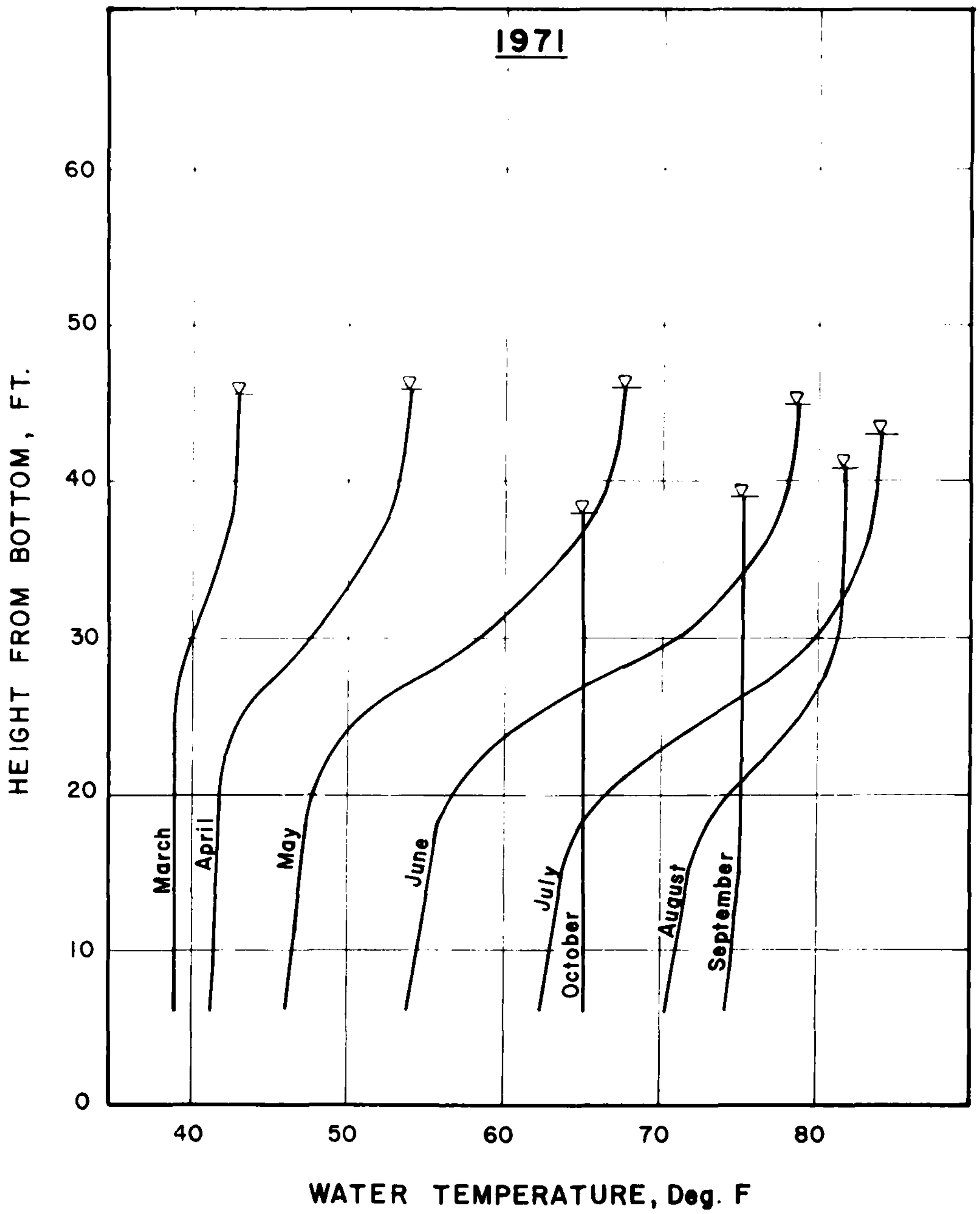
WATER RESOURCES DEVELOPMENT

BIG RIVER RESERVOIR PROJECT

TEMPERATURE STRATIFICATION PATTERNS

WATER SUPPLY WITHDRAWAL FROM RESERVOIR BOTTOM, EL. 243 NGVD

PLATE E-3



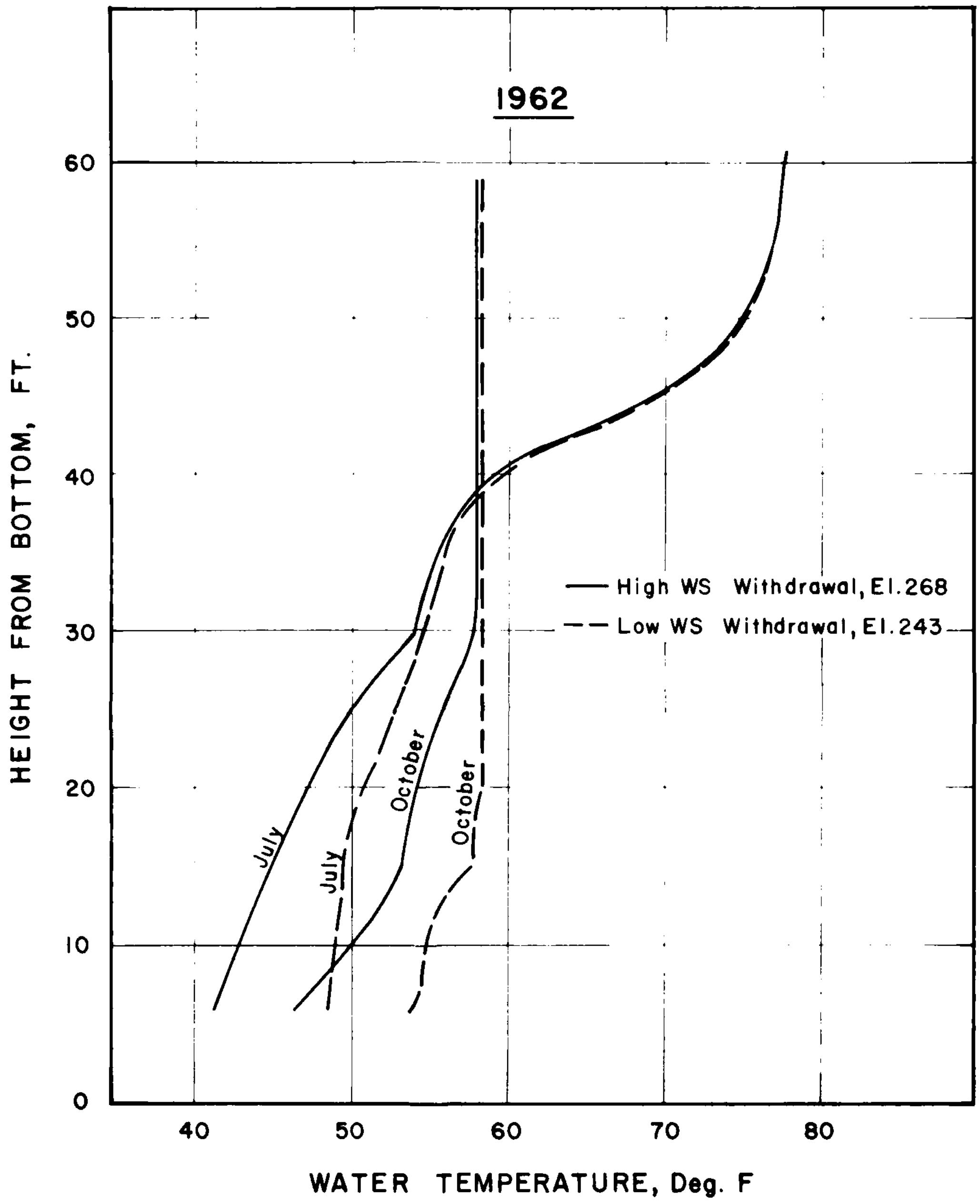
WATER RESOURCES DEVELOPMENT

BIG RIVER RESERVOIR PROJECT

TEMPERATURE STRATIFICATION PATTERNS

WATER SUPPLY WITHDRAWAL FROM RESERVOIR BOTTOM, EL. 243 NGVD

PLATE E-4

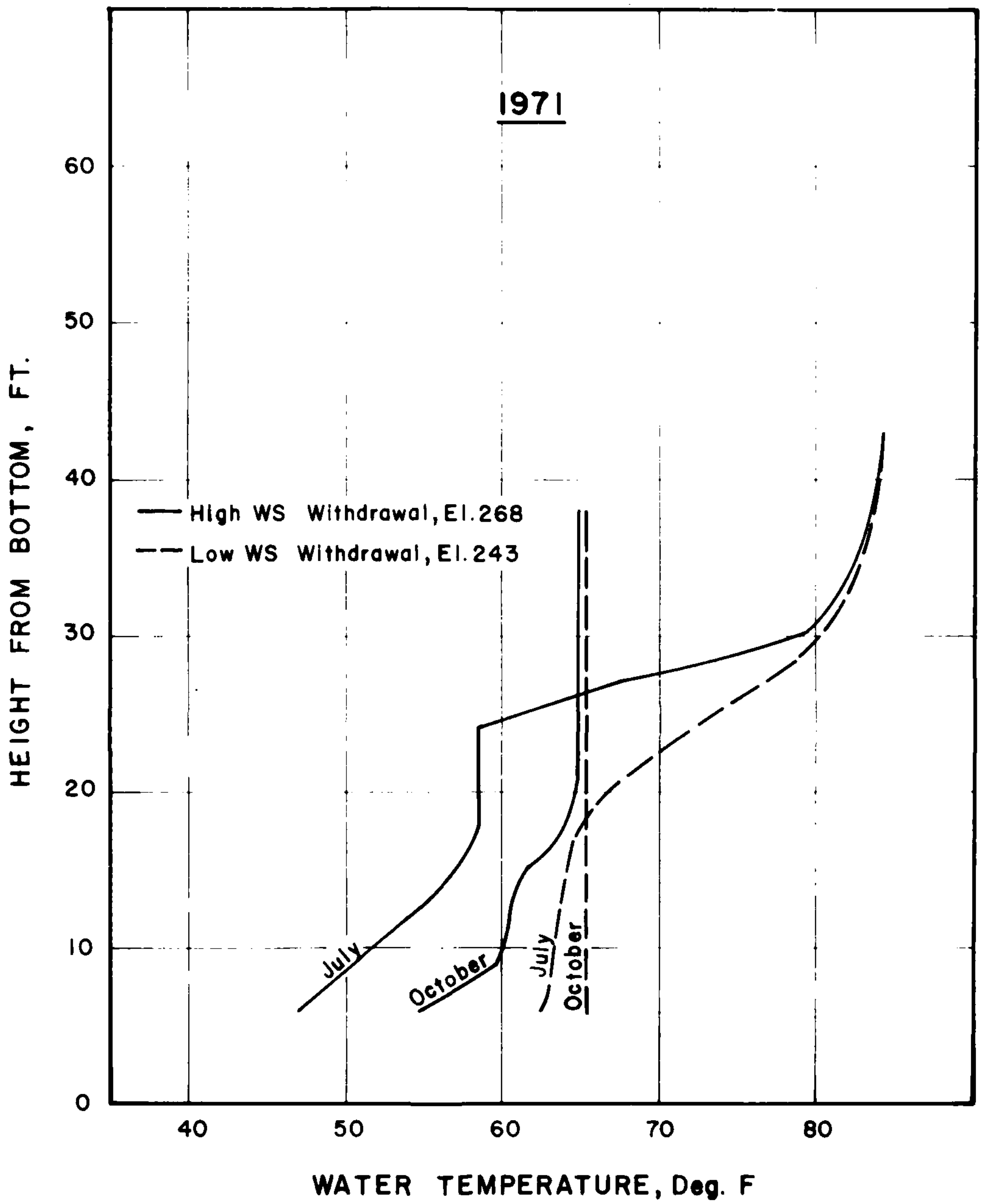


WATER RESOURCES DEVELOPMENT

BIG RIVER RESERVOIR PROJECT

TEMPERATURE STRATIFICATION PATTERNS

EFFECT OF INTAKE LOCATION



WATER RESOURCES DEVELOPMENT

BIG RIVER RESERVOIR PROJECT

TEMPERATURE STRATIFICATION PATTERNS

EFFECT OF INTAKE LOCATION

PLATE E-6

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX F

GEOTECHNICAL INVESTIGATIONS

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX F

GEOTECHNICAL INVESTIGATIONS

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A. GEOLOGY

1. General

The valley of the Big River is physiographically located within the drainage area of the Pawtuxet River Basin. The Pawtuxet River Basin is located entirely within central Rhode Island. The eastern two thirds of the basin lies within the Seaboard Lowland section of the New England Physiographic Province. The watershed area of Big River is low in relief with a maximum range in elevation of approximately 350 feet. This varies from an elevation of 250 feet in the valleys to 600 at the highest hilltops. In the immediate reservoir area relief is lower with elevations ranging from 250 feet in the valleys to 450 feet in the hills.

Glaciation has modified the pre-glacial bedrock topography by erosion and more so by dumped outwash deposits of glacial debris from moving and stagnant ice masses. Glacial till, a heterogeneous product of direct deposition, generally blankets the bedrock surface and occasionally in the area has been molded into low hill features known as drumlins. Glacial-fluvial deposits of coarse material such as gravel were deposited along the valley walls and have formed kames and kame terraces. Finer sandy material was transported further downstream in the valleys to the lowlands. Post-glacial deposits are lesser in extent and occur as alluvium and swamp deposits in the streams and in blocked drainage area on hills; see plate F-9.

The bedrock of the region is the Blackstone Series of interlayered sedimentary and volcanic rocks which solidified during the Precambrian Age. A period of medium grade regional metamorphism later took place folding these rocks and converting them into schist, gneiss, and quartzite. Two faults occur in the area and are discussed in detail in Appendix A, page A-28. Neither fault is considered major or active. The Scituate Granite Gneiss formation underlies the major portion of the drainage area of the reservoir. The proposed tunnel aqueduct alignment crosses the Cowesett Granite and the Westboro Quartzite formation. In general, all of these rock formations are sound, unweathered, and very hard; see plate F-10.

2. Foundation Investigations

a. Dam. Subsurface explorations to determine foundation conditions have consisted of 17 borings intermittently drive sampled in overburden using standard penetration tests and cored using NX 2-1/8 inch diameter cores in rock. Other subsurface explorations were made by test pits and seismic refraction surveys. A detailed tabulation of the drilling data is shown in Table 1. Borings at the dam site are identified by "B" series hole numbers on the layout of explorations shown on Plate F-1. A geologic section of the dam axis and spillway are shown on plates F-7 and F-8. Seismic survey profiles for the dam site area are shown on plates F-11 and F-12.

b. Rte. I-95 Cutoff. Subsurface explorations at the cutoff site consisted of 15 explorations and are identified as "D" series borings in Table 1. One undisturbed boring identified as FD 1-U and one foundations test pit FT-1 were made during recent investigations. The layout of explorations is shown on Plates F-1, F-13 and F-14.

c. Aqueduct.

(1) Tunnel. Two explorations (FD-2 and FD-3) and three seismic surveys (Lines A, C and D) were made on the tunnel alignment to determine depth and quality of rock. An existing boring BH-53A made by others was utilized to define subsurface conditions at the shaft connection with the exisitng Scituate Aqueduct. Explorations were located to define shaft conditions and to obtain representative rock structure conditions and samples for destructive testing of each of the three rock formations. The borings were continuously drive sampled in overburden to recover 2-1/2 inch diameter samples and core drilled in bedrock a minimum depth of 50 feet to determine the quality of rock below the weathered zone. Two borings FD-2 and FD-3 were pressure tested by zone to obtain an estimate of water inflow during tunneling. The location and graphic logs of the explorations are shown on Plate F-2 of the Big River Reserovir aqueduct facilities sheet. Representation of the seismic survey results is shown on Plates F-3 through F-5 of the Big River Reservoir aqueduct facilities. Seimsmic refraction profiling was performed using a 12 element geophcne spread at a 20-foot inter-geophone spacing. Depth of rock in some areas required "step out" shots at 60 and 120 foot distances from the spread. All spreads were run normally and reversed for analysis according to standard cross over distance techniques.

(2) Surface Aqueduct. Four borings were located along the proposed center line of the surface aqueduct, FD-3, FD-5, FD-2 and BH-53A by others. One seismic survey (Line C) and a verification boring FD-4 were also located about 2000 feet north of the aqueduct centerlines in an open airport area. The overburden along the surface aqueduct was found to be 10 to 104 feet deep. Mostly silty fine sands were encountered with some gravels. Logs and locations of the 2-1/2 inch continuously drive sampled borings are shown on Plate F-2.

d. Construction Materials. Subsurface explorations including three borings BD-1, BD-2 and BD-3 and a test trench BTT-1 were utilized to investigate impervious borrow material for construction of the dam dike embankments. The location of these explorations are located on Plate F-1.

3. Site Geology

a. Dam. The topography at the site presents a moderate relief of approximately 180 feet. The valley of the Big River is restricted by a fine sand and gravel terrace underlain by rock at a shallow depth on the northwest (left) abutment and a deep compact deposit of bouldery glacial till on the southeast (right) abutment. (See Plate F-6). The right abutment is a bedrock controlled drumloid shaped feature called Hungry Hill which rises to a maximum elevation of 417 feet above National Geodetic Vertical Datum of 1929 (NGVD). The river at the site flows between the till controlled hill on the east and sand terraces on the west.

Rock is exposed high on the left abutment and at the easterly extend of Hungry Hill. The rock is a granite gneiss pink to gray in color, medium to coarse grained and is distinguished by black patches of biotite. The texture is generally massive with local zones of distinct foliation. When foliated the dip was found to vary from horizontal to vertical. Joint structure at the surface was widely spaced at intervals of 2 to 5 feet. In general the bedrock at the site was unweathered and very hard. Permeability tests in the bedrock indicated values which ranged from 9 to 55 GPD per square foot. Most of the high losses occurred within the upper 15 feet of the rock surface.

b. Rte. I-95 Cutoff. The geologic profile along Division Street which parallels the area of the proposed cutoff is shown on Plate F-6. The area is comprised of a randomly stratified ridge of highly permeable (est. range 10 > 300 GPD per square foot) of fine to coarse sand overlying a till and bedrock valley ranging in depth of 12 to 190 feet. A uniform grain size and a layered structure indicates that these deposits may be derived from glacial lakebed deposits. Upstream and downstream of the sand ridge clay, deposits extend to depths 65 feet on the upstream and over 100 feet downstream in the area of the proposed dike. The groundwater profile as measured during exploration varies between elevation 250 and 310 NGVD and as shown on Plate F-6.

The bedrock at the site consists of medium to coarse grained granite gneiss with a singular intrusive of a finer grained gneiss. The rock is generally unweathered and only slightly foliated and fractured. Permeability tests in the bedrock indicated values which range from 7.3 to 16.8 GPD per square foot.

c. Aqueduct

(1) Tunnel. The tunnel will be designed to be constructed in bedrock. Depth of shaft at the Hungry Hill intake is 206 feet with tunnel invert at elevation 50 NGVD. Depth of the shaft in overburden is approximately 104 feet and is comprised of silty fine sand for the upper 50 feet and a compact sandy gravel with boulders for the remaining portion above rock. From exploration at the tunnel discharge made by others an overburden depth of 24 feet was largely comprised of silt, sands and gravel. The designed shaft at the discharge portal is approximately 200 feet in depth with the tunnel invert at elevation 15 NGVD. The overall length of tunnel is approximately 35,700 feet.

The bedrock structure to be traversed by the tunnel is divided into three rock formations of the approximate length and physical properties as follows:

ROCK TYPE	TUNNEL LENGTH (lf)	UNCONFINED COMPRESSION STRENGTH (psi) Avg.	DRY UNIT WT. (pcf) Avg.
Granite	11,600	7,500	166.9
Granite Gneiss	20,400	10,746	162.9
Quartzite Granite and Schist Interbedded	3,700	8,000 (est)	165.0 (est)

Pressure testing of the granite and gneiss formations indicated water losses in the upper more weathered zones in rock becoming increasingly tight with depth. Based on this it would be predicted that the tunnel would have a relatively low inflow of groundwater during the tunnel construction. The exploration by others BH-53A at the Scituate Aqueduct was not pressure tested. Based on the drilling record it would be expected that permeability of this rock formation would be low over the short length (3,700) feet of tunnel in this rock formation.

The quality of rock at tunnel grade has been predicted based on the exploratory data, and for the purpose of design, the rock quality designation (RQD) has been estimated as varying between 80 and 90 a condition of which will require only average tunnel support during construction.

The depth of tunnel varies between 50 and 200 feet below the ground surface and in all cases has at least two tunnel diameters in rock above the crown of the tunnel. The shallowest point occurs where the tunnel passes beneath the valley of the North Branch of the Pawtuxet River. No explorations were made in this area as the bedrock appears competent for rock exposures observed immediately upstream of the crossing.

(2) Surface Aqueduct. Geologic conditions along the surface aqueduct are highly variable. Surface reconnaissance, explorations, and review of available surficial geology mapping indicates that the structure will encounter approximately equal quantities of shallow till overlying bedrock in the highlands and silty sands and gravels in the valleys. Artificial fills will be encountered throughout the area where the aqueduct follows city streets.

4. Foundation Conditions

a. Dam. The compact impervious glacial till and dense terrace deposits will provide a firm foundation for the embankment. Loose surficial deposits and fills will be removed to a firm material. On the left side of the dam where bedrock is shallow, a cutoff trench to bedrock with a triple grout curtain will be utilized. Where bedrock runs out and continuing to the right abutment, a cutoff trench will be excavated into compact till and dense terrace deposits for control of under seepage.

The outlet works and the spillway will be founded on bedrock on the left abutment. The spillway discharge channel will be cut in bedrock for some distance beyond the toe of the embankment.

b. Rte. I-95 Cutoff. The overburden deposits are adequate to support the low dike structures after removal of any loose surficial material.

c. Aqueduct.

(1) Tunnel. The dense hard igneous and metamorphic rock types provide competent rock types and structure for tunneling. The massiveness of the rock coupled with the depth of tunnel would result in good tunnel shape and stability with a minimum of temporary support. Estimated rock quality designations (RQD) used in preparing a cost estimate have varied between 80 and 90 percent. These values equate to rock conditions which would be considered to vary from massive to moderately jointed to hard and intact, a condition requiring only random bolting and/or shotcrete for support. No major faults have been located on the present alignment.

The groundwater level is generally at shallow depths through the tunnel alignment being somewhat higher in the silt and sand deposits in the Mishnock Valley and at greater depths in the highland areas in the town of West Warwick. Based on present data, water inflow into the tunnel during construction is not expected to be a major construction factor and would not be expected to appreciably lower the water table during tunnel construction. For the purpose of the tunnel estimate it has been assumed that tunnel inflow will not average more than 1 GPM per lineal foot at the tunnel face.

Shaft excavation methods have assumed that no lowering of the groundwater table will take place in the immediate vicinity of the shaft. To accomplish this it is considered that water control methods will consist of compressed air for first 50 feet in the fine sand at the intake shaft and by ground injection for the remaining portion of the earth excavation at the intake shaft and for all of the earth excavation at the discharge shaft. All rock excavation at the shaft will be done by hand methods with shotcrete being used for water inflow control.

(2) Surface Aqueduct. Geologic conditions along the surface aqueduct are highly variable with much of the alignment beneath city streets. Surface reconnaissance, explorations and review of available surficial geology reveals that the aqueduct will encounter the following materials along the alignment as shown on Plate F-2 entitled Big River Reservoir Aqueduct Facilities Plan and Record of Explorations.

Subsurface Conditions	Length LF
Silts and sands with a high water table at est. depths zero to five feet	7,500
City streets on silts and sands with a high water table depth est. at five to ten feet	15,000
City streets on sand and gravel water table at est. depths of five to ten feet	16,500
Glacial till, hard dense with boulders, water table at est. depths of five to ten feet	2,000
River crossing in silts and sands	500
River crossing in shallow bedrock	500
TOTAL LENGTH	43,000 lf

5. Reservoir Leakage

The major areas of reservoir leakage occur at the sand ridge along route I-95 and at the dam site. Seepage control measures for these areas will be designed to reduce seepage to a tolerable level. Preliminary investigations into the highly pervious sand ridge which is located between Division Street and route I-95 indicate that the upper level sands are 100 times more pervious than the underlying dense, silty, medium to fine sands. Both slurry wall and impervious blanket applications were considered as preliminary seepage control measures. The impervious blanket scheme is shown in Appendix G, Plate G-8. As the typical sections indicate, the compacted impervious fill will be carried to the underlying dense silty fine sands. Throughout the remainder of the reservoir area groundwater movement is from the drainage divide of the watershed toward streams which feed into the reservoir area.

6. Reservoir Stability

Because slopes are generally low and flat, stability during and after filling the reservoir is not expected to be a problem. Local areas where slopes are steeper than 3 to 1 will be studied during the design and necessary, flattening of slopes or construction of berms will be done to assure slope stability.

7. Earthquake Analysis

The Big River project is located in Zone 1 of the seismic zone map of the United States a modification of the seismic risk map developed by the Environmental Science Administration and the Coast and Geodetic Survey and contained in Engineering Regulation 1110-2-1806 dated 30 April 1977. In accordance with this directive, since the project borders on Zone 2, the seismic probability coefficient for the higher zone will be used for the design of project structures. This map dictates that a coefficient of 0.05 will be used for the design of the dam and dikes. Confirmation of this coefficient has been verified by a detailed remote sensing analysis and fault compilation which did not reveal the presence of a major or capable fault within a 75 mile radius of the project structures. The seismic probability coefficient is further verified by the historical seismicity record which indicates that four earthquakes have occurred in the area from 1876 to the present. The nearest event with an epicenter based on non-instrumental data occurred approximately 15 miles from the site in 1965 and had an intensity of IV-V MM. The nearest event with an epicenter based on instrumental data occurred approximately 22 miles from the site in 1967 and had an intensity of V MM.

8. Construction Materials

Suitable deposits of impervious material have been located on Hungry Hill adjacent to the dam. Well graded gravelly, silty, sands with permeabilities in the order of 1 x 10^{-5} cm/sec in sufficient quantities for impervious borrow have been preliminarily sampled and tested. Random and pervious deposits are available within the reservoir area in sufficient quantities to meet the present design. Rock slope protection will be obtained from required excavation in the spillway area and aqueduct. Concrete aggregates are available from commercial sources within a 20 mile radius of the site.

9. Groundwater

The regional groundwater conditions reflect the glacial history of the area. The topography shows the marked effects of glaciation. Nearly the entire area has been heavily mantled by glacial debris so that outwash deposits vary in thickness of up to 200 feet while other areas are mantled by till which is on the average of 20 feet thick. Several buried valleys trending southerly thorugh the area have been penetrated by well systems up to 140 feet thick.

Groundwater studies in the project area indicate the most productive wells are located in glacial outwash deposits close to streams or ponds and properly constructed could yield up to 600 gpm. Water levels fluctuate seasonally within a range of about 6 feet with the average depth to water of about 12 feet. Wells in glacial till generally yield small but reliable supplies yielding not more than 5 gpm to large diameter dug wells. Water wells in till fluctuate seasonally within a range of 17 feet with the average depth to water of approximately 14 feet.

Rock formations of igneous, metamorphic and sedimentary types have a medium yield of 4 gpm. The average depth of wells in bedrock is 130 feet and the depth to water is 21 feet.

Quality of water is generally good with the water in outwash deposits being soft, that in till being hard and the quality in bedrock being soft to moderately hard. Wells in outwash and bedrock in places contain excessive iron.

Detailed groundwater mapping has been performed in most areas by the U.S. Geological Survey in coordination with the Rhode Island Water Resources Coordinating Board and local authorities. Information contained in other portions of this report represent this basic data updated to include more recent information pertaining to potential yield, present actual use and the quality of surface and groundwater.

B. EMBANKMENT AND FOUNDATIONS

1. General

Design and engineering studies have been made to the extent necessary for this report relative to the foundation, embankment and earthwork. A program of investigations consisting of subsurface explorations, seismic survey, field reconnaissance, and laboratory tests have been made to determine properties of foundations soils, limits of excavations, and locations and properties of borrow materials. The location of all subsurface explorations and seismic surveys are shown on Plates F-1 and F-2.

2. Characteristics of Foundation Soils

a. Dam. Shallow bedrock lies beneath the west abutment extending to the river bed. From the river bed eastward there is a gravelly sandy glacial outwash deposit overlying a glacial till deposit extending to 150 feet below the dam. These materials exhibit high shear strength and low compressibility.

b. Rte. I-95 Cutoff. The reservoir cutoff along Rte. I-95 will be located along a ridge consisting of up to 50 feet of silty, fine sands. Preliminary laboratory testing including grain size analysis indicate coefficients of permeability are on the order of 1 to 150 x 10^{-4} cm/sec for the lower silty, fine sands and approximately 1 x 10^{-2} cm/sec for the upper sand strata. Depth to bedrock ranges from 12 to 190 below surface elevation.

c. Aqueduct Route.

(1) The proposed aqueduct cut and cover route as shown on Plate F-2 is approximately 8 miles long. Based on borings and seismic refraction survey, and the use of surficial geology maps it is expected that silty sand and gravels will be encountered in most of the shallow excavations. In several locations along the cut and cover centerline, marshy areas will be encountered.

(2) The proposed tunnel route will be totally in rock. It is expected that silty sands and gravels would be encountered in the vertical shaft excavation.

3. Characteristics of Embankment Materials

a. Materials From Required Excavations.

(1) General. Subsurface investigations indicate that adequate quantities of earthfill materials can be obtained from within or adjacent to the reservoir area. Except for small quantities of

processed materials for drainage features in the dam embankment, pervious and random fill materials will be obtained from borrow areas developed within the glacial outwash sand deposits in the reservoir area. Impervious fill material will be obtained from a borrow area to be developed in the glacial till deposit forming the west side of Hungry Hill.

4. Embankment Design

The embankment designs for the dam and Rte. I-95 cutoff were both influenced by the availability and type of impervious borrow available on Hungry Hill. On the basis of the local soils characteristics, the glacial till and variable sands will be utilized as impervious and random fill materials, respectively, in the embankments.

The selected dam section as shown in Appendix G, Plate G-5, is zoned earth fill section with a central impervious core. Upstream of the core is a random pervious zone, where downstream of the central core is an inclined and horizontal drainage system flanked by a zone of pervious random fill. The upstream slope will be provided with layers of stone protection and gravel bedding. The downstream slope will also have stone protection on gravel bedding with a rock fill toe. Seepage through the embankment will be controlled by the arrangement of the random and impervious zones and rock fill toe. Seepage through the foundation will be controlled by the foundation cutoff extending to bedrock and grout curtain into bedrock on the west side of the dam and the foundation cutoff extending to till on the east side of the dam.

The selected section for the Rte. I-95 cutoff as shown in Appendix G, Plate G-8 is an impervious blanket covering an excavated 1 vertical on 3 horizontal slope or an existing natural slope. The 8-foot thick impervious blanket is connected to an upstream cutoff trench which extends to the semi-impervious silty sands found 5 to 30 feet below the ground surface. The blanket slope will be covered with a layer of gravel bedding and a layer of stone protection. Seepage will be kept to a minimum along this reach utilizing the impervious blanket and partial cutoff. Preliminary seepage estimates indicate that the impervious blanket in conjunction with the upstream cutoff with a permeability in the order of 1×10^{-5} cm/sec will hold seepage along the Rte. I-95 cutoff area to a tolerable level. The foundation soils which will be in contact with the cutoff trench are silty fine sands with a permeability of 1 to 150×10^{-4} cm/sec.

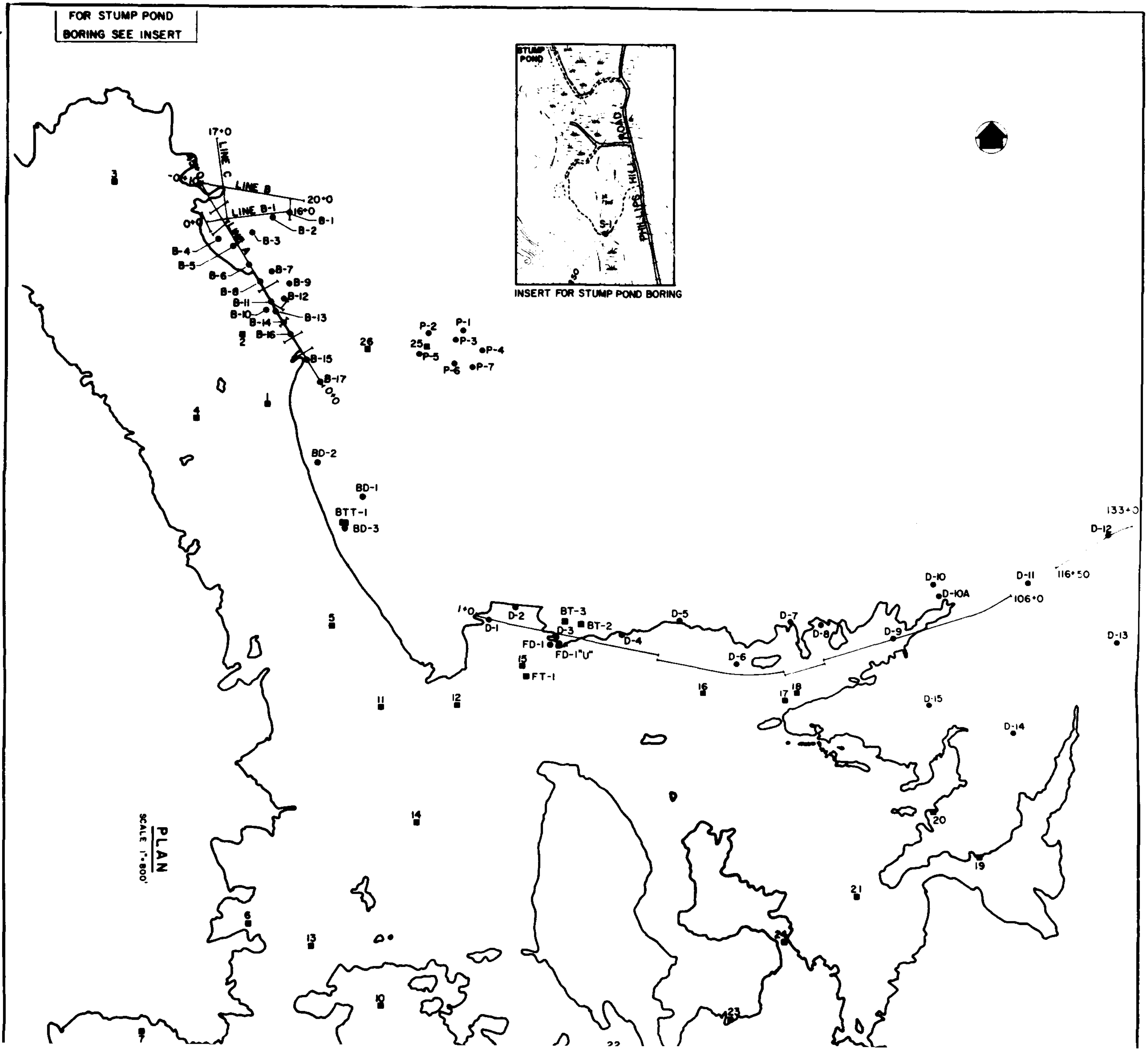
TABLE 1

TABULATION OF DRILLING DATA

Hole No.	Hole Dia. (inches)	Core Dia.	Total Depth (ft.)	Depth over-burden (ft.)	Falling Head Tests	Bedrock Packer Tests	Obser-vation Well
B-1	3-1/2	NX	29	14			
B-2	3-1/2	NX	30.5	5			
B-3	3-1/2	NX	37.5	22.5			
B-4	3-1/2	NX	14.5	1.5			
B-5	3-1/2	NX	32	17			
B-6	4-1/2	NX	20	2		X	
B-7	3-1/2	NX	30	14.5			
B-8	4-1/2	NX	23.5	4.5		X	
B-9	6	NX	26	17			
B-10	6	NX	43	33			
B-11	4-1/2	NX	39	19		X	
B-12	2-1/2	AX	41.5	24.5			
B-13	4-1/2	NX	44	14		X	
B-14	4-1/2	NX	57	18		X	
B-15	3-1/2	NX	156	148	X		
B-16	4-1/2	NX	46.5	22.3	X	X	
B-17	4-1/2	-	100	100			
D-1	3-1/2	NX	22	12		X	
D-2	6	NX	49	39		X	
D-3	2-1/2	-	62	62	X		
D-4	5	-	147	142	X		
D-5	5	-	178	173	X		X
D-6	5	-	189.8	189.8	X		
D-7	5	-	146.5	146.5	X		
D-8	5	-	87	87			
D-9	2-1/2	AX	87	87	X		
D-10	2-1/2	-	47.8	47.8			
D-11	2-1/2	-	41	41			X
D-12	2-1/2	-	114	114	X		
D-13	2-1/2	-	20	20			
D-14	6	-	30.5	30.5			
D-15	6	-	50	50	X		

TABLE 1 - (cont'd)

Hole No.	Hole Dia. (inches)	Core Dia.	Total Depth (ft.)	Depth over-burden (ft.)	Falling Head Tests	Bedrock Packer Tests	Obser-vation Well
P-1	2-1/2	-	26.5	26.5			
P-2	2-1/2	-	26.5	26.5			
P-3	6	-	26.5	26.5			
P-4	6	-	21.5	21.5			
P-5	6	-	26.5	26.5			
P-6	2-1/2	-	26.5	26.5			
P-7	2-1/2	-	50.5	50.5			
BD-1	3	-	29.0	29.0			
BD-2	3	-	25.0	25.0			
BD-3	3	-	29.2	29.2			
FD-1	3	-	20.0	20.0			
FD-1U	4	-	15.7	15.7			
FD-2	3	NX	60.0	10.0		X	
FD-3	3	BX	154.0	103.6		X	
FD-4	3	-	30.0	30.0			
FD-5	3	-	23.6	23.6			


FOR STUMP POND
BORING SEE INSERT
STUMP POND
PHILLIPS HILL ROAD
S-1
INSERT FOR STUMP POND BORING
17+0
LINE C
LINE B
20+0
LINE B-1
16+0
0+0
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
B-13
B-14
B-15
B-16
B-17
P-1
P-2
P-3
P-4
P-5
P-6
P-7
BD-1
BD-2
BD-3
BTT-1
BT-2
BT-3
FD-1
FD-1"U"
FT-1
D-1
D-2
D-3
D-4
D-5
D-6
D-7
D-8
D-9
D-10
D-10A
D-11
D-12
D-13
D-14
D-15
1+0
106+0
116+50
133+0
PLAN
SCALE 1"=800'

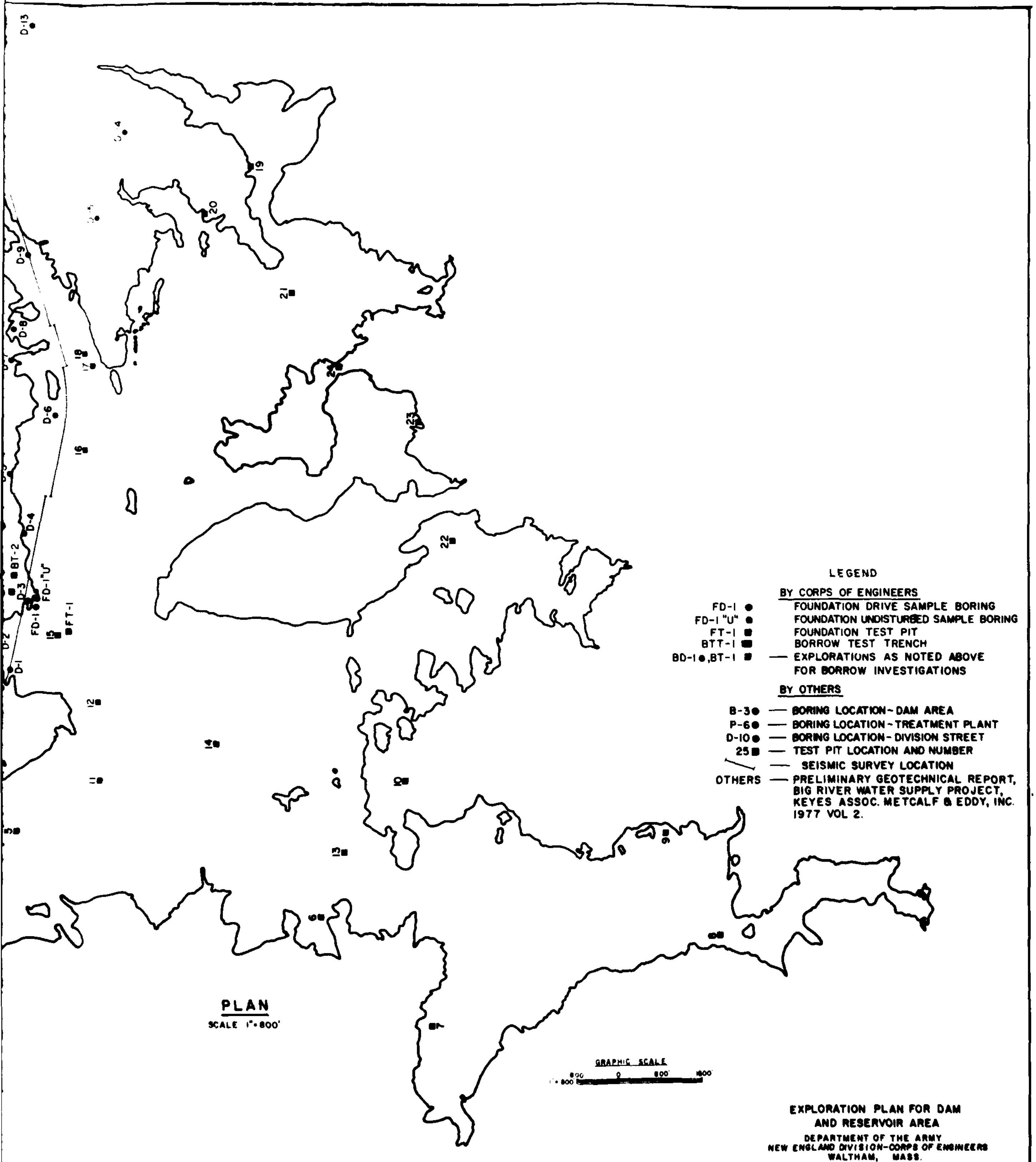
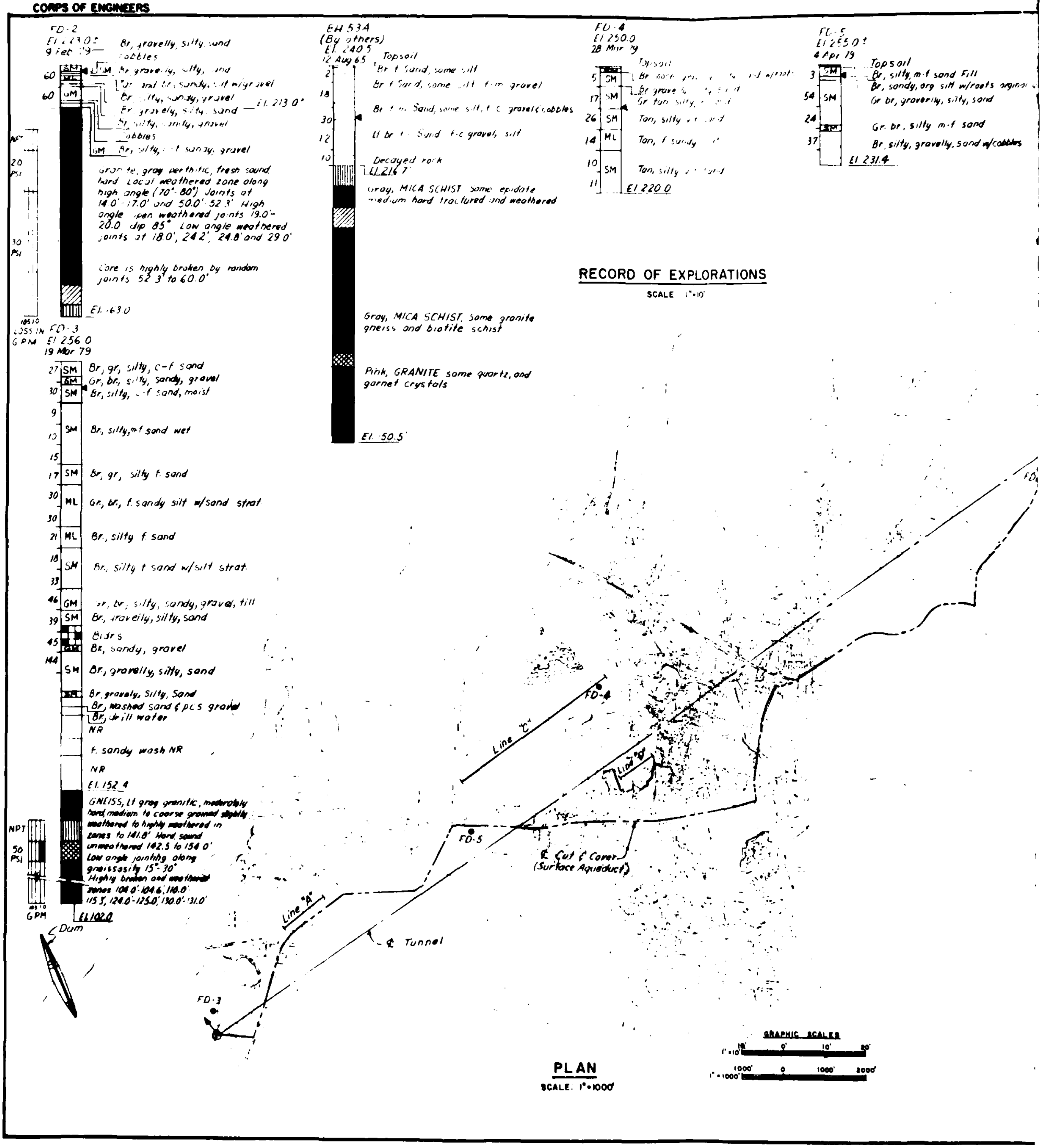

D-13
19
20
21
D-9
D-8
18
17
D-6
16
24
23
22
D-4
BT-2
D-3
FD-1"U"
FD-1
BT-1
15
D-2
D-1
12
14
11
10
13
LEGEND
BY CORPS OF ENGINEERS
FD-1 ● FOUNDATION DRIVE SAMPLE BORING
FD-1 "U" ● FOUNDATION UNDISTURBED SAMPLE BORING
FT-1 ■ FOUNDATION TEST PIT
BTT-1 ■ BORROW TEST TRENCH
BD-1●,BT-1 ■ — EXPLORATIONS AS NOTED ABOVE FOR BORROW INVESTIGATIONS
BY OTHERS
B-3● — BORING LOCATION - DAM AREA
P-6● — BORING LOCATION - TREATMENT PLANT
D-10● — BORING LOCATION - DIVISION STREET
25■ — TEST PIT LOCATION AND NUMBER
— SEISMIC SURVEY LOCATION
OTHERS — PRELIMINARY GEOTECHNICAL REPORT, BIG RIVER WATER SUPPLY PROJECT, KEYES ASSOC. METCALF & EDDY, INC. 1977 VOL 2.
PLAN
SCALE 1"=800'
GRAPHIC SCALE
800 0 800' 1600'
EXPLORATION PLAN FOR DAM AND RESERVOIR AREA
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F1

