From: Benjamin Reynolds <B.Reynolds@holtec.com>
Sent: Tuesday, December 19, 2023 2:21 PM
To: Langley, Lealdon (DEP); Jean Fleming
Subject: RE: Second request for Historic PNPS Permits
Attachments: PNPS_DEP RFI#2_12192023.pdf

Director Langley,

Based on MassDEP's December 8, 2023 request, Holtec is providing additional information to supplement the April 5, 2023 application to modify the Massachusetts surface water discharge permit (Permit No. MA0003557) for Pilgrim Nuclear Power Station.

Please let Jean Fleming or myself know if Holtec can further support the evaluation of the modification request.

Thank you and I hope you enjoy the holidays.
Ben

From: Langley, Lealdon (DEP) <lealdon.langley@mass.gov>
Sent: Friday, December 8, 2023 3:47 PM
To: Jean Fleming <J.Fleming@holtec.com>; Benjamin Reynolds <B.Reynolds@holtec.com>
Subject: Second request for Historic PNPS Permits

Ms. Fleming
Please find attached MassDEP's letter providing additional opportunity for Holtec to provide historic permit documents. Thank you. L2

Lealdon Langley, Director
Division of Watershed Management
Massachusetts Department of Environmental Protection (MassDEP)
100 Cambridge Street, Suite 900
Boston, MA 02114
Cell: (617) 259-0537
Note: MassDEP's office has moved. My prior office phone # has been deactivated.
For phone contact, please call the cell number above. Please remove my office phone # from your contact list.

HOLTEC DECOMMISSIONING INTERNATIONAL

KPS Technology Campus, 1 Holtec Blvd., Camden, NJ 08104

Telephone (856) 797-0900 – Fax (856) 797-0900

www.holtecinternational.com

December 19, 2023

Mr. Lealdon Langley
Director of Watershed Management
Massachusetts Department of Environmental Protection
100 Cambridge Street Suite 900
Boston, MA 02114

Re: Pilgrim Nuclear Power Station – Application to Modify a Massachusetts Permit to Discharge Pollutants to Surface Waters (Permit No. MA0003557, January 30, 2020)

Dear Director Langley:

On December 8, 2023 Holtec Decommissioning International, LLC (HDI) received Massachusetts Department of Environmental Protection's (MassDEP) second request for additional information to supplement the April 5, 2023 application to modify the Massachusetts surface water discharge permit (Permit No. MA0003557). Specifically, MassDEP requested the "Pilgrim Station No. 600 Boston Edison Company, Salt Water Use and Waterfront Development for Pilgrim Nuclear Power Station [Salt Water Use Report] and operating records pertaining to treatment of liquid wastes" as well as "any applications and associated materials related to the three Water Quality Certifications (July 31, 1970, April 15, 1971 and April 23, 1971)."

HDI is providing the following records (Enclosure 1 and 2):

- United States of America Atomic Energy Commission Summary of Application for an Operating License for Pilgrim Nuclear Power Station, Docket No. 50-293, August 6, 1971 (OL Application)
- Department of the Army, Corps of Engineers Application for Permit to Discharge or Work in Navigable Waters and Their Tributaries, September 30, 1971 (ACOE Application)

Please note, the OL Application contains the Salt Water Use Report as well as information regarding the treatment of liquid wastes (at the time of submittal) and the April 23, 1971 Water Quality Certification is a required approval of the ACOE Application. No additional materials were identified to support the request at this time.

Should MassDEP have any additional concerns or wish to discuss this matter further, please feel free to contact Mr. Ben Reynolds, HDI Director of Environmental Affairs, or myself at (856) 797-0900, ext. 3578.

Respectfully,

Jean A. Fleming
Vice President, Licensing, Regulatory Affairs, & PSA
Holtec International

KPS Technology Campus, 1 Holtec Blvd., Camden, NJ 08104
Telephone (856) 797-0900 – Fax (856) 797-0900
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Enclosures:

1. United States of America Atomic Energy Commission Summary of Application for an Operating License for Pilgrim Nuclear Power Station, Docket No. 50-293, August 6, 1971
2. Department of the Army, Corps of Engineers Application for Permit to Discharge or Work in Navigable Waters and Their Tributaries, September 30, 1971

Enclosure 1

United States of America Atomic Energy Commission

Summary of Application for an Operating License for Pilgrim Nuclear Power Station

Docket No. 50-293

August 6, 1971

File 1.8.9

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

SUMMARY OF APPLICATION

FOR AN OPERATING LICENSE

FOR

PILGRIM NUCLEAR POWER STATION

Docket No. 50-293

August 6, 1971

BOSTON Edison COMPANY

November 29, 1971

ERRATA IN "SUMMARY OF APPLICATION
FOR AN OPERATING LICENSE FOR
PILGRIM NUCLEAR POWER STATION"

(A) Errata incorporated in second printing

Page	
iv	Bottom line should read: "9.2 Pre-Operational and Startup Testing"
vi	In titles of Figures 4-4 and 4-5, change "1968" to "1965".
	In title of Figure 4-5 insert "and" after "Resident".
1-1	Line 16, third word is "water".
2-9	Line 2, change "Section 12.0" to "Section 10.0".
5-3	Line 4, add the word "principally" after "consist".
7-2	In the footnote, change "Section 7.5" to "Section 8.5".

(B) Errata not incorporated in any copies

8-3	Add the following at bottom of page: "vessel in the shape of a light bulb, and the pressure suppression chamber is a torus-shaped steel pressure".
8-22	Line 1, change "amendable " to "amenable".
9-4	Line 5, change "clerical" to "electrical".
10-5	Line 16, change "dispatching" to "dissipating".

(C) Suggested editorial changes (not incorporated in any copies)

<u>Page</u>

7-1	Lines 3 and 4, change "minimize radiation. . . site" to "maintain radiation exposures well below the applicable regulatory limits".
8-3	Line 19, after the word "containment", remove the word "is" and insert "consists of the drywell".
8-13	Lines 10 and 11, change "coolant system piping, pumps, valve supports, and hangers" to read "emergency coolant system piping welds."
8-16	Line 11, change "involving the gross release" to "which could potentially involve the release."

November 29, 1971

ERRATA IN "SUMMARY OF APPLICATION FOR AN OPERATING LICENSE FOR PILGRIM NUCLEAR POWER STATION"

Page	
iv	Bottom line should read: "9.2 Pre-Operational and Startup Testing"
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9-4	Line 5, change "clerical" to "electrical".
10-5	Line 16, change "dispatching" to "dissipating".

station structural design criteria differentiates between two types of station structures, Class I structures and Class II structures, and applies detailed design requirements to each classification. Class I includes those structures, equipment and components whose failure or malfunction might cause or increase the severity of an accident which might endanger the public health and safety. This category includes those structures, required for safe shutdown and isolation of the reactor. Class II includes those structures, equipment, and components which are important to reactor operation, but are not essential for preventing an accident which would endanger the public health and safety and are not essential for the mitigation of the consequences of these accidents.(1)

8.2.2 Primary Containment System(2)

The primary containment system houses the reactor vessel, the reactor coolant recirculation system and other branch connections of the reactor coolant system. The primary containment is a pressure suppression chamber which stores a large volume of water, a connecting vent system between the drywell and water pool, isolation valves, vacuum relief system, containment cooling systems, and other service equipment. The drywell is a steel pressure vessel in the shape of a light bulb, and the pressure suppression chamber is a torus-shaped steel pressure a time when the core geometry is amenable to cooling.

4. The core temperature is reduced and decay heat can be removed for an extended period of time.

The systems' power supplies have been chosen to allow initiation and operation regardless of the availability of offsite a-c power. The design of the systems allows testing to verify the operability of all active components during normal operation of the nuclear system.

The core standby cooling systems provided on Pilgrim Nuclear Power Station are functionally equivalent to those included in other operating BWR's. A short description of the systems is included in the following paragraphs.

8.5.2 Core Spray System[14]

Two independent loops are provided as a part of the core spray system to circulate water from the pressure suppression chamber pool to the reactor primary vessel. Each loop consists of a core spray pump, a sparger ring, a spray nozzle, and the necessary piping, valves, and instrumentation. The core spray system provides protection of the core for the postulated case of a large break in the nuclear system when the feedwater system, control rod drive water pumps, reactor core isolation cooling subsection 12.2.1.2 of the FSAR. A summary of the Class I protection instrument and control systems is included in subsection 7.1.1 of the FSAR. The "essential items" are identified on the Q(Quality)-List. Within the Class I mechanical and electrical systems, every item or component is not Q-listed. Rather, each component is reviewed to determine which of the following categories it falls into:

Category A

Its function is essential for the operation of a Class I component or system to meet the Class I criteria (e.g., pumps and switches that must operate to accomplish their safety objective). If so, it is included on the Q-List.

Category B

Its pressure boundary integrity is essential for the operation of a Class I component to meet the Class I criteria. If so, it is included on the Q-List and, if required for clarity, it is given a note (pressure boundary only) on the Q-List.

Category C

It is not essential for either functioning or pressure boundary integrity of A or B above shield itself. Thus the design effectively precludes the possibility of missile generation as a result of pipe or safe-end ruptures within the shield.[2]

(4) <u>Fuel Cask Drop</u>

> "The applicant proposes to assure that accidental dropping of the spent-fuel cask into the fuel storage pool will not cause leakage in excess of the make-up capacity, and will make such modifications as may be necessary."

Boston Edison Company has conducted studies to determine the effects of a spent-fuel cask dropped into the fuel storage pool. In order to assure that any resultant leakage from the pool will be within the pool makeup capability, an energy absorbing/load distributing pad will be installed in the cask loading area which will be capable of absorbing, distributing, and dissipating the kinetic energy associated with a loaded cask drop from the maximum height.[3]

(5) <u>Confirmatory Vibration Testing</u>

> "The applicant said he would make tests adequate to confirm the predicted vibrational characteristics of the vessel internals."

A program of confirmatory vibration measurements will be implemented for the Pilgrim reactor. Both cold and hot

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of	)	
	)	
BOSTON EDISON COMPANY	)	Docket No. 50-293
	)	
(Pilgrim Nuclear Power Station)	)	

SUMMARY OF APPLICATION

AUGUST 6, 1971

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FIGURES

1.0 INTRODUCTION

This document, prepared and filed by Boston Edison Company, the applicant, is a summary of the application* filed by the Company for a license from the Atomic Energy Commission to operate a nuclear power station located on a site in the town of Plymouth, Plymouth County, Massachusetts. To assist interested members of the public in understanding the complex technical material dealt with in this report, the applicant has endeavored to use non-technical language whenever possible.

The Pilgrim Nuclear Power Station occupies a 517-acre site on the shore of Cape Cod Bay. Construction and pre-operational testing is presently scheduled to be completed and the station ready for fuel loading and low power reactor operation in December, 1971. The unit is a conventional boiling water reactor (BWR) designed to generate about 685 megawatts of electricity. It has similar design characteristics to other boiling water reactors which have been licensed and are in operation.

This document has been prepared in accordance with the provisions of Title 10 of the Code of Federal Regulations, Part 2, Appendix A, Section II (e). It includes a summary description of the station, an

*The application and other pertinent documents currently in the record of this proceeding may be examined at the Plymouth Public Library, North Street, Plymouth, Massachusetts.

evaluation of the considerations important to safety, and a comparison of the Pilgrim reactor design with the design of similar reactors previously licensed and in operation. The applicant has included comments on the operating license application rendered by the Advisory Committee on Reactor Safeguards on the application pursuant to Section 29 of the Atomic Energy Act of 1954 as amended (42 U.S.C. 2039), and information incorporated in the docket in accordance with the National Environmental Policy Act of 1969, P.L. 91-190.

In addition to a summary of the application, this document contains a summary of the applicant's program of consultation with interested federal, state and local government officials in planning for the Pilgrim Nuclear Power Station. This summary also describes the status of the applicant's efforts to obtain the permits and approvals required by federal, state, and local agencies.

As set forth more fully in the ensuing sections of this summary, the station has been designed and constructed with preservation of the environment and assurance of nuclear safety as paramount considerations. The station has been designed and will be operated to keep radioactivity in station effluents at small fractions of the applicable limits specified in 10 CFR 20*, "Standards for Protection Against Radiation." Environmental monitoring programs have been established to determine environmental radiation levels prior to station operation for comparison with similar data obtained after station operation. This will serve as a check on the effectiveness of the various source controls to assure that public exposure to radiation remains at small fractions of applicable 10 CFR 20 limits.

No adverse environmental effects are expected to result from the operation of Pilgrim Station. The environmental monitoring programs include aquatic ecological surveillances for detection and evaluation of any environmental effects. If an effect of significance is detected, the applicant will take steps to correct or mitigate any adverse situation.

*10 CFR 20-Code of Federal Regulations, Title 10, Part 20.

2.0 BACKGROUND

2.1 Boston Edison Company

Boston Edison Company is the sole applicant for the facility license, and as owner and applicant, is responsible for the design, construction, and operation of the station. Boston Edison Company is a publicly-held corporation incorporated under the laws of The Commonwealth of Massachusetts in 1886, with its principal executive office at 800 Boylston Street, Boston, Massachusetts.

The applicant is an operating public utility engaged in the electric and steam businesses, supplying electricity at retail in the cities of Boston (except the Charlestown district), Somerville, Newton, Chelsea, Waltham and Woburn, in the towns of Brookline, Arlington, Watertown, Framingham, and in thirty other smaller towns in eastern Massachusetts, covering an area of approximately 590 square miles within 30 miles of Boston. It also supplies electricity in bulk at wholesale to other utilities, including the total electric requirements of the Charlestown District of Boston and thirteen other cities and towns in the vicinity of Boston.

The applicant's electric generating facilities have an aggregate peak capability of approximately two million kilowatts. The principal steam-electric generating stations operated by the applicant are the Edgar station in North Weymouth, the Mystic station in Everett, and the L Street and New-Boston stations in South Boston. The applicant also supplies steam, chiefly from its three steam generating plants located in Boston to approximately 625 customers in that city and engages in the business of purchasing and selling electrical appliances.

2.2 Applicant's Participation in the Development of Nuclear Power

Boston Edison's involvement with nuclear power plants began in 1955 and has continued up to the present time. Boston Edison was a contributor and active participant in the Power Reactor Development Corporation (PRDC), an organization which gave financial support and technical assistance to the Fermi Reactor Project. It is a sponsor of Yankee Atomic Electric Company and Connecticut Yankee Atomic Power Company, and owns 9-1/2 percent of the stock of each of those companies and receives 9-1/2 percent of the power generated by each of those companies. Boston Edison is currently contributing to the development of fast breeder reactors and, through the Edison Electric Institute, to the nuclear research and development programs of that organization.

2.3 Need for Pilgrim Station

Pilgrim Nuclear Power Station is presently scheduled for full power operation in April, 1972 and is part of the comprehensive plan to meet the applicant's electric power requirements. The peak load of the applicant for the power year commencing November 1, 1971, is forecast at 2,010 megawatts and will occur after the Pilgrim Nuclear Power Station is scheduled for full power operation. Although the Pilgrim Station will add approximately 655 net megawatts of new capacity, 140 megawatts of this capacity is contracted to utilities outside the applicant's service area as unit sales, and an additional 300 MW is contracted to other utilities as system sales based upon Pilgrim's availability.

Pilgrim Station was originally scheduled for service in 1971 when the New England region, assuming both the Pilgrim Nuclear Power Station and the Vermont Yankee Unit were in commercial operation, expected to have 15,676 MW of capacity to meet a peak load of 12,820 MW. The reserve margin was expected to be 2,856 MW, which is equal to 22.3% of the estimated peak. With the capacity of Vermont Yankee not available, the area's capacity will be reduced to 15,163 MW with 2,343 MW of reserve which is equal to 18.3%

of the estimated peak. With the capacity of the Pilgrim Nuclear Unit also not available, the area's capacity will be reduced to 14,508 MW with 1,688 MW of reserve which will equal only 13.2% of the estimated peak load.

In the most recent report of the New England Planning Committee, of which Boston Edison is a member, the 1972-73 winter peak load of the New England area is estimated to be 13,846 MW. Without any capacity additions or retirements New England will have 14,405 MW of capacity to meet this load forecast resulting in a 4.0% reserve margin. The addition of Pilgrim Station (655 net MW) will increase the New England reserve margin to 8.8%.

Other generating units under construction for service during this period are Vermont Yankee (513 MW), Maine Yankee (792 MW), Northfield Mountain (1000 MW), and two gas turbines (44.7 MW).

The Pilgrim unit is a significant part of a comprehensive plan for bulk supply and its non-availability would result in lower-than-needed capacity in the area with the resulting decrease in service reliability.

As a public utility in Massachusetts, the Company is under a legal mandate to furnish electricity to customers in its service area and to provide sufficient "plants" for that purpose. The operation of the Pilgrim Station is an integral and necessary part of the applicant's plans to provide the required service supported by sufficient reserve to insure reliability of that service.

Moreover, the applicant is a participant in a plan for coordinated New England system operations where reliability, together with economy of bulk power supply for the region as a whole, are prime considerations. Among the responsibilities of this participation are the necessity to provide its share of the region's capacity as well as its share of the overall reserve requirement. These reserves are necessary to insure the availability of power during times of scheduled maintenance, forced outages and unexpected load growth.

Load growth has increased sharply in recent years. In the fifties and early sixties load was growing at compound rate of 6% in New England. Long range load forecasts made at that time were based on the assumption that this rate of growth would continue. However, the rate actually experienced since 1964 has approached 8%. As this changing rate of growth became apparent, steps were taken to meet the additional load requirement. One step taken was the installation of combustion turbines and diesel engines which now total 1,319 megawatts of capacity for service by the summer of 1971.

It has been the recent experience of the industry that the forced outage rate of the new larger units has been much greater than was forecast at the time the units were planned. Although capacity planning now recognizes higher forced outages rates, lower rates were in use at the time the commitments were being made for the capacity now nearing construction completion. For example, estimated forced outage rates for units in the 400 megawatt class have increased from 4.8% in 1965 to 7.5% in 1969. Planning now utilizes the higher rates which result in an increase of 3 to 4% in New England reserve requirements.

The higher than predicted loads and the greater than predicted outage rates both tend to require greater generation reserves. As a consequence, in 1968, the desired reserve for the seventies was increased to the order of 20 to 22% as compared to the 14% reserve considered adequate in 1964.

The power that the Pilgrim Station will provide is an important step in establishing adequate reserve margins in the New England region as a whole and in permitting the applicant to meet its power generation obligations.

2.4 Pilgrim Station Licensing History to Date

An application for a provisional construction permit was filed with the United States Atomic Energy Commission (the "Commission") on June 30, 1967. The application was reviewed by the Regulatory Staff of the Commission and the Advisory Committee on Reactor Safeguards ("ACRS"), each concluding that the proposed Pilgrim Station could be constructed and operated without undue risk to the health and safety of the public.

On May 6, 1968, the Commission issued a "Notice of Hearing on Application for a Provisional Construction Permit" which was published in the Federal Register on May 10, 1968. Subsequently, Petitions for Leave to Intervene were filed by the Commonwealth of Massachusetts, and as joint intervenors, the Municipal Electric Association of Massachusetts ("MEAM") and the electric light departments of four Massachusetts towns. The Intervention was allowed the Commonwealth and the Towns of Wakefield and Braintree and denied as to MEAM and the other two towns.

Pursuant to the Notice of Hearing, hearings were held before the Atomic Safety and Licensing Board (ASLB) on June 18 and 19, 1968 in the Town of Plymouth. At that time, appearances were made by the Plymouth Board of

Selectmen, the Plymouth Industrial Development Corporation, the Plymouth Development and Industrial Commission and an abutting land owner.

On August 26, 1968, the ASLB handed down a decision directing the Commission's Director of Regulation to issue a provisional construction permit in which it concluded that the proposed Pilgrim Station could be constructed and operated without undue risk to the health and safety of the public. On the same date, the Commission issued the permit (CPPR-49) to the Company. MEAM and four municipals filed exceptions to the ASLB's action with the Commission, which denied them on March 20, 1970.

On January 5, 1970, the applicant filed Amendment 12 to the application, the Pilgrim Nuclear Power Station Final Safety Analysis Report (FSAR).

The FSAR and the subsequent eighteen amendments submitted in conformance with 10 CFR 50.34(b), include information that describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems and components and of the facility as a whole. The FSAR also contains answers to certain concerns raised by the US-AEC Division of Reactor Licensing and by the Advisory Committee on Reactor Safeguards.

(The subjects of the ACRS concerns and the resolutions to the concerns are discussed in Section 10.0 of this summary.)

Following a meeting with the ACRS on April 2, 1971, a a letter dated April 7, 1971 was sent to the Commission by the ACRS stating, in part, that subject to attention being given by the applicant to certain concerns of the ACRS referred to above and subject to satisfactory completion of construction and pre-operational testing, there was reasonable assurance that the Pilgrim Station could be operated without undue risk to the health and safety of the public.

The Commission, on April 23, published in the Federal Register a "Notice of Consideration of Issuance of Facility Operating License." In response to the Notice approximately forty-three generally worded requests for a hearing and three formal petitions to intervene were received.

One petition was filed jointly by the Sierra Club and the Union of Concerned Scientists, a second by the Commonwealth of Massachusetts and a third by MEAM and the four towns (on anti-trust grounds) which had sought to intervene on the issuance of a construction permit. On July 12 the Commission issued a Memorandum and Order determining that a hearing should be held and that intervenor party status should be granted to the Sierra Club and the Union of Concerned Scientists and the Commonwealth. In denying "without prejudice", MEAM and the four towns' petition to intervene, the Commission noted that they would be afforded the opportunity to intervene in later proceedings on anti-trust issues should the Commission determine on the recommendation of the Attorney General that a hearing be held on such matters.

3.0 THE EVOLUTION OF THE PILGRIM STATION DESIGN CONCEPT

The Pilgrim Nuclear Power Station utilizes a boiling water reactor (BWR) designed by the General Electric Company to produce steam for direct use in the steam turbine. The Pilgrim BWR design and safety systems have evolved from years of design and operating experience from other BWR's having similar basic design and operating characteristics.

The Vallecitos Boiling Water Reactor was started up in 1957 by General Electric to test BWR design concepts and fuel technology. The Dresden 1 BWR which began operation in 1960, was the first large-scale privately-owned nuclear power plant in the United States. Presently, there are twenty-one BWR's designed by General Electric which are in operation, generating electricity, with an aggregate capacity of approximately 6,570,000 kilowatts.

Principal design characteristics of the Pilgrim Station are compared in Tables 3.1, 3.2, 3.3 and 3.4 to three operating boiling water reactors; Dresden II, Monticello and Millstone I. The Pilgrim Station design characteristics are most comparable to those of Millstone I which was granted an operating license in October, 1970, and which has now generated over 2 billion kilowatthours of electricity.

Table 3.1

COMPARISON OF NUCLEAR SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
THERMAL AND HYDRAULIC DESIGN				
Core Power, MWt	1998	2527	1670	2011
Steam Flow Rate, lb/hr	7.983×10^6	9.945×10^6	6.77×10^6	7.94×10^6
Core Coolant Flow Rate lb/hr	69×10^6	98×10^6	57.6×10^6	69×10^6
Feedwater Flow Rate, lb/hr	7.983×10^6	9.94×10^6	6.77×10^6	7.94×10^6
Feedwater Temperature, °F	359.4	348	376.3	350.1
System Pressure Nominal in Steam Dome psia	1020	1015	1015	1015
Average Power Density kW/liter	40.5	41.08	40.6	40.8
Maximum Thermal Output kW/ft	17.5	17.5	17.5	17.5
Average Thermal Output kW/ft	5.66	5.7	5.7	5.7
Maximum Heat Flux Btu/hr-ft^2	405,200	405,200	405,200	405,200
Average Heat Flux Btu/hr-ft^2	131,100	131,860	131,350	129,000
Maximum UO_2 Temperature, °F	4230	4230	4230	4230
Average Volumetric Fuel Temperature, °F	1059	1050	900	1050
Average Fuel Rod Surface Temperature, °F	558	558	558	558
Minimum Critical Heat Flux Ratio (MCHFR)	>1.9	>1.9	>1.9	>1.9
Coolant Enthalpy at Core Inlet, Btu/lb	522.5	520.5	522.9	519.4
Core Maximum Exit, % Voids Within Assemblies	78.2	76	76	79.1
Core Average Exit Quality, % Steam	11.8	10.1	12.1	11.8
Power Peaking Factor				
Maximum Relative Assembly Power	1.66	1.50	1.58	1.57
Local Peaking Factor	1.24	1.30	1.24	1.25
Axial Peaking Factor	1.5	1.57	1.57	1.57
Total Peaking Factor	3.09	3.06	1.09	3.08
NUCLEAR DESIGN (First Core)				
Water/UO_2 Volume Ratio (Cold)	2.41	2.41	2.42	2.41
Reactivity with Strongest Control Rod Out, K_{eff}	<0.99	<0.99	<0.99	<0.99
Moderator Temperature Coefficient				
At 68°F, Δk/k–°F Water	-8.0×10^{-5}	-8.0×10^{-5}	-8.0×10^{-5}	-8.0×10^{-5}
Hot, no voids, Δk/k–°F Water	-20.0×10^{-5}	-17.0×10^{-5}	-17.0×10^{-5}	-17.0×10^{-5}

Table 3.1
COMPARISON OF NUCLEAR SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
Moderator Void Coefficient				
Hot, no voids, Δk/k–% Void	-1.0×10^{-3}	-1.0×10^{-3}	-1.0×10^{-3}	-1.0×10^{-3}
At Rated Output, Δk/k–% Void	-1.6×10^{-3}	-1.4×10^{-3}	-1.4×10^{-3}	-1.4×10^{-3}
Fuel Temperature Doppler Coefficient				
At 68°F, Δk/k–°F Fuel	-1.3×10^{-5}	-1.2×10^{-5}	-1.2×10^{-5}	-1.2×10^{-5}
Hot, No Void, Δk/k–°F Fuel	-1.2×10^{-5}	-1.2×10^{-5}	-1.2×10^{-5}	-1.2×10^{-5}
At Rated Output, Δk/k–°F Fuel	$<-1.3 \times 10^{-5}$	$<-1.2 \times 10^{-5}$	$<-1.2 \times 10^{-5}$	$<-1.2 \times 10^{-5}$
Initial Average U-235 Enrichment, W/O	2.19%	2.12%	2.25%	2.07%
Fuel Average Discharge Exposure, MWd/Ton	19,000	19,000	19,000	15,000
CORE MECHANICAL DESIGN				
Fuel Channel				
Overall Dimension inches (length)	166.875	166.875	166.875	166.875
Thickness, inch	0.080	0.080	0.080	0.080
Cross Section Dimensions, inches	5.438 X 5.438	5.438 X 5.438	5.438 X 5.438	5.438 X 5.438
Material	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4
Core Assembly				
Total Weight of UO_2, pounds	280,325	356,200	238,370	284,500
Core Diameter (equivalent) inches	163.1	182.2	149	163.1
Core Height (Active Fuel) inches	144	144	144	144
Reactor Control System				
Method of Variation of Reactor Power	Movable Control Rods and Variable Coolant Pumping	Movable Control Rods and Variable Coolant Pumping	Movable Control Rods and Variable Coolant Pumping	Movable Control Rods and Variable Coolant Pumping
Number of Movable Control Rods	145	177	121	145
Shape of Movable Control Rods	Cruciform	Cruciform	Cruciform	Cruciform
Pitch of Movable Control Rods	12.0	12.0	12.0	12.0
Control Material in Movable Rods	B_4C granules Compacted in SS Tubes	B_4C granules Compacted in SS Tubes	B_4C granules Compacted in SS Tubes	B_4C granules Compacted in SS Tubes
Type of Control Rod Drives	Bottom entry, Locking Piston	Bottom entry, Locking Piston	Bottom Entry, Locking Piston	Bottom entry, Locking Piston
Fuel Assembly				
Number of Fuel Assemblies	580	724	484	580
Fuel Rod Array	7 X 7	7 X 7	7 X 7	7 X 7

Table 3.1

COMPARISON OF NUCLEAR SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
Overall Dimensions, inches	175.88	175.88	175.88	175.88
Weight of UO_2 per Assembly pounds	Undished 490.53 Dished 480.62	492.5	Undished 492.5 Dished 481.7	490.2
Weight of Fuel Assembly pounds	Undished 676.91 Dished 667.00	678.9	Undished 678.9 Dished 668	690.3
Fuel Rods				
Number per Fuel Assembly	49	49	49	49
Outside Diameter, inch	0.563	0.563	0.563	0.570
Clad Thickness, inch	0.032	0.032	0.032	0.036
Gap–Pellet to Clad, inch	0.0055	0.0055	0.005	0.0055
Length of Gas Plenum, inches	11.24	11.24	11.24	11.24
Clad Material	Zircaloy-2	Zircaloy-2	Zircaloy-2 and/or Zr-4	Zircaloy-2
Cladding Process	Free standing loaded tubes	Free standing loaded tubes	Free standing loaded tubes	Free standing loaded tubes
Fuel Pellets				
Material	Uranium Dioxide	Uranium Dioxide	Uranium Dioxide	Uranium Dioxide
Density, % of theoretical	93%	93%	93%	93%
Diameter, inch	0.488	0.488	0.488	0.488
Length, inch	0.5	0.5	0.5	0.5
Number of Temporary Control Curtains	264	340	216	264
Curtain Material	Flat, boron–stainless steel	Flat, boron–stainless steel	Flat, boron–stainless steel	Flat, boron–stainless steel
In-Core Neutron Instrumentation				
Number of In-Core Neutron Detectors (Fixed)	120	164	96	120
Number of In-Core Detector Assemblies	30	41	24	30
Number of Detectors per Assembly	4	4	4	4
Number of Flux Mapping Neutron Detectors	4	4	2	4
Range (and Number) of Detectors				
Source Range Monitor	Source to 0.001% power (4)	Source to 0.001% power (4)	Source to 0.001% power (4)	Source to 0.001% power (4)
Intermediate Range Monitor	0.0001% to 10% Power (8)	0.0003% to 10% power (8)	0.0001% to 10% power (8)	0.0003% to 10% power (8)
Local Power Range Monitor	5% to 125% power (120)	5% to 125% power (164)	5% to 125% power (96)	5% to 125% power (120)
Average Power Range Monitor	5% to 125%	5% to 125%	5% to 125%	5% to 125%
Number and Type of In-Core Neutron Sources	5 Sb–Be	7 Sb–Be	5 Sb–Be	5 Sb–Be

Table 3.1

COMPARISON OF NUCLEAR SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
REACTOR VESSEL DESIGN				
Material	← Carbon Steel/Clad Stainless Steel →			
Design Pressure, psia	1265	1265	1265	1265
Design Temperature, °F	575	575	575	575
Inside Diameter ft-in.	18-8	20-11	17-11	18-8
Inside Height, ft-in	64-8½	64-8	63-2	68-7
Side Thickness (including clad)	5.688	6.125	5.187	5.688
Minimum Clad Thickness, inches	1/8	1/8	1/8	1/8
REACTOR COOLANT RECIRCULATION DESIGN				
Number of Recirculation Loops	2	2	2	2
Design Pressure				
Inlet Leg. psig	1148	1175	1148	1175
Outlet Leg. psig	1241	1325	1248	1325
Design Temperature, °F	562	565	562	564
Pipe Diameter, inches	28	28	28	28
Pipe Material	304/316	304/316	304	304/316
Recirculation Pump Flow Rate, gpm	45,200	45,200	45,200	45,200
Number of Jet Pumps in Reactor	20	20	20	20
MAIN STEAM LINES				
Number of Steam Lines	4	4	4	4
Design Pressure, psig	1146	1146	1146	1146
Design Temperature, °F	563	563	563	563
Pipe Diameter, inches	20	20	18	20
Pipe Material	← Carbon Steel (ASTM A155 KC70 or ASTM A106 Grade B) →			
CORE STANDBY COOLING SYSTEMS (These systems are sized on design power)				
Core Spray System				
Number of Loops	2	2	2	2
Flow Rate (gpm)	3600 at 104 psid	4500 at 90 psid	3020 at 307 psid	3600 at 90 psid
High Pressure Coolant Injection System (No.)	1	1	1	1
Number of Loops	1	1	1	1
Flow Rate (gpm)	4250	5600	3000	8000*
Automatic Depressurization System (No.)	1	1	1	1

*Utilizes feedwater pumps

Table 3.1

COMPARISON OF NUCLEAR SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
Low Pressure Coolant Injection (No.)	1	1	1	1
Number of pumps	4	4	4	4
Flow Rate (gpm/pump)	4800 at 20 psid	5350 at 0 psid	4000 at 20 psid	5000 at 0 psid
AUXILIARY SYSTEMS				
Residual Heat Removal System				
Number of pumps	4	3	4	4
Flow Rate (gpm/pump)	4800	5350	4000	5000
Number of heat exchangers	2	3	2	2
Capacity (Btu/hr/heat exchanger)[1]	64×10^6	27×10^6	24.5×10^6	40×10^6
Service Water System				
Number of pumps	5	4	4	4
Flow rate (gpm/pump)	2700	3500	3500	2500
Reactor Core Isolation Cooling System				
Flow Rate (gpm)	400 at 1120 psid	*	400 at 1120 psid	*
Fuel Pool Cooling and Cleanup System				
Capacity (Btu/hr)	6.53×10^6	3.65×10^6	2.87×10^6	7.84×10^6
Reactor Building Closed Cooling Water System				
Number of pumps	6	-	-	-
Flow Rate (gpm)	1700	-	-	-
Number of heat exchangers	2	-	-	-
Capacity (Btu/hr/heat exchanger)[2]	65×10^6	-	-	-

[1] Capacity during post-accident cooling mode with 165°F shell side inlet temperature maximum service water temperature, and 1 RHR pump in operation.

[2] Capacity during post-accident cooling mode at 65°F service water temperature with 2 RBCCW pumps and 1 RBCCW heat exchanger in operation.

*No RCIC, these units utilize isolation condenser in place of RCIC.

Table 3.2
COMPARISON OF POWER CONVERSION SYSTEM DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
TURBINE-GENERATOR				
Design Power, MWe (Net)	655	810	543	652
Generator Speed, rpm	1800	1800	1800	1800
Steam Flow, lb/hr	7.983×10^6	9.945×10^6	6.77×10^6	7.94×10^6
Turbine Inlet Pressure psig	965	950	965	965
TURBINE BYPASS SYSTEM				
Capacity, percent of turbine design steam flow	25	40	15	105
MAIN CONDENSER				
Heat removal capacity, Btu/hr	4433×10^6	-	3750×10^6	-
CIRCULATING WATER SYSTEM				
Number of Pumps	2	3	2	4
Flow Rate, gpm/pump	155,500	-	140,000	105,000
CONDENSATE AND FEEDWATER SYSTEMS				
Flow Rate, lb/hr	7.983×10^6	9.725×10^6	6.77×10^6	7.94×10^6
Number of Condensate Pumps	3	4	2	3
Number of Condensate Booster Pumps	-	4	-	3
Number of Feedwater Pumps	3	3	2	2
Condensate Pump Drive	a-c power	a-c power	a-c power	a-c power
Condensate Booster Pump Drive	-	a-c power	-	a-c power
Feedwater Pump Drive	a-c power	a-c power	a-c power	a-c power

Table 3.3
COMPARISON OF ELECTRICAL POWER SYSTEMS DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
TRANSMISSION SYSTEM				
Outgoing lines (number-rating)	2–345 kV	5–345 kV	2–345 kV	2–345 kV
NORMAL AUXILIARY A-C POWER				
Incoming lines (number–rating)	2–345 kV 1–23 kV	5–345 kV 6–138 kV	1–345 kV 1–115 kV	2–345 kV 1–27.6 kV
Auxiliary transformers	2*	4	2	1
Startup transformers	1	1	1	1
STANDBY A-C POWER SUPPLY				
Number diesel generators	2	3	2	1 plus 1 (Gas)
Number of 4160V standby buses	2	4	4	6
Number of 480V standby buses	3	2	4	4
D-C POWER SUPPLY				
Number of 125V or 250V batteries	2–125V 1–250V	2–125V 1-250V	2–125V 1–250V	1–125V
Number of 125V or 250V buses	3–125V 1–250V	2–125V 2–250V	2–125V 1–250V	2–125V

* 1 unit auxiliary transformer, 1 shutdown transformer

Table 3.4

COMPARISON OF CONTAINMENT DESIGN CHARACTERISTICS

	Pilgrim	Dresden II	Monticello	Millstone I
PRIMARY CONTAINMENT				
Type	Pressure Suppression	Pressure Suppression	Pressure Suppression	Pressure Suppression
Construction				
Drywell	Light bulb shape; steel vessel	Light bulb shape; steel vessel	Light bulb shape; steel vessel	Light bulb shape; steel vessel
Pressure Suppression Chamber–Internal Design Pressure (psig)	+56	+62	+62	+62
Pressure Suppression Chamber–External Design Pressure (psi)	+2	+1	+2	+1
Drywell–Internal Design Pressure (psig)	+56	+62	+56	+62
Drywell–External Design Pressure (psi)	+2	+2	+2	+2
Drywell Free Volume (ft^3)	147,000	158,236	134,200	146,900
Pressure Suppression Chamber Free Volume (ft^3)	110,000	117,245	108,250	109,900
Pressure Suppression Pool Water Volume (ft^3)	84,000	112,203	77,970	83,500
Submergence of Vent Pipe Below Pressure Pool Surface (ft)	4	3–5 in.	4	4
Design Temperature of Drywell (°F)	281	281	281	281
Design Temperature of Pressure Suppression Chamber (°F)	281	281	281	281
Downcomer Vent Pressure Loss Factor	6.21	6.21	6.21	6.21
Break Area Per Total Vent Area	0.0194	0.0194	0.0194	0.0194
Calculated Maximum Pressure After Blowdown Drywell (psig)	45	47	41	43
Pressure Suppression Chamber (psig)	26	28	26	26
Initial Pressure Suppression Pool Temperature Rise (°F)	35	50	45	35
Leakage Rate (% Free Volume/Day)	0.5	0.5	0.5	0.5
SECONDARY CONTAINMENT				
Type	Controlled Leakage, Elevated Release	Controlled Leakage, Elevated Release	Controlled Leakage, Elevated Release	Controlled Leakage, Elevated Release

Construction				
Lower Levels and Foundation	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete
Upper Levels	Precast Panels and Reinforced Concrete	Steel Super-structure and Siding	Steel Super-structure and Siding	Steel Super-structure and Siding
Roof	Steel Sheeting	Pre-cast Concrete	Built up on steel decking	Steel Sheeting
Internal Design Pressure (psig)	0.25	0.25	0.25	0.25
Design Inleakage Rate (% of free volume/day at 0.25 inches H_2O)	100	100	100	100
ELEVATED RELEASE POINT				
Type	Stack	Stack	Stack	Stack
Construction	Steel	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete
Height (above ground)	*400 feet	310 feet	238 feet	385½ feet

*Above Mean Sea Level

4.0 SITE CHARACTERISTICS

4.1 Location (1)

The Pilgrim Nuclear Power Station is located on the western shore of Cape Cod Bay in the Town of Plymouth, Plymouth County, Massachusetts. Figure 4-1 shows the station site location with respect to major population centers. The nearest urbanized area is Plymouth located approximately four miles to the west as shown in Figure 4-2. Brockton is the nearest densely populated center having more than 25,000 residents, with the nearest boundary about 23 miles from the site.

The site contains approximately 517 acres owned in fee by the applicant. The site boundaries are posted and a security fence is erected around the immediate station area. The nearest site boundary is approximately 1,600 feet from the reactor to the northwest. The nearest residences are approximately 2,000 feet from the reactor to the northwest and southeast. The site plot plan is included as Figure 4-3. Normal access to the site is by a two-lane paved road which was built across the site to Route 3A, leading to either Plymouth or nearby Route 3. Alternate access from the site to Plymouth and Route 3 via Route 3A is provided by Rocky Hill Road.

4.2 Population[2]

The estimated resident population distribution for the years 1965 and 2015 are presented in Figure 4-4. The 1965 resident population within a four-mile radius was estimated as approximately 3,700 while the corresponding total summer population (resident plus seasonal) was estimated as approximately 8,800. The increase results from the influx of seasonal residents during the summer months which is typical of the coastal region of Massachusetts. Estimates of the total resident and seasonal population distribution for the years of 1965 and 2015 are presented in Figure 4-5.

Brockton is the nearest densely populated center having more than 25,000 residents and is located about 25 miles to the west-northwest of the site. Other population centers include New Bedford which is 27 miles to the southwest, Boston which is 36 miles to the northwest, and Providence, Rhode Island, which is 44 miles west of the site.

4.3 Land Use[3]

Since the site is located along the coast, approximately 60 percent of the area within a 50-mile radius is open water. The area within 2 miles of the site is sparsely developed with the exception of the seasonal residences along Priscilla Beach and White Horse Beach.

Approximately 85 percent of the land within a 10-mile radius of the site is categorized as open space and vacant. Approximately 7 percent of the land use is agricultural, the major portion of which is cranberry bogs. The remaining land is utilized for residential, commercial, or industrial purposes. The adjacent waters of Cape Cod Bay are used for commercial fishing and sport fishing. The principal marine species harvested in the vicinity of the site are lobsters and Irish moss.

Although little published data are available for predicting future land use, it appears that the increased land use will be primarily residential as the resort areas and suburbs experience growth.

4.4 Recreational Use

The applicant has made provisions for public access to two areas on the station site, the station overlook area and the shorefront, breakwater area as shown on Figure 4-3.

The station overlook area was opened in January, 1969 to permit site visitors to safely observe the generating station area during construction phases and will be retained after station operation commences.

The shorefront, breakwater area, will be opened to the public following completion of the breakwater and access facilities. This area will permit observation from the shorefront and fishing from the shorefront and main breakwater.

The individual public use of the station overlook area is expected to be infrequent and of short duration after construction activities are completed. Parking space has been provided in this area for up to fifty automobiles. The time spent by an individual at the overlook during a visit averages less than one half hour.

Public use of the shorefront breakwater area can only be estimated at this time, but public use is expected to be principally for fishing during fair weather conditions. Parking space has been provided for about one hundred automobiles in this area.

The applicant maintains control of access to both of these areas by gates provided at the entrances to these access roads from Rocky Hill Road. These gates will be closed, locked and posted during those periods when access is not permitted. The following restrictions on public access are planned:

1) Access to the breakwater area will be terminated when weather or ocean conditions make the area hazardous.

2) Access to both the breakwater and overlook area will be terminated from about December 1 to March 1 because of the prevalence of hazardous conditions and unpleasant weather.

3) Access to the breakwater and overlook areas will be terminated whenever necessary to permit continued station operation within the radiation exposure limitations established by regulatory agencies.

4.5 Meteorology

The main features of the weather of eastern Massachusetts are variety and changeability since it lies in a transition zone of westerly air currents which encompass the southward movement of polar air masses and northward movement of tropical air masses. The area is frequently situated in or near the tracks of low pressure systems during the Fall, Winter, and Spring seasons. As a result, the region has no dry season, with Summer precipitation coming in the form of showers or thunderstorms. The coastline location of the site results in seasonal temperatures which are less extreme than inland locations due to on-shore winds in the Summer (seabreeze) and the presence of relatively warm water in the Winter. The storm cycle in this area consists generally of northeasters in the Winter and Spring, thunderstorms in late Spring and Summer. Hurricanes sometimes occur in the late Summer and Fall. Tornado activity in eastern Massachusetts is uncommon.[4]

The station is designed with protection against storm flooding from either Northeasters or hurricanes. Analysis and model studies have shown that flooding due to the combined effects of storm surge and wave action from the most severe storms do not subject the reactor building to a flooding condition.[5]

Meteorological data for the Pilgrim site has been collected from the site meteorological tower. The tower instrumentation has made measurements of wind speed, wind direction, directional variability, temperature and the occurrence or non-occurrence of precipitation. The most frequent wind directions observed were from the SSW through NNW which are all offshore directions. The site experienced onshore winds 36% of the time, offshore winds 63.6% of the time, and calm conditions the remaining 0.4% of the time.

The annual mean wind speed observed was about 16 mph. Figure 4-6 presents the annual wind rose for the site developed from observations at 300 feet above mean sea level. The meteorological observations have been utilized to evaluate the diffusion climatology at the Pilgrim Station site and to evaluate atmospheric dispersion of radioactive effluents from the station.

4.6 Hydrology[6] and Oceanography[7]

The site is located in a small isolated drainage area on the northeast side of the Pine Hills as shown on Figure 4-2. All surface drainage in the station site area is into Cape Cod Bay. The ground water table generally follows the site surface topography and as a result, moderately steep ground water gradients are present with flow toward Cape Cod Bay.

Ground water usage in the area is limited to a few locations since most of the residents are supplied with water from the Town of Plymouth. The closest Plymouth water supply source is the Manomet Well located two and three-quarters miles southeast of the site.

The site is located on Cape Cod Bay and water from the Bay is utilized as cooling water within the station. Within Cape Cod Bay the general ocean circulation pattern is counterclockwise. A portion of a coastal current that flows southward along the coasts of Maine and Massachusetts enters Cape Cod Bay along the western shore of the bay, circulates in a counterclockwise direction, leaves the bay on the eastern side, swings eastward around the Cape and then continues southward again. This general circulation pattern coupled with tidal exchange and wind induced motion of the waters within the bay are the principal natural mechanisms which contribute to renewal and effective flushing waters of Cape Cod Bay.

The dispersion of liquid effluents (that is, the movement and mixing of the station discharge in and with the receiving waters of Cape Cod Bay) occurs in three stages. First, the excess momentum associated with the condenser cooling water as it is discharged into the waters of Cape Cod Bay will produce an entraining jet which will be diluted by the mechanical entrainment required to reduce the velocity of the jet to that of the surrounding waters. Secondly, natural turbulent diffusion will further mix the waters of the diluted condenser water plume as it moves downcurrent with the natural flow. Finally, the large scale circulation pattern coupled with tidal flushing, will carry any conserved component out of the Bay.

In the case of the rejected heat, surface cooling will have returned the temperatures to ambient long before the large-scale circulation pattern will have carried the condenser cooling water out of the bay.

The most important mechanism for the rapid dispersion of the heat rejected from the station is the mechanical entrainment required to reduce the initial momentum of the discharge to that of the receiving waters of the Bay. This phenomenon, momentum mixing, causes rapid reduction of the temperature rise above ambient of the discharge and significantly reduces the areas of the discharge isotherms. Table 4-1 summarizes the area inside several surface temperature isotherms. To indicate the importance of momentum mixing, the last column of Table 4-1 gives the area inside the surface isotherms which would be required if the heated discharge were spread over the surface without mixing and heat loss by surface cooling only.

Both theoretical and empirical studies of momentum mixing in a jet discharge provide the basis for computing the isotherms (temperature rise above ambient) in the vicinity of the site. Model studies of the thermal discharge were conducted which showed three significant features:

TABLE 4-1
SURFACE TEMPERATURE ISOTHERMS
DIMENSIONS AND AREA

Temperature Rise Above Ambient (°F)	Length of Area (ft)	Width of Area (ft)	Predicted Area (Acres)	Comparable Area* Surface Cooling Only (Acres)
20°	430	110	1.1	248
10°	1100	250	6.3	725
5°	3400	900	70.3	1203
3°	5900	1300	176	1557
2°	8400	2200	425	1834

* This column is shown for purposes of comparison only, and represents the area within the designated isotherms which would be required if the temperature reduction resulted only from surface cooling.

1. Even when a current flow near the maximum observed at the site is simulated in the model, and directed downcoast, thus bending the plume of heated water toward the intake structure, very effective two-sided entrainment of cool diluting water occurs. The circulation pattern set up by the entraining jet actually brings new water at near ambient temperature to the intake.
2. There is little significant difference in the effectiveness of the jet entrainment between low tide and high tide conditions. In both cases, the heated plume appears confined primarily to the upper 5 feet of the water column, and the areas within given isotherms appear to be essentially independent of tidal height.
3. There is little difference in the shape and size of the heated plume for ambient current conditions varying from 0.2 knot, which is near the average observed off the plant site, to 0.6 knot, a speed exceeded in the observations to date less than 1% of the time.

The distributions of the surface temperature rise above ambient resulting from operation of the station have been predicted and are included as Figures 4-7 and 4-8. Two cases were considered, the first with the offshore current directed toward the ESE (Figure 4-7), and the second with the offshore current directed toward the WNW (Figure 4-8). The temperature distributions appear to be relatively independent of tidal stage and of the strength of the current in the range from 0.2 knot to 0.6 knot, at least with respect to the general shape of the temperature isotherm and the area within a given isotherm. The strength of the current will influence the rate of bending of the plume from the initial offshore-directed jet discharge to a plume extending downcurrent. Thus, for the weaker current speeds, the heated discharge will extend somewhat farther offshore than in the case of a strong current parallel to shore.

Introduction of any radioactive effluents into the cooling water discharge will be controlled so that, after mixing, the concentration of radioactive materials in the discharge will be only a fraction of the allowable concentrations specified in 10 CFR Part 20 for drinking water. Radioactive materials discharged from the station will experience further physical dilution as a result of momentum mixing and natural dispersion in the receiving waters of Cape Cod Bay. Such further dilution serves as an additional safety factor which is not, however, used in computing allowable concentrations for release of radioactive materials.

4.7 Geology and Seismology[8]

The natural surface stratum in the station area consists of approximately 20 feet of silty and clayey fine sands with scattered boulders. The soils underlying the upper stratum are moderately compact to compact with poorly to well graded sands with some gravel and cobbles. Boulders are scattered throughout the overburden soil and a discontinuous thin layer of small boulders overlies bedrock. Bedrock is approximately 30 to 90 feet below Mean Sea Level. There are no known faults at or near the station site.

It is indicated from geologic and tectonic history that the region is relatively quiescent. Low magnitude seismic events can occur, but should be infrequent. The horizontal ground acceleration at the site due to the maximum expected earthquake is less than 8 percent of gravity. For the design of safety-related structures and equipment, however, a horizontal ground acceleration of 8 percent of gravity has been used with no increase in code allowable stresses. Safety-related structures and equipment have also been examined for a horizontal ground acceleration of 15 percent of gravity to ascertain that no failure can occur that would prevent safe shutdown of the station.