CORPS OF ENGINEERS



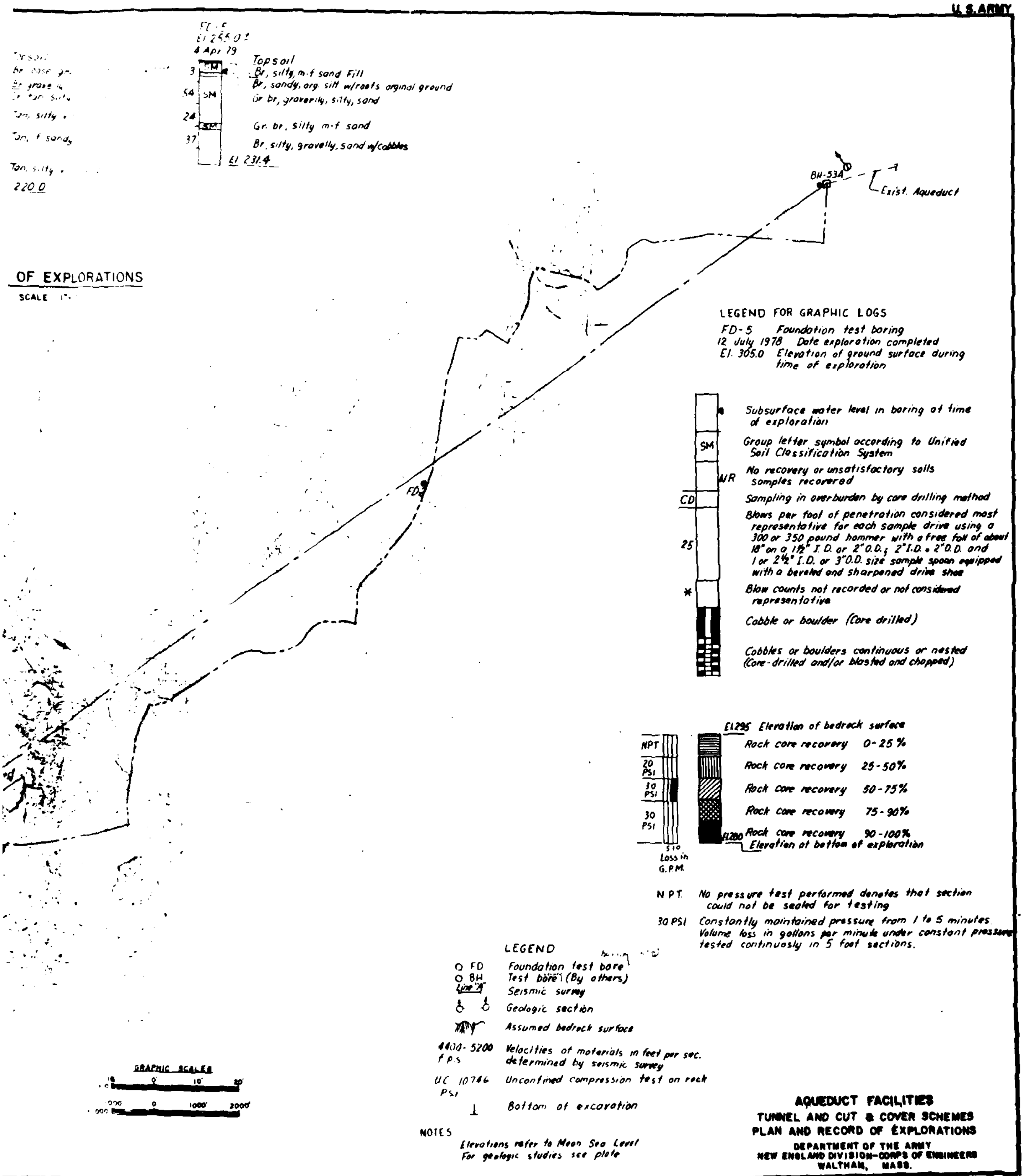
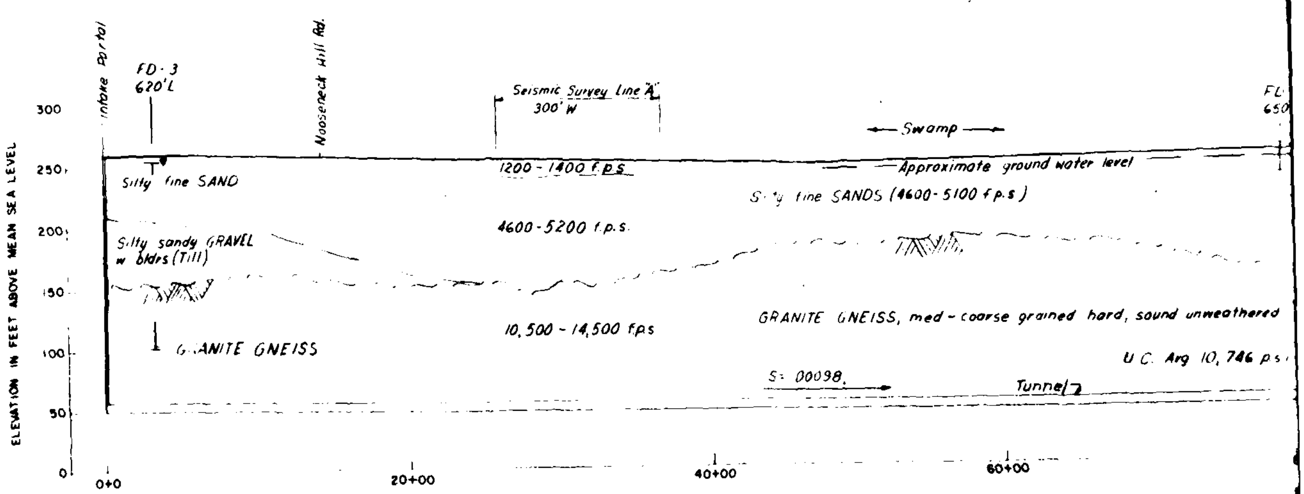

U.S. ARMY
4 Apr 79
Topsoil
Br, silty, m-f sand Fill
Br, sandy, org. silt w/roots orginal ground
Gr br, graverily, silty, sand
Gr. br, silty m-f sand
Br, silty, gravelly, sand w/cobbles
El 231.4
220.0
OF EXPLORATIONS
SCALE
BH-53A
Exist. Aqueduct
FD-2
LEGEND FOR GRAPHIC LOGS
FD-5 Foundation test boring
12 July 1978 Date exploration completed
El. 305.0 Elevation of ground surface during time of exploration
Subsurface water level in boring at time of exploration
SM Group letter symbol according to Unified Soil Classification System
NR No recovery or unsatisfactory soils samples recovered
CD Sampling in overburden by core drilling method
25 Blows per foot of penetration considered most representative for each sample drive using a 300 or 350 pound hammer with a free fall of about 18" on a 1½" I.D. or 2" O.D.; 2" I.D. • 2" O.D. and / or 2½" I.D. or 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe
* Blow counts not recorded or not considered representative
Cobble or boulder (Core drilled)
Cobbles or boulders continuous or nested (Core-drilled and/or blasted and chopped)
El.295 Elevation of bedrock surface
Rock core recovery 0-25%
Rock core recovery 25-50%
Rock core recovery 50-75%
Rock core recovery 75-90%
Rock core recovery 90-100%
El.280 Elevation at bottom of exploration
NPT
20 PSI
30 PSI
30 PSI
5 10
Loss in G.P.M.
N.P.T. No pressure test performed denotes that section could not be sealed for testing
30 PSI Constantly maintained pressure from 1 to 5 minutes. Volume loss in gallons per minute under constant pressure tested continuosly in 5 foot sections.
LEGEND
O FD Foundation test bore
O BH Test bore (By others)
Line "A" Seismic survey
Geologic section
Assumed bedrock surface
4400-5200 f.p.s. Velocities of materials in feet per sec. determined by seismic survey
UC 10746 PSI Unconfined compression test on rock
Bottom of excavation
NOTES
Elevations refer to Mean Sea Level
For geologic studies see plate
GRAPHIC SCALES
AQUEDUCT FACILITIES
TUNNEL AND CUT & COVER SCHEMES
PLAN AND RECORD OF EXPLORATIONS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F2

CORPS OF ENGINEERS

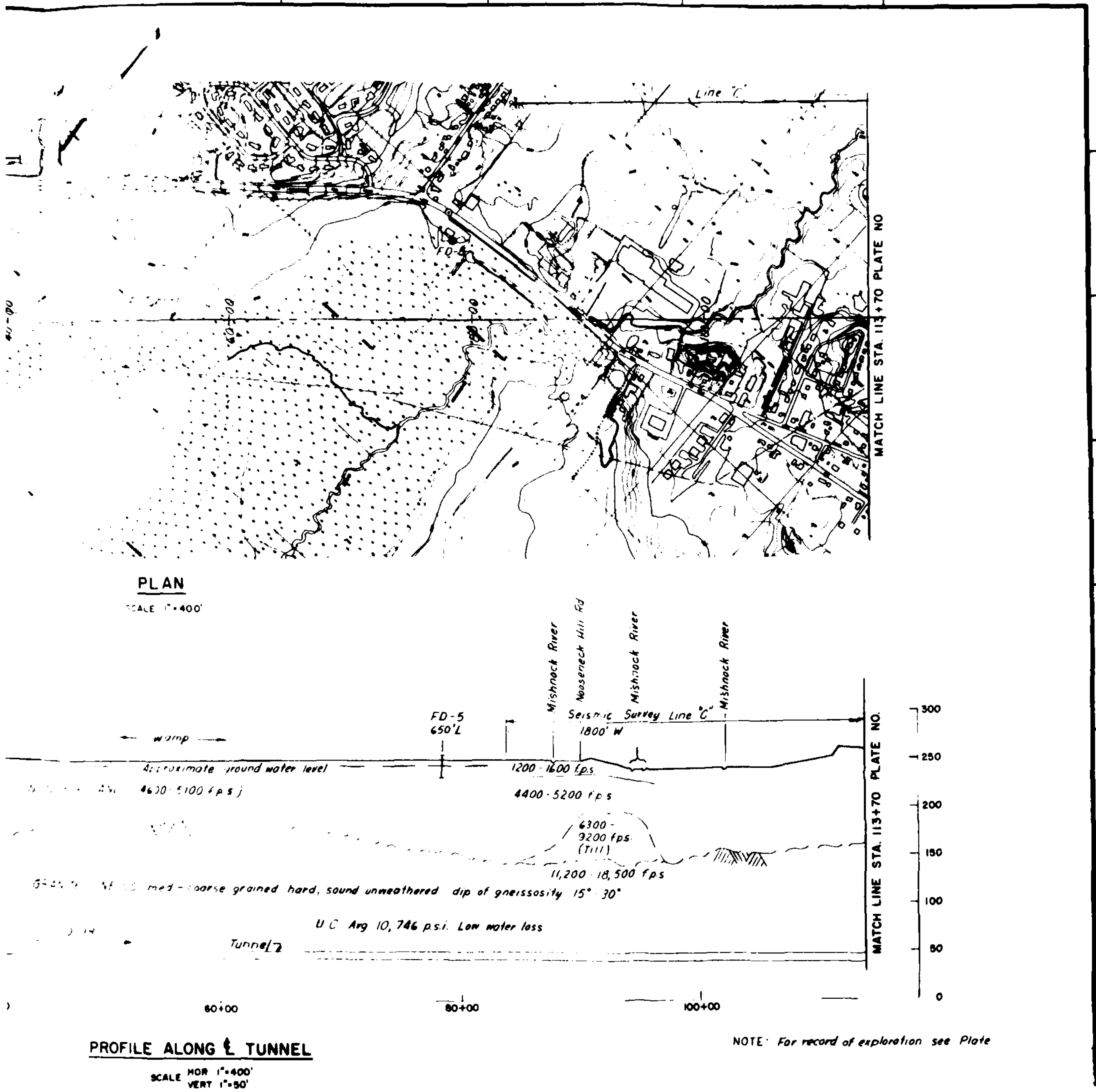
PLAN

SCALE 1"=400'



PROFILE ALONG ℄ TUNNEL

SCALE HOR 1"=400' VERT 1"=50'



NOTE: *For record of exploration see Plate*

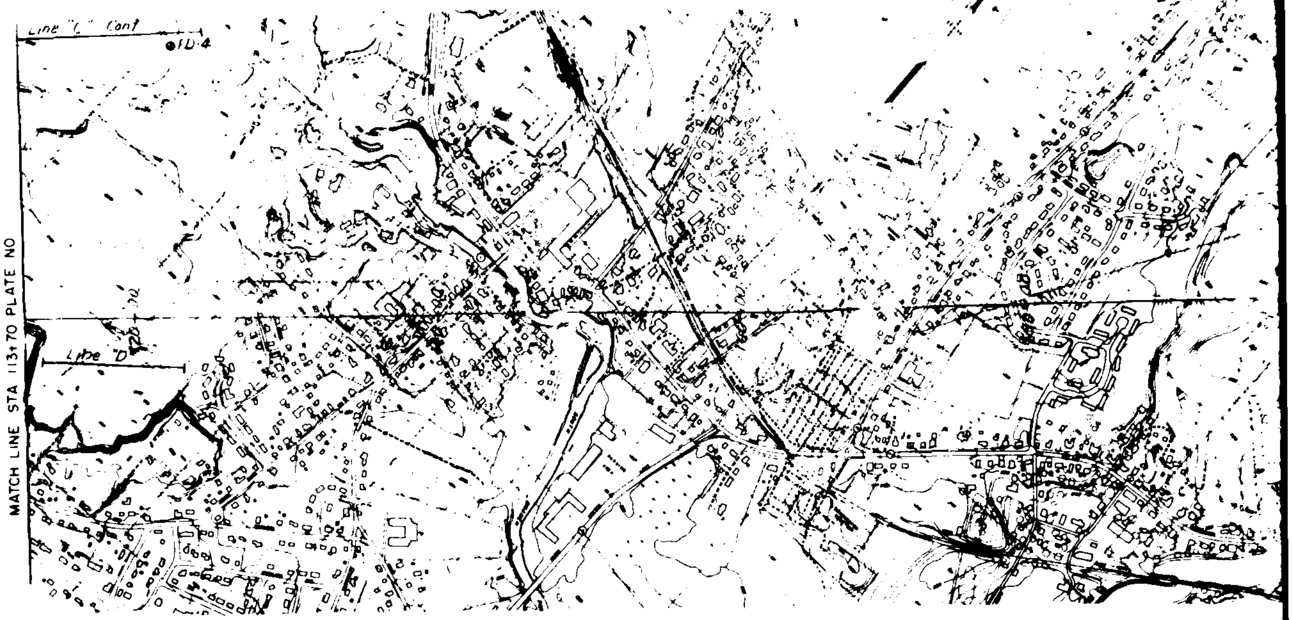
GRAPHIC SCALES

AQUEDUCT FACILITIES
GEOLOGIC SECTION - TUNNEL
STA. 0+0 - STA. 113+70

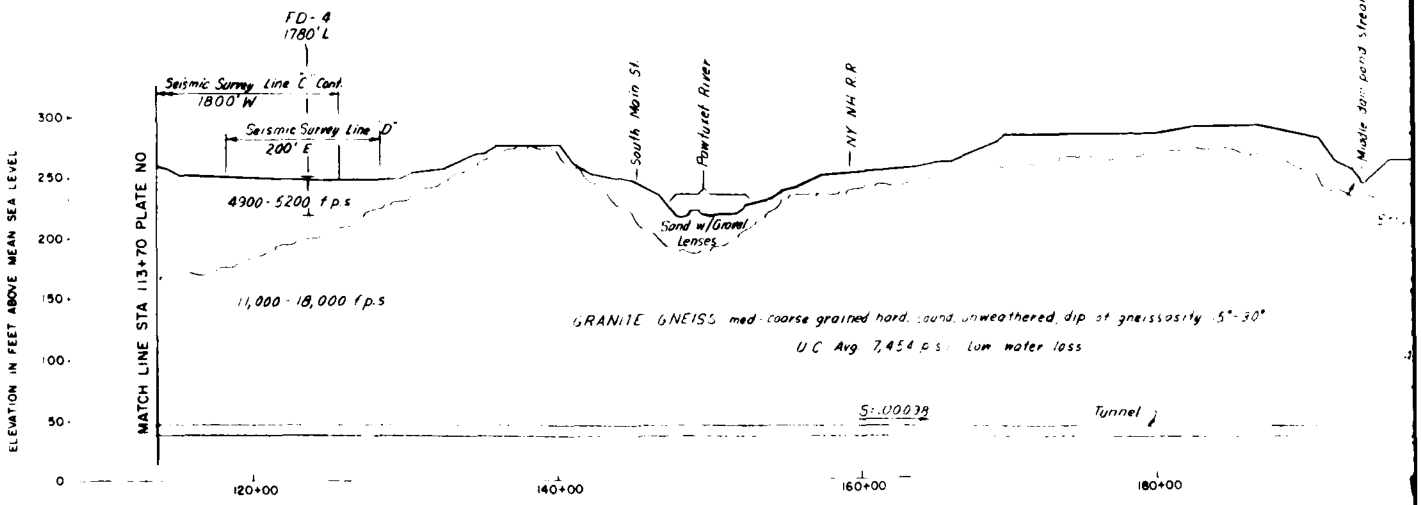
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F3

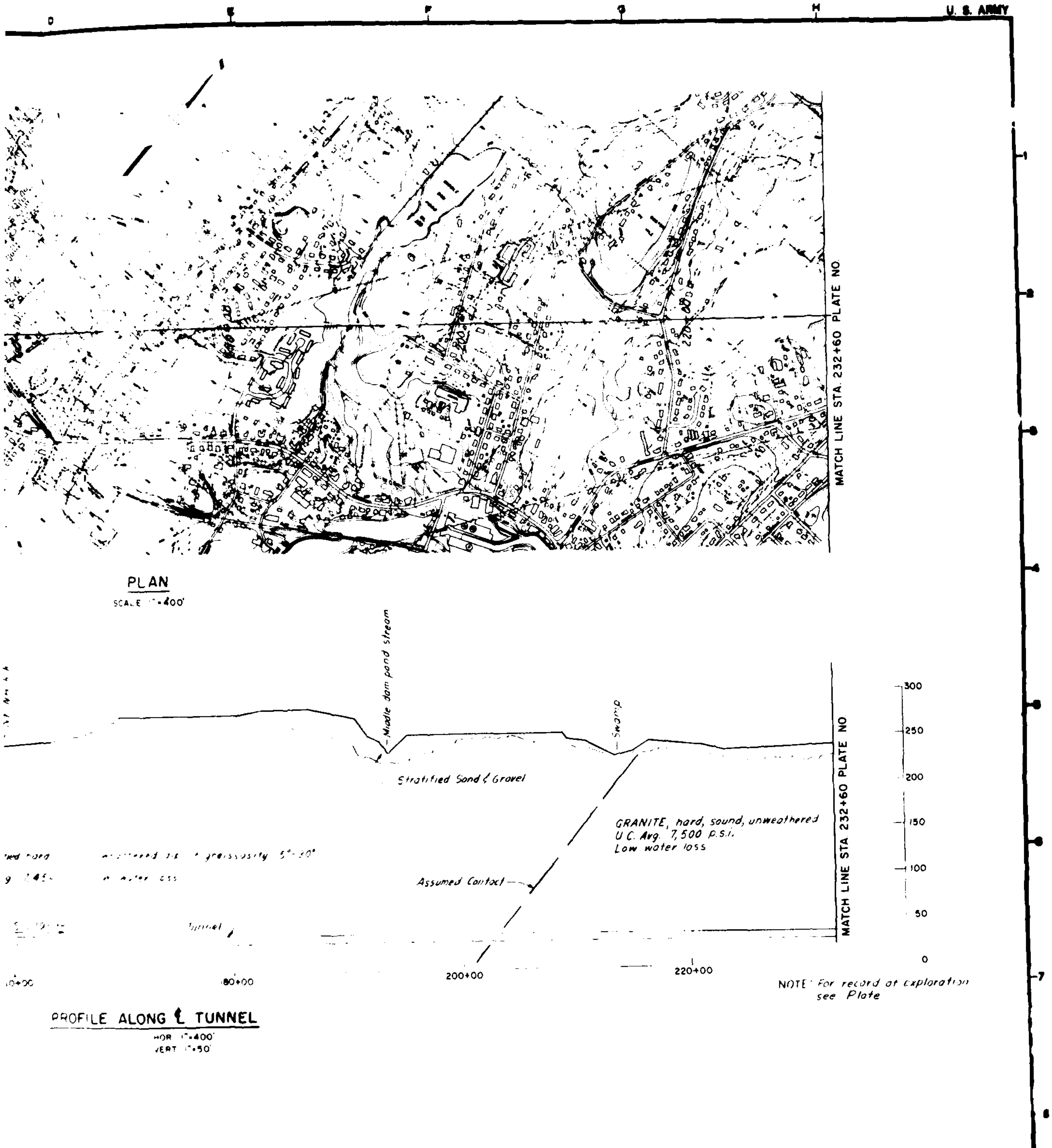
CORPS OF ENGINEERS



PLAN
SCALE 1"=400'



PROFILE ALONG ℄ TUNNEL
HOR 1"=400'
VERT 1"=50'



AQUEDUCT FACILITIES

GEOLOGIC SECTION-TUNNEL

STA 113+70 – STA. 232+60

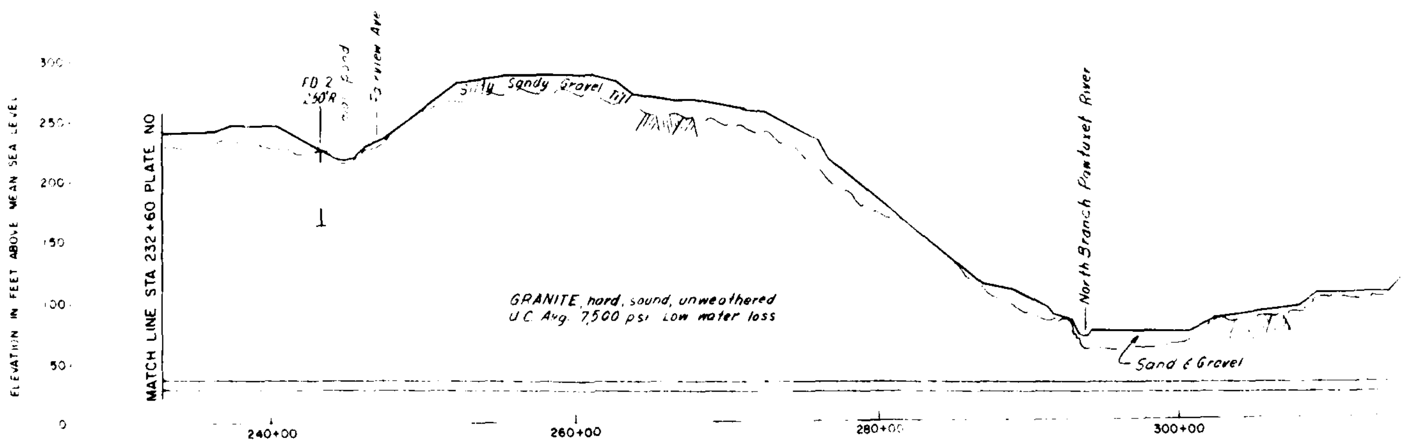
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F4

CORPS OF ENGINEERS

PLAN

SCALE 1"=400'



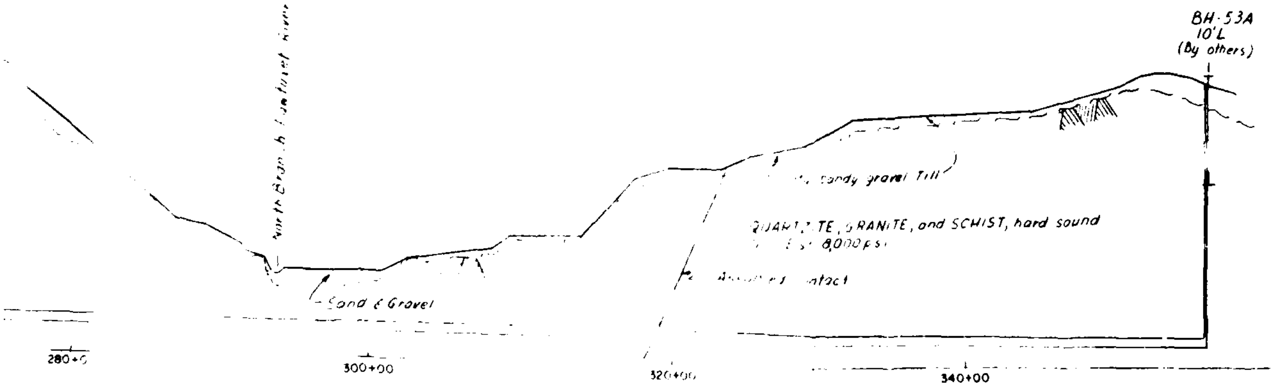
PROFILE ALONG ℄ TUNNEL

SCALE HOR 1"=400'
VERT 1"=50'

U. S. ARMY

PLAN

SCALE 1"=400'



PROFILE ALONG ℄ TUNNEL

SCALE HOR. 1"=400' VERT. 1"=50'

GRAPHIC SCALES

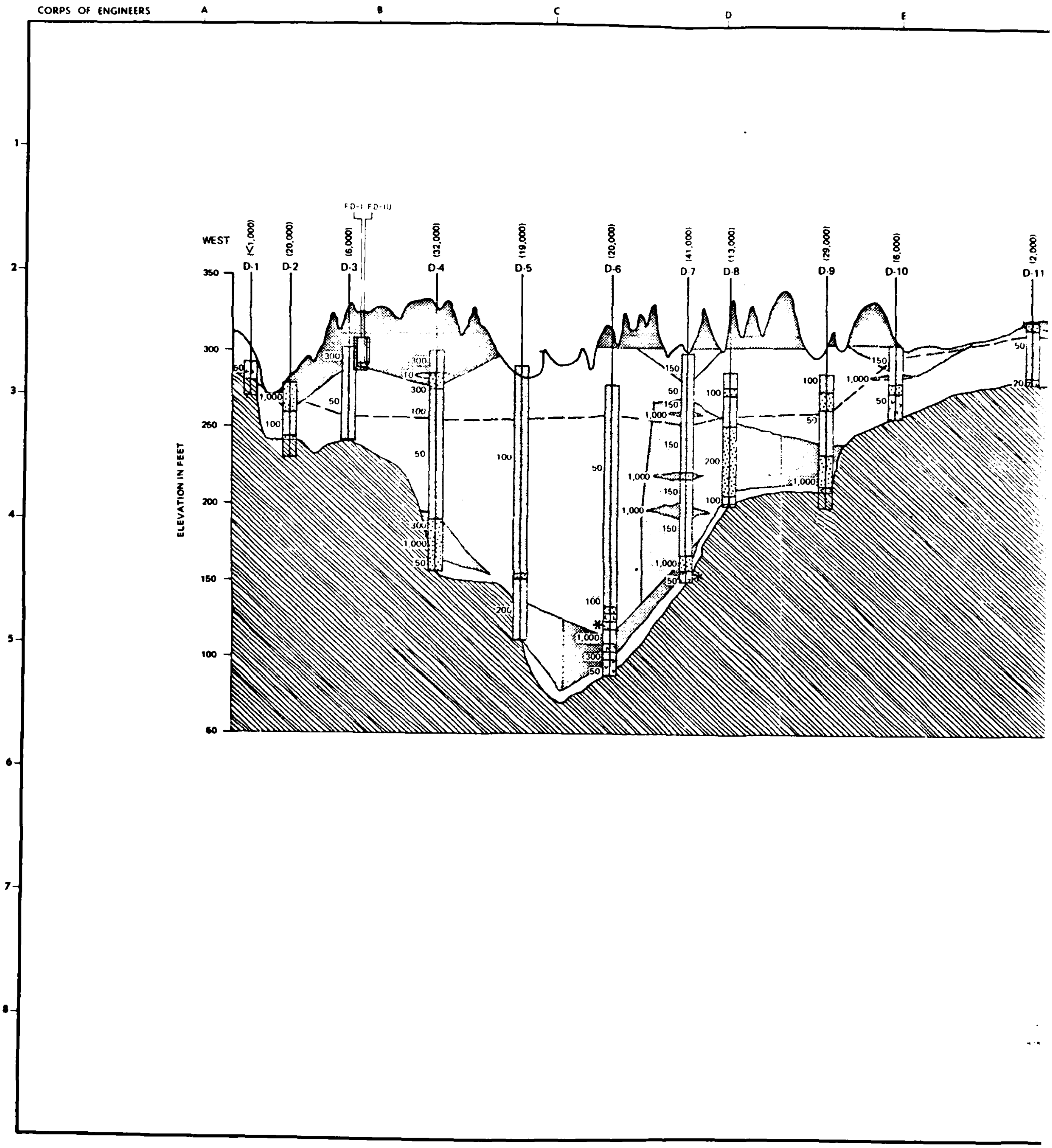
1"=50' 50 0 50 100

1"=400' 400 0 400 800

AQUEDUCT FACILITIES
GEOLOGIC SECTION-TUNNEL
STA 232+60 - STA 356+00

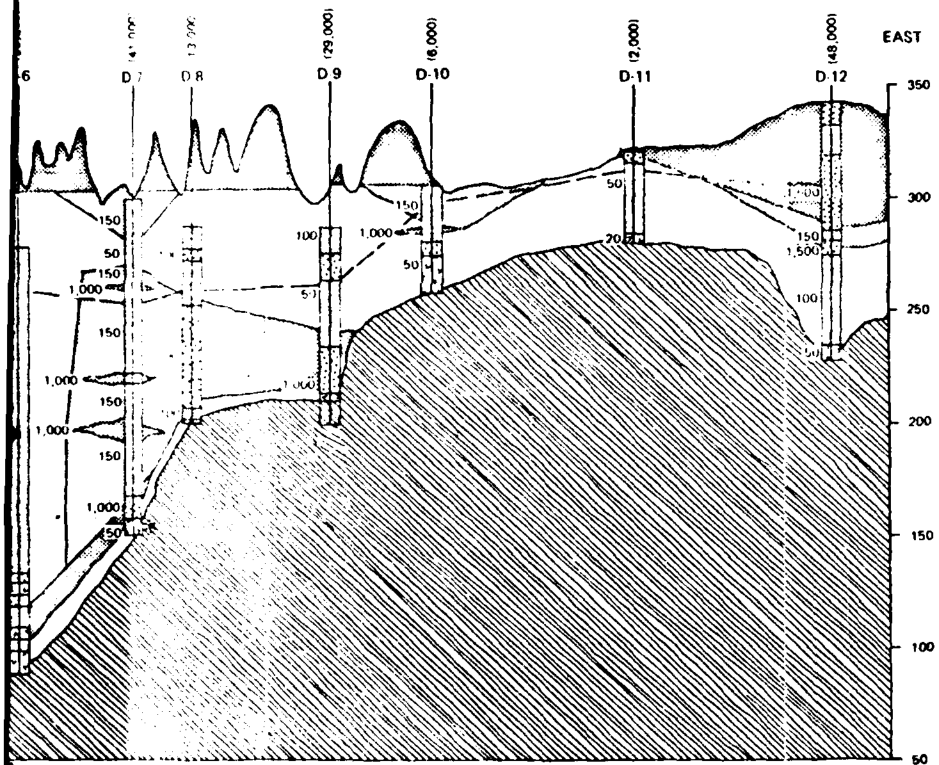
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F5



CORPS OF ENGINEERS
A
B
C
D
E
WEST
ELEVATION IN FEET
D-1
D-2
D-3
D-4
D-5
D-6
D-7
D-8
D-9
D-10
D-11
(<1,000)
(20,000)
(6,000)
(32,000)
(19,000)
(20,000)
(41,000)
(13,000)
(29,000)
(6,000)
(2,000)

U S ARMY



LEGEND

FD-1 N E D BORING
FD-1U N E D BORING (UNDISTURBED)
D-11 BORING NUMBER BY OTHERS
— — LOCATION OF GROUNDWATER

GEOLOGIC UNITS

FINE TO VERY FINE SAND
MEDIUM TO COARSE SAND
GLACIAL TILL
* INTERBEDDED MEDIUM SAND AND TILL
BEDROCK

HYDROLOGIC UNITS:

10-100 gpd/ft^2 (4×10^{-4} - 4×10^{-3} cm/sec) ESTIMATED PERMEABILITY
150-200 gpd/ft^2 (7×10^{-3} - 9×10^{-3} cm/sec) ESTIMATED PERMEABILITY
$>$300 gpd/ft^2 ($> 1 \times 10^{-2}$ cm/sec) ESTIMATED PERMEABILITY
(6000) gpd/ft ESTIMATED TRANSMISSIVITY

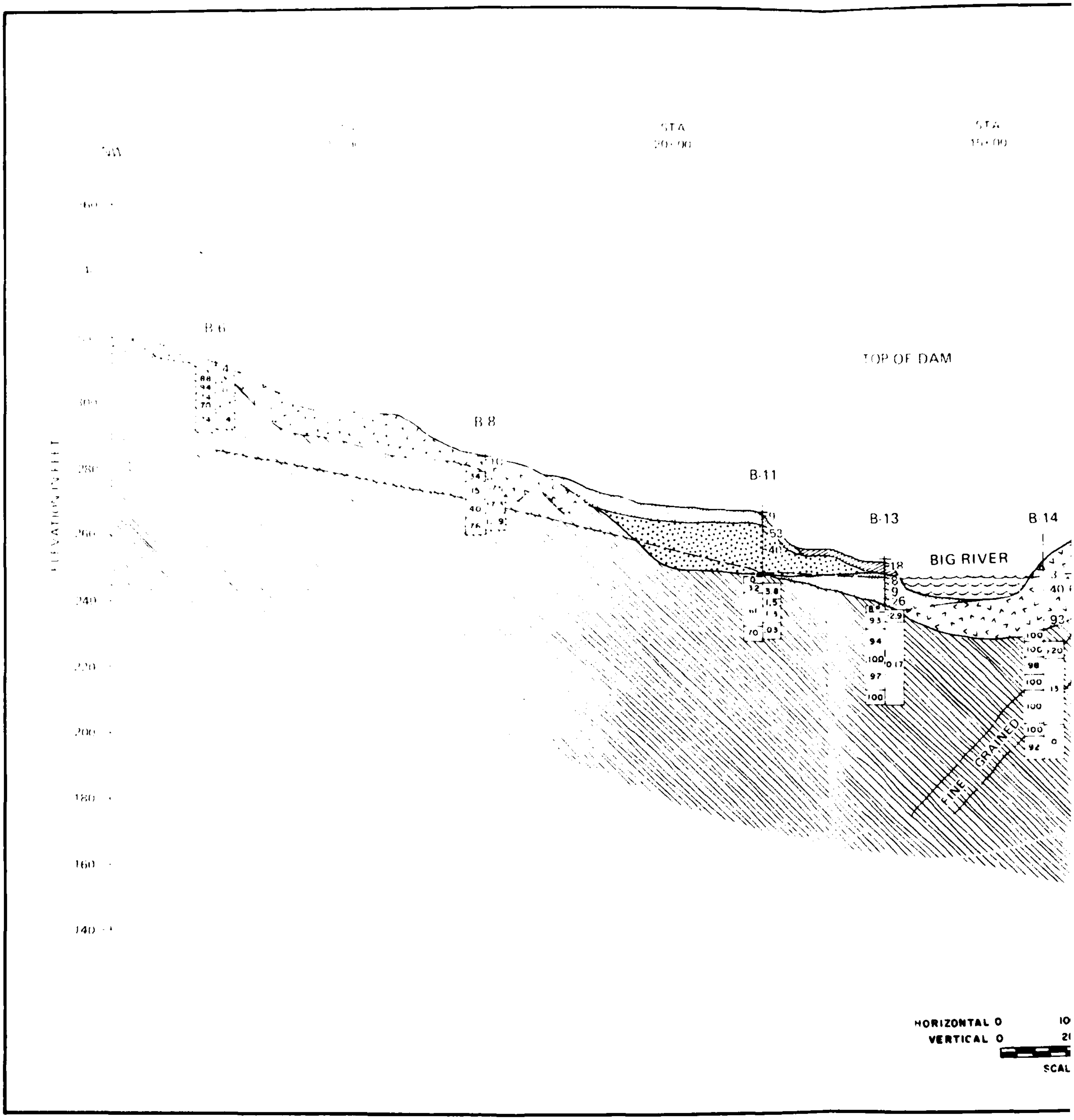
NOTES

PERMEABILITY VALUES BASED ON GRAIN SIZE ANALYSIS OF SPLIT SPOON SAMPLES.
FOR BORING LOGS SEE PLATE F1 LEGEND

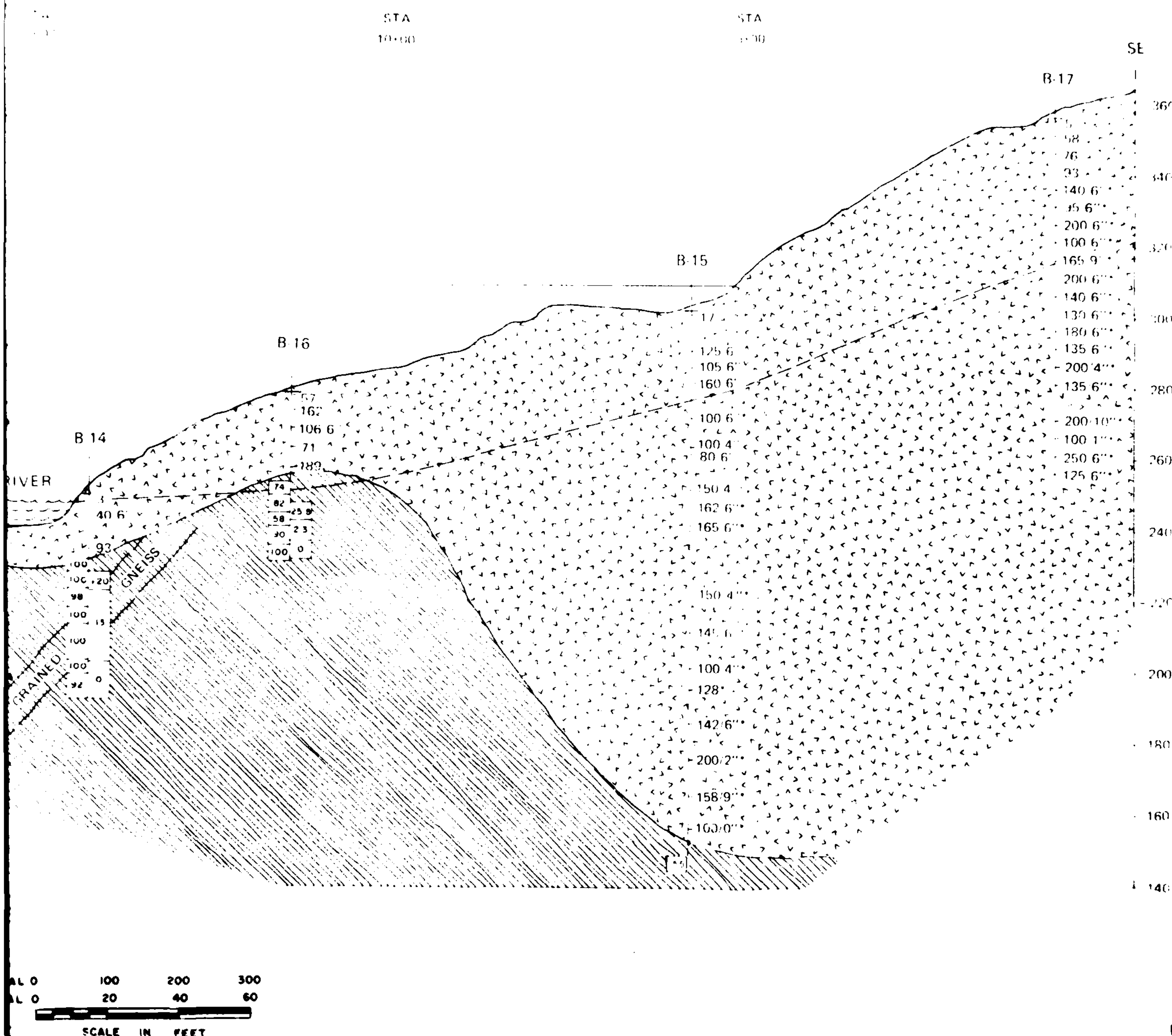
GRAPHIC SCALES

PROFILE ALONG DIVISION STREET
IMPERVIOUS CUT OFF AREA
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS

PLATE F6

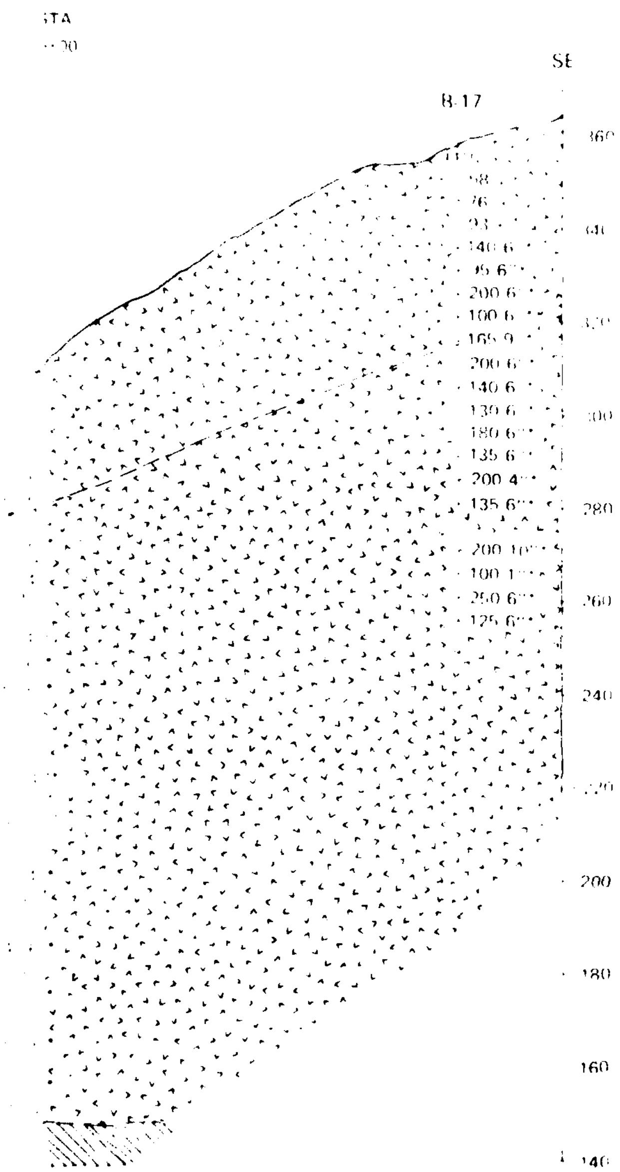


STA 20+00
STA 15+00
ELEVATION IN FEET
300
280
260
240
220
200
180
160
140
B-6
B-8
B-11
B-13
B-14
TOP OF DAM
BIG RIVER
FINE GRAINED
HORIZONTAL 0
VERTICAL 0