<u>References for Section 4.0</u>

1. FSAR, Section 2.2.1
2. Environmental Report, Part C. I. b
3. Environmental Report, Part C. I. c
4. Environmental Report, Part C. I. d
5. FSAR, Section 2.4.4
6. FSAR, Section 2.4.1
7. FSAR, Section 2.4.3
8. FSAR, Section 2.5

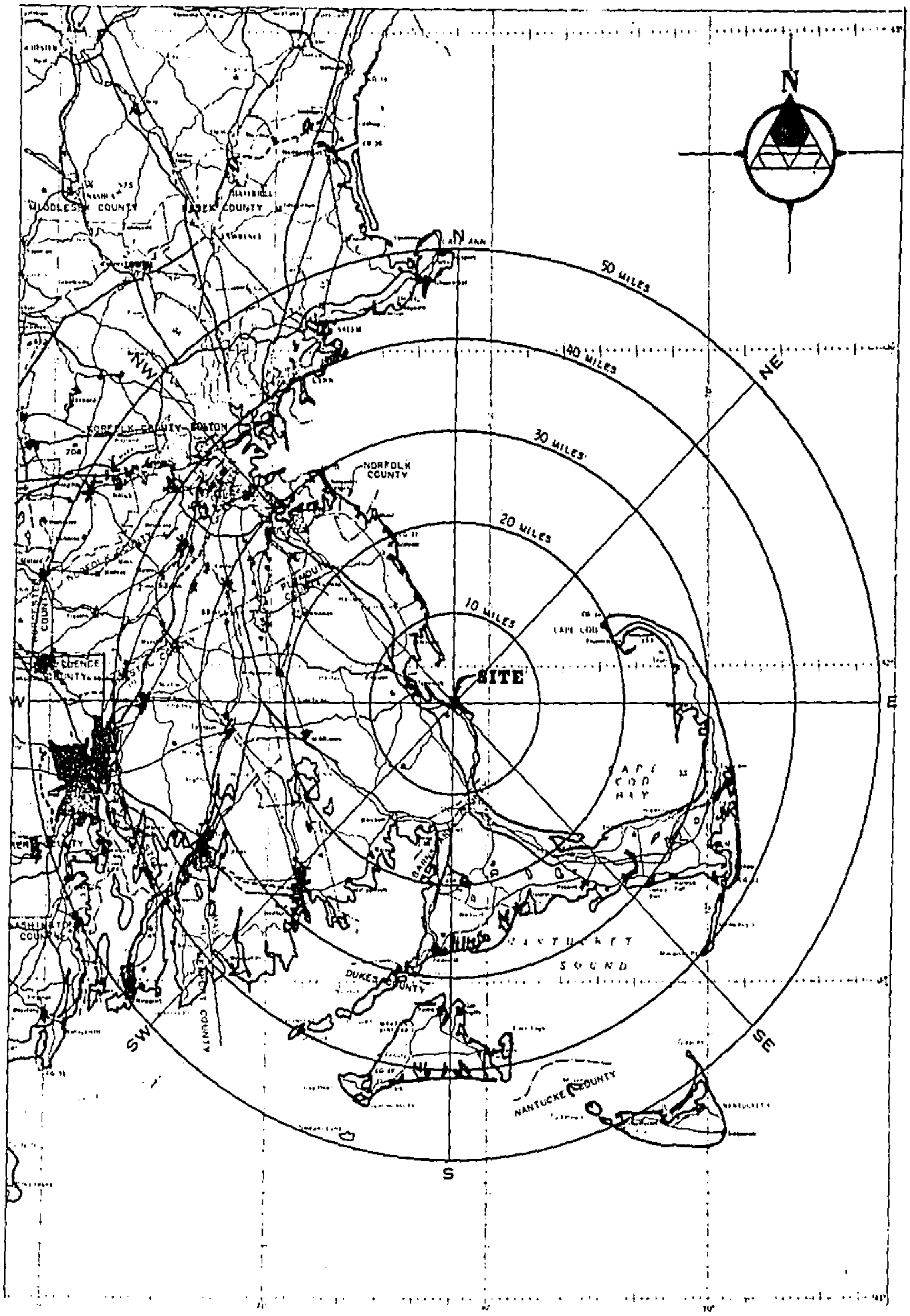


FIGURE 4-1
STATION SITE LOCATION MAP
(0 to 50 Miles Radius)

REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF USGS. BOSTON, SECTIONAL AERONAUTICAL CHART, 1965.

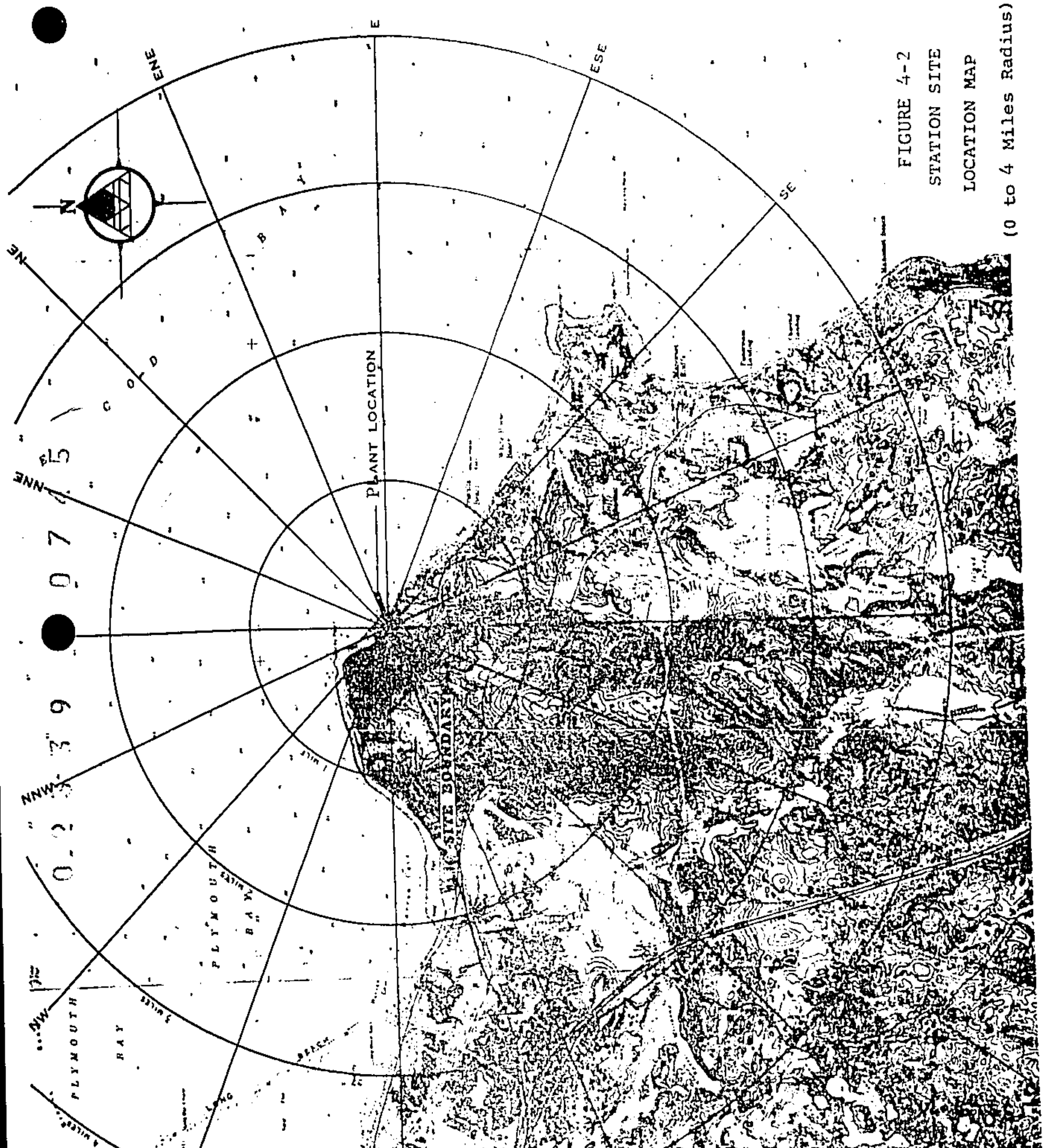
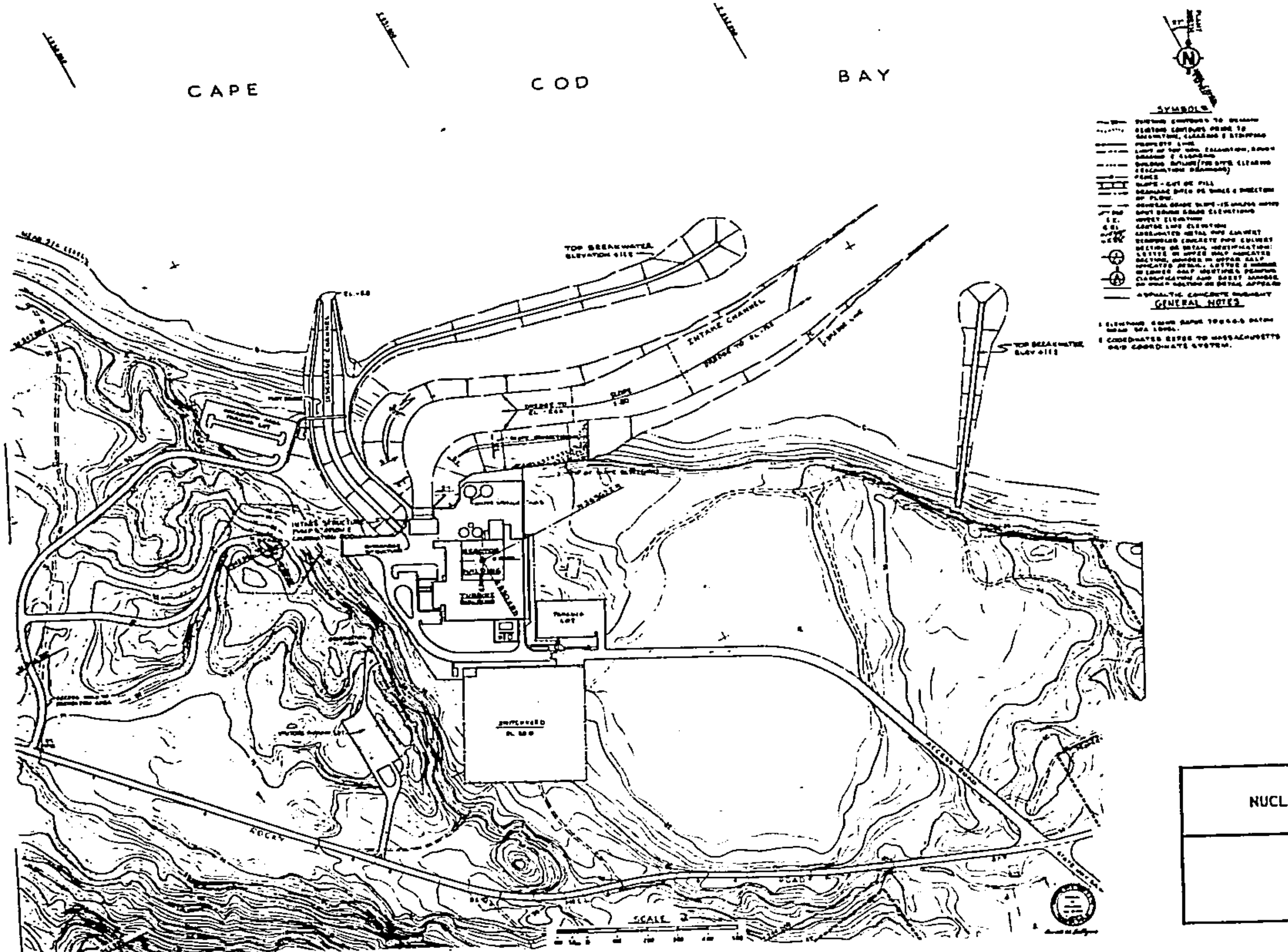


FIGURE 4-2
STATION SITE
LOCATION MAP
(0 to 4 Miles Radius)

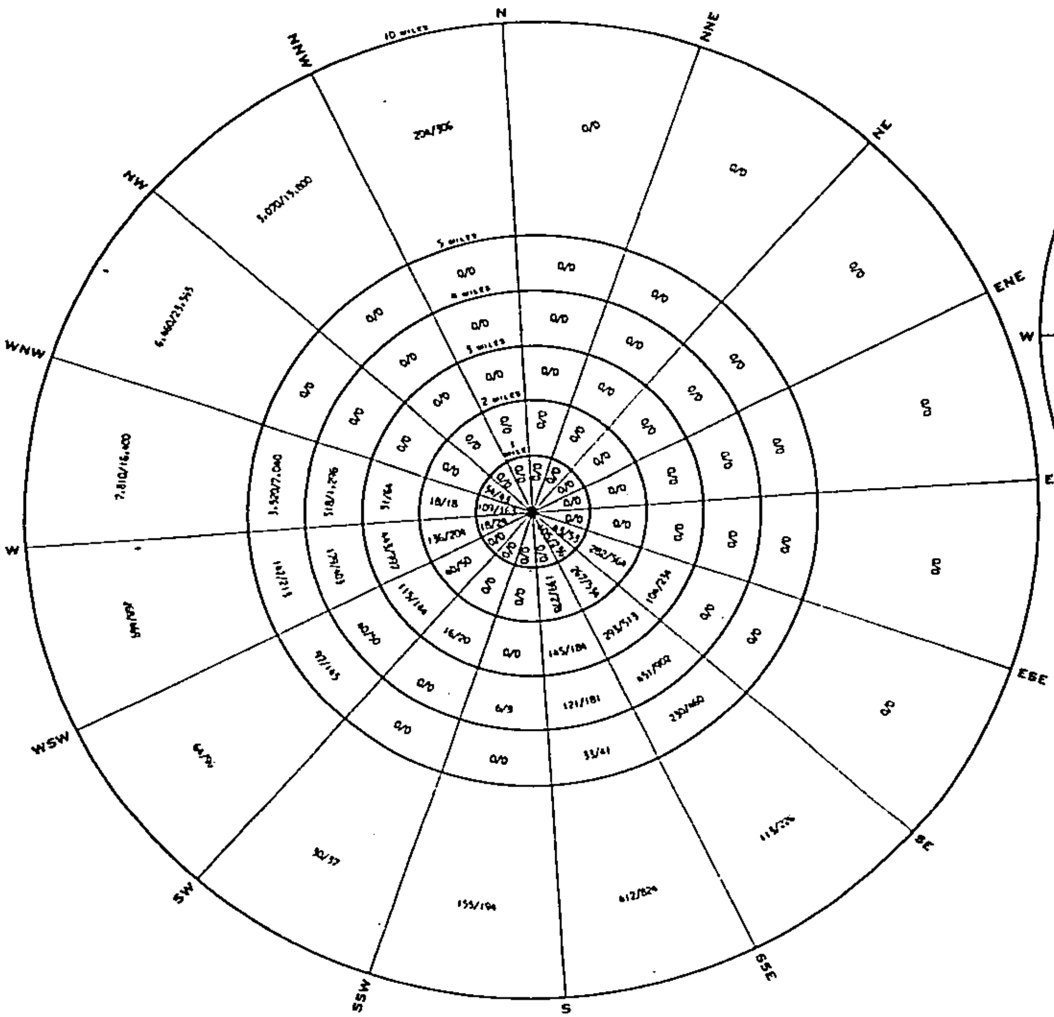
REFERENCE:
THIS MAP WAS PREPARED FROM THE FOLLOWING
USGS QUADRANGLES: MANOMET, MASS., 1962
AND PLYMOUTH, MASS., 1962.

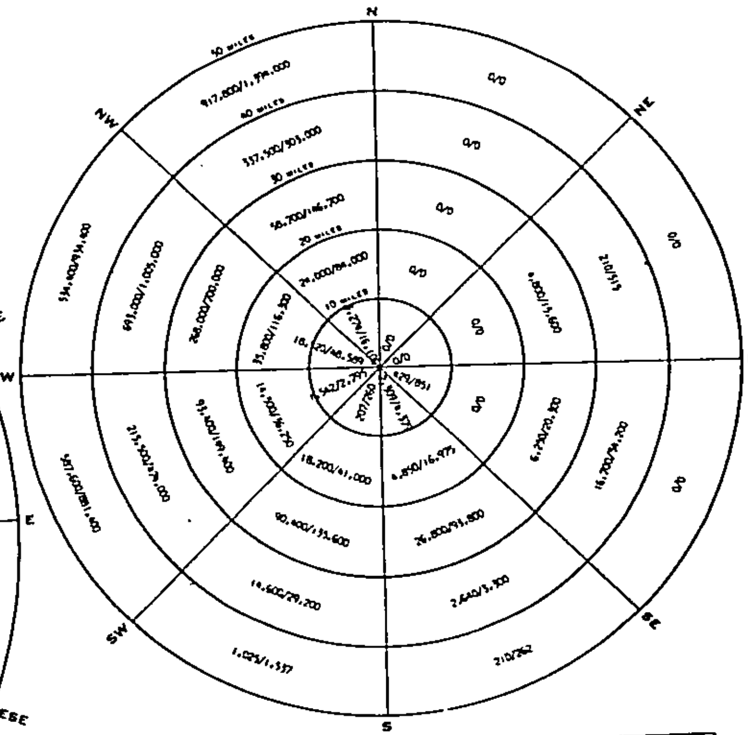
0 2 3 3 9 0 7 4 6



PILGRIM
NUCLEAR POWER STATION

Plot Plan
FIGURE 4-3



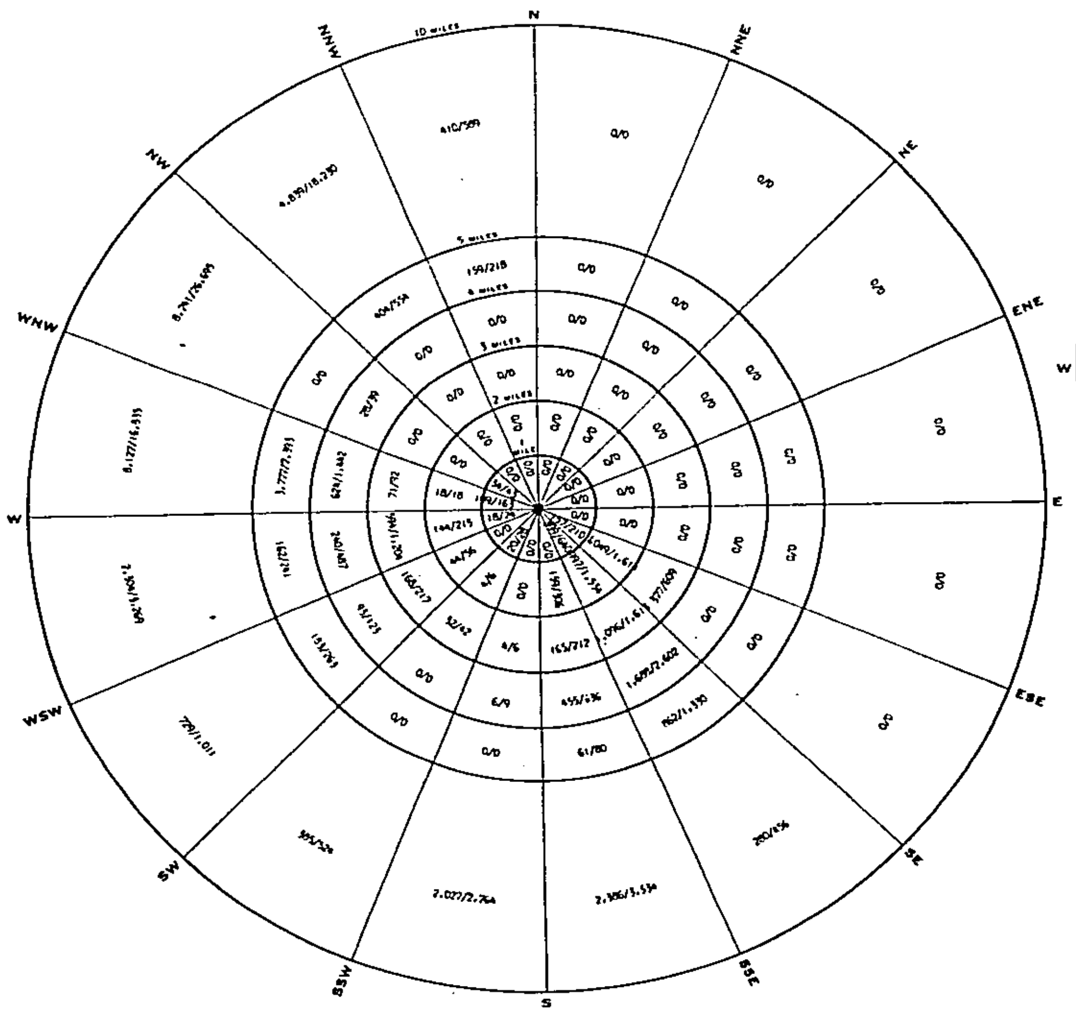


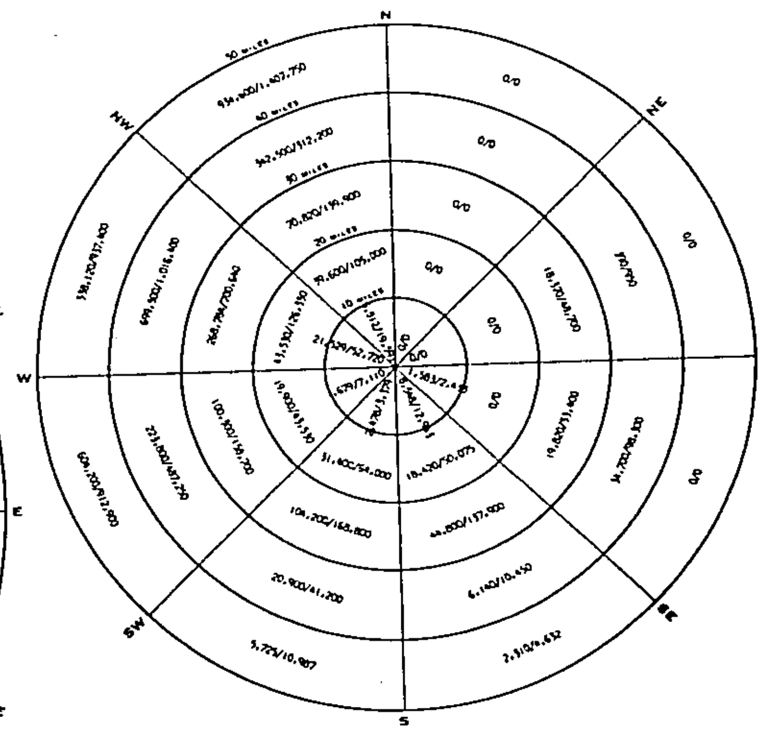
RADIUS IN MILES		0-1	0-2	0-3	0-4	0-5	0-10	0-20	0-30	0-40	0-50
ACCUMULATIVE TOTAL	1965	309	1,191	2,358	3,675	7,695	26,281	123,631	671,981	1,952,131	3,995,166
	2015	519	2,167	4,523	7,164	15,063	72,980	367,505	1,628,905	3,498,120	5,709,719

KEY:
EST. 1965 POPULATION/EST. 2015 POPULATION

PILGRIM
NUCLEAR POWER STATION

Station Site
Resident Population
Distribution Years 1965 & 2015
FIGURE 4-4





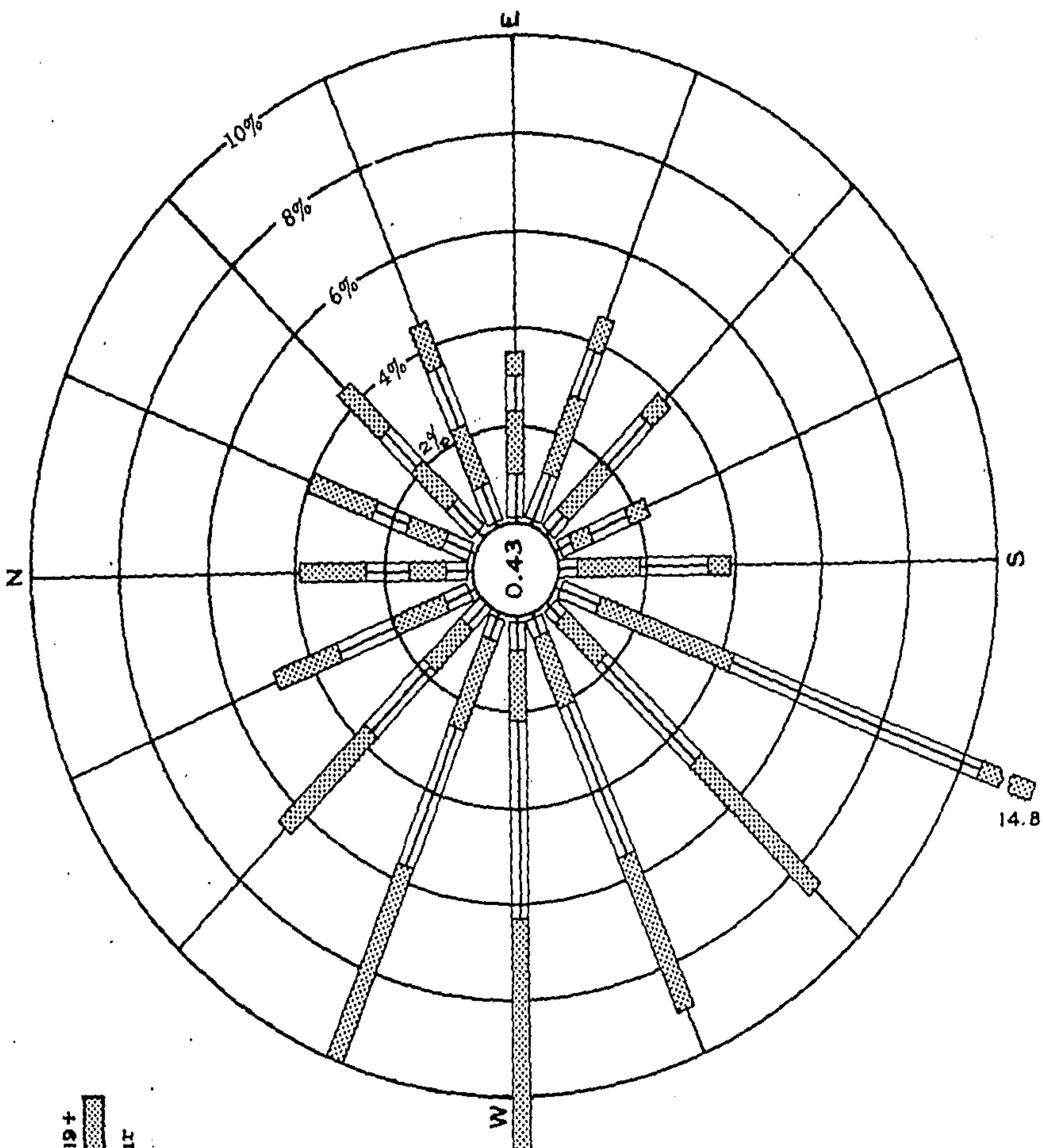
RADIUS IN MILES		0-1	0-2	0-3	0-4	0-5	0-10	0-20	0-30	0-40	0-50
ACCUMULATIVE TOTAL	1965	737	3,152	5,659	8,793	14,401	44,626	197,479	824,575	2,152,505	6,237,458
	2015	1,108	4,857	8,852	14,190	24,269	98,176	487,131	1,915,171	5,081,921	7,195,590

EST. 1965 POPULATION/EST. 2015 POPULATION

PILGRIM NUCLEAR POWER STATION

Station Site Resident & Seasonal Population Distribution Years 1965 & 2015

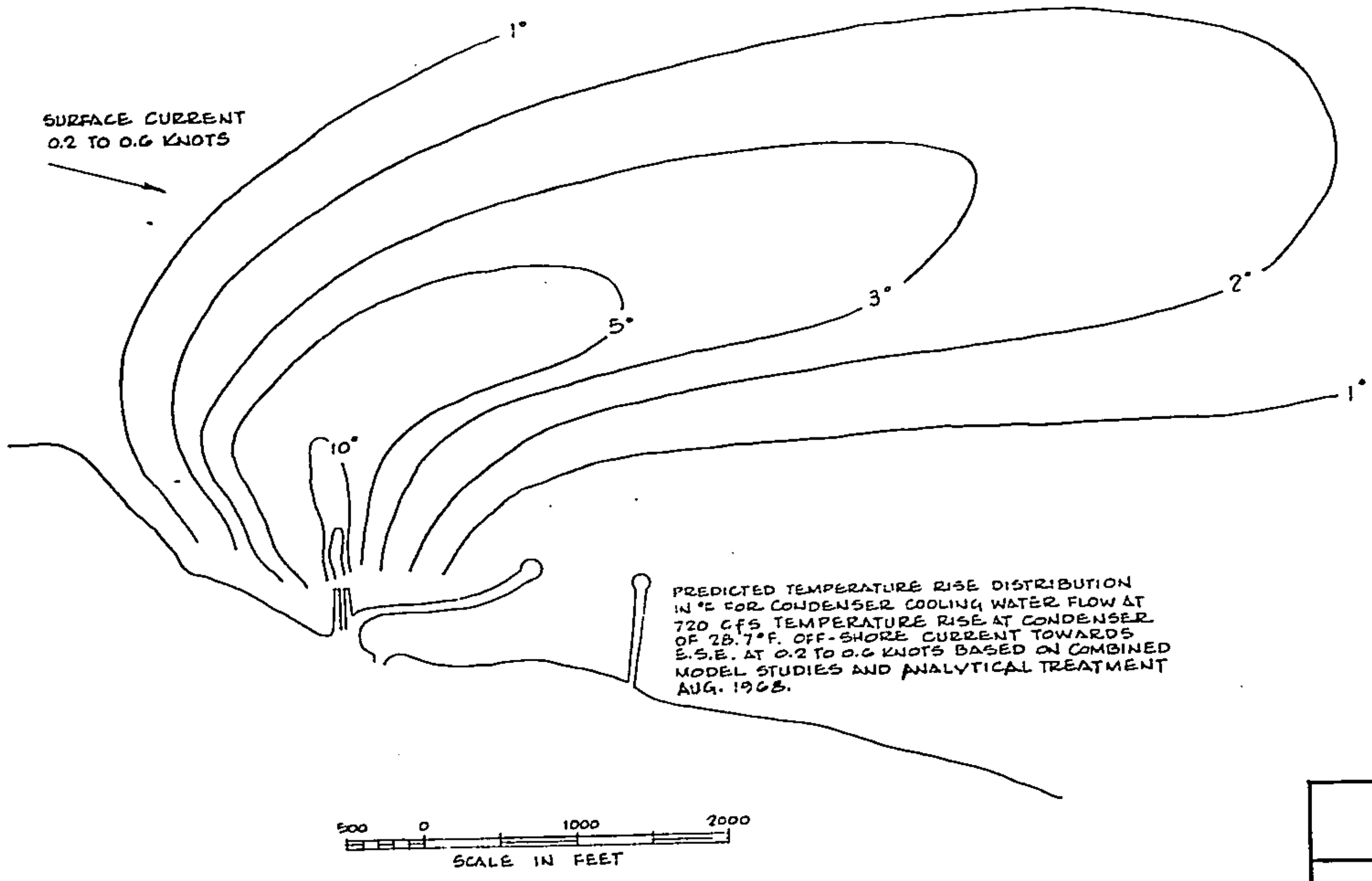
FIGURE 4-5



PILGRIM
NUCLEAR POWER STATION

Elevation 300 ft MSL—Wind Rose Annual
Pilgrim Site
FIGURE 4-6

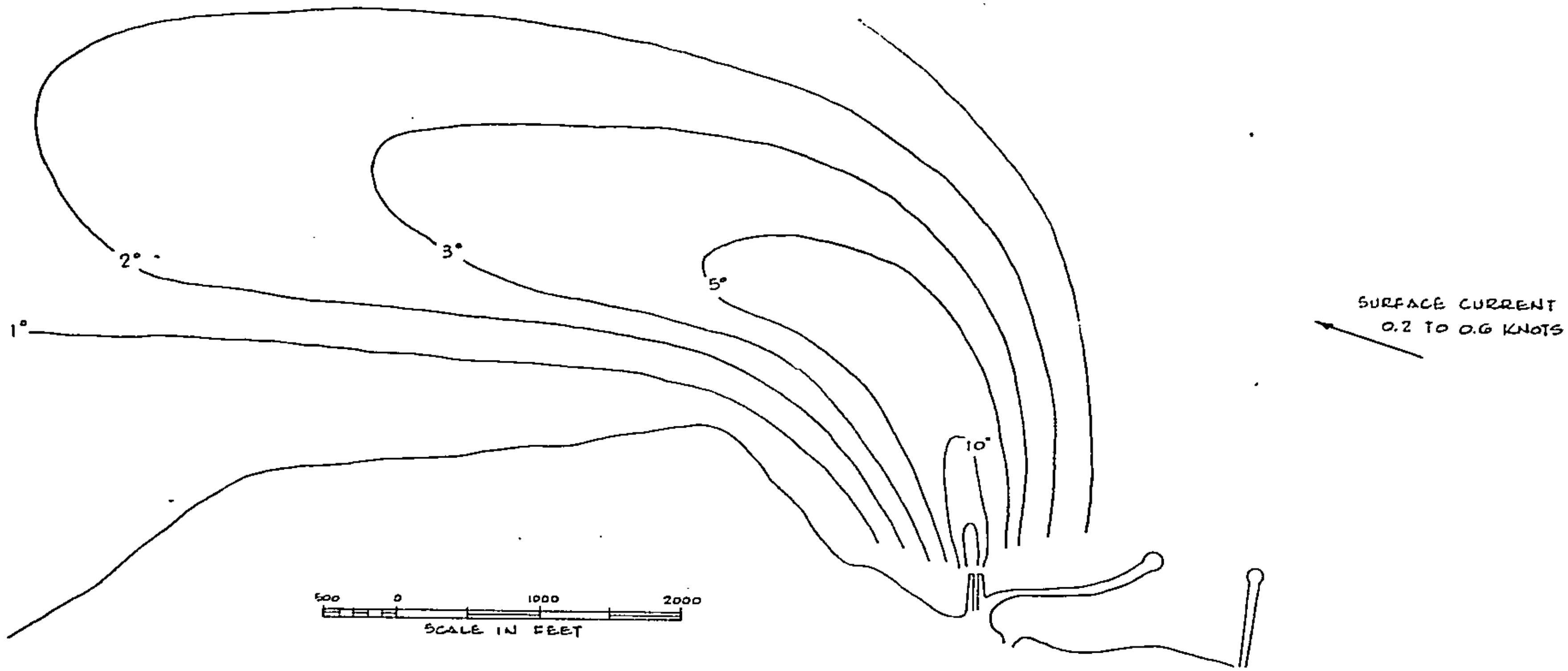
02339 0750



PILGRIM
NUCLEAR POWER STATION

Cooling Water Dispersion
FIGURE 4-7

0 2 3 3 9 0 7 5 1



PREDICTED TEMPERATURE RISE DISTRIBUTION IN °F FOR CONDENSER COOLING WATER FLOW AT 720 cfs TEMPERATURE RISE AT CONDENSER OF 28.7°F. OFF-SHORE CURRENT TOWARDS W.N.W. AT 0.2 TO 0.6 KNOTS BASED ON COMBINED MODEL STUDIES AND ANALYTICAL TREATMENT AUG. 1968.

PILGRIM NUCLEAR POWER STATION
Cooling Water Dispersion FIGURE 4-8

5.0 ENVIRONMENTAL QUALITY

5.1 General

Pilgrim Nuclear Power Station has been designed and constructed with preservation of the environment as a paramount consideration. Boston Edison Company is making every effort to ensure that environmental quality is not adversely affected due to the design, construction, or operation of Pilgrim Station. These efforts are reflected in the station design and the special environmental studies and environmental monitoring programs which have been established.

5.2 Aesthetics and Land Use

In the design of Pilgrim Nuclear Power Station special effort has been devoted to combining pleasing appearance with functional design, recognizing the area's natural aesthetics and integrating the facility's structures into the existing environment. Station structures and developments have been harmoniously grouped within the total station concept of scale, form, materials, and color with the intent of preventing any detrimental effect on the natural beauty of the area. Boston Edison Company has developed recreational facilities on the site with the intent of enhancing the recreational uses of the area. Provision has been made for public access under the control of Boston Edison Company to the station site to permit observation from the station overlook and fishing from the shore front and breakwater. Areas of the station site not utilized for the facility's structures, developed for recreational purposes, or landscaped for aesthetic effect, have been retained in their natural state.[1] Refer to Sections 4.3 and 4.4 of this summary.

5.3 Thermal and Chemical Discharges

Circulating seawater used to remove rejected heat from the station's main condenser will be discharged through the high velocity discharge canal to the waters of Cape Cod Bay with a temperature increase of about 29°F. The discharge canal has been designed to promote rapid mixing of the heated water effluent with the colder water of the bay. This is accomplished by discharging the heated water on to the surface of the receiving body of water with sufficient velocity to promote momentum mixing, thereby, significantly reducing the total area of thermal effect. (See Section 4.6 of this summary). The station low velocity intake canal and the station intake structure with its trash racks and traveling screens, have been designed to prevent fish larger than 3/8 inch from being drawn into the intake.[2]

Limited chemical additions from the station found in the circulating water discharge will consist principally of sodium sulfate, which is produced during regeneration of the condensate and makeup demineralizer resins, and sodium hypochlorite, which is added to the condenser cooling water to control biological fouling in the intake bays, the circulating water system piping, and the main condenser. These chemical additions will be maintained below the allowable concentrations specified in available standards on water quality. No adverse effect on the environment is predicted to occur as a result of the station discharges.[3]

5.4 Radiological Discharges

The radioactive waste control systems designed to minimize releases of radioactivity in station effluents are described in Section 8.10 of this summary. Boston Edison Company intends to make full utilization of the station process equipment to maintain offsite releases as low as practicable. The release of radioactivity from PNPS* during normal operation will

*Pilgrim Nuclear Power Station.

be small fractions of the applicable limits of 10 CFR Part 20, Standards For Protection Against Radiation. Thus, the annual average exposure levels due to station effluents will generally be only a fraction of the exposure resulting from natural background radiation.[4] The orderly, immediate shutdown of the station will be required in any situation in which the radioactive releases approach the maximum levels permitted by the Technical Specifications, which are established to maintain annual average exposure levels due to station effluents at small fractions of the 10 CFR Part 20 limits.

5.5 Environmental Surveillance Program

A comprehensive environmental surveillance program designed to monitor the atmospheric, terrestrial and aquatic environments in the vicinity of the Pilgrim Station has been in effect to establish a base line from which any increase in radiation or temperature in the environs during operation can be detected and evaluated. The program includes the collection and analysis of air, domestic water, seawater, marine life, bottom sediment, milk, and commercially harvested crops. This program is described more fully in Section 6.0

of this summary.

5.6 National Environmental Policy Act of 1969

The National Environmental Policy Act (NEPA) requires, among other things, that all agencies of the federal government include in every recommendation or report on major federal action significantly affecting the quality of the human environment, a detailed statement by the responsible official on the following:

"(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented;

(iii) alternatives to the proposed action;

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

Prior to making such a detailed statement, the agency is required to consult with and obtain comments of any federal state, or local agency which has jurisdiction by law or special expertise with respect to environmental impact.

In compliance with the policy of the Atomic Energy Commission, the applicant has prepared and filed with the Commission (on September 14, 1970), an environmental report providing information on the above five points. The Atomic Energy Commission has circulated it for comments to federal and state agencies having jurisdiction or special expertise with respect to environmental impact and, by publication of notice in the Federal Register on October 16, 1970, has made the report available to local agencies.

Comments on the Environmental Report were subsequently received by the AEC and transmitted to Boston Edison Company from the following agencies: Department of Defense, Department of Health, Education and Welfare; Department of Agriculture; Federal Power Commission, Department of the Interior; and the Fish and Wildlife Service. Some of the comments indicated that further clarifications and/or more detailed information would be useful to the particular agency making the comment. Boston Edison Company has since supplied additional information to the AEC in all cases for which it was requested. Specific recommendations made to the AEC by the Department of Health, Education and Welfare have either already been implemented or have been considered in accordance with the resolution of certain concerns raised by the Advisory Committee on Reactor Safeguards and summarized in Section 10.0 of this summary.

5.7 Water Quality Improvement Act of 1970

The Federal Water Quality Improvement Act of 1970 requires that a certification be obtained from the Commonwealth of Massachusetts as to the reasonable assurance that the Pilgrim Nuclear Power Station can be operated in compliance with applicable water quality standards. The Water Resources Commission, Division of Water Pollution Control, of the Commonwealth of Massachusetts has reviewed Boston Edison Company's application for certification and, on April 23, 1971 did issue the certification, subject to the conditions of the salt water use permit.[5] The certification[6] states, in part:

"In accordance with the provisions of

Section 21 (b) (1) of the Federal Water Quality Improvement Act of 1970 (Public Law 91-224), this Division hereby certifies that, based on information and investigations, there is reasonable assurance that the proposed activity will be conducted in a manner which will not violate applicable water quality standards adopted by this Division under authority of Section 27 (4) of Chapter 21 of the Massachusetts General Laws, said water quality standards as filed with the Secretary of State of the Commonwealth on March 6, 1967."

References for Section 5.0

1. Environmental Report, p. B-8

2. Environmental Report, p. C-21

3. Environmental Report, p. C-42

4. FSAR, Amendment 16, Section 9.9 as amended in Amendment 30.

5. Environmental Report, Part D, Attachment 5.

6. The Commonwealth of Massachusetts, Water Resources Commission, Division of Water Pollution Control, Letter to Boston Edison Company, April 23, 1971.

6.0 ENVIRONMENTAL MONITORING PROGRAMS

6.1 Aquatic Ecological Surveillance[1]

A six-year program of studies on the thermal discharge from Pilgrim Station was begun in early 1967 and is scheduled to be completed in January 1973. The objective of the program is to assure that every reasonable precaution is taken in the operation of the station relative to the environment.

The initial studies were used to establish the design of the breakwaters, intake structure and discharge canal. These studies were guided by consultants that are recognized authorities in the fields of coastal engineering, physical oceanography, cooling water dispersion and marine ecology as well as by comments and suggestions from the Division of Marine Fisheries of the Commonwealth of Massachusetts and the Fish and Wildlife Service of the Department of the Interior. Model studies at the Alden Research Laboratories and the Massachusetts Institute of Technology provided the basis for design of the intake and discharge structures and prediction of thermal patterns.

The ongoing work consists of a four-year, before-and-after field and laboratory ecology study of Cape Cod Bay in the vicinity of the station. This work is being conducted by the Massachusetts Division of Marine Fisheries under a grant to the Commonwealth of Massachusetts by Boston Edison Company. These studies will document, through field surveys, any changes in the distribution of important marine species that may be brought about by the operation of the station. An administrative-technical committee coordinates the work, reviews the results, and provides overall supervision of the program. The committee includes representatives from the Commonwealth of Massachusetts (Division of Marine Fisheries and Division of Water Pollution Control), the Federal Government (Bureau of Commercial Fisheries, Bureau of Sport Fisheries and Wildlife, Water Quality Administration of the Environmental Protection Agency, the University of Massachusetts, and Boston Edison Company.

These studies are designed to provide quantitative data on the floral and faunal components of the marine ecosystem in the vicinity of the site. The studies being conducted include finfish sampling, lobster investigations, plankton studies, and a benthic inventory. This information, in conjunction with the results of laboratory investigations and hydrographic data collected at the site, will be used as a basis for detecting and evaluating the nature and extent of station influence upon marine resources. Boston Edison Company will take steps to correct or mitigate any adverse situation which comes to light as a result of these studies.

6.2 Environs Radiation Surveillance[2]

A study of environmental radiation levels in all media of interest was started during 1969 and 1970 to provide baselines from which any increases in radiation due to operation of the station may be detected and evaluated. This radiation surveillance program will continue to be conducted during start-up and operation of the Pilgrim Station to evaluate the effect of station operation on the surrounding environs and to provide a check on the effectiveness of the various source controls.

During operation airborne particulates will be collected on a routine basis at six locations within a 5-mile radius of the station and at a control point approximately 23 miles away. Gaseous iodine will be collected on special filters used in conjunction with the air particulate filters. These sample stations have been in operation since March and September 1970.

Background gamma radiation levels have been measured since June 1970 using thermoluminescent dosimeters (TLD) at 18 monitoring locations within a 10-mile radius of the station. Background gamma radiation levels have also been measured at a control point approximately 23 miles away. Six of these monitoring points are presently located onsite, and the remainder are distributed throughout Kingston and Plymouth.

Samples of domestic water are collected monthly from the Deep Water Pumping Station (Lout Pond Well and Little South Pond) and Warner's Pond Pumping Station (Manomet Well) which control the bulk of the town water supplies for most of the residences in the area. An additional monthly grab sample for control purposes is collected from the Weymouth Great Pond Pumping Station, approximately 24 miles from the station.

Grab samples of sea water are being collected monthly during the preoperational phase of the program from various points offshore in the vicinity of the station. This sampling began in August 1969. After the station becomes operational, routine sampling of the intake and discharge canals will be utilized to collect monthly composites from these areas.

The Massachusetts Division of Marine Fisheries, as part of its Ecology Study (see Section 6.1), has been supplying the applicant since November 1969 with samples of fish and lobster which are indigenous to the area. Edible marine species are sampled principally during the commercial harvesting seasons when the species are readily available. For example, lobster samples are obtained between the months of May through October and flounder samples are obtained during November or December. Irish Moss samples are collected between the months of May through September. Edible molluscs will be sampled during the summer months if such organisms can be found within a reasonable distance from the station. Samples of bottom sediment are collected semiannually from an area encompassing the discharge canal outfall.

There is presently only one dairy herd within the Town of Plymouth. This herd is located approximately 3-1/2 miles west of the station. Grab samples of milk have been collected monthly since August 1969 from this point. Grab samples of milk have also been obtained from a dairy in Hingham, Massachusetts, as a control point.

Grab samples of cranberries and other crops having commercial significance are collected annually during their principal harvesting seasons from areas within a 5-mile radius of the station. Samples of cranberries have been collected and analyzed starting in the fall of 1968. The collection and analysis of other selected crops was initiated in the fall of 1969.

All the samples as well as the thermoluminescent dosimeters (TLD) are being collected by Boston Edison Company but are being analyzed or "read out" by an independent laboratory.

<u>References for Section 6.0</u>

1. Environmental Report, Part C. III. a
2. FSAR, Section 2.6.

7.0 STATION SAFETY ANALYSIS

The safety objective of the design of Pilgrim Nuclear Power Station is to minimize radiation exposures to any persons either on or off the station site.

In order to meet this objective, the station design and operation include the following:

(a) Positive control of all station processes.

(b) Inherent safety features and automatic devices to prevent an accident. Tests are conducted periodically to assure proper functioning of such devices.

(c) Multiple barriers to contain the radioactive materials. The reactor core is conservatively designed to operate with thermal parameters significantly below those which could lead to fuel damage.

(d) Operating personnel thoroughly knowledgeable in the operating characteristics of the station, and trained to follow written procedures to minimize the occurrence of operating errors.

In order to evaluate the ability of the station systems to protect the public, a series of events--abnormal operational transients and hypothetical accidents which are postulated for design basis purposes--have been analyzed to provide a safety evaluation of the Pilgrim

Nuclear Power Station. The extreme accidents postulated are highly improbable because of the large degree of quality control, design conservatism, and multiplicity of safeguards which are built into the system. However, for analysis purposes the accidents have been evaluated to include the far end of the spectrum of challenges to station design; thus they are referred to as the "design basis accidents". The results of the analyses of these accidents show that the effects of radioactivity released to the environment in the unlikely event that an accident should occur are well within the guidelines established by the AEC (10 CFR Part 100).

Of the numerous malfunctions evaluated, the design basis loss-of-coolant accident would be the most severe. Core standby cooling systems are provided to limit fuel clad damage for the entire spectrum of reactor coolant system failures ranging from the smallest leak to the complete severance of the largest reactor coolant pipe. The core cooling systems* insure that core integrity would be maintained[1]. Either the primary containment sprays or suppression pool cooling system would maintain the integrity of the primary containment which acts in conjunction with the secondary containment to assure that

*The systems referred to here are described in Section 8.5 of this summary.

the public would be protected against potential radiation hazards from the postulated accidents[2]. Emergency electrical power is available on-site to insure operation of these systems even if all external sources of electric power to the station are assumed to be unavailable at the time of the accident[3].

Results of the safety analyses show that, even in the event of a loss-of-coolant accident, no core melting would occur[4]. However, in order to further demonstrate that the operation of a nuclear power station at the proposed site does not present a hazard to the general public, a "maximum hypothetical accident" has been analyzed assuming a release from the fuel of 100 percent of the noble gases, 50 percent of the halogens and 1 percent of the solids in the fission product inventory. Fifty percent of the released halogens would then plate out within the containment. To have such a gross release of fission products, one must postulate a multitude of failures in the engineered safeguards systems[5]; therefore, the accident is not regarded as credible. Even given these assumptions, however, the low leakage rate of the primary containment, the existence of the secondary containment and the iodine removal by the standby gas treatment system would limit the potential radiation doses to below the AEC safety guideline values (10 CFR Part 100)[6].

References for Section 7.0

1. FSAR, Sections 4.5 and 17.6.3
2. FSAR, Sections 11.2, 11.3 and 17.6.3
3. FSAR, Section 7
4. FSAR, Section 4.5
5. FSAR, Section 17.9
6. FSAR, Section 17.9

8.0 DESCRIPTION OF PILGRIM NUCLEAR POWER STATION

8.1 Introduction

The Pilgrim Nuclear Power Station reactor is a single cycle, forced circulation, boiling water reactor, substantially similar, except as to the reactor rating and specific engineered safeguard systems to several other stations which have been previously licensed. (see Section 3.0) A simplified station system process flow diagram (Figure 8-1) is attached.

The nuclear steam supply system will operate at power levels up to 1998 MW thermal with a gross electrical output of approximately 685 MWe and a net electrical output of approximately 655 MWe. The station engineered safeguard systems performance and design and the safety and accident analyses have been examined on the basis of the 1998 MW thermal power level operation.

The principal architectural and engineering criteria for the design of this unit, including reactor design, containment systems, reactor auxiliary, station service and plant cooling systems, control and instrumentation systems, electric power systems, shielding and access control, and fuel handling and storage systems are summarized in Section 1 of the Final Safety Analysis Report (FSAR). The principal design features of Pilgrim Nuclear Power Station are compared to other boiling water reactors in Section 3 of this document. Refer also to Table 8-1 of this Section for a summary of the Station Engineered Safeguards and other safety related systems and components provided for Pilgrim Nuclear Power Station.

8.2 Containment Systems

8.2.1 General

The station employs two independent containment systems. The primary containment system consists of a drywell, a pressure suppression chamber, and inter-connecting vent pipes, and provides the first containment barrier around the reactor primary system. The reactor building, together with the reactor building isolation and control system, standby gas treatment system and the station main stack, provides the second containment barrier. The containment systems for the reactor are basically the same as those being provided for other BWR power stations.

These containment systems, as station structures, are designed in accordance with the governing codes and regulations, design criteria, and loading considerations discussed in Section 12 of the Final Safety Analysis Report (FSAR) and amplified in Appendix C of the FSAR. The station structural design criteria differentiates between two types of station structures, Class I structures and Class II structures, and applies detailed design requirements to each classification. Class I includes those structures, equipment and components whose failure or malfunction might cause or increase the severity of an accident which might endanger the public health and safety. This category includes those structures, required for safe shutdown and isolation of the reactor. Class II includes those structures, equipment, and components which are important to reactor operation, but are not essential for preventing an accident which would endanger the public health and safety and are not essential for the mitigation of the consequences of these accidents.[(1)]

8.2.2 Primary Containment System[(2)]

The primary containment system houses the reactor vessel, the reactor coolant recirculation system and other branch connections of the reactor coolant system. The primary containment is a pressure suppression chamber which stores a large volume of water, a connecting vent system between the drywell and water pool, isolation valves, vacuum relief system, containment cooling systems, and other service equipment. The drywell is a steel pressure vessel located below and encircling the drywell and which has approximately 40% of its volume filled with water.

The primary containment system is designed to withstand the forces from any size breach of the nuclear system primary barrier up to and including an instantaneous circumferential break of the reactor recirculation piping and provides a hold-up time for decay of any radioactive material released. The water stored within the torus of the primary containment system is sufficient to condense the steam released as a result of a breach in the nuclear system primary barrier and to supply water to the core standby cooling systems. The vent system from the drywell terminates below the water level in the pressure suppression chamber, so that in the event of a pipe failure in the drywell, the released steam passes directly to the suppression pool water where it is condensed. This transfer of energy to the water pool rapidly reduces the residual pressure in the drywell and substantially reduces the potential for subsequent leakage from the primary containment.

Provisions are made for the removal of heat from within the primary containment to maintain the integrity of the primary containment system following a loss-of-coolant accident. Capability is provided in the primary containment structural design to withstand the forces exerted in the event that it is necessary to flood the primary containment vessel (drywell and suppression chamber) to a level which would flood the reactor core.

Isolation valves are provided on lines penetrating the drywell and the suppression chamber to provide integrity of the containment when required. These valves are actuated automatically by signals received from the primary containment isolation system. The valves of the reactor auxiliary and station cooling systems are left open or are closed, depending upon the functional requirements of the system, without reducing the integrity of the primary containment system.

Provisions are made for initial preoperational and subsequent periodic leak rate testing of the primary containment system. The primary containment system will be tested on a periodic basis to verify that, under design basis accident conditions, the leak rate of the system would not be in excess of the maximum allowable leak rate at the calculated peak accident pressure. The tests will be performed in accordance with the conditions and evaluated against the limits specified in the Technical Specifications for Pilgrim Nuclear Power Station issued by the Commission.

Based upon the system design and the specified allowable leak rate, the effectiveness of the primary containment system (in conjunction with other engineered safeguards and nuclear safety systems) has been evaluated in Section 14 of the FSAR; and it has been concluded that the system would be effective in reducing the consequences of a postulated design basis loss-of-coolant accident to below the guideline values of 10 CFR Part 100.

8.2.3 Secondary Containment System [3]

The safety objective of the secondary containment system, in conjunction with other engineered safeguards and nuclear safety systems, is to limit the release to the environs of radioactive materials so that off-site doses from a postulated design basis accident will be below the guideline values of 10 CFR Part 100.

The secondary containment system consists of four subsystems. These subsystems are the reactor building, the reactor building isolation and control system, the standby gas treatment system and the main stack. The secondary containment system surrounds the primary containment system and is designed to provide secondary containment for the postulated loss-of-coolant accident. The secondary containment system also surrounds the refueling facilities and is designed to provide primary containment for the postulated refueling accident.

The secondary containment system utilizes four different features to mitigate the consequences of a postulated loss-of-coolant accident (pipe break inside the drywell) and the refueling accident (fuel handling accident). The first feature is a negative pressure barrier which minimizes the ground level release of fission products by exfiltration. The second feature is a low leakage containment volume which provides a hold-up time for fission product decay prior to release. The third feature is the removal of particulates and iodines by filtration prior to release. The fourth feature is the exhausting of the secondary containment atmosphere through an elevated release point which aids in dispersion of the effluent by atmospheric diffusion. Each of the features is provided by a different combination of subsystems: the first by the reactor building, the reactor building isolation and control system and the standby gas treatment exhaust fans; the second by the reactor building and the reactor building isolation and control system; the third by the standby gas treatment system filters; and the fourth by the main stack.

The reactor building is a massive concrete and steel Class I structure which completely encloses the reactor and its pressure suppression primary containment system. The reactor building houses the refueling and reactor servicing equipment, new and spent fuel storage facilities and other reactor auxiliary and service equipment. Also housed within the reactor building are the core standby cooling systems, reactor clean-up demineralizer system, standby liquid control system, control rod drive system, reactor protection system and electrical equipment components.

The effectiveness of the secondary containment system, in conjunction with other engineered safeguards and nuclear safety systems, in reducing the consequences of postulated design basis accidents to below the guideline values in 10 CFR Part 100 has been evaluated in Section 14 of the FSAR.

8.3 Reactor Description [4]

The reactor is a single-cycle, forced circulation, boiling water reactor producing steam for direct use in the steam turbine. The fuel consists of uranium dioxide pellets contained in sealed Zircaloy-2 clad fuel rods. Water serves as both the moderator and coolant. Figure 8-2 is an isometric drawing of the reactor vessel.

Water enters the bottom of the reactor core and flows upward through the fuel assemblies where boiling produces steam. The steam-water mixture is separated by steam separators and dryers located within the reactor primary vessel. The separated water mixes with the incoming feedwater and is returned to the reactor core inlet through jet pumps located within the reactor primary vessel. The steam passes through the main steam lines to the turbine.

The reactor vessel has an inside diameter of approximately 18 feet-8 inches and an inside height between heads of approximately 64 feet-8 inches. The main connections to the reactor vessel include the main steam lines, the reactor coolant recirculation pump suction lines and jet pump reactor coolant recirculation system lines, the reactor feedwater system lines, the reactor core spray cooling system lines and the control rod drive housings. Other connections are provided for the standby liquid control system, the control rod drive system supply lines and the instrumentation systems.

The bottom-entry cruciform control rods are moved vertically within the reactor core by individual control rod drives. The drives are of the hydraulically-operated, locking-piston type. The control rod drive hydraulic system is designed to allow control rod withdrawal or insertion at a limited rate, one control rod at a time, for reactor power level control and neutron flux shaping during reactor operation. Stored energy available from gas-charged accumulators and from reactor pressure provides hydraulic power for rapid insertion of all control rods simutaneously for reactor shutdown. Each drive has its own separate control and scram devices. The control rod drive housings are provided with a support structure designed to prevent significant movement of the control rod drive housing in the unlikely event of drive housing structural failure.

In addition, there is provided a standby liquid control system containing a neutron-absorbing boron solution which is capable of shutting down the reactor and maintaining it in a shutdown condition. This system is an independent system that would be used to shut down the reactor in the unlikely event that shutdown cannot be accomplished with the control rod system alone.

Two reactor coolant recirculation system loops with a connecting equalizer line are provided, each having a variable speed centrifugal pump with mechanical seals, motor operated gate valves for isolation of the pumps, and instrumentation for recirculation flow measurement. The motive force for the jet pumps is supplied by the water discharged from the two reactor coolant recirculation pumps. Variable frequency motor-generator sets power the recirculation pump motors. Changing the pump speed changes the recirculation flow rate, which changes reactor power level. Two important features included in the design are as follows: (a) the internal reactor core arrangement provides the function of a second vessel around the core formed by the core shroud and the jet pump diffuser system pipes, and (b) the recirculation water provides the motive force for the jet pumps located inside the reactor primary vessel. The features noted in (a) together with internal design features of the vessel and core, enable the core to be reflooded with water in the event of a loss-of-coolant accident.

The reactor core includes the fuel assemblies, control rods and temporary control curtains. The mechanical, thermalhydraulic and nuclear design of this reactor is similar to other boiling water reactors as discussed in Section 3.0.

The blades of each control rod consist of an assembly of sealed stainless steel tubes filled with compacted boron carbide powder. These tubes are held in a cruciform array by a stainless steel sheath. The assembly is provided with a rod drop velocity limiter, which is designed to limit the free-fall velocity of the control rod.

The temporary control curtains are made of boron stainless steel and supplement the control rods for reactivity control of the initial core load.

Neutron sources are positioned within the reactor core to provide detectable neutron level when the reactor is shutdown.

A control rod reactivity limiting device, called a control rod worth minimizer is used as back-up for procedural controls. The control rod worth minimizer is coupled to an interlock system which prevents high control rod worth withdrawals.

A reactor core isolation cooling (RCIC) system is provided to remove decay heat when the reactor feedwater system capability is lost. The system consists of a steam turbine driven makeup pump which supplies water from either the condensate storage tank or the suppression chamber pool. Steam to drive the turbine comes from a main steam line and exhausts to the suppression chamber pool.

The station has removable insulation in specified areas which permit direct inservice inspection of the exterior of the reactor vessel and other primary system components. This permits inspection of selected nozzle-to-shell welds, inspection of reactor vessel studs, nuts and bushings, selected sampling of high cyclic stress vessel welds, and selected sampling of coolant system piping, pumps, valve supports, and hangers.

8.4 Station Instrumentation and Control Systems

8.4.1 Reactor Control

Reactor power is controlled by movement of control rods and by regulation of the reactor coolant recirculation system flow rate. Control rods are used to bring the reactor through the full range of power (from shutdown to power operation) and to shape the reactor core power distribution. Changing recirculation flow rate provides a second and more convenient operational method for controlling reactor power level. Adjustments in reactor power level, and load following, are accomplished with recirculation flow control. Procedural controls and protective devices are used so that thermal performance does not exceed established limits.[5]

Reactor pressure is automatically controlled by the initial pressure regulator (IPR), which varies steam flow to the turbine to maintain constant pressure in the reactor. As a result, the turbine power output follows the reactor power output.[6]

The turbine-bypass system, having a capacity of approximately 25 percent rated turbine steam flow, is supplied with the turbine to regulate steam pressure during startup and shutdown and to restrict overpressure transients resulting from sudden turbine control valve or stop valve closure. The turbine bypass system valves are operated on an over-pressure signal from the IPR. Rapid partial load rejection (approximately 25 percent of rated turbine steam flow) can be accommodated by the turbine bypass system without shutting down the reactor.[7]

8.4.2 Protection Systems

Protection systems are provided which automatically initiate appropriate action whenever the station conditions monitored by the systems approach pre-established limits. These protection systems act to shut down the reactor, close primary containment isolation valves, and initiate secondary containment isolation, the operation of the standby gas treatment system, the diesel generators and the core standby cooling systems as required.

8.4.2.1 Reactor Protection System

The reactor protection system automatically initiates reactor scram* upon appropriate inputs from system sensors which monitor station conditions in order to provide timely protection against the onset and consequences of conditions that could threaten the integrity of the fuel barrier and the nuclear system process barrier. The reactor protection system limits the uncontrolled release of radioactive material from the fuel and nuclear system process barrier by terminating excessive temperature and pressure increases through the initiation of an automatic scram. The reactor protection system is designed so that no single failure will prevent it from accomplishing its protective function (scram) or cause spurious tripping of the reactor at power. The reactor protection system is designed to initiate scram on loss of power to the system. Components of the reactor protection system can be removed from service for testing or maintenance without interrupting station operations and without negating the ability of

*Scram - immediate shut-down of the reactor.

the reactor protection system to perform its protective function upon receipt of appropriate signals.[8]

8.4.2.2 Primary Containment and Reactor Vessel Isolation Control System

The primary containment and reactor vessel isolation control system initiates automatic isolation of appropriate pipelines which penetrate the primary containment whenever monitored variables exceed pre-selected operational limits in order to provide timely protection against the onset and consequences of accidents involving the gross release of radioactive materials from the fuel and the nuclear system process barrier. A gross failure of the fuel barrier would allow the escape of fission products from the fuel. A gross failure of the nuclear system process barrier could allow the escape of gross amounts of reactor coolant. The loss of coolant could lead to overheating and failure of the fuel. For a gross failure of the fuel, the primary containment and reactor vessel isolation control system initiates isolation of the reactor vessel to contain released fission products. For a gross breach in the nuclear system process barrier outside the primary containment, the isolation control system acts to interpose additional barriers (isolation valve closure) between the reactor and the breach, thus limiting the release of radioactive materials and conserving reactor coolant. For gross breaches in the nuclear system process barrier inside the primary containment, the primary containment and reactor vessel isolation control system acts to close off release routes through the primary containment barrier, thus trapping the radioactive material inside the primary containment.

The system is designed so that no single failure will prevent it from accomplishing its protective function or cause spurious isolation. The system is designed to cause isolation of appropriate lines on loss of electrical power to the system. Components of the system can be removed from service for testing or maintenance without interrupting station operation and without negating the ability of the system to perform its protective functions upon receipt of appropriate signals.(9)

8.4.2.3 Core Standby Cooling Systems Control and Instrumentation

The core standby cooling systems control and instrumentation initiate appropriate responses from the various cooling systems so that the fuel is adequately cooled under abnormal or accident conditions. The cooling provided by the systems restricts the release of radioactive materials from the fuel by limiting the extent of fuel damage following situations in which reactor coolant is lost from the nuclear system. Controls and instrumentation are designed to automatically initiate and control with precision, reliability and timeliness the core standby cooling systems to allow removal of heat from the reactor core in time to limit fuel clad damage, so that fuel deformation would not limit effective cooling of the core.

The instrumentation and controls for the core standby cooling systems are designed so that no single failure, maintenance, calibration, or test operation can prevent the integrated operations of the core standby cooling systems from providing adequate core cooling. The power supplies for the controls and instrumentation for the core standby cooling systems have been chosen so that core cooling can be accomplished concurrently with a loss of off-site ac power.[10]

8.4.2.4 Reactor Building Isolation and Control System

The reactor building isolation and control system automatically initiates secondary containment isolation and standby gas treatment system operation upon receipt of appropriate signals in order to minimize the potential for ground level release of airborne radioactive materials, and to provide for controlled filtered elevated release of the reactor building atmosphere under postulated design basis accident conditions. The system is designed so that no single failure can prevent it from accomplishing its protective functions. The system is designed so that it is fully testable during station power operation.[11]

8.4.2.5 Diesel Generator Instrumentation and Control System

The diesel generators provide standby ac power to the core standby cooling systems and primary containment isolation system. The diesel generators are initiated by appropriate signals which also initiate the core standby cooling systems or by signals from the ac auxiliary power system. The diesel generator initiation circuitry may be tested independently of the station operation. The diesel generator load carrying capability may be demonstrated during station operation by synchronization with the auxiliary power system.[12]

8.4.3 Reactor Nuclear Instrumentation

Reactor power (neutron level) is monitored from the source (start-up) range up through the power (operating) range by suitable neutron monitoring channels. All detectors for neutron monitoring are placed inside the reactor vessel. This location has been selected to provide maximum sensitivity to control rod movement during the startup period and to provide accurate monitoring in intermediate and power ranges.

The neutron monitoring system provides information for the efficient, expedient operation and control of the reactor. It consists of six major subsystems whose particular functions encompass the range of neutron flux from startup to power operation and include operator aids and calibration information. This system of incore neutron detectors and out-of-core electronics monitoring equipment provides neutron flux measurements that can be correlated to thermal power level for the entire range of flux conditions that may exist in the core.

8.5 Core Standby Cooling Systems and Related Auxiliary Cooling Water Systems

8.5.1 General

Several automatically initiated, reliable, redundant, diverse core standby cooling systems are provided to insure adequate cooling of the reactor core under abnormal operational transients and postulated accident conditions. The integrated operation of these systems is designed to provide for continuity of core cooling over the complete range of postulated break sizes in the nuclear system process barrier, removing the residual heat from the reactor core, thereby limiting peak fuel clad temperatures and limiting fission product release from the fuel.

The core standby cooling systems for Pilgrim Nuclear Power Station have been recently reevaluated in accordance with the USAEC's <u>INTERIM ACCEPTANCE CRITERIA FOR EMERGENCY CORE COOLING SYSTEMS FOR LIGHT-WATER POWER REACTORS</u>, June 19, 1971. The results of this analysis show that the PNPS core standby cooling systems, when evaluated in strict accordance with Appendix A, Part 2 of the interim policy statement, do meet the criteria of Section IV, A; i.e.,

1. The calculated maximum fuel element cladding temperature does not exceed $2,300^{\circ}$F.

2. The amount of fuel element cladding that reacts chemically with water or steam does not exceed 1% of the total amount of cladding in the reactor.

3. The clad temperature transient is terminated at

a time when the core geometry is amendable to cooling.

4. The core temperature is reduced and decay heat can be removed for an extended period of time.

The systems' power supplies have been chosen to allow initiation and operation regardless of the availability of offsite a-c power. The design of the systems allows testing to verify the operability of all active components during normal operation of the nuclear system.

The core standby cooling systems provided on Pilgrim Nuclear Power Station are functionally equivalent to those included in other operating BWR's. A short description of the systems is included in the following paragraphs.

8.5.2 Core Spray System[14]

Two independent loops are provided as a part of the core spray system to circulate water from the pressure suppression chamber pool to the reactor primary vessel. Each loop consists of a core spray pump, a sparger ring, a spray nozzle, and the necessary piping, valves, and instrumentation. The core spray system provides protection of the core for the postulated case of a large break in the nuclear system when the feedwater system, control rod drive water pumps, reactor core isolation cooling

(RCIC) system and the high pressure coolant injection (HPCI) system are unable to maintain reactor vessel water level.

The protection provided by the core spray system also extends to a small break condition in which the feedwater system, control rod drive water pumps, RCIC, and HPCI are all unable to maintain the reactor vessel water level, and the automatic depressurization system has operated to lower the reactor vessel pressure so that the low pressure coolant injection, (LPCI), system and the core spray system can provide core cooling. The water from this system is distributed directly on the reactor core by spray headers mounted inside the plenum above the reactor core.

8.5.3 High Pressure Coolant Injection (HPCI) System

The HPCI is provided to assure that the reactor core is adequately cooled to limit fuel clad temperature in the event of a small break in the nuclear system and loss of coolant which does not result in rapid depressurization of the reactor vessel. The HPCI permits the reactor to be shut down while maintaining sufficient reactor vessel water inventory until the reactor vessel is depressurized. The HPCI continues to operate until reactor vessel pressure is below the pressure at which LPCI operation or core spray system operation maintain core cooling. The system is designed to perform its function without reliance on electrical power supplies other than the station battery system. The system consists of a steam turbine driven makeup pump which supplies water from either the condensate storage tank or the pressure suppression pool. Steam to drive the turbine comes from a main steam line and exhausts to the suppression chamber pool.

8.5.4 Pressure-Relief System/Automatic Depressurization System[16]

The primary system relief and safety valves open on a reactor vessel overpressure to protect the nuclear system process barrier. In addition, the relief valves will function as an automatic depressurizer in case the capability of the feedwater system, the control rod drive water pumps, RCIC , and HPCI is not sufficient to maintain the reactor water level. The automatic depressurization system functions to reduce the reactor pressure so that flow from LPCI and the core spray system enters the reactor vessel in time to cool the core and limit fuel clad temperature. In order to accomplish this function the valves open, when signalled to do so, following a loss-of-coolant accident, and remain open below a preset closing pressure.

8.5.5 Reactor Core Residual Heat Removal System (RHR)[17]

The residual heat removal system is made up of the following three sub-systems:

A. A low pressure coolant injection system (LPCI) is provided as an independent, redundant means of removing stored and decay heat from the reactor core following a loss-of-coolant accident. The system is designed to restore the water level in the reactor vessel and to maintain this water level by making up any leakage from the core shroud.

B. A Containment Cooling System is provided:

(1) To limit the suppression chamber pool water temperature following the design basis loss-of-coolant accident to 170°F. Removal of this heat load is accomplished by circulating the pool water through the RHR heat exchangers via the containment cooling system operation.

(2) To increase the containment capability for metal-water reaction by providing the capability to

remove energy from the containment by means of spray cooling.

C. A reactor shutdown cooling system is provided to remove decay and sensible heat from the reactor core during normal shutdown operation. A head spray cooling system is provided to condense the steam dome in the reactor vessel during normal shutdown operation.

The major equipment of the RHR consists of two heat exchangers and four main system pumps. The RHR heat exchangers are cooled by the reactor building closed cooling water system which is, in turn, cooled by the station salt service water system. The main system pumps are sized on the basis of the flow required during the low pressure coolant injection (LPCI) mode of operation, which is the mode requiring maximum system flow rate. The heat exchangers are sized on the basis of their required duty for the shutdown cooling function, which is the mode of RHR operation requiring the maximum heat exchanger surface area.

The RHR has the capability of being intertied with the fuel pool cooling system. This capability increases the spent fuel pool cooling capacity in the event that such additional capacity is necessitated by removal from the core of an unusually large number of fuel elements.

8.5.6 Reactor Building Closed Cooling Water System[18]

The reactor building closed cooling water system is designed to provide the required cooling to the equipment located in the reactor building during normal planned operations, to provide cooling to the core standby cooling systems and their related auxiliaries during transient and accident conditions and to provide a heat sink for the RHR heat exchangers. The systems consists of two independent loops with three pumps per loop, either loop with two pumps operating being capable of providing the required heat transfer for the design basis accident conditions. The system power supplies have been chosen to allow initiation and operation regardless of the availability of offsite a-c power. The operability of the major system components and instrumentation can be verified during normal station power operation. The system is designed so that no single failure can prevent it from accomplishing its safety function of providing cooling to the CSCS*

*Core Standby Cooling System

components when required.

8.5.7 Salt Service Water System[19]

The salt service water system provides cooling to the reactor building closed cooling water system and the turbine building cooling water system during normal planned operation and under transient and postulated accident conditions. The system consists of two loops, two pumps per loop, with a common spare pump which can be valved into either loop. The system can be initiated and operated regardless of the availability of offsite a-c power.

8.6 Steam Power Conversion Systems[20]

The power conversion systems are designed to produce electrical energy through conversion of a portion of the thermal energy contained in the steam supplied from the reactor, condense the turbine exhaust steam into water, and return the water to the reactor as heated feedwater, with a major portion of its gaseous, dissolved and particulate impurities removed.

The major components of the power conversion system are: turbine-generator, main condenser, condensate pumps, air ejector, turbine gland seal system, turbine bypass system, condensate demineralizers, reactor feed pumps, feedwater heaters, and condensate storage system. The heat rejected to the main condenser is removed by the circulating water system.

The saturated steam produced by the boiling water reactor is passed through the high pressure turbine where the steam is expanded and then exhausted through the moisture separators. Moisture is removed in the moisture separators, and the steam is then passed through the low pressure turbines where the steam is again expanded. From the low pressure turbines the steam is exhausted into the condenser where the steam is condensed and deaerated, and then returned to the cycle as condensate. A small part of the main steam supply is continuously used by the steam jet air ejectors and by the plant heating system. The condensate pumps, taking suction from the condenser hotwell, deliver the condensate through the air ejector condensers, turbine gland seal condenser, condensate demineralizer and three stages of low pressure feedwater heaters to the reactor feed pumps. The reactor feed pumps supply feedwater through two stages of high pressure feedwater heaters to the reactor. Steam for heating the feedwater in the heating cycle is supplied from turbine extractions. The feedwater heaters also provide the means of handling the moisture separated from the steam in the turbine and in the moisture separators. Normally, the turbine utilizes all the steam being generated by the reactor; however, an automatic pressure-controlled steam bypass system is provided to discharge excess steam up to 25% of the design flow directly to the condenser.

8.7 Electrical Power Systems[21]

The station electrical power systems provide a diversity of dependable power sources which are physically separated. The station electrical power systems consist of unit and preferred a-c power systems, the secondary a-c power system, auxiliary power distribution system, standby a-c power system, 125/250 volt d-c power system, 24 volt d-c power system and the 120 volt a-c power system.

The unit a-c power source provides a-c power to all station auxiliaries and is the normal station a-c power source when the main generator is operating. The station preferred (off-site) a-c power source can provide a-c power to all station auxiliaries and is in use when the unit a-c power source is unavailable.

The secondary (off-site) a-c power source can provide a-c power to essential station auxiliaries. It is used to supply essential station auxiliary loads only when the reactor is shut down and there is an extended outage of the preferred a-c power source.

The station auxiliary power distribution system distributes all a-c power necessary for startup, operation, or shutdown of station loads. All portions of this distribution system receive a-c power from the unit a-c power source or the preferred a-c power source. The emergency service portions of this distribution system also can receive a-c power from the standby a-c power source or the secondary a-c power source.

The standby a-c power source provides two independent diesel generators as the on-site sources of a-c power to the emergency service portions of the station auxiliary power distribution system. Each on-site source is automatically initiated upon loss of unit and preferred a-c power sources or upon signals which initiate the core standby cooling systems. Each diesel generator unit is capable of providing a-c power to safely shut down the reactor, maintain the safe shutdown condition, and operate all auxiliaries necessary for station safety.

The station 125/250 volt d-c power systems provide independent on-site sources of d-c power for start-up, operation, shutdown and all loads essential to station safety.

The station 24 volt d-c power system, provides a reliable on-site source of power to some radiation monitoring instrumentation.

The station 120 volt a-c power system provides a versatile distribution system to supply a-c power to the station computer, instruments and control devices requiring uninterruptable power, and conventional instrumentation and monitoring systems.

The electrical output of Pilgrim Station is fed through the station's switchyard via two 345 kV transmission lines to New England Gas and Electric Association's Canal Station and Montaup Electric Company's Bridgewater Station. The Canal and Bridgewater Stations are connected to the New England Power Grid and the Boston Edison system by two 345 kV lines. When the station is not operating, off-site auxiliary electrical power is available from the New England Power Grid through either of the two 345 kV lines or one 23 kV line which provides a secondary a-c power source to shutdown the station.

8.8 Radiation Monitoring Systems[22]

The station radiation monitoring systems include process and area radiation monitoring systems. The following are the significant process radiation monitoring systems:

1) The main steam line radiation monitoring system monitors for the gross release of fission products from the fuel and, upon indication of such failure, initiates appropriate action to limit fuel damage and contain the released fission products.

2) The air ejector offgas radiation monitoring system indicates when limits on the release of airborne radioactive material to the environment are approached and effects appropriate control of the offgas so that short term limits are not exceeded during normal station operation.

Abnormally high radiation levels will cause a time delay switch to be activated which, in turn, closes drain valves and an outlet valve on the air ejector offgas line. A time delay of not greater than 15 minutes is provided to allow the operator to reduce power or correct for a spurious trip condition before the outlet valve is closed.

3) The main stack radiation monitoring system indicates and records the rate of radioactive material release from the main stack. Two alarms are provided on this system based on the technical specifications on average annual release limit and short term maximum release limit.

4) The refueling ventilation exhaust monitoring system provides prompt indication of a gross release of fission products from the spent fuel in the refueling floor area and provides appropriate signals to the reactor building isolation and control system to effect secondary containment isolation and standby gas treatment system operation prior to the transport of fission products from the refueling area to the normal building exhaust location.

5) The building exhaust vent radiation monitoring system records the rate of radioactive material release from the building vent to the environs and alarms whenever abnormal amounts of radioactive material exist in the building vent effluent.

6) The radwaste liquid discharge radiation monitoring system records the radioactivity level of material released through the liquid radwaste discharge header

during planned operations. Whenever abnormal amounts of radioactive material are detected in the liquid radwaste discharge header, an upscale trip alarms in the main control room, trips the monitor tank pumps, and terminates the discharge.

The area radiation monitoring system provides the operating personnel with a record and indication in the main control room of the radiation levels in selected locations within the various station buildings and provides local alarms in areas where it is necessary to warn personnel of substantial immediate changes in radiation levels.

Whenever alarms indicating abnormally high station effluent levels are sounded, appropriate operator action will be taken to ensure that the station technical specifications are not violated.

8.9 Shielding, Access Control, and Radiation Protection Procedures[23]

Control of radiation exposure of station personnel and people external to the station exclusion area is accomplished by a combination of radiation shielding, control of access into certain areas, and administrative procedures. Shielding is used to reduce radiation dose rates in various parts of the station to acceptable limits consistent with operational and maintenance requirements. Access control and administrative procedures are used to limit the integrated dose received by station personnel to less than that set forth in 10 CFR 20. Access control and administrative procedures are also used to limit the potential spread of radioactive contamination from various areas, particularly areas where maintenance occurs. Access control is established in the station arrangement and design so that, in general, most areas and equipment are kept freely accessible, and areas where radiation and/or contamination may be present are entered and exited via access control stations.

Procedures have been established for use of survey instruments, protective clothing, film badges, and dosimeters for personnel protection. During operation, periodic surveys will be made to determine radiation levels and to maintain control of potentially contaminated areas. Surveys will also be made prior to maintenance or unusual work to provide exposure control.

8.10 Radioactive Waste Control Systems

8.10.1 General

The radioactive waste control systems, i.e., the liquid radwaste system, the solid radwaste system and the gaseous radwaste system, are designed to collect radioactive and potentially radioactive station wastes and process and dispose of them in a safe manner.

The radioactive waste control systems are designed to minimize the potential for the inadvertent release of radioactivity from the station and to assure that the discharge of radioactive wastes will be within the regulatory limits. The releases of radioactivity from PNPS* during normal operation will be small fractions of the allowable limits of 10 CFR Part 20, "Standards For Protection Against Radiation." Thus annual average exposure levels due to station effluents will generally be small fractions of the average exposure resulting from natural background radiation.

Boston Edison Company recognizes its obligation to exert its best efforts to keep levels of radioactive materials in effluents as low as practicable. Boston Edison Company intends to operate PNPS in a manner consistent with that obligation compatable with its

*PNPS - Pilgrim Nuclear Power Station.

legal mandate to furnish a depe·.dable source of power. The applicant has initiated a program of selecting, designing, and installing additional equipment* to reduce radioactivity releases from Pilgrim Station to comply with the requirements of 10 CFR Part 50 Appendix I, "Numerical Guides For Design Objectives and Limiting Conditions For Operation To Meet the Criterion 'As Low As Practical' For Radioactive Material In Light-Water-Cooled Nuclear Power Reactor Effluents".** The applicant plans to initiate installation of that equipment when approved by the USAEC and to complete installation as soon as practicable.

8.10.2 Liquid Radwaste System

The liquid radwaste systems collects and processes radioactive and potentially radioactive liquid wastes. The liquid radwaste system is composed of three subsystems, the clean radwaste subsystem, the chemical radwaste subsystem, and the miscellaneous radwaste subsystem; hence, different types of liquid wastes from various sources from within the station can be segregated and processed more efficiently, thus maximizing the recycling of liquid wastes and minimizing the radioactivity

*i.e., beyond the equipment on which the radwaste system description in this summary is based.

**These guides are not yet part of the regulations but are proposed to be incorporated into the regulations.

in the discharge of liquid effluent. Cross connections between the subsystems have been provided to obtain the availability of additional flexibility for processing liquid wastes.

The clean radwaste subsystem processes low conductivity radioactive liquid wastes, viz., equipment leakage collected in equipment drain sumps, condensate demineralizer backwash, and resin transfer water. Water from these sources are transferred to the clean waste receiver tank and are processed on a batch basis through filters and demineralizers before collection in the treated waste holdup tanks. After processing, the water in the treated water holdup tanks normally is no longer classified as liquid radwaste; rather, the water quality is such that it may be recycled for use in the station by transfer to the condensate storage tank. Normally, there is no liquid effluent discharge from the station resulting from the clean radwaste subsystem and, hence, no radioactivity released to the environs as a result of the operation of this subsystem.

The chemical radwaste subsystem processes high conductivity, potentially radioactive liquid wastes collected in floor drain sumps and resulting from chemical regeneration of th condensate demineralizer system. These wastes are transferred to the chemical waste receiver for batch processing. After neutralization the wastes are filtered to remove insoluables, and the processed liquid is then transferred to the monitor tanks for holdup and radioactive decay. After decay, the low level liquid wastes are sampled, analyzed, and then released on a controlled basis to the circulating water discharge canal.

The miscellaneous radwaste subsystem processes those wastes which have a potentially high detergent level but typically a very low radioactivity concentration. These wastes are collected, sampled and analyzed for radioactivity concentration. If within allowable limits the wastes are filtered and discharged on a controlled basis to the circulating water discharge canal. Miscellaneous wastes of high radioactivity concentrations are transferred to the chemical waste receiver tanks for processing in the chemical radwaste subsystem.

Records will be maintained of the discharge rates, concentrations and quantities of liquid radwaste released to the environs. Analyses of the effluent batch samples will be used to assure that the limits of the applicable regulations are not exceeded.

8.10.3 Gaseous Radwaste System[25]

The gaseous radwaste system collects radioactive gaseous wastes from the main condenser air ejectors, the startup mechanical vacuum pump, and the turbine gland seal condenser and monitors their release to the atmosphere. The waste gases are routed via hold-up pipes to the main stack for dilution, and elevated release to the atmosphere. The discharge of radioactive effluents to the environment through the main stack are continuously monitored and recorded.

The main condenser air ejector subsystem consists of a thirty minute hold-up line, high efficiency filters, isolation valves, dilution fans and the main stack. During power operation, the main condenser off-gas is the major contributor to the activity in the station off-gas release. The gases entering this subsystem are the non-condensibles from the main condenser, consisting of hydrogen and oxygen formed in the reactor by radiolytic decomposition of water, air in-leakage to the turbine-condenser, water vapor, and trace quantities of fission gases resulting from leakage through defects in the fuel cladding and carried over in the steam to the turbine-condenser. The hold-up time in this system for radioactive decay of the fission gases carried over with the steam effects an approximate reduction of 50 or greater in radioactivity. This hold-up time allows the radioactive Xenon and Krypton isotopes with short half-lives to decay to their solid particulate daughter isotopes which are retained on the High Efficiency Particulate Absorber (HEPA) filters at the end of the hold-up pipe. Approximately 98% of the noble gas activity present in the steam at the reactor vessel nozzle experiences decay to stable or radioactive solid daughters prior to reaching the end of the hold-up pipe, and essentially all the solid particulates are retained on the HEPA filters.

The turbine gland seal off-gas subsystem collects non-condensible gases from the turbine gland seal condenser during operation of the vacuum pump during startup and passes them through holdup piping prior to release to the stack. During power operation the gland seal off-gas subsystem provides a 1.75 minute hold-up time to allow decay of N-16 and short-lived Xenon and Krypton isotopes.

Both the thirty minute hold-up pipe and the turbine gland seal off-gas pipe discharge into the base of the station main stack where the effluent streams are mixed with dilution air by high flow fans and pass up the main stack for dispersion into the atmosphere. Radiation monitors on the main stack continuously monitor and record the activity of the discharge.

The annual average release rates of radioactivity from the Pilgrim Nuclear Power Station will be maintained by Boston Edison Company significantly below the limits allowed by 10 CFR Part 20.

8.10.4 Solid Radwaste System[26]

The solid radwaste system processes the dry and wet solid radioactive wastes from the station. Wet solid wastes include backwash sludge wastes from the reactor water cleanup system and all spent resins from radwaste, spent fuel pool, and condensate demineralizers. Dry solid wastes include rags, paper, small equipment parts, solid laboratory wastes, etc. All solid radwastes are collected, processed, packaged and temporarily stored on the site to permit accumulation and radioactive decay prior to shipment to a licensed burial site in accordance with applicable regulations.

TABLE 8·1

SUMMARY OF STATION ENGINEERED SAFEGUARDS

System or Component	Function
Control Rod Velocity Limiter	To limit control rod velocity during free fall to less than five feet per second.
Control Rod Drive Housing Support	To prevent a control rod drive mechanism from falling away from the reactor primary vessel in the unlikely event of failure of a housing assembly.
Standby Liquid Control System	To provide a redundant, independent control mechanism in the event the control rod drive system becomes inoperable.
Main Steam Line Flow Restrictor	To provide a constriction in each main steam line to limit the rate of steam flow in the event of a postulated severence of a main steam line.

TABLE 8-1 (Continued)

System or Component	Function
Reactor Core Spray Cooling System	To cool and/or reflood the reactor core after a postulated loss-of-coolant accident.
Low Pressure Coolant Injection System	To restore the water level in the reactor vessel after a postulated loss-of-coolant accident.
Containment Spray and Cooling System	To provide for cooling of the primary containment system.
High Pressure Coolant Injection System	To provide adequate core cooling for a spectrum of reactor primary system breaks smaller than those covered by the reactor core spray cooling and low pressure coolant injection systems.
Auto-Depressurization System (ADS)	To provide automatic depressurization of the reactor primary system, if necessary, to

TABLE 8-1 (Continued)

System or Component	Function
Auto-Depressurization System (ADS) (Cont.)	allow core spray and RHR operation. The ADS coupled with the LPCI and/or the Core Spray System provide a back-up to the HPCI.
Primary Containment	To isolate the primary containment system automatically, if required, under postulated accident conditions.
Reactor Building Isolation and Control System	To isolate the normal reactor building ventilation system and initiate the standby gas treatment system under postulated accident conditions.

0 2 3 3 9 0 8 1 8

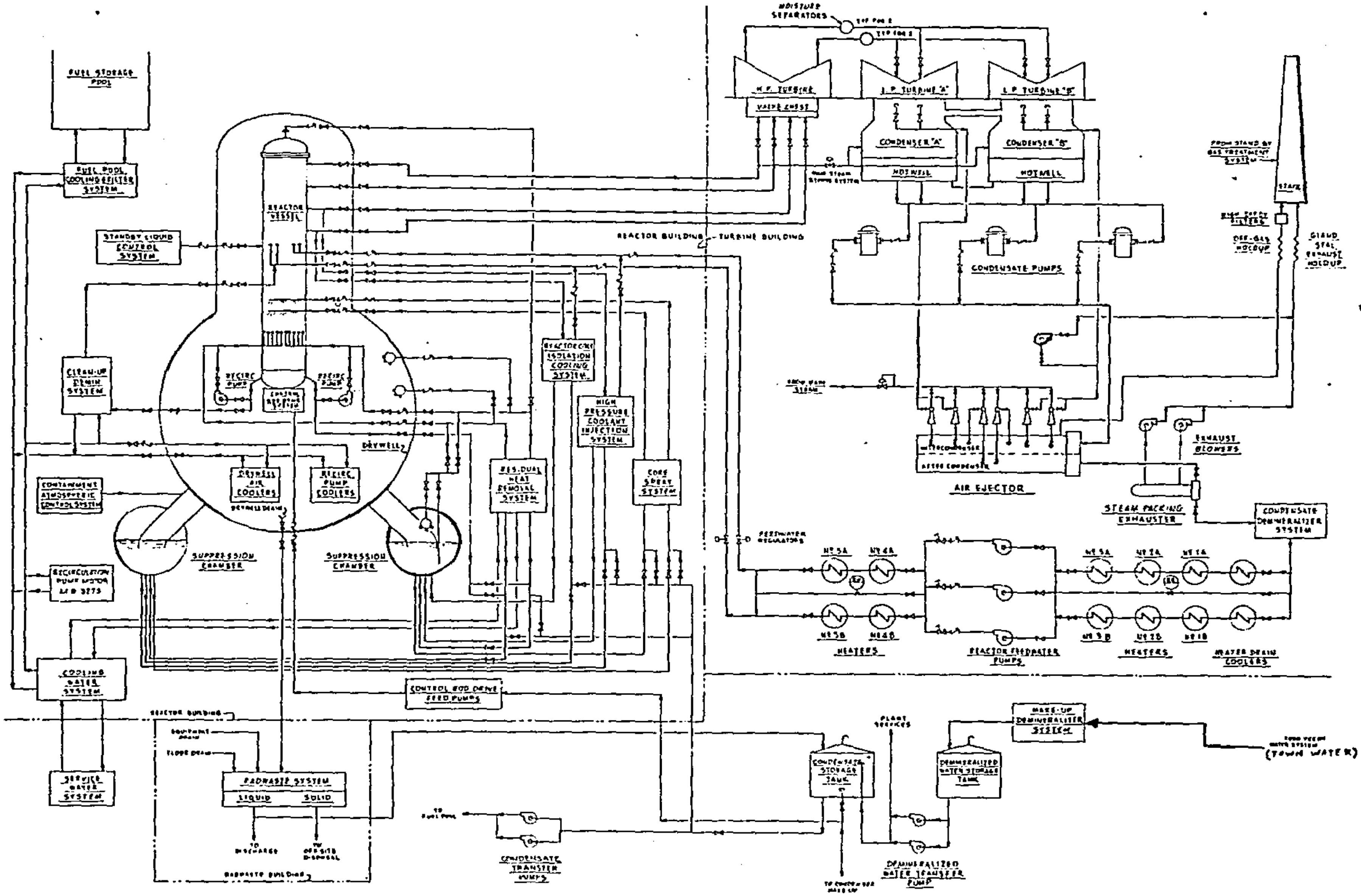
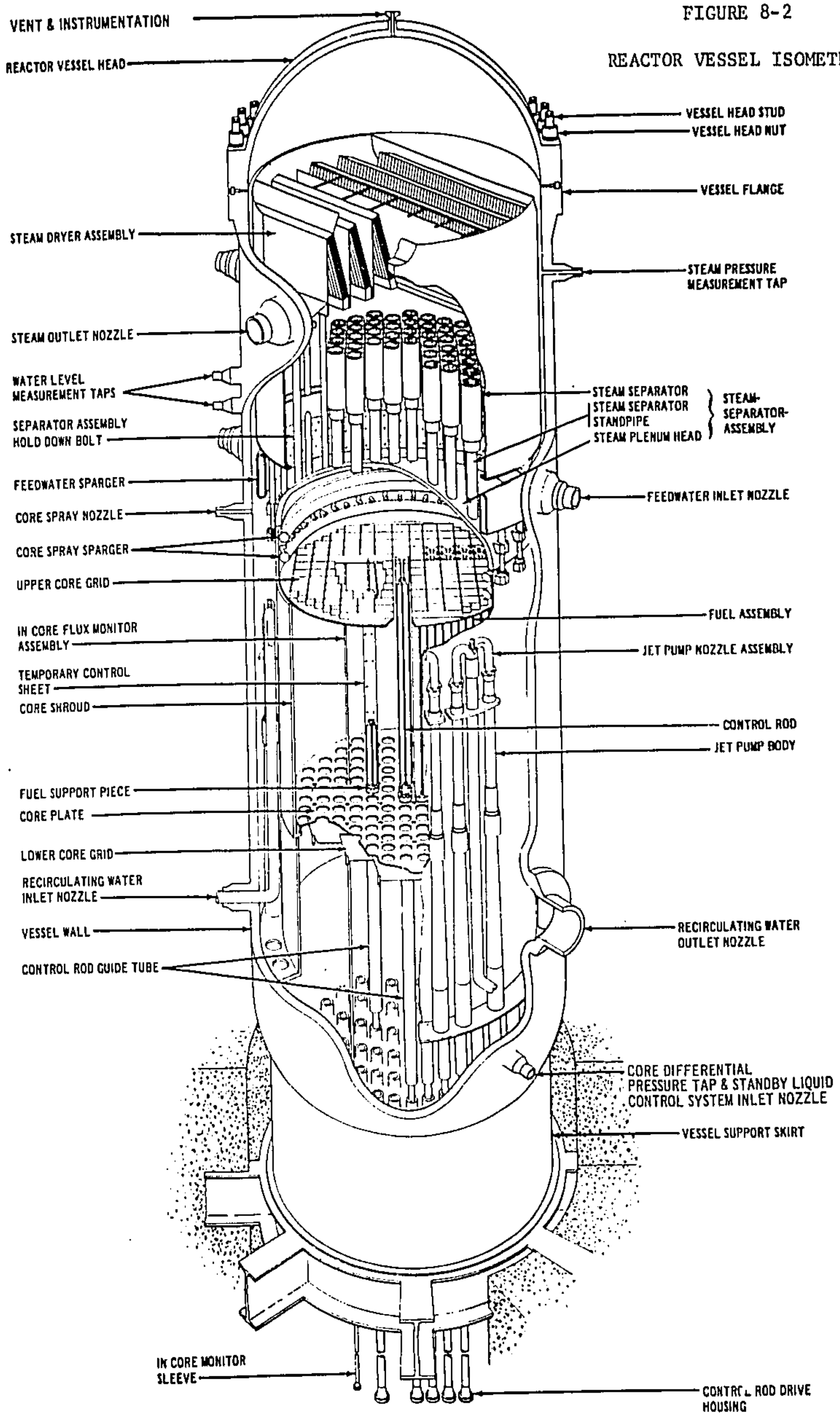


FIGURE 8-1
SIMPLIFIED STATION PROCESS FLOW DIAGRAM

FIGURE 8-2

REACTOR VESSEL ISOMETRIC



References for Section 8.0

1. FSAR, Section 12.2.3
2. FSAR, Section 5.2
3. FSAR, Section 5.3
4. FSAR, Sections 3 and 4
5. FSAR, Sections 3.4 and 3.7
6. FSAR, Section 7.9 and 7.11
7. FSAR, Section 7.11
8. FSAR, Section 7.2
9. FSAR, Section 7.3
10. FSAR, Section 7.4
11. FSAR, Section 7.18
12. FSAR, Section 8.5
13. FSAR, Section 7.5
14. FSAR, Section 6.4.3
15. FSAR, Section 6.4.1
16. FSAR, Sections 4.4 and 6.4.2
17. FSAR, Sections 4.8 and 6.4.4
18. FSAR, Section 10.5
19. FSAR, Section 10.7
20. FSAR, Section 11
21. FSAR, Section 8
22. FSAR, Sections 7.12 and 7.13
23. FSAR, Section 12.3

24. FSAR, Section 9.2

25. FSAR, Section 9.4

26. FSAR, Section 9.3

9.0 QUALITY ASSURANCE AND STATION TESTING PROGRAMS

9.1 Quality Assurance[(1)]

Pilgrim Nuclear Power Station is owned and will be operated by Boston Edison Company. The applicant assumes full responsibility and authority for the project and has ultimate responsibility for quality assurance.

Bechtel Corporation is architect-engineer with additional responsibility for all construction on site.

General Electric Company provides design engineering and procurement of equipment associated with the Nuclear Steam Supply System, together with technical direction of installation for this system.

The applicant's Nuclear Quality Assurance Organization has the responsibility to assure that quality requirements of essential items affecting the integrity and safety of the station are identified, specified, and performed in accordance with sound engineering principles, appropriate codes and standards, specifications, regulations, and procedures. This NQA organization consists of a Senior Quality Assurance Engineer who reports to the Assistant Vice President - Nuclear. Reporting to the Senior Quality Assurance Engineer are the Quality Assurance Engineers assigned with mechanical and electrical experience and background.

Programs in Quality Control and Quality Assurance have been established by the Architect-Engineer, Bechtel, and by the Nuclear Steam System Supplier, General Electric. Control of quality is accomplished through communications with project contractors, consultants, inspectors, and equipment manufacturers, and by surveillance and audit of quality control records, inspection reports and audits, test reports, certifications of code compliance, and by any other means necessary to accomplish the quality assurance objectives.

Functional responsibility for quality control, quality assurance, engineering design, procurement, expediting, inspection, construction, systems checkout, and acceptance testing are indicated on Table 9-1, Project Functional Responsibility Summary. This table covers the nuclear steam supply system, nuclear fuel, and balance of plant.

Figure 9-1, Quality Assurance - Quality Control Responsibility Chart, presents the organizational quality assurance responsibility covering materials and equipment subvendors, through various contractors, suppliers, architect-engineer, constructor, and ultimately to the prime responsible company, Boston Edison.

Figure 9-2 - Site Construction Quality Assurance Organization Chart, presents the organization and interrelationships of quality-oriented personnel at the Pilgrim construction site. Functional lines of reporting and communication are established to coordinate quality control and quality assurance, and to assure that all site construction activities are carried out in accordance with project requirements for inspection, testing, and documentation.

Structures, systems, and components are classified for purposes of identifying and assigning quality control and quality assurance requirements. The classification is made to identify "essential items" and to establish quality levels consistent with the requirements of Boston Edison Company and to comply with the intent of the quality-related AEC General Design Criteria.

The "essential items" that are controlled by the Quality Assurance Program are those structures and systems identified as Class I in the FSAR. A summary of Class I structures and equipment is included in subsection 12.2.1.2 of the FSAR. A summary of the Class I protection instrument and control systems is included in subsection 7.1.1 of the FSAR. The "essential items" are identified on the Q(Quality)-List. Within the Class I mechanical and clerical systems, every item or component is not Q-listed. Rather, each component is reviewed to determine which of the following categories it falls into:

Category A

Its function is essential for the operation of a Class I component or system to meet the Class I criteria (e.g., pumps and switches that must operate to accomplish their safety objective). If so, it is included on the Q-List.

Category B

Its pressure boundary integrity is essential for the operation of a Class I component to meet the Class I criteria. If so, it is included on the Q-List and, if required for clarity, it is given a note (pressure boundary only) on the Q-List.

Category C

It is not essential for either functioning or pressure boundary integrity of A or B above (e.g., pressure, temperature, and position indicators or alarms, computer inputs etc.). If so, it is not included on the Q-List.