GEOLO
DEPARTM
NEW ENGLAND DI

7



LEGEND

B-8 BORING NUMBER

LOCATION OF GROUNDWATER TABLE – SUMMER 1976

71 BLOWCOUNT USING 140 LB HAMMER

100 4" BLOWCOUNT USING 300 LB HAMMER

PERMEABILITY VALUES IN 10^{-4} CM/SEC

92 RQD VALUES IN PERCENT

GEOLOGIC UNITS

FILL

FINE TO VERY FINE SAND, SOME FINE GRAVEL

COARSE TO MEDIUM SAND

GLACIAL TILL

BEDROCK SCITUATE GRANITE GNEISS

NOTES

1. FOR BORING LOCATIONS, SEE EXPLORATION PLAN, PLATE F-1.
2. PLATE DERIVED FROM KEYES ASSOCIATES, METCALF & EDDY

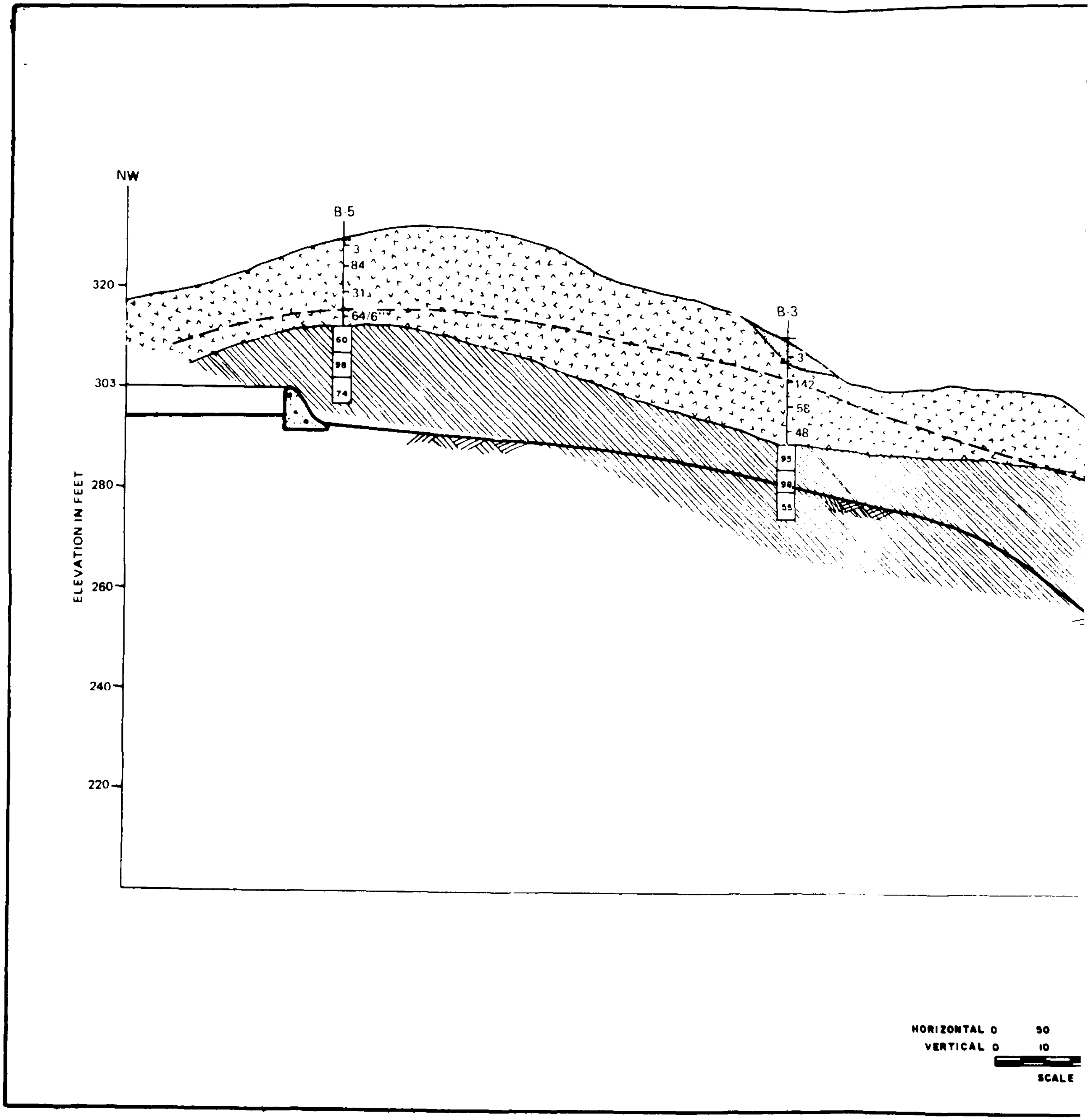
GEOLOGIC SECTION

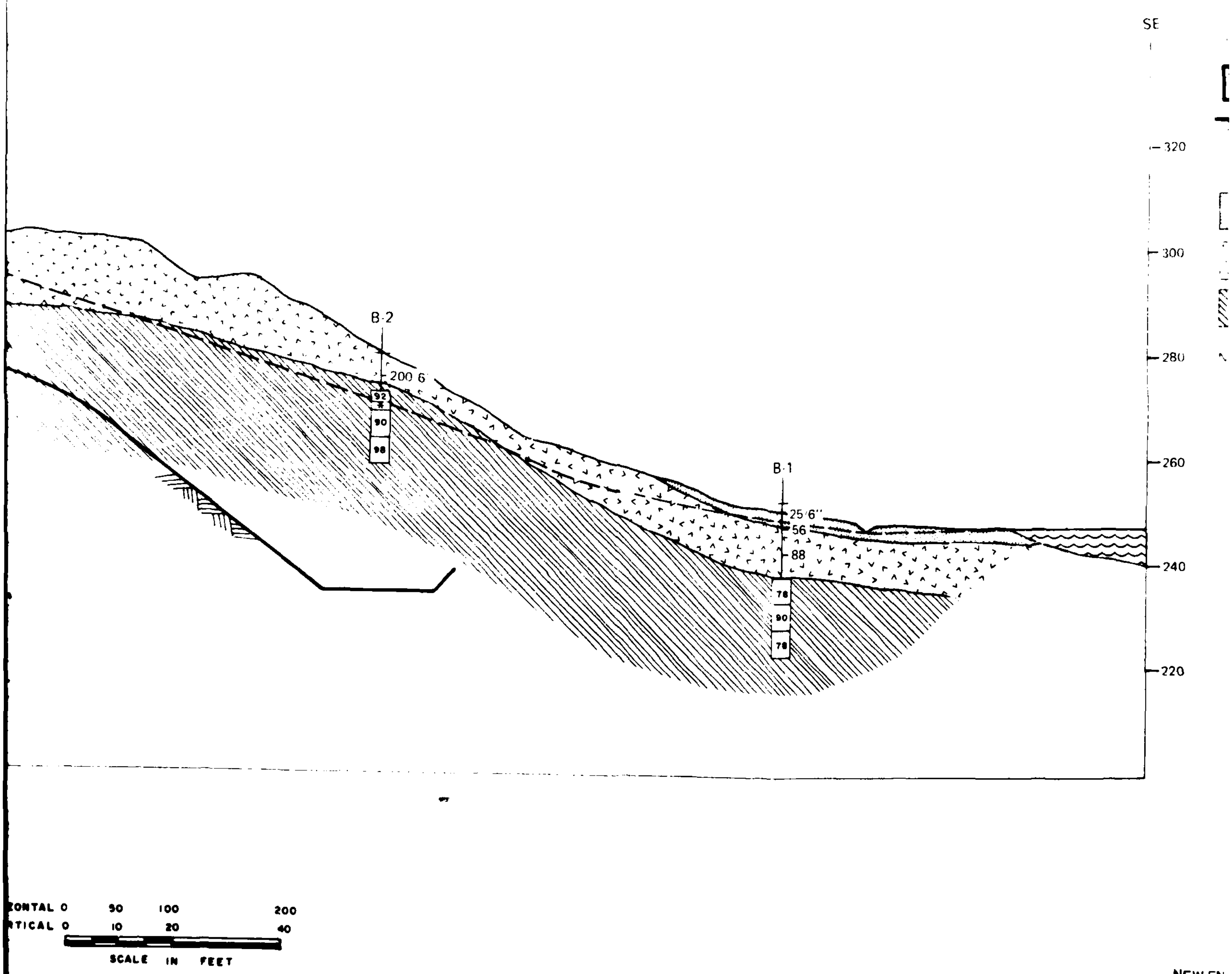
DAM AXIS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F-7

3

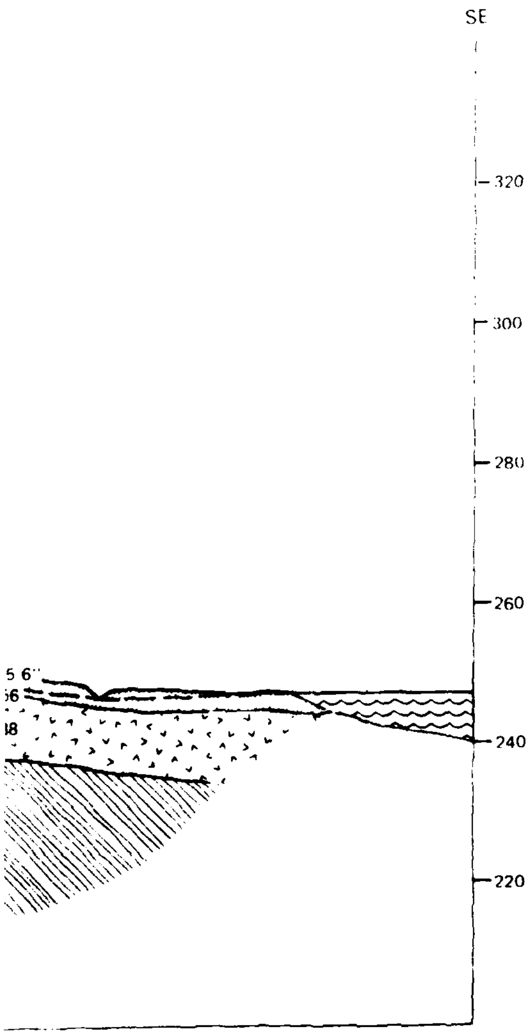

NW
B-5
3
84
31
64/6"
60
98
74
B-3
3
142
58
48
95
98
55
320
303
280
260
240
220
ELEVATION IN FEET
HORIZONTAL 0 50
VERTICAL 0 10
SCALE



SE
320
300
280
260
240
220
B-2
200 6
92
90
98
B-1
25 6"
56
88
78
90
78
ZONTAL 0 50 100 200
RTICAL 0 10 20 40
SCALE IN FEET

NEW EN

2



LEGEND

D-3 BORING NUMBER

LOCATION OF GROUNDWATER TABLE - AUGUST 1976

55 BLOW COUNT

|98| RQD VALUES IN PERCENT

|*| PART OF CORE MISSING

SPILLWAY WEIR

ROCK CUT FOR SPILLWAY

GEOLOGIC UNITS

FINE SAND

GLACIAL TILL

BEDROCK SCITUATE GRANITE GNEISS

NOTES

1. FOR LOCATION OF BORINGS SEE EXPLORATION PLAN, PLATE F-1.
2. PLATE DERIVED FROM KEYES ASSOCIATES, METCALF & EDDY

GEOLOGIC SECTION

SPILLWAY

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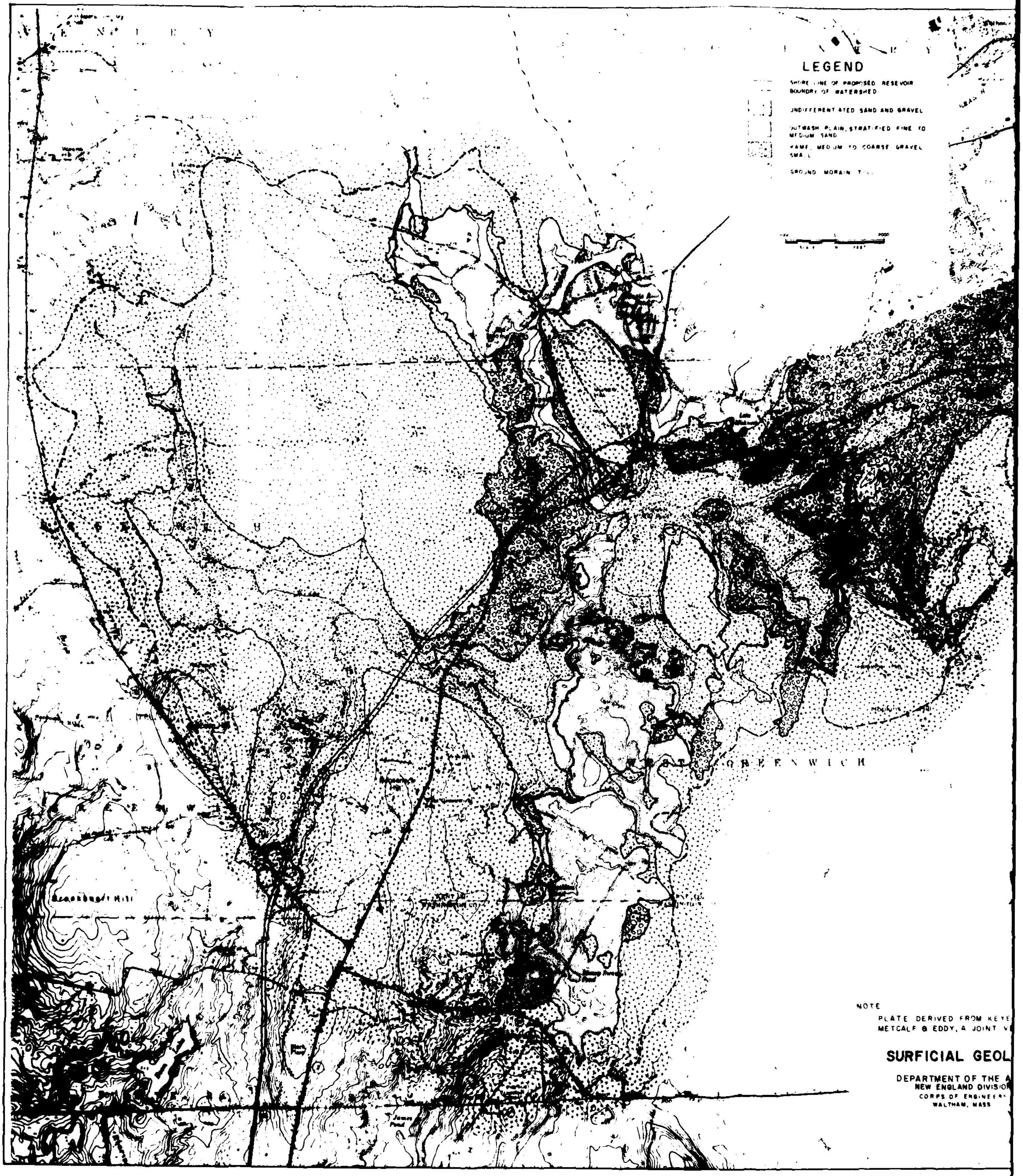
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

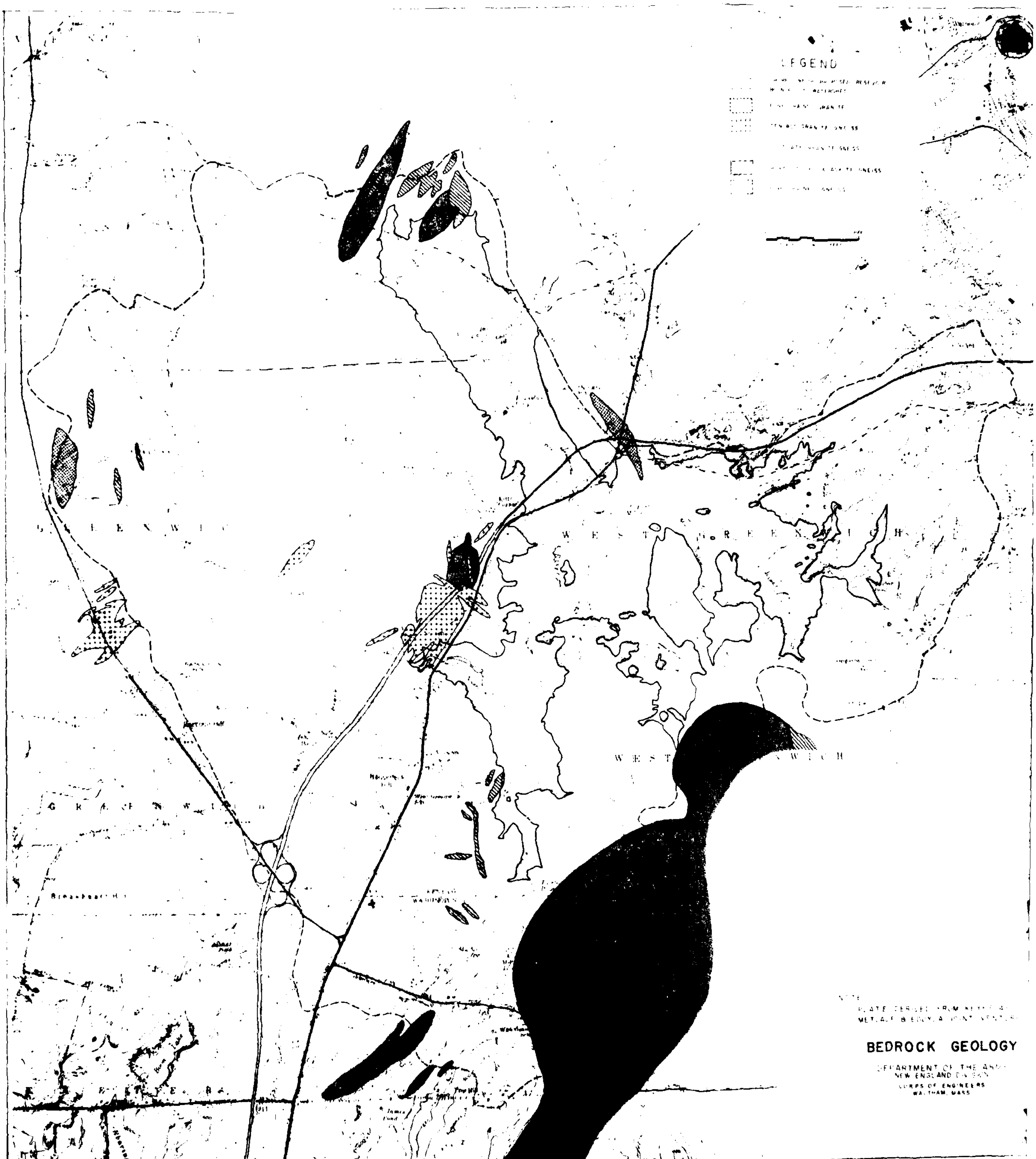
PLATE F-8

3


LEGEND
SHORE LINE OF PROPOSED RESEVOIR
BOUNDRY OF WATERSHED
UNDIFFERENTIATED SAND AND GRAVEL
OUTWASH PLAIN, STRATIFIED FINE TO MEDIUM SAND
KAME, MEDIUM TO COARSE GRAVEL SMALL
GROUND MORAIN
GREENWICH
NOTE
PLATE DERIVED FROM KEYE
METCALF & EDDY, A JOINT V
SURFICIAL GEOL
DEPARTMENT OF THE A
NEW ENGLAND DIVISIO
CORPS OF ENGINEERS
WALTHAM, MASS

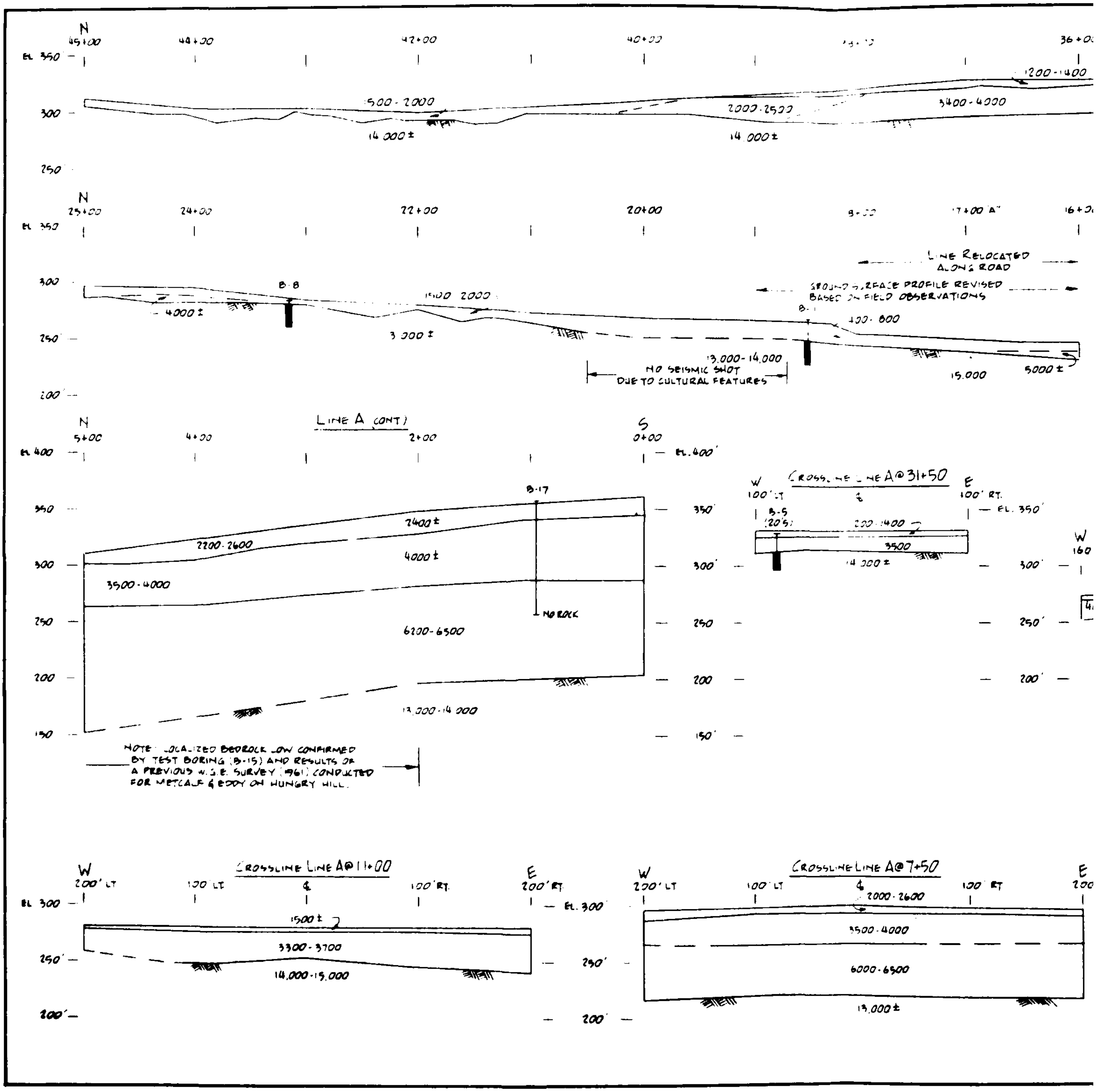

LEGEND
SHORE LINE OF PROPOSED RESERVOIR
BOUNDARY OF WATERSHED
UNDIFFERENTIATED SAND AND GRAVEL
OUTWASH PLAIN, STRATIFIED FINE TO MEDIUM SAND
WEST GREENWICH
NOTE
PLATE DERIVED FROM KEYES ASSOCIATES, METCALF & EDDY, A JOINT VENTURE
SURFICIAL GEOLOGY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS

PLATE F-9

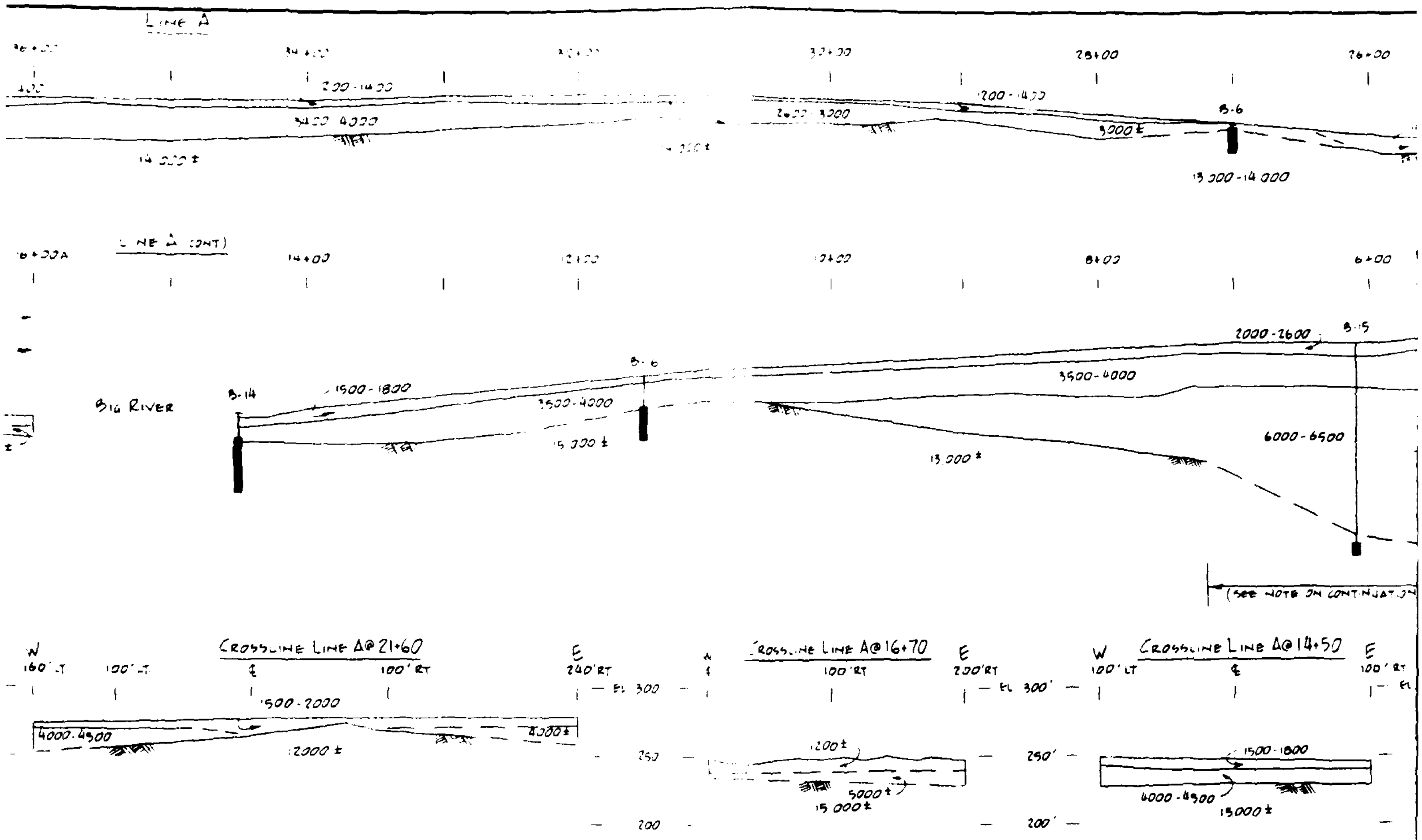

LEGEND
BEDROCK GEOLOGY

LEGEND
BEDROCK GEOLOGY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE F-10



N
45+00
44+00
42+00
40+00
36+00
EL 350
300
250
1200-1400
1500-2000
2000-2500
3400-4000
14,000±
14,000±
N
25+00
24+00
22+00
20+00
17+00 "A"
16+00
EL 350
300
250
200'
LINE RELOCATED ALONG ROAD
GROUND SURFACE PROFILE REVISED BASED ON FIELD OBSERVATIONS
B-8
1500-2000
4000±
3000±
400-800
13,000-14,000
NO SEISMIC SHOT DUE TO CULTURAL FEATURES
15,000
5000±
N
5+00
4+00
LINE A (CONT)
2+00
S
0+00
EL 400
EL. 400'
350
300
250
200
150
B-17
2400±
2200-2600
4000±
3500-4000
NO ROCK
6200-6500
13,000-14,000
NOTE: LOCALIZED BEDROCK LOW CONFIRMED BY TEST BORING (B-15) AND RESULTS OF A PREVIOUS W.S.E. SURVEY (1961) CONDUCTED FOR METCALF & EDDY ON HUNGRY HILL.
W
CROSSLINE LINE A@31+50
E
100' LT
100' RT.
EL. 350'
B-5
(20'S)
200-1400
3500
14,000±
300'
250'
200'
W
CROSSLINE LINE A@11+00
E
200' LT
100' LT
100' RT.
200' RT.
EL 300
EL. 300'
250'
200'
1500±
3300-3700
14,000-15,000
W
CROSSLINE LINE A@7+50
E
200' LT
100' LT
100' RT
2000-2600
3500-4000
6000-6500
13,000±

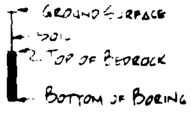


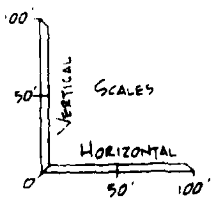
NOTES:
1. SEISMIC SURVEY DAMS
2. PLATE DERIVED FROM
ENGINEERS, INC UNDER
KAME, A JOINT VEN

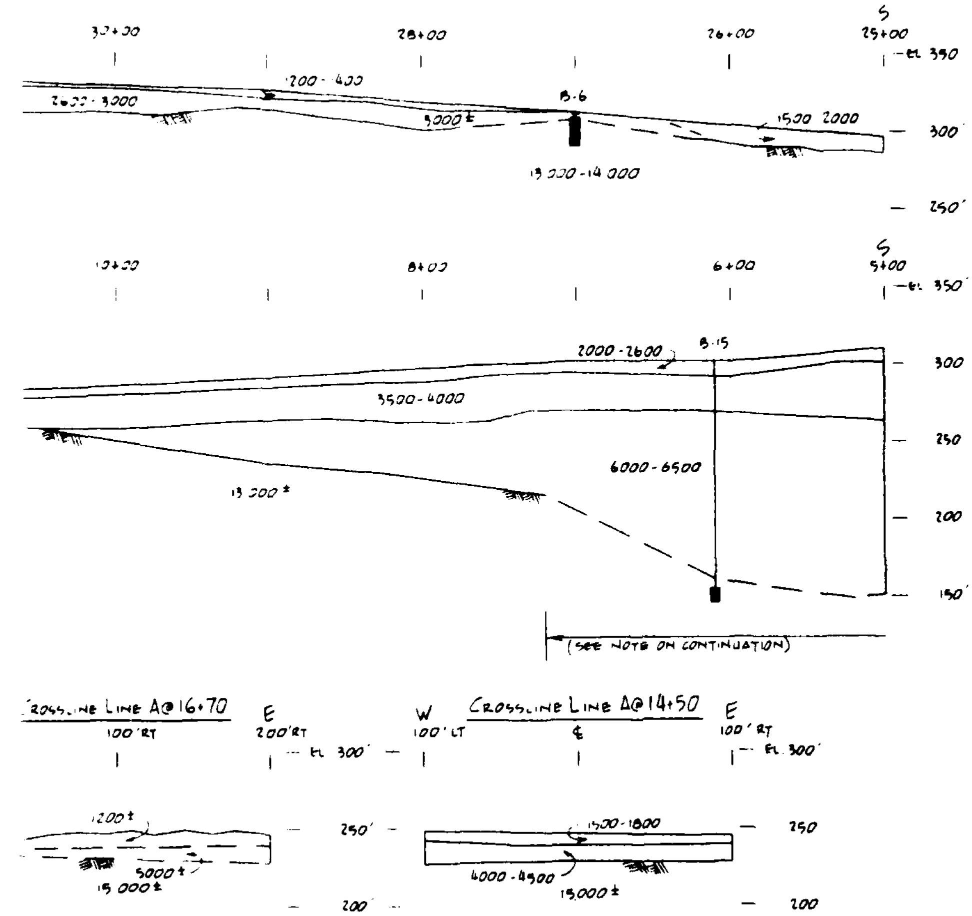
DEPARTMENT O
NEW ENGLAND DIVISION,
WALTHAM
SEISMIC

BIG RIVER RE
COVENTRY, R

NOTES
1. BORINGS MORE THAN 50' AWAY FROM SEISMIC LINES NOT SHOWN ON PROFILES.
2. SEISMIC VELOCITIES SHOWN ARE IN FEET/SECOND.





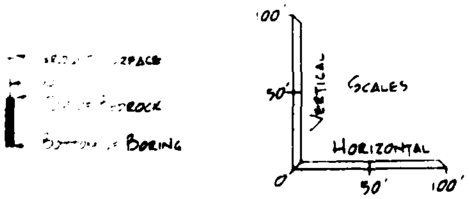


NOTES:
1. SEISMIC SURVEY DAMSITE, SEE PLATE F-1
2. PLATE DERIVED FROM WESTON GEOPHYSICAL ENGINEERS, INC UNDER THE DIRECTION OF K A M E, A JOINT VENTURE.

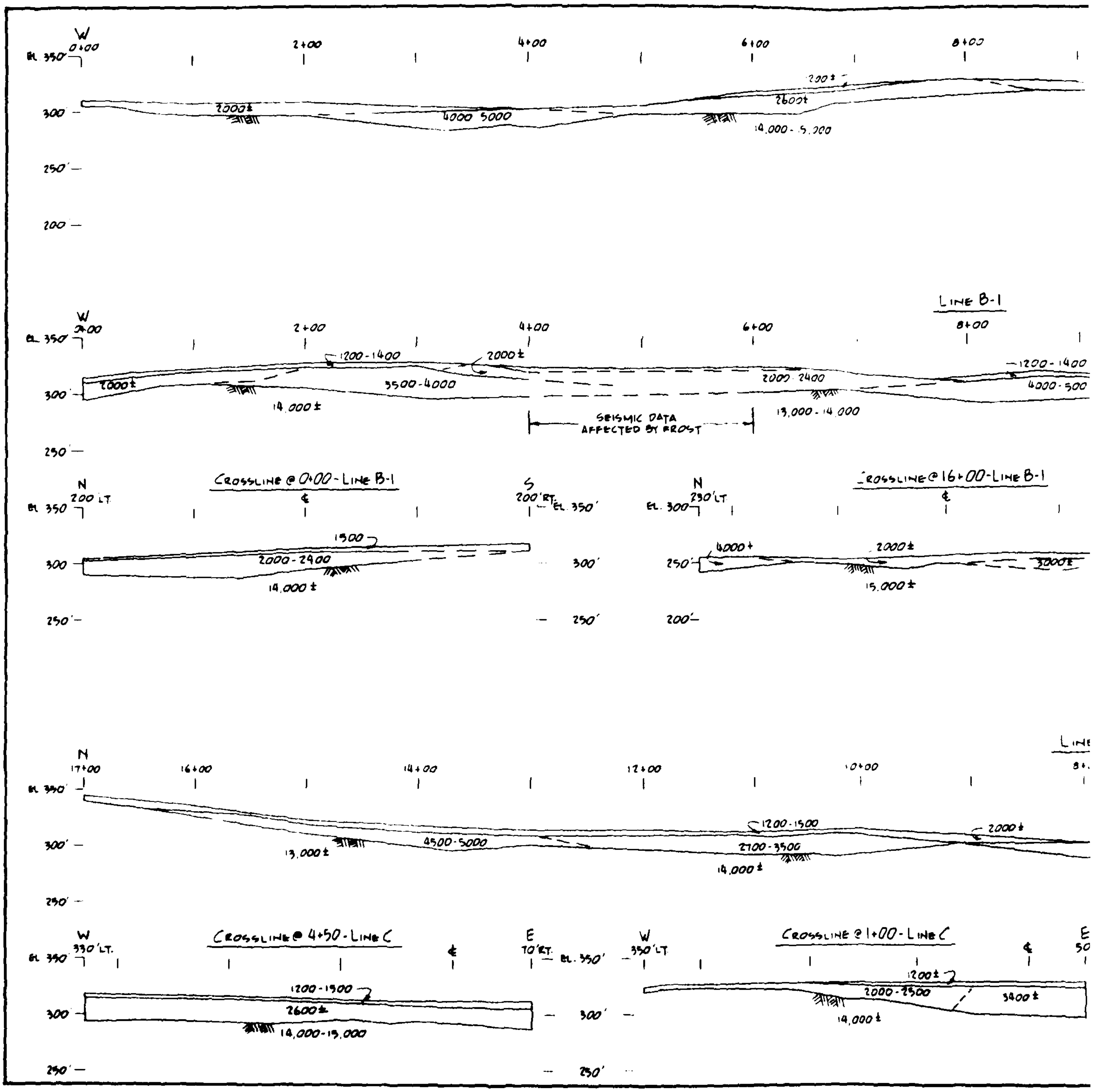
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SEISMIC SURVEY

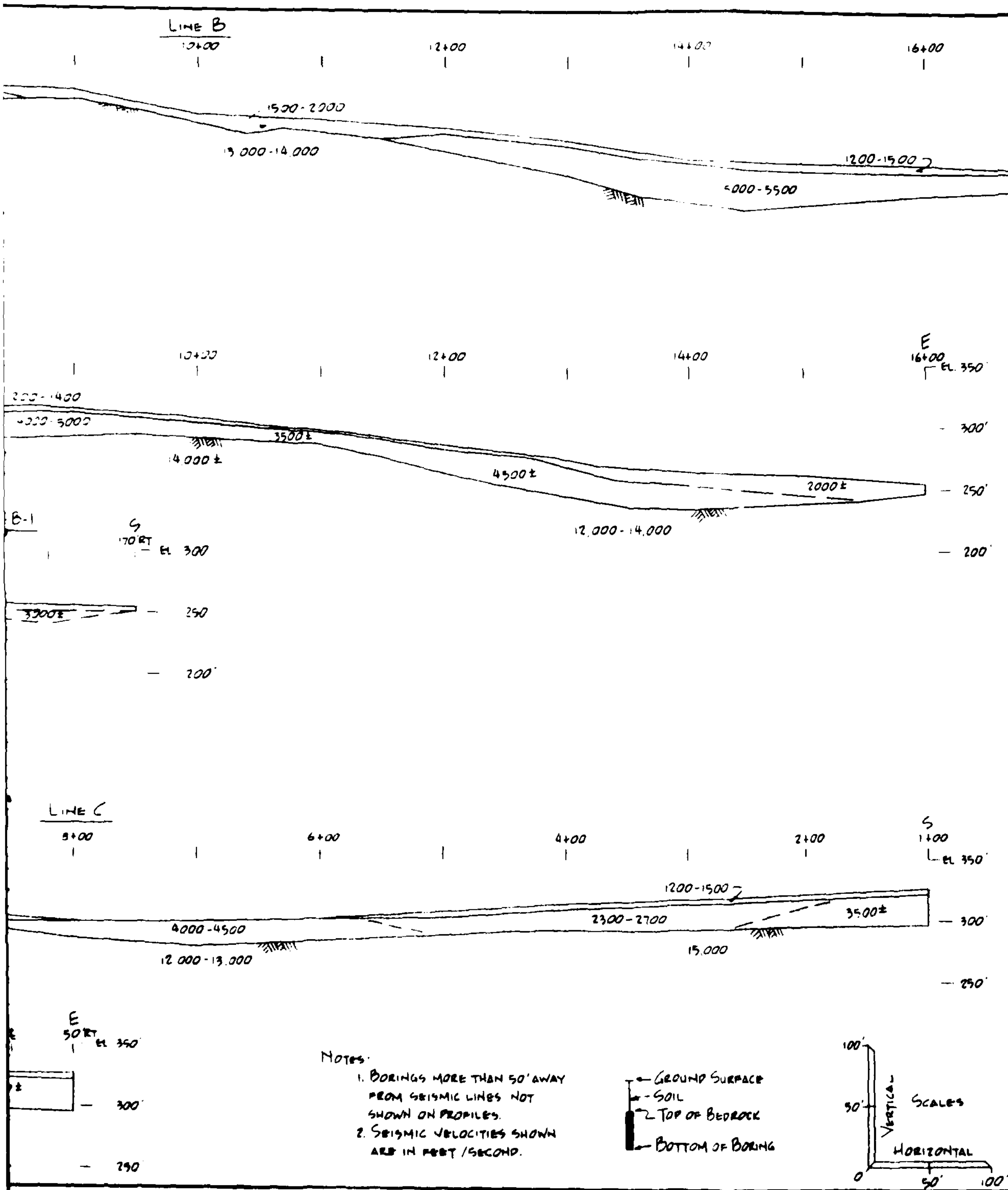
BIG RIVER RESERVOIR DAM
COVENTRY, RHODE ISLAND



3



W
0+00
2+00
4+00
6+00
8+00
EL. 350'
300
250'
200
2000±
4000-5000
200±
2600±
14,000-15,000
LINE B-1
W
0+00
2+00
4+00
6+00
8+00
EL. 350'
1200-1400
2000±
2000±
3500-4000
2000-2400
1200-1400
4000-500
14,000±
13,000-14,000
SEISMIC DATA AFFECTED BY FROST
300'
250'
CROSSLINE @ 0+00 - LINE B-1
N
200' LT.
S
200' RT.
EL. 350'
1500
2000-2400
14,000±
300'
250'
CROSSLINE @ 16+00 - LINE B-1
N
230' LT.
EL. 300'
4000+
2000±
3000±
15,000±
250'
200'
N
17+00
16+00
14+00
12+00
10+00
EL. 350'
1200-1500
2000±
4500-5000
13,000±
2700-3500
14,000±
300'
250'
CROSSLINE @ 4+50 - LINE C
W
330' LT.
E
70' RT.
EL. 350'
1200-1900
2600±
14,000-15,000
300'
250'
CROSSLINE @ 1+00 - LINE C
W
350' LT.
1200±
2000-2500
3400±
14,000±

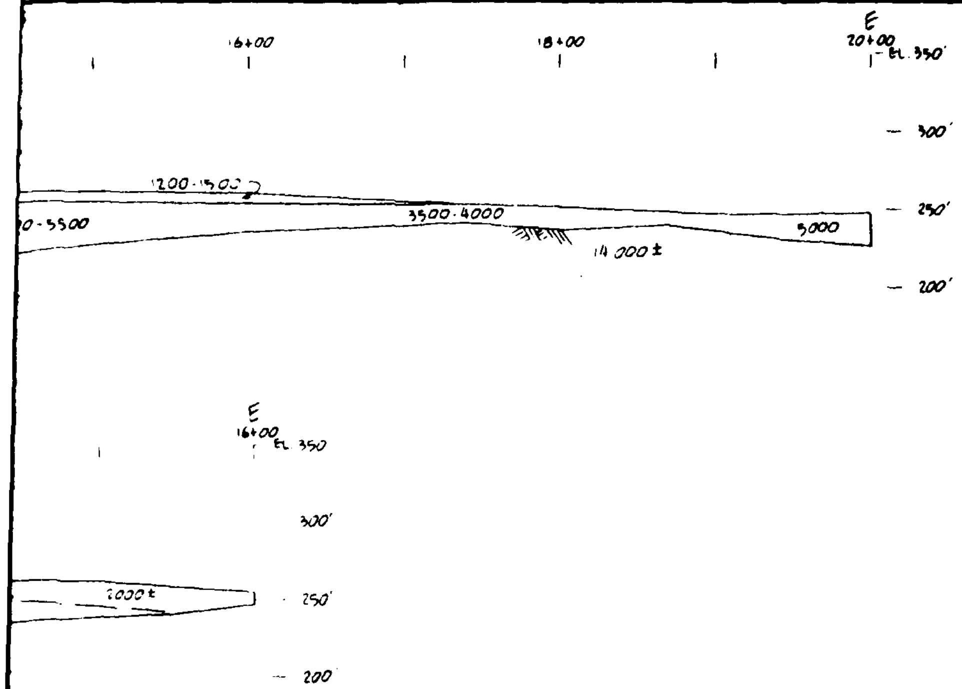


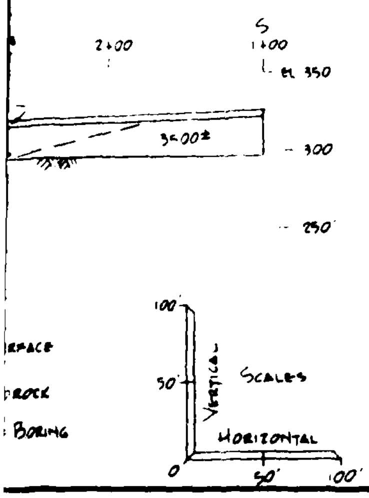
NOTES:
1. SEISMIC SURVEY D
2. PLATE DERIVED F
ENGINEERS, INC U
K A M E, A JOINT

DEPARTME
NEW ENGLAND DIVIS
WAL
SEIS

BIG RIVER
COVENTR

7





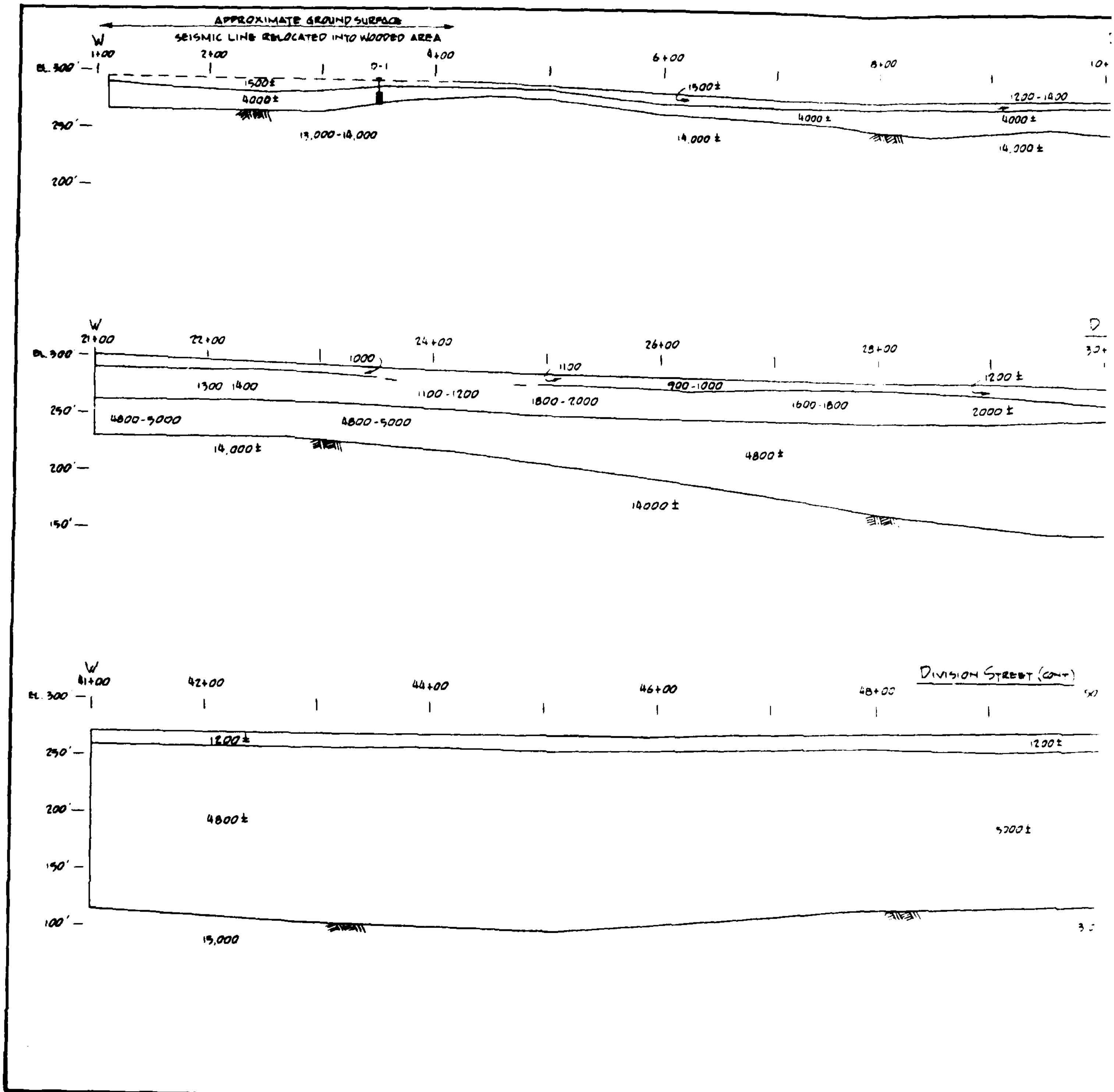
NOTES.
1. SEISMIC SURVEY DAMSITE, SEE PLATE F-1
2. PLATE DERIVED FROM WESTON GEOPHYSICAL ENGINEERS, INC. UNDER THE DIRECTION OF K A M E, A JOINT VENTURE.