9.2 Pre-Operational and Startup Testing [2]

The Station will be made operational by Boston Edison operating personnel under the technical direction of General Electric and Bechtel using written test procedures and operating instructions.

The applicant is responsible for all station operations from the start of preoperational testing and is responsible for providing properly licensed personnel to operate the station. General Electric personnel will provide technical guidance for preoperational testing, initial core loading, startup, and precommercial operation. Prior to initial fuel loading, General Electric will have a sufficient number of their startup personnel obtain AEC licenses to properly assist the applicant's licensed personnel during the period preceding commercial operation.

The Pilgrim Division Head is responsible for the safe operation of the facility. A training program has been established which will provide a properly trained staff of technical, maintenance, and licensed operating personnel to accomplish all of the various station functions within their respective disciplines as shown on the station organization chart (see Figure 9-3).

Preoperational and acceptance test procedures identify the systems and equipment which are to be tested and state the requirements of the tests. Test procedures and test results are reviewed and approved by Boston Edison and either Bechtel or General Electric, as appropriate, based upon original design responsibility.

The purpose of the preoperational test program is three-fold: confirm that construction is complete to the extent that equipment and systems can be put into use during completion of other construction; adjust and calibrate the equipment to the extent possible in the "cold" plant; assure that all process and safety equipment is operational, and in compliance with license requirements, to the extent necessary to proceed into initial fuel loading and the startup program. The foregoing is achieved by construction tests, formal written preoperational tests on systems related to nuclear safety, and acceptance tests on systems not related to nuclear safety.

The formal preoperational and acceptance tests are an important phase in the training of operating personnel. Experience and understanding of station systems and components is gained with a minimum of risk to the equipment or personnel. This gives maximum opportunity to evaluate and train individual operators and to troubleshoot systems. In addition, equipment and systems are operated for a sufficient period of time to discover and correct any design, manufacturing, or installation errors, and to adjust and calibrate the equipment.

After each preoperational test is completed, General Electric or Bechtel and Boston Edison operating personnel check off that the tests have been completed and that the results are in accordance with acceptance criteria of the test procedure.

Initial fuel loading and startup testing are performed by Boston Edison operating personnel under the technical direction of General Electric. Startup test specifications define the test program for startup with defined limits and changes permitted during startup test activities.

Startup test procedures present the recommended test method and describe the steps necessary to perform the tests defined in the startup test specification.

The applicant's Quality Assurance Organization audits the preoperational and startup testing programs for satisfactory completion of test program requirements.

References for Section 9.0

1. FSAR, Appendix D and Amendment 20, Part 5.

2. FSAR, Appendix D and Section 13.1 and 13.4.

Table 9-1

PROJECT FUNCTIONAL RESPONSIBILITY SUMMARY

PILGRIM NUCLEAR POWER STATION

PROJECT PART	Quality Control	Quality Assurance	Engineering Design	Procurement	Mfg. Inspection	Mfg. Expediting	QC Construction	QA Construction	Systems Checkout and Acceptance Testing
I Nuclear Power Station*	B	Edison	B	B	B	B	B	B	Edison(1)
II Nuclear Steam Supply System	G.E.	Edison	G.E.	G.E.	G.E.,B	G.E.,B	B(2)	B(2)	Edison(2)
III Nuclear Fuel	G.E.	Edison	G.E.	G.E.	G.E. Edison	G.E.	-	-	Edison(2)

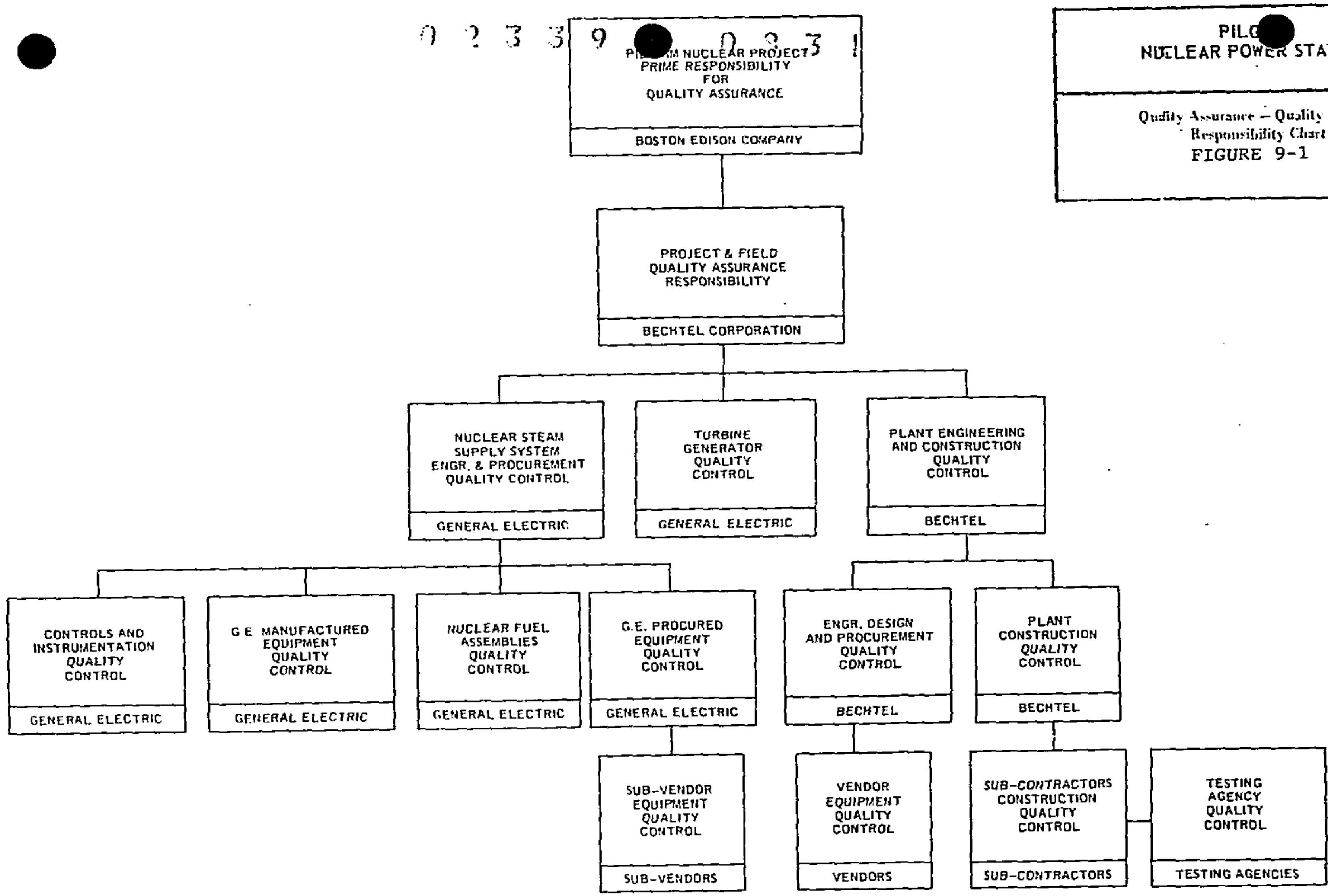
Notes:

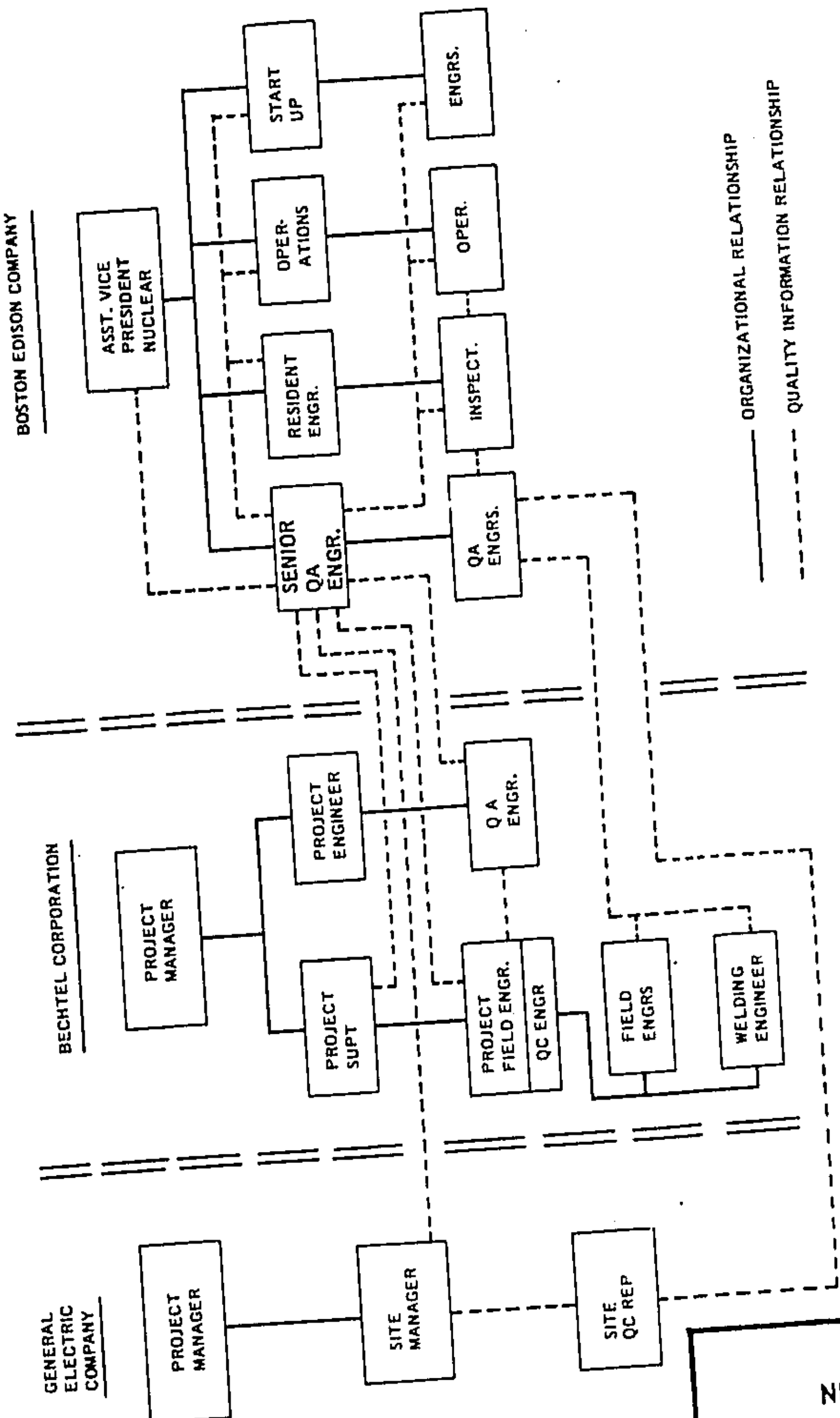
Edison = Boston Edison Company
B = Bechtel Corporation
G.E. = General Electric Company
* Except Parts II and III
(1) Technical direction provided by Bechtel Corp.
(2) Technical direction provided by G.E. Corp.

0 2 3 3 9

PIL[illegible] NUCLEAR POWER STATION

Quality Assurance – Quality Control
Responsibility Chart
FIGURE 9-1





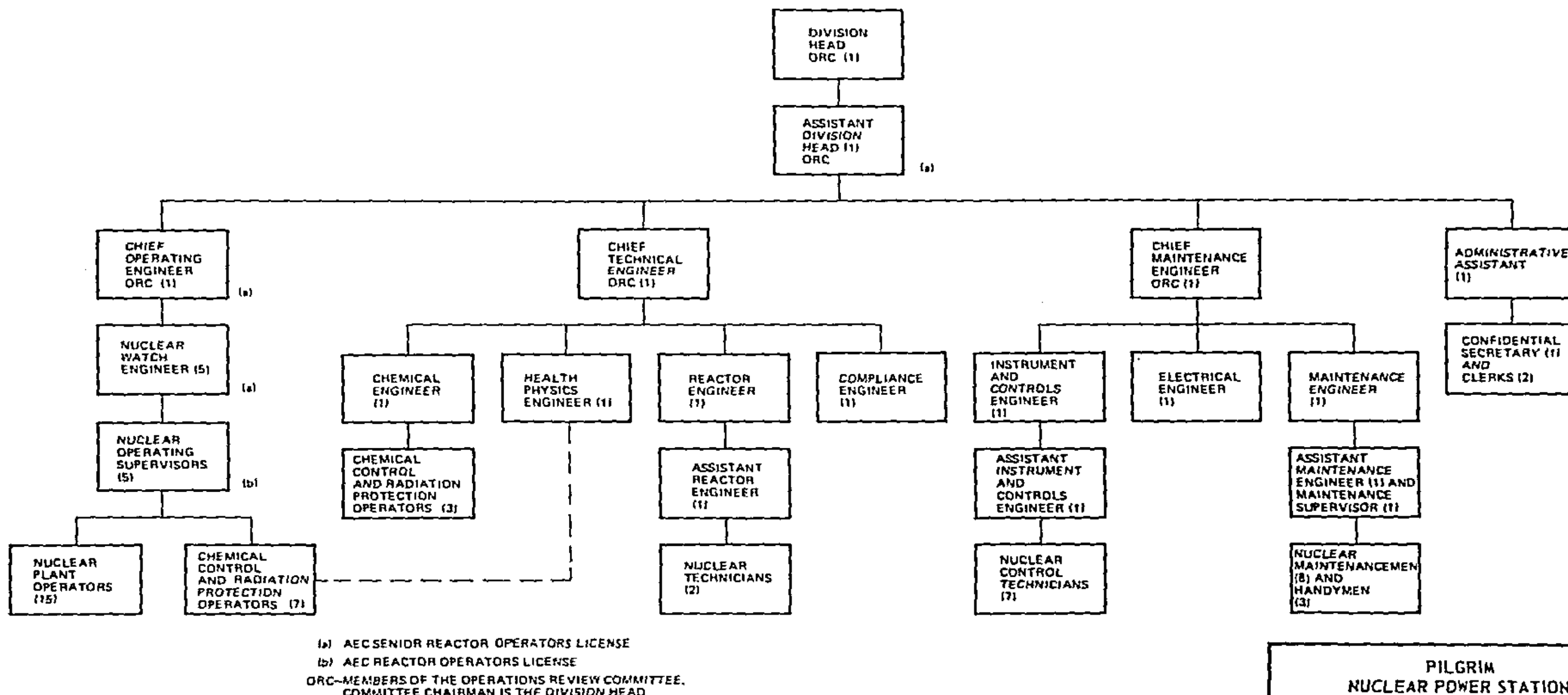
0 2 3 3 9 0 3 3 2

PILGRIM
NUCLEAR POWER STATION

Site Construction
Quality Assurance Organization Chart

FIGURE 9-2

0 2 3 3 9 0 8 3 3



PILGRIM
NUCLEAR POWER STATION

Pilgrim Nuclear Power Station Organization Chart
FIGURE 9-3

10.0 COMMENTS ON ACRS REPORT

In its letter of April 7, 1971 to the Chairman of the Atomic Energy Commission on Pilgrim Nuclear Power Station, the Advisory Committee on Reactor Safeguards identified certain areas requiring further consideration and resolution and made several recommendations with respect to the requested operating license. These recommendations and the actions taken by Boston Edison Company are summarized below:

(1) Liquid Radwaste System

"The applicant has not provided equipment for concentrating and separating radioactivity from liquid wastes, and he states that the radioactivity concentration in the condenser circulating water discharge will not exceed that permitted by 10 CFR 20. During the first reactor shutdown for refueling, the applicant will install an evaporator designed to permit the holdup of liquid wastes and thereby reduce the gross radioactivity discharged. The Committee believes that the design and operation of this evaporator system should be such as to reduce to levels as low as practicable the amount of long-lived radioisotopes discharged. The Regulatory Staff should review and approve the design and operating mode of this equipment. The Committee also believes that prior to the installation of this equipment, effort should be made to reduce the radioactivity released."

The liquid radwaste concentrator is expected to be operable during the summer of 1972. Boston Edison Company recognizes its obligation prior to and following the installation of the concentrator, to keep levels of radioactive materials in liquid effluents as low as practicable. Boston Edison Company intends to operate Pilgrim Nuclear Power Station in a manner consistent with that obligation compatible with its legal mandate to furnish a dependable source of power. In accordance with this obligation Boston Edison Company will operate the station such that, when discharges are controlled on a radionuclide basis, the maximum concentration (above background) in the condenser cooling water discharge canal after mixing with the service water and circulation water will be limited to values which do not exceed 0.25 times the MPC* values stated in Appendix B, Table II, Column 2 of 10 CFR Part 20 and note 1 thereto. (1)

*MPC - Maximum Permissible Concentration

(2) Gaseous Radwaste System

"The applicant proposes that the gaseous and particulate radioactivity discharged through the stack will not exceed 10 CFR 20 limits. The Committee believes the applicant should set a much lower operating limit and should make such equipment changes as may be necessary to accomplish this."

Boston Edison Company, in its Technical Specifications for PNPS, has set a limit on the annual average release rate of radioactivity to be discharged through the station mainstack which, based upon the applicant's analysis presented in Appendix E of the FSAR, will maintain the exposure levels to approximately one quarter of those allowed in 10 CFR Part 20, paragraph 105(a). Concurrently the applicant has initiated a program of selecting, designing and installing additional equipment to reduce radioactivity releases from the station mainstack to comply with the requirements of 10 CFR Part 50 Appendix I, and plans to initiate installation of that equipment when approved by the USAEC and to complete installation as soon as practicable.*

(3) Primary Containment Integrity

"The applicant proposes to protect the containment against breaching that may be caused by whipping of

* Refer to footnotes on p. 8-38

unrestrained piping in the event of a pipe rupture, and also to guard against missiles that could be generated from the biological shield by rupture of pipes, including safe-ends, within the shield."

Boston Edison Company is installing at selected locations inside the Pilgrim primary containment system on the drywell shell an energy absorbing/load transmitting system of steel plates and I-beams which will significantly reduce the possibility of the mechanical effects associated with a rupture of a high pressure pipe resulting in breaching the primary containment system. The protective system being installed distributes the mechanical energies over a wider area allowing the drywell to deform through the two inch air gap between the drywell and the outer biological shield without rupture.

The inner biological shield's capability to withstand internal pressures resulting from the failure of vessel nozzle safe-ends within the annular space between the reactor vessel and the shield has been evaluated, and the capability is greater than the maximum internal pressure which could be generated. The restraints for the shield plugs surrounding pipes penetrating the biological shield are designed with the same capability as the inner biological shield itself. Thus the design effectively precludes the possibility of missile generation as a result of pipe or safe-end ruptures within the shield.[2]

(4) <u>Fuel Cask Drop</u>

"The applicant proposes to assure that accidental dropping of the spent-fuel cask into the fuel storage pool will not cause leakage in excess of the make-up capacity, and will make such modifications as may be necessary."

Boston Edison Company has conducted studies to determine the effects of a spent-fuel cask dropped into the fuel storage pool. In order to assure that any resultant leakage from the pool will be within the pool makeup capability, an energy absorbing/load distributing pad will be installed in the cask loading area which will be capable of absorbing, distributing, and dispatching the kinetic energy associated with a loaded cask drop from the maximum height.[3]

(5) <u>Confirmatory Vibration Testing</u>

"The applicant said he would make tests adequate to confirm the predicted vibrational characteristics of the vessel internals."

A program of confirmatory vibration measurements will be implemented for the Pilgrim reactor. Both cold and hot tests will be conducted over a range of power and flow conditions to verify the applicability of more extensive data obtained from previous tests conducted on other similar, operating boiling water reactors. [3]

(6) Failure to Scram

"The Committee believes the applicant should make timely proposals for resolution of the problem of possible failure to scram on anticipated transients."

A common mode failure study was completed and has been documented in Topical Report NEDO-10189, "An analysis of Functional Common Mode Failures in General Electric BWR Protection and Control Instrumentation." This Report was submitted in October 1970 to the AEC and includes a complete analysis of common mode failures in the initiation of scram signals.

Studies are continuing to evaluate the consequences of an incredible, undefined failure of the scram protection system. A report on failure to scram has recently been documented as a General Electric Topical Report, NEDO-10349, "Analysis of Anticipated Transients Without Scram," and submitted to the AEC for review. [4]

(7) ECCS Performance Evaluation

"The applicant should reevaluate, before routine operation at full power, the performance of the emergency core cooling system, using recent heat transfer data and calculational methods."

The core standby cooling systems for Pilgrim Nuclear Power Station have been recently reevaluated in accordance with the USAEC's INTERIM ACCEPTANCE CRITERIA FOR EMERGENCY CORE COOLING SYSTEMS FOR LIGHT-WATER POWER REACTORS, adopted on June 19, 1971. The results of this analysis show that the PNPS core standby cooling systems, when evaluated in strict accordance with Appendix A, Part 2 of the interim policy statement, do meet the interim acceptance criteria. (These criteria are listed in section 8.5.1 of this summary.) [5]

(8) Station Instrumentation and Electrical Systems

"Several items regarding plant instrument systems and electrical systems are under review by the Regulatory Staff. All these matters should be resolved to the satisfaction of the Regulatory Staff; the Committee wishes to be kept informed."

Additional discussions have been held with the Regulatory Staff, and all items regarding station instrument systems and electrical systems have been resolved. [6]

(9) Inservice Inspection

"The Committee believes the applicant should continue to explore means of improving access to vessel welds for inservice inspection."

The design of the removable vessel insulation and shield plugs have been modified to facilitate access to selected vessel welds for inservice inspection.

(10) Reactor Vessel Temperature and Pressure Limitations

"The Committee also believes that the reactor vessel pressure should be limited in accordance with current AEC bases when the vessel temperature is below 180°F."

The proposed Technical Specifications have been revised to comply with current AEC bases for vessel pressurization when vessel temperature is below 180°F. [7]

(11) Offsite Electrical Power Systems

"The site is served by two 345 kV electrical transmission lines on the same towers and a separate 23 kV line. Over a short distance, the lines are adjacent and it is physically possible for the fall of a tower to break the 23 kV line. The Committee believes that the applicant should explore the feasibility of using an alternative 23 kV supply or of making local changes to reduce the possibility of losing the 345 and 23 kV lines simultaneously."

The 23 kV line supplying the Pilgrim Station will be placed underground at selected locations to prevent loss of the 23 kV supply as a result of 345 kV tower failures.

References for Section 10.0

1. FSAR, Amendment 29
2. FSAR, Amendment 29
3. FSAR, Amendment 29
4. FSAR, Amendment 29
5. Boston Edison Company, letter to the USAEC,
6. July 22, 1971.
7. FSAR, Amendment 29
8. FSAR, Amendment 29

11.0 OTHER GOVERNMENTAL AGENCIES

In addition to applying to the Atomic Energy Commission for the requisite licenses under the Atomic Energy Act of 1954, as amended, Boston Edison Company has applied for other necessary federal, state and local approvals. Boston Edison Company has applied for and received permits and licenses as discussed in the following paragraphs.

The Town of Plymouth through its Board of Approvals has issued to the Company a special permit under Town zoning ordinances to authorize the building of a nuclear powered generating station at the site where the Pilgrim Station is located.

The Massachusetts Department of Natural Resources, Division of Water Pollution Control, has issued an interim industrial discharge permit dated January 8, 1969 and the certification required under the Water Quality Improvement Act of 1970. The Department of Natural Resources through its Division of Marine Fisheries has also worked with the Applicant regarding permit matters within the jurisdiction of the Division.

The Applicant has received from the Massachusetts Department of Public Works a license relative to various station undertakings including construction and maintenance of a breakwater and dredging.

The Company has received a permit from the U.S. Army Corps of Engineers similar to that issued by the Massachusetts Department of Public Works which allows the Company to build and maintain the station breakwaters and to construct and maintain the intake and discharge channels and to dredge. Application has also been made to the Corps for a discharge permit under the New Federal Refuse Act Permit Program.

Boston Edison Company has applied to the Massachusetts Department of Public Health for such approvals as may be required to permit operation of the station under the "Regulations for the Control of Air Pollution in the Southeastern Massachusetts Air Pollution Control District."

Applicant has sought and will continue to seek all other required federal, state and local approvals necessary to the operation of the station. Furthermore, the applicant will continue its program of information and liaison with federal, state and local officials (see e.g., Section 6.1).

12.0 TECHNICAL QUALIFICATIONS

12.1 Boston Edison Company

Boston Edison Company has been engaged over the past 85 years as a public utility in the business of generation, transmission and retail and wholesale distribution of electricity and has accumulated in-depth experience in the construction and operation of fossil-fueled generating stations and the related transmission and distribution facilities.

Boston Edison operates four major fossil-fueled generating stations; Mystic Station with 6 generating units and 1 unit under construction, Edgar Station with 3 generating units, L Street Station with 5 generating units, and New Boston Station with 2 generating units. In addition Edison operates several stations that supply steam for commercial sale and also operates several generating installations utilizing combustion turbines.

Boston Edison is part owner of the Yankee Nuclear plant in Rowe, Massachusetts and of the Connecticut Yankee nuclear plant in Haddam Neck, Connecticut. Boston Edison is represented on the Board of Directors of these two companies and has participated technically by working assignments of Edison personnel during the design and startup phases at these plants.

Boston Edison personnel from the Engineering and Construction Department and from the Operations Department have participated in the Pilgrim Station project throughout the engineering, construction and pre-operational test phases. Operating personnel permanently assigned to the Pilgrim Station Organization have participated in special training programs and in the pre-operational test programs in preparation for startup of the station. In addition to the training and experience obtained by Edison personnel during the Pilgrim Station project, many of these personnel have prior nuclear experience totalling about 70 man-years obtained at other nuclear facilities which include: Yankee Rowe, Connecticut Yankee, Vallecitos, Dresden 1, Humboldt Bay, Oyster Creek, KRB (West Germany), Nuclenor (Spain), Millstone 1, Elk River, Hallam, Piqua, Hanford, Savannah River, SM-1, Westinghouse Reactor Evaluation Center, and the Walter Reed Medical Reactor.

12.2 Bechtel Corporation

The Boston Edison Company retained Bechtel Corporation as the Architect/Engineer and Constructor for Pilgrim Nuclear Power Station. Working under the overall direction of Boston Edison Company and in close coordination with the General Electric Company, Bechtel has designed or furnished (or both) all portions of the station except the turbine generator, nuclear steam supply system, and nuclear fuel.

Bechtel has been continuously engaged in construction or engineering activities since 1898. For more than 20 years, Bechtel has been active in the fields of petroleum, power generation and distribution, harbor development, mining and metallurgy, and chemical and industrial processing.

Since the close of World War II, Bechtel has been responsible for the design of over 186 power generating units, representing more than 73 million kilowatts of thermal generating capacity, which includes units of the largest and most modern types. Of this number, more than 32 million kilowatts are produced by nuclear-fueled units.

For over 20 years, Bechtel has been engaged in the study, design and construction of nuclear installations. Its experience includes design or construction, or both, of such facilities as accelerators, nuclear research laboratories, hot cells, experimental reactors and nuclear fuel processing plants, as well as nuclear power plants.

12.3 General Electric Company

The supplier of the nuclear steam supply system and the turbine-generator is the General Electric Company. The General Electric Company has been engaged since 1955 in the design, construction, and operation of boiling water reactors. Among the operating reactors with which the General Electric Company has been associated are the Vallecitos, Dresden 1, 2, and 3, Humboldt Bay, Big Rock Point, Oyster Creek, Nine Mile Point, Millstone, Monticello and a number of reactors in foreign countries. They are also designing and have under various stages of construction many other BWR reactors, similar to the Pilgrim plant. Thus, General Electric has a substantial knowledge, capability, and experience with this type of reactor.

13.0 EMERGENCY PLAN

The potential for incidents resulting in the release of significant radioactivity is extremely low. Several independent barriers exist between the source of activity and station personnel or the general public. The consequences of any postulated accident and the extent of any resultant radiation emergency are dependent upon the degree of violation of these barriers. Information on the status of these barriers is continuously available in the control room. Annunciation and automatic protective action is initiated when necessary to maintain barrier integrity. Direct information is also available in the control room as to the effectiveness of these protective actions.

Even though the chances are extremely low that any accidental release of significant quantities of radioactivity will ever occur, nevertheless, a plan of action has been formulated to deal with any such occurrence. This plan will function to confine and minimize the consequences of any incident involving the uncontrolled or unplanned release of radioactive materials, in order to protect the health and safety of the general public and the applicant's station personnel.

Details of the emergency plan are given in Amendment 22 of the FSAR. Procedures for abnormal operating conditions, emergency operating conditions and radiation emergency procedures are available. Station supervisory personnel are trained so that authority, responsibilities and functions are properly defined and implemented in emergency or potential emergency situations.

Prior to startup of the station, every station employee will be trained and required to understand the detailed emergency plan and his individual responsibilities as required by the Emergency Procedures. All new employees at the station will undergo the same training.

The applicant has made provisions so that local, state and federal authorities can appropriately respond in the case of an emergency. The agencies involved include the Massachusetts State Police, the U.S. Coast Guard, the State Department of Public Health, the Civil Defense Agency, the Plymouth Police, the Plymouth Fire Department, and the New York Operations Office of the Atomic Energy Commission. Reliable communications are provided for and training has been provided where necessary.

The applicant has provided approximately 14 hours training each, for the local police and fire departments on radiological safety and on the applicant's emergency plans and procedures.

An Emergency Medical Plan has been established to insure adequate medical expertise and facilities in the event of injuries concomitant with contamination. Physicians trained in the specialized techniques required in the treatment of radiation patients are on call at the local medical facilities.

Drills on the emergency procedures will be conducted annually to assure that employees of the applicant are familiar with their specific duties, and to provide other persons and/or agencies whose assistance may be needed in the event of an emergency, the opportunity to participate in the drills. The continued validity and appropriateness of agreements with outside agencies will be reviewed in connection with the drills. The status of emergency equipment will be checked at least annually to insure continued availability.

14.0 COMMON DEFENSE AND SECURITY

Boston Edison Company is a corporation organized under the laws of the Commonwealth of Massachusetts. It is engaged in the generation, transmission, and retail and wholesale distribution of electricity. All of the Directors and principal Officers of the applicant are citizens of the United States; and the applicant is not owned, controlled, or dominated by any alien, foreign corporation or foreign government.

The applicant is acting solely on its own behalf and is not acting as an agent for anyone else.

The application contains no restricted or other defense information, and the applicant has agreed that it will not permit any individual to have access to any Restricted Data until an investigation and report on such individual has been made by the Civil Service Commission and the Atomic Energy Commission shall have determined that permitting access to such Restricted Data by such individual will not endanger the common defense and security.

The applicant will, as a licensee, be subject to regulations of the Atomic Energy Commission relating to the possession, use, transfer and accountability for special nuclear material in its possession; to the possession, use and transfer of source and byproduct material; and to the possession, use and transfer of the utilization facility designed as Pilgrim Nuclear Power Station.

For the reasons stated above, the issuance of an operating license for Pilgrim Nuclear Power Station will not be inimical to the common defense and security.

15.0 FINANCIAL QUALIFICATIONS

Boston Edison Company is the major retail supplier of electricity in the greater Boston area, and in addition supplies electricity at wholesale for resale to other utilities (see Sec. 2.1). Net income derived from all the Company's operations for the period 1966-1970 is as follows:

Net Income (000's)

1970	1969	1968	1967	1966
$37,455	$33,886	$31,664	$29,361	$26,818

At current net operating income levels, combined with expected fuel savings due to its Pilgrim investment, Boston Edison Company believes it will have sufficient revenues to meet the annual costs of operating Pilgrim.

16.0 FINANCIAL PROTECTION

Boston Edison Company has taken the following action to comply with the requirements of the Commission's Rules and Regulations relating to financial protection in 10 CFR Part 140:

a) Nuclear Energy Liability Insurance Association (NELIA) has issued to Boston Edison Policy No. NF-188, providing nuclear fuel storage liability in the amount of $1,000,000.

b) Indemnity Agreement No. B-48 dated 11/20/70, effective 11/20/70, has been issued by the Commission to Boston Edison in the amount of $500 million.

c) In addition, Boston Edison has obtained commitments from the private sector of the insurance industry to provide liability insurance in the aggregate amount of $82 million, which is the amount required by 10 CFR 140. NELIA is committed to provide $63,550,000 and Mutual Atomic Energy Liability Underwriters is committed to provide $18,450,000. These policies will be issued before issuance of the operating license.

17.0 CONCLUSION

On the basis of the application as summarized herein, the applicant respectfully submits that:

1. Construction of Pilgrim Nuclear Power Station has been substantially completed in conformity with the construction permit and with the application, as amended, the provisions of the Atomic Energy Act of 1954, as amended (the Act), and the rules and regulations of the Commission.

2. Pilgrim Nuclear Power Station will operate in conformity with the application, as amended, the provisions of the Act, and the rules and regulations of the Commission.

3. There is reasonable assurance (i) that the activities authorized by the operating license can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the regulations of the Commission.

4. Boston Edison Company is technically and financially qualified to engage in the activities authorized by the operating license in accordance with the regulations of the Commission.

5. The applicable provisions of 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements" of the Commission's Regulations have been satisfied.

6. The issuance of the license will not be inimical to the common defense or security or to the health or safety of the public.

FINAL

1.9.9
3/69

AGREEMENT

Agreement entered into this 17 day of March 1969, between and among the Massachusetts Division of Marine Fisheries of the Department of Natural Resources (Hereinafter referred to as the Commonwealth), and Boston Edison Company (Hereinafter referred to as the Company).

WITNESSETH:

Whereas, the Company is constructing a power plant in Plymouth, Massachusetts adjacent to the Rocky Neck area; and

Whereas, it is the consensus of the parties that a biological investigation of marine life both before and after the plant is in operation in this area be undertaken; and

Whereas, it is the consensus that the Commonwealth acting under authority of G.L. Chapter 130, Section 17 (3) and (9) should conduct or have conducted such biological investigation; and

Whereas, the Commonwealth has developed and proposes to implement a Work Program, attached hereto as Exhibit A and made a part hereof; and

Whereas, the Company is willing to provide to the Commonwealth under the provisions of G. L. Chapter 130, Section 17 (9) monies hereinafter set forth for the implementation of the Work Program for the benefit of the economy and general welfare of the area as a whole:

Now Therefore It Is Agreed:

1. Upon payment of the sums hereinafter set forth, the Commonwealth agrees to implement the Work Program substantially in accordance with the time schedule, methods, and techniques outlined herein.

2. The Company will provide the Commonwealth with a sum not to exceed $60,000 during the First Year of the biological investigation, payment to be made quarterly in advance. The Company will provide the Commonwealth with a sum not to exceed $73,000 during the Second Year of the biological investigation, $73,000 for the Third Year and $73,000 for the Fourth Year in equal advance quarterly payments. All sums provided by the Company shall be deposited in the State Treasury as a trust fund to be expended only for the purposes set forth herein.

3. The Company shall be under no obligation to contribute any funds in excess of those set forth in paragraph 2 above, except that if the plant has not been in operation for 50% or more of the time during the January-March quarter of at least one of the four contract years, then the contract shall be extended to cover the next subsequent January-March quarter after the expiration of the four-year period; and similarly, if the plant has not been in operation for 50% or more of the time in the April-June, or the July-September, or the October-December quarter, of at least one of the four contract years, then the contract shall be extended to cover the comparable quarter of the next subsequent year; the Company agrees to provide the Commonwealth with the sum of $15,500 in advance payments for each quarter year of the extension. If the actual cost of the items set forth in Exhibit A are less than the estimated cost, the Company's obligation hereunder shall be appropriately reduced and the advance quarterly payments adjusted to reflect such cost savings.

4. The Company shall cooperate with personnel of the Commonwealth in connection with such personnel's work hereunder.

5. The Commonwealth shall furnish to the Company:

(a) From time to time, all basic data gathered in the implementation of the Work Program. The data and all such reports shall also be available to the public;

(b) On July 1, 1969 and at three-month intervals thereafter, periodic reports on the progress of the Work Program, including a summary of the data gathered and a preliminary evaluation of the data;

(c) Within six months after the Preliminary Work Program shall have been implemented a draft copy of the regular Work Program, to be finalized after conference(s) with the Company;

(d) Draft reports summarizing the Work Program, the data gathered, and the evaluation of such data as required to support the Company in obtaining permits and licenses for the Pilgrim Station;

(e) As soon as practicable after the ascertainment thereof, any facts obtained pursuant hereto which would suggest a modification of design or construction of the intake and discharge;

(f) Within six months after completion of the Work Program a draft copy of a topical report describing the Work Program, the data gathered, and the final evaluation of such data, to be finalized after conference(s) with the Company and prior to the public issuance of any final report. The Company shall be entitled to use copies of said reports and data in the furtherance of its operation of the Pilgrim plant.

(g) Except for the first quarter, one month prior to the date that advance quarterly payments are payable to the Commonwealth by the Company, a statement of expenditures incurred to-date with an estimate of the expenditures anticipated through the next succeeding quarter. The advance quarterly payment shall be adjusted to reflect the actual and projected quarterly expenditure rate.

6. The Company shall have the right to observe activities being undertaken by the Commonwealth hereunder.

7. Neither the Company nor any of its officers, agents, or employees shall be liable for any loss of or damage to property and/or injuries, including death, to any person or persons which may arise directly or indirectly from the implementation by the Commonwealth of the Work Program.

8. In all matters relating to the administration of this agreement, the representative of the Commonwealth shall be the Director, Division of Marine Fisheries or his designated representative; and the representative of the Company shall be whoever the Company designates or his representative.

9. This agreement shall become effective as of March 14, 1969.

Date____________________

Boston Edison Company

by________________

Commonwealth of Massachusetts

by________________
Director
Division of Marine Fisheries

APPROVED:____________________
Commissioner, Department
of Natural Resources

Exhibit A

Preliminary Work Program of
Fishery Investigations

Introduction

It is agreed by the Boston Edision Company (the Company) and the Commonwealth of Massachusetts (the Commonwealth) that:

1. The construction and operation of the Pilgrim Nuclear Power Station (the plant) may change the ecological environment of the marine life in the waters of Cape Cod Bay in the proximity of the Plant (the Area)

2. The operation of the Plant may have an adverse effect on some important commercial or sports species of finfish, crustacea or shellfish in the Area and may have a beneficial effect on others and,

3. Every reasonable precaution must be taken in the operation of the Plant to prevent a significant overall reduction in the commercial or sport fishery resources in the Area.

The Company and the Commonwealth, therefore, agree that biological fishery studies will be undertaken or arranged for by the Commonwealth to determine the changes in the distribution of important fish species in the Area that may be brought about by the construction and operation of the Plant. These studies will include a determination of the life stages and distribution of important fish species, their ability to avoid, survive or benefit from the heat discharge waters, the currents generated by the operation of the Plant and the fish screens at the intake structures.

One of the objectives of the above studies is to develop bases for recommendations relative to the design and operation of the Plant that would prevent a significant overall reduction in the commercial or sport fishery resources in the Area.

It has been agreed by the representatives of the Boston Edison Company and the Division of Marine Fisheries that an Administrative and Technical Committee will be formed to co-ordinate the fishery investigations with the progress of plant construction, to review the results of the studies, and to provide overall supervision of the Work Program. This Committee will be formed at an early date and in addition to the Commonwealth and the Company will include, if possible, representatives of the Massachusetts Division of Water Pollution Control, the U. S. Bureau of Commercial Fisheries, the U. S. Bureau of Sport Fisheries and Wildlife and the Federal Water Pollution Control Agency. Progress reports as required under 5 (b) in the Agreement will be submitted to the Administrative and Technical Committee. The Work Program required under 5 (c) in the Agreement will be submitted to the Administrative and Technical Committee for review and comment.

Preliminary Work Program

A. Administration

One full-time leader will be in charge of the field investigations. Laboratory and specialized investigations will be subcontracted by the Commonwealth with the approval of the Company to a qualified individual, institution or firm which will provide necessary personnel and facilities to conduct such investigations.

An administrative charge of 10 percent of the total amount of the subcontract(s) will be charged by the Commonwealth to cover technical coordination and administrative overhead. No other administrative charges will be made.

	First Year	Second Year	Third Year	Fourth Year
Administrative Costs:	$3,000	$3,000	$3,000	$3,000

B. Field Investigations:

Objectives:

1. To determine the seasonal distribution, concentration and utilization of marine life in the Plymouth area and, more specifically, in the proximity of the proposed power plant.
2. To determine the water temperature pattern at various tidal stages before the plant is in operation and to measure the thermal pattern which results after the warmed water discharge commences in order to evaluate possible effects on the marine biota.
3. To study the intake and discharge structures and their operation to determine their effect on the various forms of marine life in the area.

Explanation:

It is known that the seasonal and spatial distribution of marine fishes in the Plymouth area vary considerably. Fish species have significant variations of distribution in time and space depending upon their stage of growth. The Plant site is on an exposed, rocky section of coastline quite different from areas previously studied in coastal Massachusetts or New England. For this reason basic fish inventories will be included in the field studies.

Fishes are highly sensitive to temperature changes, particularly those which occur suddenly. In order to properly evaluate the effect of the warm water effluent on the fishery, temperature patterns in the Rocky Neck area at various tidal stages will be determined before and after the plant goes into operation.

Procedures:

Qualitative and quantitative collections of marine life throughout each year of the program at selected stations in the Plymouth area will be made. This activity will be designed to sample both the vertical and horizontal distribution of marine organisms at various distances from the plant site including selected control locations which are sufficiently remote from the plant site to be unaffected by plant operation.

A survey of existing fisheries will be made to determine what species are involved, the magnitude of the catch, seasonality of the fishery and amount of effort expended. A comparison of these pre-operational data in conjunction with similar statistics from control locations collected while the plant is in operation will provide a reference from which any significant changes in the fishery, due to plant operation or other causes, can be detected and evaluated.

The thermal patterns for the various tidal stages and seasons will be determined through the use of thermographs and electrical resistance thermometers both before and after the plant is put into operation. Where available, temperature records from other sources will be utilized as much as possible. Records of fish distribution and relative abundance will be correlated with these data. When operating thermal contours have been established for the area of discharge, this information will be applied to the laboratory investigations concerning the effects of increased water temperatures on various species.

Factors such as intake velocity, type of screening employed, effect of turbulence and other physical features will be studied with a view towards modification, if warranted.

<u>Duration of Study:</u>

March 15, 1969 to February 28, 1973

Cost: $147,000

Principal Features	First* Year	Second Year	Third Year	Fourth Year
Personnel Salaries: Project leader, marine biologist, marine technician temporary help secretarial service	$15,000	$32,000	$32,000	$32,000

Principal Features (con't)	First* Year	Second Year	Third Year	Fourth Year
Major Equipment	6,000	2,000	2,000	2,000
Travel Expenses	1,000	1,000	1,000	1,000
Equipment Maintenance & Miscellaneous Supplies	2,000	2,000	2,000	2,000
Vessel Time (30 days at $100/day)	3,000	3,000	3,000	3,000
Totals	$27,000	$40,000	$40,000	$40,000

*During the first year of the project, personnel will work on a half-time basis.

C. Laboratory and Specialized Investigations:

Laboratory investigations and specialized studies will be conducted under subcontract to the Commonwealth.

Objectives:

To determine the effect of both short term and long range temperature changes on important species of finfish, crustacea and algae in the Plymouth area.

Explanation:

The laboratory studies will be designed to provide detailed information not capable of being derived from the field investigations. This will include laboratory analysis of exposure panels recovered from the waters off the plant site to determine growth of various fouling organisms and seasonal variations in these organisms both before and after plant operation.

Long term temperature changes on selected organisms will be carried out in the laboratory to determine whether exposure to these above normal temperatures may seriously interfere with or benefit the life history of any given species. Special emphasis on the effects of temperature on Irish moss and lobsters will be included in these studies. The results of the laboratory analysis will be correlated with data collected in the field.

Procedures:

Exposure panels will be collected on a regular monthly basis by the field investigators and turned over to the laboratory for detailed analysis. These panels will be taken from a minimu of three different sites and will include both short term and long term exposure panels. Short term panels will be utilized to determine which attaching organisms attach during each month and the long term panels will be used to gain growth information over extended periods.

Using specialized laboratory equipment, studies on the long term effects of temperature on various species will be conducted in the laboratory. Such studies will include histological analysis of various tissues, especially gonadal tissues, to determine possible effects on these organs by the changed temperature regime.

A special detailed study of the life history of the Irish moss will be conducted since very little is known of the basic processes of this valuable marine product. Studies on the effect of temperature on growth rates, reproduction, etc. will be carried out. Special attention will be given to those factors which may be significantly altered by the construction and operation of the plant.

Duration of Study:

March 1, 1969 to February 28, 1973

	First Year	Second Year	Third Year	Fourth Year
Cost:	$30,000*	$30,000*	$30,000*	$30,000*
Total Cost:	$120,000			

*Includes $10,000 for each year for special study of Irish moss.

BROCKTON DAILY ENTERPRISE
MAR. 11, 1969

To Study Effect Of Nuclear Plant On Marine Life

STATE HOUSE, BOSTON. — Gov. Sargent today accepted the contribution from the Boston Edison Co. to finance a study of the effect of the Plymouth Power Plant on Marine Resources.

Sargent granted approval to Commissioner of Natural Resources Arthur Brownell to accept $277,000 from Boston Edison to finance a four-year study of the bioligical effects of the new Plymouth Nuclear Power Station at Rocky Neck, Plymouth, on the Marine Resources of the area.

The Governor said these studies will result in recommendations to protect Marine Resources of the Commonwealth from any harmful effect that might result from the operation of this plant.

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OFFICE OF THE DIRECTOR
DIVISION OF WATER POLLUTION CONTROL

The Commonwealth of Massachusetts
Water Resources Commission
State Office Building, Government Center
100 Cambridge Street, Boston 02202

January 8, 1969

Boston Edison Company
800 Boylston Street
Boston, Massachusetts 02199

Gentlemen:

Upon receipt of your application on October 17, 1968 for a Permit Pursuant to Section 43, Chapter 21 of the Massachusetts General Laws for the discharge of industrial wastes from Pilgrim Station into Cape Cod Bay, this Division has reviewed your report entitled "Pilgrim Station No. 600, Boston Edison Company, Salt Water Use and Waterfront Development for Pilgrim Nuclear Power Station."

This Division hereby issues to the Boston Edison Company an interim permit, having an expiration date three years following the Power Station's initiation of operation date. However, the interim permit is subject to the following provisos:

1. That radiological and ecological studies of the receiving waters as previously discussed with members of the Department of Public Health and the Division of Marine Fisheries, indicate to the satisfaction of these agencies that the discharge of effluents from the station will not be harmful to human or marine life. The permittee shall advise this Division as to who will perform the studies and the starting dates. Further, the permittee shall make any modifications to equipment and/or operations that may be necessary to comply with recommendations resulting from the aforementioned studies.

2. That a method be developed satisfactory to this Division for the operation and control of the use of chlorine in the circulation cooling water system.

3. That the permittee maintain and make available to members of this Division operating records pertaining to the treatment of liquid wastes including levels of radioactivity and to the discharge of effluents to Cape Cod Bay, as are considered necessary by the Division.

Very truly yours,

Thomas C. McMahon
Director

TCM/RC/mpf

March 31, 1969

Mr. H. L. Price
Director of Regulations
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Price:

We are pleased to comply with your request for a summary of our program concerning the thermal discharge from the Pilgrim Nuclear Power Station. As you know, the Pilgrim Station is rated at 655,000 kilowatts (net) and is scheduled to be operational in October, 1971. It is located on the shores of Cape Cod Bay near Rocky Point some five miles east and south of Plymouth.

STATEMENT OF THE PROBLEM

The Pilgrim Station will use a portion of the off-shore sea water for condenser cooling. The design flow through the condenser is 311,000 gallons per minute. The full-power temperature rise across the condenser is 28 degrees Fahrenheit and the full-power thermal discharge is 4.3×10^9 BTU's per hour.

It has been determined by the Commonwealth of Massachusetts that the most sensitive use of the off-shore waters is commercial and sport fishing for certain species of finfish, crustacea (lobsters) and shellfish. There is also a commercial harvest of Irish moss in the area.

SUMMARY OF THE PROGRAM

A six-year program of studies on the thermal discharge from the Pilgrim Station was begun in early 1967 and is scheduled to be completed in January 1973.

The objective of the program is to assure that every reasonable precaution is taken in the operation of the Pilgrim Station to prevent a significant overall reduction in the commercial or sport fishery resources in the area.

The program can be divided into two, overlapping phases. The Phase-1 studies were used to establish the design of the breakwaters, intake structure and discharge canal. These studies were guided by consultants that are recognized authorities in the fields of coastal engineering, physical oceanography, cooling water dispersion and marine ecology as well as by comments and suggestions from the Division of Marine Fisheries of the Commonwealth of Massachusetts and the Fish and Wildlife Service of the Department of the Interior. Phase-1 included model studies at the Alden Research Laboratories and the Massachusetts Institute of

Technology.

The Phase-2 work consists of a four-year, before-and-after operation, field and laboratory study. This work is being conducted by the Massachusetts Division of Marine Fisheries under a $279,000 grant to the Commonwealth of Massachusetts by the Boston Edison Company. They are expected to confirm the predictions made at the conclusion of the Phase-1 studies. These studies will document, through field surveys, any changes in the distribution of important fish species that may be brought about by the construction and operation of the plant.

An administrative and Technical Committee will coordinate the work, review the results and provide overall supervision of the program. The committee will include representatives of the Commonwealth and Boston Edison and, to the extent possible, representatives of the Massachusetts Division of Water Pollution Control, the U.S. Bureau of Commercial Fisheries, the U.S. Bureau of Sport Fisheries and Wildlife and the Federal Water Pollution Control Agency.

DOCUMENTATION

Documentation of the planning, conduct and results of the several tasks and sub-tasks that make up the total six-year program occur in several interim reports and in correspondence among the parties involved. It also includes testimony taken at the Public Hearing that was held by the AEC before the issuance of the construction permit.

We believe that the most complete and factual information is contained in the following documents:

1. Salt Water Use and Waterfront Development for the Pilgrim Nuclear Power Station; Bechtel Corporation, October 1968

2. Agreement between the Commonwealth of Massachusetts and Boston Edison Company; March 14, 1968 and the

3. Interim Permit for the Discharge of Industrial Wastes issued by the Water Resources Commission, Commonwealth of Massachusetts; January 8, 1969.

Two copies of each of the above three documents are enclosed. We are also enclosing two copies each of two newspaper clippings that give an indication of the local interest in the Pilgrim Station and the thermal discharge from the station.

THE CONDUCT OF THE PROGRAM

The program began by establishing the existing temperature distributions in Cape Cod Bay and how these temperatures are affected by the winds, the tides and the daily and seasonal variation in air temperatures. We then made a prediction of the direction and the extent of the three-dimensional thermal plume resulting from the discharge of the condenser-cooling water with due consideration for the topography of the bottom of Cape Cod Bay adjacent to the plant and the proposed design of the breakwaters, the discharge canals and the intake structures. With this information we made a prediction of the effects of the thermal discharge on existing sport and commercial fisheries and modified the proposed designs as required until we reached a satisfactory solution.

In performing these studies we have been guided by our consultants and the valued suggestions of the Department of Marine Fisheries of the Commonwealth of Massachusetts and the Fish and Wild Life Service of the Department of the Interior. Our consultants are:

Coastal Engineering - R. O. Eaton and Dr. A. T. Ippen, both of the Massachusetts Institute of Technology;

Physical Oceanography and Cooling Water Dispersion - Dr. D. W. Pritchard, Chesapeake Bay Institute;

Ecology - Dr. John H. Ryther, Woods Hole Oceanographic Institute.

The original oceanographic studies of the existing conditions were made by Dames and Moore. Later studies were made by Marine Advisers under the direction of Dr. Pritchard through literature searches, drogue and dye (ocean current) studies, and the installation and operation of off-shore instrumentation to measure sea temperatures and currents.

Hydraulic studies using a scale model of the topography of Cape Cod Bay in the vicinity of the Pilgrim Station were conducted to establish the height, contours, and location of the breakwaters and discharge canal. These were performed at the Alden Research Laboratories of the Worcester Polytechnic Institute at Holden, Massachusetts under the direction of Dr. L. J. Hooper and Dr. L. C. Neale.

Using this information and a second scale model, that included the proposed design of the off-shore structures, a hydraulic thermal model study of the cooling water dispersion in Cape Cod Bay was performed at the Hydrodynamics Laboratory of the Massachusetts Institute of Technology at Cambridge, Massachusetts under the direction of Dr. A. T. Ippen and the technical supervision of Professor Donald R. F. Harleman.

Dr. D. W. Pritchard, of the Chesapeake Bay Institute, used the results of the oceanographic and scale model studies to estimate the distribution of the temperature rise above ambient in the Cape Cod Bay under a range of tide and weather conditions.

Dr. John H. Ryther, of the Woods Hole Oceanographic Institute, then used

Dr. Pritchard's work, together with his own knowledge of the marine ecology of Cape Cod Bay and adjacent waters, to predict the effects of the operation of the Pilgrim Station on the commercial and sport fisheries in the area adjacent to the plant discharge.

Finally, we authorized the four year, before-and-after studies of the oceanographic distribution and the commerical "catches" of the important marine fisheries, the food chains that support these fisheries and a more basic study of Irish moss, an article of commerce that is harvested near the Plant site.

RESULTS TO DATE

The results of the studies to date have enabled us to choose a design for the off-shore breakwaters, intake structure and discharge canal that, to the best of our belief as well as the belief of recognized experts, will serve the combined functions of: (1) protecting the plant from wave actions due to the worst forseeable combinations of high tides and storms at sea, (2) effectively separating the warm water in the discharge and cool water in the intake and (3) assuring that the operation of the Pilgrim Station will not have an adverse effect on the important commercial and sport species of finfish, crustacea and shellfish.

There is some reason to expect, but no assurance at this time, that the resulting warmer waters may have a beneficial effect on some important species, in particular the lobster population.

Intake Structure

The design of the intake structure is such that the condenser cooling water will be taken below minus 12 feet, mean sea level. The design inlet velocity of the entering sea water is about 1 ft/sec.

The Salt Water Use Report contains the following comments on the design of the intake structure; "The velocity into the intake structure is about 1 ft/sec., this being low enough to prevent fish being forced into the structure. Trash racks . . . will prevent fish from reaching the pump chambers.", and "The low velocity of the intake will also help prevent fish and other marine organisms from being attracted to, concentrated by, and eventually caught up in the intake . . . most of the lobster larvae will (avoid being entrained in the condenser cooling water) because the cooling water will be taken below minus 12 ft. mean sea level".

Effects on Commercial and Sport Fishing

The most important commercial and sport fishing that now takes place in the off-shore waters is lobstering. Selected quotes on this subject from the Salt Water Use Report are: "Most of the pot fishing (for lobsters) is done within a mile from the shore in depths of 30' or less . . . . Several independent estimates placed the annual landings from the area under consideration (the one square mile described above) at above 200,000 lobsters." and "Sport fishing does not appear to be an important recreational resource of the area under consideration. Few, if any, shell fish are taken commercially from the intertidal shore line in the vicinity of the Pilgrim Station".

The Effects of the Thermal Discharge

The effects of the thermal discharge from the Pilgrim Station, based upon the design of the discharge structure that evolved as a result of the model studies, are best summarized by the following quotations from the Salt Water Use Report:

> "In view of the fact that most, if not all, of the marine species of commercial importance are bottom living organisms, it is preferable to discharge the heated water as a thin surface layer over a large area rather than confining it to a smaller area by mixing it vertically."

> "Pritchard's evaluation of thermal and radiological dispersion . . . indicates that the desirable objective of rapid mixing, combined with a relatively thin surface of warmer water, appears to have been achieved by the proposed design."

> "Generally speaking, few if any harmful effects to the commercially important species of the area are to be expected as a result of the warm water discharge, at least beyond a mixing area in the immediate vicinity of the discharge. There are two reasons for making this assumption. First, the temperature of the water in Cape Cod Bay is, on the whole, rather cold, averaging no more than just above 60°F in mid-summer. Most of the marine species of commercial importance are representatives of a temperature-water fauna which also occur south of Cape Cod in considerably warmer water. The above statement holds true for lobster, the most important commercial species of the region. The one possible exception to the above generalization is the Irish moss. This seaweed is a northern species which cannot survive in warm water. Surprisingly, for a species of its commercial importance, its temperature tolerances are not known."

CONCLUSIONS

All of the above predictions will be tested and evaluated during the four-year, before-and-after field studies.

The biggest open question at this time is the effect of the operation of the Pilgrim Station on the Irish moss harvest. This uncertainty is largely due to the scarcity of scientific information about this marine alga. The before-and-after studies to be conducted by the Commonwealth include basic studies on the growth habits of Irish moss. It is known that Irish moss attaches itself to rocks and that it prefers to grow in cool water. We believe that it will find the rocks used for the breakwater compatible with its needs and that it will flourish on both the inlet and outlet sides of the breakwaters.

The harvest of Irish moss in the Rocky Point area is now a one-family industry. The owner of this industry, or his attorney, has appeared at two public hearings concerning the issuance of permits for the off-shore work and he has gone on record to the effect that he does not oppose the work that is to be performed.

A final matter that bears on the subject of the effects of the operation of the Pilgrim Station on sport fishing is that, at the suggestion of the Commonwealth, we plan to construct an access road, a parking lot and a bridge across the discharge canal to the longer breakwater so that the public can take fish from both sides of the breakwater.

Very truly yours,

Claude A. Pursel
Ass't Vice President

CAP/lh

Encls.

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Edison replies in detail to queries by Plymouth Conservation Commission

The Plymouth Conservation Commission has been active during the past months in determining the effects of heated water discharge from the nuclear Pilgrim Station on the flora and fauna of the bay. John Loupos, commission vice chairman, has taken the initiative in this effort.

Mr. Loupos says that he has received 100 per cent cooperation from Boston Edison in replying to all his questions, some of which came up after a meeting of 35 area lobstermen concerned about possible effect of heated water on what they estimate to be a $250,000 yearly business.

In response to queries from Mr. Loupos, Boston Edison, over the signature of William F. Hamm, district manager, sent the following information in a letter to the commission vice chairman.

"We want to thank you for forwarding the item from the "Maine Coast Fisherman" about the conditions imposed on the discharge from the Maine Yankee Atomic Power Plant.

"We believe that the net effort of the conditions that we have already voluntarily imposed on the discharge from the Pilgrim Station are at least as stringent as those required of Maine Yankee. We divided our consideration of the effects of the Pilgrim Station discharge into three parts. These are — the discharge of toxic materials, the discharge of radionuclides and the discharge of heated water.

"The potentially toxic materials are used to control the growth of algae and mussels in the intake and discharge pipes. We will assure that these materials are diluted to such levels that they are not toxic to the aquatic life in Cape Cod Bay.

"The radioactivity of the

(Continued on Page 8)

OLD COLONY MEMORIAL (PLYMOUTH) Sept. 12, 1968

Edison gets okay

(Continued from Page 1)

condenser cooling water discharge will be monitored and kept well below the levels that would make them unfit for drinking water (if the water were fresh). We will begin a program of radioactivity measurement about two years before the plant starts up and plan to continue these measurements throughout the operating life of the plant. In the beginning we will measure the radioactivity that is now present in the shellfish due to the concentration of radionuclides that naturally occurs in all sea water. The measurements after plant startup will determine the amount that is added due to the discharge from the Pilgrim Station. We will not permit any reconcentration to render the shellfish or other edible aquatic life unfit for human consumption. Our work will be monitored by the Atomic Energy Commission and by the Commonwealth of Massachusetts.

"As for the thermal effects, our goal is to assure that the net effect is beneficial or at least not harmful when one considers all of the fish and shellfish that are used for food and sport in the surrounding waters.

"We and our consultants expect that the warmer water will float to the surface of the bay and will be directly beneficial to some species such as stripers. We expect it may be indirectly beneficial to lobsters by increasing their food supply. The temperature in the water at the depths normally inhabited by the lobsters will not be affected. On the other hand, we expect that the warmer water may be harmful to some species in the region immediately adjacent to the outlet of the discharge. We now have detailed studies under way at Alden Laboratories, MIT, and Woods Hole Oceanographic Institute. The purposes of these studies is to predict the net effects on aquatic life and to develop a program of measurements to test our predictions. During the year immediately prior to startup, we will measure the population density of the species of fish and shellfish that are important for food or sport in the vicinity of the plant discharge. We will continue this program for about a year after startup to measure any changes in the population of aquatic life that may have occurred.

"In summary, we believe that the goals that we have imposed upon ourselves are as stringent as those imposed on the Maine Yankee Plant. We further believe that our planned programs will permit us to document that we have reached our goals.

"If we can be of any further assistance please write or call this office.

PILGRIM STATION NO. 600
BOSTON EDISON COMPANY

SALT WATER USE AND WATERFRONT DEVELOPMENT FOR PILGRIM NUCLEAR POWER STATION

Bechtel Corporation
San Francisco, California
October, 1968

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SALT WATER USE AND WATERFRONT DEVELOPMENT

FOR

PILGRIM NUCLEAR POWER STATION

1.0 INTRODUCTION

1.1 Location

The site of the Pilgrim Nuclear Power Station is in the town of Plymouth on the west coast of Cape Cod Bay near Rocky Point, Massachusetts. It is about 4-1/2 miles east of the town center, as shown on Plate 1. The power station is to be owned and operated by the Boston Edison Company.

1.2 Scope

This document describes the proposed waterfront development; gives the results of model studies and analyses of the action of waves, storms and tides, and thermal effects; presents an analysis of the ecological effects and discusses programs proposed to verify the analysis.

Section 2: A general description of the Pilgrim Station arrangement, with descriptions of offshore and waterfront construction and of the circulating water system.

Section 3: Physical oceanography, incorporating date from existing sources and from recent studies for Pilgrim Station.

Section 4: Pilgrim Station hydraulic model studies performed to assist in evaluating storm protection and dispersion of plant effluents.

Section 5: Chemical, thermal and radioactive characteristics of station liquid effluents.

Section 6: Dr. D. Pritchard's analysis of cooling water dispersion.

Section 7: Dr. John D. Ryther's analysis of marine ecology and effects of station operation.

Section 8: Proposed environmental programs.

1.3 Consultants

This report was prepared with the assistance of the following consultants:

Coastal Engineering - R. O. Eaton
Dr. A. T. Ippen, Mass. Institute of Technology

Physical Oceanography and Cooling Water Dispersion -	Dr. D. W. Pritchard, Chesapeake Bay Institute
Ecology	- Dr. John H. Ryther, Woods Hole Oceanographic Institute
Radiology	- Professor Merril Eisenbud, New York University Medical Center

2.0 SITE ARRANGEMENT

2.1 Station Arrangement

The general arrangement of the proposed Pilgrim Power Station is shown on Plate 4. The major buildings on the site include the reactor building, the turbine building, the administration building, the intake and discharge structure for plant cooling water, and the switchyard. Station grade is at +20 feet MSL (+24.8 feet MLW).

2.2 Waterfront Development

Shoreline and offshore structures are required to provide the functional requirements of the cooling water systems in the plant and the necessary protection of the plant under storm conditions. They will consist of: 1) a pump house and screen well near the shoreline with protective breakwaters along a dredged intake channel; 2) a discharge head works near the shoreline with a dredged outlet channel which is protected by short jetties. The waterfront development is shown on Plate 4.

The breakwaters and jetties will be of rubble mound construction; both will be protected by heavy capstone. The breakwater on the north-west will be approximately 2000 feet long and the breakwater on the south-east will be approximately 930 feet long. Top elevation of both breakwaters is +11 feet MSL. (approx. +16 feet MLW).

The breakwaters are required to prevent rapid siltation of the dredged channels. They also provide a first line of defense, to protect the intake structure and sea wall from excessive wave action and overtopping due to wave run-up, and to limit storm flooding of the plant site.

The sea walls on either side of the intake structure will provide shore stabilization and prevent flooding of the reactor building by wave overtopping during severe storms. They are designed to act as a second line of defense in conjunction with the break-waters such that any overtopping that might occur under the extreme design storm tide level of +13.5 feet MSL (+18.3 feet MLW) would not affect the reactor building or the emergency systems required to safeguard the reactor.

The cooling water intake structure houses two sets of pumps. One set provides cooling water for the condenser (circulating water system) and the other set provides cooling water for the service water system. The service system pumps supply cooling water for the reactor and turbine building closed cooling systems. These systems remove heat during normal, shutdown, and accident conditions. It is essential that the service water pumps function properly even under extreme storm or tide conditions. The water-front development is designed to prevent overtopping of the intake structure, and assure continuous operation of the service system.

To minimize mixing of warm surface water with cooler bottom water and thus improve plant efficiency it is necessary to maintain low velocities inside the breakwaters. To maintain such velocities, the dredged channel width at the entrance between the breakwater crests will be 675 feet. Channel invert will vary from -25 feet MSL just in front of the intake structure to -20 feet MSL at the entrance. Channel depths, the transition slopes between them, and channel widths are shown on Plate 4.

A skimmer wall at the front of the intake structure is designed to assist in preventing the warmer surface water from entering the intake structure; the skimmer also acts as a trash and ice barrier. The bottom of the skimmer wall is at Elevation (-) 12 MSL. The velocity into the intake structure is about 1 ft/sec, this being low enough to prevent fish from being forced into the structure. Trash racks (3" clear between bars) and traveling screens (3/8" square openings) will prevent fish from reaching the pump chambers.

The discharge structure and channel are to the northwest of the intake structure as shown on Plate 4. The circulating water system and the service water system will discharge through this channel back to the sea. Other process system liquid effluents from the station are discharged into the circulating water system for dilution before entering the discharge channel.

The discharge channel is approximately 870 feet long and is extended over the beach to mean low water by rock-fill breakwaters. The breakwaters have a nominal elevation of +16 MLW (approximately +11 MSL) sloping down to a height of 4 ft. at MLW. The elevation of the bed of the discharge channel is 0 ft. MLW.

The water velocity at the outlet of the channel will be about 8 ft/sec at mean low water and 2 ft/sec at mean high water. These high water velocities in the discharge channel are provided to promote mixing of the heated water with colder sea water at the point of discharge from the channel.

The discharge channel jetties will also serve as protection of the intake and discharge structures from wave action.

3.0 PHYSICAL OCEANOGRAPHY

3.1 Introduction

General oceanographic data from outside sources has been supplemented by Boston Edison's Oceanographic Study Program conducted specifically for the Pilgrim Station Site.

3.2 Oceanographic Study Program

3.2.1 Scope

The Physical Oceanography Program at Pilgrim Station has included:

(a) Preliminary drogue studies and collection of sea temperature data by Dames and Moore (1967).
(b) Interim drogue studies (November, 1967).
(c) Extended drogue and dye studies (August, 1968).
(d) Installation and operation of an offshore instrumentation station to measure sea temperatures and currents.

Condensed data developed by the program is included in this section of the Report.

3.2.2 Offshore Instrumentation Station

The location and details of the Offshore Instrumentation Station, "Station B", are shown on Plates 2 and 3. The instrumentation station site, at the -30 foot contour (Mean Low Water Datum), has been selected as highly representative of the area in which a thermal plume will be created.

The station consists of an elastically moored buoy, supporting an equipment array which includes thermistors and current meters, with a submarine cable connection to an onshore recorder.

Temperature measurements are made by three sensors or thermistors located 2-feet, 9-feet, and 15-feet respectively below still-water level, and by a fourth located 2-feet off the bottom.

Instrumentation for current magnitude and direction measurements consists of one Marine Advisers Q-15 meter close to the surface and one Marine Advisers Q-16 meter 3-feet above the sea-bed.

Recording instruments on shore print out a digital record of readings from the current meters and temperature sensors.

The instrumentation was installed in late April, 1968 but following four weeks of service, it was damaged by wave action, and recording was temporarily suspended. Multilevel temperature records were obtained by hand sampling between June 29, 1968 and August 10, 1968, at which time the offshore station was returned to service.

3.3 Tide Levels

Tides at the Pilgrim Station site are of the semi-diurnal type, with two highs and two lows occurring each day. Tide records for this area are available from Coast and Geodetic Survey Tide Stations in Boston Harbor and at the eastern entrance to Cape Cod Canal. Tide levels at the Pilgrim Station site are similar to those at Boston. The mean tidal range is 9.1 feet and the spring tidal range is 10.6 feet. The datum relationship at the Pilgrim Station site is that Mean Sea Level is 4.78 feet above Mean Low Water.

The highest still-water tide level ever recorded in this area is +10.5 feet MSL. This level occurred at Boston on February 24, 1723 and has not been repeated. Tide levels of +10.0 feet MSL have occurred twice; once in 1851 and again in 1909. The extreme design storm tide level selected for Pilgrim Station of +13.5 feet MSL is 3.0 feet higher than has been observed in the Boston Harbor area in 244 years of record.

The estimated average yearly maximum astronomical high tide is +11.5 feet MLW, and the estimated average yearly minimum astronomical low tide is -2.3 feet MLW. These water elevations are expected to occur once every year.

It has been calculated that the 100-year storm could produce a still-water level of +15.8 feet MLW. This is a combination of storm surge combined with astronomical high tide. This tide level is based on tide data for 1922 to 1960 and is from Figure 27 of NHRP Report No. 68, "Criteria for a Standard Project Northeaster for New England North of Cape Cod," Hydrometeorological Section, Hydrologic Services, Washington, D.C. This tide level is 0.5 feet higher than the high tide of 1723.

Studies have shown that in the Cape Cod area, northeast gales produce higher storm surge than do hurricanes due to their longer fetch and longer duration. The Hydrometeorological Section of the U. S. Weather Bureau, which has conducted these studies, has established a Standard Project Northeaster for New England. Using this storm, the peak storm surge, having a return frequency of 1,000 years, is 6.6 feet. The concurrence of peak storm surge with an astronomical high tide of +11.7 feet MLW would give an extreme storm tide level of +18.3 feet MLW, with a probability of occurrence of once every 4,000 years. This extreme storm tide level of +18.3 feet MLW has been used as the maximum design tide level.

3.4 Ocean Temperature

3.4.1 Introduction

This sub-section reviews ocean temperature records for the Cape Cod Bay Area and presents some recent data obtained offshore, adjacent to the Pilgrim Station. The locations of temperature stations are shown on Plate 2.

3.4.2 Data Sources

The longest term measurements of sea-water temperatures in Cape Cod Bay are those made at Coast and Geodetic Survey Tide Stations. (1,2). Two Tide Stations were considered in this study: Boston, north of the site and the eastern entrance of Cape Cod Canal, south of the site. Surface temperatures are measured daily at each station by a single bucket thermometer. The depth of water at both tide stations is about 10 feet at mean low water. Records are available for Boston from 1922 to 1962, and for Cape Cod from 1955 to 1962. In addition, there has been continuous measurements of bottom water temperature at Boston since 1955.

The World Atlas of Sea Surface Temperatures (3) is a source of mean monthly temperatures for the Cape Cod area. Published in 1944, these figures are the results of a number of temperature surveys in the North Atlantic.

Data is available from the Woods Hole Oceanographic Institute, Woods Hole, Massachusetts (4). The data consists of bathythermograph records for stations throughout the western half of Cape Cod Bay. These measurements were made by oceanographic research vessels, and records date back to about 1880. None of these measurements are continuous recordings. All are spot measurements made on one day. Similarly, there is rarely more than one measurement for any particular point in the Bay. Also available are monthly averages of all the Woods Hole Data.

Two sets of data are available from the Division of Marine Fisheries of the Massachusetts Department of Natural Resources (5,6). The first set is daily midwater temperature ranges at buoy No. 1, Duxbury Channel, from June to October, 1964. Mid-water Duxbury Channel is approximately 15-feet below the surface. The second set is surface and bottom temperatures made in conjunction with Otter Trawl Samples between 1964 and 1966. The measurements were made mainly during the winter months between Gurnet Point and the entrance to Cape Cod Canal, just off the coast. A total of 18 samples was made.

Data for Station "A", approximately 3.5 nautical miles northeast of the site, is presented in a report by Dames and Moore. (7) The water depth at this location is 115 feet. Temperature profiles were recorded at Station "A" between December, 1924 and June, 1925. A total of 12 readings were made.

3.4.3 Pilgrim Station Records

Sea-water temperatures have been recorded for this project close offshore at Plymouth during August 1967, between April 26, 1968 and May 21, 1968 (Offshore Station "B"), between June 29, 1968 and August 10, 1968 (Manual), and between August 12, 1968 and August 29, 1968 (Offshore Station "B").

3.4.4 Data

Figure 1

Figure 1 shows maximum, minimum, and mean temperatures for the Cape Cod Canal and Boston Tide Stations. Also plotted are mean temperatures from the World Atlas of Sea Surface Temperatures. The maximum at Boston is 75°F, while Cape Cod Canal is slightly cooler with a maximum of 74°F during the summer. The mean temperature at Cape Cod Canal is less than at Boston due to much lower minimum temperatures.

The mean temperatures from the World Atlas follow closely the means for the two Tide Stations. The difference in temperatures between Boston and Cape Cod Canal is possibly due to Boston's large estuary and Cape Cod's more exposed location.

Figure 2

Figure 2 shows the temperature structure at Station "A" from December, 1924 to June, 1925. The temperature structure was isothermal between December and April. The warming trend commenced in May and by mid-June a strong thermocline (a water layer of high temperature gradient) had developed between depths of 30 and 60 feet. No data is available to tell how long this thermocline remains. It is important to note that this figure is based on 12 readings and there is, therefore, a good deal of extrapolation of temperature structure.

Figure 3

Figure 3 is similar to Figure 2. The temperatures plotted are from the Woods Hole data for the western half of Cape Cod Bay. Here a temperature stratification is developed about the beginning of June and lasts into October. The thermocline is very weak; however, it must be remembered that these temperatures are averages over the Bay. For each station the thermocline is well-developed and occurs between depths of 30 and 60 feet. Therefore, Station "A" is considered to be fairly typical of Cape Cod Bay at the greater depths encountered further offshore than Station "B".

Figure 4

Figure 4 shows average sea-water temperature measurements recorded at the Pilgrim Station site for the month of August, 1967 and comparable records from Boston U.S.C.&G.S. Station.

The Plymouth temperatures plotted are daily averages of the highest and lowest readings. The highest single reading was 66°F and within a 24-hour period, surface temperature differences of up to 9°F were observed. The differences between Plymouth surface and sea-bed temperatures ranged between 1^oF and 7.5^oF. The Plymouth surface temperatures are typically more than 5^oF less than those recorded at Boston. However, it must be noted that Boston temperatures between August 7 and August 11 were taken during the early afternoon and are probably close to the daily peaks, leading to relatively poor correlation with Plymouth on those days.

Figure 5

Figure 5 presents 1968 average surface and sea-bed water temperature records from Pilgrim Station and U.S.C.&G.S. surface records for a comparable period at Boston. The site records were obtained from the offshore instrumentation for the periods April 26 to May 21 and August 12 to August 24. Hand samples were used between June 29 and August 10, 1968.

The records show good correlation, with a consistently higher temperature at Boston and a typical differential of about 5^o above the surface temperature at Plymouth. The difference between surface and sea-bed temperatures at Plymouth ranges between zero and 10^oF, indicating the instability of the thermocline. The incidence of a high surface temperature is accompanied by a relatively low sea-bed temperature. During August, a sharp reduction in both surface temperature and an increase in sea-bed temperature occur together, implying that the vestigial thermocline was lost due to increased mixing of surface and lower water.

3.4.5 Conclusions

The collected sea-water temperature data for Pilgrim Station indicates a temperature pattern similar to both the eastern entrance of Cape Cod Canal and Boston. The temperatures will be cooler at Pilgrim Station than at Boston, where long term records are available.

In deep water a thermocline develops at depths of between 30 and 60 feet during the months of June through October. At -30 MLW, the temperature stratification is less consistent. Although a differential of up to 10^oF commonly exists between surface and bottom temperatures, the temperature stratification is very sensitive to disruption by turbulence following wind action when differential temperatures of 1^o - 2^o are commonly observed. However, the decrease in temperature differential is accompanied by a drop in absolute surface temperature.

Short term natural temperature fluctuations exceeding 7^oF are routinely observed at the site within 24-hour periods.

3.5 Ocean Currents

3.5.1 General

The general current regime in Cape Cod Bay is discussed by Dr. Pritchard in Section 6 of this report. Currents more directly related to Pilgrim Station site have been measured and recorded by a series of drogue studies, a dye study and by the offshore instrumentation, which is described earlier in this section.

The regime close to the site is much less well-defined than is the case farther out. Current velocities are much lower. During a period of four weeks during April and May, 1968, currents measured 5-feet below the surface exceeded 0.6 knots for less than 1% of the total time. The counterclockwise movement within the Bay is reduced but not entirely eliminated by the reduction in depth, and proximity of submarine ledges offshore from Rocky Point and Manomet. This basic southeasterly direction is modified but not reversed by tidal action and the resultant currents are small on the surface and almost negligible close to the bottom.

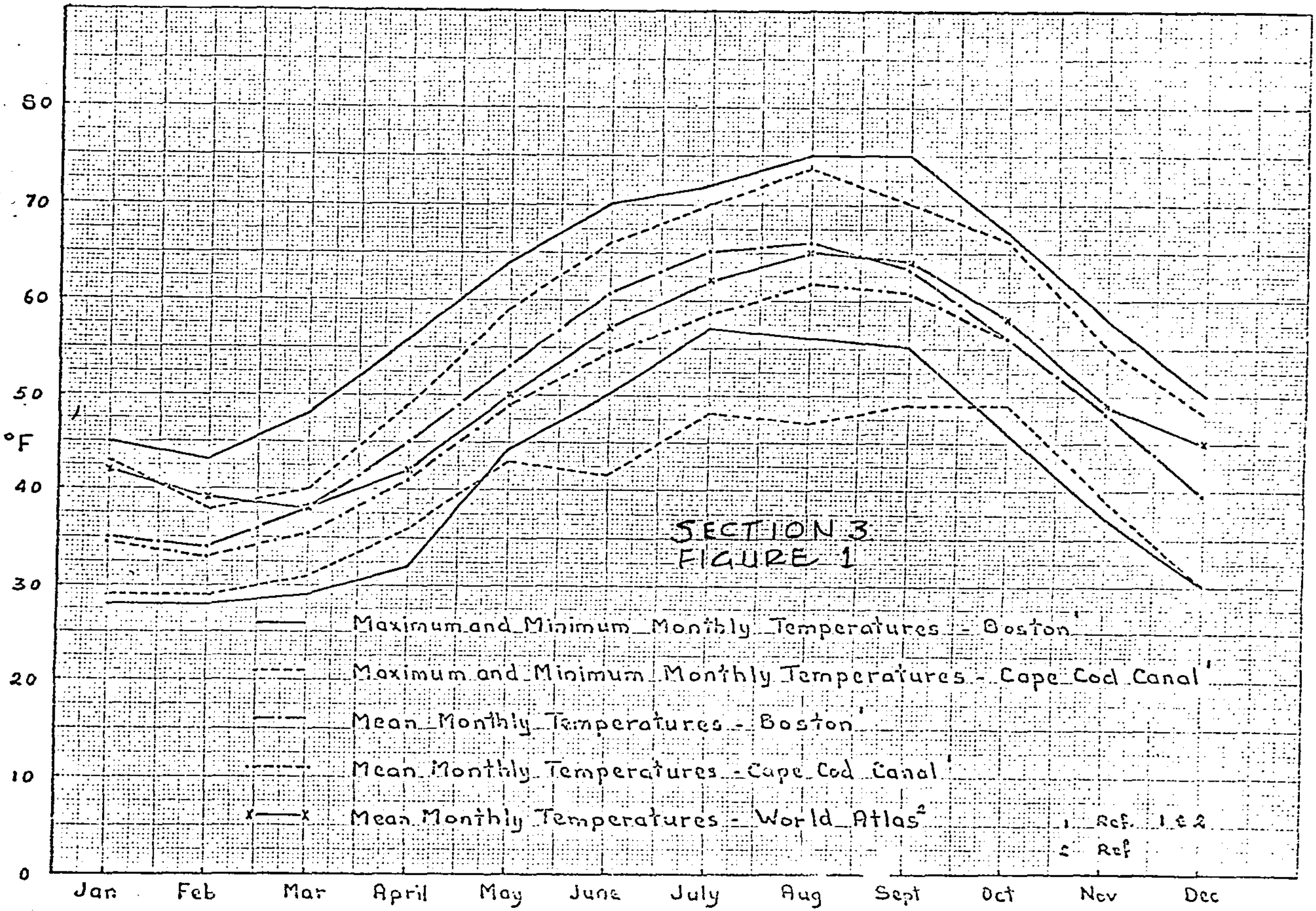
A close correlation between wind and surface water motion was observed in all the drogue tests and also by the dye test. During the latter, conditions were almost wind-free for the early part of the test and the southeasterly movement persisted throughout the tidal cycle. During the latter part of the test, offshore winds approached 10 knots and the direction of dye dispersion closely followed the wind.

The behavior of near-surface currents during four weeks of April and May, 1968, has also been compared with wind records from Boston Edison's on-shore weather station. Close correlation was established between wind and surface water movements. Wind influences normally decrease sharply with depth and are occasionally offset by upwellings and reversals in direction of lower level flow.

3.5.2 Conclusion

The correlative movement of water at the site is southeasterly in direction and corresponds to the well defined counterclockwise movement farther out. The basic direction is modified but not reversed by tidal action. The net southeasterly movement probably averages less than 0.1 knots over the entire depth. Short-term surface currents are closely correlated to wind action which is more readily detected than tidal effects. The currents at the site are relatively small and highly irregular in magnitude and direction.

0 7 3 3 9 0 8 9 1


80
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Dec
SECTION 3
FIGURE 1
Maximum and Minimum Monthly Temperatures - Boston[1]
Maximum and Minimum Monthly Temperatures - Cape Cod Canal[1]
Mean Monthly Temperatures - Boston[1]
Mean Monthly Temperatures - Cape Cod Canal[1]
Mean Monthly Temperatures - World Atlas[2]
1. Ref. 1 & 2
2. Ref

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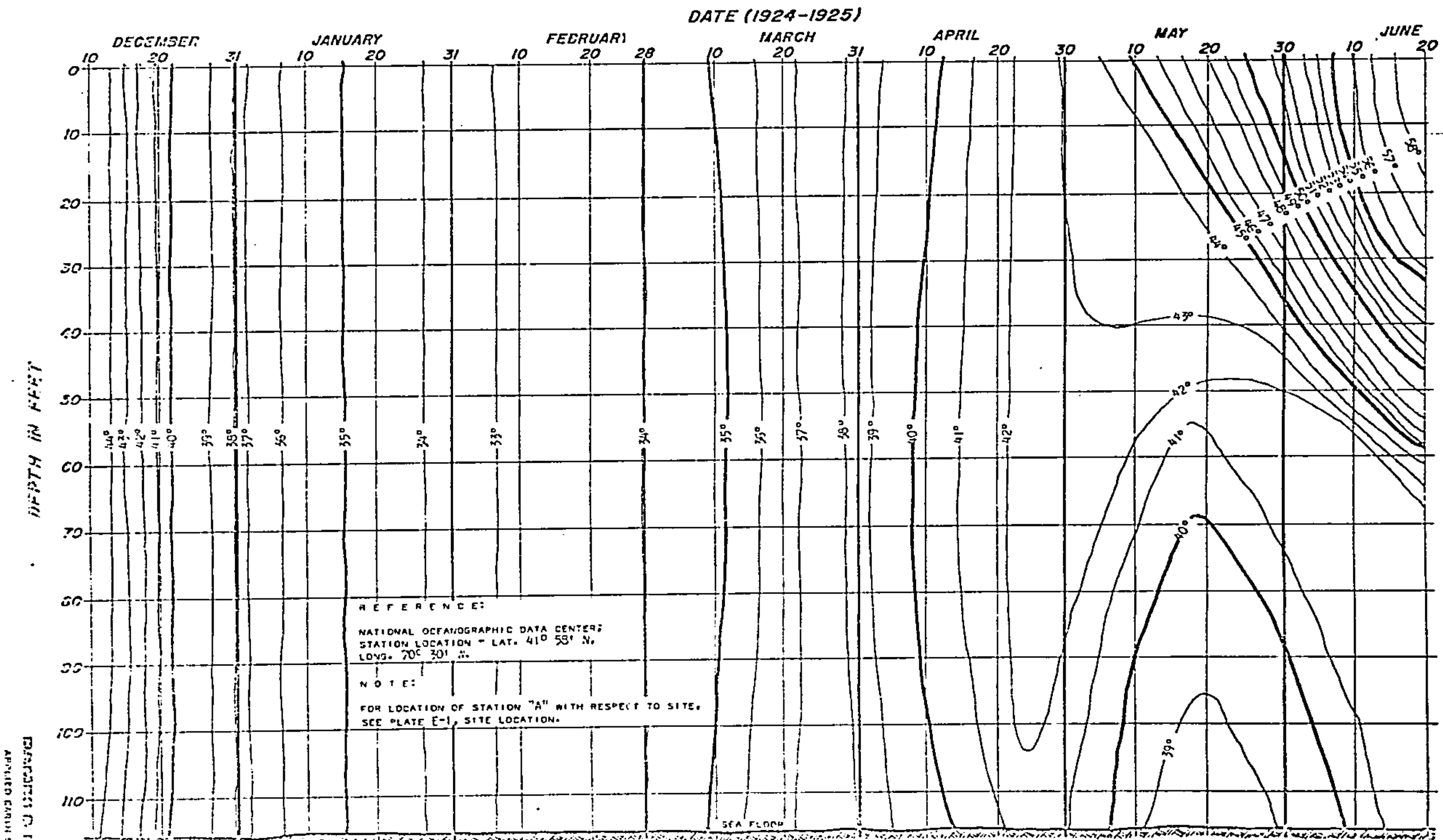
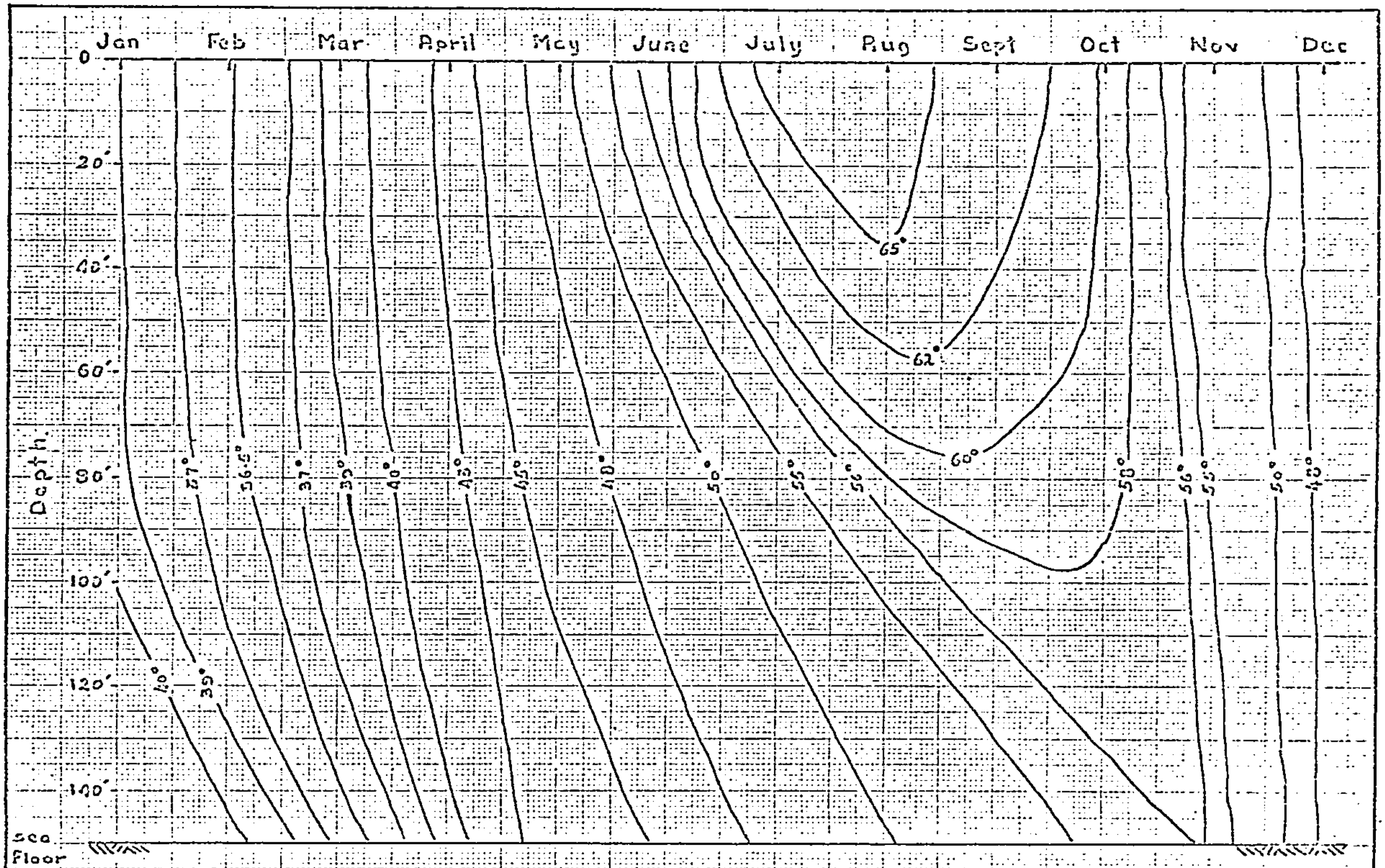


WINTER AND SPRING TEMPERATURE STRUCTURE

(°F) AT STATION "A"

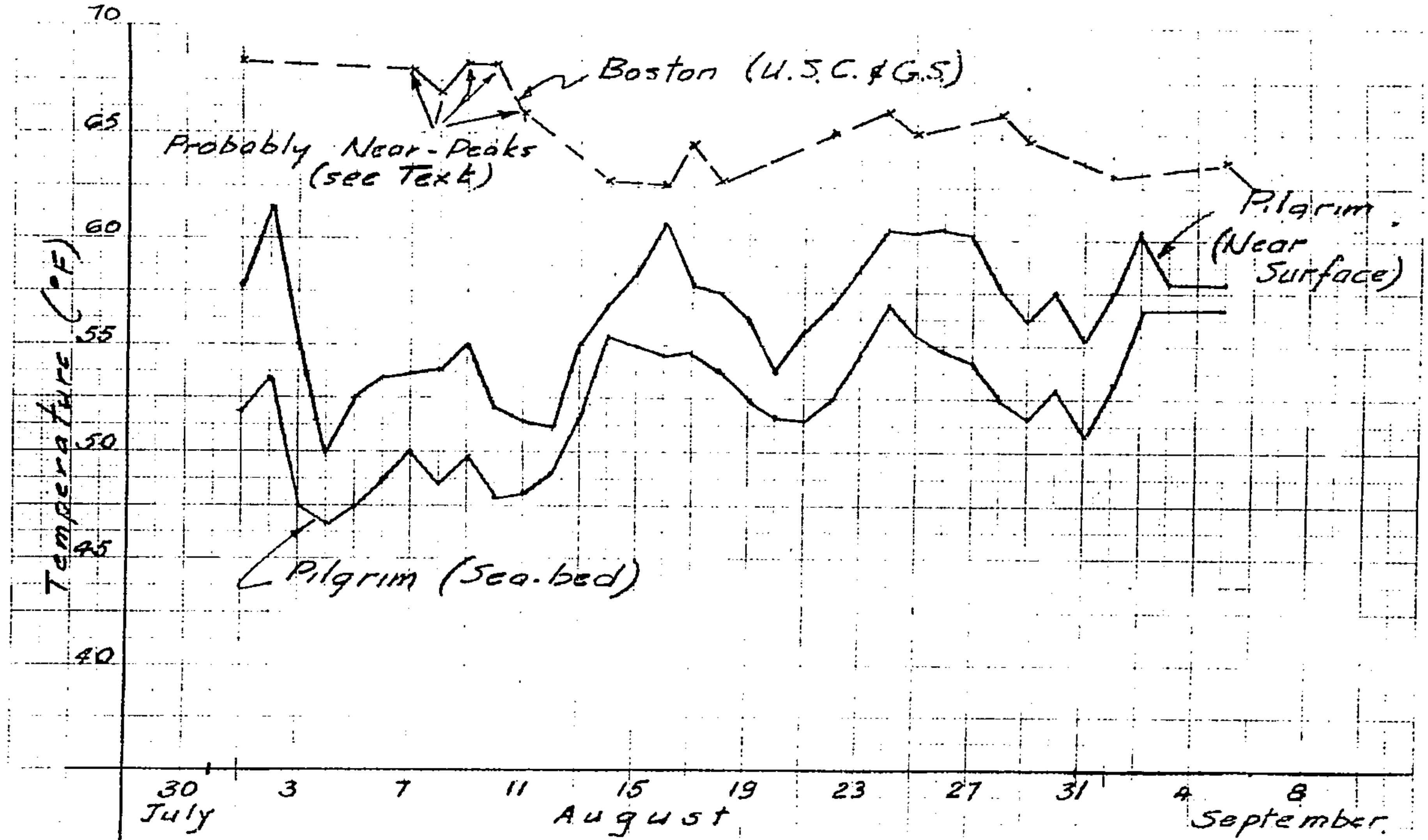
SECTION 3 - FIGURE 2



Temperature Structure in Western Half of Cape Cod Bay (°F)

Data is from Woods Hole Oceanographic Institute

SECTION 3 - FIGURE 3



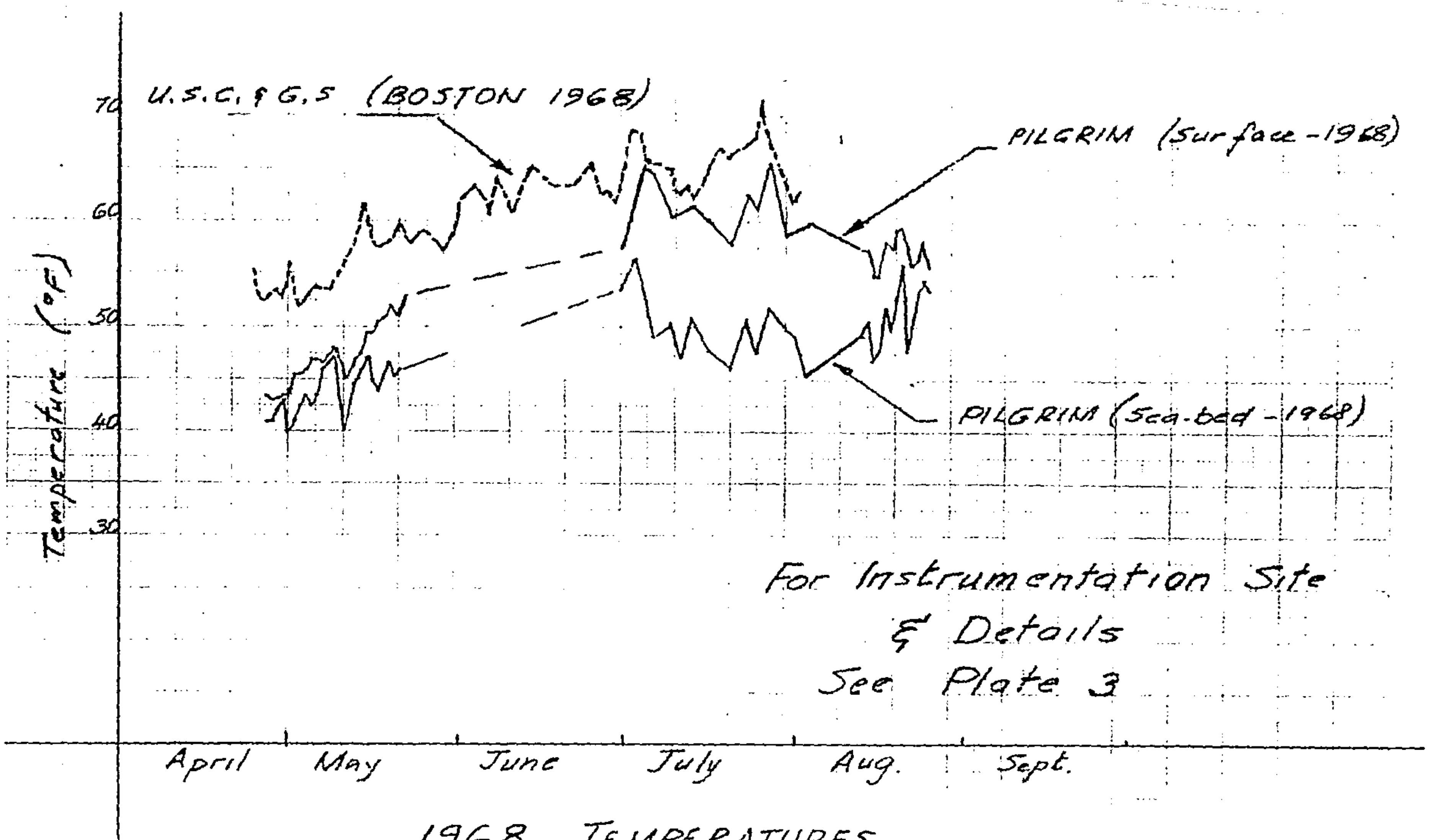
1967 TEMPERATURES

Pilgrim Station & Boston

Pilgrim Temps. are averages of highest & lowest daily readings.

SECTION 3 - FIGURE 4

0 2 3 3 9 0 8 9 5



1968 TEMPERATURES
Pilgrim Station & Boston.

SECTION 3 - FIGURE 5

4.0 HYDRAULIC STUDIES

4.1 Introduction

Hydraulic Model Studies performed for waterfront development at Pilgrim Station have investigated the following:

(a) Wave action and site storm protection.

(b) Thermal dispersion of circulating water effluent.

4.2 Wave Action Study

A series of wave action model studies has been performed in two phases at the Alden Research Laboratories of Worcester Polytechnic Institute at Holden, Massachusetts under the direction of Dr. L. J. Hooper and Dr. L. C. Neale.

4.2.1 Objectives

The purpose of the Alden Model Studies has been to assist in developing the design of the waterfront development including the breakwaters and jetties, the intake and discharge channels and the on-shore revetments. The effectiveness of the selected design in protecting the plant site and circulating water system against wave action has been demonstrated and evaluated.

4.2.2 Model Construction

The Alden Model has been constructed to an undistorted scale of 1:50. It is a fixed bed model, with topography simulated by a thin layer of cement mortar on compacted sand. Vertical control is provided for the topography and the improvements by wooden templates spaced at 3-foot intervals.

Crushed rock has been used to simulate the armor protection of the breakwaters, shoreline, and discharge channel. The reinforced concrete intake structure is modeled in wood. Water circulation through the intake structure is provided by a small electrically driven pump, flow being measured using an orifice plate and manometer. Station buildings protected by the waterfront improvements are simulated in the model.

4.2.3 Wave Generation

Wave generation is by means of a paddle maker 40-feet long, with a variable stroke and speed capable of producing waves of variable heights and periods, including wave periods of 8, 10 and 12 seconds, which are those mose likely to occur at the site during a severe storm. Preliminary tests indicated that an 8-second wave period produced less severe conditions than 10 and 12 second periods.

Wave heights are measured with 9 variable resistance probes and recorded on a 10 channel moving mirror galvanometer oscillograph.

4.2.4 <u>Test Program</u>

The proposed design has been subjected to tests at four still-water elevations:

(a) El. +11.5 MLW, the estimated average yearly maximum astronomical tide.

(b) El. +15.8 MLW, the level of the 100 year storm, expected not more than once during the life of the installation.

(c) El. +18.3 MLW, the design maximum tide level with a 4,000 year return frequency.

(d) El. +19.5 MLW, an arbitrary elevation which exceeds any postulated design condition and is the highest elevation at which the model can be operated satisfactorily.

Slope protection and the effectiveness of the breakwaters were evaluated by tests at all four still-water elevations during which waves were simulated from due north and from N 60 E, with wave periods of 10 and 12 seconds. The wave heights were adjusted to give maximum run-up at the intake structure and revetments. The critical condition was obtained with a 12 second period.