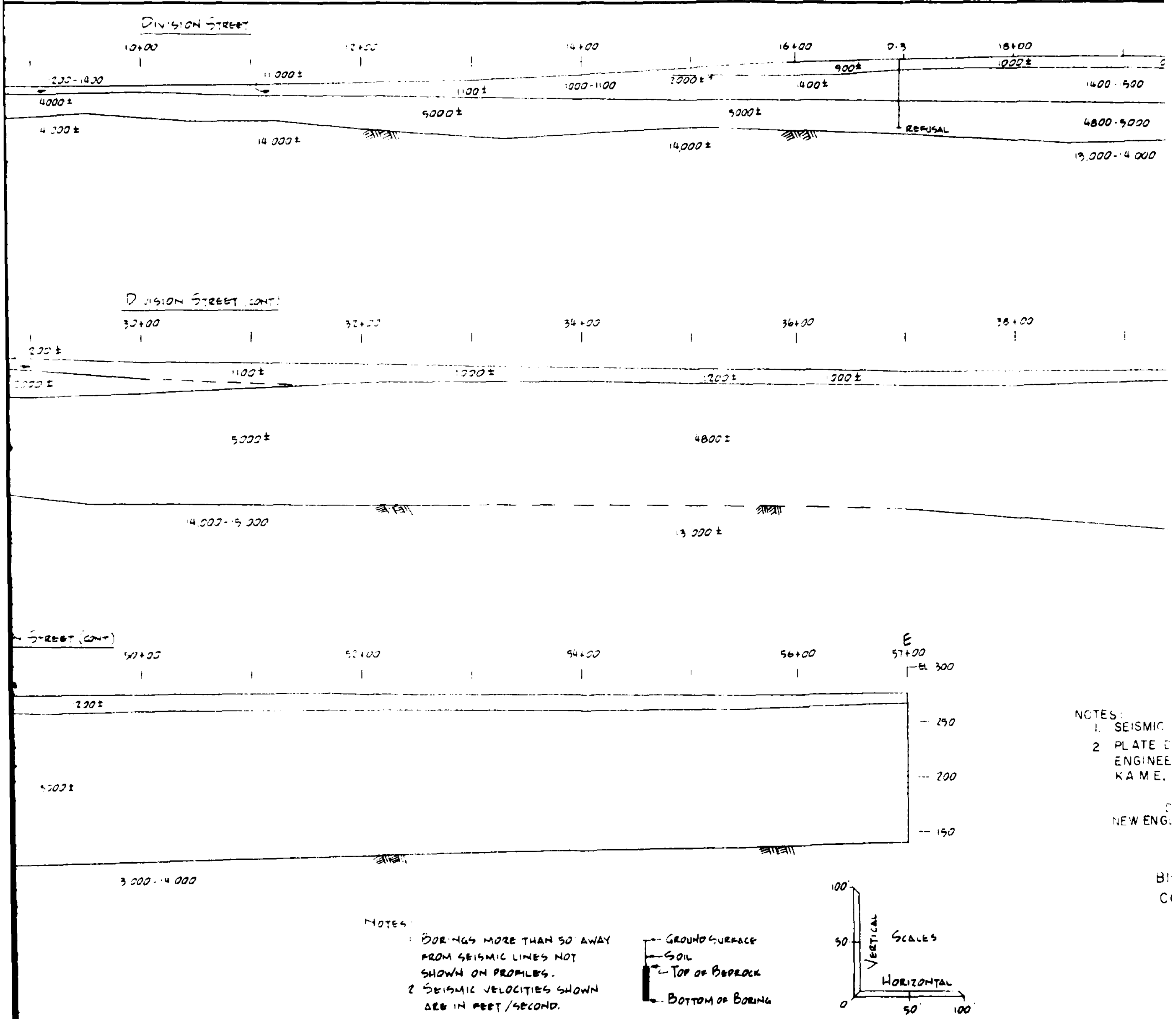
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SEISMIC SURVEY

BIG RIVER RESERVOIR DAM
COVENTRY, RHODE ISLAND

PLATE F-12

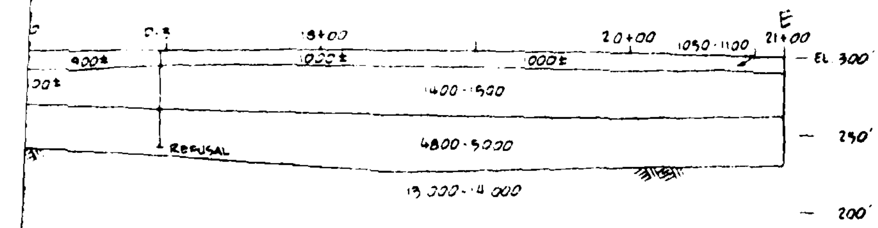

APPROXIMATE GROUND SURFACE
SEISMIC LINE RELOCATED INTO WOODED AREA
W
1+00
2+00
4+00
6+00
8+00
EL. 300'
250'
200'
150'
100'
1500±
4000±
13,000-14,000
1300±
14,000±
1200-1400
21+00
22+00
24+00
26+00
1000
1100
1300 1400
1100-1200
1800-2000
900-1000
1600-1800
1200±
2000±
4800-5000
14,000±
4800±
14000±
41+00
42+00
44+00
46+00
48+00
DIVISION STREET (CONT)
1200±
4800±
15,000

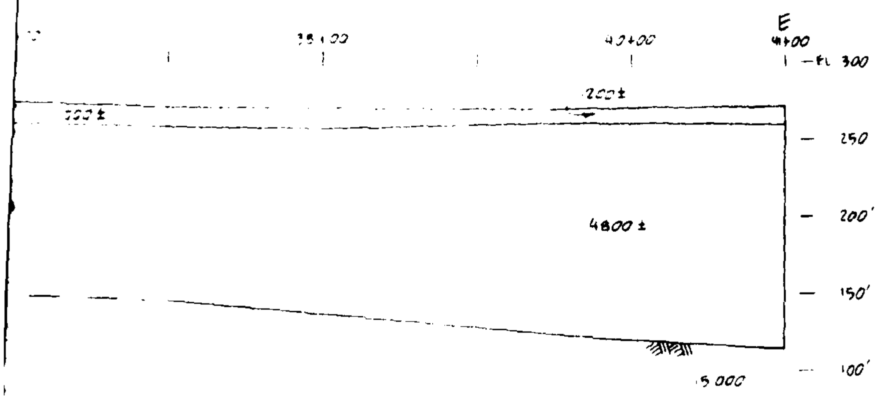


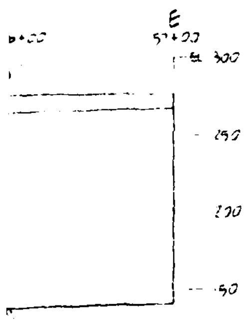
Notes:

1. Borings more than 50' away from seismic lines not shown on profiles.
2. Seismic velocities shown are in feet/second.

2

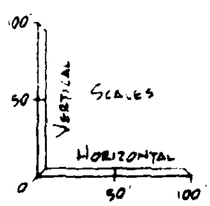






NOTES

1. SEISMIC SURVEY DIV STREET AREA, SEE PLATE F-1
2. PLATE DERIVED FROM WESTON GEOPHYSICAL ENGINEERS, INC UNDER THE DIRECTION OF K.A.M.E, A JOINT VENTURE.



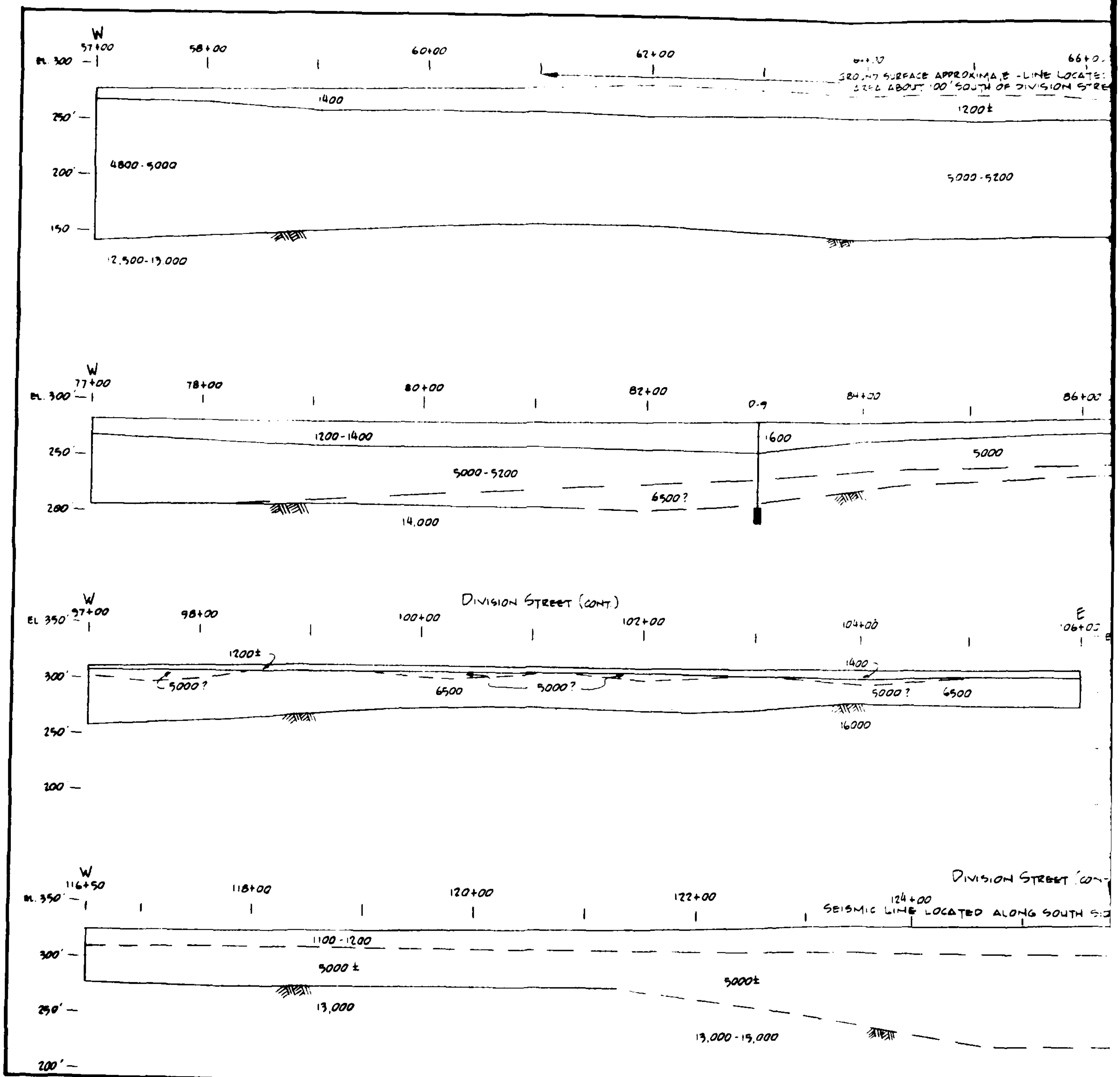
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

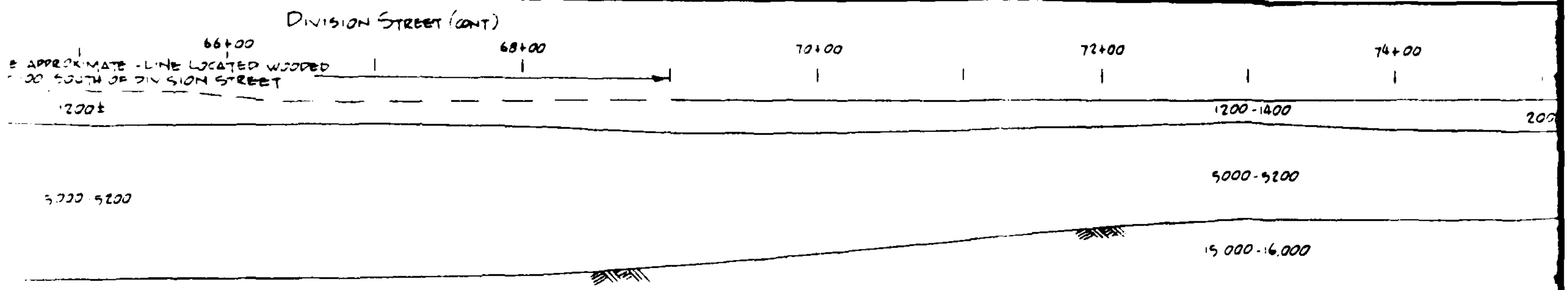
SEISMIC SURVEY

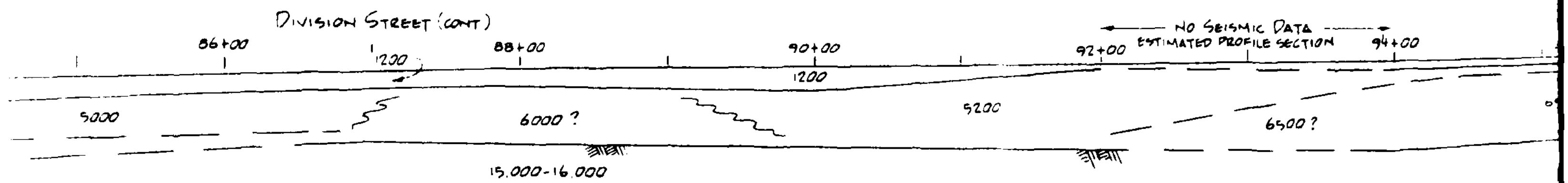
BIG RIVER RESERVOIR DAM
COVENTRY, RHODE ISLAND

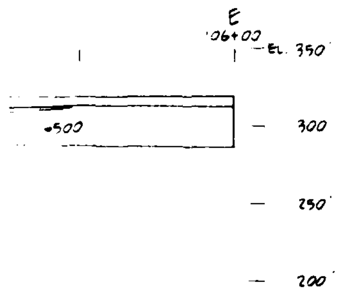
PLATE F-13

3


W
57+00
58+00
60+00
62+00
66+0
EL. 300
GROUND SURFACE APPROXIMATE - LINE LOCATED ABOUT 100' SOUTH OF DIVISION STREET
250'
200'
150
1400
1200±
4800-5000
5000-5200
12,500-13,000
W
77+00
78+00
80+00
82+00
84+00
86+00
EL. 300
250'
200
1200-1400
1600
5000-5200
5000
6500?
14,000
Division Street (cont.)
W
97+00
98+00
100+00
102+00
104+00
E
106+0
EL 350'
300'
250'
200
1200±
1400
5000?
6500
5000?
5000?
6500
16000
W
116+50
118+00
120+00
122+00
124+00
Division Street (con
Seismic Line Located along South Side
EL. 350'
300'
250'
200'
1100-1200
5000 ±
5000±
13,000
13,000-15,000





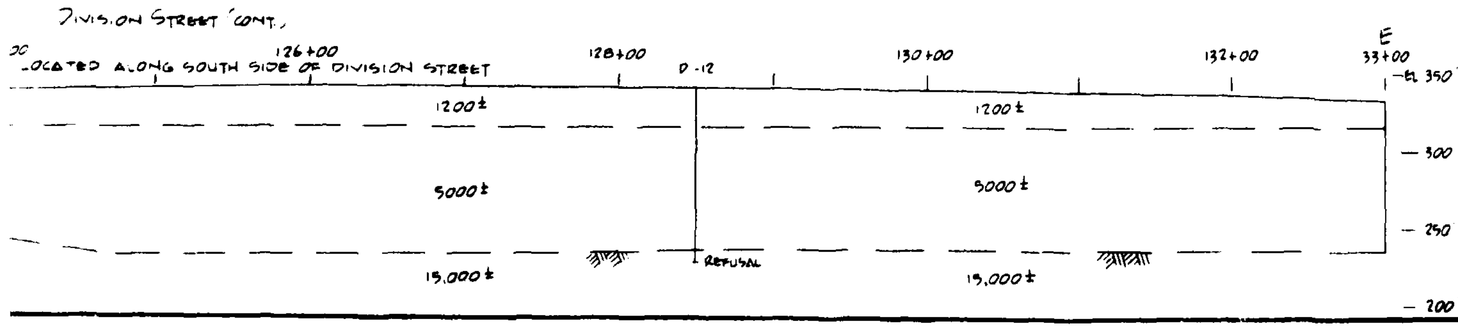


Notes
1. Borings more than 50' away from seismic lines not shown on profiles.
2. Seismic velocities shown are in feet/second

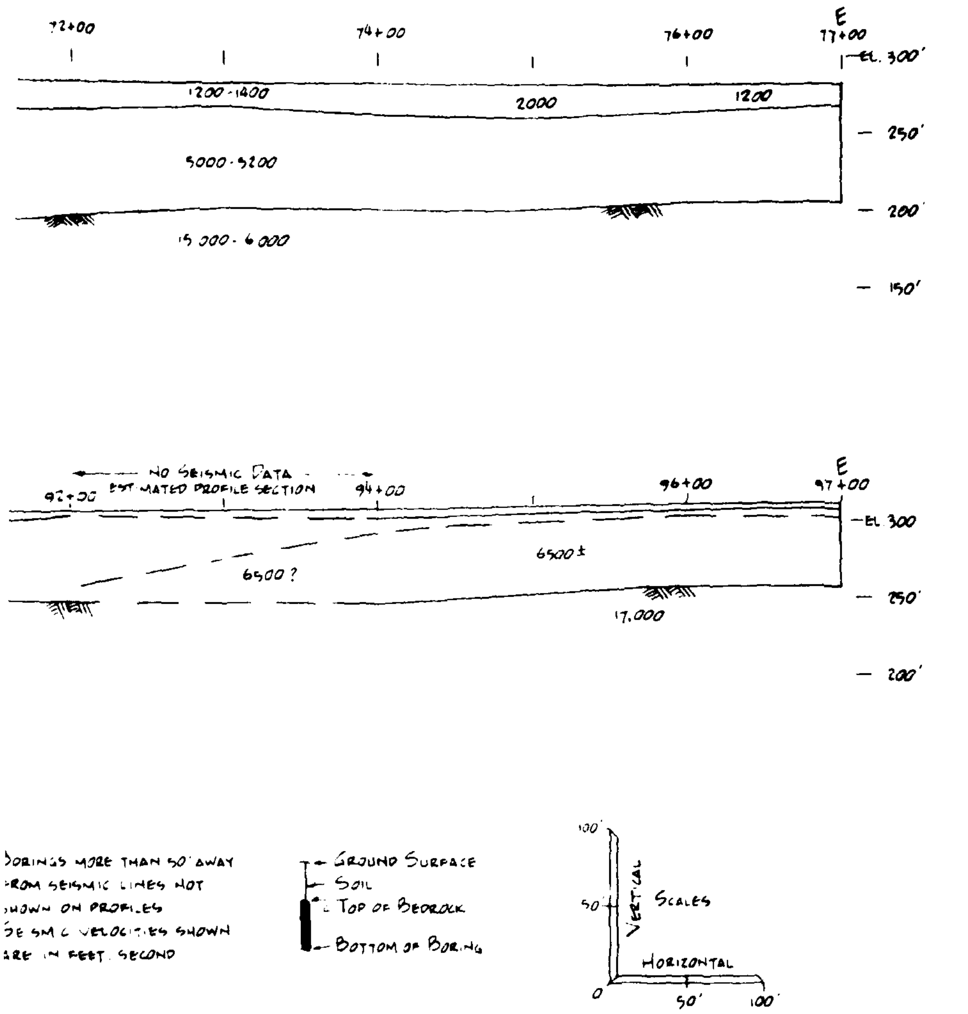
Ground Surface
Soil
Top of Bedrock
Bottom of Boring

NOTES
1 SE
2 PL
EN
KA

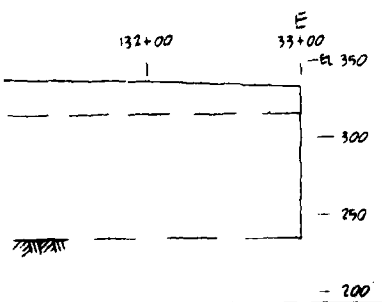
NEW



2



NOTES:
1 SEISMIC SURVEY DIV. STREET AREA, SEE PLATE F-1
2 PLATE DERIVED FROM WESTON GEOPHYSICAL ENGINEERS, INC. UNDER THE DIRECTION OF KAME, A JOINT VENTURE.



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SEISMIC SURVEY

BIG RIVER RESERVOIR DAM
COVENTRY, RHODE ISLAND

3

ADDENDA AND ERRATA TO
Appendix G, "Design and Cost Estimates"

1. p. G-1: Reservoir usable storage is 73,600 acre-feet.
   conservation storage is 12,300 acre-feet.

2. p. G-5, second paragraph: "weir creast elevation" should read "weir crest elevation"

3. p. G-25, fourth paragraph: "other structural componenets" should read "other structural components"

4. p. G-31, Table 1:
   a. Alternative Single Purpose water supply project construction expenditure should be 56,060.
   b. Allocation of Construction Expenditure:
      - specific investment in recreation facilities should be 275.
      - construction expenditure in joint-use facilities should be 195.
      - percent of construction expenditures in joint-use facilities should be 0.348.
      - construction expenditures in specific facilities should be 240.

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

APPENDIX G

DESIGN AND COST ESTIMATES

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

APPENDIX G

DESIGN AND COST ESTIMATES

TABLE OF CONTENTS

AD-A105 362 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS WATER AND --ETC(U)
JUL 81

UNCLASSIFIED NL

8 OF 8
AD
A105362

END
DATE
FILMED
11-81
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TABLE OF CONTENTS - continued

TABLE OF CONTENTS - continued

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF PLATES

BIG RIVER, RHODE ISLAND

A. PERTINENT DATA

1. Big River Dam

a. Purpose — Multipurpose: Water Supply Flood Control and Recreation

b. Location

State	Rhode Island
County	Kent
River	Big River

c. Streamflow — (At South Branch Gage)

Average Annual Runoff	27.42 inches
Maximum discharge	1,860 cfs
Minimum daily discharge	2.8 cfs
Average annual discharge	128 cfs

d. Reservoir

Drainage area	29.7	square miles
Maximum operating level	300	feet NGVD
Minimum operating level	267	feet NGVD
Total storage	95,400	acre-feet
(Flood Control)	(9,500)	
(Useable storage)	(12,300)	
(Conservation storage)	(73,600)	
Water area at maximum operating level El. 300.0	3,240	acres
Water area at Spillway crest El. 303.0	3,400	acres

e. Embankment

Type: Rolled earth fill with rock slope protection on upstream and downstream faces.

Elevation, top of embankment	312	feet NGVD
Top width	25	feet
Length	2,240	feet
Maximum height above streambed	70	feet

Maximum base width	480	feet
Slope, upstream above El. 303 ft. NGVD	1 on 2.5*	
Slope, upstream below El. 303	1 on 3	
Slope, downstream	1 on 3	

f. Spillway

Type: Uncontrolled, concrete ogee overflow weir with converging chute channel.

Crest elevation	303	feet NGVD
Crest length	400	feet
Maximum design surcharge	4	feet
Design discharge	11,900	cfs

g. Outlet Works

(1) Water Supply
Type - concrete conduit
Size - 90 inch, inside diameter
Invert elevation at intake, ft. NGVD = 240.0
Number of service gates = 1
Size of gate - 90-inch diameter
Type of gate - Hydraulically operated slide
Capacity of Conduit, diversion period, cfs = 1,000
Capacity of conduit for water supply = 100 MGD
= 155 cfs

(2) Flood Control
Type - concrete conduit
Size - 5 ft. x 5 ft. box conduit
Invert elevation at intake, ft. NGVD = 240.0
Number of service gates = 2
Size of gates - 3 ft. x 5 ft.
Type of gates - hydraulically operated slide
Capacity of conduit at
spillway crest, cfs = 950

h. Water Transmission Lines

(1) Dam to Water Treatment Plant
Type: Reinforced Concrete Pipe

Conduit:	Size (inside dia.)	7.5	feet
	Length	3,200	feet

*All slopes expressed in ratio of vertical to horizontal dimension.

(2) Water Treatment Plant to Connector

Type: Tunnel with 7-inch Precast Concrete Liner

Conduit:	Size (inside dia.)	7.0 feet
	Length	35,200 feet

i. Impervious Cut-off (Vicinity Division St. & Rte. 95)

Type: Impervious Fill Blanket with rock slope protection face

Elevation, top of cut-off	312 feet NGVD
Length	8,000 feet

j. Principal Quantities - Embankment

Common Excavation	1,800,000 c.y.
Rock Excavation	190,000 c.y.
Earth Fill	1,290,000 c.y.
Rock fill and slope protection	100,000 c.y.
Concrete	15,400 c.y.

2. Relocations

State and local highways	8.6 miles
Telephone and electric lines	10.5 miles

3. Estimated Project Costs

02.	Relocations	$ 4,660,000
03.	Reservoir	2,352,000
04.	Dam	12,048,000
06.	Water Transmission Lines	20,813,000
08.	Roads	42,000
19.	Building, Grounds and Utilities	180,000
20.	Permanent Operating Equipment	120,000
	TOTAL ESTIMATED PROJECT COST	$40,215,000*

*Lands and Damages, Water Treatment Plant, Recreation, Cultural Resources Preservation, Engineering and Design, Supervision and Administration costs not included.

B. RECOMMENDED PROJECT PLAN

The recommended project plan consists of a rolled earth fill dam with rock slope protection 2,240 feet long and 70 feet in height above the streambed (Plates G-4 and G-5). A chute type spillway with a 400-foot uncontrolled concrete weir will be located in a rock cut in the left abutment with the spillway crest at Elvation 303.0. The project will contain a total storage capacity of 95,400 acre-feet consisting of 73,600 a.f. for water supply, 9,500 a.f. for flood control and 12,300 a.f. for conservation storage. The water surface area at spillway crest would be 3,400 acres. Releases for flood control would be by means of a 5 feet x 5 feet reinforced concrete conduit whereas the water supply released through the dam will utilize a 90-inch reinforced concrete pipe.

C. DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

1. General

The following paragraphs provide a detailed description of the project's major construction features.

2. Dam Embankment

The embankment would be rolled earth fill with rock slope protection on the upstream and downstream faces. The top of the dam would be 25.0 feet wide with 20-foot wide bituminous surfacing on gravel base which will provide access to the gate house. Access to the top of the dam would be by a 20-foot wide access road from existing Harkney Hill Road to the south end of the dam. (See Plate G-4).

The top elevation would be 312.0 feet NGVD, providing a freeboard of 5.0 feet above water surface at maximum flood surcharge elevation of 307.0 feet NGVD. Length of the dam would be approximately 2,240 feet with a maximum height above streambed of 70 feet.

The embankment would consist of a central impervious core section flanked by compacted random fill zones. The downstream section would have filter and drain zones between the core and random fill for control of seepage. At the center of the dam, the impervious core will be founded on a grout curtain when over bedrock or a cutoff trench when in earth sections. (See Plate G-5).

3. Spillway

An uncontrolled concrete ogee weir with converging chute channel spillway would be constructed adjacent to the north abutment of the dam. The greater portion of the spillway would be formed in rock cut, after removal of the earth overburden. The remaind :r of the discharge channel would be in earth cut. The bottom of the discharge channel would be overlaid with concrete from the weir to where relocated Harkney Hill Road crosses the channel, a distance of 500 feet. The channel walls in the same area and for an additional 600 feet would be concrete lined to approximately 2 feet above the maximum water flow line. Concrete in the spillway would be anchored to rock and relief drains provided. Earth cuts would be graded and finished with seeded topsoil. The remainder of the spillway would be unlined rock. (See Plate G-6).

The weir creast elevation would be 303.0 feet NGVD, with a length of 400 feet. The approach channel would be at Elevation 297.0 feet NGVD. Surcharge at maximum design flood would be 4 feet with a design discharge over the spillway of 11,900 cfs. A stilling basin would be provided to reduce velocity of flow before discharge into Flat River Reservoir. A bridge spanning the discharge channel would be constructed for relocated Harkney Hill Road.

4. Outlet Works

The outlet works are located in the left abutment and consist of an intake channel, gatehouse, two conduits on rock under the dam, junction structure, outlet structure and an outlet channel. (See Plate G-7).

The approach to the gatehouse is through a 20-foot wide intake channel about 450 feet long with the bottom elevation set at 240 feet, excavated in earth and rock and contained by concrete retaining walls supporting the dam embankment.

The gatehouse is located about 140 feet upstream of the centerline of the dam and will be either a combined wet/dry well or twin wet well type structure about 93 feet in height. Water supply releases will be made through one wet well equipped with multi-level outlets. The other wet well or dry well will contain the gates and controls for flood control and low flow operation with multi-level outlets provided for low flow regulation. The number and location of the selective withdrawal portals will be determined in subsequent design hydraulic analysis of the Big River project and will be reported in future design memoranda. For additional information refer to Appendix E, "Water Quality." A 12-foot wide service bridge, about 94 feet long, will provide access to the gatehouse.

A transition section will be provided from the gatehouse to the conduits. The conduits will consist of a 90-inch reinforced concrete pipe and a 5 feet x 5 feet reinforced concrete conduit, both of which will be encased in concrete. The 90-inch pipe will be used for water supply and the 5 feet x 5 feet conduit for low flow regulation and flood control. Low flow regulation would be provided by either a wet well or piping arrangement. Both pipes will also be used for diversion during the construction period. The 90-inch pipe will extend into the junction structure on the downstream side of the dam. It will then continue on for about 3,200 feet to the water treatment plant.

The 5 feet x 5 feet conduit will extend through the junction structure into the outlet structure.

The junction structure will be a reinforced concrete unit about 17 feet square. Two openings will be provided for the 90-inch pipe within the junction structure. During construction, the flow of water will run into the outlet structure and channel. After completion of construction, this 90-inch opening will be plugged and the water will flow through the other opening to the water treatment plant.

The outlet channel excavated in rock and earth is 25 feet wide and approximately 200-feet long having an invert elevation of 240 feet at its start. Downstream of the junction structure will be a concrete outlet structure about 25 feet in length. A small stilling basin will be provided in the outlet structure.

5. Reservoir Clearing

Corps of Engineers policies and practices for clearing civil works project reservoir lands of woody vegetative growth and structures prior to impoundment are outlined in Engineer Regulation (ER) 415-2-1 and Civil Works Construction Guide Specification CE 1301. A principal factor in the prediction of future lake water quality is the amount of vegetative growth remaining in the reservoir at the time of impoundment since forest organics can exert a demand on the oxygen resource of a lake, and can release nutrients and color causing substances in the lake's ecosystem. Thus, an initial consideration on how much land to clear and to what extent is based primarily upon obtaining desirable water quality conditions in the future lake. In planning the clearing of reservoirs, however, there is a general objective to clear only to the extent required in order to obtain an overall-effective project. A preliminary study of the extent of necessary clearing indicates that all growth 2 inches or greater in diameter and over 6 feet high would be removed to within 6 inches of the ground within the reservoir area below Elvation 303.0 NGVD. To strip and grub all vegetative growth within the same area would add approximately 12 million dollars to the project. By increasing the water treatment at a fraction of this cost, the water supply quality would be controlled to compensate for leaving the balance of vegetative materials. Normally such materials will decompose within ten years after impoundment occurs. In addition, to timber clearing, all man-made strucutres would be removed or filled to the ground surface. The reservoir area, and portions of the watershed would be surveyed to locate, identify, and remove or seal off sources of contamination which could degrade the water quality.

The area below Elevation 303.0 totals about 3,400 acres. However, there is a wide-range in the scope of clearing required. It is estimated that 2,800 acres of the reservoir area is forest land.

6. Access

Existing roads and trails traverse the project locale in sufficient number and in reasonable locationto provide construction access. Additional access to completed project features are described under Section F Access Roads.

7. Administrative Facilities

All local administrative activities necessary to operate the project would be located at the water treatment plant. Remote sensing equipment would report conditions at the reservoir to the plant control room.

8. Housing Facilities

Adequate housing would be assured for key project personnel on-site or within reasonable commuting distance in accordance with Corps of Engineers Regulation (ER) 415-2-301. After project authorization and operation agreements are concluded, the housing needs would be evaluated and determination made as to whether housing is available under private enterprise or operator's quarters would be required under the project. It is presently considered that property now under State (WRB) ownership within the watershed area would be suitable for such housing, subject to some rehabilitation.

9. Overlook Areas

During the final design period, the sites for visitor overlooks would be identified and provided. These overlooks would be sited to permit parking for a limited number of vehicles at locations where points of interest or a broad expense of the project can be viewed.

10. Water Transmission Tunnel

a. General. An 84-inch (inside diameter) tunnel with a 7-inch precast reinforced concrete liner will connect the proposed water treatment plant to the existing shaft of an aqueduct approximately 35,200 feet to the northeast. (See Plate F-2, Appendix F).

b. Hydraulic Analysis.

(1) General. Preliminary criteria has established a capacity of 90-100 MGD for the proposed aqueduct. Pertinent data concerning the hydraulic gradient was obtained from the 1968 report by C. A. Maguire, engineers for the City of Providence Water Supply Board. The report gives water surface elevations of 255 feet, NGVD in the clear well at the treatment plant and 237 feet, NGVD at the West Warwick junction shaft.

(2) Tunnel. An 84 to 87-inch diameter tunnel is needed to meet capacity and head requirements. For preliminary analysis, an 84-inch inside diameter, concrete lined tunnel has been selected. Headloss due to friction is approximatley 17.6 feet for a capacity of 92 MGD. This was computed using a Manning's "n" value of 0.013 and a tunnel length of 35,200 feet. Other minor losses totaling 0.4 feet occur at the intake, at the junction shaft and at two vertical bends.

c. Inlet Structure. Between the water treatment plant and the upstream shaft of the proposed tunnel, an inlet structure will be constructed to provide for the following:

(1) Meter - A Venturi meter shall be in line to record all flows through the conduit.

(2) An electrically operated sluice gate will allow for a fast positive shut-off of flow in the pipe.

(3) Stop logs shall be provided as a means of emergency closure and to allow for repairs on the sluice gate and meter.

d. Access Manholes. Access to the tunnel will be provided with a structure in the vicinity of its intersection with the Pawtuxet River. The surface is relatively close to the tunnel at this point and it has the convenient drainage facility of discharging water to the river at this point. The structure will be of watertight construction.

e. Outlet Structure. An outlet structure will be constructed between the downstream shaft and its connection to the existing aqueduct. This structure will be provided for maintenance operations and contains the shut-off capability provided with the inlet structure.

D. OTHER PLANS INVESTIGATED

1. General

Alternate sites for the multipurpose project have not been investigated to any great extent as part of this study since the State of Rhode Island has committed itself to the extent of having already acquired the necessary lands. Alternate schemes for certain structural features of the authorized project were analyzed during the current planning effort to assure the most economical, safe and functional design compatible with specific on-site conditions. The following paragraphs describe evaluations of alternative plans investigated for various features of the Big River structures.

2. Spillway

a. Potential Sites. A careful study of the watershed indicates that there are only two potential sites for a spillway i.e., the left abutment and the right abutment of the dam. The right abutment was discarded as a site of the spillway since bedrock was at a considerable depth below the ground surface. Where a choice is available, a spillway cut into rock is preferred over a spillway founded on earth for economic reasons. The left abutment has bedrock at a favorable depth. Consequently, the right abutment was quickly discarded.

b. Left Abutment. Rock conditions favor either a chute type or side channel type spillway. The side channel was previously studied by a consulting firm on behalf of the State of Rhode Island. The side channel would include a spillway weir of 400 feet in length and a discharge channel about 40 feet wide and 1800 feet long. The estimated cost of the side channel spillway was determined to be less than the chute spillway. Hydraulically, a chute spillway is preferred over a side channel, all things being equal. Although for this report, a chute type spillway has been selected over a side channel, during advance design, a side channel should be considered when more design information is available.

3. Dam Structure

In addition to an earth embankment, a concrete structure has been investigated as an alternate for the dam structure. The concrete structure would be gravity type approximately 2,190 feet long with a top elevation of 310.0 (see Plates G-10 and G-11). A 400-foot segment of the structure would act as a spillway and would be built with a crest elevation at 303.0. The structure would be constructed on bedrock except for a 670 foot segment on the right abutment which would be located on till. The concrete structure would encompass multi-level intakes, inspection chamber, as well as operating room and machinery rooms. The cost of the concrete structure was determined to be $16,000,000 i.e., about $8,000,000 greater than the earth embankment and companion spillway. Although an earth embankment has been selected for economic reasons, the concrete structure or a combination of concrete earth structure should be reconsidered during an advance design stage when more engineering information is available.

4. Route I-95 Cutoff

A segment of Rte. I-95 extending from Nooseneck Hill Road easterly for a distance of approximately 8000 feet consists of a pervious foundation material which would permit an excessive amount of leakage from the reservoir. Three methods of reducing the leakage were investigated consisting of an impervious blanket, a cement-bentonite slurry wall and a combination of impervious blanket and slurry wall.

a. Impervious Blanket. The alignment for the impervious blanket was tailored to the topography essentially between Division Street and Rte. I-95. The blanket consists of impervious material carried down to level ground including a toe trench of 15 feet minimum depth, or to dense silty fine sand, and extending along the hillside with a minimum thickness of impervious material of 8 feet. The exposed face of the blanket in the pool fluctuation zone would be with rock slope protection and gravel bedding. (See Plates G-8 and G-9).

b. Cement-Bentonite Slurry Wall. The slurry wall alignment selected runs parallel to Route I-95 for a distance of approximately 8,000 feet. The slurry wall was carried down to a semi-impervious soil strata and was designed to be 4-feet thick. Recent advances in the state of the art indicate that cement-bentonite slurry walls as thin as 2 feet are being installed. A substantial savings in cost can be realized if a 2 foot thick wall is utilized. However, this analysis would be made during the advance design stage.

c. Combination Impervious Blanket and Slurry Wall. The topography indicates that in certain reaches, a slurry wall is more suitable whereas in other areas, an impervious blanket is preferable. This system proved to be less expensive than the pure slurry wall but more expensive than the impervious blanket.

d. Selected System. The impervious blanket proved to be the most economical and consequently has been used in the project plan. A substantial savings can be realized if future investigations permit thinner slurry walls.

5. Water Transmission Lines

In addition to the 84-inch tunnel with a carrying capacity of approximately 100 MGD, other conduit sizes were considered for projected future requirements. A tunnel program has also been developed to provide cost data for different diameter tunnels.

Initial estimates indicate that the 84-inch tunnel with a 7-inch precast reinforced concrete liner is more economical than the cut and cover installation for a reinforced concrete pressure pipe capable of carrying the same flow. Other considerations are shown in the following table.

Pipe Diameter (inches)	Tunnel Diameter (inches)	Flow Capacity MGD	Remarks
78	72	61.1	Estimated maximum day flow by year 2020.
90	84	100	Design Capacity
108	102	150	Ultimate development capability of Big River

E. CONSTRUCTION PROCEDURES AND DIVERSION PLAN

1. Big River Dam

The most critical year of construction for the embankment would be during the second year of construction. During that year, Big River would be diverted through the diversion conduits that would include a 5 feet x 5 feet conduit and a 90-inch pipe encased in concrete. Eventually, the 5 feet x 5 feet conduit would be used for flood control release and low flow regulation while the 90-inch conduit would be used to transmit water from the reservoir to the treatment plant. Upon completion of the two conduits, the diversion would be accomplished by constructing an upstream cofferdam across the river to a minimum elevation. Construction of the cofferdam would be initiated after the heavy river flows have subsided. A downstream cofferdam would be constructed (lagging slightly behind) to protect against back water. Once the embankment site is isolated, dewatered and the river bottom cleaned, placement of the embankment materials would be initiated.

F. ACCESS ROADS

1. General

Access roads would be provided to service the completed project features within the State (WRB) owned property. Principal features to which access would be provided are the dam, spillway and the water treatment plant. An access road will be built from Harkney Hill Road to the top of the dam to provide access to the Gate House. (See Par. 2a.) Another road will be provided from Nooseneck Hill Road to the water treatment plant. The present road network is considered suitable for travel between the dam and the water treatment plant and a new access road is not required between these sites. Provisions for access by emergency and maintenance vehicles to isolated ares are not included under the scope of this project, but may be included under conservation and watershed management programs as operation plans are developed. Until such time as inundation occurs, the areas would be adequately serviced by roads and trails. Haul and other temporary toads would either be inundated or obliterated upon completion of construction.

G. CONSTRUCTION MATERIALS

1. General

The embankment section for the rolled earth fill dam will be of the zoned type with impervious and random fill zones, drainage features, upstream and downstream rock slope protection.

2. Impervious Material

A source of material suitable for use in the impervious sections of the embankment blanket is located on the east side of the valley known as Hungry Hill. The right abutment of the dam ties into the northern limit of the hill. The material needed for the embankment will be taken from an area to be inundated.

3. Pervious and Random Material

Materials from required excavation will consist of outwash materials, lake sediments and till which may be modified within wide limits. All these materials will be utilized in the random fill portion of the embankment. Pervious materials will be obtained from borrow areas developed within the reservoir area.

4. Embankment Drainage Materials, Gravel Bedding and Road Gravel

Extensive deposits of sands and gravels occur in the region within 25 miles of the site and commercial operations are active in several of these deposits. It is currently planned that drainage materials, gravel bedding and road gravel will be furnished by the Contractor from offsite sources.

5. Rock Slope Protection and Riprap

Rock from required excavations will be available for rock slope protection and riprap. Estimated quantities of rock to be excavated are sufficient for the upstream and downstream slope protection and rock toe of the dam and rock slope protection along the Route I-95 impervious blanket.

H. ENVIRONMENTAL QUALITY ENHANCEMENT

1. General

Final design of the Federal portion of this project would incorporate the environmental quality objectives required by Corps of Engineers Manual (EM) 1110-2-38. The design of the water treatment plant and appurtenant facilities would be the responsibility of others. In addition to the ecological and cultural values discussed elsewhere, there would be aesthetic values to be considered in designing the project.

2. Architectural Design

Mass relationships and architectural concepts would be visualized and then integrated into the design and related to surroundings insofar as possible. Structures and facilities would be designed to fulfill the functional needs and present neat, clean lines with uncluttered appearance. Predominant project structures would be the earth fill dam, spillway, and outlet works. Architectural detailing and materials would be selected on the basis of the design concepts and appropriateness in relation to the adjacent environment.

3. Landscape Architecture

As an integral part of the design and construction, landscape architectural development would be utilized for aesthethic enhancement of project features. The goal of site planning for project facilities including roads, parking lots, overlooks, and recreation areas, is to have them "blend" both visually and physically with their immediate surroundings in such a way that they retain the character of the area, insofar as possible. Various types of materials and techniques would be relied on to perform numerous functions in the landscape development phases of construction. Where feasible, vegetation would be used to emphasize, accent or blend project facilities to their surroundings. Groupings of trees and shrubs would be used as focal points and specimen plantings would add color, variety, and form to the landscape. Plant materials would also perform the physical function of screening in those areas where visually obtrusive objects may be located. Vegetation would also be employed to separate areas that have different functions, e.g. public parking facilities, project storage and work areas. Plantings of grasses and other vegetation would be utilized for slope stabilization and erosion control in those areas where maintenance operations could be a problem or not be practical. Restoration of possible borrow areas and lands disturbed by construction activities would be accomplished by reseeding and planting to insure a minimal amount of landscape defacement. The degree of landscape restoration would vary, with some areas undergoing total reforestation and others just reseeding. Native vegetation would be utilized in all planting plans to insure that they blend properly to the surrounding environment.

I. RELOCATIONS

1. General

Within the project area are a number of existing features which would require relocation, abandonment, or reconstruction. Several vehicle ways which range from unpaved roads to numbered state highways pass through the reservoir areas or dam and spillway sites and would have to be relocated or reconstructed, in part, to by-pass the inundated areas, etc. Roads which would no longer be required for access would be abandoned. (See Plate G-3). Existing water, gas, sanitary and storm sewers, telephone and electrical utilities which would conflict with construction of the project would be identified and provisions made for relocation, either on a temporary or permanent basis. Relocation of 17 small cemeteries within the inundated areas of the reservoir would be included in the construction of the project.

J. CONSTRUCTION FACILITIES

1. Contractor's Facilities

The construction of the project will require a moderate size work force with varied construction skills, but largely in the heavy equipment and semiskilled trades. Within the greater Providence area, there is a sufficient number of workers who would commute to work and not require housing near the project. There would be a need for administration, mobilization, storage, and maintenance areas in several locations throughout the project. In the vicinity of the reservoir and dam construction activities, there would be suitable space designated for such areas within the State owned property. The Contractor for the water transmission line beyond the treatment plant would be required to make his own arrangements for use of such areas as would suit his operations. Temporary facilities required by the Contractor would be removed at the conclusion of work and the site(s) restored, or finished, as required.

2. Government Facilities

A field office would be required in the vicinity of the project. There are serveral existing residences near the dam site which will eventually be removed and one or more could be utilized for office purposes, if agreeable to the Water Resources Board which has title to them. An alternative field office arrangement would be the use of winterized office trailers furnished as an ancillary obligation under the construction cost.

K. SCHEDULE OF CONSTRUCTION

1. Relocations

Harkney Hill Road passes through the dam site and certain elements of construction must be initiated early in the construction program in order to clear the work area for construction of the spillway and embankment. Since the removal of the segment of road in the vicinity of the dam would not isolate residences on either end, only the relocation of utilities need be accomplished prior to construction of the embankment. Relocation of utilities on Harkney Hill Road would be initiated and completed in Construction Year One. Construction of the new segment of Harkney Hill Road would be part of the embankment contract since a segment of the road is built integrally with the embankment. Relocation of the Nooseneck Hill, Congdon Mill, Hopkins Hill Roads, as well as the New London Turnpike, do not interfere with construction of the embankment and are expected to be accomplished while the dam is being built. Construction of the relocation of electrical distribution and telephone lines would be accomplished under separate contracts negotiation with the respective utility company.

2. Dam and Appurtenant Structures

Construction of the dam, outlet works, spillway, Harkney Hill Road and clearing of the reservoir would be accomplished under a single continuing contract to be awarded in the middle of Construction Year One when the utilities on Harkney Hill Road have been completed. An estimated construction schedule follows:

a. First Season of Dam Construction. During the remainder of the construction season (remainder of Construction Year One) mobilize and initiate construction of the access roads and complete the clearing and grubbing of the sites of the structures and a segment of the borrow area and initiate excavation and construction of the outlet works.

b. Second Season of Dam Construction. The Contractor will complete the excavation of the outlet works and by June must complete the inlet and outlet channel, the intake tower to an elvation above the permanent cofferdam, the conduit, the stilling basin, and initiate excavation of the spillway discharge channel. He will construct by 1 July temporary cofferdams upstream and downstream of the dam site and divert Big River through the outlet works. After the diversion has been completed, the Contractor will strip the remainder of the dam site, construct the cofferdam and initiate and complete the foundation grout curtain. The Contractor will also continue as needed the cofferdam.

c. Third Season of Dam Construction. With return of favorable weather, the Contractor will continue with placement of the embankment fill, excavation of the spillway channel, complete the construction of the intake tower and the placing of the spillway concrete.

d. Fourth Season of Dam Construction. The clearing of the reservoir will be completed as will the buildings. The service bridge will be constructed and the remainder of the earth slopes will be protected with stone protection. All work is expected to be completed by June.