4.2.5 <u>Test Results</u>

Test results indicated adequate reduction of the generated wave at the intake structure. Minor overtopping of the adjacent seawall occurred at the higher elevations (18.3 MLW and 19.5 MLW) but flooding was limited to the open space north of the reactor building, which was itself at no time subjected to flooding. The limited overtopping which occurred would have no effect on the emergency core cooling water pumps or the service water pumps which are enclosed in a structure water protected to an elevation of approximately +28 MLW.

Test results were documented by moving and still photography.

4.2.6 <u>Intake Structure Oscillations</u>

A special series of tests was conducted to insure that unduly adverse conditions for intake pump operation could not be generated by wave action. It was observed that with typical still-water elevations even severe wave action produced very minor fluctuation of the water surface elevation. It was possible to develop a resonant condition with wave periods of approximately 14 seconds at still-water levels of 18.3 MLW and 19.5 MLW, but even the greatest amplitudes of surface movement obtainable were within the range tolerated by the pumps.

4.3 Thermal Model Study

A hydraulic scale model simulation of cooling water dispersion has been performed at the Hydro-Dynamics Laboratory of Massachusetts Institute of Technology at Cambridge, Massachusetts, under the general direction of Dr. A. T. Ippen and the technical supervision of Professor Donald R. F. Harleman.

4.3.1 Objectives

The primary objectives of the M.I.T. Model Study have been:

(a) To demonstrate the locations of isotherms in the thermal plume.

(b) To determine the magnitude of recirculation of the cooling water, if any.

4.3.2 Thermal Model Construction

The Thermal Hydraulic Model has been constructed within the confines of an existing 27-feet by 46-feet model basin in the M.I.T. Laboratory. The horizontal scale is 1:250 and the vertical scale is 1:40. Approximately 11,000-feet of coastline has been reproduced with a distance from shore of 5,000 to 6,000 feet and a water depth of approximately 40 feet.

Currents are simulated by pumping and draining from either end of the model. Water temperatures are measured by thermistor probes.

4.3.3 Thermal Model Test Program

The Thermal Model of the proposed design has been tested for the following simulated conditions, each with a simulated circulating water flow of 720 c.f.s. and a nominal temperature rise of 28.7°F.

(a) Still-water Elevation: MLW (0.0)
Current: southeasterly direction, 0.2 knots.

(b) Still-water Elevation: MHW (+9.4)
Current: southeasterly direction, 0.2 knots.

(c) Still-water Elevation: MHW
Current: southeasterly direction, 0.6 knots.

(d) Still-water Elevation: MHW
Current: south-southeasterly direction, 0.6 knots.

(e) Still-water Elevation: MHW
Current: 0.0 knots.

The tests selected are considered to simulate the most critical conditions for temperature rise and recirculation.

4.3.4 <u>Thermal Model Test Results</u>

Behavior of the model was considered very satisfactory under all test conditions. The following characteristics of the thermal plume were observed:

(a) The great energy of the discharge was a dominant feature in ensuring thermal mixing and dispersion under all current conditions.

(b) Double (two-sided) entrainment of cold water was observed in all tests.

(c) Thermal mixing and dispersion was essentially identical with water surface elevation at Mean High Water and at Mean Low Water.

(d) Thermal mixing and dispersion were relatively unaffected by currents which included simulated wind-generated movements corresponding to those detected at the site. Thermal dispersion is discussed more fully in Section 6.

(e) The heated plume extended to a depth of approximately five feet from the surface.

(f) In none of the tests was significant recirculation observed.

5.0 STATION LIQUID EFFLUENTS

5.1 Introduction

The station utilizes salt water from Cape Cod Bay as cooling water in the circulating water system and in the service water system. The cooling water used in these two systems is separated from potentially radioactive fluids in the process systems by the condenser and by the service system salt water heat exchangers.

The salt water returned to Cape Cod Bay from the station has been modified by the addition of heat or thermal energy and by the addition of liquid wastes discharged from the station. Station liquid effluents are categorized below for discussion as thermal effluents, radioactive effluents and non-radioactive effluents. Table 5-1 is a summary of the station effluents expected to be discharged annually to Cape Cod Bay.

5.2 Thermal Effluents

The thermal effluents consist mainly of condenser circulating water and service water system cooling water. The circulating water system has a normal flow rate of about 311,000 gpm and removes approximately 4.3×10^9 Btu/hr of heat from the condenser resulting in a water temperature rise of about 28°F at rated load. The service water system has a normal flow rate of about 10,000 gpm and removes approximately 7.8×10^7 Btu/hr from the salt water heat exchangers resulting in a water temperature rise of about 16°F during normal station operation. Under emergency conditions postulated for station design, the service water system flow rate could be reduced to about 5,000 gpm while removing about 65×10^6 Btu/hr of heat resulting in a water temperature rise of approximately 25°F in this system. Service water flow rates may be reduced when inlet water temperatures are low in order to regulate temperatures in the station closed loop cooling systems.

Radioactive Liquid Effluents

5.3 The liquid radwaste system in the station is designed to collect, process, monitor and dispose of all the potentially radioactive wastes generated in the reactor and turbine systems. The design basis for this system is described below.

5.3.1 Collection of Liquid Radwastes

The liquid radioactive wastes are classified at their point of origin into either of two separate drainage and processing systems, the clean radwaste or the chemical radwaste. The wastes are collected in sumps or drain tanks and are then transferred into either the clean waste receiver tanks or the chemical waste receiver tanks in the radwaste building for processing. Clean radwastes are defined as those liquid

TABLE 5-1

SUMMARY OF ESTIMATED ANNUAL STATION EFFLUENTS

DISCHARGED TO CAPE COD BAY

Type	Annual Volume	Annual Radioactivity Additions	Chemical or Heat Additions
A. THERMAL(1)	(C.F. = 0.92)		
Circulating Water	1.5×10^{11} gals.	Below limits of 10 CFR20(2)	4.3×10^{9} Btu/hr(3)
Service Water	5.5×10^{9} gals.	Below limits of 10 CFR20(2)	7.8×10^{7} Btu/hr(3)
B. RADIOACTIVE			
Clean Radwastes	Normally reused in station..		
Chemical Radwastes	4.0×10^{6} gals. = 11,500 GPD	7-50 curies	8.6×10^{5} lbs. of Na_2SO_4
C. NON-RADIOACTIVE			
Make-up System	2.9×10^{6} gals. = 8,000 GPD ≈ 1 Mgal/day	None	66,000 lbs. of dissolved solids and 2,200 lbs. of particulates.

Notes: (1) Normal operation at rated load.

(2) Ocean cooling water is naturally radioactive. The radioactive content of the station effluent will be increased slightly during the controlled release of liquids from the radioactive waste system. The liquid effluent from the radioactive waste system will be below the limits specified in 10CFR20 after mixing with the cooling water.

(3) Addition of hypochlorite to these systems is expected for about one hour each day resulting in residual chlorine of approximately 1 ppm in the effluent during this period.

wastes which have a low conductivity and are potentially turbid. Chemical radwastes have a high conductivity and can be slightly turbid. Floor drainage from those building areas which are under access control are processed as chemical wastes.

5.3.2 Treatment of Liquid Radwastes

Clean radwastes are normally treated in a batch process by first filtering to remove suspended particulate matter followed by demineralization to remove dissolved contaminants. After treatment, clean radwastes are collected in the treated waste storage tanks for sampling and analysis. If this water meets the water quality requirements for condensate, it may be returned to the condensate storage tanks for reuse in the station. If this water is not suitable for reuse in the station, it may be released at a controlled rate to the circulating water effluent.

Chemical radwastes are normally treated in a batch process by first neutralizing the acid and caustic solutions followed by filtering to remove any suspended particles. After treatment, chemical radwastes are collected in the monitor waste storage tanks for sampling and anaylsis. After analysis, this water will be released at a controlled rate to the circulating water effluent.

Prior to discharge from the station, each batch of liquid radwaste is sampled and analyzed for radioactivity to determine the allowable rate of discharge ~~of the batch to the circulating water system~~. In addition, the liquid radwaste discharge line is provided with a continuous radioactivity monitor to record the activity of any liquids released to the circulating water system. After mixing with the circulating water, the radioactivity of liquid wastes discharged from the station will be below the limits specified in 10 CFR 20, Standards for Protection Against Radiation.

5.3.3 Sources and Estimated Amounts of Liquid Radwastes

The radioactive liquid wastes consist mainly of wastes produced during regeneration of the condensate demineralizers and wastes from floor washdown and floor drainage. Additional radwastes are collected from laboratory drains, decontamination wastes, and equipment drainage for maintenance. All laundry will be sent to outside commercial facilities. Clean radwastes are normally reused in the station rather than being discharged. Chemical radwastes produce an estimated annual volume of about 4,000,000 gallons which contains an estimated 862,000 pounds of Na_2SO_4 (from regeneration wastes) to be discharged to the circulating water system.

5.3.4 Radioactivity of Liquid Effluents

The annual release of radioactive substances to Cape Cod Bay from Pilgrim Station is estimated to be between 7 and 50 curies of mixed fission and activation products. This mixture can be expected to include radioactive isotopes of Cobalt-60, Cobalt-58, Manganese-54, Iron-59, Chromium-51, and Zinc-65, with possible additional fission products of Iodine-131 and Cesium-137, Technisium-99, and Molybdenum-99. Depending on the ratios of the various nuclides present, the maximum permissible concentration of such radioactive mixture in water supplies is expected to be in the range of 10^{-6} to 10^{-5} $\mu c/ml$.

Assuming that 50 curies per year are released at a uniform rate, the average radioactivity of the circulating water at the point of discharge into Cape Cod Bay will be increased by approximately 9×10^{-8} $\mu c/ml$ (90 picocuries/liter) This radioactivity release is on the order of 2% of the maximum permissible concentration in potable water according to AEC regulations for the mixture of radionuclides anticipated.

It must, of course, be recognized that the ocean water is not potable and that the factors that limit the amount of radioactivity that can be discharged safely into Cape Cod Bay are related to the tendency of certain radionuclides to concentrate biologically. However, the disparity between the permissible concentration in drinking water and the expected concentration of radioactive substances released from the station is a useful starting point in attempting to assess the significance of the radioactive substances that will be discharged from the Pilgrim Station.

Ocean water is naturally radioactive having an activity of about 300 picocuries per liter on the New England coast. The annual release of radioactive liquids from the station, as estimated above, would increase the activity of the salt water effluent from the station by an average of about 90 picocuries per liter representing an increase of about 30% of the original radioactivity of the ocean. In Dr. Pritchard's analysis (Section 6.0), he finds that the flushing action of Cape Cod Bay is such that not more than ten days of discharge from the station could be accumulated in the Bay and that this accumulated discharge would be diluted by a factor of 1:2580 because of the large volume of the Bay relative to the circulating water flow rate. Therefore, the radioactive releases from the station would increase the activity of water in the Cape Cod Bay by less than 0.04 picocuries per liter or an increase of about 0.01% above the natural radioactivity level of the water.

It has been estimated that in the seven year period since 1961, about 80 curies of Manganese-54 and Cesium-137 and about 40 curies of Strontium-90 have been deposited in the

Bay from fallout from nuclear weapons tests. The two situations arising from coolant discharge and fallout from nuclear weapons tests are not exactly comparable, as in one case, the material is released from a point source and in the other, fallout from nuclear weapons is diffuse. Nevertheless, the comparison of these figures is useful in illustrating relative amounts of radioactive substances under consideration. With the possible exception of Cobalt-60, the nuclides to be discharged from the Pilgrim Station are among those which have been present in fallout from nuclear weapons and there is extensive experience from these nuclides in a wide variety of aquatic situations.

The controlling effect on allowable radiological discharges will be the possible biological reconcentration of radioisotopes in edible marine organisms. Limitations on allowable radiation exposure to man are established at levels far below those at which any radiation damage to wildlife would be observed.

The environmental radiology program (Section 8.1) will provide factual assurance that the accumulated effects of radiological discharges from Pilgrim Station are not significant from a Public Health point of view.

5.4 Non-Radioactive Liquid Effluents

The non-radioactive liquid process wastes are produced mainly from backwash of the make-up filters and from regeneration of the make-up demineralizers. The make-up water system processes water obtained from the Town of Plymouth for use in the station. The make-up system produces an estimated annual liquid volume for discharge of 2,900,000 gallons which contains an estimated 2,200 pounds of suspended particulates (suspended material filtered from the town water supply) and 66,000 pounds of dissolved solids which includes Na_2SO_4 from regeneration as well as dissolved solids removed from the town water supply. These liquid wastes are neutralized before being discharged.

The salt water used for station cooling water (condenser circulating water and service water systems) will require chlorination to assist in controlling marine growth in these systems. Chlorination of the salt water into the station is expected for about one hour each day with residual chlorine of approximately 1 ppm expected in the station salt water effluent during this period.

Sanitary sewage will be treated by a septic tank and leaching field located northwest of the main station buildings. This system will be constructed in accordance with the requirements of the Massachusetts Department of Public Health with particular attention to clearances from open waterways.

6.0 COOLING WATER DISPERSION

6.1 Introduction

This study of condenser cooling water discharge has been prepared by Dr. D. W. Pritchard of the Chesapeake Bay Institute.

6.1.1 Scope

Dispersion of condenser cooling water discharged from the Pilgrim Nuclear Power Station in waters of Cape Cod Bay including predicted distributions of temperature rise above ambient.

6.2 Oceanographic Factors Pertinent to Problem

6.2.1 Physical Description of Cape Cod Bay

The U. S. Coast and Geodetic Survey Chart 1208 shows Cape Cod Bay to be a broad, open mouthed water body formed by the eastward and then northward extension of Cape Cod out from the coast of Massachusetts. The Bay faces to the north, with Race Point, the westward extension of the hook of Cape Cod, distinctively marking the mouth of the Bay on its eastern side. The mouth is not well marked on the western side, but for purposes of this brief description a line extending from Race Point westward to Bartlett Rock, just off the entrance to Green Harbor, is considered to designate the mouth of Cape Cod Bay. The length of this line is 17½ nautical miles, and the Bay has its greatest width of 24 nautical miles along an east-west line near the southern limits of the Bay. The north-south dimension of the Bay is just under 20 nautical miles.

Cape Cod Bay has a surface area of approximately 430 square miles (nautical), or 365,000 acres. Except for the southeast corner of the Bay, where Billingsgate shoal is found, depths generally increase rapidly from shore. The largest depths, about 180 feet, occur at the mouth of the Bay. About one-half the surface area of the Bay has depths greater than 100 feet, and the volume-mean depth is also about 100 feet. The volume of Cape Cod Bay is therefore about 1.6×10^{12} cubic feet.

6.2.2 Tide and Tidal Currents

Information compiled by the U. S. Coast and Geodetic Survey (1, 2) indicates that the tidal wave entering Cape Cod Bay from the north proceeds southward along the western shore of the Bay and then eastward along the southern shore of the Bay somewhat faster than the southward movement of the wave along the eastern shore of the Bay. The following lists the time difference between the time of high water at several locations around the Bay and the time of the corresponding high water at Boston. Also listed is the time difference between the time of low water at these locations and the time of low water at Boston, as well as the average of these two differences for each location. The locations are listed in order of increasing distance from Boston, proceeding along the shoreline of Cape Cod Bay in a counter-clockwise direction.

Location	Time Difference High Water (minutes)	Time Difference Low Water (minutes)	Average Time Difference (minutes)
Gurnet Pt.	+ 02	+ 07	+ 04 ½
Plymouth	+ 05	+ 20	+ 12 ½
Barnstable	+ 09	+ 28	+ 18 ½
Wellfleet	+ 12	+ 28	+ 20
Provincetown	+ 14	+ 16	+ 15
Race Pt.	- 03	- 04	- 03 ½

The data for the northern end of Cape Cod Canal have not been included in this compilation, since the canal produces anomalous time differences at that location. The above data show that the tide is progressively later for successive locations proceeding southward along the western shore of the Bay, and then eastward along the southern coastline of the Bay. Likewise, the tide is progressively later for successive positions proceeding southward along the eastern shore of the Bay from Race Point at the mouth of the Bay as far as Wellfleet, which appears to be close to the location of the nodal point for the tide in Cape Cod Bay.

If high water occurred simultaneously throughout the Bay, the tide in Cape Cod Bay would have the characteristics of a pure standing wave. In this case high water would occur at the time of slack water (that is, zero tidal current) between flood and ebb flows, and low water would occur at the time of slack water between ebb and flood flows. The observed progressive differences in the time of high water and in the time of low water at the several locations along the shore of Cape Cod Bay indicate that the tide in the Bay departs slightly from a pure standing wave. We would therefore expect that high water would not occur at the same time as slack before ebb in the tidal current, but rather a short time before slack water during the later half of the flood current phase. Likewise, low water should occur at a time between the time of maximum ebb current and the succeeding slack water.

The results of the measurement and analysis of tidal currents made off Gurnet Point, off Manomet Point, and a mile east of Ellisville Harbor have been published by the U. S. Coast and Geodetic Survey (2). Tidal currents along the western and southwestern sides of Cape Cod Bay are generally directed parallel to the coast, except in or near the entrances to appended harbors. Flood current is directed down the coastline, that is toward the southeast, while ebb flow is directed northerly up the coastline. A comparison of the times of the various stages of the tide and of the tidal current show that for the coastline in the vicinity of the plant site, high water occurs approximately one hour before the end of flood flow, and low water occurs approximately one hour before the end of ebb flow. Maximum ebb and flood current speeds appear to vary considerably with location. For the three locations nearest the plant site for which tidal current data are given by the U. S. Coast and Geodetic Survey (2) (that is, for Gurnet Point, Manomet Point, and off Ellisville Harbor) the maximum predicted tidal current speeds varied from 0.3 knots to 1.4 knots.

As will be discussed more fully in Section 6.2.5, a current measurement program was initiated in the immediate vicinity of the plant site as part of an overall environmental study. The results of these measurements to date indicate that in the inshore waters off the plant site, out to a distance of about 3/4 mile from shore (i.e., in water depths of 40 feet and less), the tidal component of the currents is quite weak, being certainly less than 0.1 knot and probably less than 0.05 knot. The local water movement near the plant site appears to be primarily related to wind action.

Tidal data compiled from a number of locations around the periphery of Cape Cod Bay show that the range in tide is reasonably uniform throughout the Bay, with a mean value of about 9.3 feet. Even though the departure of the tidal wave in Cape Cod Bay from a pure standing wave leads to a measurable phase difference between high water and slack current, the actual differences in the time of high water from one location to another in the Bay are small compared to a quarter tide period. Consequently, the net fractional change in volume of the Bay due to the rise and fall of the tide is closely approximated by the ratio of the mean tidal range to the mean depth of the Bay. Since, as stated in the previous section, the mean depth of the Bay is about 100 feet, the fractional change in the volume of the Bay during one tidal cycle is then 0.093 or 9.3%.

6.2.3 General Circulation Pattern

Available information on the general pattern of flow in the northwest Atlantic off the coasts of the New England States and the Maritime Provinces of Canada, as summarized in Oceanographic Atlas of the North Atlantic Ocean, Section I, Tides and Currents, U. S. Naval Oceanographic Office Publication No. 700, shows that a coastal current flows southward along the coast of Maine and Massachusetts. A portion of the flow enters Cape Cod Bay along the western shore of the Bay, circulates in a counter-clockwise direction, and leaves the Bay on the eastern side. The flow then swings eastward around the Cape and then southward again. Interpolation of the isopleths of mean speed given in the above cited reference suggests that the probable average speed of this counter-clockwise flow in the Bay is not less than 0.3 $ft.sec^{-1}$.

6.2.4 Wind Induced Motion

The speeds associated with the tidal motion and with the general circulation pattern in Cape Cod Bay are in a range which suggests that wind-induced motion will at times dominate the flow. Wind blowing over deep water produces a direct wind-driven motion in the surface layers directed to the right of the wind in the Northern Hemisphere. In shallow water the wind-induced flow is more nearly in the direction of the wind. The speed of the surface wind-induced flow has been shown to be about 2% of the wind speed. Thus, a wind speed of 15 knots would produce a wind-induced surface current of about 0.3 knot or 0.5 $ft \cdot sec^{-1}$.

The variation of wind velocity in time and space over Cape Cod Bay should produce relatively rapid large scale exchange and mixing of the surface waters within the Bay. Also, prolonged winds from the northwest quarter should produce an additional mechanism for exchange of waters in the Bay with adjacent open coastal waters. The wind-induced surface layer flow into the Bay under such wind conditions would be accompanied by a sub-surface counter-flow out of the Bay. A sustained wind from the south would produce a surface flow out of the Bay and a sub-surface counter-flow into the Bay.

The rate at which the waters of the Bay are renewed by this mechanism can be only very grossly estimated, and will in any case be of an intermittent character. From a long-term standpoint, however, wind-induced flushing of Cape Cod Bay certainly contributes to the renewal of the waters of the Bay.

6.2.5 Water Movements Near Plant Site

An oceanographic observational program was initiated in the vicinity of the plant site to provide information on the temperature regime and on the movement and mixing of the waters off the plant site. As part of this program an anchored, buoy-supported instrument array has been established about one-half mile offshore from the plant site where the water depth is about 30 feet at MLW. In addition to temperature sensors set at several depths, this array includes two recording current meters, one located near the bottom and the other located near the surface. The instrument array is connected to the shore by cable, and a digital printout of speed and direction at the two current meters is provided every one-half hour.

This instrument station has been carried out by storms twice since first being installed. However, records for the period 26 April through 20 May 1968 have been analyzed. During this period approximately 1150 individual measurements of current speed and direction near the surface and near the bottom were obtained.

These observations show that both the speed and direction of the current at this location are highly variable. The speed of the current decreases with depth, with the mean speed near the bottom less than one-half that near the surface. During this period of observation, the current was directed down the coast (i.e., roughly toward the SE) about twice as frequently as in the up-coast, or northwesterly direction. The shoreline at the plant site is approximately parallel to the line 310°T to 130°T. Thus, currents having a direction falling in the quadrant 40°T to 130°T would have components both downcoast and offshore; those filling in the quadrant 130°T to 220°T would have components both downcoast and onshore; those falling in the quadrant 220°T to 310°T would have components both upcoast and onshore; and those falling in the quadrant 310°T to 40°T would have components both upcoast and offshore. The same 1150 individual measurements of the surface current off the plant site were subjected to a frequency sort into these four quadrants, depending on the observed direction, with the results as shown in Table 6-1. The magnitude of the current velocity varied from below the threshold of the current meter to a high of 1.1 knots. The average of the approximately 1150 measures of the near surface current was 0.15 knot. The statistical distribution of speeds as shown by a frequency sort is given below:

Speed Range (knots)	% of Total Observations
<0.09	40.7
0.10 - 0.19	31.9
0.20 - 0.29	16.0
0.30 - 0.39	7.9
0.40 - 0.49	2.0
0.50 - 0.59	0.8
>0.60	0.7

Table 6-1

Statistical Distribution of Observed Surface Current Direction off Station Site for Period 26 April - 20 May 1968

(Approximately 1150 individual measures)

Quadrant 1 Down-coast* and off-shore	36.9%
Quadrant 2 Down-coast and on-shore	29.4%
Quadrant 3 Up-coast* and on-shore	12.9%
Quadrant 4 Up-coast and off-shore	20.8%

Total with Down-coast Component	-	66.3%
Total with Up-coast Component	-	33.7%
Total with Off-shore Component	-	57.7%
Total with On-shore Component	-	42.3%

* Note: Down-coast is roughly towards the SE, while Up-coast is roughly towards the NW.

Both current speed and direction appear to be related most closely to the wind. In the absence of the wind, a weak tidal oscillation is superimposed on a small net drift down the coast toward the southeast. This weak southeastward drift is associated with the general counter-clockwise circulation of Cape Cod Bay described in Section 6.2.3 of this report.

6.3 Rate of Renewal of the Waters of Cape Cod Bay

The waters of Cape Cod Bay are exchanged for "new" water from outside the Bay by at least three processes: (1) tidal exchange, (2) the general counter-clockwise circulation, and (3) wind-induced motion. The first two of these are amenable to first order numerical estimates of the fractional rate at which the waters of the Bay are replaced by new water.

6.3.1 Tidal Flushing

As described in Section 6.2.2 of the intertidal volume (that is, the difference in the volume of the Bay at high water and at low water), represents about 9.3% of the mean volume of the Bay. This means that 9.3% of the volume of the Bay moves in and out through the mouth each tidal cycle. Experience in other coastal water bodies has shown that perhaps as much as 70 to 80% of the water which leaves the Bay on ebb tide returns to the Bay on the next flood. The remaining 20 to 30% represents "new" water. Taking the lower limit of this range, and also taking into account the fact that two tidal cycles occur each 24.84 hours, the fractional rate of renewal of the waters of the Bay per day by tidal action is given by:

$$2 \times 0.093 \times 0.2 \times \frac{24.00}{24.84} = 0.035 \text{ or } 3.5\% \text{ per day}$$

Thus, tidal flushing provides a renewal rate of about 3.5% per day of the volume of the water in Cape Cod Bay.

6.3.2 Rate of Renewal of the Waters of Cape Cod Bay by the General Counter-Clockwise Circulation Pattern

The general counter-clockwise circulation pattern in Cape Cod Bay was described in Section 6.2.3. The inflowing current at the mouth of the Bay having a mean speed of at least 0.3 $ft \cdot sec^{-1}$ is conservatively estimated to occupy at least one-third of the cross-section at the mouth. The mean depth at the mouth of the Bay is 150 feet, and the width is 17.5 nautical miles, or 1.064×10^5 ft. The cross-sectional area of the mouth is therefore $1.6 \times 10^7\ ft^2$. The volume rate of inflow of new water into the Bay with the current is then given by:

$$0.3\ ft \cdot sec^{-1} \times \frac{1.6 \times 10^7\ ft^2}{3} = 1.6 \times 10^6 ft^3 \cdot s^{-1}$$

$$= 1.4 \times 10^{11} ft^3 \cdot day^{-1}$$

Since the volume of the Bay is $1.6 \times 10^{12} ft^3$, the fractional rate of renewal by this process is given by:

$$\frac{1.4 \times 10^{11} ft^3 \cdot day^{-1}}{1.6 \times 10^{12} ft^3} = 0.088\ day^{-1} \text{ or } 8.8\% \text{ per day}$$

Considering that, in addition to the combined effect of tidal flushing and renewal by the general circulation pattern, wind-induced flows will also, in the long run, contribute to renewal of water in the Bay, we can assume that the mean renewal rate is at least on the order of 10% per day and probably larger. A renewal rate of 10% per day would provide a mean residence time for water, or for any water-borne component, of 10 days.

This means that no more than 10 days of discharge from the plant could accumulate in the Bay before being effectively flushed out of this water body. During a 10-day period, the volume of water discharged from the plant at full load would be given by:

$$10 \text{ days} \times 720\ ft^3 \cdot sec^{-1} \times 0.864 \times 10^5 sec \cdot day^{-1} = 6.2 \times 10^8 ft^3$$

This volume, mixed into the volume of the Bay ($1.6 \times 10^{12} ft^3$) would be diluted by the ratio:

$$\frac{6.2 \times 10^8 ft^3}{1.6 \times 10^{12} ft^3} = 1{:}2580$$

This dilution is sufficiently large, so that in computing the close in pattern of concentration of excess heat (temperature) or of any other component of the condenser cooling water discharge, we can consider that the discharge is made into a water body of infinite size.

6.4 General Description of the Fate of the Rejected Heat and of Other Components of the Cooling Water after Discharge into Cape Cod Bay

The Pilgrim Station has a rated output of 655 MW of electrical energy and will reject about 4.3×10^9 BTU per hour of heat to the condensers at this load. The analysis and evaluations reported in this section were made assuming a total salt water flow of 720 cfs and a temperature rise in the station of 28.7°F which result in a total heat rejection of about 4.5×10^9 BTU per hour. Periodically, very low levels of radioactive isotopes will be discharged with the cooling water. We are here concerned with the dispersion within and ultimate loss from the Bay of the rejected heat and of any other contaminants carried with the cooling water effluent.

The dispersion (that is, the movement and mixing of the condenser discharge in and with the receiving waters), is considered in three stages. First, the excess momentum associated with the condenser cooling water as it is discharged into the waters of Cape Cod Bay will produce an entraining jet which will be diluted by the mechanical entrainment required to reduce the velocity of the jet to that of the surrounding waters. Secondly, natural turbulent diffusion will further mix the waters of the diluted condenser water plume as it moves downcurrent with the natural flow. Finally, the large scale circulation pattern coupled with tidal flushing, as discussed in the previous section, will carry any conservative component out of the Bay. In the case of the rejected heat, surface cooling will have returned the temperatures to ambient long before the large-scale circulation pattern will have carried the condenser cooling water out of the Bay.

6.5 Distribution of Temperature in the Vicinity of the Plant Site

The most important mechanism for rapid reduction of the temperature rise above ambient of the condenser cooling water discharge from the plant is the mechanical entrainment required to reduce the initial momentum of the discharge to that of the receiving waters. Both theoretical and empirical studies of momentum entrainment in a jet discharge provide a means of computing the probable temperature distribution in the vicinity of the plant site. Note that here the term "temperature distribution" is used in place of the longer expression "temperature rise above ambient." The temperature distribution in the vicinity of the discharge will be somewhat higher than the ambient water temperature because of the heat content of the station cooling water discharge.

There are two factors at Pilgrim Station which restrict the degree of confidence which can be placed on the use of existing momentum entrainment relationships for the prediction of the temperature distribution off the plant site resulting from the discharge of the heated condenser cooling water. First, in the presence of a current flow directed along the coast in the Bay waters off the plant site, the plume of mixed, heated water will be bent in the direction of the current, ultimately becoming parallel to the coastline. It is not possible to determine on theoretical basis alone whether or not entrainment will occur on the inshore side of such a bent jet. Secondly, the effective velocity of the discharge for this design, an important parameter in considering the effectiveness of momentum entrainment, is not readily determined from theory alone.

In order to determine the effective velocity if discharge, as well as to determine the shape and extent of the plume of heated water in the vicinity of the discharge, an hydraulic model of a segment of Cape Cod Bay, centered on the plant site, has been constructed and a series of model tests have been run. This model is built on a scale of 1:250 in the horizontal and 1:40 in the vertical. It extends along the shore for a distance equivalent to about 11,000 feet in the prototype, and outward from the plant site for an equivalent prototype distance of about 6,000 feet.

Currents off-shore from the plant site are simulated in the model by introducing water through a control structure running approximately perpendicular to the general trend of the shoreline in the vicinity of the plant, and located at the northwesterly end of the model (prototype direction), and withdrawing water from a control structure extending along the southeasterly end of the model. The plant intake and discharge structures are properly scaled in the model. Water is withdrawn from the model through the intake structure, and heated water is introduced to the model through the discharge structure, to simulate plant operations.

A series of tests under the most critical conditions has been completed. These tests show three significant features: (1) Even when a current flow near the maximum observed at the site is simulated in the model, and directed down-coast, thus bending the plume of heated water toward the intake structure, very effective two-sided entrainment of cool diluting water occurs. The circulation pattern set up by the entraining jet actually brings new water at near ambient temperature to the intake. (2) There is little significant difference in the effectiveness of the jet entrainment between low tide and high tide conditions. In both cases, the heated plume appears confined primarily to the upper five feet of the water column, and the areas within given temperature isolines appear to be essentially independent of tidal height. (3) There is little difference in the shape and size of the heated plume for ambient current conditions varying from 0.2 knot, which is near the average observed off the plant site, to 0.6 knot, a speed exceeded in the observations to date less than 1% of the time.

As described in a previous section, the tidal oscillations and the residual net southeastward drift off the plant site are quite small, and at any given time the speed and direction of the current depend primarily on the time history of the wind. Thus, the current may extend either up-coast in a northwesterly direction or down-coast in a southeasterly direction, and in either case may have components directed either on-shore or off-shore. The current observations to date show that a flow in a southeasterly direction, with an off-shore component, occurs most frequently; however, flows in other directions are of sufficient frequency so as to require consideration.

Predictions of the distribution of excess temperature resulting from operation of the Pilgrim Station have been prepared using the results of the hydraulic model tests comgined with theory to take into account the finite size of the model, and to extend the distribution beyond the model boundaries. Because only a finite segment of the Cape Cod Bay can be modeled in this way, and because the water withdrawn from the model to simulate the current regime must be recirculated to provide the inflow at the upstream end, care must be taken in applying the model results directly to the prototype. In the predictions of the temperature distributions given here, the model results have been modified to take into account the finite renewal rate of the segment of the coastal waters represented by the model. Thus, in all cases, the predicted distributions of the temperature rise above ambient given here are conservative compared to the model results; that is, the plume of heated water is here shown to be more extensive than is shown by direct application of the model results to the prototype. The analysis assumed a total cooling water flow of 720 fps and a temperature rise in the station of 28.7°F. Two cases are considered, the first with the off-shore current directed toward the ESE (Figure 1), and the second with the off-shore current directed toward the WNW (Figure 2). As pointed out above, the temperature distributions appear to be relatively independent of tidal stage and of the strength of the current in the range from 0.2 knot to 0.6 knot, at least with respect to the general shape of the temperature isotherm and the area within a given isotherm. The strength of the current will influence the rate of bending of the plume from the initial off-shore directed jet discharge to a plume extending downcurrent. Thus, for the weaker current speeds, the heated discharge will extend somewhat farther off-shore than in the case of a strong current parallel to shore.

The shoal extending out from Rocky Point appears to exert considerable influence on the currents flowing past the plant site inshore of about the -25 foot MLW depth contour. As a consequence of the sheltering effect of this shoal, the model studies showed that the plume of heated water extends outward from the point of discharge very nearly along the extension of the axis of the discharge canal for about 1200 feet before starting to bend in a down-current direction, even in the presence of a 0.6 knot current directed toward the ESE. This feature is shown in Figure 3, in which the temperature distribution in the vicinity of the discharge canal, as observed in the model studies, is depicted. The size, shape and orientation of the plume as defined by the 10°F temperature isotherm apparently depend primarily on the dynamics of the discharge and are insignificantly influenced by the ambient currents in the Bay waters adjacent to the Plant site.

Measurements of the vertical distribution of temperature in the model tests have shown that for the conditions studied, the temperature rise above ambient is primarily restricted to the upper five feet. Figure 4 shows three representative vertical profiles of temperature distribution vs. depth from the model studies. Somewhat greater vertical mixing will probably occur in the presence of wind waves, but on the basis of the evidence now available, it is very unlikely that the temperatures at 10 feet below the water surface will exceed 4°F above ambient, and then only in the very small area in the vicinity of the discharge. In Figure 5 the predicted distribution of maximum temperatures, above ambient, on the bottom is shown. Isotherms are drawn for temperatures, above ambient, of 3°F and greater. Areas outside the 3°F isotherm as shown should have bottom temperatures less than 3°F above ambient.

Table 6-2 summarizes the area inside each of the surface temperature isotherms shown in Figures 1, 2 and 3. To indicate the importance of dilution due to momentum entrainment and natural diffusion, the last column of this table gives the area inside each isotherm which would be required if the effluent were to gently spread over the surface without mixing with the receiving waters, and lost heat only by surface cooling.

The predicted temperature distributions given here apply to an ambient temperature of 75°F, which represents the extreme ambient temperatures observed in the waters of Cape Cod Bay adjacent to the plant site. While the ambient temperature will influence both the amount of entrainment and the rate of surface cooling slightly, these effects would not significantly alter the shape and size of the individual temperature isotherms, and for all practical purposes, the predicted temperature distribution above ambient given here can be applied to any ambient temperature from 50°F up to 80°F.

TABLE 6-2

Dimensions of and Area within the Predicted

Isotherms for Surface Temperature Rises above

Ambient Temperatures for the Pilgrim Station

Temperature Rise above Ambient (^oF)	Length of Area (ft.)	Width of Area (ft.)	Predicted Area (Acres)	Comparable Area * Surface Cooling Only (Acres)
20^o	430	110	1.1	248
10^o	1100	250	6.3	725
5^o	3400	900	70.3	1203
3^o	5900	1300	176	1557
2^o	8400	2200	425	1834

* This column is shown for purposes of comparison only, and represents the area within the designated isotherms which would be required if the temperature reduction resulted only from surface cooling.

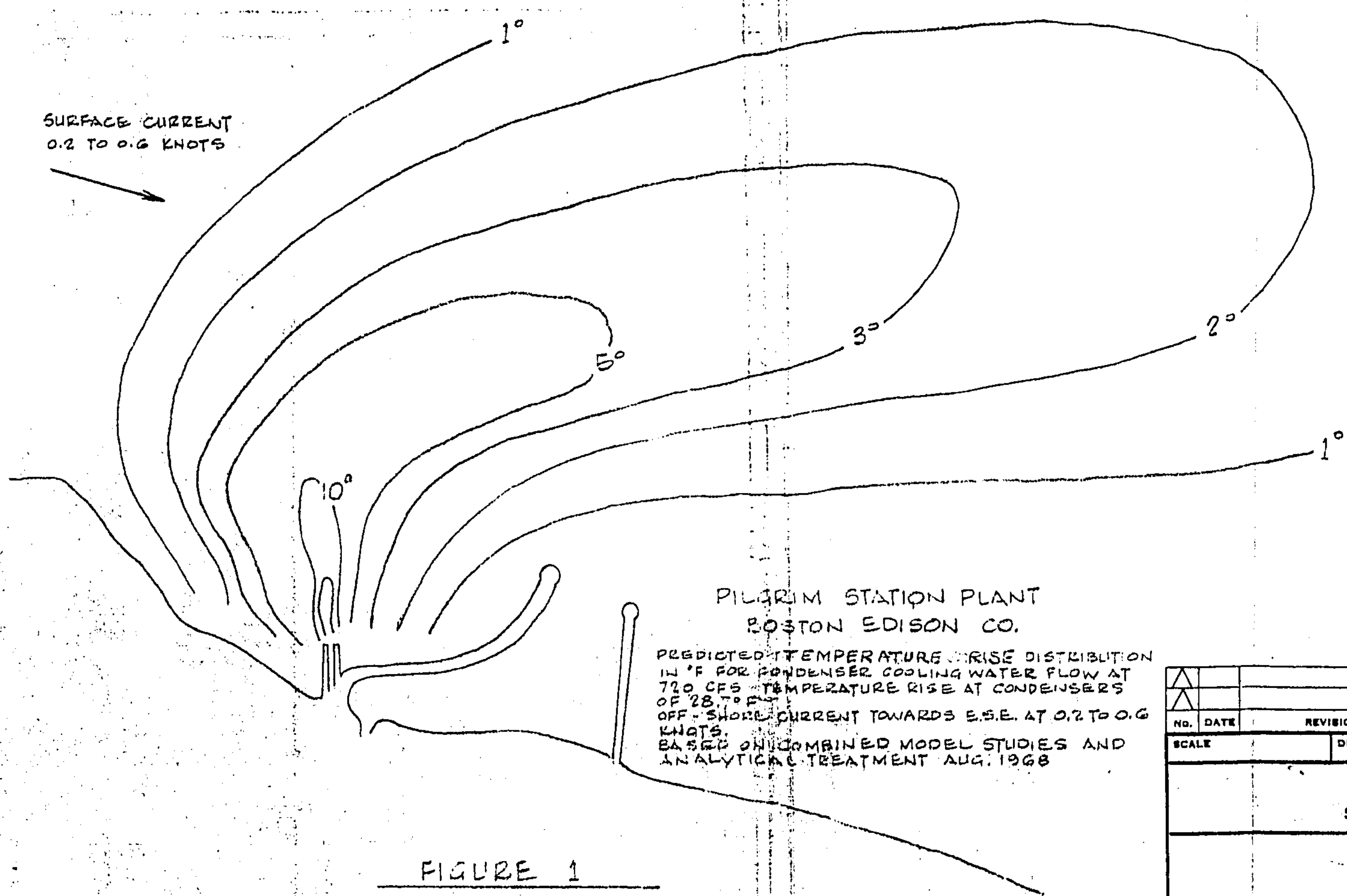
6.6 Concentration Distribution of Radioactive Isotopes Released in the Condenser Cooling Water

Under normal operating conditions, introduction of any radioactive isotopes into the condenser cooling water discharge would be controlled so that after mixing, the concentration in the cooling water effluent would not exceed the maximum concentrations specified for off-site areas in 10 CFR 20, "Standard for Protection Against Radiation." We are here concerned with the further physical dilution of such radioisotopes in the natural environment. Such further dilution serves as an additional safety factor which is not, however, used in computing allowable release rates.

There is no physical process which would lead to reconcentration of the radionuclides within the receiving waters of Cape Cod Bay nor in any of the tributary embayments. The temperature distributions above ambient shown in Figures 1 and 2 result primarily from physical dilution of the condenser cooling water discharge by the receiving waters. For the situation studied here, surface cooling does not become a significant contributor to the reduction of temperature except for surface temperatures less than 2°F above ambient.

The isotherms given in Figures 1 and 2 may therefore be interpreted as dilution lines for radioisotopes discharged with the condenser cooling water, by dividing the labeled temperature rise values by 28.7°, the initial temperature rise in the station. Thus, the isotherms of 20°, 10°, 5°, 3° and 2° shown in Figures 1 and 2 represent dilutions of 1:1.43, 1:2.87, 1:5.74: 1:9.56 and 1:14.35, respectively. Dilution will continue with distance from the site, producing a decrease in concentration approximately in proportion to the inverse of the distance from the source. On this basis the concentration of any component in the condenser cooling water discharge would be reduced by a factor of 100 at a distance of 11 nautical miles from the point of discharge.

0 2 3 3 9 0 9 1 8



PILGRIM STATION PLANT
BOSTON EDISON CO.

PREDICTED TEMPERATURE RISE DISTRIBUTION IN °F FOR CONDENSER COOLING WATER FLOW AT 720 CFS TEMPERATURE RISE AT CONDENSERS OF 28.7° F
OFF-SHORE CURRENT TOWARDS E.S.E. AT 0.2 TO 0.6 KNOTS.
BASED ON COMBINED MODEL STUDIES AND ANALYTICAL TREATMENT AUG. 1968

FIGURE 1

500 0 1000 2000

SCALE IN FEET

NO.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV.	ENG'R	CHIEF ENG'R	APP'D
△								
△								

SCALE | DESIGNED | DRAWN

BECHTEL
SAN FRANCISCO

SECTION 6 - FIGURE 1

	JOB No.	DRAWING No.	REV.
BECHTEL	6498-3		

SIZE B 11x17

02339 0919

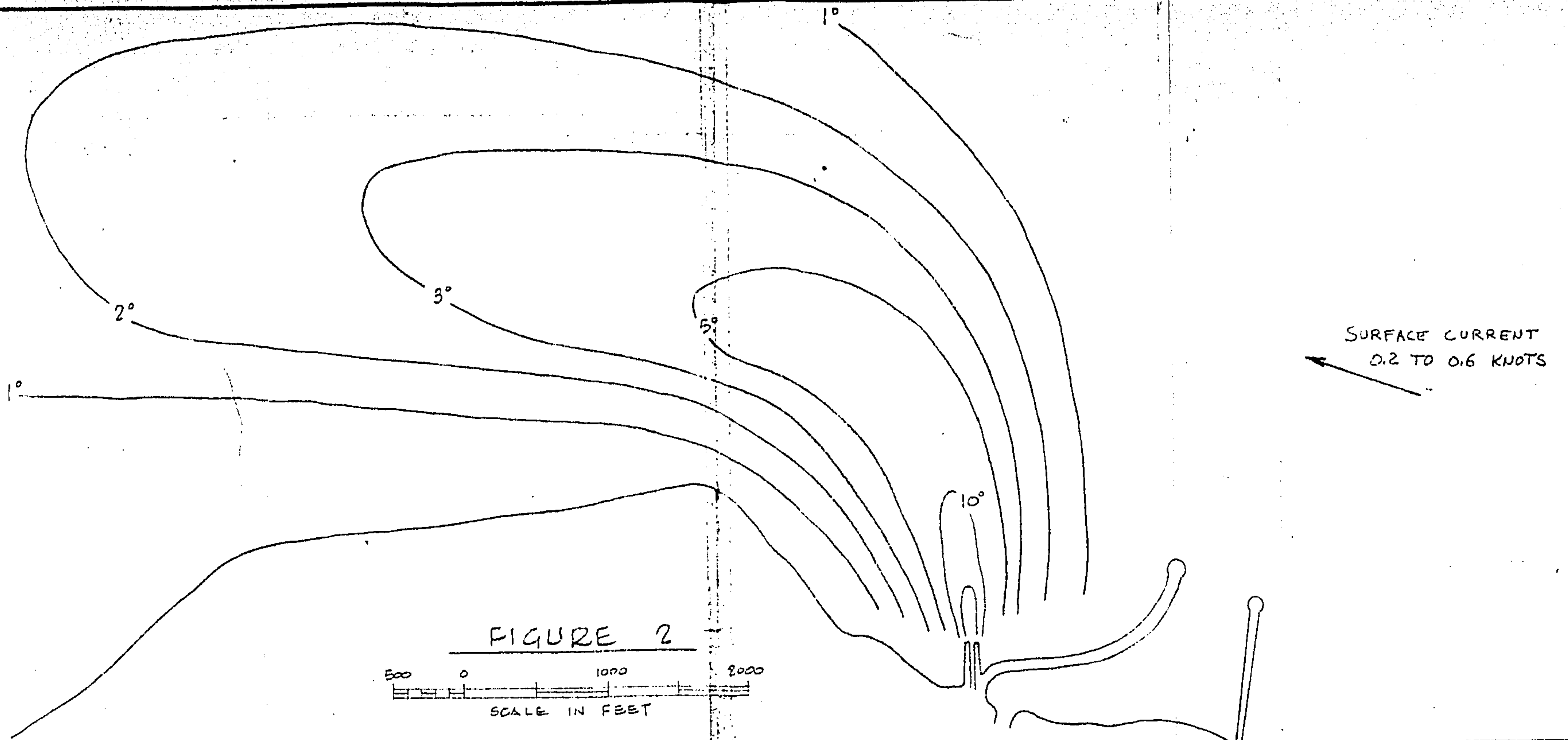


FIGURE 2

PILGRIM STATION PLANT
BOSTON EDISON CO.

PREDICTED TEMPERATURE RISE DISTRIBUTION IN °F FOR CONDENSER COOLING WATER FLOW AT 720 CFS TEMPERATURE RISE AT CONDENSERS OF 28.7°F
OFF-SHORE CURRENT TOWARDS W.N.W AT 0.2 TO 0.6 KNOTS.
BASED ON COMBINED MODEL STUDIES AND ANALYTICAL TREATMENT AUG. 1968

NO.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV.	ENG'R	CHIEF ENG'R	APPR'D

SCALE | DESIGNED | DRAWN

BECHTEL
SAN FRANCISCO

SECTION 6 - FIGURE 2

JOB No.	DRAWING No.	REV.
6498-3		

SIZE B 11×17

PILGRIM STATION PLANT
BOSTON EDISON CO.

PREDICTED TEMPERATURE RISE ABOVE AMBIENT IN °F, IN VICINITY OF DISCHARGE, FOR CONDENSER COOLING WATER FLOW OF 720 cfs, TEMPERATURE RISE AT CONDENSER OF 28.7°F BASED ON MODEL STUDIES.

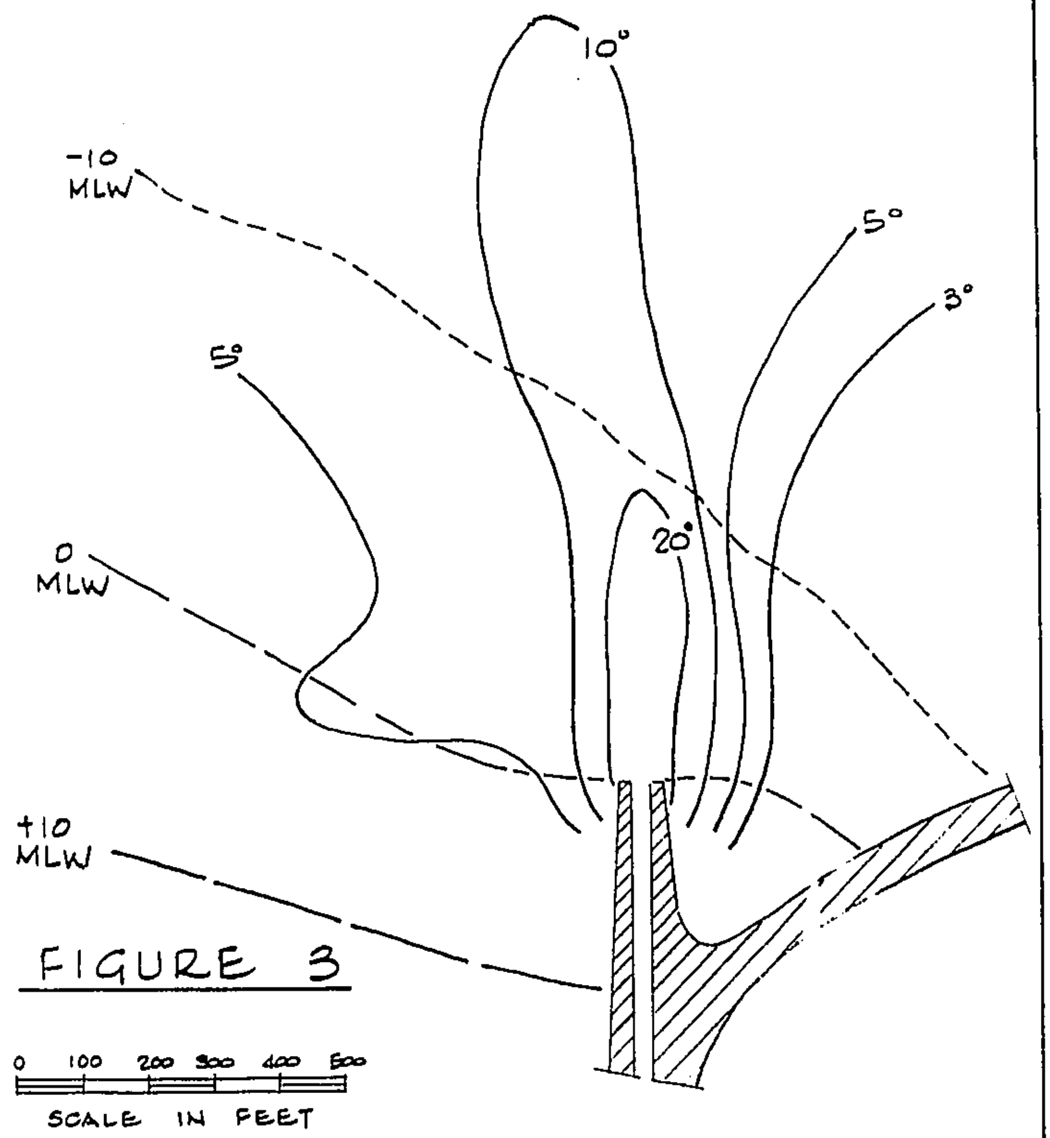


FIGURE 3

NO.	DATE	REVISIONS	DR.	SUPVR.	ENG.	PROJ. ENG.	CLIENT
△							
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BECHTEL

SECTION 6 - FIGURE 3.