L. **ESTIMATE OF COST**

ESTIMATE OF COST
DAM AND APPURTENANCES
(JANUARY 1979 PRICE LEVELS)

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	AMOUNT
02. RELOCATIONS					
1. Roads					$2,260,000
2. Cemeteries and Utilities					
Cemeteries					403,000
Utilities - Electric	$400,000				
Telephone	790,000				
Gas	20,000				
Water	10,000				1,220,000
		Sub-Total - 02. RELOCATIONS			$3,883,000
		Contingencies (20%)			779,000
TOTAL - 02. RELOCATIONS					$4,660,000
03. RESERVOIR					
1. Clearing		2,800	Ac.	700	$1,960,000
		Sub-Total - 03. RESERVOIR			$1,960,000
		Contingencies (20%)			392,000
TOTAL - 03. RESERVOIR					$2,352,000

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
04. DAM				
1. Site Clearing	1	Job	L.S.	$ 50,000
		Sub-Total - 1.	Site Clearing	$ 50,000
2. Dam				
Diversion Cofferdam and Control of Water	1	Job	L.S.	$ 120,000
Stripping, Including Grubbing	18,000	C.Y.	1.50	27,000
Excavation, Cutoff Trench & Toe Drain	143,000	C.Y.	1.50	214,500
Grout Curtain	1	Job	L.S.	375,000
Rock Fills	49,000	C.Y.	4.50	220,500
Gravel Fills	27,000	C.Y.	4.00	108,000
Sand Fills	130,500	C.Y.	8.00	1,044,000
Compacted Impervious Fill	174,000	C.Y.	2.20	382,800
Compacted Random Fill	189,000	C.Y.	.60	113,400
Bituminous Concrete Paving	5,600	S.Y.	4.25	23,800
Guard Railing	4,700	L.F.	9.00	42,300
		Sub-Total - 2.	Dam	$2,671,300
3. Outlet Works				
Preparation of Site	1	Job	L.S.	$ 10,000
Excavation, Earth	72,000	C.Y.	1.50	108,000
Excavation, Rock	5,500	C.Y.	6.00	33,000
Rock Slope Protection	1,000	C.Y.	6.00	6,000
Gravel Bedding	500	C.Y.	5.00	2,500
Concrete - Retaining Walls	550	C.Y.	80.00	44,000

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
3. Outlet Works - (continued)				
Concrete - Intake Tower to El. 299.0	1,470	C.Y.	150.00	220,500
Concrete - Above El. 299.0	270	C.Y.	280.00	75,600
Concrete - Conduit and Transition	2,000	C.Y.	90.00	180,000
Concrete - Junction Structure	110	C.Y.	120.00	13,200
Concrete - Outlet Structure	180	C.Y.	120.00	21,600
Concrete - Service Bridge Abutment	200	C.Y.	140.00	28,000
Concrete - Bridge Superstructure	40	C.Y.	250.00	10,000
Service Bridge - Structural Steel	1	Job	L.S.	50,000
90-inch RCP	320	L.F.	110.00	35,200
Misc. Items - Tower	1	Job	L.S.	245,000
Gates and Accessories	1	Job	L.S.	340,000
	Sub-Total - 3.		Outlet Works	$1,422,600
4. Spillway				
Preparation of Site	1	Job	L.S.	$ 14,000
Excavation, Earth	190,000	C.Y.	1.50	285,000
Excavation, Rock	185,000	C.Y.	4.40	814,000
Concrete, Mass	3,700	C.Y.	90.00	333,000
Concrete, Lining	6,850	C.Y.	115.00	787,800
Drilling for Anchors	35,000	L.F.	5.00	175,000
#11 Anchors	190,000	LB	0.40	76,000
Drain Holes	8,400	L.F.	10.00	84,000
Chain Link Fencing	3,800	L.F.	7.50	28,500
	Sub-Total - 4.		Spillway	$2,597,300

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
5. **Impervious Blanket - (at Division Street)**				
Preparation of Site	1	Job	L.S.	$ 100,000
Excavation, Earth	700,000	C.Y.	1.40	980,000
Impervious Borrow	680,000	C.Y.	1.50	1,020,000
Rock Slope Protection	53,000	C.Y.	6.00	318,000
Gravel Bedding	53,000	C.Y.	5.00	265,000
Compacted Impervious Fill	590,000	C.Y.	.80	472,000
Compacted Random Fill	116,000	C.Y.	.60	69,600
Topsoil, seeded	12,400	C.Y.	6.00	74,400
	Sub-Total - 5. Impervious Blanket			$ 3,299,000
	Sub-Total - 04. DAM			$10,040,200
	Contingencies (20%)			2,007,800
TOTAL - 04. DAM				$12,048,000
06. WATER TRANSMISSION LINES				
1. Water Transmission Line to Treatment Plant	1	Job	L.S.	$ 856,000
2. Water Transmission Line to Connector	1	Job	L.S.	16,488,000
	Sub-Total - 06. WATER TRANSMISSION LINES			$17,344,000
	Contingencies (20%)			3,469,000
TOTAL - 06. WATER TRANSMISSION LINES				$20,813,000

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
08. ROADS				
Access Road to Dam	1	Job	L.S.	$ 17,000
Access Road to Water Treatment Plant	1	Job	L.S.	18,000
	Sub-Total - 08. ROADS			$ 35,000
	Contingencies (20%)			7,000
TOTAL - 08. ROADS				$ 42,000
19. BUILDINGS, GROUNDS AND FACILITIES				
Buildings, Grounds and Facilities	1	Job	L.S.	$ 150,000
	Sub-Total - 19. BUILDINGS, GROUNDS AND FACILITIES			$ 150,000
	Congingencies (20%)			30,000
TOTAL - 19. BUILDINGS, GROUNDS AND FACILITIES				$ 180,000
20. PERMANENT OPERATING EQUIPMENT				$ 100,000
	Sub-Total - 20. PERMANENT OPERATING EQUIPMENT			$ 100,000
	Contingencies (20%)			20,000
TOTAL - 20. PERMANENT OPERATING EQUIPMENT				$ 120,000
	TOTAL ESTIMATED PROJECT COST			$40,215,000*

*Lands and Damages, Water Treatment Plant, Recreation, Cultural Resources Preservation, Engineering and Design, Supervision and Administration costs not included.

M. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

1. Introduction

The estimated first costs and average annual costs of the detailed water resources plans considered in this study are presented in Appendix J, "Economics". Cost estimates of the intermediate and detailed plans for flood protection are contained in "Attachment 1" of the study report while cost estimates of intermediate water supply management alternatives were derived from data contained in subsequent paragraphs of this section and from a computer-assisted cost estimating model developed by the Corps of Engineers. The computer model, Methodology for Areawide Planning Studies (MAPS), is a tool developed by the Environmental Laboratory of the U.S. Army Engineer Waterways Experiment Station to assist in the screening of water supply alternatives. The model utilized unit cost data, for the various elements of water supply development, considered applicable to the study area. First costs of the plans include charges arising from construction of the projects, including costs of contingencies, engineering, design, supervision and administration. Items included in the cost estimates are reservoir and dam construction, groundwater development costs, aqueduct, transmission mains, pumping stations, relocations, reconstruction costs, channel improvements, dikes and floodwalls, recreation facilities, contingencies, engineering and design, supervision, administration and overhead, and real estate costs. The estimates also include the cost of mitigation measures and the demand modification program.

Generalized cost estimating data developed for water supply studies conducted as part of the entire PNB water resources investigations were utilized for all groundwater development costs, water treatment facilities, sludge treatment facilities, transmission mains and pumping stations. These costs were updated to January 1979 price levels equivalent to an Engineering News Record (ENR) Construction Cost Index of 2870.

Detailed cost estimates of the proposed Big River Reservoir and aqueduct facilities were presented in preceding sections of this appendix. Preliminary estimates of real estate costs for the aqueduct and reservoir development are presented in Attachments G1 and G2 respectively at the end of this Appendix G. Each of these cost estimates was undertaken to provide detailed costs of the water resources elements considered part of any Federal project and also due to the overall significance of these items in the determination of project feasibility.

An allowance for contingencies, equal to 20 percent of construction costs, was included in the estimated costs of detailed plans to account for unforeseen conditions and due to the extent of basic data.

The following paragraphs in this section describe the components included in cost estimates of the various water resources plans that were derived from detailed and generalized cost estimating data.

2. Wellfield Development

The total construction costs for wellfield development shown on Plate G-12 include the costs of aquifer exploration and testing, the production well, well pumping station and intra-wellfield pipelines, where required.

The costs for exploration and testing at each well site include drilling three 2-½ inch exploration wells, drilling one 8 or 10 inch well for test pumping, drilling three 2-½ inch observation, wells and test pumping the large diameter well for a period of five days. The cost for these items are based on current estimates obtained from local well drillers operating in the study area.

The construction costs for production wells are based on bid prices from local well drillers during the past several years. The costs include the construction of the well and a three-day pump test to size the final pumping equipment.

Well pumping station construction costs are also based on bid prices from local contractors over the past several years. The costs of the station include the pump, motor, well house, site work, wiring, controls and other miscellaneous instrumentation and appurtenances including disinfection equipment. An allowance of $2000 per acre has been added to wellfield development costs for the cost of real estate.

The construction costs of intra-wellfield pipelines were included where more than one well would be required to satisfy the water demand. For multi-well systems, wells were spaced at distances of 500-1500 feet depending on the capacity, and interconnecting pipelines were sized to carry the anticipated maximum flow. Costs were based on current prices for ductile iron pipe and the cost of installation in sandy, undeveloped terrain.

3. Surface Water Treatment Facilities

Construction costs for water treatment facilities shown on Plates G-13(a) and G-13(b) are based on conventional alum coagulation followed by sedimentation, filtration and disinfection. The costs were developed from actual bid prices and construction cost estimates for similar projects. All cost data for treatment plants were based on facilities located in the northeastern region of the United States with the greatest concentration in New England. The cost data used represent plants of approximately four hour detention time for settling and a filtration rate of four gallons per minute per square foot.

Construction costs include site development, administration, chemical storage and control buildings, rapid mixing, flocculation, sedimentation, filtration and disinfection. Costs of high-lift pumping stations and on-site mechanical alum sludge treatment, which were included in the bid price or construction estimate for a plant, were extracted from the cost. High-lift pumping facilities, in all cases where required, were estimated separately.

4. Alum Sludge Treatment Facilities

Construction costs for on-site mechanical alum sludge treatment shown on Plate G-14 include proportioned costs of the water treatment facilities control building, filter washwater settling, washwater and clarifier sludge thickening, and either filter presses, vacuum filters or centrifuges as a method of sludge dewatering for ultimate land disposal. The inclusion of alum recovery facilities for plants 50 mgd and larger was assumed.

5. Pumping Stations

Pumping station construction costs shown on Plates G-15(a) and G-15(b) are based on bid prices for projects constructed in the region and include the pump house, site work, instrumentation, inside piping, valves, auxiliary power generation, pumps and standby pumps.

6. Transmission Mains

The construction costs of all water transmission mains with the exception of the Big River Reservoir aqueduct (tunnel) include the following: pipe, excavation, backfill, bedding, laying, valves and fittings and are shown on Plate G-16. An allowance of 15 percent of total excavation for rock and minimum 4-foot cover were assumed for all sizes. For mains 8 to 36 inches in diameter, the costs include a hydrant and valve assembly every 1,000 feet. Ductile iron pipe was considered for those sizes while reinforced concrete pressure pipe was considered for all larger sizes. An allowance of $3.00 per linear foot has been allowed for the purchase of pipeline easements. Paving costs are excluded as transmission mains were assumed to run cross-country or off the travelled way where constructed in public rights-of-way.

7. Tunnel Estimates

The construction cost for the tunnel was prepared utilizing a computerized tunnelling program, assuming a mechanical rock tunnelling (MOLE) method of construction. Factors used in developing the estimates were based on recent geophysical exploration and test data. A profit margin of 5 percent and an overhead margin of 30 percent were used for the program. Detailed tunnel investigations are presented in Appendix F, "Geotechnical Investigations", and provide the basis of cost estimates based upon straight-line, minimum distance determination.

8. Interest During Construction

This is the additional investment necessary to construct the project. Interest during construction was estimated by multiplying the 7-3/8 percent interest rate by one-half the estimated construction period times the estimated total project first cost.

9. Engineering and Construction Services

Cost estimates for engineering and design and construction supervision, administration and overhead were taken as a percentage of the estimated total construction cost. Percentages used are taken from a 7 January 1974 directive from the Office, Chief of Engineers.

10. Operation and Maintenance Costs

Annual operation and maintenance costs for all project components were taken as a percentage of estimated construction cost and are based on recent actual costs. Costs for surface water treatment facilities shown on Plate C-17 were taken as 5 percent of construction costs and are based on costs for labor, supplies and materials, power and chemicals.

Operation and maintenance costs for alum sludge waste treatment facilities were considered similar to those for water treatment facilities. Costs also include sludge hauling to landfill. O&M costs for waste treatment and removal facilities were estimated at 5 percent of total construction cost.

Annual operation and maintenance costs for other structural componenets were based on a percentage of the total capital cost of the component. The percentages used were 1 percent for transmission mains, and 3 percent for pumping stations and wells (excluding electric power costs). Estimated average annual operation and maintenance costs associated with the Big River Reservoir and dam are based on past experience with Corps reservoir projects in New England.

11. Electric Power Charges

Cost of electric power were estimated separately from operation and maintenance costs for surface and groundwater pumping stations as they represent such a large percentage of the operating costs of these facilities. Costs are based on the general service rates, charged by electric utilities in the study area. These costs are shown on Plate G-18 and include a demand, energy, and fuel adjustment charge.

12. Annual Charges

Water resources management plans considered for the study area were evaluated using present worth economic analyses as presented in Appendix J, "Economics". All features of the plans such as reservoirs, dams, aqueducts, water and sludge treatment structures, pumping station structures, and transmission mains were estimated to have a useful project life of 100 years, provided an adequate maintenance program is adhered to. This project life was also considered the economic life of all water resources components in deriving equivalent average annual costs.

The interest rate used to convert investment costs (project first cost plus interest during construction) to an equivalent annual cost was based on the 100-year economic life at 7-3/8 percent. Likewise, the amortization period, which is the period of time selected for economic recovery of the net investment in a project, was based on the 100-year life at an interest rate of 7-3/8 percent.

The annual cost of mechanical equipment, for pumping stations, water treatment facilities, and sludge treatment facilities, that would be expected to be replaced before the end of the project life was estimated by calculating the future cost of its replacement, determining the present worth of that value, and then converting the amount to an equivalent average annual value over the entire period of economic analysis. The project life of all major mechanical equipment was assumed to be 30 years which meant that replacement costs would be expected a maximum of three times during the 100-year analysis period. Equipment costs for pumping stations were estimated at 60 percent of total construction costs while those for water and sludge treatment facilities were estimated to be 40 percent.

All of the equivalent annual costs for the items identified above in addition to average annual operation and maintenance costs associated with plan components provide the basis for equivalent average annual costs used in economic justification evaluations.

13. Phasing of Development

Phasing of structural development is generally more preferable to an immediate investment in total development for several reasons. Postponing construction of facilities that would not be needed for many years permits public funds to be utilized for other purposes in the intervening years. There is also the possibility that projected requirements may not materialize and the need for later stage developments would not exist. Phasing of facilities will generally result in a lower present worth cost than an immediate investment in total development. This is so because discounting future expenditures back to the present will realize a greater savings than the small economies of scale possible in providing full capacity initially for all facilities, in most considerations. Phasing of pipeline construction would never be expected to yield a lower present worth value because of the associated economies of scale.

To facilitate the phasing of development the following considerations were made:

1. Costs of facilities were assumed to occur at the same time as the facility would be required to go on-line. It was recognized that funds for the various projects would have to be committed prior to the expected time of need.

2. Costs for facilities required to meet existing deficiencies were assumed to occur in 1980. It was recognized that funds could not possibly be committed to meet 1980 requirements but instead emphasize the immediate need for such facilities.

3. Generally, new groundwater supply facilities were staged to meet projected demands for at least five years.

4. It was assumed that transmission mains (including tunnel facilities) would be constructed to full projected capacity at the outset rather than in several stages.

N. ALLOCATION OF COSTS

1. Introduction

Information presented in this section describes the procedures used to allocate the costs of the multiple-purpose Big River Reservoir project which was considered for Federal implementation. The procedure allocates total investment costs and equivalent average annual costs for operation, maintenance, and major equipment replacement among the project purposes and in so doing presents an analysis of each purpose's economic justification.

The purpose of the cost allocations shown in Table 1 is to distribute project costs so that all project purposes share equitably in the savings of multiple-purpose construction. The Separable Cost Remaining Benefits (SCRB) method of cost allocation was used to distribute project costs among the three project purposes. The costs allocated to a particular purpose cannot exceed the corresponding benefits of that purpose. Likewise each purpose will be allotted at least its separable cost, the separable cost being the difference in cost between the recommended project and the dual purpose project with that one project purpose missing.

Benefits - The benefits for each project purpose are estimates and discussed in Appendix J, "Economics". Flood damage reduction benefits were considered as the value of damages prevented by the project. Water supply benefits were considered equal to the cost of the least expensive alternative that would provide the needed water. For this study it was considered to be a single-purpose water supply reservoir at the Big River site. The recreation benefits as discussed in Appendix H, "Recreation and Natural Resources", were calculated on a cost per user day basis.

Alternative Projects - The SCRB allocation procedure requires several alternative project estimates to be determined. The multiple-purpose project, is of course estimated; however, it is also necessary to prepare estimates of alternative projects that have one of the project purposes missing. For this study cost estimates were prepared for three dual-purpose projects: 1) water supply and recreation; 2) flood damage reduction and recreation, and 3) flood damage reduction and water supply.

The estimates of costs associated with dual-purpose projects enable the calculation of separable costs by project purpose. For instance, the separable cost of flood damage reduction would be calculated by subtracting the cost of the dual-purpose water supply and recreation project from the proposed multiple-purpose project. The difference is the amount that would be added to the dual-purpose project for flood damage reduction to be included as a project purpose.

Cost estimates were also developed for three single-purpose projects, each to provide one category of the project benefits that would be developed by the multiple-purpose project.

The dual-purpose alternatives developed considered reservoirs at the project site. Pool levels varied since each project was designed for only two of the three project purposes. The single-purpose flood damage reduction alternative is a reservoir at the site, as is the single-purpose water supply alternative. The single-purpose recreation project, however, did not consider development of a reservoir. It was found that the least expensive alternative for developing recreation benefits of the same magnitude as would be generated by the multiple-purpose project, would be several recreational sites that are located on the State-owned lands at the Big River site, but do not presently optimize recreational opportunity. The single-purpose recreation alternative therefore consists of land based recreational development at the Big River site and water based development at the Carr Pond and Phelps Pond sites.

Joint Use and Specific Costs - Elements that make up the project cost must be categorized as use specific or joint-use. Specific costs are defined as the costs of project features that normally serve only one project purpose. The test of whether or not the cost of an item of construction is specific or not is to consider how the project would function if that item were removed from the project. For the multiple-purpose project, specific costs were considered for the water supply and recreation components only, as no costs could be specifically assigned to the flood damage reduction features. Costs associated with the raw water aqueduct from the reservoir to the proposed water treatment facilities were included in the specific costs of the multiple-purpose project.

Part of the cost of recreation is incurred in developing $66,000 of benefits, while part of the cost goes into mitigating the $99,000 annual loss of existing recreational opportunities in the area if the Big River Reservoir project were built. Recreation facilities included in the multiple-purpose project therefore serve to generate both new benefits and to mitigate the loss of existing recreation opportunity. Since recreation mitigation would be necessary if the proposed reservoir were built (with or without new recreation opportunity) it is a non-specific or joint-use element of cost. However, the costs associated with new recreation development are considered specific costs and were so included.

Construction Period - A four-year construction period was assumed to be most realistic for the larger alternative projects where water supply is a major project purpose. The smaller project alternatives with less capital expenditures were considered as having a two-year construction period.

Interest Rate - The approved Fiscal Year 1981 government interest rate is 7-3/8 percent. This rate was used in the project evaluation.

Project Life - A 100-year project economic life was considered for the Big River Reservoir project. With normal maintenance and the periodic replacement of items subject to wear the project is expected to be fully functional well beyond the 100-year period.

Interest During Construction - It was considered reasonable to expect that construction expenditures, including real estate costs, would be equally distributed over the 2 and 4-year construction periods. Interest during construction costs were therefore computed as one-half the construction period multiplied by the interest rate multiplied by the construction expenditure.

Estimates - Cost estimates were prepared for all of the alternative projects described above. Preconstruction engineering and design, supervision and administration during construction and real estate costs were all added to the construction cost estimates to arrive at the total investment costs used in the allocation procedures.

Operation and Maintenance - Estimates were made of the average annual operation and maintenance expenses associated with the multiple-purpose project and each of the alternatives. The estimates were based on past experience on Corps reservoir projects of approximately similar size in the New England area.

Operation and maintenance costs of recreation facilities were estimated at $45,000 annually. The cost, as with capital expenditure for recreational facilities, was considered both a joint-use cost and a specific cost because, as discussed earlier, the recreation facilities serve to both generate new benefits and to mitigate the loss of existing recreation opportunity in the area.

Major Replacements - Because of the relatively small amount of replaceable items and the high interest rate (low amortization), major replacements were found to play an insignificant role in project evaluation.

Loss of Taxes on Land - The land on which the project would be located is now owned by the State of Rhode Island and yields no taxes. Therefore, the project would incur no tax losses.

Net Loss to Fish and Wildlife - Measures, including the enhancement of certain land and habitat were included in the multiple-purpose project considerations. For this reason, it is felt that the project would not incur a net loss to the region's fish and wildlife resources.

TABLE 1

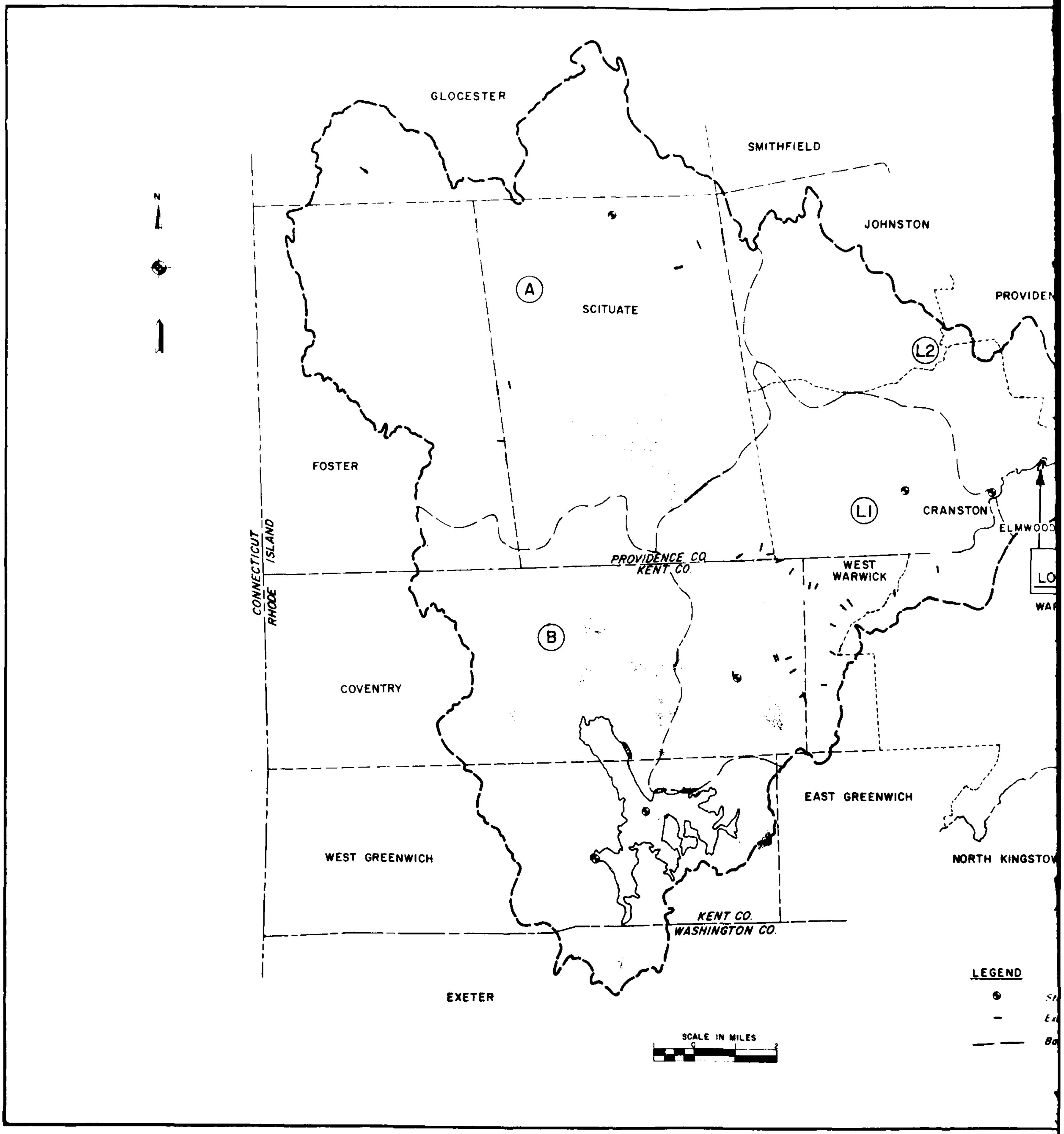
SUMMARY OF COST ALLOCATIONS
(In Thousands of Dollars - January 1979 Price Level)

	ALTERNATIVE DUAL PURPOSE PROJECTS			ALTERNATIVE SINGLE PURPOSE PROJECT		
	WATER SUPPLY AND RECREATION	FLOOD CONTROL AND RECREATION	FLOOD CONTROL AND WATER SUPPLY	FLOOD CONTROL	WATER SUPPLY	RECREATION
CONSTRUCTION PERIOD (Years)	4	[illegible]	4	2	[illegible]	[illegible]
INVESTMENT AND ANNUAL CHARGES						
Construction Expenditure	56,3[illegible]	14,660	57,220	13,630	50,0[illegible]0	470
Interest During Construction	8,306	1,081	8,440	1,005	8,264	35
Present Val. of Future Rec. Fac.	-	-	-	-	-	-
Total Investment	64,616	15,741	65,660	13,635	54,329	505
Annual Charges						
Interest / Amortization	4,769	1,162	4,846	1,080	4,748	[illegible]
Operation & Maintenance	370	230	355	220	355	-
Major Replacements	1	-		-	1	
Loss of Taxes on Land	-	-	-	-	-	-
Net Loss to Fish & Wildlife	-	-	-	-	-	-
TOTAL ANNUAL CHARGES	5,140	1,392	5,202	1,300	5,104	82

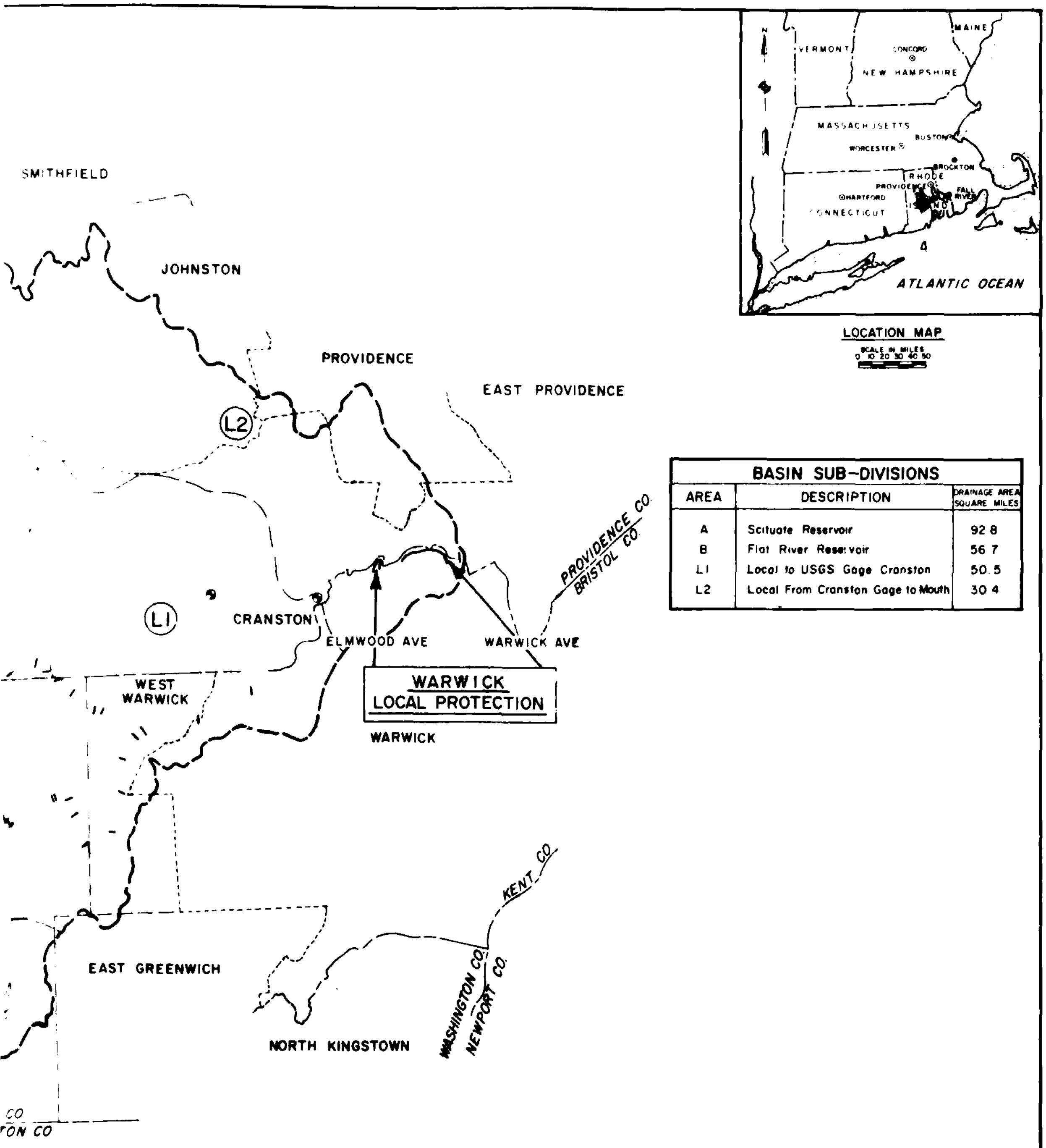
	MULTIPLE-PURPOSE PROJECT				
	SPECIFIC COSTS				
CONSTRUCTION PERIOD (Years)	FLOOD CONTROL	WATER SUPPLY	RECREATION	JOINT USE COST	TOTAL 4
INVESTMENT AND ANNUAL CHARGES					
Construction Expenditure	-	1,230	410	55,820	57,460
Interest During Construction	-	181	60	8,234	8,4[illegible]
Present Val. of Future Rec. Fac.	-	-	-	-	[illegible]
Total Investment	-	1,411	470	64,054	[illegible]
Annual Charges					
Interest / Amortization	-	104	35	4,728	[illegible]
Operation & Maintenance	-	10	15	345	3[illegible]
Major Replacements	-	-	-	1	[illegible]
Loss of Taxes on Land	-	-	-	-	-
Net Loss to Fish & Wildlife	-	-	-	-	-
TOTAL ANNUAL CHARGES	-	114	50	5,074	5,238
ALLOCATION OF ANNUAL CHARGES					
Benefits	782	5,104	66	-	5,952
Alternate Cost	1,300	5,104	82	-	6,486
Benefits Limited by Alternate Cost	782	5,104	66	-	5,952
Separable Cost	98	3,846	36	-	3,990
Remaining Benefits	684	1,258	30	-	1,972
Ratio of Remaining Benefit - %	34.686	63.793	1.521	-	100.000
Allocated Joint Costs	436	803	19	-	1,258
TOTAL ALLOCATION, PROJECT COST	534	4,649	55	-	5,238
ALLOCATION OF LOSS OF PRODUCTIVITY					
Separable Costs	-	-	-	-	-
Allocated Joint Costs	-	-	-	-	-
Total Allocations	-	-	-	-	-
ALLOCATION OF O&M					

Total Investment	-	1,411	[illegible]		
Annual Charges					
Interest }		[illegible]			
Amortization }					
Operation & Maintenance	-	[illegible]			
Major Replacements	-	-			
Loss of Taxes on Land	-	-	-	-	
Net Loss to Fish & Wildlife	-	-	-	-	
TOTAL ANNUAL CHARGES	-	114	50	[illegible]	[illegible]
ALLOCATION OF ANNUAL CHARGES					
Benefits	782	5,104	66	-	[illegible]
Alternate Cost	1,300	5,104	82	-	6,486
Benefits Limited by Alternate Cost	782	5,104	66	-	5,952
Separable Cost	98	3,846	36	-	[illegible]
Remaining Benefits	684	1,258	30	-	1,972
Ratio of Remaining Benefit - %	34.686	63.793	1.521	-	[illegible]
Allocated Joint Costs	436	803	19	-	[illegible]
TOTAL ALLOCATION, PROJECT COST	534	4,649	55	-	5,238
ALLOCATION OF LOSS OF PRODUCTIVITY					
Separable Costs	-	-	-	-	-
Allocated Joint Costs	-	-	-	-	-
Total Allocations	-	-	-	-	-
ALLOCATION OF O&M					
Separable Costs	-	140	15	-	[illegible]
Allocated Joint Costs	75	137	3	-	-
Total Allocation	75	277	18	-	
Specific Costs	-	10	15	-	-
Allocated Joint-Use Costs	75	267	3		
ALLOCATION OF MAJOR REPLACEMENTS					
Separable Costs	-	-			
Allocated Joint Costs	-	1	-	-	
Total Allocations	-	1	-	-	
ALLOCATION OF INVESTMENT & FIRST COST					
Annual Investment	459	4,371	37	-	[illegible]
Allocated Investment	6,224	59,212	499	-	65,935
Present Val. of Future Rec. Fac.	-	-	-	-	-
Ratio of Allocated Annual Investment - %	9.440	89.803	0.757	-	[illegible]
Initial Construction Expenditure	5,424	51,601	435	-	57,460
ALLOCATION OF CONSTRUCTION EXPENDITURE					
Specific Investment	-	1,411	470	-	[illegible]
Construction Expenditure in Joint-Use Facilities	5,424	50,371	25	-	[illegible]
Percent of Construction Expenditures in Joint Use Facilities	9.717	90.238	0.046	-	100.000
Construction Expenditures in Specific Facilities	-	1,230	410	-	1,640
Total Construction Expenditures	5,424	51,601	435	-	57,460
SUMMARY					
Total Construction Expenditures	5,424	51,601	435	-	[illegible]
Annual Costs	534	4,649	55	-	5,238
Annual Benefits	782	5,104	66	-	[illegible]
Benefit/Cost Ratio	1.46	1.10	1.20	-	[illegible]

2



GLOCESTER
SMITHFIELD
JOHNSTON
PROVIDEN
A
SCITUATE
L2
FOSTER
L1
CRANSTON
ELMWOO
CONNECTICUT
RHODE ISLAND
PROVIDENCE CO.
KENT CO.
WEST WARWICK
LO
WA
B
COVENTRY
EAST GREENWICH
WEST GREENWICH
NORTH KINGSTO
KENT CO.
WASHINGTON CO.
EXETER
LEGEND
SCALE IN MILES
0
2
N



BASIN SUB-DIVISIONS

AREA	DESCRIPTION	DRAINAGE AREA SQUARE MILES
A	Scituate Reservoir	92.8
B	Flat River Reservoir	56.7
L1	Local to USGS Gage Cranston	50.5
L2	Local From Cranston Gage to Mouth	30.4

LEGEND

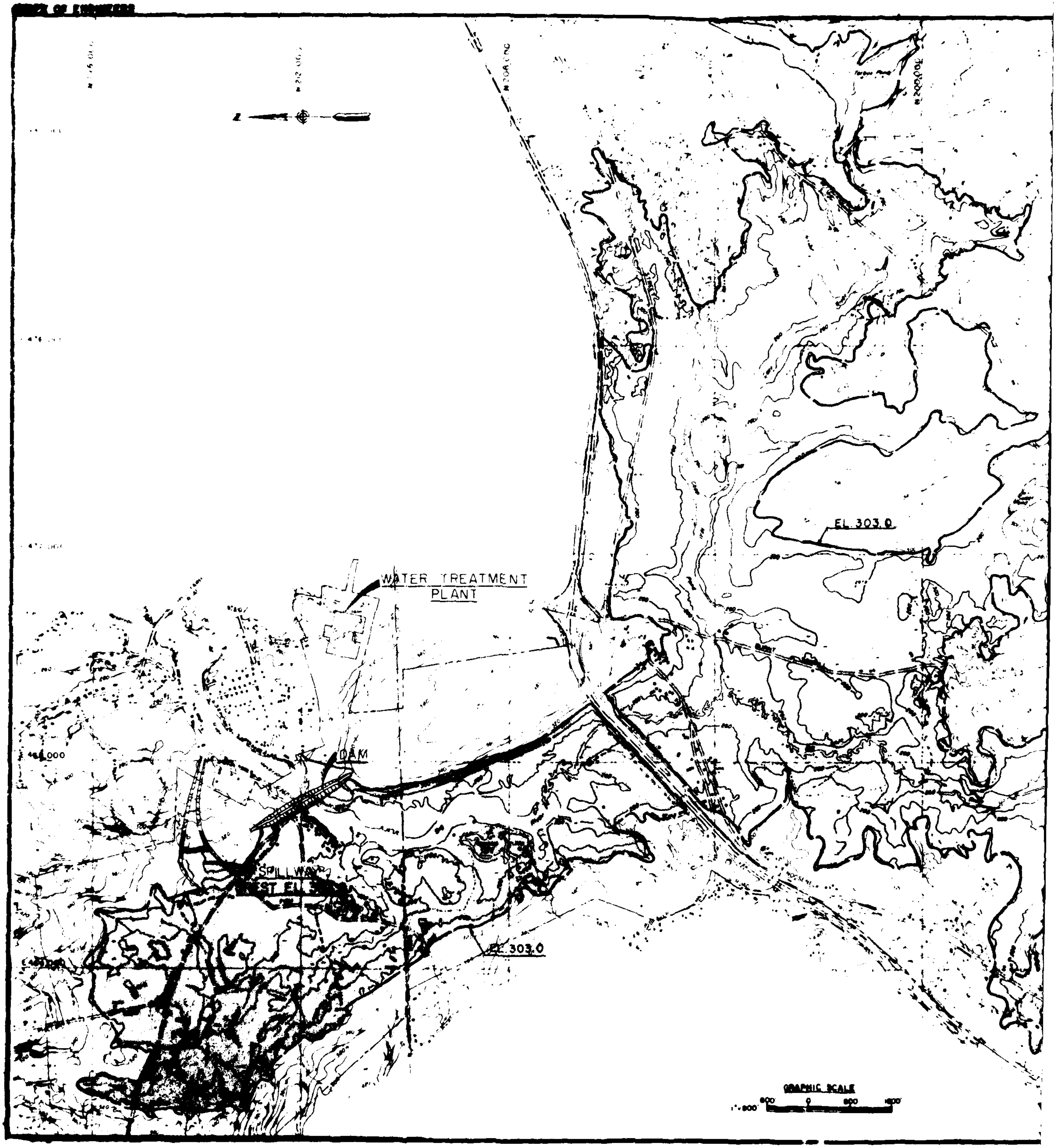
- Stream Gaging Station
- Existing Dams
- Basin and Sub-area Limits

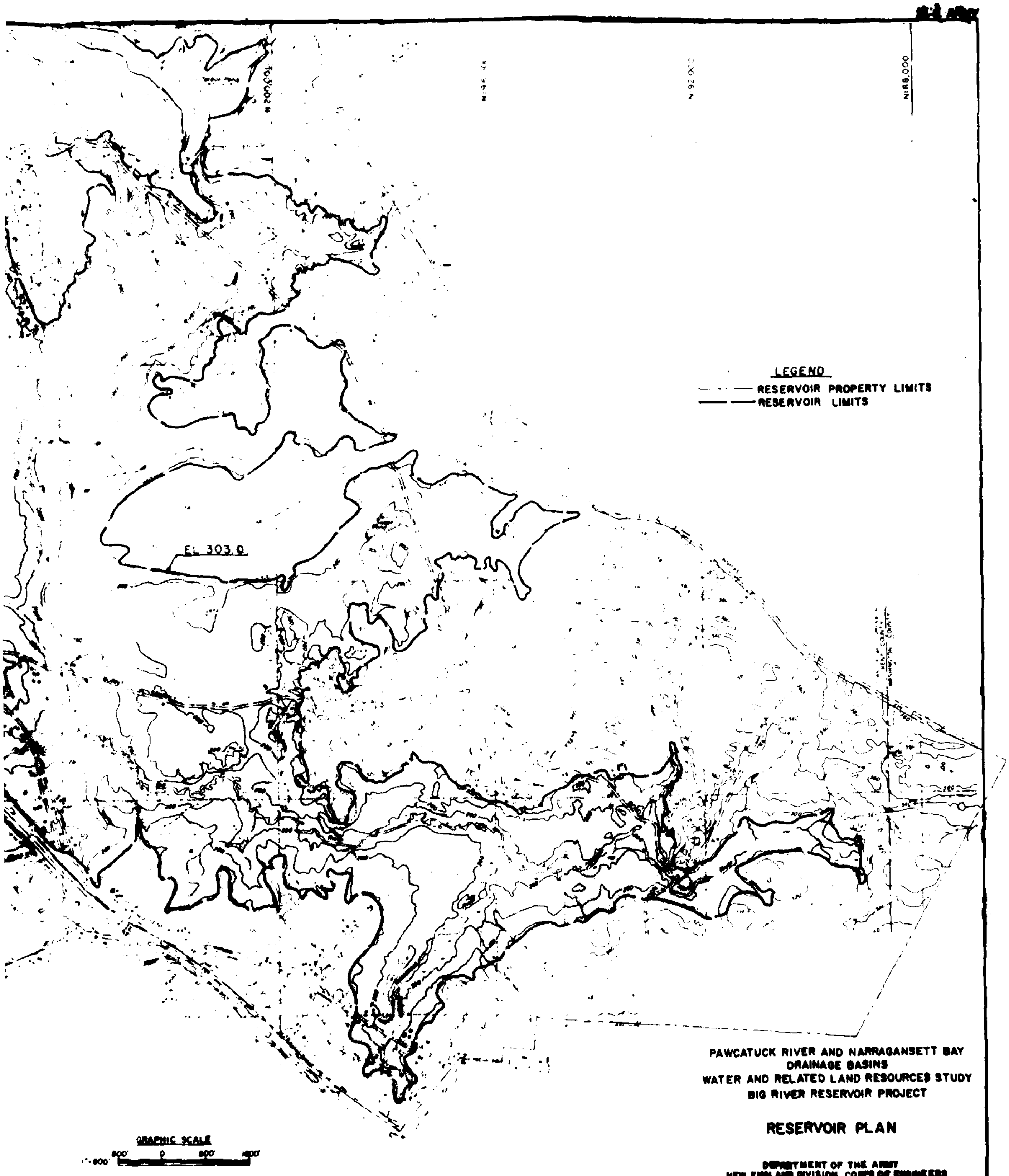
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PAWTUXET RIVER
BASIN MAP

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE G-1


WATER TREATMENT PLANT
DAM
SPILLWAY
EL. 303.0
EL. 303.0
GRAPHIC SCALE

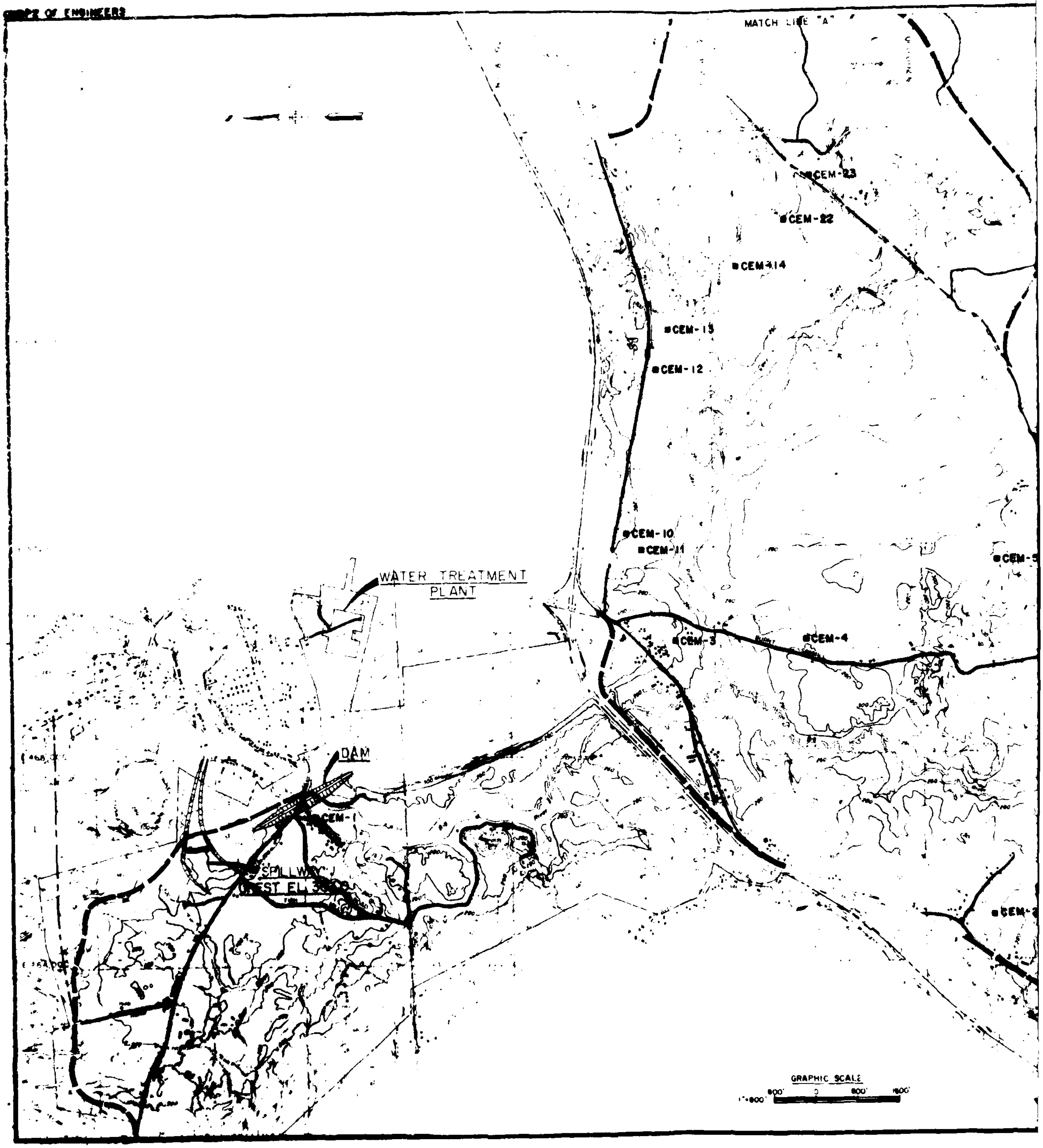


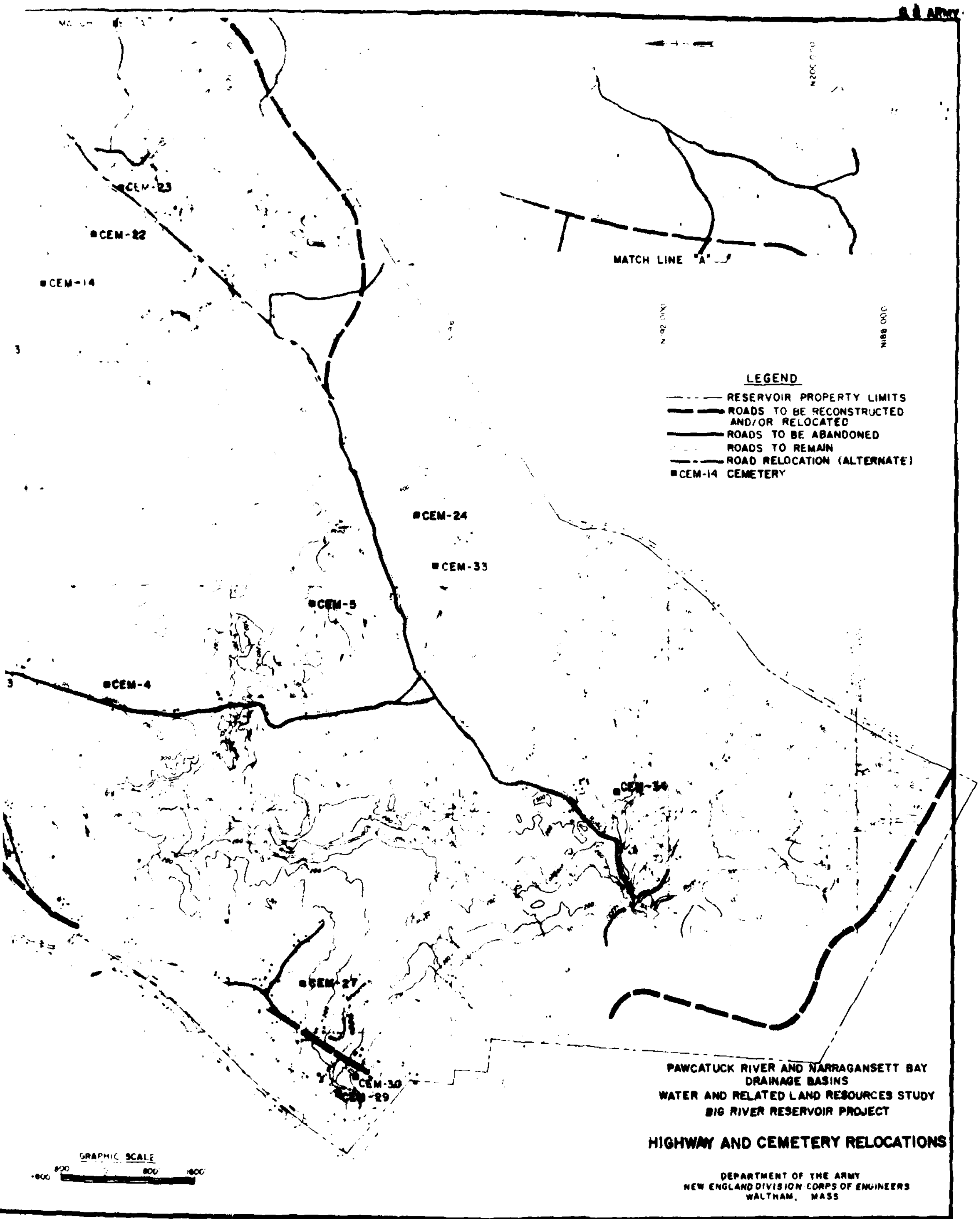
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