JOB No. 6498-3

DRAWING No.	REV.

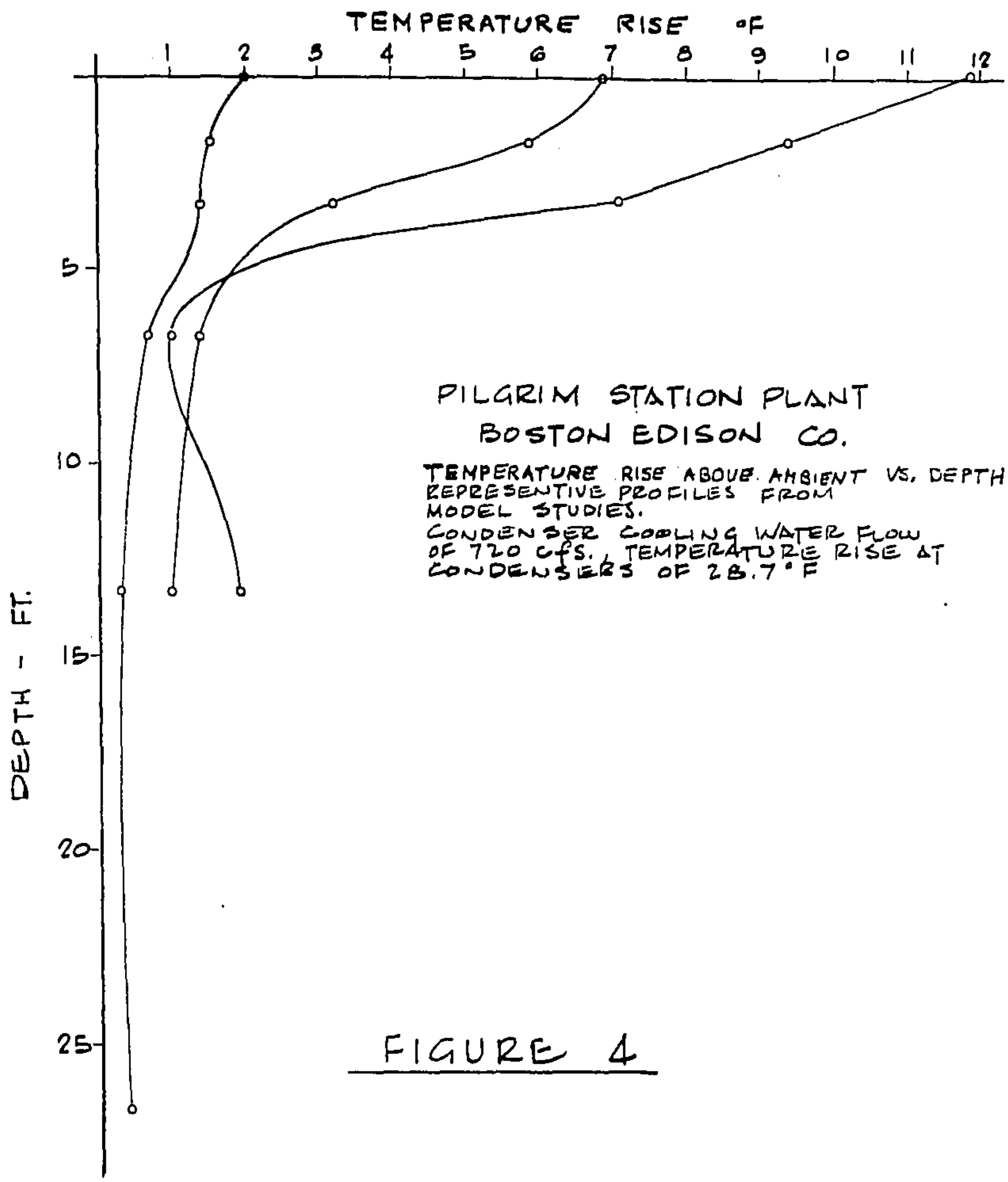

FIGURE 4

NO.	DATE	REVISIONS	DR.	SUPVR.	ENG.	PROJ. ENG.	CLIENT
△							
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△							

BECHTEL

SECTION 6 - FIGURE 4

JOB No. 6498-3

DRAWING No.	REV.

PILGRIM STATION PLANT
BOSTON EDISON CO.

PREDICTED MAXIMUM TEMPERATURE RISE DISTRIBUTION ON THE BOTTOM FOR CONDENSER COOLING WATER DISCHARGE OF 720 cfs, TEMPERATURE RISE AT THE CONDENSER OF 28.7°F

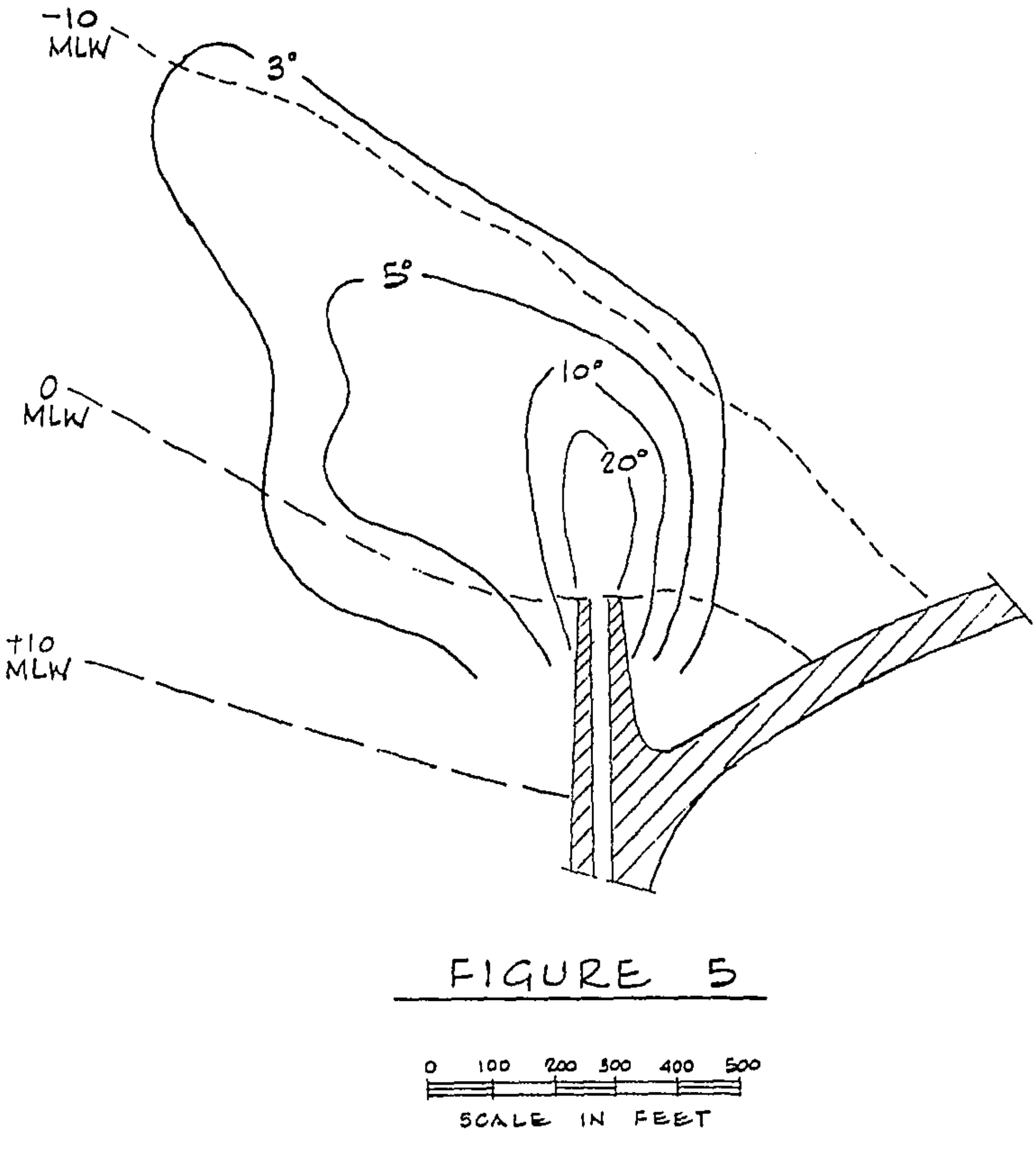


FIGURE 5

0 2 3 3 9 0 9 2 2

NO.	DATE	REVISIONS	DR.	SUPVR.	ENG.	PROJ. ENG.	CLIENT

BECHTEL

SECTION 6 - FIGURE 5

JOB No. 6498-3

DRAWING No. | REV.

7.0 ECOLOGY

7.1 Introduction

This section of the report has been prepared by Dr. John H. Ryther, of the Woods Hole Oceanographic Institution.

7.1.1 Scope

The ecology of the inshore water of Plymouth, Massachusetts and vicinity with special reference to the marine fisheries of the region and their relationship to the Pilgrim Nuclear Power Station.

7.2 General Description of the Region

Cape Cod Bay is a nearly circular embayment having a north-south demension of about 20 nautical miles. Plymouth is located at the north-western extremity of the Bay where it opens onto Massachusetts Bay, and the Rocky point site of the Pilgrim Nuclear Power Station constitutes the western lip of the bowl-shaped embayment. Farther to the north and west of Rocky Point, the coastline recedes into the region of Plymouth Bay and the harbors of Plymouth, Kingston, and Duxbury. These harbors are formed by two spits of land, Duxbury Beach terminating as Gurnet Point on the north and Plymouth Beach on the south, enclosing a shallow, soft-bottom area of some 25 square miles, much of which is intertidal.

The depth of Cape Cod Bay at its center ranges from about 100 feet in the southern portion to about 180 feet at the northern, open part of the Bay. Beyond the immediate intertidal shoreline, the bottom drops off rapidly to its maximum depth. This is especially true of the western side of Cape Cod Bay (near Rocky Point) where a depth of 50 feet at mean low water is found about one mile and 100 feet less than two miles offshore.

The sediments in the central basin consist of fine sand and/or mud and the same material characterizes most of the intertidal bottom of the Bay. However, along the western edge of the Bay, from Plymouth to the Cape Cod Canal, the sand beaches are interspersed with regions of gravel, stones, rocks and boulders. Where these occur, they may extend out from the shoreline to depths of 25 feet or more.

The site of the Pilgrim Nuclear Power Station, just south of Rocky Point, lies between two rock ledges, Rocky Hill or Tautog Ledge to the north and White Horse Ledge to the south. These ledges extend out a mile or more from shore. Between them, for a distance of about one mile, lies an area which is rocky along the immediate shoreline but of sandy bottom a few hundred feet offshore.

7.3 Hydrography

The effects of tides, winds and currents on the general hydrography of the region have been discussed in some detail by Dr. Pritchard (Section 6 of this report) and will therefore only be summarized here.

The mean tidal excursion in Cape Cod Bay is 9.3 feet. The tidal wave enters the Bay from the north producing a southerly-flowing current on the rising tide which reaches a maximum velocity of about 1.5 knots, and a northerly flow of comparable velocity on the ebbing tide. Tidal action alone is estimated to exchange 3.5% of the volume of Cape Cod Bay during each tidal cycle.

Superimposed upon the tidal effect is the general coastal current system which flows southward along the New England shore. This coastal current enters Cape Cod Bay on its western side, describes a counter-clockwise path within the Bay, and leaves it from the eastern side, swinging around Race Point and thence southward. The average velocity of this current is of the order of 0.5 knots or less. This coastal current, which is a southerly extension of the Labrador Current, is responsible for the universally low temperatures which characterize coastal New England waters from Maine to Cape Cod. The diversion of this current to the east and offshore by the Cape Cod peninsular results in a sharp increase in the summer seashore temperatures on the south side of Cape Cod and to its south. As a result Cape Cod is a faunal barrier, marking the northern or southern distributional limit of many species of marine life.

Conditions offshore at Pilgrim Station are greatly modified by proximity to shore and the existence of rock ledges which reduce currents, resulting in a much less well-defined regime.

Depending upon its speed, direction and velocity, the wind may have a pronounced effect upon the circulation of Cape Cod Bay and may, in fact, overshadow the combined effects of the tides and coastal currents. As Pritchard points out, the effects of the winds can be predicted only in general and qualitative terms. If they blow from the south, the over-all effect will be to produce a surface flow out of Cape Cod Bay which will be compensated for by a subsurface flow into the Bay. As the subsurface waters rise to replace the surface water which is wind-driven from the Bay, the surface temperature may drop sharply, particularly in summer.

On the other hand, a strong, prevailing wind out of the north quarter will tend to produce a surface current into and a subsurface current out of the Bay. This will have the effect of 'piling-up' surface water along the shore to considerable depths and, at times, to the bottom. Lobster pound operators in Plymouth Harbor complain that their intake water, taken from as deep as is possible in order to achieve minimum temperatures, may increase by $10^{o}F$ or more during periods of strong, onshore winds.

While the prevailing winds of the region are from the southwest, northeast storms are not uncommon and their possible effect in driving a surface layer of heated cooling water from the power plant inshore along the coast and to the bottom is an important consideration which will be discussed later.

Pritchard has estimated that the combined effects of tides, winds and currents result in a mean flushing rate of Cape Cod Bay of at least 10% per day, and probably more. A renewal rate of 10% per day would provide a mean residence time for water, or for any water-borne component, of 10 days.

Some exchange of water between Cape Cod Bay and Buzzards Bay takes place through the Cape Cod Canal as a result of the reversing tidal flow in the Canal. This exchange is believed to be small and its effects localized. Published data (Anraku, 1964) indicates that the net flow is to the west, from Cape Cod Bay to Buzzards Bay.

The existing seawater temperature data for Cape Cod Bay have been collected, summarized and reviewed in Section 3 of this report, in which it is concluded that the water temperature of Cape Cod Bay in the vicinity of the Pilgrim Nuclear Power Station is similar to that at the eastern entrance of the Cape Cod Canal, the closest location for which appropriate long-term data are available These were taken at the tide station operated by the Coast and Geodetic Survey at the Canal entrance, records from which are available for the period 1955-1962. Because they are pertinent to the discussion which follows, the mean surface temperature data from that station are reproduced in this section in Figure 1. Shown on the same graph are the 60-year mean surface water temperature (for an unspecified period) of the rearing tanks in the Massachusetts Division of Marine Fisheries Lobster Hatchery at Oak Bluffs, Martha's Vineyard (from Hughes and Matheissen, 1967). The significance of these data will be discussed later in this report.

In summer, the surface waters of Cape Cod Bay increase in temperature due to solar heating, and a well-developed thermocline (a zone of rapid decrease in temperature) develops between 30 and 50 feet. The temperature-depth profile in late summer is shown in Figure 2 of Section 7 of this report for a position 4.5 miles east of the Center Hill Point (data from D. Grant, Marine Biological Laboratory, Woods Hole, Massachusetts). This is probably typical of the whole of Cape Cod Bay, though the thermocline may be somewhat shallower nearer shore and in more shallow water. On the basis of the available information, one would expect substantially lower water temperatures at depths below about 50 feet throughout the year and throughout the Bay, or at a distance of about 1 mile offshore from the Pilgrim Station site.

7.4 Commercial and Sport Fisheries of the Area

The most important commercial marine species of the area is the lobster, for which there is a small but intensive local pot fishery. The lobsters are normally found on rocky bottom and are numerous on the two ledges (Rocky Hill and White Horse Ledges) which bracket the Pilgrim Station site. They also occur inshore on the rocky-bottom area between the ledges and, at times, are taken further offshore on the sand-bottom between the ledges. When found in the latter area, the lobsters are believed to be undertaking a migration, the nature of which is unknown.

Most of the pot fishing is done within a mile from shore in depths of 30 feet or less, before the bottom begins to drop off sharply. At the opposite extreme, pots are set along the shore in water where they are barely covered at low tide.

Within the area of roughly one square mile between (and including) the two ledges and the 50-foot bottom contour it is estimated that some 10,000 pots are fished at the height of the season. These are operated by approximately 25 full-time, professional fishermen (whose principal income derives from lobstering), and by an undeterminate, but large number of part-time, "summer fishermen". The former operate a larger number (i.e., several hundred) of pots per capita and probably account for 75% or more of the total catch.

The lobsters are relatively inactive and do little if any feeding during the winter months. This fact plus the unfavorable weather restricts the lobstering season to 8-9 months a year, from mid-April to December. The lobsters in the area under consideration moult (or shed) in June, and they reach their peak of feeding activity and growth at that time. Most of the year's catch is landed during the summer months of June - August.

Several independent estimates place the annual landings from the area under consideration (the one square mile described above) at about 200,000 lobsters. Statistics for the lobster fishery for the Town of Plymouth for 1966 compiled by the Massachusetts Division of Marine Fisheries, placed the total landings at 556,815 lobsters. On that basis the areas off the Pilgrim Station site produce about half of the lobsters landed in Plymouth.

Little is known of the ecology of the lobsters except in general terms. One important aspect of their life history in connection with the power plant operation is the behavior of the lobster larvae. Spawning takes place during the late spring or early summer. The newly-hatched larvae are planktonic or free-swimming during the first 2-3 weeks of their life, often swimming at the very surface of the water during that period. After the larvae have moulted four times, they assume the appearance of an adult lobster and take up a bottom-living existence for the remainder of their lives. It is not known, however, whether the population of adult lobsters in the Rocky Point area grow up from larvae which developed in the same waters or whether they have migrated as adults into the region over the bottom from offshore populations, as many people believe.

There are several species of fin fishes which are fished commercially in Cape Cod Bay. These are all bottom-living species and include cod, haddock, flounder and hake. They are fished wherever there is sufficiently smooth, sand bottom to operate the bottom trawls. However, this type of fishing is restricted to a distance of at least three miles from shore from April 1 to November 1. During the five winter months (November - April) there is some trawling in the sandy-bottom area between Rocky Point and White Horse Ledges. Catch statistics are not available for the fish landed from this area.

Sports fishing does not appear to be an important recreational resource of the area under consideration. There is some bottom fishing around the ledges for tautog and other species which inhabit rocky bottoms. Pelagic species such as tunas, striped bass and mackerel are no more numerous near Rocky Point than elsewhere in Cape Cod Bay and the density of lobster - pot floats during the fishing season makes the area a difficult and hence unpopular one for trolling, the popular local method of sports fishing.

Few if any shellfish are taken commercially from the intertidal shoreline in the vicinity of the Pilgrim Station, primarily because of the rocky bottom but also because the exposed nature of the coast and the resulting instability of the intertidal sediments discourages the establishment of mollusc populations. The closest commercial shellfish beds are located within the Plymouth-Kingston-Duxbury Bay areas, in those places where pollution has not closed them to digging. The same region also supports a modest commercial seaworm industry. In the opposite direction from Rocky Point, the first shellfish-producing area encountered is the White Cliffs section of Manomet. Based on the isotherms developed by Pritchard, both of the above regions are too far from the Pilgrim Station to be directly affected by its operation.

The remaining species of commercial importance in the area is the marine alga Chondrus crispus, known variously as "Irish moss" or "sea moss." This plant grows attached to rocks or stones from the low water level to a depth of 25-30 feet. Because of its requirement for an attachment site, it is restricted in its distribution to rocky bottom areas. The principle "belt" of the sea moss extends from Plymouth Beach to Priscilla Beach with its center of abundance off Rocky Point. A secondary center of abundance occurs off Ellisville.

The sea moss fastens to the rocks by an organ of attachment called a holdfast. It is harvested by means of a special steel rake which breaks the plant off near its base, leaving the holdfast on the rock. When harvested in this way, a new plant is regenerated from the holdfast. In the Plymouth area three crops of sea moss can be grown in a year. The first crop is ready for harvesting in mid-May or June, the second is taken in July and the third and final crop is harvested in early September.

The Plymouth sea moss industry is a family business. For the past 28 years the family has carried out this operation, with the help of a crew of some 25-30 college students employed each summer for the harvesting. They operate a fleet of roughly 20 dories and a dozen trucks throughout the summer. The algae are delivered to their plant in Kingston, Massachusetts, where it is machine dried and baled. It is then sold under contract to Marine Colloids, Inc., of New Jersey, where the colloids are extracted from the algae and used as a filler or suspending agent in medicines, paints, foods, and a great variety of other products.

The annual harvest of sea moss from the Plymouth beaches amounts to about 1.5 million pounds (dry weight), nearly half of which comes from the one-mile stretch from Rocky Hill Ledge to White Horse Ledge.

7.5 Predicted Marine Biological Effects of the Pilgrim Nuclear Power Station Operation

Not including the subject of radioactivity, which will be considered elsewhere, the impact of the Pilgrim Nuclear Power Station upon the ecology of the adjacent marine environment may be expected to result from the following causes: (1) physical effects from construction, (2) effects associated with the cooling water intake, (3) chemical additions to the cooling water discharge, and (4) thermal addition to the cooling water discharge.

During construction of the breakwaters and the cooling water intake and discharge systems, sediments will be stirred up, the water will become turbid and silting will occur on lobster pots, Irish moss plants, etc. Some destruction of life or avoidance of the area by motile species may occur. The extent of such possible damage can hardly be predicted, but it would be expected to be highly localized and temporary.

No significant adverse biological effects are expected to result from or be associated with the intake of cooling water per se. The broad intake channel between the breakwaters will insure low intake velocities in order to avoid mixing of the warm surface water with the cooler bottom water. The low velocity of the intake will also help to prevent fish and other marine organisms from being attracted to, concentrated by, and eventually caught up in the intake. Some planktonic and free-swimming larval forms or marine organisms will inevitably be entrained in the cooling water and many of these will undoubtedly be killed from the thermal or chemical alterations of the water, as will be discussed below. Any such mortality will be minimized, however, by taking water from subsurface levels, the reduction being generally in direct proportion to the depth of the intake. For example, most of the lobster larvae will be avoided because the cooling water will be taken below elevation (-) 12MSL. As a matter of practical importance to the plant operation, the majority of fouling organisms (barnacles, mussels, algae) will also be avoided in the same way, again in direct proportion to the depth of the intake.

Even if all the microorganisms entrained in the cooling water were killed by its passage through the plant, the volume of water so involved per day is less than 1/10,000 of the volume of Cape Cod Bay and less than 1/1000 of the new water which is brought into the Bay each day by the flushing action of winds, tides and currents.

Chemical pollution of Cape Cod Bay by materials added to the cooling water will also be negligible for the same reasons given above. As stated in Section 5, the only significant chemical addition to the cooling water will be sodium sulfate (Na_2SO_4) which will be discharged into Cape Cod Bay at a rate of 8.6×10^5 pounds per year. However, the volume of cooling water which passes through the plant each day contains some 130×10^6 pounds of salts including 10×10^6 pounds of sulfate and 46×10^6 pounds of sodium ion.

The sodium hypochlorite to be used as an antifouling agent in the salt water cooling system will result in a residual concentration of free chlorine in the discharge water of approximately 1 ppm. This is 5-10 times the lethal concentration for most bacteria and is very close to the lethal threshold for the majority of plants and animals of the plankton, if they were exposed continuously to that concentration. Since the cooling water is diluted by a factor more than tenfold within a few hours of the time of its discharge, no toxic effects from chlorine in the discharge would be expected to occur to the organisms in the receiving water.

The discharge will consist of 311,000 gallons per minute of water, the temperature of which will be approximately 28°F above that of the intake water. In his report, Pritchard has constructed isotherms showing the predicted distribution at high and low tide of water which is 20°, 10°, 5°, and 3°F above the ambient surface temperature. The areas enclosed by these isotherms range from 1.1 acres of +20° water to 176 acres of +3° water.

Generally speaking, few if any harmful effects to the commercially important species of the area are to be expected as a result of the warm water discharge, at least beyond a mixing area in the immediate vicinity of the discharge. There are two reasons for making this assumption. First, the temperature of the water in Cape Cod Bay is, on the whole, rather cold, averaging no more than just above 60°F in mid-summer. Most of the marine species of commercial importance are representatives of the temperate water fauna which also occur south of Cape Cod in considerably warmer water.

The above statement holds true for the lobster, the most important commercial species of the region. Figure 1 shows the mean annual surface temperatures for Cape Cod Bay and Woods Hole. Lobsters are taken from both areas but the summer temperature in Woods Hole averages some 10°F warmer than in Cape Cod Bay. As also shown in Figure 1, even higher late summer temperatures occur in Lagoon Pond, Martha's Vineyard and in the rearing tanks of the State Lobster Hatchery which that body of water supplies. Presumably the Hatchery is located in a favorable environment for lobsters. While the curves show only monthly mean temperatures, the extremes are much greater in the shallow waters of Lagoon Pond than in Cape Cod Bay.

Actually lobsters are much more tolerant of warm water than is generally believed. Figure 1 also shows the lethal temperature for lobsters which have acclimated to high temperatures, which is about 85°F (at optimal conditions of salinity and oxygen). The research on which this statement is based is that of McLeese (1956). The same studies showed that temperature tolerance is independent of the size or age of the lobsters and applies equally well to both the free-swimming larvae and the benthic adults.

The decline in lobster production in Maine during the past several years has, in fact, been attributed to the current climatic cooling trend, according to Robert L. Dow, Research Director of the Maine Sea and Shore Fisheries Department (Dow, 1967). Mr. Dow is presently engaged in a research project in Casco Bay, Maine, in which an attempt is being made to utilize the warm water discharge from the Cousins Island Station of the Maine Central Power Company for the artificial cultivation of lobsters.

Similar statements may be made with respect to the finny fishes and shellfish of commercial or sports fishing importance to the region. The range of all of these species extends well down the east coast of the United States south of Cape Cod.

The one possible exception to the above generalization is the Irish moss, Chondrus crispus. This seaweed is a northern species which cannot survive in warm water. Although its range extends at least as far south as Rhode Island, it does not grow as abundantly or follow the same seasonability in its life history south of Cape Cod as it does in the Plymouth area. Surprisingly, for a species of its commercial importance, its temperature tolerances are not known.

The second reason for believing that the warm water discharge will not be harmful to the commercially important species of the region is that all the latter are bottom-living organisms. The warm water, being less dense, will float on the surface of the untreated cooler water. Pritchard has reported that the excess temperature is primarily restricted to the upper five feet of water; therefore, bottom organisms outside the mixing zone should be completely unaffected by its presence. The only forms of life which might be influenced under these circumstances would be planktonic larvae, such as those of the lobster. As stated above, the latter can withstand temperatures as high as 85°F, more than 10° above the maximum temperature recorded for Cape Cod Bay. In addition, near-shore, where the water is more shallow, the sea moss, though attached to the bottom, may extend its fronds (leaves) near or into the surface layer, particularly at low tide, and thereby become exposed to the warm water.

7.6 Recommendations

In view of the fact that most if not all of the marine species of commercial importance are bottom-living organisms, it is preferable to discharge the heated water as a thin, surface layer over a large area rather than confining it to a smaller area by mixing it vertically. This method has the added advantage that dissipation of heat from the water to the atmosphere is more rapid.

Lethal conditions for many of the local species will be reached or passed if the water temperature exceeds 85°F. As summer surface temperatures may be greater than 70°F, an increase of more than 10°F beyond a reasonable mixing zone should be avoided. The presence of water at or above lethal temperature levels, no matter how confined geographically or vertically, is always a threat to the biota. An unusual combination of hydrographic or meteorological conditions (such as onshore winds during a northeast storm, as mentioned earlier) could potentially move such water to the organisms.

In view of the above considerations, the immediate mixing of the discharged water to the extent necessary to create sub-lethal temperature conditions is recommended. In that connection, however, it would not appear to be necessary to discharge the cooling water at a depth below the summer thermocline, as has been recommended by the U. S. Department of the Interior, Fish and Wildlife Service. Adequate mixing with surface water, through appropriate mechanical means, should be able to achieve the same objective.

In order to verify these predictions of the effects of station effluents on the marine ecology, an ecological study of the region both before and after the plant goes into operation is recommended. Such a survey should consist of two parts:

1. Hydrographic and hydrodynamic studies of the effects of winds, tides, and currents on the surface circulation and flushing rate of Cape Cod Bay. Such studies are, in fact, already underway. They should also be continued for a reasonable period of time after the plant is in operation, when the actual distribution of the effluent can be examined directly, vertically and horizontally, under different environmental conditions.

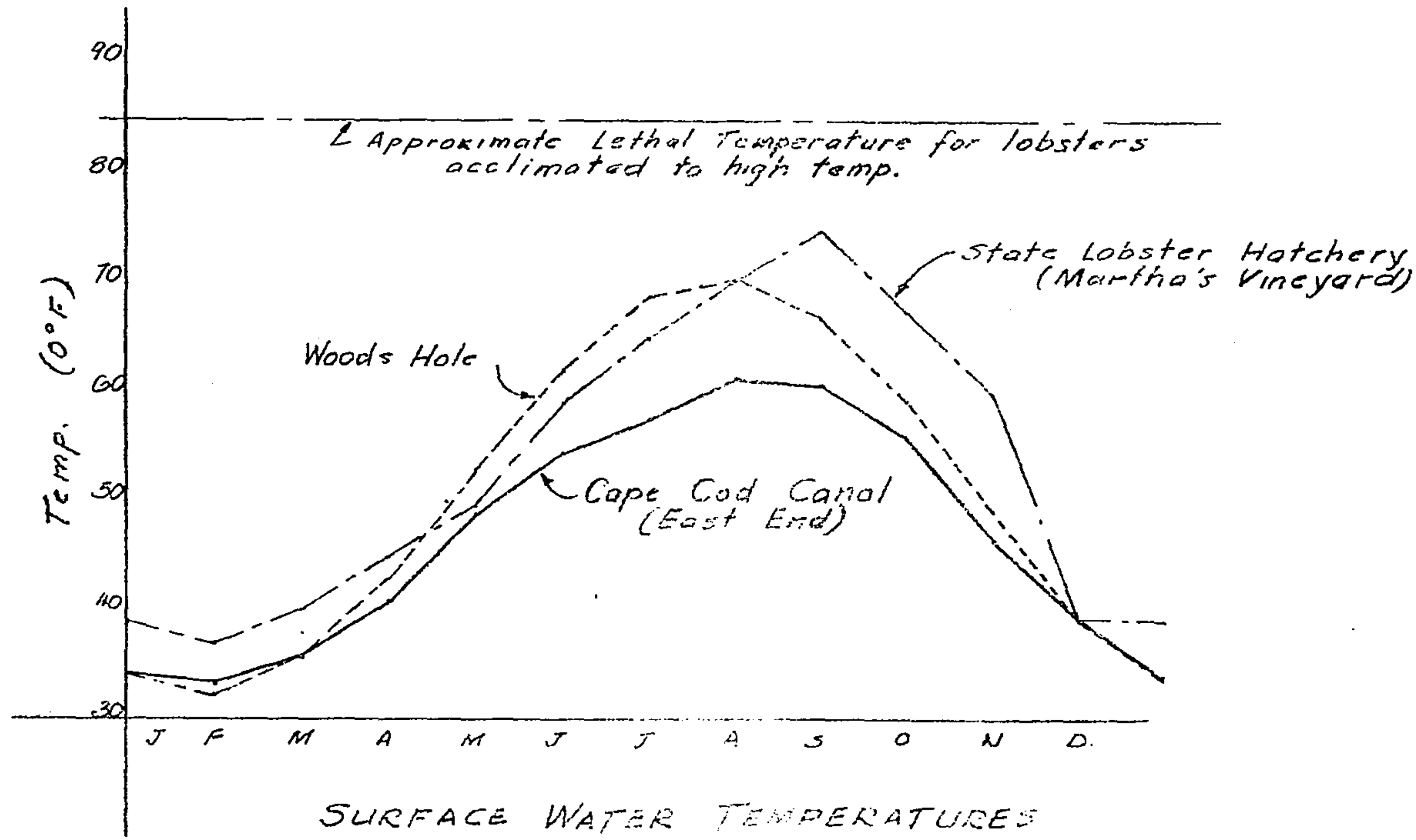
2. A biological survey of the abundance and distribution of marine organisms of commercial importance in representative areas which are likely to be affected by or exposed to the power plant effluent. Sampling or observation of the biota should be carried out at different times of the year and for a period of at least two years before and after the plant goes into operation. The biological survey should include a careful collection of the landing statistics of the commercial species of importance from the area or areas in question. The environmental survey should include the radiological assay of marine organisms as has already been planned.

The biological survey need not be large or extensive in order to provide the necessary information. Local organizations which would be qualified to undertake such a study, include, the Marine Laboratory of the Battelle Memorial Institute in Duxbury, the Systematics and Ecology Program of the Marine Biological Laboratory of Woods Hole, and the Division of Marine Fisheries of the Massachusetts Department of Natural Resources. The Division of Marine Fisheries has recently completed a survey of the Plymouth-Kingston-Duxbury Bay region and is now participating, together with the U. S. Department of the Interior, Bureau of Sport Fisheries, in a "before-and-after" study of the ecology of the Cape Cod Canal and the influence of the new power company at Sandwich, Massachusetts upon its biota. Any one of the above-mentioned organizations would be capable of carrying out the type of ecological survey which is proposed.

7.7 Conclusions

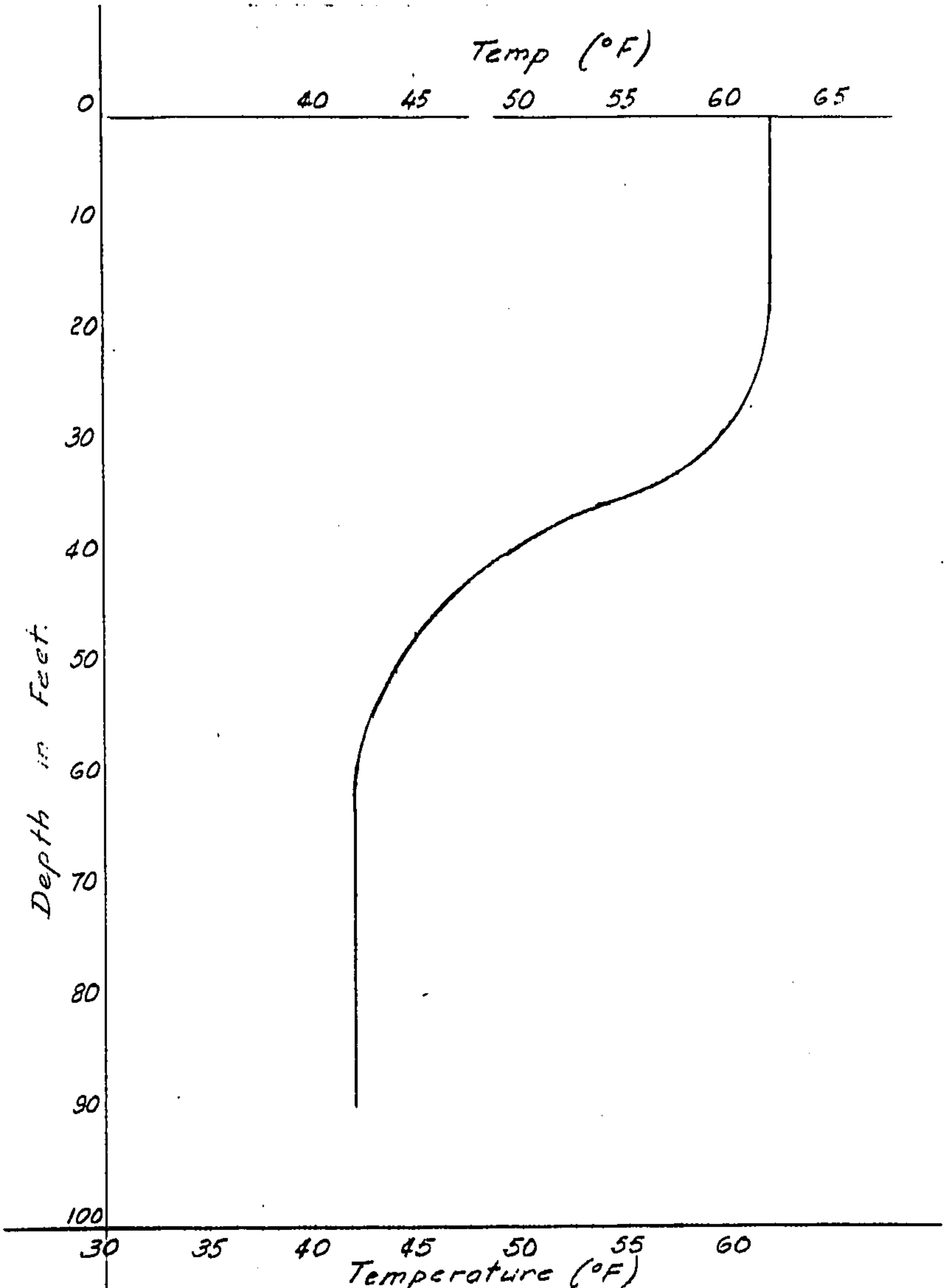
Pritchard's evaluation of thermal and radiological dispersion, expressed in Section 6 of this report, indicates that the desirable objective of rapid mixing, combined with a relatively thin surface layer of warmer water, appears to have been achieved by the proposed design.

The recommended hydrographic and hydrodynamic studies have been completed or initiated. A summary of the proposed ecological survey is included in Section 8 of this report.



SURFACE WATER TEMPERATURES
(MONTHLY MEANS)

SECTION 7-FIGURE 1.



TEMPERATURE - DEPTH PROFILE
(August 18, 1967, 4.5 Miles East of Center Hill Pt.)

SECTION 7-FIGURE 2

8.0 ENVIRONMENTAL PROGRAMS

8.1 Environmental Radiology Program

The environmental radiology program for Pilgrim Station is being developed in cooperation with the Massachusetts Department of Public Health and will provide measurements of radiation levels in the site area prior to operation for comparison with similar measurements to be made after the station begins operation.

Preliminary measurements of the environmental radiation levels are scheduled to begin about July, 1969 to verify that procedures and equipment are satisfactory. Routine measurements will be obtained starting about April, 1970 to obtain one year of pre-operational data. Measurements will be continued during startup and after normal operation of the station.

This program will include measurement of the radiation and radioactivity present in the local air, land and marine environment as necessary to obtain adequate information concerning background radiation levels. The data obtained from the pre-operational environmental radiology surveys in conjunction with control data obtained during operation will provide a reference from which any increase in radiation, due to station operation or other causes, can be detected and evaluated.

A continuing evaluation of the program will be performed, and modifications will be made as necessary to insure the adequacy and applicability of the data produced and to provide assurance that the environmental radiology program satisfies Public Health requirements.

A detailed description of the environmental radiology program is now being prepared and should be available for review by the Department of Public Health during November, 1968. Test results from this program will be made available to the Department of Public Health.

8.2 Environmental Ecology Program

The environmental ecology program for Pilgrim Station will be developed in cooperation with the Massachusetts Department of Marine Fisheries and will provide surveys of the ecology in the offshore areas near the site prior to operation for comparison with similar surveys to be made after the station begins operation.

The pre-operational ecology surveys in conjunction with data from control locations during operation will provide a reference from which any changes in ecology, due to station operation or other causes, can be detected and evaluated.

From predictions of the degree and distribution of the heated effluent, it is recommended that environmental ecology surveys be concentrated in an offshore area within a radius of approximately one mile from the discharge location. Topographic features may dictate some slight modification of this area definition, but this is the region within which surface temperature increases of a few degrees Fahrenheit or more would ever be expected to occur and is generally the region within which ecological changes might be statistically determinable. In addition, control locations outside the study area should be established for selected biological sampling to permit detection of changes not related to the operation of Pilgrim Station. The location of these control stations should vary depending upon the particular kind of organism being studied. The collection of selected marine samples for the environmental radiology program will extend beyond the area proposed for ecology studies because of the reconcentration potential of certain marine species.

The physical environment within the ecological study area should be monitored during the period of the ecology studies and should include the measurement of water temperature, salinity and currents. Measurements of the distribution of these physical parameters in the study area should be obtained whenever the ecology surveys are made.

It is recommended that the ecology surveys include studies of plankton, lobsters, Irish moss, and any selected game and commercial fish species which are later determined to be important in the study area.

The plankton (floating plant and animal microorganisms) either directly or indirectly constitutes the basic food for all marine life. It is particularly susceptible to environmental changes and occurs in the surface waters where the heated effluent predominates. Plankton also includes the free-swimming larvae of many species of commercial importance including lobster, shellfish, worms, and seaweeds. It is, therefore, recommended that quantitative samples of plankton be taken routinely from both surface and subsurface (near bottom) waters in the study area for:

1. Identification and enumeration of the quantitatively important species of both phytoplankton and zooplankton.

2. Total quantity (biomass) of both phytoplankton and zooplankton.

3. Identification and quantitative estimation of larval forms of commercial importance, with special attention to lobster larvae.

Similar samples should be obtained from a representative control location for comparison with those obtained in the study area. Sampling is recommended throughout the year at intervals of approximately one-month from April through October and at approximately two-month intervals at other times.

As lobsters are the most important commercial species of the region, an intensive study of the abundance and distribution of lobsters in the study area should be carried out. This should include the study of lobster larvae which was discussed above as part of the plankton study. Studies on adult lobsters in the study should include:

1. Estimates of natural abundance and distribution of lobsters on the bottom by scuba diving.

2. Compilation of "landing statistics" for lobsters.

Similar information should be obtained from a representative control location for comparison with that obtained in the study area. Obtaining a valid comparison of harvest statistics for the study area and the control area will probably require a statistical approach using data from a large number of pots within each area. No measurable changes in the lobster harvest are expected as a result of operation of the station; however, historical confirmation of this is considered essential because of the large economic value of the lobster harvest off the station site. It may be desirable to perform experimental studies regarding temperature effects on lobsters under controlled laboratory conditions to supplement information currently available. Such laboratory information might be valuable in predicting effects of water temperature changes on lobsters which would not be discernable in the field studies. Additional information regarding the temperature effects on lobsters may be available from other studies being conducted in the New England area.

Irish moss (the seaweed, Chondrus crispus) is probably the second most important commercial species taken from the study area. Compilation of "landing statistics" for Irish moss harvested in the study area should be compared to similar information from a control area. Ellisville is another commercially important area for Irish moss that might be considered as a control location. Laboratory studies and monitoring of experimental plots of Irish moss may be desirable to permit evaluation of temperature effects which might not be detectable from field studies. A student from Cornell University plans independently to begin an ecological study of this alga in the Rocky Point area during the spring of 1969 and it is recommended that he assist in any studies done for Pilgrim Station. Studies of Irish moss are also being done at other New England locations and information may become available from these programs.

Game and commercial fishing in the study area is not extensive and information concerning these activities is difficult to obtain. Some semi-quantitative data could be gathered periodically by the following methods, but such information is not considered to be essential:

1. Creel census of sports fishermen working from boat liveries or marinas in the Plymouth area. The striped bass sports fishing should be emphasized in this type of study. Information obtained in such a study might include number of hours fished in the study area, number of fish caught, and catch per unit effort, within, as compared to outside, the study area.

2. Interviews with commercial bottom trawlers who fish the study areas, obtaining the same type of information as above.

3. General abundance and distribution of bottom fishes, as observed by scuba diving. This can be accomplished at the same time as the scuba lobster survey.

It is recommended that the proposed environmental ecology surveys begin in the spring of 1969 and continue through the summer of 1973 to provide two years of data before and two years of data after initial power operation of Pilgrim Station which is scheduled for the summer of 1971.