RESERVOIR PLAN

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-2


CORPS OF ENGINEERS
MATCH LINE "A"
CEM-23
CEM-22
CEM-14
CEM-13
CEM-12
CEM-10
CEM-11
CEM-5
WATER TREATMENT
PLANT
CEM-3
CEM-4
DAM
CEM-1
SPILLWAY
CREST EL.
CEM-2
GRAPHIC SCALE

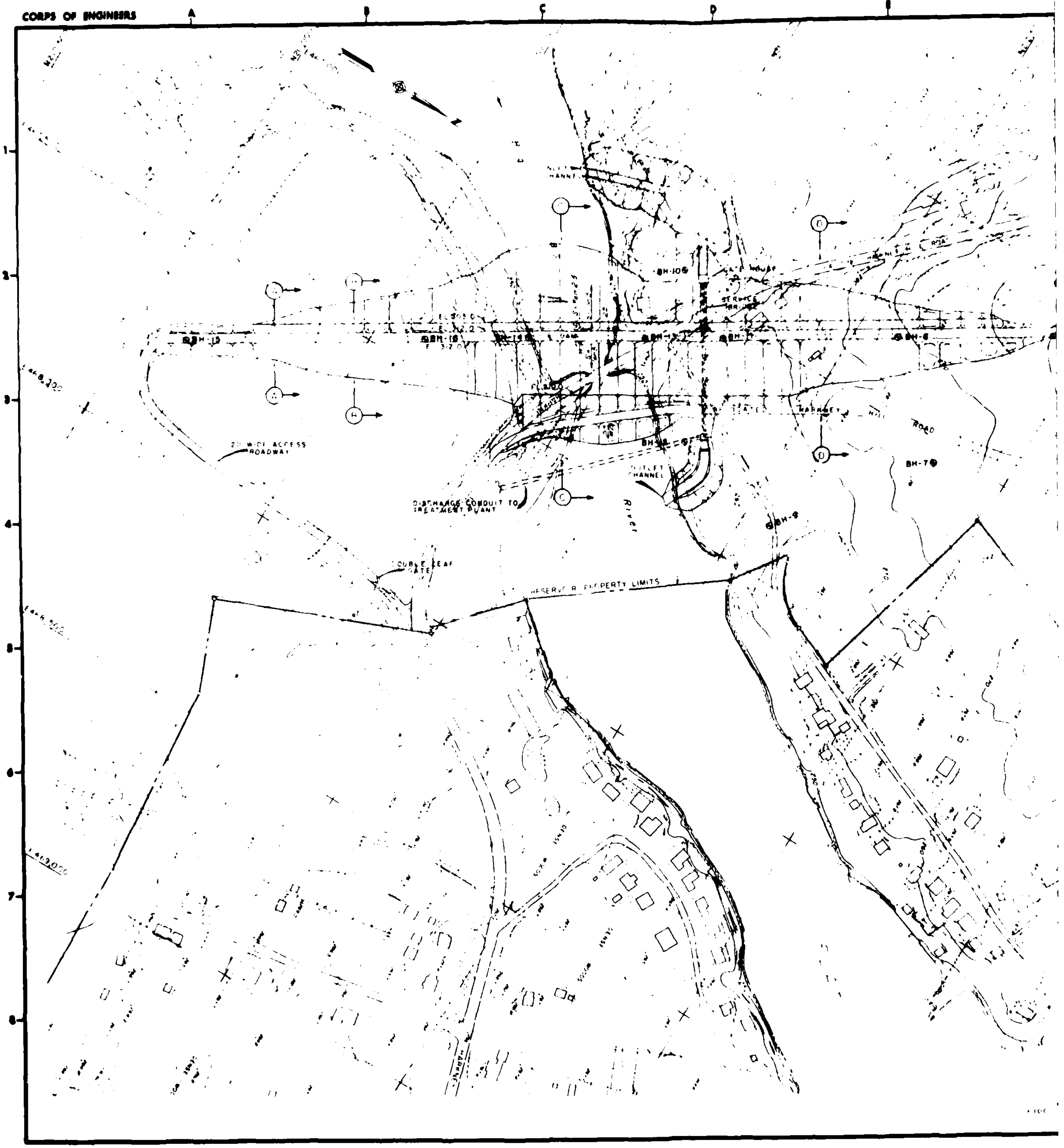


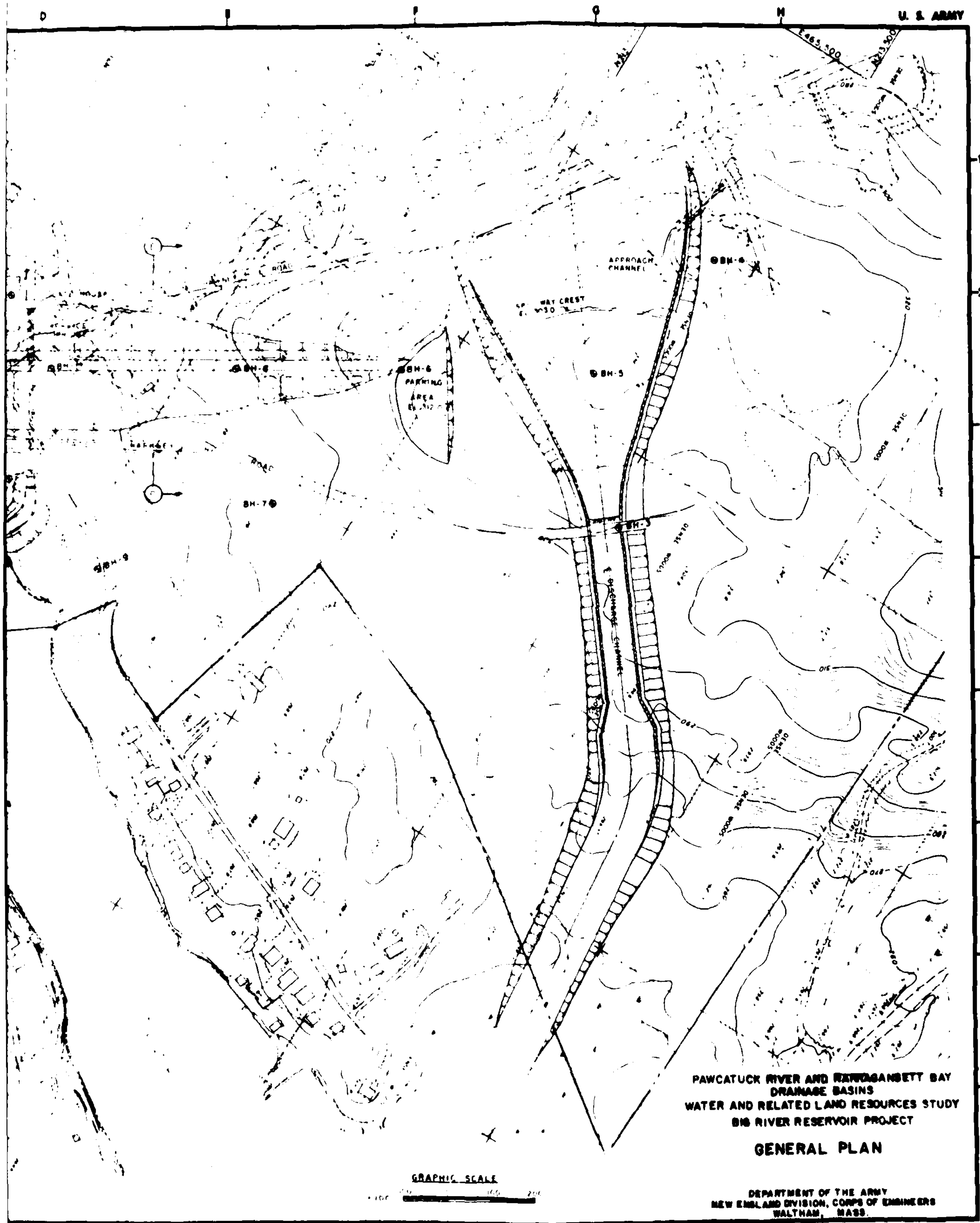
PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

HIGHWAY AND CEMETERY RELOCATIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS

PLATE G-3


CORPS OF ENGINEERS
A
B
C
D
E
1
2
3
4
5
6
7
8
BH-10
BH-15
BH-16
BH-8
BH-7
BH-9
SERVICE BRIDGE
OUTLET CHANNEL
20' WIDE ACCESS ROADWAY
DISCHARGE CONDUIT TO TREATMENT PLANT
DOUBLE LEAF GATE
RESERVOIR PROPERTY LIMITS
River
ROAD

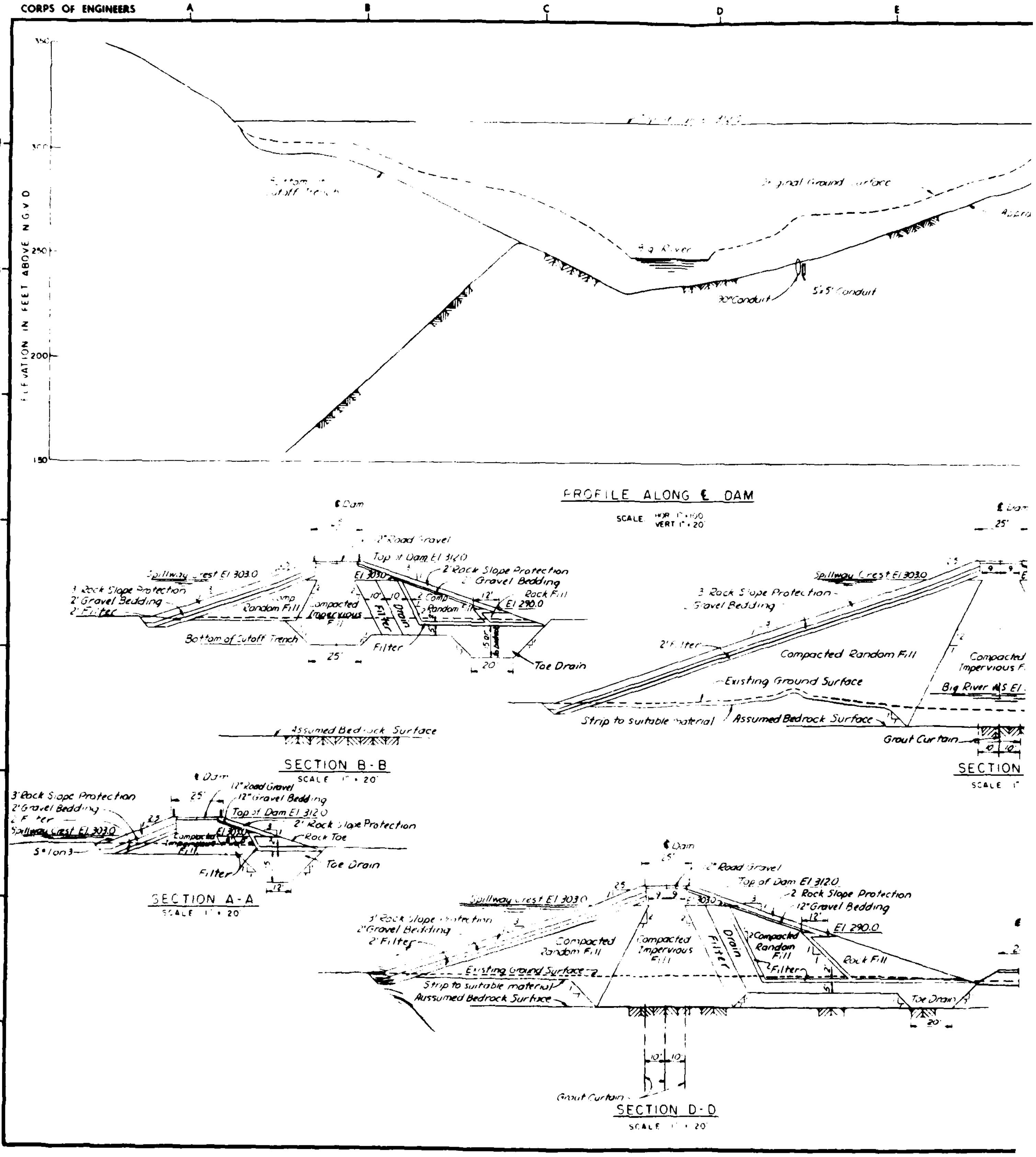


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

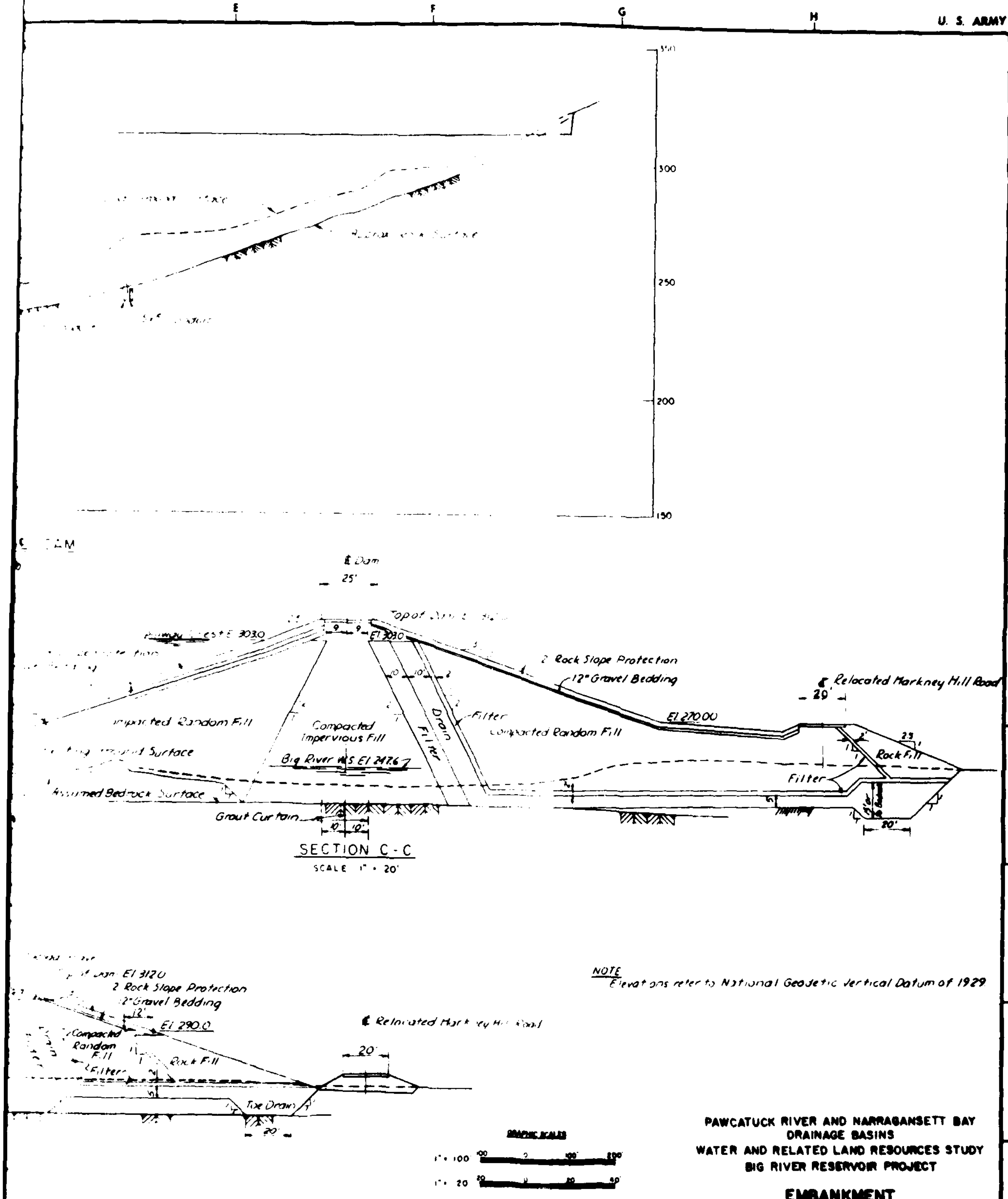
GENERAL PLAN

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-4



CORPS OF ENGINEERS
A
B
C
D
E
ELEVATION IN FEET ABOVE N G V D
350
300
250
200
150
Original Ground Surface
Big River
30" Conduit
5'x5' Conduit
PROFILE ALONG ℄ DAM
SCALE HOR 1" = 100 VERT 1" = 20
℄ Dam
12" Road Gravel
Top of Dam El 312.0
Spillway Crest El 303.0
3' Rock Slope Protection
2' Gravel Bedding
2' Filter
2' Rock Slope Protection
2' Gravel Bedding
Rock Fill
El 290.0
Comp Random Fill
Compacted Impervious Fill
Filter
Drain
Bottom of Cutoff Trench
Toe Drain
25'
20'
Assumed Bedrock Surface
SECTION B-B
SCALE 1" = 20'
Compacted Random Fill
Compacted Impervious Fill
Existing Ground Surface
Strip to suitable material
Big River WS El
Grout Curtain
SECTION
12" Road Gravel
12" Gravel Bedding
Top of Dam El 312.0
2' Rock Slope Protection
Rock Toe
Toe Drain
Filter
5 + on 3
12'
SECTION A-A
SCALE 1" = 20'
℄ Dam
25'
12" Road Gravel
Top of Dam El 312.0
2 Rock Slope Protection
12" Gravel Bedding
Spillway Crest El 303.0
3' Rock Slope Protection
2' Gravel Bedding
2' Filter
Compacted Random Fill
Compacted Impervious Fill
Filter
Drain
2' Compacted Random Fill
Rock Fill
Filter
El 290.0
Existing Ground Surface
Strip to suitable material
Assumed Bedrock Surface
Toe Drain
20'
10'
10'
Grout Curtain
SECTION D-D
SCALE 1" = 20'

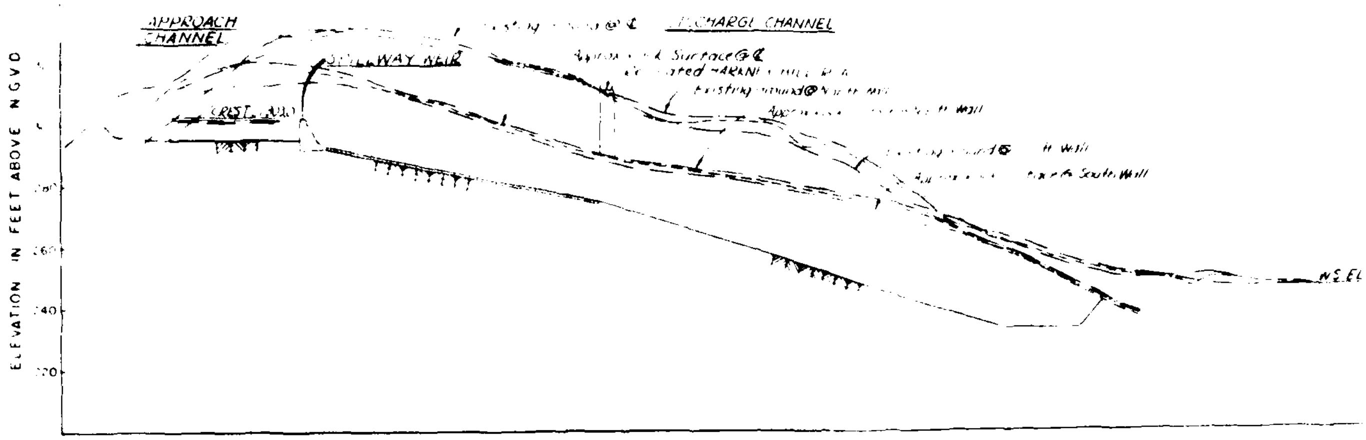


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

EMBANKMENT
PROFILE AND SECTIONS

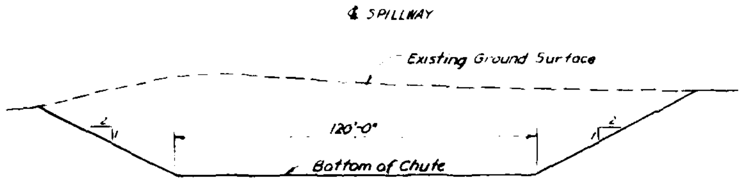
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-5



PROFILE ALONG SPILLWAY

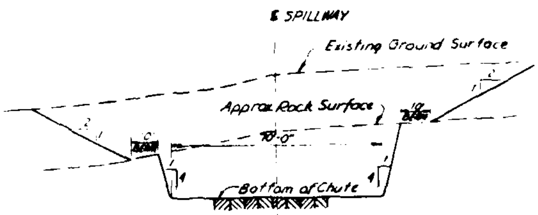
SCALE HOR 1" = 100' VERT 1" = 20'



TYPICAL SECTION OF CHUTE

(IN EARTH CUT)

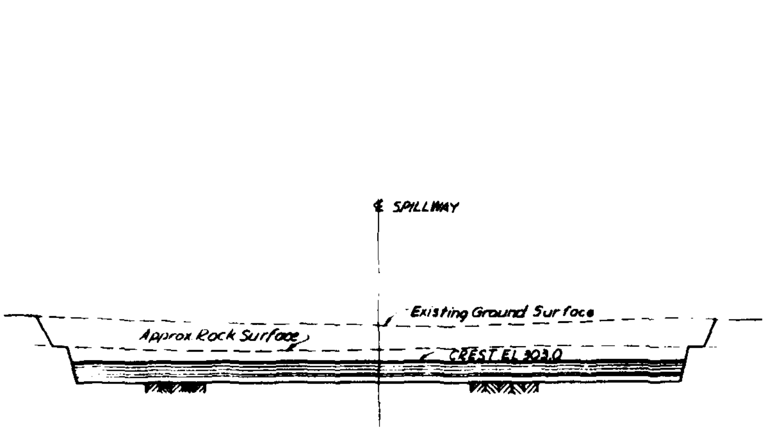
SCALE 1" = 20'



TYPICAL SECTION OF CHUTE

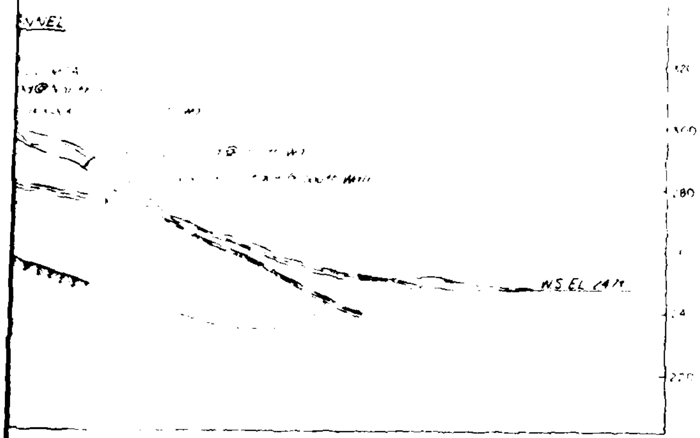
(IN ROCK CUT)

SCALE 1" = 20'

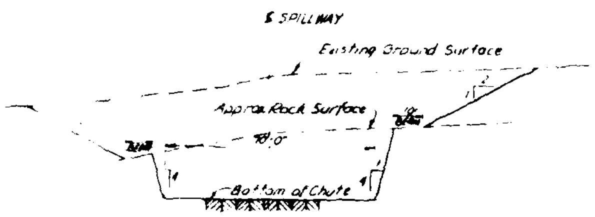


SECTION AT SPILLWAY WEIR

SCALE 1" = 40'



SPILLWA



TYPICAL SECTION OF CHUTE

(IN ROCK CUT)

SCALE 1" = 20'

GRAPHIC SCALES

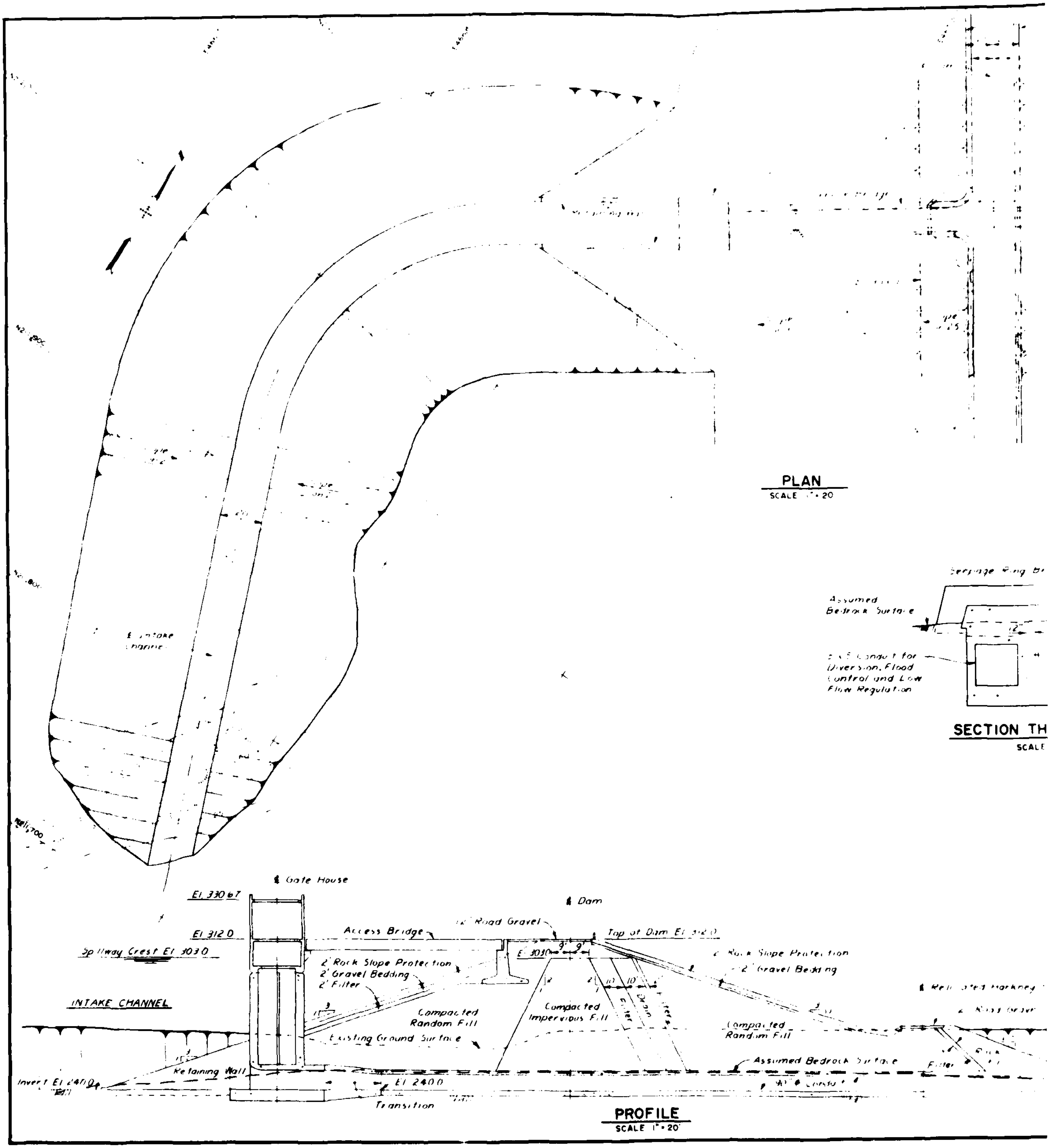
1" = 20'	20'	0	20'	40'
1" = 40'	40'	0	40'	80'
1" = 100'	100'	0	100'	200'

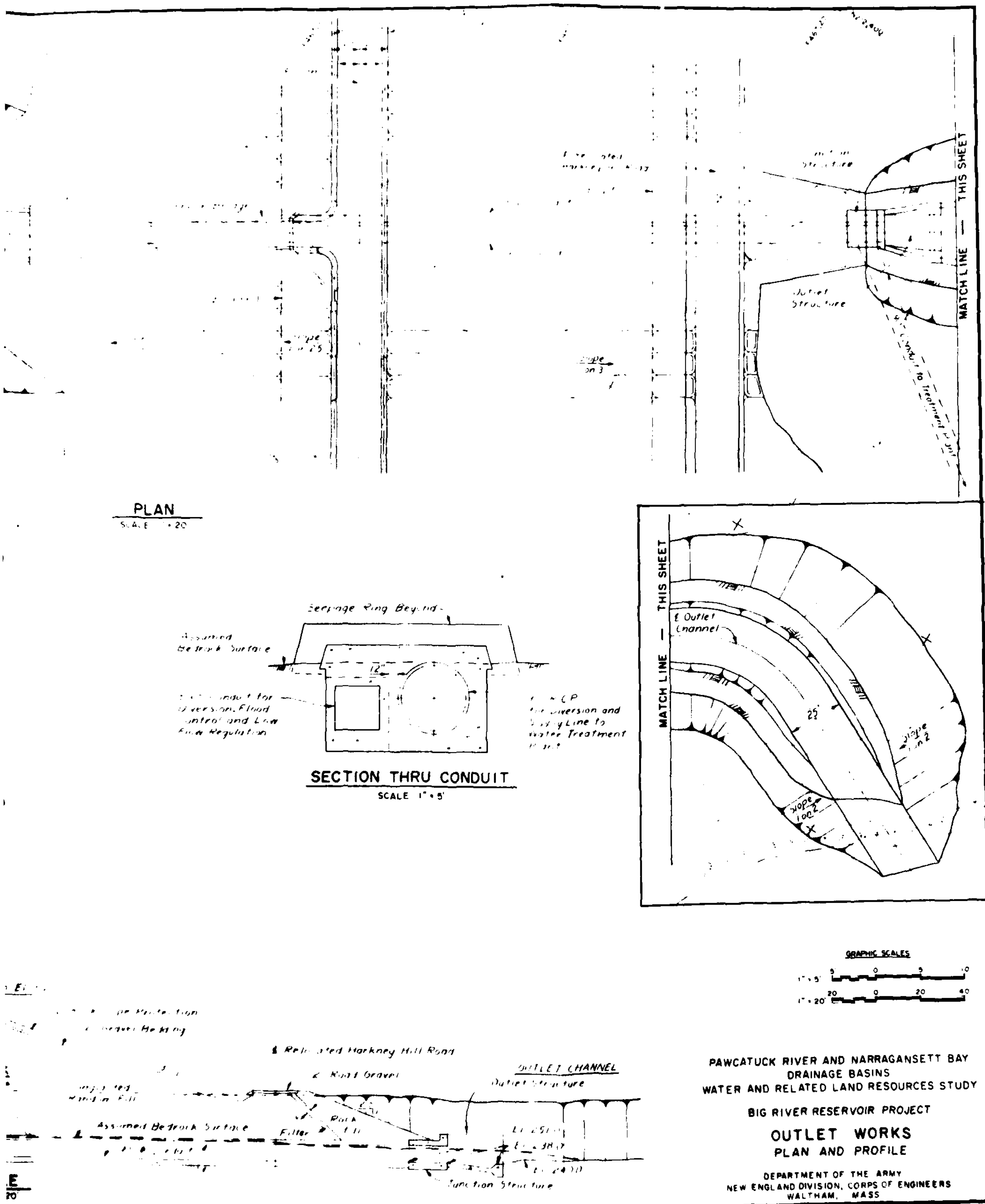
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

SPILLWAY
PROFILE AND SECTIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-6


PLAN
SCALE 1"=20
Assumed Bedrock Surface
Conduit for Diversion, Flood Control and Low Flow Regulation
SECTION TH
SCALE
Gate House
El 330.67
El 312.0
Spillway Crest El 303.0
Access Bridge
Road Gravel
Dam
Top of Dam El 312.0
El 303.0
2' Rock Slope Protection
2' Gravel Bedding
2' Filter
INTAKE CHANNEL
Compacted Random Fill
Compacted Impervious Fill
Existing Ground Surface
Compacted Random Fill
Rock Slope Protection
2' Gravel Bedding
Assumed Bedrock Surface
Retaining Wall
Invert El 240.0
El 240.0
Transition
PROFILE
SCALE 1"=20'



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY

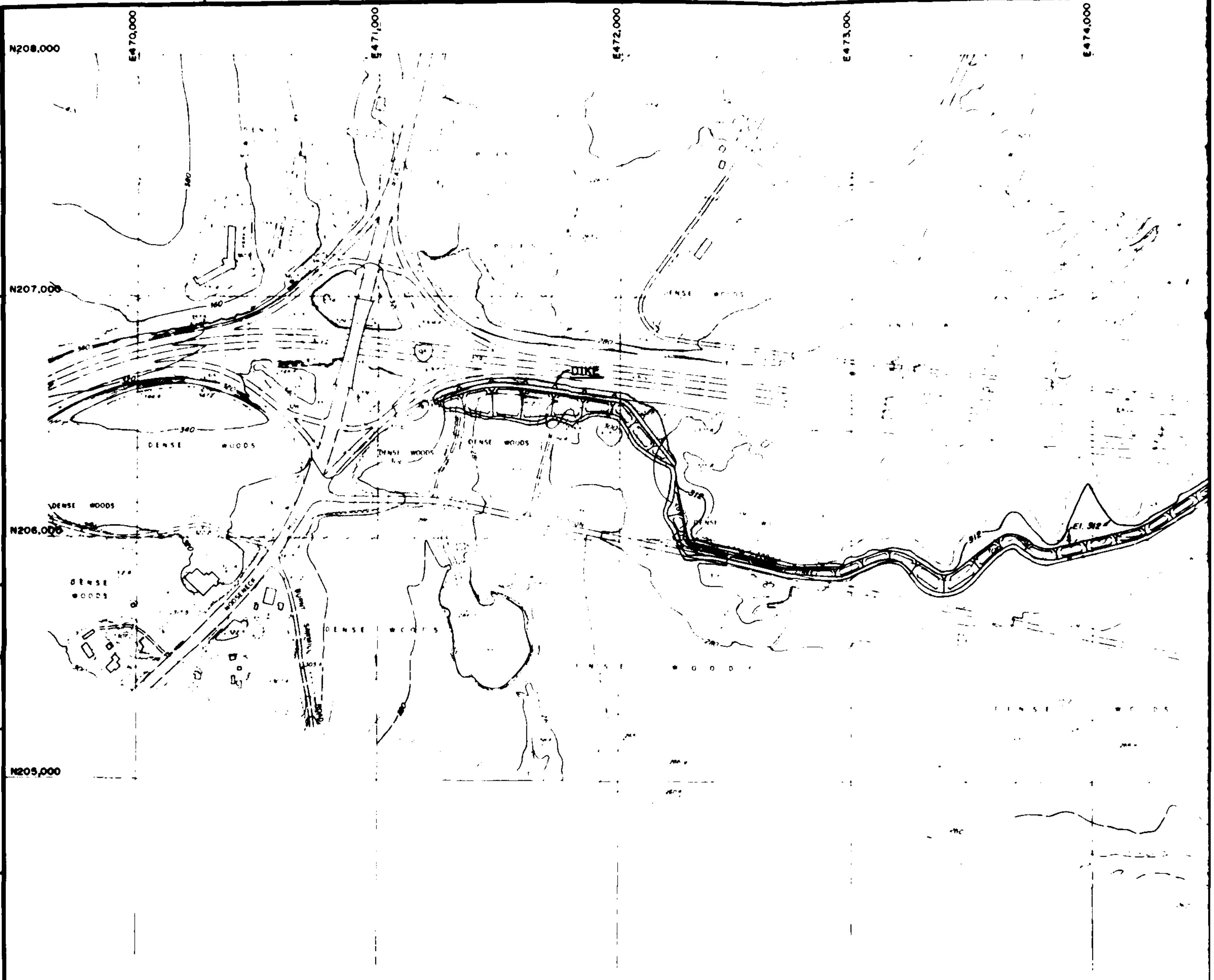
BIG RIVER RESERVOIR PROJECT

OUTLET WORKS
PLAN AND PROFILE

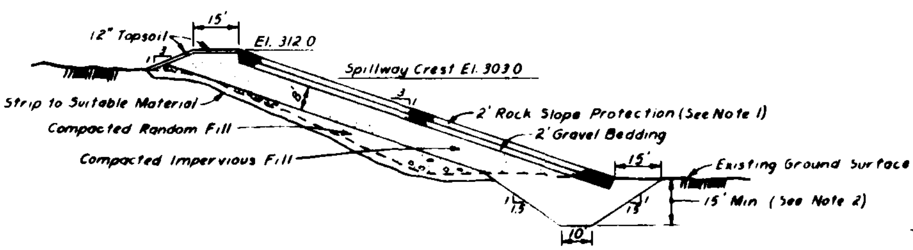
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE G-7

CORPS OF ENGINEERS



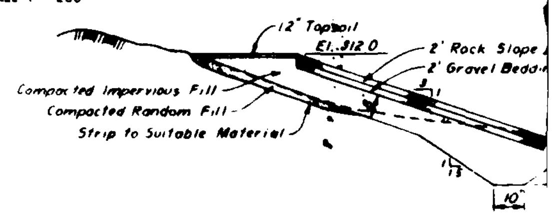
PLAN
SCALE 1" = 200'



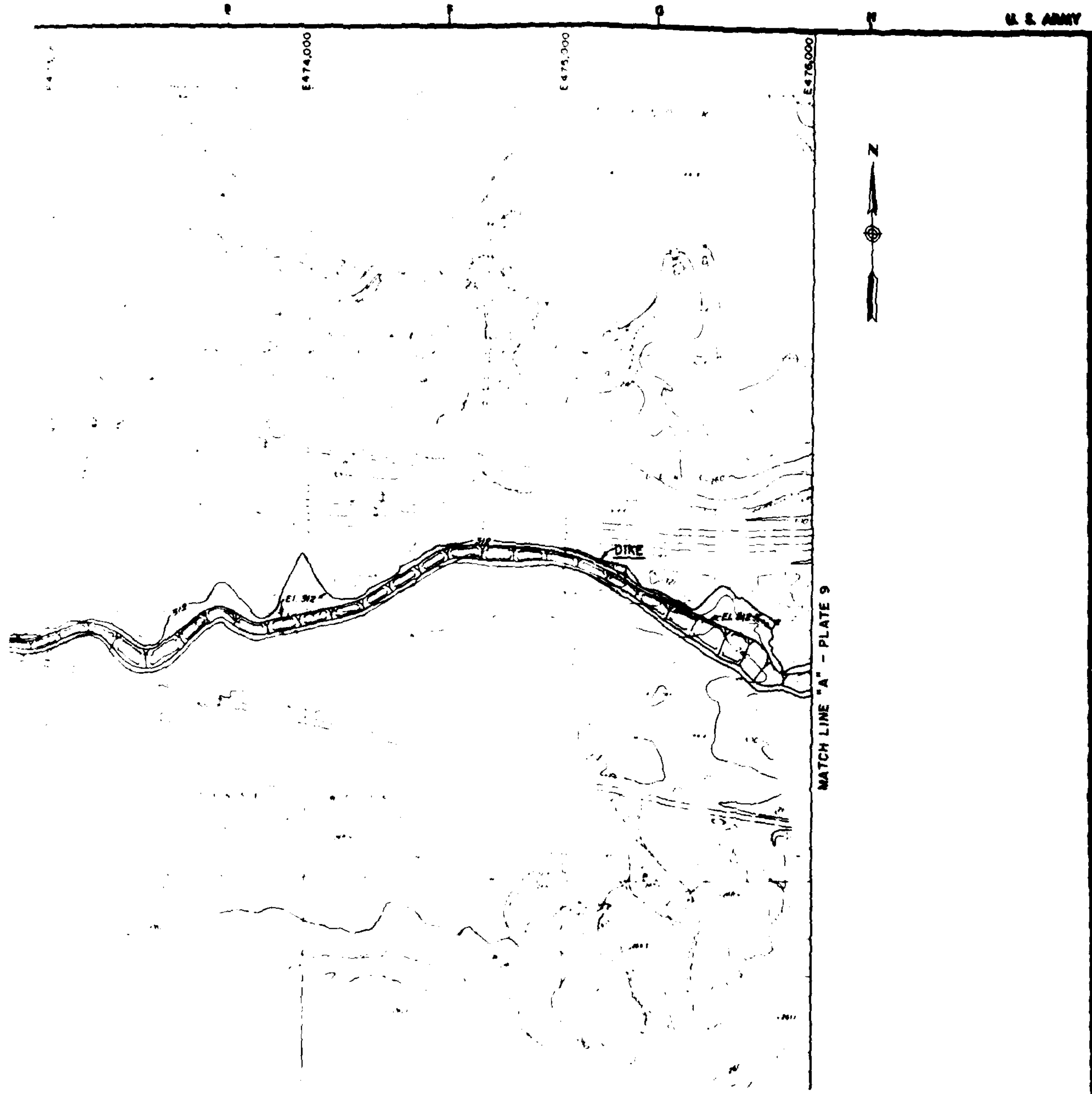
TYPICAL DIKE SECTION
SCALE: 1" = 20'

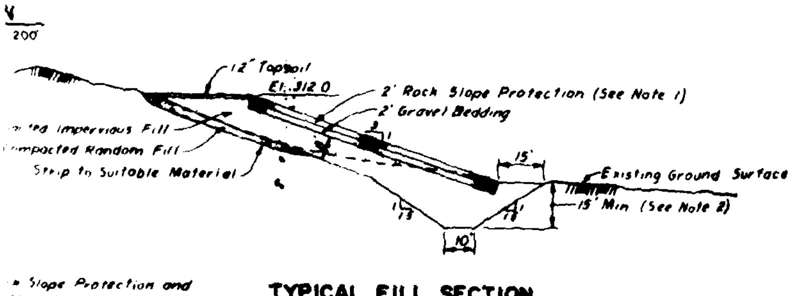
NOTES

1. Carry Rock Slope Protection and Gravel Bedding to existing ground or to Min elevation 267.0
2. Depth of Toe Trench varies. Carry to dense silty fine sands



TYPICAL FILL SECT
SCALE 1" = 20'





TYPICAL FILL SECTION
SCALE 1" = 20'

GRAPHIC SCALES

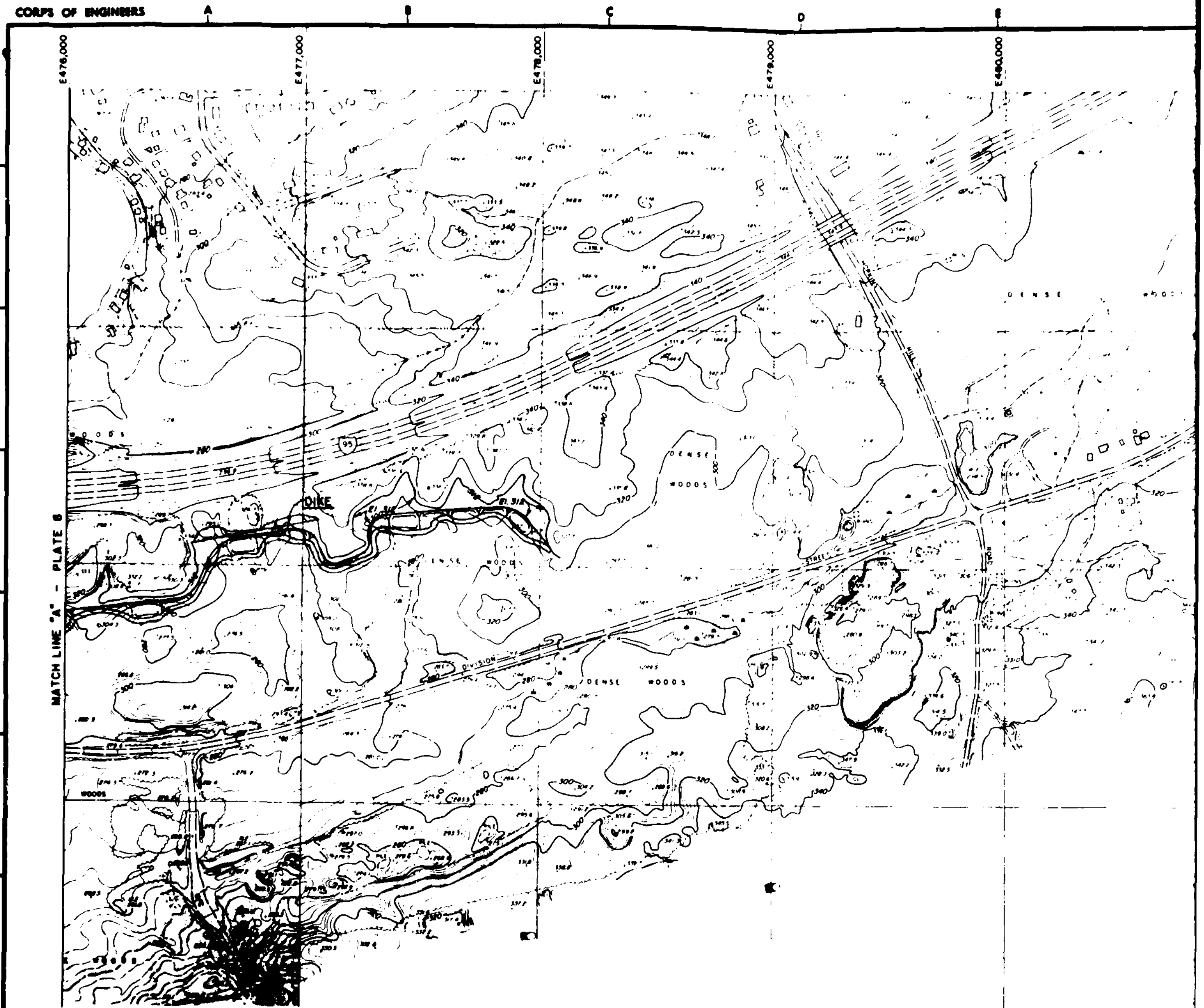
PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

DIVISION STREET-IMPERVIOUS CUT OFF
PLAN NO. 1 AND SECTIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

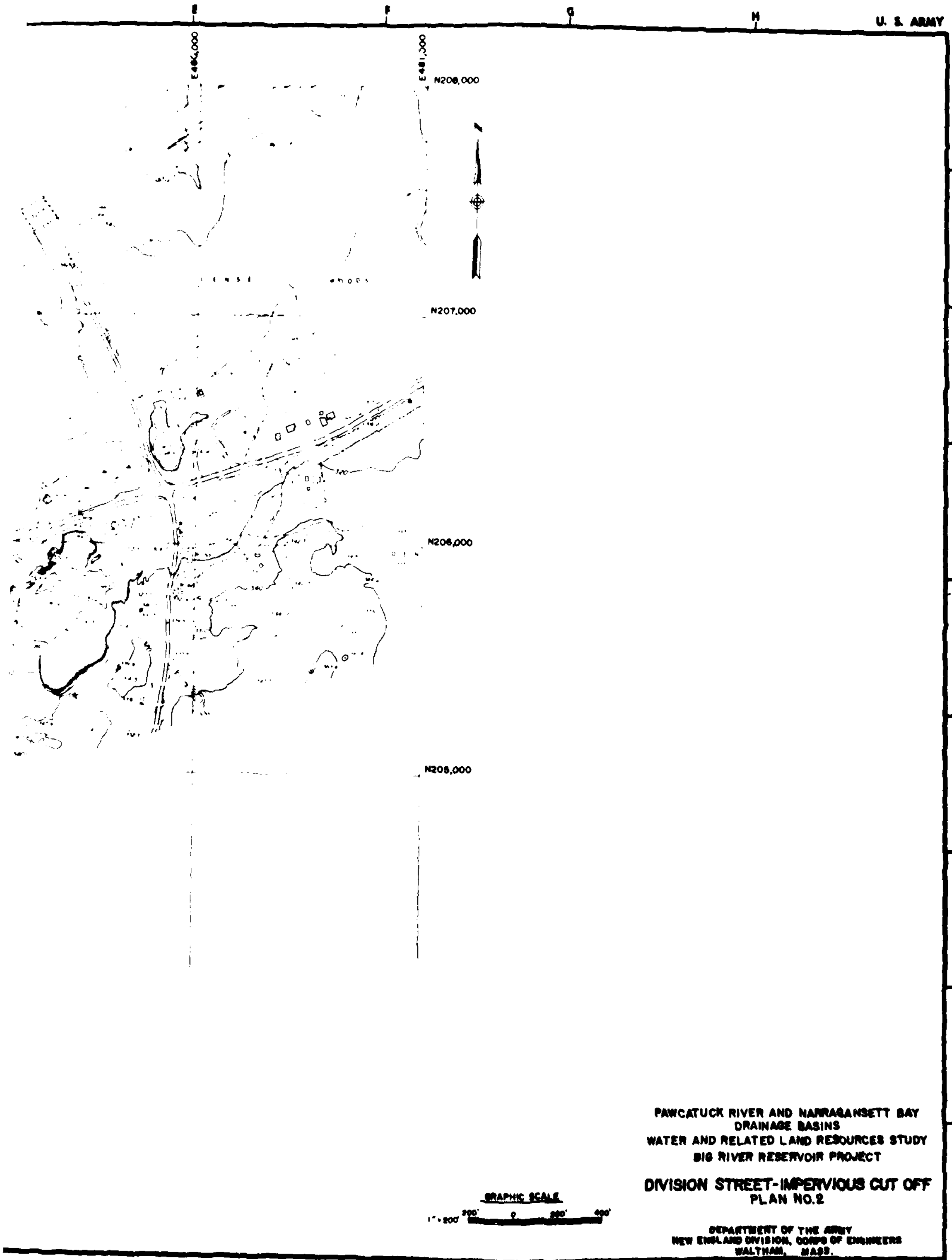
PLATE G-8

CORPS OF ENGINEERS



PLAN

SCALE: 1" = 200'



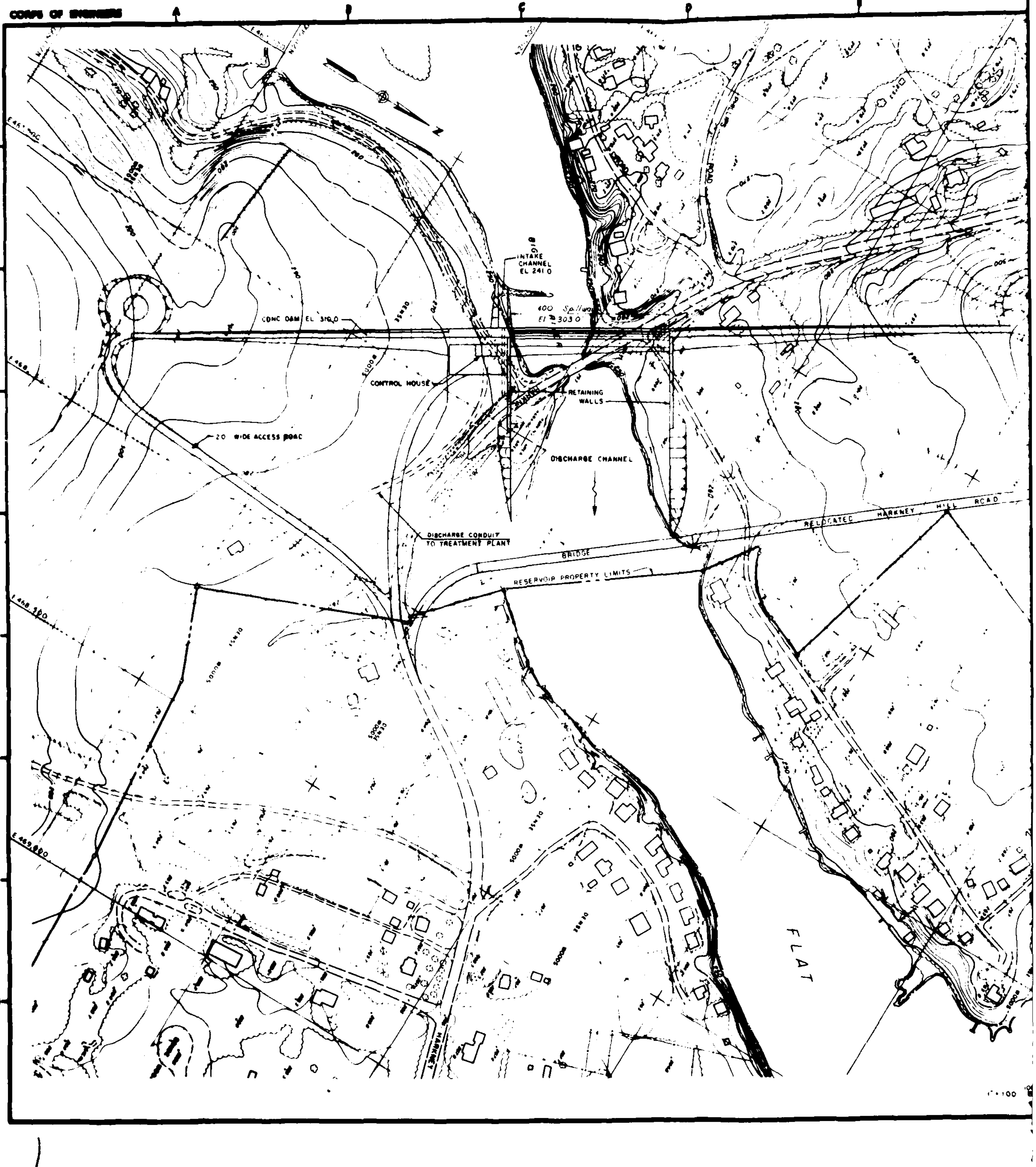
PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

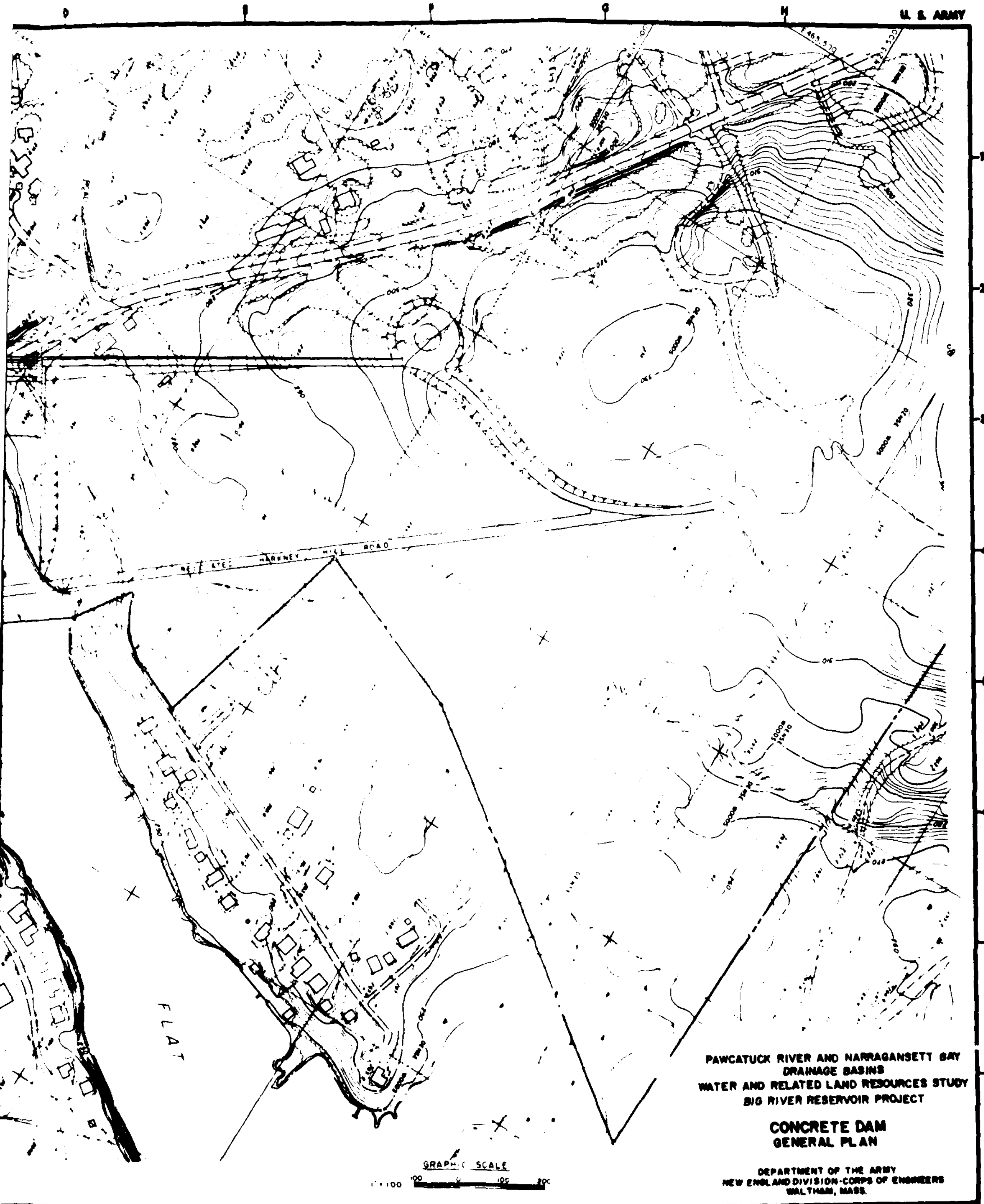
DIVISION STREET-IMPERVIOUS CUT OFF
PLAN NO.2

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-9

CORPS OF ENGINEERS



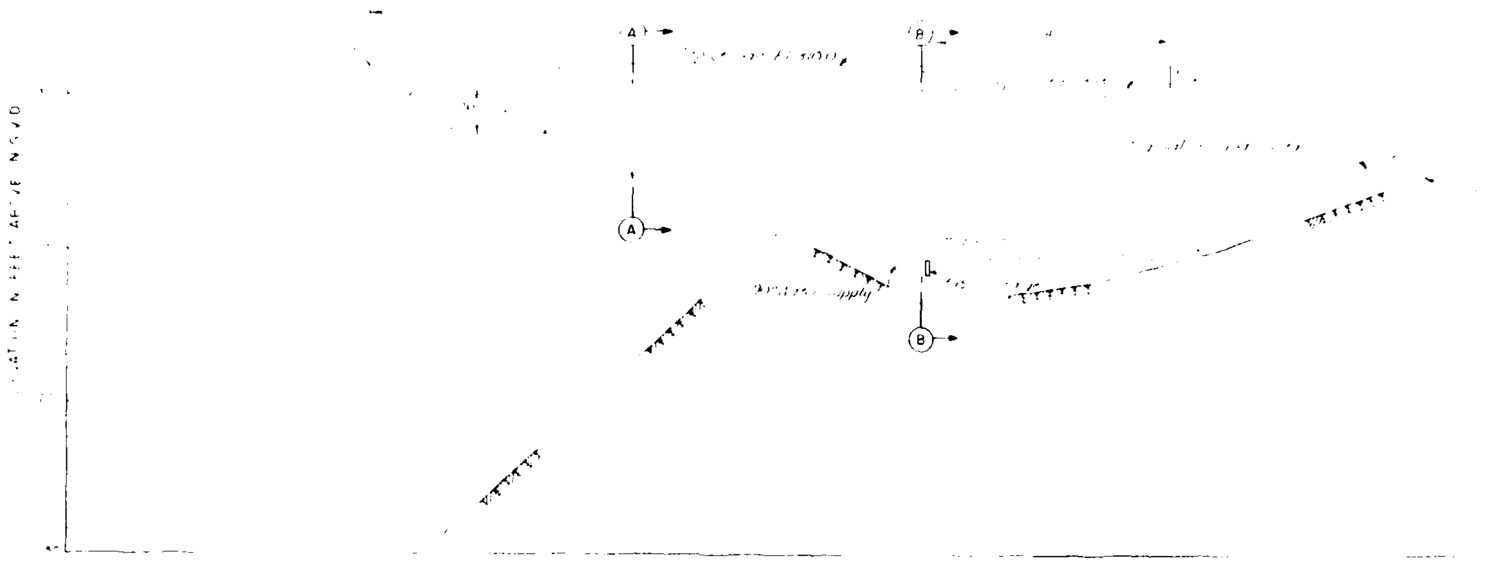


PAWCATUCK RIVER AND NARRAGANSETT BAY DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

CONCRETE DAM
GENERAL PLAN

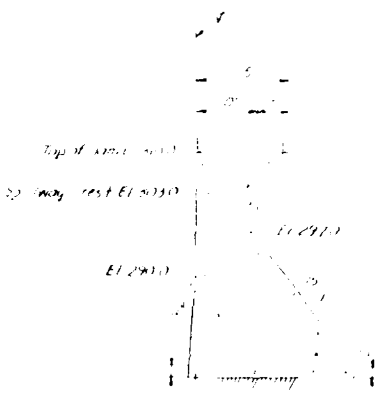
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE G-10



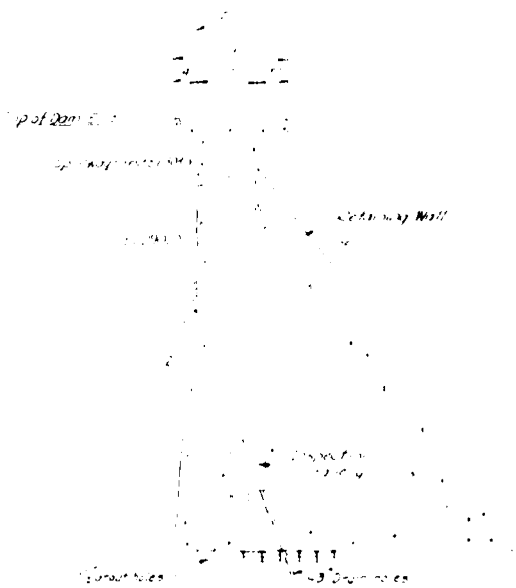
PROFILE ALONG ℄ DAM

SCALE HOR 1" = 100' VERT 1" = 20'



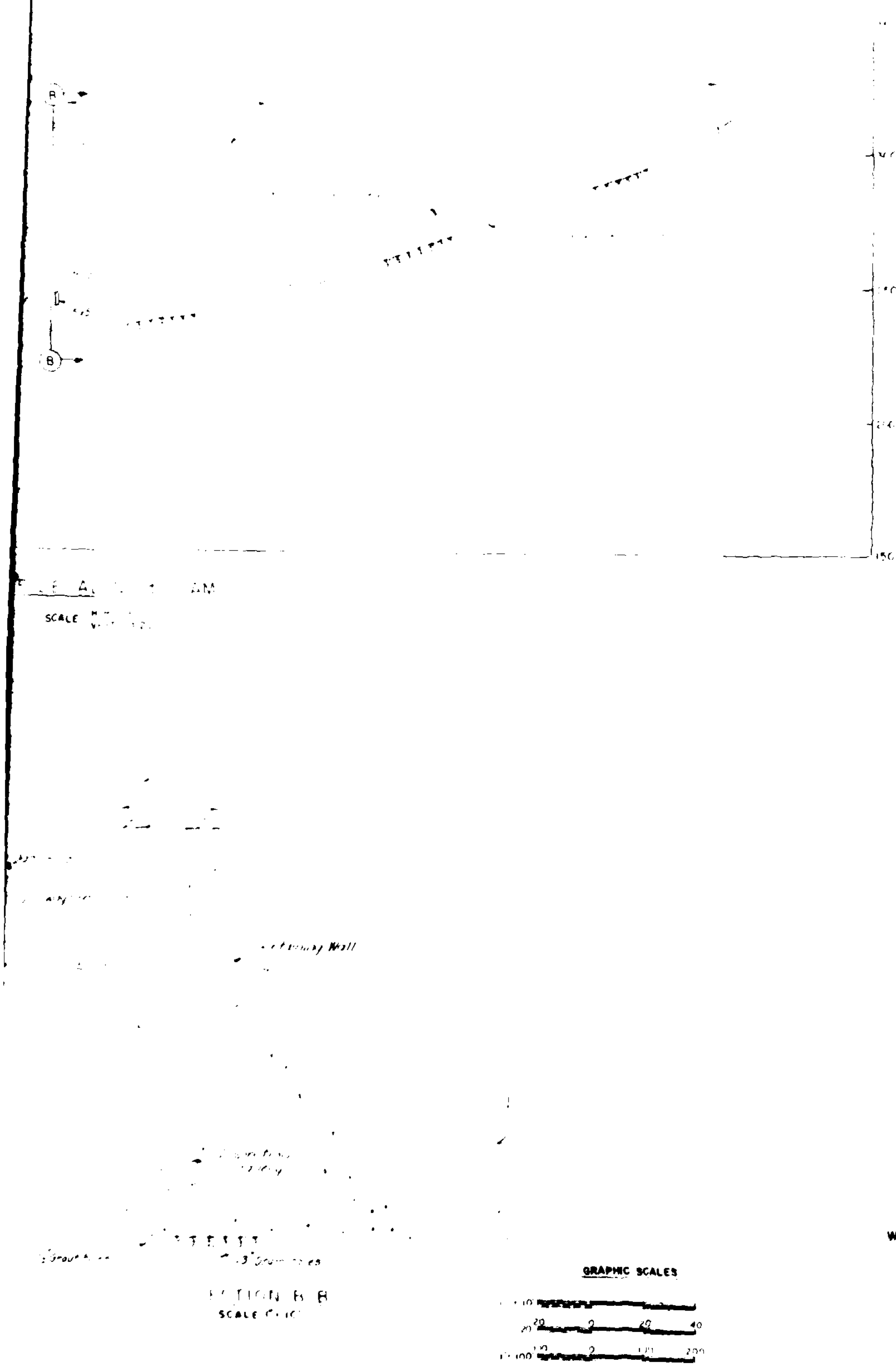
SECTION A-A

SCALE 1" = 10'



SECTION B-B

SCALE 1" = 10'

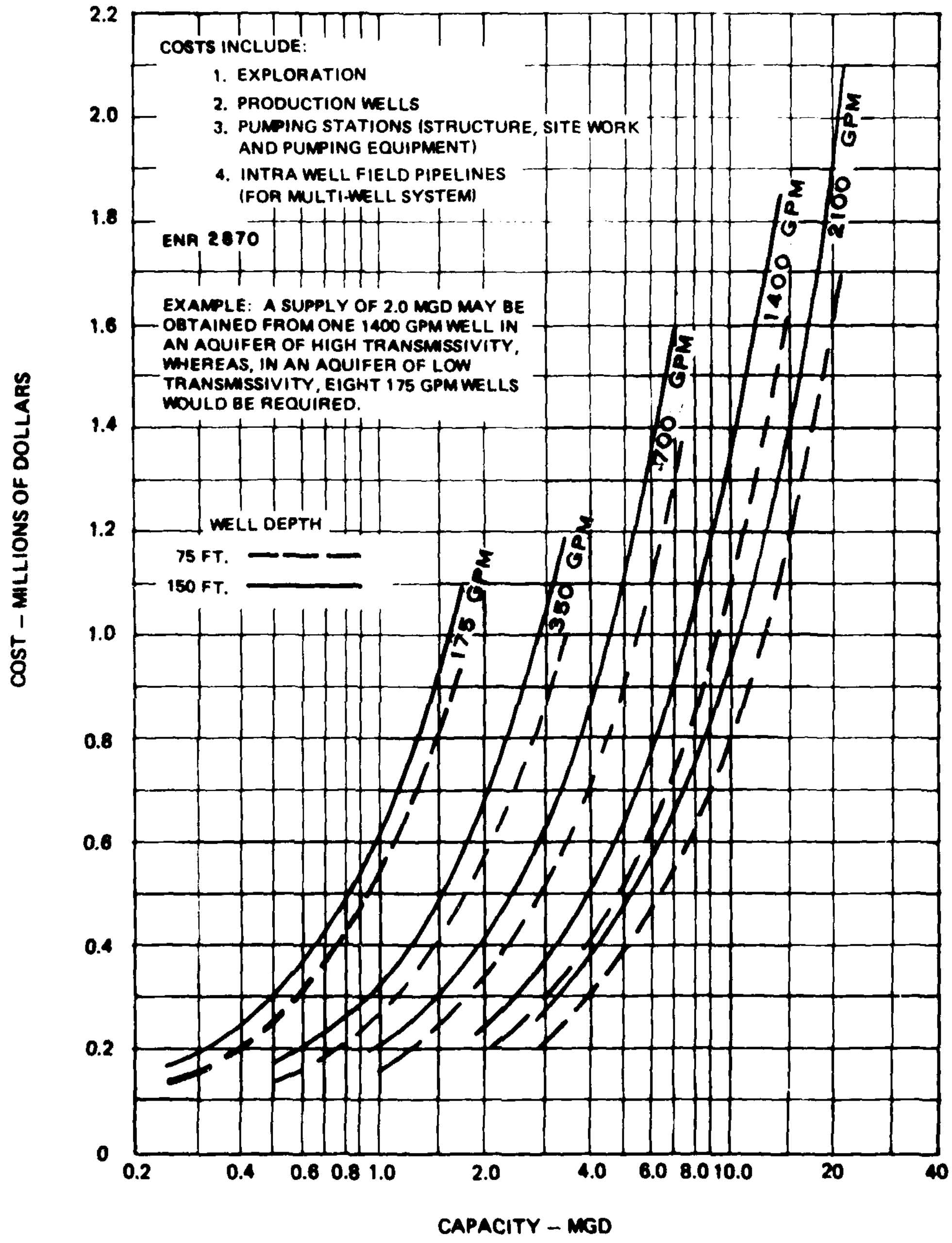


PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

CONCRETE DAM
PROFILE AND SECTIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS

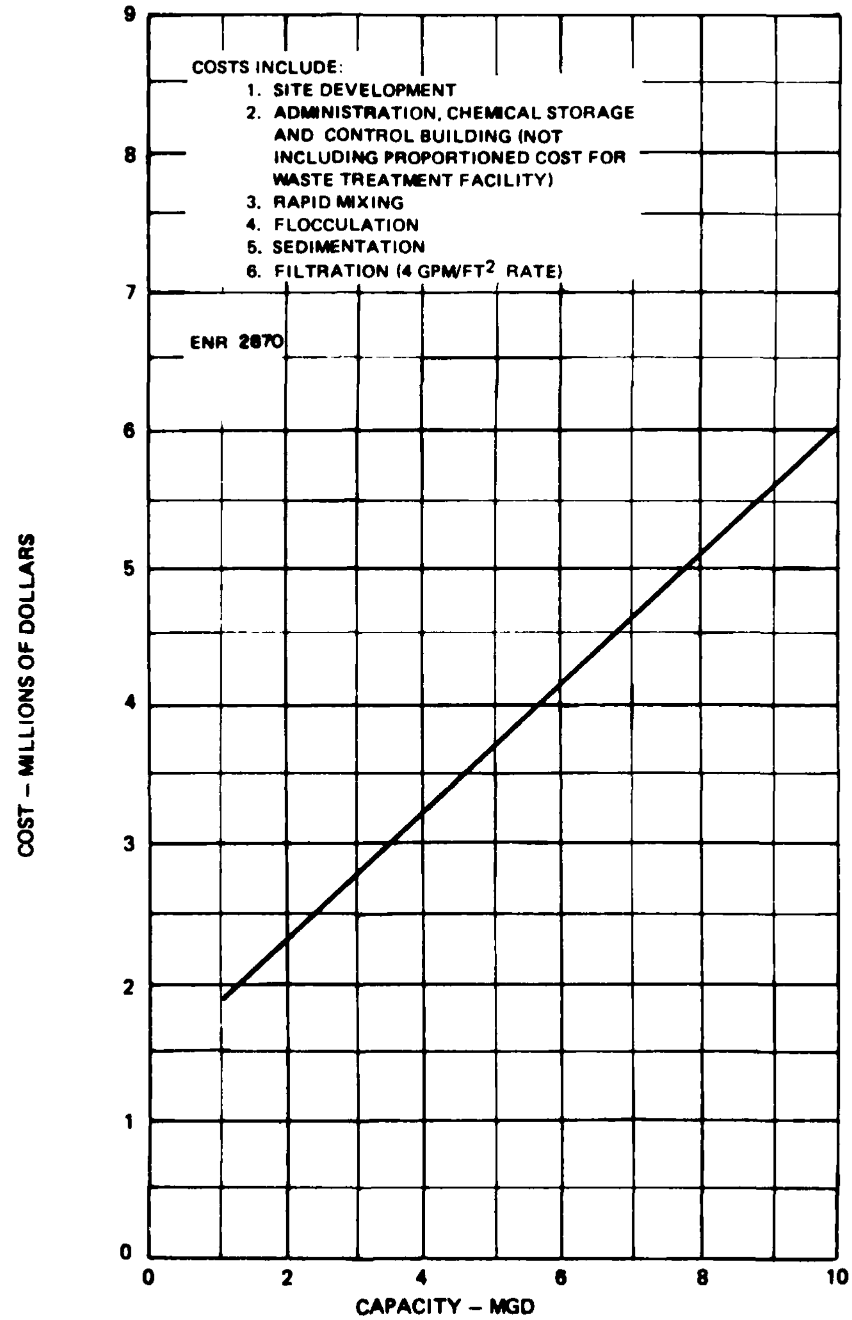
PLATE G-11



PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

WELL FIELD DEVELOPMENT COST CURVES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

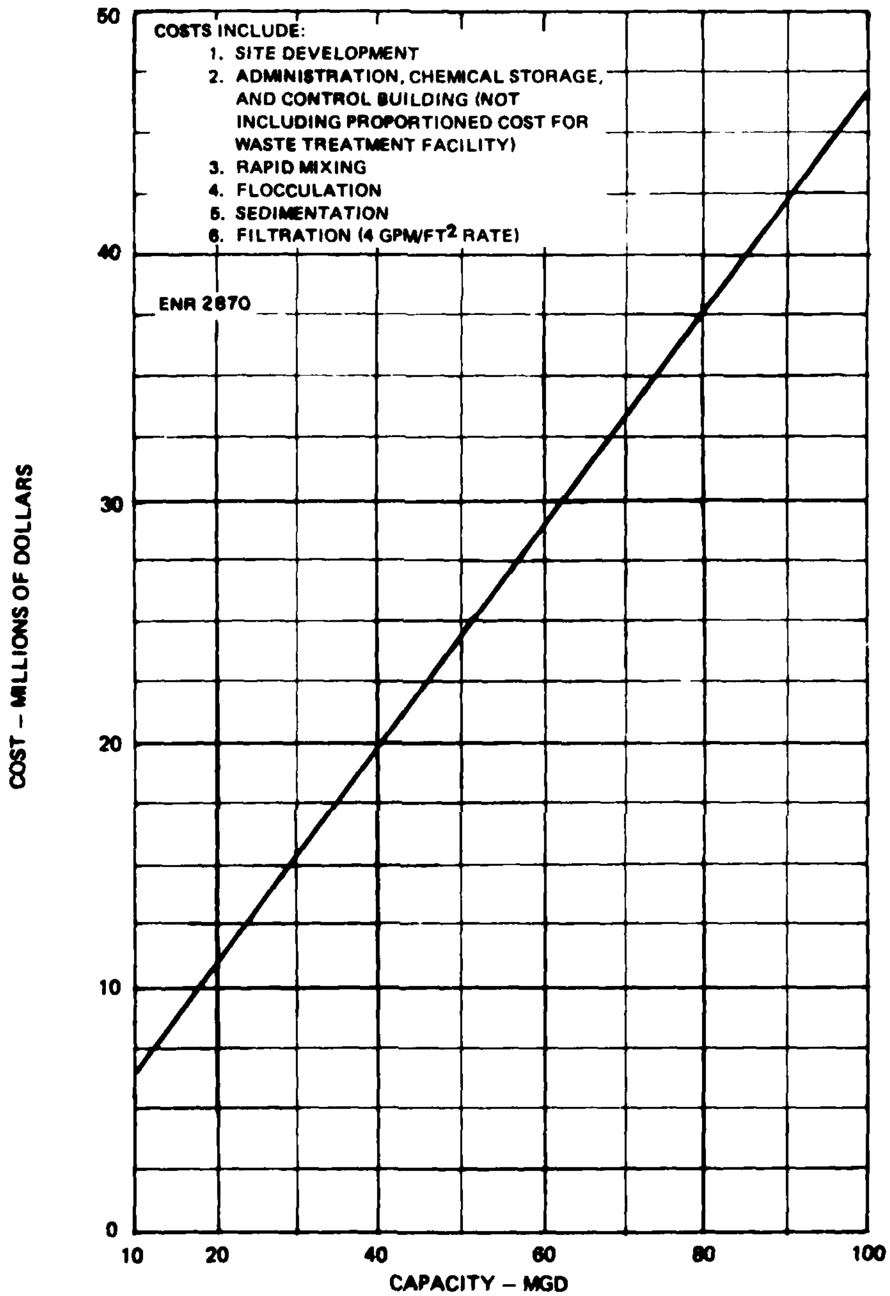


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

CONVENTIONAL ALUM COAGULATION SURFACE WATER TREATMENT PLANT CONSTRUCTION COST CURVE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. G-13(a)

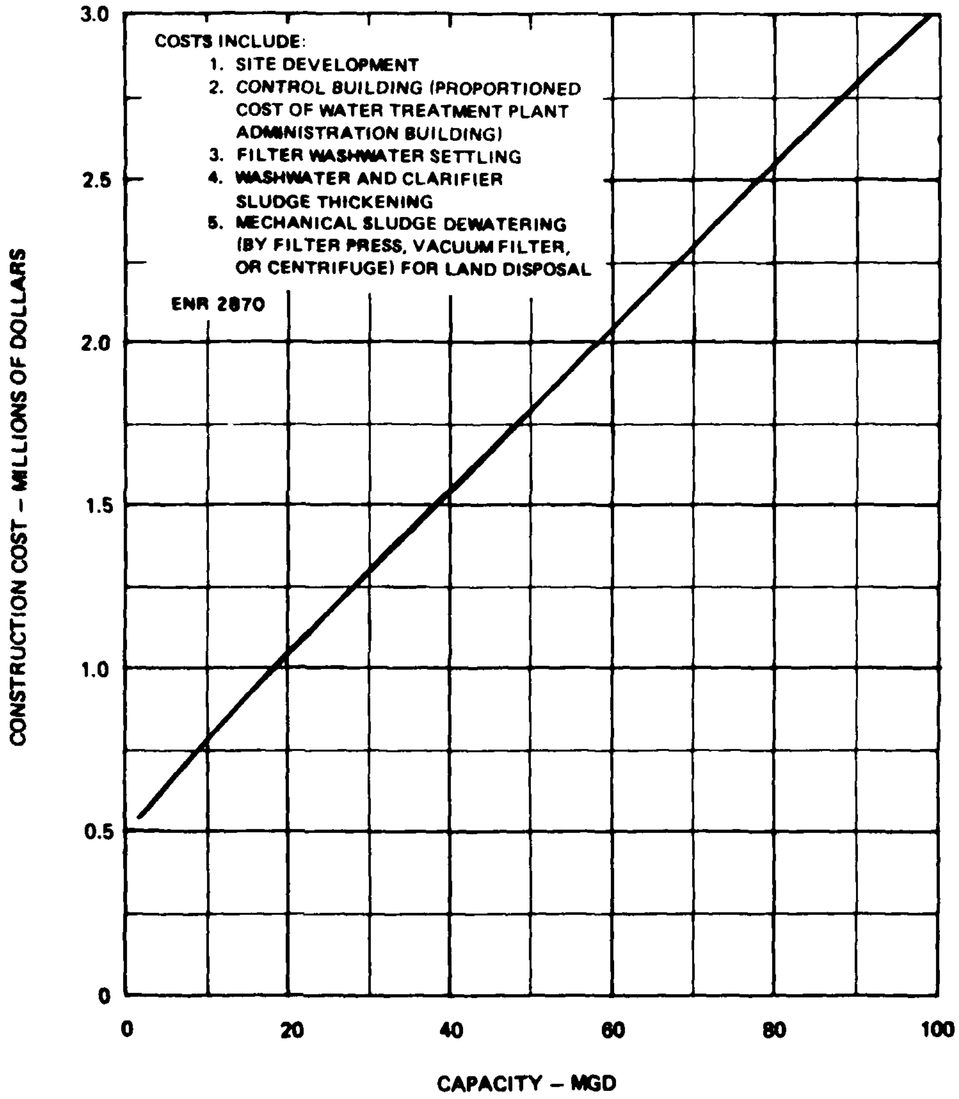


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

CONVENTIONAL ALUM COAGULATION SURFACE WATER TREATMENT PLANT CONSTRUCTION COST CURVE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. G-13(b)

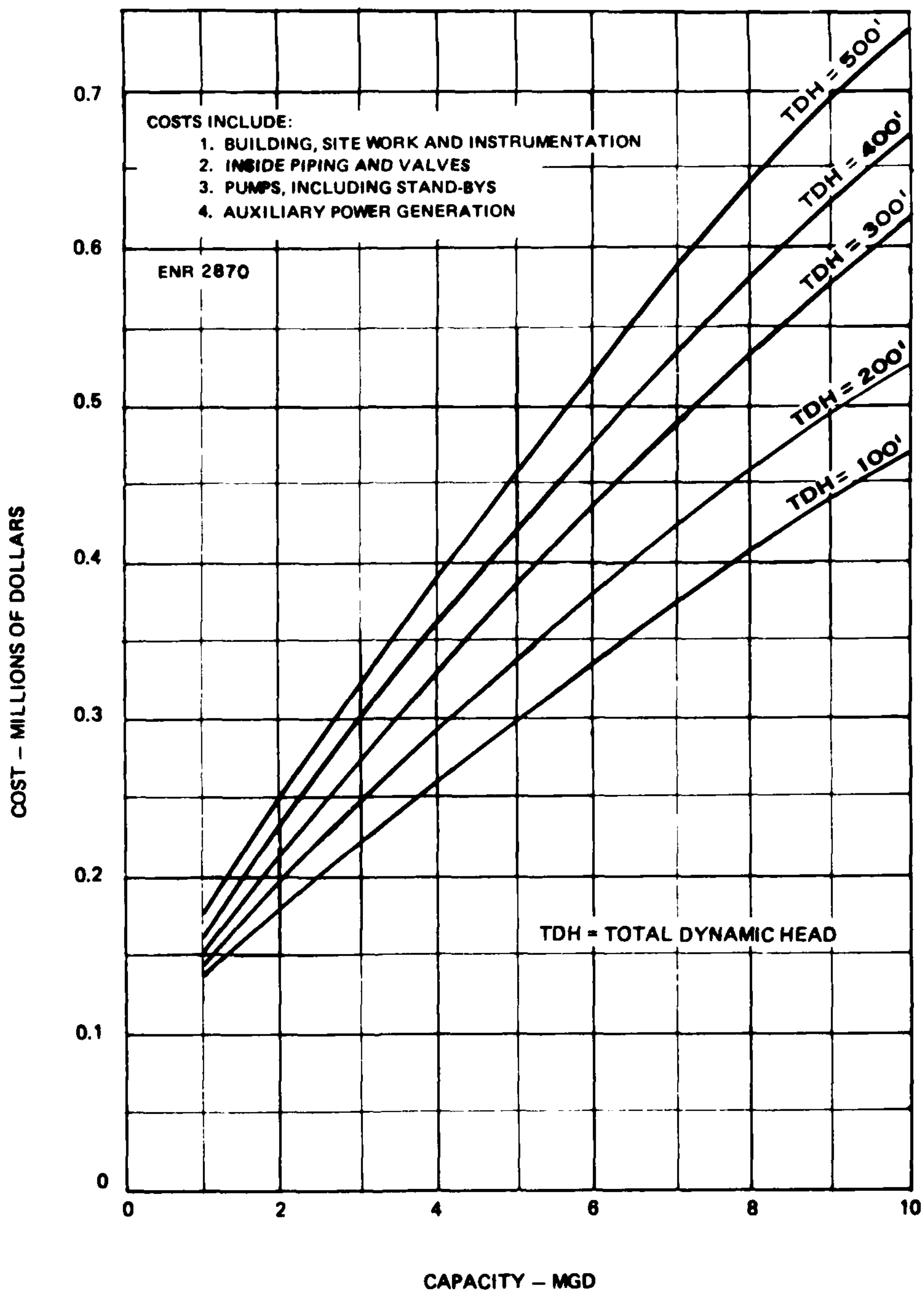


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

ALUM SLUDGE TREATMENT FACILITIES
CONSTRUCTION COST CURVE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. G-14

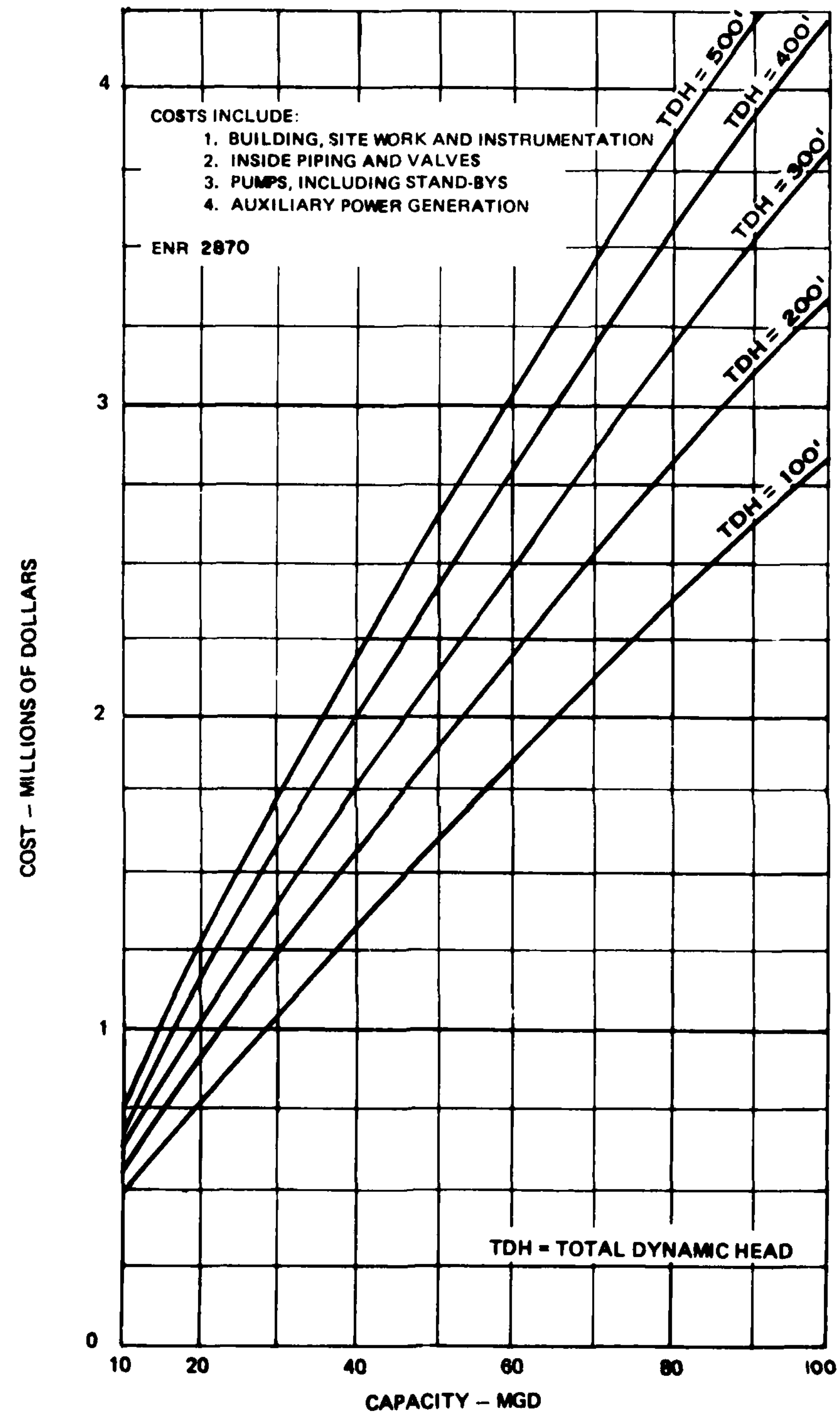


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

PUMPING STATION CONSTRUCTION COST CURVES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. G-15(a)

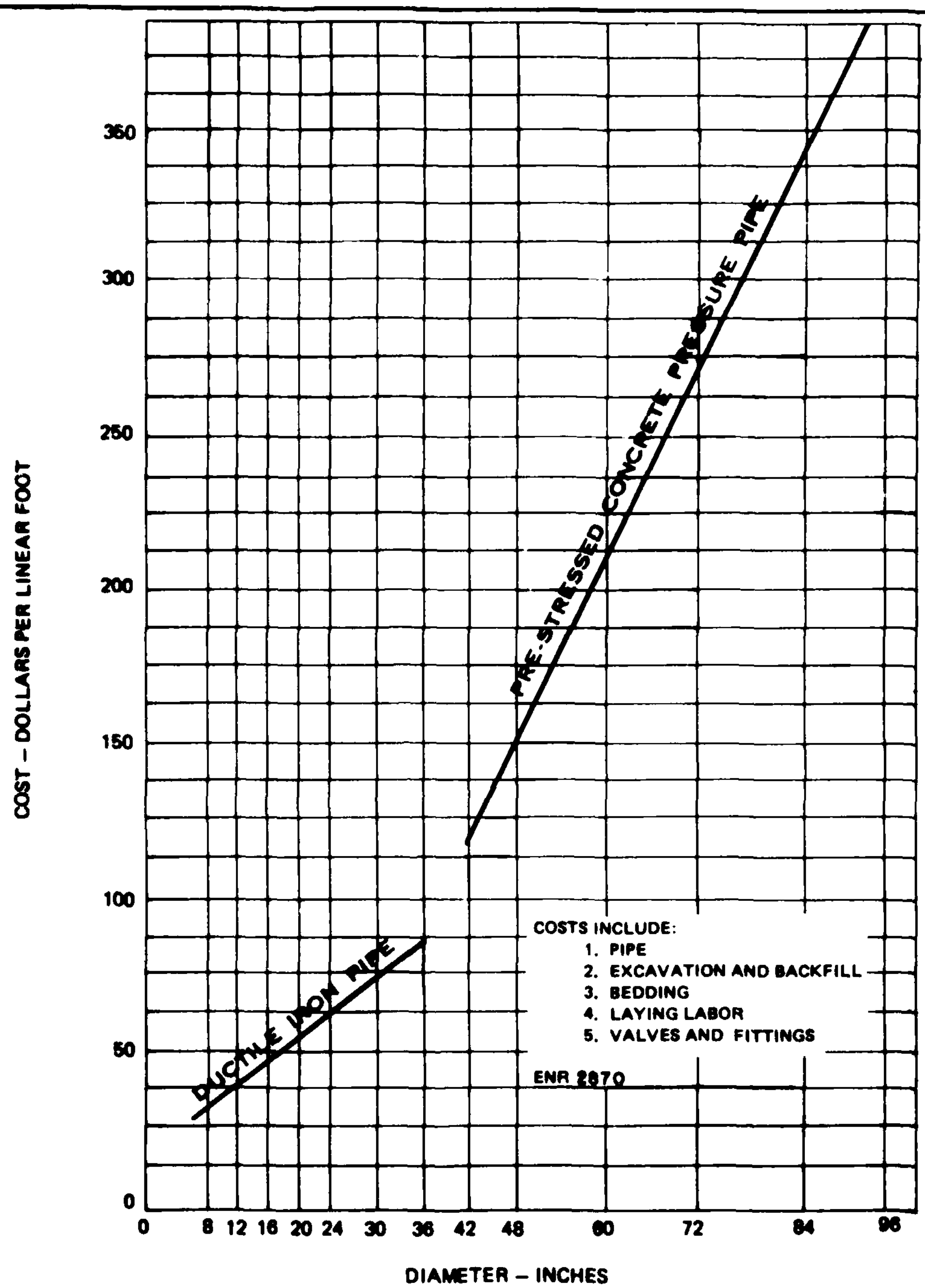


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

PUMPING STATION CONSTRUCTION COST CURVES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

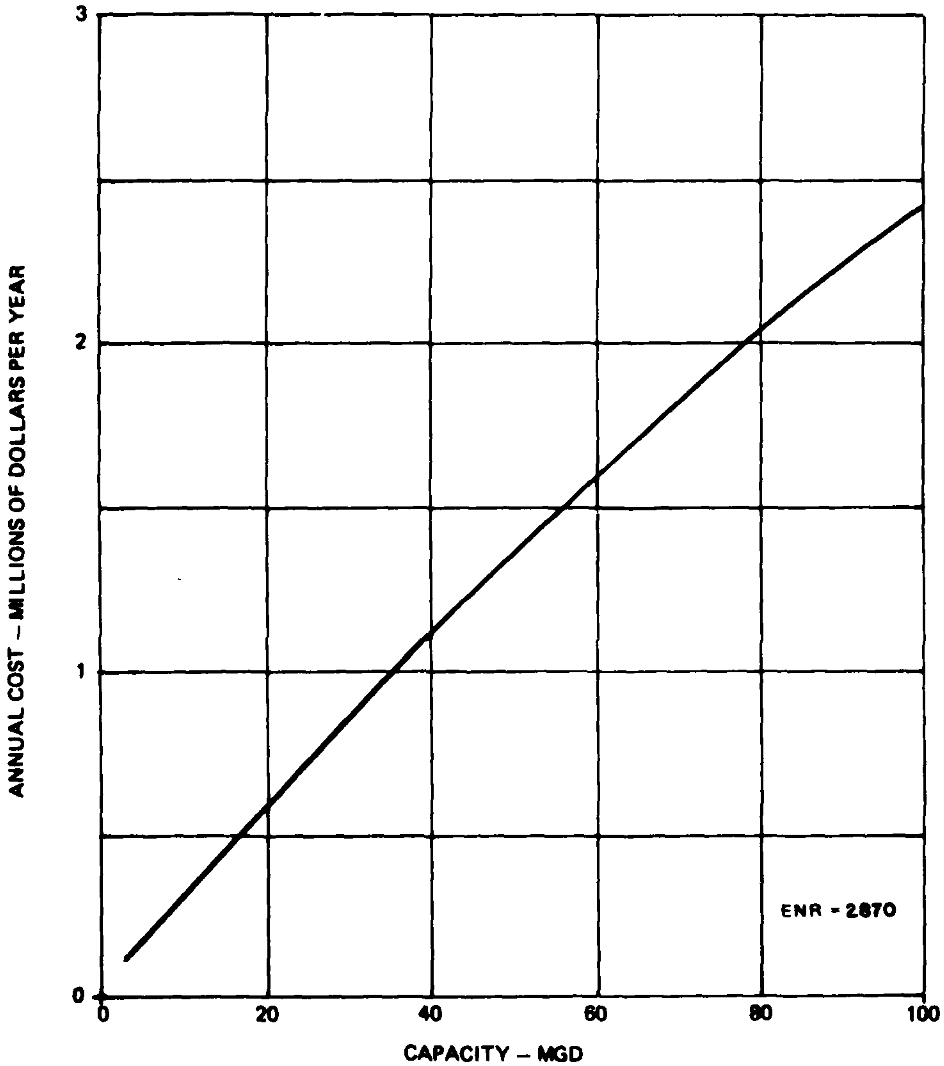
PLATE NO. 6-15(b)



PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

TRANSMISSION MAIN CONSTRUCTION COST CURVE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

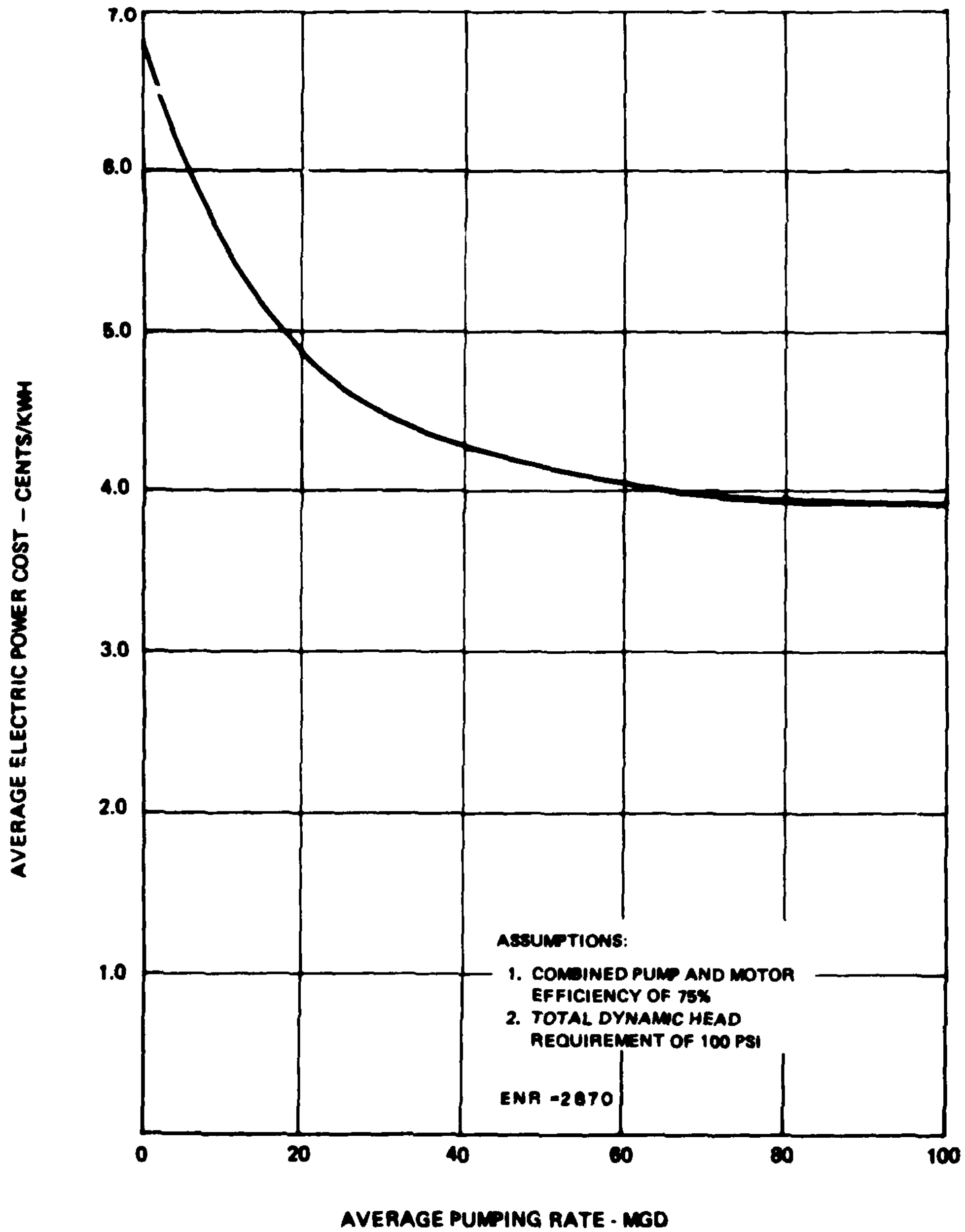


PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

WATER TREATMENT PLANT OPERATION AND MAINTENANCE COSTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. G-17



PAWCATUCK RIVER AND NARRAGANSETT BAY
WATER AND RELATED LAND RESOURCES STUDY

ELECTRIC POWER COST CURVE FOR PUMPING STATIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. 6-18

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

PRELIMINARY ESTIMATE OF REAL ESTATE COSTS
SUBSURFACE WATER TRANSMISSION LINE ALIGNMENT
OF
BIG RIVER RESERVOIR PROJECT
RHODE ISLAND

7 SEPTEMBER 1979

PREPARED BY Edward J. Fallon
EDWARD J. FALLON
Appraiser

REVIEWED BY William Brown Jr.
WILLIAM BROWN, JR.
Review Appraiser

APPROVED BY William R. Coke
WILLIAM R. COKE
Chief, Appraisal Branch

ATTACHMENT G-1

PURPOSE

The purpose of this report is to estimate the preliminary real estate costs concerning the Subsurface Water Transmission Line of the Big River Reservoir Project, Rhode Island, as of 7 September 1979.

INSPECTION OF THE REAL ESTATE

The properties affected by the proposed construction of the subsurface water line were viewed in the field by real estate personnel in the summer of 1979.

LOCATION

The alignment of the subject subsurface conduit, a segment of the Big River Reservoir Project, would be constructed beneath certain public street rights-of-way and private lands in the towns of Coventry and West Warwick, Rhode Island.

PROJECT DESCRIPTION (Water Transmission Line)

The water transmission line consists of a deep drilled eight-foot diameter conduit. It would commence within proposed reservoir lands at a point just west of the Maple Root Trailer Park in Coventry, Rhode Island. At an invert depth of about 300 feet it would extend a distance of about seven miles, terminating at the existing shaft of the Providence Water Supply Board's supplemental tunnel in the rural northeast section of West Warwick.

In that the construction would be at a depth of 300 feet beneath the street rights-of-way and private lands, real estate interests in the nature of permanent subsurface easements would be acquired. From its point of beginning near Maple Root Trailer Park in Coventry, it will run in a northeasterly direction about 0.40 miles to Nooseneck Hill Road, then continue in its straight line projection under Mishnock Swamp about 1.50 miles, bisecting the irregular layout of Nooseneck Hill Road. Continuing to the West Warwick town line, a distance of about 3.30 miles, it would pass beneath approximately 140 private ownerships, the South Branch Flat River and about 37 public streets. From the Coventry-West Warwick town line to its termination point in West Warwick, the conduit would pass beneath about 75 private ownerships, the North Branch Pawtuxet River, two cemeteries, a golf course and approximately 15 public street rights-of-way, a distance of about 1.80 miles. The overall length of the water transmission line is approximately 7.00 miles.

PERMANENT SUBSURFACE EASEMENTS

Permanent subsurface easements would be acquired affecting a total of approximately 215 private ownerships. A nominal value in the amount of $100 per ownership is estimated to be a fair and reasonable cost for the easement interest. Preliminary investigations indicate that after the imposition of the easement interest, the highest and best use of all the properties affected by this proposed acquisition program will not be materially affected. However, it is historically known that the mere knowledge and existence of the imposition infers a restrictive aspect of a perpetual cloud on the title which runs with the land. The estimated costs for the easement rights are predicated on the assumption that construction methods will not be of the blasting magnitude that would adversely affect surface or near-surface in-ground improvements. If it is determined and found that selected methods of construction would cause damage to surface or near-surface in-ground improvements, then the estimated nominal value for the easement rights would not remain valid and a new in-depth real estate study of the proposed taking area would be required.

However, it is reported by sources deemed reliable that construction of the conduit alignment will be in bed rock and that for the most part a preferred moling method of construction will be utilized.

DEFINITION OF IMPROVEMENTS

A clarifying definition of surface or near-surface in-ground improvements are structures at surface elevations and in-ground near-surface structures, including structures at surface elevations connected to near-surface conventional foundations, footings, in and off street subsurface utilities and wells.

PROTECTION AND ENHANCEMENT OF CULTURAL ENVIRONMENT

There are no known structures of historic significance which will be affected by this segment of the Big River Reservoir Project.

TAX LOSS

No tax loss is anticipated for this segment of the Big River Reservoir Project.

ACQUISITION COSTS

Acquisition costs will include costs for mapping and surveys, legal descriptions, title evidence, appraisals, negotiations, and closing and administrative costs for possible condemnations. The acquisition costs, based upon this office's experience in similar civil works projects in this general area, are estimated at $3,000 per ownership. About 215 private ownerships will be affected.

RELOCATION ASSISTANCE COST

Public Law 91-646, Uniform Relocation Assistance Act of 1970, provided for equitable treatment of persons displaced from their homes, businesses, or farms by a Federally assisted program. No persons, businesses or farms would be displaced.

In accordance with this law, a sum of $200 per ownership is estimated to cover possible reimbursable expenses which may be incurred in this acquisition program.

SEVERANCE DAMAGES

No severance damages are anticipated in this segment of the Big River Reservoir project.

CONTINGENCIES

A contingency allowance of 20 percent is considered to be reasonably adequate to provide for possible appreciation of property values from the time of this estimate to acquisition date, for possible minor property line adjustments or for additional hidden ownerships which may be developed by refinement to taking lines, for adverse condemnation awards and to allow for practical and realistic negotiations.

GOVERNMENT-OWNED FACILITIES

Section III of the Act of Congress approved 8 July 1958, (PL85-500) authorized the protection, realteration, reconstruction, relocation or replacement of municipally-owned facilities. A preliminary inspection of the project area indicates no Government-owned facilities are affected.

TEMPORARY CONSTRUCTION EASEMENTS

Temporary work areas would not be required as the entire Water Transmission Line would be subsurface and construction work areas would be required only at the beginning and terminating areas. Lands at the area of beginning of the construction are within lands that would be devoted to reservoir purposes and the area at point of termination are currently publicly controlled for water supply aqueduct services. Therefore no temporary easements would be acquired for this segment of the Big River Project.

CONCLUSIONS AND SUMMARY OF REAL ESTATE COSTS

The area of study for this segment of the Big River Reservoir Project was based upon a line projection superimposed upon U.S. Geological Survey Maps dated 1955, photo revised 1970. The Water Transmission Line projection line is subject to refinement prior to proposed construction of this segment of the Big River Project.

There follows an estimate of the real estate costs for the interests proposed for acquisition:

SUMMARY OF REAL ESTATE COSTS

Permanent Easements	
215 Tracts @ $100	$ 21,500
Temporary Easements	0
Severance Damages	0
Contingencies (20% of $21,500)	4,300
Subtotal	$25,8000
Acquisition Costs	
215 Tracts @ $3,000	$645,000
Relocation Assistance Costs	
215 Tracts @ $200	43,000
Total Estimated Real Estate Costs	$713,800
Rounded to	$714,000

DEPARTMENT OF THE AMRY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS

PRELIMINARY ESTIMATE OF REAL ESTATE COSTS
BIG RIVER RESERVOIR PROJECT
RHODE ISLAND

12 DECEMBER 1979

Prepared By Edward J. Fallon
EDWARD J. FALLON
Appraiser

Reviewed By William D. Brown Jr.
WILLIAM D. BROWN, JR.
Review Appraiser

Approved By William R. Coke
WILLIAM R. COKE
Chief, Appraisal Branch

ATTACHMENT G-2

CONTENTS

EXHIBITS

PURPOSE

The purpose of this report is to estimate the real estate costs concerning various plans for the Big River Reservoir Project as of December 1979.

SCOPE OF REPORT

Included in this report are estimates of the real property values and the inherent real estate costs for seven alternative development plans. Also included are preliminary estimates for additional recreational and mitigation lands. The alternative projects are identified by an assigned number and are in keeping with current real estate acquisition criteria as set forth in Engineer Pamphlet 405-1-2, dated 2 January 1979. It is noted that all of the described lands are currently owned by the State of Rhode Island. Therefore, no provision was estimated for a contingency factor.

LOCATION

The lands concerning the Big River Reservoir Project are entirely within the State of Rhode Island. Four towns are affected by the proposed project. The major portion of the affected lands are primarily in West Greenwich. In the adjacent towns of Coventry, East Greenwich and Exeter other smaller areas are affected. The dam and spillway would be situated at the mouth of the Big River near the most southerly reach of the existing Flat River Reservoir in Coventry.

West Greenwich is located on Interstate 95, the principal north-south route through the Metropolitan area. Route 102 (Victory Highway) crosses Routes 95 and 3 near the Exeter town line. Route 102 connects with main routes to Worcester and points north.

HISTORY AND TREND

Prior to its establishment as a town in 1741, West Greenwich formed the western portion of East Greenwich. Most of the town is largely wooded and is the most sparsely populated area in the State. Approximately 10,000 acres or about 1/3 of the town's total area is State-owned for parks and recreation. During the Civil War era, when water power was paramount, manufacturing flourished in the town. Manufactured products such as textiles, shingles, carriages, farming implements and molasses contributed considerably to the town's development during this period.

In recent years moderate residential growth has taken place in the Mishnock area, along Weaver Hill Road, Carr's Pond Road, Victory Highway, Plain Meeting House Road and Breakheart Hill Road.

In 1962 the State of Rhode Island acquired land in and around the Big River and Wood River areas in West Greenwich. The acquisition was planned for a large reservoir. The trend of land values in the area has been upward for the past several years. Many factors have caused this to happen, such as inflation through the country, and the general desire to invest in land and to live beyond the densely populated inner suburbs and enjoy the amenities of rural living. In 1975 West Greenwich had a population of 2,500.

SITE DATA

The proposed project lands are irregularly shaped containing about 8,167 acres. The land in the northwest section of the project lies primarily in the town of Coventry, and is very hilly with numerous valley, bogs, brooks and swamps. It is mainly woodlands with the exception of a 9-hole golf course and Country Club which is located on the south side of Harkney Hill Road. This area has relatively few improved properties, being sparsely developed by a few farms and rural residental units.

Along Route 3, a major highway (Nooseneck Hill Road), which is southeast of the bisecting Interstate 95, there are numerous improved parcels devoted primarily to residential use with a few commercial units. South of Route 3 this area is of undulating terrain with two major rivers, the Big River and Nooseneck River, with extensive woodland, and numerous swamps, ponds, meadows and brooks. The remaining area south of Division Road, which parallels Route 95, is heavily wooded, has a few gravel roads and is improved by farms and residential units, and some commercial enterprises.

Between Division Road and Interstate 95 there is an area of sand dunes known as "the Rhode Island Desert." Just off of Burnt Sawmill Road, there is a large gravel pit which is in operation, considered to be the largest single mineral deposit in the region. Throughout the area there are a few scattered automobile salvage yards.

ZONING

A zoning ordinance was adopted by West Greenwich in May 1969, allowing the following permitted uses:

Rural, Farming, Residential
Neighborhood Business
Highway Business
Industrial A
Industrial B

Minimum lot size is two acres with minimum 200-foot frontage. The area affected by the project in Coventy is zoned Rural Residential requiring a lot size of two acres with minimum 225-foot frontage.

HIGHEST AND BEST USE

Generally, the present uses of the lands located within the project area, are considered to their highest and best use. Currently, the entire project area is owned in fee by the State with use and occupancy of the lands controlled by agreement and lease.

UTILITIES

Electric power and telephone facilities are available to the subject area. Sewage disposal and water are by on-site facilities.

MINERAL DEPOSITS

Within the limits of the subject area there are three private contractors currently removing sand and gravel. Their present agreements with the State are expected to end in 1980 or 1981; however, considerable gravel remains in the area. It has been reliably reported that this sand and gravel resource has been identified as the largest single mineral deposit located in the region.

TIMBER

A large portion of the land located within the project area is classified as wooded, and there are a few small stands of merchantable species. The value of any timber within the subject area is reflected in the land value.

AGRICULTURE

There are some meadow lands and fields that were at one time used for farming purposes but due to the anticipated reservoir project only a few remain under agreement with the State.

RELOCATIONS

a. Roads

West Greenwich. The following roads in West Greenwich are scheduled for relocation: Nooseneck Hill Road (Route 3) beginning at a point just north of the intersection of Exit #6 on Route #95. This portion of Nooseneck Hill Road will be relocated alongside Route #95.

Coventry. Harkney Hill Road from a point beginning at approximately 3/4 mile to the west of the intersection of Noosneck Hill Road in Coventry, Rhode Island and ending at a point approximately 1/4 mile to the west of Fish Hill Road, a distance of approximately two miles. The road will be relocated just north of and parallel to its present location, heading in a northerly direction and ending at Exit #6 of Route #95. The relocations will occur within lands which are presently owned by the State of Rhode Island. Congdon Mill Road will be relocated beginning at New London Turnpike and heading in a north-westerly direction for approximately 1-3/4 miles, terminating at a point approximately 1/4 mile east of Nooseneck Hill Road. The road relocations are subject to refinement.

b. Cemeteries. Thirty four known cemeteries are located within the project. Of these fifteen are located within the 300′ contour line.

The fifteen cemeteries within the 300′ contour line are as follows:

Arrowhead Road Number Fifty-One (Greene)	CEM-1
Burnt Sawmill Road Number Fifty-Three (Matteson)	CEM-3
Burnt Sawmill Road Number Twenty-Seven (Whitford)	CEM-4
Burnt Sawmill Road Number Unnumbered (Kettle)	CEM-5
Division Street Number Twenty Five (Andrews)	CEM-10
Division Street Unnumbered (Matteson)	CEM-11
Division Street Number Forty-Six (Whitman, Woodward)	CEM-12
Division Street Number Forty-Seven (Harrington)	CEM-13
Division Street Unnumbered	CEM-14
New London Turnpike Unnumbered (Carr)	CEM-22
New London Turnpike Unnumbered (Case)	CEM-23
New London Turnpike Unnumbered (Hopkins)	CEM-24
Nooseneck Hill Road Number Twenty-Three (Hall)	CEM-29
Sweet Sawmill Road Unnumbered (Briggs)	CEM-33
Sweet Sawmill Road Number Fifty-Four (Cleveland, Congdon, Nichols)	CEM-34

There is also the possibility of other graves and/or burial plots within the reservoir area that are unknown.

SEVERANCE DAMAGES

Current planning by the State would provide portions of certain roads to be relocated which would assure adequate approach to abutting ownerships. Therefore, no severance damages are anticipated.

PROTECTION AND ENHANCEMENT OF THE CULTURAL ENVIRONMENT

Executive Order No. 11593, dated May 15, 1971, and titled "Protection and Enhancement of the Cultural Environment," specifies under Section 1, Policy, that the Federal Government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Agencies of the Executive Branch of the Government shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that Federally-owned sites, structures, and objects of historical, architectural or archaelogical significance are preserved, restored and maintained for the inspiration and benefit of the people, and (3) in consultation with the Advisory Council on Historic Preservation (16 U.S.C. 4701), institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-Federally owned sites, structures and objects of historically, architectural or archaelogical significance. There are many historical and architectural sites within the proposed project area. Reference is made to an inventory of the cultural resources by Thematic Category on file at the Rhode Island Water Resouces Board.

GOVERNMENT OWNED FACILITIES

Public Law 85-800, Section III of the Act of Congress, approved 3 July 1958, states that whenever, during the construction or reconstruction of any navigation, flood control, or related water development project under the direction of the Secretary of the Army, the Chief of Engineers determines that any structure or facility owned by an agency of Government and utilized in the performance of a Governmental function should be protected, altered, reconstructed, relocated, or replaced to meet the requirements of navigation or flood control, or both; or to preserve the safety or integrity of such facility when its safety or usefulness is determined by the Chief of Engineers to be adversely affected or threatened by the project, the Chief of Engineers may, if he deems such action to be in the public interest, enter into a contract providing for the payment from appropriations made for the construction or maintenance of such project, of the reasonable actual cost of such remedial work, or for the payment of a lump sum representing the estimated reasonable cost. Provided, that this section shall not be construced as modifying any existing or future requirements of local cooperation, or as indicating a policy that local interests shall not hereafter be required to assume costs of modifying such facilities. The provisions of this section may be applied to projects hereafter authorized and to those heretofore authorized but not completed, as of the date of this Act, and notwithstanding the navigation servitude vested in the United States, they may be applied to such structures or facilities occupying the beds of navigable waters of the United States. There are no known Government-owned facilities that would come under the purview of this Executive Order.

WATER RIGHTS

Within the limits of the State-owned sites, there are several rivers and ponds. Any water rights were extinguished by State fee acquisition.

LAND REQUIREMENTS AND ESTATES ACQUIRED

The total estimated areas for each alternate project are included in the lands that have been acquired in fee by the State of Rhode Island.

The estimated land areas concerning Alternative Projects I through VII, plus Recreation and Mitigation lands are as follows:

ALTERNATIVE PROJECT I

Single Purpose - Flood Control

270' Guide Contour Line. This project includes the lands necessary for a five foot freeboard elevation.

Total Estimated Area Required	1,396 Acres

ALTERNATIVE PROJECT II

Single Purpose - Water Supply

300' Pool Elevation at Spillway Crest. This project includes lands 300 feet horizontal from the established pool elevation which includes necessary freeboard elevation.

Total Estimated Area Required	4,545 Acrea

ALTERNATIVE PROJECT III

Dual Purpose - Flood Control and Water Supply

The land requirements under this project are the same as Single Purpose Water Supply (Alternative Project II).

Total Estimated Area Required	4,545 Acres

ALTERNATIVE PROJECT IV

Dual Purpose - Flood Control and Recreation

The land requirements for this project are the same as Single Purpose Flood Control plus 20 acres planned for recreational purposes.

Estimated Area Required for Flood Control	1,396 Acres
Estimated Area Required for Recreation	20 Acres
TOTAL ESTIMATED AREA REQUIRED	1,416 Acres

ALTERNATIVE PROJECT V

Dual Purpose - Water Supply and Recreation

The land requirements for this project are the same as Single Purpose Water Supply with an additional 20 acres planned for recreational purposes.

Estimated Area Required for Water Supply	4,545 Acres
Estimated Area Required for Recreation	20 Acres
Total Estimated Area Required	4,565 Acres

ALTERNATIVE PROJECT VI

Multiple Purpose - Flood Control/Water Supply and Recreation

The land requirements for this project are the same as Alternative Project VI which includes 20 acres for recreational purposes.

Estimated Area Required for Flood Control/Water Supply	4,545 Acres
Estimated Area Required for Recreation	20 Acres
Total Estimated Area Required	4,565 Acres

ALTERNATIVE PROJECT VII

Multiple Purpose - Flood Control/Water Supply/Recreation and Mitigation

The land requirements for this project include all of the lands that would be devoted to all of the above levels of development.

Estimated Area Required for Flood Control/Water Supply Recreation and Mitigation:

Estimated Area Required for Flood Control/Water Supply	4,545 Acres
Estimated Area Required for Recreation	20 Acres
Estimated Area Required for Mitigation	3,602 Acres
Total Estimated Area Required	8,167 Acres

RECREATION LAND

There are four areas of study consisting of 10 acres each considered for recreation purposes. The areas are identified as follows:

Area No. 1 - Zeke's Bridge Swimming, Boat Launch and Picnic Area	10 Acres
Area No. 2 - Carr Pond Swimming and Picnic Area	10 Acres
Area No. 3 - Phelps Pond Swimming and Picnic Area	10 Acres
Area No. 4 - Hungry Hill and Harkney Hill Camping Areas	10 Acres

MITIGATION LAND

The mitigation lands include all of the remaining State fee-owned land outboard and contiguous to the Flood Control, Water Supply and Recreation Multiple-Purpose

Total Estimated Mitigation Lands	3,602 Acres

ACQUISITION COSTS

The State of Rhode Island currently holds fee title to all of the lands required for project purposes. Therefore, the costs would be limited to mapping, survey, legal descriptions, appraisal, and administrative expense. Based on the foregoing the one detailed ownership is estimated at about $30,000 for each respective plan of development.

PROJECT BOUNDARY MARKINGS

Boundary markings and survey costs for each plan of development are estimated at $3,000 per mile. There follows a breakdown of those estimates for each plan.

ALTERNATIVE PROJECT I

28.7 Perimeter Miles @ $3,000 Per Mile	$ 86,000.

ALTERNATIVE PROJECT II

36.0 Perimeter Miles @ $3,000 Per Mile	$108,000.

ALTERNATIVE PROJECT III

36.0 Perimeter Miles @ $3,000 Per Mile	$108,000.

ALTERNATIVE PROJECT IV

28.7 Perimeter Miles @ $3,000 Per Mile	$ 86,000.

ALTERNATIVE PROJECT V

36.0 Perimeter Miles @ $3,000 Per Mile	$108,000.

ALTERNATIVE PROJECT VI

36.0 Perimeter Miles @ $3,000 Per Mile	$108,000.

ALTERNATIVE PROJECT VII

24.0 Perimeter Miles @ $3,000 Per Mile	$ 72,000.

RELOCATION ASSISTANCE COSTS

Public Law 91-646, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, provides for uniform and equitable treatment of persons displaced from their homes, businesses, or farms by Federal and Federally assisted programs. Since all of the project lands are owned by the State of Rhode Island, benefits payable under the Act will be mostly for displaced tenants who are currently occupying the affected residences under rental agreements with the State of Rhode Island. Applicable benefits are moving expenses, replacement housing for tenants and relocation advisory services.

Within a reasonable time prior to displacement, the Division Engineer must be assured by the local sponsor that there will be available in areas generally not less desirable and at rents and prices within the financial means of the families and individuals displaced, decent, safe and sanitary dwellings, equal in number to the number of, and available to, such displaced persons who require such dwellings and reasonably accessible to their places of employment. It appears that the supply of replacement housing will be sufficient to accommodate the tenants that will be displaced by the project. Should it be determined that adequate replacement housing is not available and cannot otherwise be made available, such housing will be provided by the local sponsor as a last resort. The estimated costs for moving expenses, replacement housing for tenants and relocation advisory services attributable to each alternative project are as follows:

Alternative Project I	- Single Purpose Flood Control	$172,000.
Alternative Project II	- Single Purpose Water Supply	$340,000.
Alternative Project III	- Dual Purpose Flood Control and Water Supply	$340,000.
Alternative Project IV	- Dual Purpose Flood Control and Recreation	$172,000.
Alternative Project V	- Dual Purpose Water Supply and Recreation	$340,000.
Alternative Project VI	- Multiple Purpose Flood Control, Water Supply, and Recreation	$340,000.
Alternative Project VII	- Multiple Purpose Flood Control, Water Supply, Recreation and Mitigation	$560,000.

REAL ESTATE COST SUMMARY

Included in the following summaries of real estate costs are all of the necessary land areas, estimated fair market values and other inherent real estate costs for each designated alternative development.

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT I - SINGLE PURPOSE FLOOD CONTROL

Land	
1,396 Acres	$3,828,000
Improvements	
33 Residential Units and 3 Commercial Units	1,475,000
Total Estimated Cost of Land and Improvements	$5,303,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	86,000
Relocation Assistance Costs	172,000
Total Estimated Real Estate Costs - Alt. Proj. I	$5,591,000
Call	$5,590,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT II - SINGLE PURPOSE WATER SUPPLY

Land	
4,545 Acres	$14,915,000
Improvements	
62 Residential Units and 7 Commercial Units	2,880,000
Total Estimated Cost of Land and Improvements	$17,795,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	108,000
Relocation Assistance Costs	340,000
Total Estimated Real Estate Costs - Alt. Proj. II	$18,273,000
Call	$18,270,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT III - DUAL PURPOSE FLOOD CONTROL AND WATER SUPPLY

Land	
4,545 Acres	$14,915,000
Improvements	
62 Residential Units and 7 Commercial Units	2,880,000
Total Estimated Costs of Land and Improvements	$17,795,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	108,000
Relocation Assistance Costs	340,000
Total Estimated Real Estate Costs - Alt. Proj. III	$18,273,000
Call	$18,270,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT IV - DUAL PURPOSE FLOOD CONTROL AND RECREATION

Land	
1,416 Acres	$ 3,918,000
Improvements	
33 Residential Units and 7 Commercial Units	1,475,000
Total Estimated Cost of Land and Improvements	$ 5,393,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	86,000
Relocation Assistance Costs	172,000
Total Estimated Real Estate Costs - Alt. Proj. IV	$ 5,681,000
Call	$ 5,680,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT V - DUAL PURPOSE WATER SUPPLY AND RECREATION

Land	
4,565 Acres	$15,005,000
Improvements	
62 Residential Units and 7 Commercial Units	2,880,000
Total Estimated Costs of Land and Improvements	$17,885,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	108,000
Relocation Assistance Costs	340,000
Total Estimated Real Estate Costs - Alt. Proj. V	$18,363,000
Call	$18,360,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT VI - MULTIPLE PURPOSE FLOOD CONTROL, WATER SUPPLY AND RECREATION

Land

4,565 Acres	$15,005,000

Improvements

62 Residential Units and 7 Commercial Units	2,880,000
Total Estimated Cost of Land and Improvements	$17,885,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	108,000
Relocation Assistance Costs	340,000
Total Estimated Real Estate Costs - Alt. Proj. VI	$18,363,000
Call	$18,360,000

REAL ESTATE COST SUMMARY

ALTERNATIVE PROJECT VII - MULTIPLE PURPOSE FLOOD CONTROL, WATER SUPPLY, RECREATION AND MITIGATION

Land	
8,167 Acres	$25,511,000
Improvements	
110 Residential Units and 7 Commercial Units	4,595,000
Total Estimated Costs of Land and Improvements	$30,106,000
Acquisition Costs (one detailed ownership)	30,000
Project Boundary Markings	72,000
Relocation Assistance Costs	560,000
Total Estimated Real Estate Costs - Alt. Proj. VII	$30,768,000
Call	$30,800,000

REAL ESTATE COST SUMMARY - RECREATION LAND

AREA 1 - ZEKE'S BRIDGE SWIMMING, BOAT LAUNCH AND PICNIC AREA

Land

10 Acres	$ 60,000

AREA 2 - CARR POND SWIMMING AND PICNIC AREA

Land

10 Acres	$ 30,000

AREA 3 - PHELPS POND SWIMMING AND PICNIC AREA

Land

10 Acres	$ 30,000

It is noted that of the above recreational options, no detailed mapping was available at the time of this writing. Two of the recreational study areas are contiguous to all of the project plans and all three areas are located within the land planned for mitigation purposes. Therefore, no estimate was included other than their estimated land values. Two of the above designated areas were used where recreational features were required and Area 1 was used in all of the plans with recreational requirements.

REAL ESTATE COST SUMMARY - MITIGATION LAND

Land

*3,602 Acres	$10,506,000

Improvements

48 Residential Units and 1 Commercial Unit	1,715,000
Total Estimated Cost of Land and Improvements	$12,221,000
Relocation Assistance Costs	** 220,000
Total Estimated Real Estate Costs - Mitigation Lands	$12,441,000
Call	$12,440,000

*The total estimated real estate costs would not include the 20 acre area planned for recreation purposes.

**Relocation Assistance cost is included for information purposes only. It is included within the Multiple-Purpose Flood Control, Water Supply, Recreation and Mitigation (Alternative Project VII).

CEMETERIES MASTER LIST

COVENTRY

<u>Arrowhead Road</u>

- Historical Cemetery Number Fifty-one (Greene) CEM-1

WEST GREENWICH

<u>Big River Road</u>

- Historical Cemetery Number Twenty-six (Matteson) CEM-2

<u>Burnt Sawmill Road</u>

- Historical Cemetery Number Fifty-three (Matteson) CEM-3
- Historical Cemetery Number Twenty-seven (Whitford) CEM-4
- Historical Cemetery, unnumbered (Kettle) CEM-5

<u>Carr Pond Road</u>

- Historical Cemetery, unnumbered (Tarbox, Jackson) CEM-6
- Historical Cemetery Number Twenty-nine (Tarbox, Whitford) CEM-7
- Historical Cemetery, unnumbered (Kettle) CEM-8

<u>Congdon Mill Road</u>

- Historical Cemetery, unnumbered (Whitford) CEM-9

<u>Division Street</u>

- Historical Cemetery Number Twenty-five (Andrews) CEM-10
- Historical Cemetery, unnumbered (Matteson) CEM-11
- Historical Cemetery, Number Forty-six (Whitman, Woodward) CEM-12
- Historical Cemetery Number Forty-seven (Harrington) CEM-13
- Historical Cemetery, unnumbered CEM-14

EXHIBIT "A"

- Historical Cemetery Number Thirty-seven (King, Howard) CEM-15
- Historical Cemetery Number Thirty-eight (Matteson, Shippee) CEM-16
- Historical Cemetery, unnumbered CEM-17

Hopkins Hill Road

- Historical Cemetery Number Thirty-six (Greene) CEM-18
- Historical Cemetery Number Thirty (Barbour, Hopkins, Potter) CEM-19
- Historical Cemetery, unnumbered (Spink) CEM-20
- Historical Cemetery, unnumbered (Potter) CEM-21

New London Turnpike

- Historical Cemetery, unnumbered (Carr) CEM-22
- Historical Cemetery, unnumbered (Case) CEM-23
- Historical Cemetery, unnumbered (Hopkins) CEM-24
- Historical Cemetery Number Twenty-eight (Hopkins) CEM-25

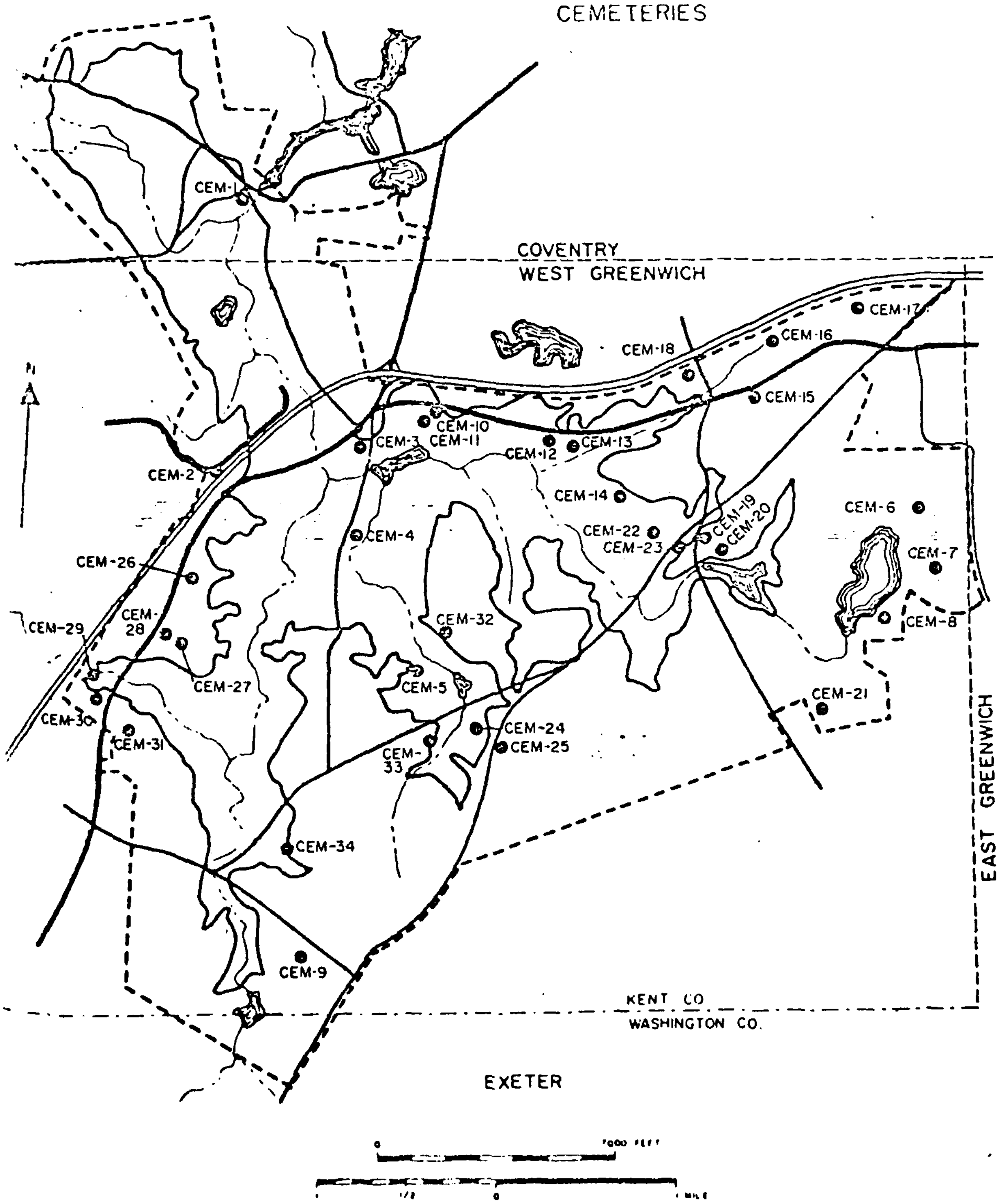
Nooseneck Hill Road

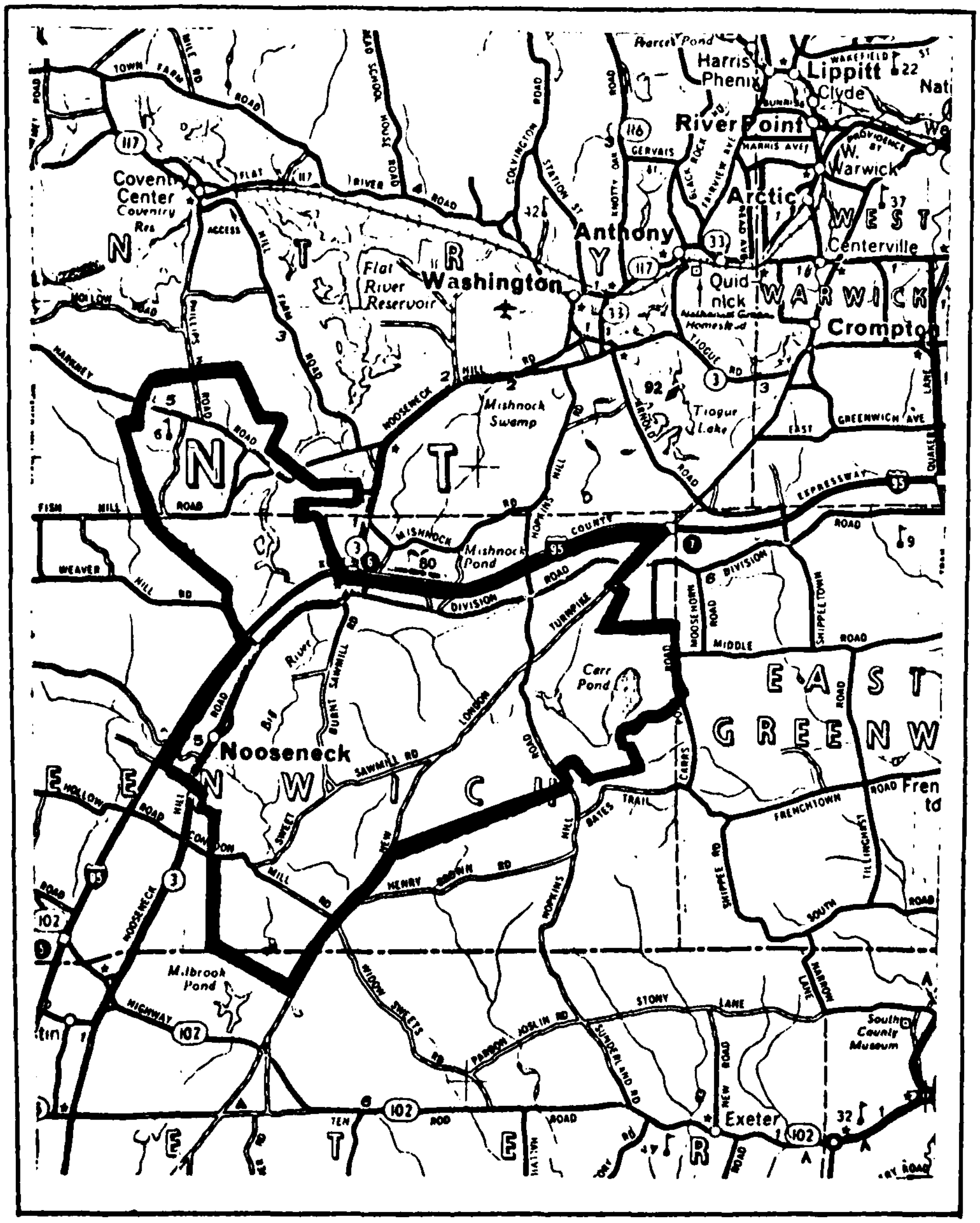
- Historical Cemetery, unnumbered (Matteson, Shippee) CEM-26
- Historical Cemetery, unnumbered (Matteson) CEM-27
- Historical Cemetery Number Twenty-three (Hall) CEM-29
- Historical Cemetery, unnumbered (Johnson) CEM-28
- Historical Cemetery, unnumbered (Hall) CEM-30
- Historical Cemetery, unnumbered (Andrews, Edwards, Gardner) CEM-31

Sweet Sawmill Road

- Historical Cemetery Number Fifty-two (Sweet Burying Ground) CEM-32
- Historical Cemetery, unnumbered (Briggs) CEM-33
- Historical Cemetery Number Fifty-four (Cleaveland, Congdon, Nichols) CEM-34

BIG RIVER RESERVOIR AREA
CEMETERIES





Location Map of Big River Reservoir Area in Coventry, Exeter and West Greenwich, Rhode Island

EXHIBIT "B"

CERTIFICATION

This is to certify that I have personally inspected the lands described herein, that the facts and data used herein are, to the best of my knowledge and belief, true and correct, and that the appraisal values and costs represent my best and unbiased judgment of the Fair Market Value of the properties. I have no present nor intended future interest in the property.

Edward J. Fallon 12 December 1979

Edward J. Fallon
Appraiser

Date

DATE
ILME