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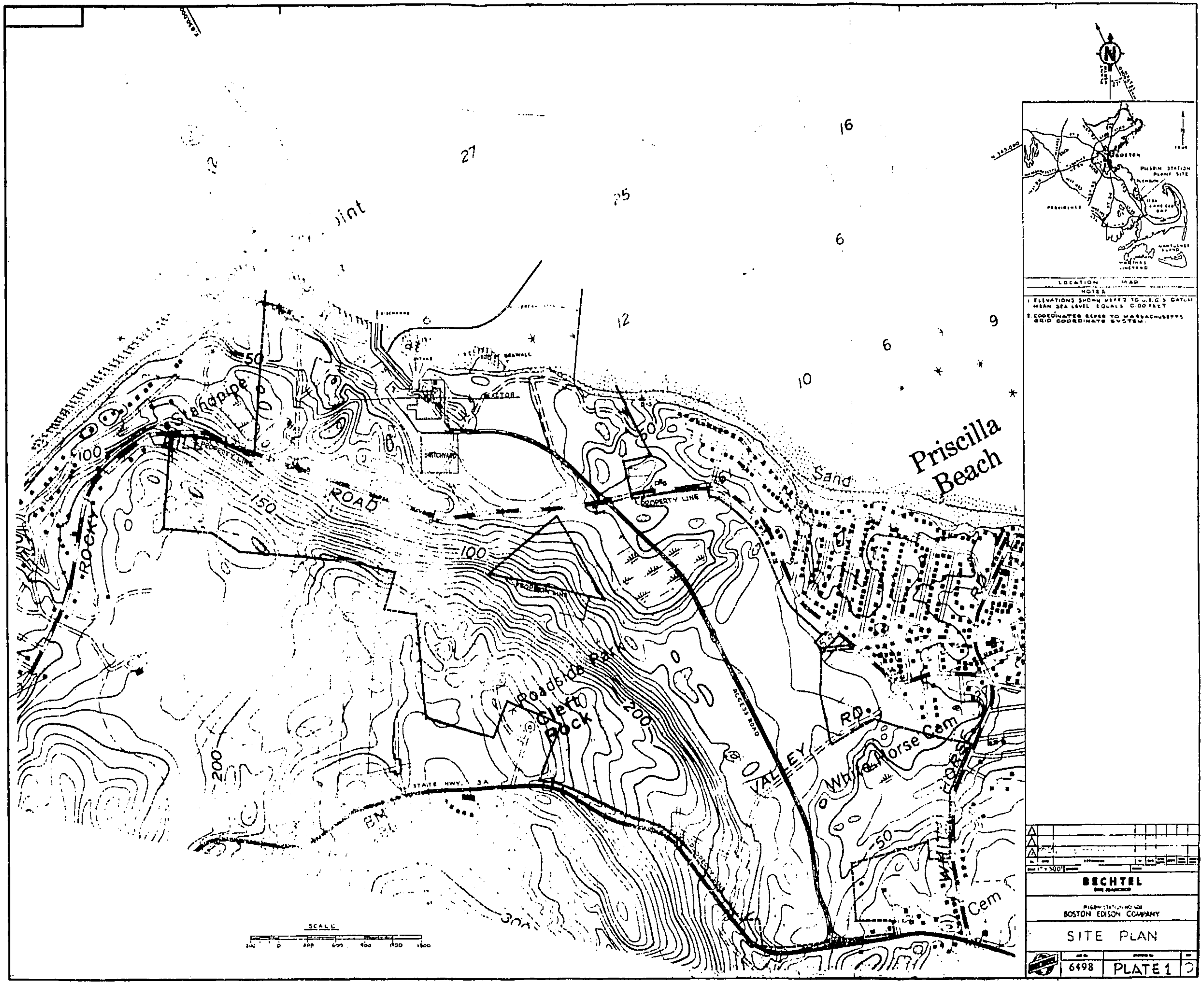
Priscilla Beach
Sand
ROCKY
ROAD
Standpipe
PROPERTY LINE
SWITCHYARD
REACTOR
SEAWALL
ACCESS ROAD
Roadside Park
Cleft Rock
VALLEY RD.
White Horse Cem
Cem
STATE HWY. 3A
BM
100
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LOCATION MAP
BOSTON
PILGRIM STATION PLANT SITE
PROVIDENCE
NOTES
SCALE
1" = 300'
BECHTEL
BOSTON EDISON COMPANY
SITE PLAN
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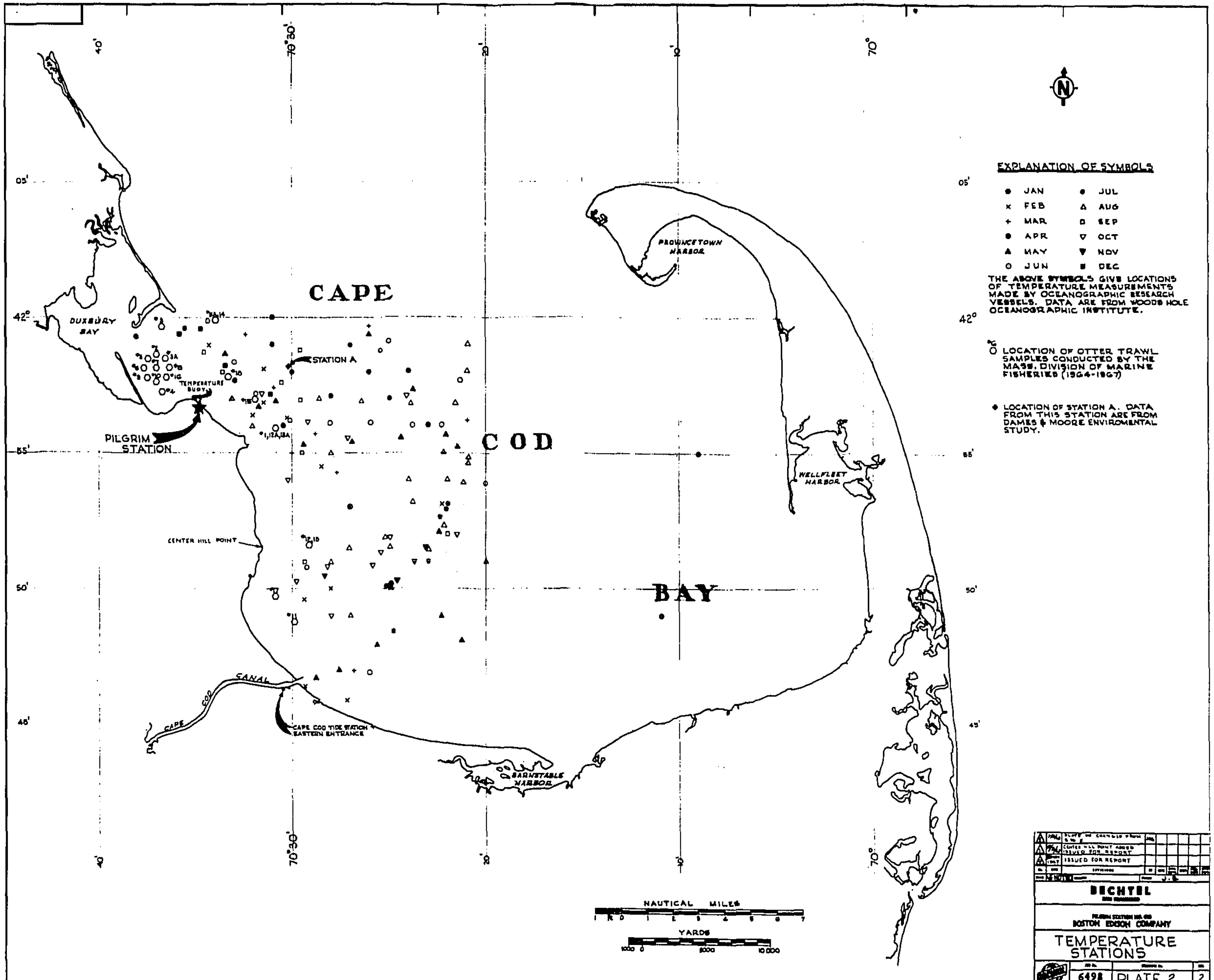
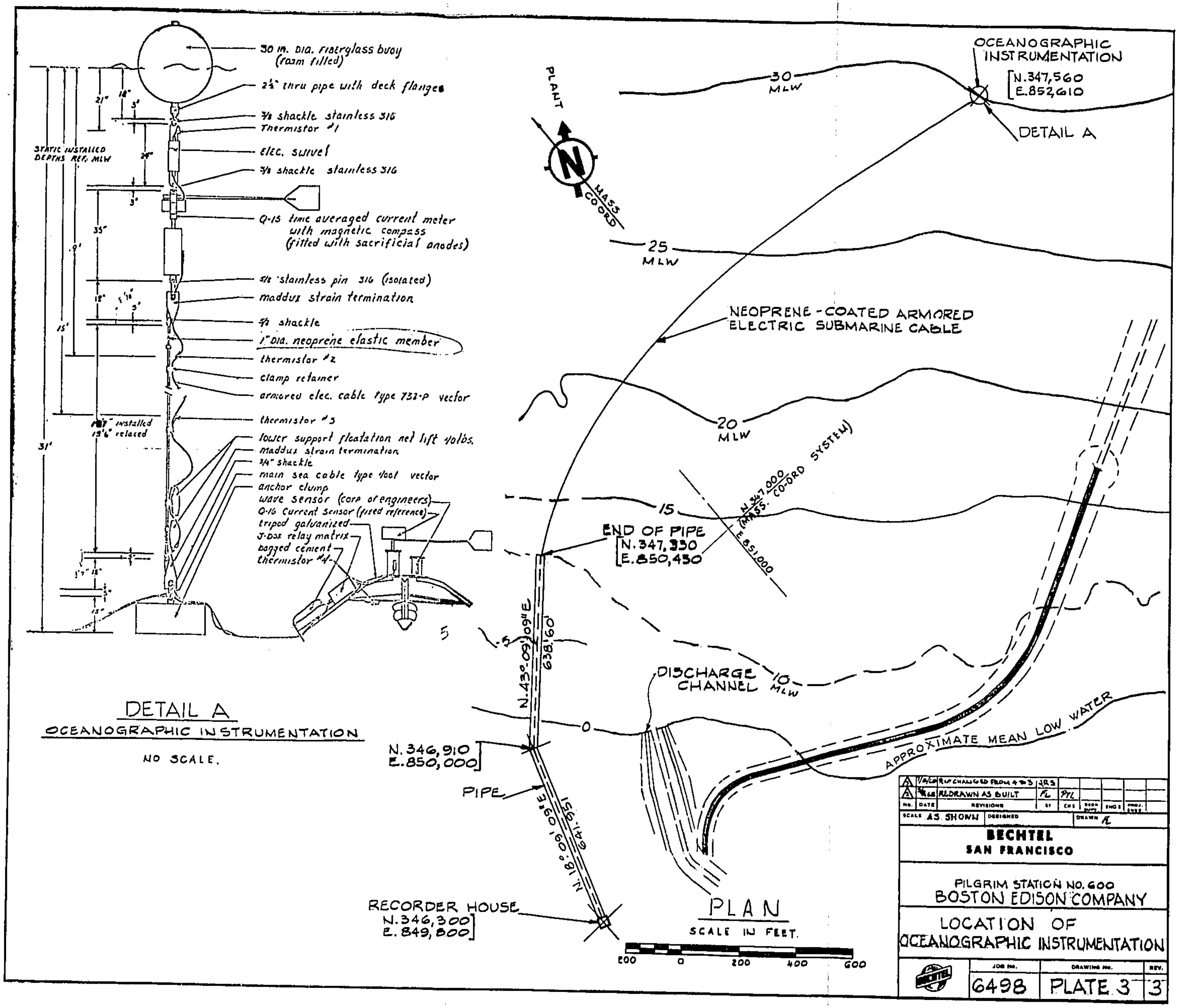
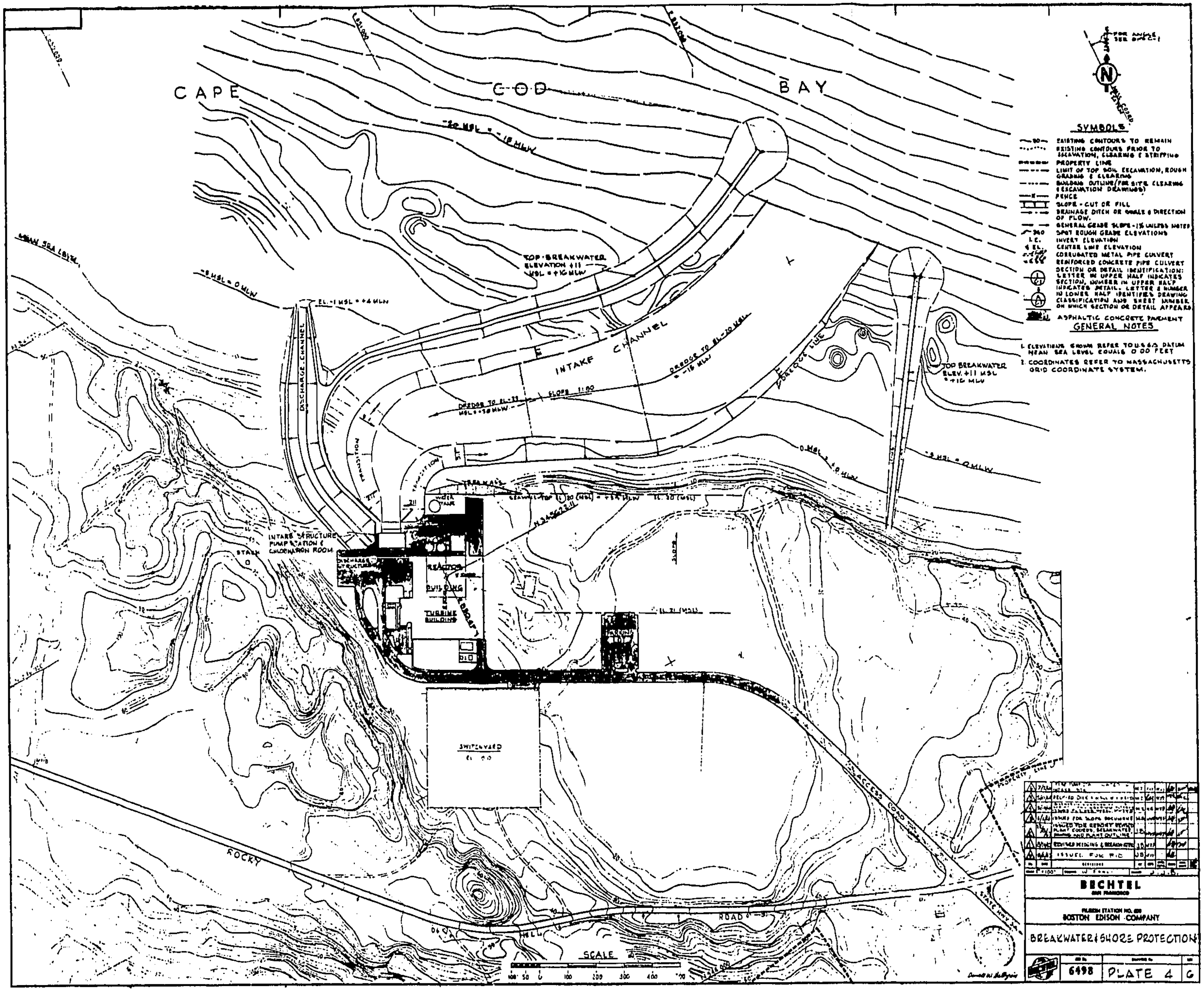
PLATE 1


CAPE
COD
BAY
DUXBURY BAY
STATION A
TEMPERATURE BUOY
PILGRIM STATION
CENTER HILL POINT
CANAL
CAPE COD
CAPE COD TIDE STATION EASTERN ENTRANCE
BARNSTABLE HARBOR
PROVINCETOWN HARBOR
WELLFLEET HARBOR
70°30'
70°
42°
05'
55'
50'
45'
40'
20'
10'
EXPLANATION OF SYMBOLS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
THE ABOVE SYMBOLS GIVE LOCATIONS OF TEMPERATURE MEASUREMENTS MADE BY OCEANOGRAPHIC RESEARCH VESSELS. DATA ARE FROM WOODS HOLE OCEANOGRAPHIC INSTITUTE.
LOCATION OF OTTER TRAWL SAMPLES CONDUCTED BY THE MASS. DIVISION OF MARINE FISHERIES (1964-1967)
LOCATION OF STATION A. DATA FROM THIS STATION ARE FROM DAMES & MOORE ENVIROMENTAL STUDY.
NAUTICAL MILES
YARDS
ISSUED FOR REPORT
BECHTEL
BOSTON EDISON COMPANY
TEMPERATURE STATIONS
6498
PLATE 2
2


30 in. Dia. fiberglass buoy (foam filled)
2½" thru pipe with deck flanges
¾ shackle stainless 316
Thermistor #1
elec. swivel
¾ shackle stainless 316
Q-15 time averaged current meter with magnetic compass (fitted with sacrificial anodes)
5/8 stainless pin 316 (isolated)
maddux strain termination
5/8 shackle
1" Dia. neoprene elastic member
thermistor #2
clamp retainer
armored elec. cable type 733-P vector
thermistor #3
lower support floatation net lift 40lbs.
maddux strain termination
¾" shackle
main sea cable type 1001 vector
anchor clump
wave sensor (corp of engineers)
Q-16 current sensor (fixed reference)
tripod galvanized
J-box relay matrix
bagged cement
thermistor #4
STATIC INSTALLED DEPTHS REF. MLW
installed 13'6" relaxed
DETAIL A
OCEANOGRAPHIC INSTRUMENTATION
NO SCALE.
PLANT
N
MASS COORD
OCEANOGRAPHIC INSTRUMENTATION
N. 347,560
E. 852,610
DETAIL A
30 MLW
25 MLW
20 MLW
15
10 MLW
5
0
NEOPRENE-COATED ARMORED ELECTRIC SUBMARINE CABLE
N. 347,000 (MASS. CO-ORD SYSTEM)
E. 851,000
END OF PIPE
N. 347,330
E. 850,450
N. 43°-09'-09"E 638.60'
N. 346,910
E. 850,000
PIPE
N. 18°-09'-09"E 641.551
RECORDER HOUSE
N. 346,300
E. 849,800
DISCHARGE CHANNEL
APPROXIMATE MEAN LOW WATER
PLAN
SCALE IN FEET
200 0 200 400 600
REDRAWN AS BUILT
REVISIONS
SCALE AS SHOWN
BECHTEL
SAN FRANCISCO
PILGRIM STATION NO. 600
BOSTON EDISON COMPANY
LOCATION OF OCEANOGRAPHIC INSTRUMENTATION
JOB NO. 6498
DRAWING NO. PLATE 3
REV. 3

02339 0943


CAPE COD BAY
SYMBOLS
EXISTING CONTOURS TO REMAIN
EXISTING CONTOURS PRIOR TO EXCAVATION, CLEARING & STRIPPING
PROPERTY LINE
LIMIT OF TOP SOIL EXCAVATION, ROUGH GRADING & CLEARING
BUILDING OUTLINE (FOR SITE CLEARING & EXCAVATION DRAWINGS)
FENCE
SLOPE - CUT OR FILL
DRAINAGE DITCH OR SWALE & DIRECTION OF FLOW.
GENERAL GRADE SLOPE - 1% UNLESS NOTED
SPOT ROUGH GRADE ELEVATIONS
INVERT ELEVATION
CENTER LINE ELEVATION
CORRUGATED METAL PIPE CULVERT
REINFORCED CONCRETE PIPE CULVERT
SECTION OR DETAIL IDENTIFICATION: LETTER IN UPPER HALF INDICATES SECTION, NUMBER IN UPPER HALF INDICATES DETAIL. LETTER & NUMBER IN LOWER HALF IDENTIFIES DRAWING CLASSIFICATION AND SHEET NUMBER ON WHICH SECTION OR DETAIL APPEARS
ASPHALTIC CONCRETE PAVEMENT
GENERAL NOTES
1. ELEVATIONS SHOWN REFER TO U.S.G.S. DATUM MEAN SEA LEVEL EQUALS 0.00 FEET
2. COORDINATES REFER TO MASSACHUSETTS GRID COORDINATE SYSTEM.
TOP BREAKWATER ELEVATION +11 MSL = +16 MLW
TOP BREAKWATER ELEV. +11 MSL +16 MLW
INTAKE CHANNEL
DISCHARGE CHANNEL
INTAKE STRUCTURE PUMP STATION & CHLORINATION ROOM
DISCHARGE STRUCTURE
REACTOR BUILDING
TURBINE BUILDING
SWITCHYARD
ACCESS ROAD
ROCKY
ROAD
STATE HWY
SCALE
BECHTEL
BOSTON EDISON COMPANY
BREAKWATER & SHORE PROTECTION
6498
PLATE 4
G

Enclosure 2

Department of Army, Corps of Engineers

Application for Permit to Discharge or Work in Navigable Waters and Their Tributaries

September 30, 1971

FORM APPROVED
OMB NO. 49-R 0408

DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

APPLICATION FOR PERMIT TO DISCHARGE OR WORK IN NAVIGABLE WATERS AND THEIR TRIBUTARIES

A0008557

SECTION I. GENERAL INFORMATION	1. State	Application Number (to be assigned by Corps of Engineers)			
	M A	07Y	000	3	000084
		Div.	Dist.	Type	Sequence No.

2. Name of applicant and title of signing official

Boston Edison Company

Maurice J. Feldmann, Vice President - Operations and Engineering

3. Mailing address of applicant

Boston Edison Company
800 Boylston Street
Boston, Massachusetts 02199

4. Name, address, telephone number and title of applicant's authorized agent for permit application coordination and correspondence.

~~Claude A. Pursel~~ William M. Irving
~~Assistant Vice President - Nuclear~~ J.E. Howard V.P.
Boston Edison Company P.J. McGuire, Plant Mgr
800 Boylston Street
Boston, Massachusetts 02199
(617) 424-2477

NOTE TO APPLICANT: Refer to the pamphlet entitled "Permits for Work and Structures in and for Discharges or Deposits into Navigable Waters" before attempting to complete this form.

Required Information

a. All information contained in this application will, upon request, be made available to the public for inspection and copying. A separate sheet entitled "Confidential Answers" must be used to set out information which is considered by the applicant to constitute trade secrets or commercial or financial information of a confidential nature. The information must clearly indicate the item number to which it applies. Confidential treatment can be considered only for that information for which a specific written request of confidentiality has been made on the attached sheet. However, in no event will identification of the contents and frequency of a discharge be recognized as confidential or privileged information.

b. The applicant shall furnish such supplementary information as is required by the District Engineer in order to evaluate fully an application.

c. If additional space is needed for a complete response to any item on this form, attach a sheet entitled "Additional Information." Indicate on that sheet the item numbers to which answers apply.

d. Drawings required by items 20 and 21 should be attached to this application. Other papers which must be attached to this application include, if applicable, copies of a water quality certification or a written communication which describes water quality impact (see Item 22 and Item 10 of Section II below), the additional information sheet(s) in "c" above, and the confidential information sheet described in "a" above.

Fees

If any discharge or deposit is involved, an application fee of $100 must be submitted with this application. An additional $50 is required for each additional point of discharge or deposit.

Signature

a. If a discharge is involved, an application submitted by a corporation must be signed by the principal executive officer of that corporation or by an official of the rank of corporate vice president or above who reports directly to such principal executive officer and who has been designated by the principal executive officer to make such applications on behalf of the corporation. In the case of a partnership or a sole proprietorship, the application must be signed by a general partner or the proprietor. Other signature requirements are discussed in the pamphlet.

b. If no discharge is involved, an application may be signed by the applicant or his authorized agent.

Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate.

[signature]
Signature of Applicant

9/30/1971

18 U.S.C. Section 1001 provides that:

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and wilfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

FOR CORPS OF ENGINEERS USE ONLY

Acronym name of applicant ______

Are discharge structures Major? ☐ Minor? ☐ N/A? ☐

Date received, form not complete — — — — — — —
Date received, form complete but without certificate — — — — — — —
Date received, form complete — — — — — — —
Date of Cert./Ltr. — — — — — — —
day mo yr

Date sent to EPA, form not complete — — — — — — —
Date sent to EPA, NOAA, D/I, AEC, FPC in complete form — — — — — — —
day mo yr

ENG FORM MAY 71 4345

1 - OCT 1971

255

ate Sept. 29 _
mo day yr

(Office use only)

heck type of application: a. Original [ ] b. Revision [X]

7. Number of original application
3-000084

. Name of facility where discharge or construction will occur.
Pilgrim Nuclear Power Station, No. 600

9. Full mailing address of facility named in item 8 above.
Boston Edison Company
Pilgrim Nuclear Power Station — Attn: Michael Naughton, Chief Tech. Operator
RFD #1, Rocky Hill Road
Plymouth, Massachusetts 02360

10. Names and mailing addresses of all adjoining property owners whose property also adjoins the waterway.
1. (Northwest) Joint Property Owners (3) - Francis W. Sears, Charlotte Sears, Marion V. Sears - Pine Tree Road, Norwich, Vermont
2. (Southeast) Property Owner (1) - Richard N. Greenwood, RFD #1, Plymouth, Massachusetts 02360

11. Check to indicate the nature of the proposed activity:
a. Dredging [X] * b. Construction [ ] c. Construction with Discharge [X] ** d. Discharge only [ ]

12. If activity is temporary in nature, estimate its duration in months.
Permanent

If application is for a discharge:

List intake sources

Source	Estimated Volume in Million Gallons Per day or Fraction Thereof
Municipal or private water supply system	0.0265
Surface water body (sea water)	474.
Ground water	0.
Other	0.

scribe water usage within the plant

Type	Estimated Volume in Million Gallons Per day or Fraction Thereof
Cooling water	474.
Boiler Feed water (recycled)	0.
Process water (recycled)	0.
Sanitary system*	.0025
Other (make-up to process flows)	.024

volume of discharges or losses other than into navigable waters.

Type	Estimated Volume in Million Gallons Per day or Fraction Thereof
Municipal waste treatment system	0.
Surface containment	0
Underground disposal	0.0025
Waste Acceptance firms	0.
Evaporation	0.
Consumption	0.

Indicate number employees served per day 100

4345 *Maintenance dredging as indicated in Item 24.
**Construction complete. See Item 22.

a: Name the corporate boundaries within whic[...] [...]ctures exist or the activity will occur.

State | County | City or Town

16. Massachusetts 17. Plymouth 18. Plymouth

b. Name of waterway at the location of the activity

19. Cape Cod Bay

20. Maps which show the location of each structure or activity, including any and all outfall devices, dispersive devices, and non-structural points of discharge, must be attached to this application.

21. The character of each structure must be fully shown on plans to be submitted with this application. Note on the drawings those structures for which separate discharge information (Section II of this form) has been submitted.

22. List all approvals or denials granted by Federal, interstate, State or local agencies for any structures, construction, discharges or deposits described in this application.

Type of document	Id. No.	Date	Issuing Agency

See Attachment No. 1

23. Check if facility existed or was lawfully under construction prior to April 3, 1970. [X]

[2]4. If dredging or filling will occur:

State the type of materials involved, their volume in cubic yards, and the proposed method of measurement.

Maintenance dredging of intake channel, (unscheduled) on a contingency basis, measured by disposal barge capacity and number of barges filled.

Describe the proposed method of instrumentation which will be used to measure the volume of any solids deposited and to determine its effect upon the waterway.

Only suspended and dissolved solids will be discharged. These are expected to remain in suspension indefinitely and will not effect the waterway. Total volumes of all such solids will be determined periodically from effluent samples and the plant operations log books which will include records of all discharge volumes.

[...] rates and periods of deposition described in Item 25.

[...]uid discharges are continuous, but no deposition is expected.

[...] Attachment 2 for further information on rates of discharge.)

[...] 4345.

SECTION II. PLANT PROCESS AND DISCHARGE DESCRIPTION

1. Discharge described below is
   a. Present [x]
   b. Proposed new or changed [ ]

2. Implementation schedule [ ]

(Office use only)

6. Discharge Serial No. 001

Name of corporate boundaries within which the point of discharge is located.

State	County	City or Town
3. Massachusetts	4. Plymouth	5. Plymouth

State the precise location of the point of discharge.

7. Latitude 4 1 Degrees; 5 6 Min; 5 1 Sec.

8. Longitude 7 0 Degrees; 3 4 Min; 4 8 Sec.

9. Name of waterway at the point of discharge.

Cape Cod Bay

10. Has application for water quality certification or description of impact been made? If so, give date:

Date: Aug. (mo) 24 (day) 71 (yr)

Check if certificate is attached to form [ ]

Name Issuing Agency:
The Commonwealth of Mass.
Water Resources Commission
Div. of Water Pollution Control

11. Narrative description of activity (include terms of general 4-digit Standard Industrial Classification, and specific manufacturing process).

Production of electric power by steam turbine generator; steam supplied by boiling water nuclear reactor.

12. Standard industrial classification number.

SIC-491

13. Principal product.

Electric power

14. Amount of principal product produced per day.

16.45 million kilowatt hours

15. Principal raw material.

Uranium

16. Amount of principal raw material consumed per day.

Approximately 6 lbs./day irretrievable

17. Number of batch discharges per day.

See Attachment 2

18. Average gallons per batch discharge.

See Attachment 2

19. Date discharge began.

See Attachment 2
mo day yr

20. Date discharge will begin.

See Attachment 2
mo day yr

21. Describe waste abatement practices.

Dispersion and loss from the bay of the rejected heat from the discharge is enhanced by the discharge structure design as follows: The excess momentum associated with the condenser cooling water as it is discharged into the waters of Cape Cod Bay produces an entraining jet which is diluted by the mechanical entrainment required to reduce the velocity of the jet to that of the surrounding waters. Surface discharge promotes conductive and convective cooling to the air over the receiving body. Prior to discharge from the station each batch of liquid radwaste is sampled and analyzed for radioactivity to determine the allowable rate of discharge. In addition, the liquid radwaste discharge line is provided with a continuous radioactivity monitor to record the activity of any liquids released to the circulating water system. After mixing with the circulating water, the radioactivity of liquid wastes discharged from the station will be below the limits specified in 10 CFR 20, Standards for Protection Against Radiation. The Station will be operated to keep radioactivity in effluents as low as practicable.

22. PHYSICAL DESCRIPTION OF INTAKE WATER AND DISCHARGE

Intake	Discharge	(Office use only)
		Discharge Serial No. 001

Parameter and (Code)	(1) UNTREATED INTAKE WATER	(2) TREATED INTAKE WATER	(3) AVERAGE (DAILY)	(4) MINIMUM (OPERATING YEAR)	(5) MAXIMUM (OPERATING YEAR)	(6) SAMPLE FREQUENCY	(7) CONTINUOUS MONITORING
Flow (Gallons per day) 50050	474 *MGD*		474	474	474		ABS
pH 00400	7.7 ± 0.5		7.7	7.2	8.2	MNLY	ABS
Temperature (Winter) (°F) 74028	35	*average*	64	32	69	DYLY	MON*
Temperature (Summer) (°F) 74027	60 *70 max*		89	36 *actually middle* *Bottom temp*	99	DYLY	MON*

23. DISCHARGE CONTENTS (See Item 25)

PARAMETER	PRESENT	ABSENT	PARAMETER	PRESENT	ABSENT	PARAMETER	PRESENT	ABSENT
Color 00080		x	Aluminum 01105		x	Nickel 01067		x
Turbidity 00070		x	Antimony 01097		x	Selenium 01147		x
Radioactivity 74050	x		Arsenic 01002		x	Silver 01077		x
Hardness 00900		x	Beryllium 01012		x	Potassium 00937		x
Solids 00500	x		Barium 01007		x	Sodium 00929	x	
Ammonia 00610		x	Boron 01022	x		Titanium 01152		x
Organic Nitrogen 00605		x	Cadmium 01027		x	Tin 01102		x
Nitrate 00620		x	Calcium 00916		x	Zinc 01092		x
Nitrite 00615	x		Cobalt 01037		x	Algicides 74051	x	
Phosphorus 00665		x	Chromium 01034		x	Oil and Grease 00550		x
Sulfate 00945	x		Copper 01042		x	Phenols 32730		x
Sulfide 00745		x	Iron 01045		x	Surfactants 38260		x
Sulfite 00740		x	Lead 01051		x	Chlorinated Hydrocarbons 74052		x
Bromide 71870		x	Magnesium 00927		x	Pesticides 74053		x
Chloride 00940	x		Manganese 01055		x	Fecal Streptococci Bacteria 74054		x
Cyanide 00720		x	Mercury 71900		x	Coliform Bacteria 74056		x
Fluoride 00951		x	Molybdenum 01062		x			

ENG FORM MAY 71 4345-1 * Values recorded, but not continuously.

24a. Have all known hazardous or potentially hazardous substances in your plant been inventoried?

[X] Yes [ ] No

24b. If yes, have steps been taken to insure that there exists no possibility of any such known hazardous or potentially hazardous substance entering this discharge?

[X] Yes [ ] No

25. Remarks. Parts A & B-2, Column 4 - Units are pounds/day per million kWhr/day.
Item 22 - pH and temperature values for discharge are based on measurements of intake water properties and changes predicted to occur after full power operation is initiated.
Item 23 - "Discharge Contents," lists only those discharges which are added to the normal sea water inventory.

The information above completes the basic reporting requirements which are required of all applicants. Those applicants whose discharge results from an activity included within any of the Standard Industrial Classification Code (SIC Code) categories listed below must complete Part A of this form as well.

CRITICAL INDUSTRIAL GROUPS

SIC	098	FISH HATCHERIES, FARMS, AND PRESERVES
SIC	10–14	DIVISION B – MINING
SIC	201	MEAT PRODUCTS
SIC	202	DAIRY PRODUCTS
SIC	203	CANNED PRESERVED FRUITS, VEGETABLES (EXCEPT SEAFOODS, SIC 2031 AND 2036)
SIC	2031, 2036	CANNED AND CURED FISH AND SEAFOODS; FRESH OR FROZEN PACKAGED FISH AND SEAFOODS
SIC	204	GRAIN MILL PRODUCTS
SIC	206	SUGAR
SIC	207	CONFECTIONARY AND RELATED PRODUCTS
SIC	208	BEVERAGES
SIC	209	MISCELLANEOUS FOOD PREPARATIONS AND KINDRED PRODUCTS
SIC	22	TEXTILE MILL PRODUCTS
SIC	23	APPAREL AND OTHER FINISHED PRODUCTS MADE FROM FABRICS AND SIMILAR MATERIALS
SIC	242	SAWMILLS AND PLANING MILLS
SIC	2432	VENEER AND PLYWOOD
SIC	2491	WOOD PRESERVING
SIC	26	PAPER AND ALLIED PRODUCTS
SIC	281	INDUSTRIAL INORGANIC AND ORGANIC CHEMICALS (EXCEPT SIC 2818)
SIC	2818	INDUSTRIAL ORGANIC CHEMICALS
SIC	282	PLASTICS MATERIALS AND SYNTHETIC RESINS, SYNTHETIC RUBBER, SYNTHETIC AND OTHER MAN-MADE FIBERS, EXCEPT GLASS
SIC	283	DRUGS
SIC	284	SOAP, DETERGENTS, AND CLEANING PREPARATIONS, PERFUMES, COSMETICS, AND OTHER TOILET PREPARATIONS
SIC	285	PAINTS, VARNISHES, LACQUERS, ENAMELS, AND ALLIED PRODUCTS
SIC	2871	FERTILIZERS
SIC	2879	AGRICULTURAL PESTICIDES, AND OTHER AGRICULTURAL CHEMICALS, NOT ELSEWHERE CLASSIFIED
SIC	2891	ADHESIVES AND GELATIN
SIC	2892	EXPLOSIVES
SIC	29	PETROLEUM REFINING AND RELATED INDUSTRIES
SIC	3011, 3069	TIRES AND INNER TUBES; FABRICATED RUBBER PRODUCTS, NOT ELSEWHERE CLASSIFIED
SIC	3079	MISCELLANEOUS PLASTICS PRODUCTS
SIC	311	LEATHER TANNING AND FINISHING
SIC	32	STONE, CLAY, GLASS, AND CONCRETE PRODUCTS
SIC	331	BLAST FURNACES, STEEL WORKS, AND ROLLING AND FINISHING MILLS
SIC	332	IRON AND STEEL FOUNDRIES
SIC	333, 334	PRIMARY SMELTING AND REFINING OF NONFERROUS METALS; SECONDARY SMELTING AND REFINING OF NONFERROUS METALS
SIC	336	NONFERROUS FOUNDRIES
SIC	347	COATING, ENGRAVING, AND ALLIED SERVICES
SIC	35	MACHINERY, EXCEPT ELECTRICAL
SIC	36	ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES
SIC	37	TRANSPORTATION EQUIPMENT (EXCEPT SHIP BUILDING AND REPAIRING, SIC 3731)
SIC	3731	SHIP BUILDING AND REPAIRING
SIC	491	ELECTRIC COMPANIES AND SYSTEMS
SIC	493	COMBINATION COMPANIES AND SYSTEMS

(Note: Submission of Part A is required of all applic ose processes are listed on page 3 above.)

(Office use only)

000084

Discharge Serial No. 001

INFORMATION REQUIRED OF SPECIFIED INDUSTRIES *

	Intake		Discharge								
PARAMETER AND CODE	(DAILY AVG. CONCENTRATION) UNTREATED INTAKE WATER (1)	(DAILY AVG. CONCENTRATION) TREATED INTAKE WATER (2)	MAXIMUM CONCENTRATION (3)	MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	MAXIMUM POUNDS PER DAY (5)	DAILY AVG. CONCENTRATION (6)	AVERAGE POUNDS PER DAY (7)	SAMPLE TYPE (8)	SAMPLE FREQUENCY (9)	METHOD OF ANALYSIS (10)	CONTINUOUS MONITORING (11)
ALKALINITY (as $CaCO_3$) 00410	109.±1.		110.			109.		Aver.	Wkly.	Stand.	ABS
B.O.D. 5-DAY 00310	9.±7.		12.			7.		Aver.	Wkly.	Stand.	ABS
CHEMICAL OXYGEN DEMAND (C.O.D.) 00340	426. ± 58.		520.			373.		Aver.	Wkly.	Stand.	ABS
TOTAL SOLIDS 00500	37,705 ±1,585		38,444 (11)	(790)	(13,000)	37,535 (1.2)	(4,200)	Aver.	Wkly.	Stand.	ABS
TOTAL DISSOLVED SOLIDS 70300	37,704 ±1,585		38,444 (10)	(790)	(13,000)	37,533 (1.2)	(4,200)	Aver.	Wkly.	Stand.	ABS
TOTAL SUSPENDED SOLIDS 00530	2.± 1.		4. (1.)	(3.)	(40)	3. (<1.)	(40)	Aver.	Wkly.	Stand.	ABS
TOTAL VOLATILE SOLIDS 00505	4,008 ±1,632		4,008 (<2.0)	(<100)		3,997		Aver.	Wkly.	Stand.	ABS
AMMONIA (as N) 00610	0.07 ±0.05		0.20			0.10		Aver.	Wkly.	Stand	ABS
KJELDAHL NITROGEN 00625	0.00		0.00			0.00		Aver.	Wkly.	Stand.	ABS
NITRATE (as N) 00620	0.00		0.00			0.00		Aver.	Wkly.	Stand.	ABS
PHOSPHORUS TOTAL (as P) 00665	Trace		Trace			Trace		Aver.	Wkly.	Stand.	ABS

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* Supplementary information on chemical additions in liquid discharge is given in Attachment 3.

PART B DISCHARGE DESCRIPTION

(Note: Submission of Part B is required of all ap… nts who are also required to submit Part A. Only those parameters specifically indicated in the instructions are to be reported by a particular industry)

(Office use only)

000084

Discharge Serial No.
001

B-1. PHYSICAL AND BIOLOGICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-1)

	Intake		Discharge				
PARAMETER AND CODE	UNTREATED INTAKE WATER (1)	TREATED INTAKE WATER (2)	AVERAGE (DAILY) (3)	MINIMUM (OPERATING YEAR) (4)	MAXIMUM (OPERATING YEAR) (5)	SAMPLE FREQUENCY (6)	CONTINUOUS MONITORING (7)
COLOR 00080			NC	X			
SPECIFIC CONDUCTANCE 00095			NC				
TURBIDITY 00070			NC	X			
FECAL STREPTOCOCCI BACTERIA 74054			NC	X			
FECAL COLIFORM BACTERIA 74055			NC	X			
TOTAL COLIFORM BACTERIA 74056			NC	X			

NOTE: NC - No Change occurs in these parameters.

PART B

(Office use only)

000084

Discharge Serial No. 001

B-2. CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-2)

Intake

Discharge (See Remarks)

PARAMETER AND CODE	UNTREATED INTAKE WATER (1)	TREATED INTAKE WATER (2)	MAXIMUM CONCENTRATION (3)	MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	MAXIMUM POUNDS PER DAY (5)	DAILY AVG. CONCENTRATION (6)	AVERAGE POUNDS PER DAY (7)	SAMPLE TYPE (8)	SAMPLE FREQUENCY (9)	METHOD OF ANALYSIS (10)	CONTINUOUS MONITORING (11)
ACIDITY (as $CaCO_3$) 00435			NC								
TOTAL ORGANIC CARBON (T.O.C.) 00680			NC								
TOTAL HARDNESS 00900			NC								
NITRITE (as N) 00615	0.0		0.0 (0.3)	0.0 (6.1)	0.0 (100)	0.0 (0.0)	0.0 (8.)	A	W	S	A
ORGANIC NITROGEN 00605			NC								
PHOSPHORUS-ORTHO (as P) 70507			NC								
SULFATE(as SO_4) 00945	2386.0 ±115.		2583.5 (2.2)	(180.)	(2900.)	2402.8 (0.2)	(1000.)	A	W	S	A
SULFIDE 00745			NC								
SULFITE 00740			NC								
BROMIDE 71870			NC								

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PART B

(Office use only) 000084

Discharge Serial No. 001

B-2. (cont.) CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-2)

PARAMETER AND CODE	Intake: UNTREATED INTAKE WATER (1)	Intake: TREATED INTAKE WATER (2)	Discharge: MAXIMUM CONCENTRATION (3)	MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	MAXIMUM POUNDS PER DAY (5)	DAILY AVG. CONCENTRATION (6)	AVERAGE POUNDS PER DAY (7)	SAMPLE TYPE (8)	SAMPLE FREQUENCY (9)	METHOD OF ANALYSIS (10)	CONTINUOUS MONITORING (11)
CHLORIDE 00940	17,867. ± 695.	(<4.) as NaOCl	18,400. (4.)	(500.)	1600. (8100.)	18,100. (<1.)	8. (<4100.)	A	W	S	A
CYANIDE 00720			NC								
FLUORIDE 00951			NC								
ALUMINUM-TOTAL 01105			NC								
ANTIMONY-TOTAL 01097			NC								
ARSENIC-TOTAL 01002			NC								
BARIUM-TOTAL 01007			NC								
BERYLLIUM-TOTAL 01012			NC								
BORON-TOTAL 01022	2,900. ±1,200.		3,600. (870.)	(29.)	(480.)	2,800. (30.)	(48.)	A	W	S	A
CADMIUM-TOTAL 01027											

PART B

(Office use only)

000084

Discharge Serial No. 001

B-2. (cont.) CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-2)

PARAMETER AND CODE	Intake: UNTREATED INTAKE WATER (1)	Intake: TREATED INTAKE WATER (2)	Discharge: MAXIMUM CONCENTRATION (3)	MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	MAXIMUM POUNDS PER DAY (5)	DAILY AVG. CONCENTRATION (6)	AVERAGE POUNDS PER DAY (7)	SAMPLE TYPE (8)	SAMPLE FREQUENCY (9)	METHOD OF ANALYSIS (10)	CONTINUOUS MONITORING (11)
CALCIUM-TOTAL 00916			NC								
CHROMIUM-TOTAL 01034	52. ± 61.		110			42.		A	W	S	A
COBALT-TOTAL 01037			NC								
COPPER-TOTAL 01042			NC								
IRON-TOTAL 01045			NC								
LEAD-TOTAL 01051			NC								
MAGNESIUM-TOTAL 00927			NC								
MANGANESE-TOTAL 01055			NC								
MERCURY-TOTAL 71900			NC								
MOLYBDENUM-TOTAL 01062			NC								

(Office use only)

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Discharge Serial No. 001

B-2. (cont.) CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-2)

Intake | Discharge

PARAMETER AND CODE	(1) UNTREATED INTAKE WATER	(2) TREATED INTAKE WATER	(3) MAXIMUM CONCENTRATION	(4) MAXIMUM POUNDS PER DAY PER PROCESS UNIT	(5) MAXIMUM POUNDS PER DAY	(6) DAILY AVG. CONCENTRATION	(7) AVERAGE POUNDS PER DAY	(8) SAMPLE TYPE	(9) SAMPLE FREQUENCY	(10) METHOD OF ANALYSIS	(11) CONTINUOUS MONITORING
NICKEL-TOTAL 01067			NC								
POTASSIUM-TOTAL 00937			NC								
SELENIUM-TOTAL 01147			NC								
SILVER-TOTAL 01077			NC								
SODIUM-TOTAL 00929		9,520. ± 278. (1.)	9,840. (4.)	(440.)	1,400. (7,300.)	9,520. (1.)	57. (3,300.)	A	W	S	A
THALLIUM-TOTAL 01059			NC								
TIN-TOTAL 01102			NC								
TITANIUM-TOTAL 01152			NC								
ZINC-TOTAL 01092	40.± 23.		70.			57.		A	W	S	A
OIL AND GREASE 00550			NC								

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Discharge Serial No. 001

B-2. (cont.) CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-2)

PARAMETER AND CODE	Intake: UNTREATED INTAKE WATER (1)	Intake: TREATED INTAKE WATER (2)	Discharge: MAXIMUM CONCENTRATION (3)	Discharge: MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	Discharge: MAXIMUM POUNDS PER DAY (5)	Discharge: DAILY AVG. CONCENTRATION (6)	Discharge: AVERAGE POUNDS PER DAY (7)	Discharge: SAMPLE TYPE (8)	Discharge: SAMPLE FREQUENCY (9)	Discharge: METHOD OF ANALYSIS (10)	Discharge: CONTINUOUS MONITORING (11)
PHENOLS 32730	0.		0.			0.					
SURFACTANTS 38260			NC								
ALGICIDES* 74051 Chlorine	A	<1.000 (2.000) (NaOCl)	<0.100 (0.100)	< 24. (24)	<400. (400)	<0.050 (0)	<200 (0)	X	D	O	R
CHLORINATED HYDROCARBONS* (EXCEPT PESTICIDES) 74052			NC								
PESTICIDES* 74053			NC								

*Name specific compound(s) and fill in the required data for each. Use extra blanks at the end of the form and the "Remarks" space as necessary.

PART B

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Discharge Serial No. 001

B-3. RADIOACTIVE PARAMETERS OF INTAKE WATER AND DISCHARGE (See Table B-3)

Intake | Discharge (See Remarks)

PARAMETER AND CODE	UNTREATED INTAKE WATER (1)	TREATED INTAKE WATER (2)	AVERAGE (DAILY) (3)	MINIMUM (OPERATING YEAR) (4)	MAXIMUM (OPERATING YEAR) (5)	SAMPLE FREQUENCY (6)	CONTINUOUS MONITORING (7)
ALPHA-TOTAL 01501	3100.			X		0	A
ALPHA COUNTING ERROR 01502	3500.			X		0	A
BETA-TOTAL 03501 (3)	< 35.			X		M	A
BETA COUNTING ERROR 03502	10.			X		M	A
GAMMA-TOTAL 05501 (4)	< 50.			X		M	A
GAMMA COUNTING ERROR 05502	50.			X		M	A
TRITIUM-TOTAL 07000	0.0			X		M	A
TRITIUM COUNTING ERROR 07001	0.0			X		M	A

B-4. REMARKS

See Attachment 4.

Attachment No. 1

3-000084

ITEM #22

Type of Document	I.D. No./Date	Agency
Permit to construct and maintain intake structure, breakwaters, & dredge intake and discharge channels.	DACW33-69-6-0178 April 17, 1969	U.S. Army Engineer Div. New England Corps of Engineers
Interim permit for Salt Water Use and Waterfront Development.	Letter from the Agency Director Jan. 8, 1969	Massachusetts Water Resources Commission
License to construct and maintain intake structure and breakwaters and dredge intake and discharge channels.	License No. 5504 April 3, 1969	Mass. Department of Public Works
Construction Permit	Construction Permit No. CPPR-49 August 26, 1968	U.S. Atomic Energy Commission
Order of Conditions for breakwater construction and dredging.	DF-329 March 5, 1969	Massachusetts Department of Natural Resources
Water Quality Standards Certification.	Letter from the Director April 23, 1971 (attached)	Massachusetts Water Resources Commission

Attachment 2

Items 17 through 20 -

Discharge will consist of three components as listed in the following table. These components are will mixed in the discharge canal prior to entering the receiving body of water. They are listed separately here because of the different columes and different initial dates of discharge, as presented in the table. Values shown represent expected yearly averages. Maximum daily volumes could be as much as twice these values.

	Item 17 No. of Batch Discharges Per Day	Item 18 Avg. Gallons Per Batch Discharge	Item 19 Date Discharge Began	Item 20 Date Discharge Will Begin
(a) Circulating sea water for cooling.	Continuous*		3-20-71	**
(b) Radwaste system effluents (potentially radioactive)	1	20,000		7-71***
(c) Make-up system effluents (non-radioactive)	1-5	20,000	11-15-70	

* 474,000,000 gallons per day.

** Discharge which began 3-20-71 has negligible temperature increase. Temperature rise in this discharge will increase about January, 1972 when power operation is initiated.

*** Discharge which will begin about July, 1971 contains no added radioactivity. Radioactivity in this discharge will increase about December, 1971 when reactor operation is initiated.

NOTE: Values reported in Part A (page 4) are estimates taken from the literature cited below. Actual quantities will be measured periodically during plant operation.

Reference 1

Sverdrup, H. U., The Oceans, Their Physics, Chemistry, and General Biology. Prentice Hall, Inc., New York (1946).

Reference 2

Hodgman, C. D., Handbook of Physics and Chemistry, 42nd Edition, Chemical Rubber Publishing Co., 1960.

Reference 3

Koczy, F. F., "Seawater," International Science and Technology, December, 1966.

ATTACHMENT 3

PRINCIPAL CHEMICAL ADDITIONS TO LIQUI

Chemical	Normal Discharge Volume (Gallons)	Average Flow Duration	Average Discharge Frequency	Average Concentration (mg/liter) *	Maximum Discharge Volume (Gallons
1. Sodium Pentaborate	400	75 minutes	1 per yr.	3.4	4,000
2. Sodium Nitrite from CCW System ***	5,000	25 minutes	1 per yr.	0.77	25,000
3. dium Nitrite from Plant Heating Sys.	2,400	12 minutes	1 per yr.	0.77	12,000
4. B_2O_3 from CCWS ***	5,000	25 minutes	1 per yr.	1.4	25,000
5. B_2O_3 from Plant Heating System	2,400	12 minutes	1 per yr.	1.4	12,000
6. Dissolved Sodium Sulfate from Makeup System	16,000	80 minutes	1 per 5 days	0.8	16,00
7. Suspended Solids From Makeup System	2,800	15 minutes	1 per 5 days	0.4	2,80
3. ssolved Solids odium sulfate) rom the Condensate Demineralizer Sys.	450/day	Continuous	Continuous	0.3	20,0
). Sodium Hydroxide	-	-	-	Trace	
). Sulfuric Acid	-	-	-	Trace	
.. Chlorine From Hypochlorite Addition	10 GPM	As required	As required	0	10

* Based on circulating water flow of 3.2×10^5 GPM; concentrations listed are tho

* Predictions for time periods after full power operation is initiated (currently

** CCWS - Closed cooling water systems.

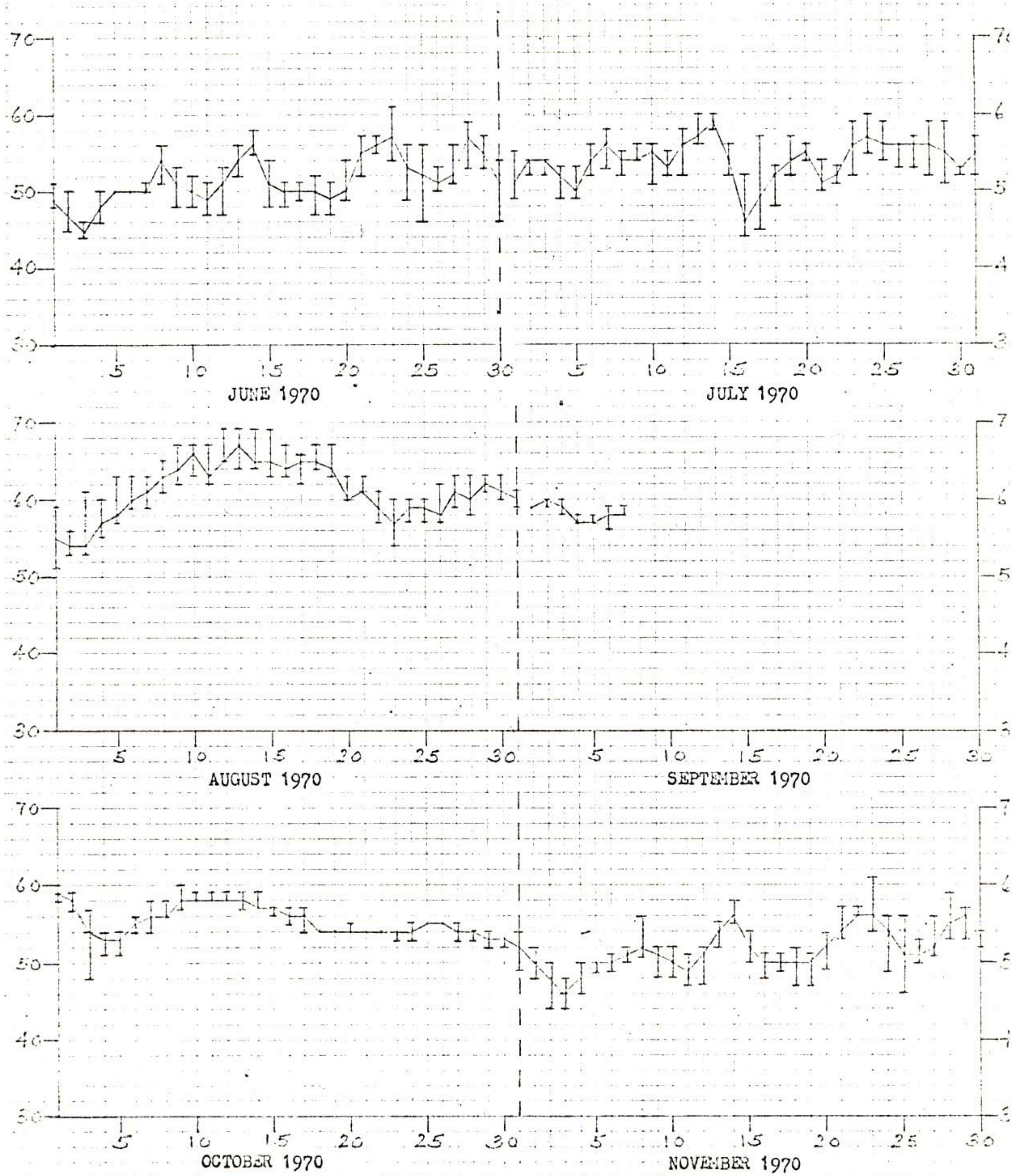
MONTHLY TEMPERATURE AVERAGES
JUNE 1970 THROUGH JUNE 1971
DERIVED FROM DATA COLLECTED AT MONITORING STATIONS 2' BELOW THE SURFACE, 10' BELOW THE SURFACE, AND ON THE BOTTOM (-30' MLW)

	2'	10'	Bottom
June 1970	53	46	45
July	54	53	46
August	63	60	54
September	50[a]	58	53
October	55	55	45[b]
November	52	45	44[c]
December	35	38[b]	39
January 1971	—	No Data	—
February	—[d]	33[e]	32[e]
March	37	36	37
April	41[f]	40[f]	37[f]
May	45	47	41
June	55	53	44

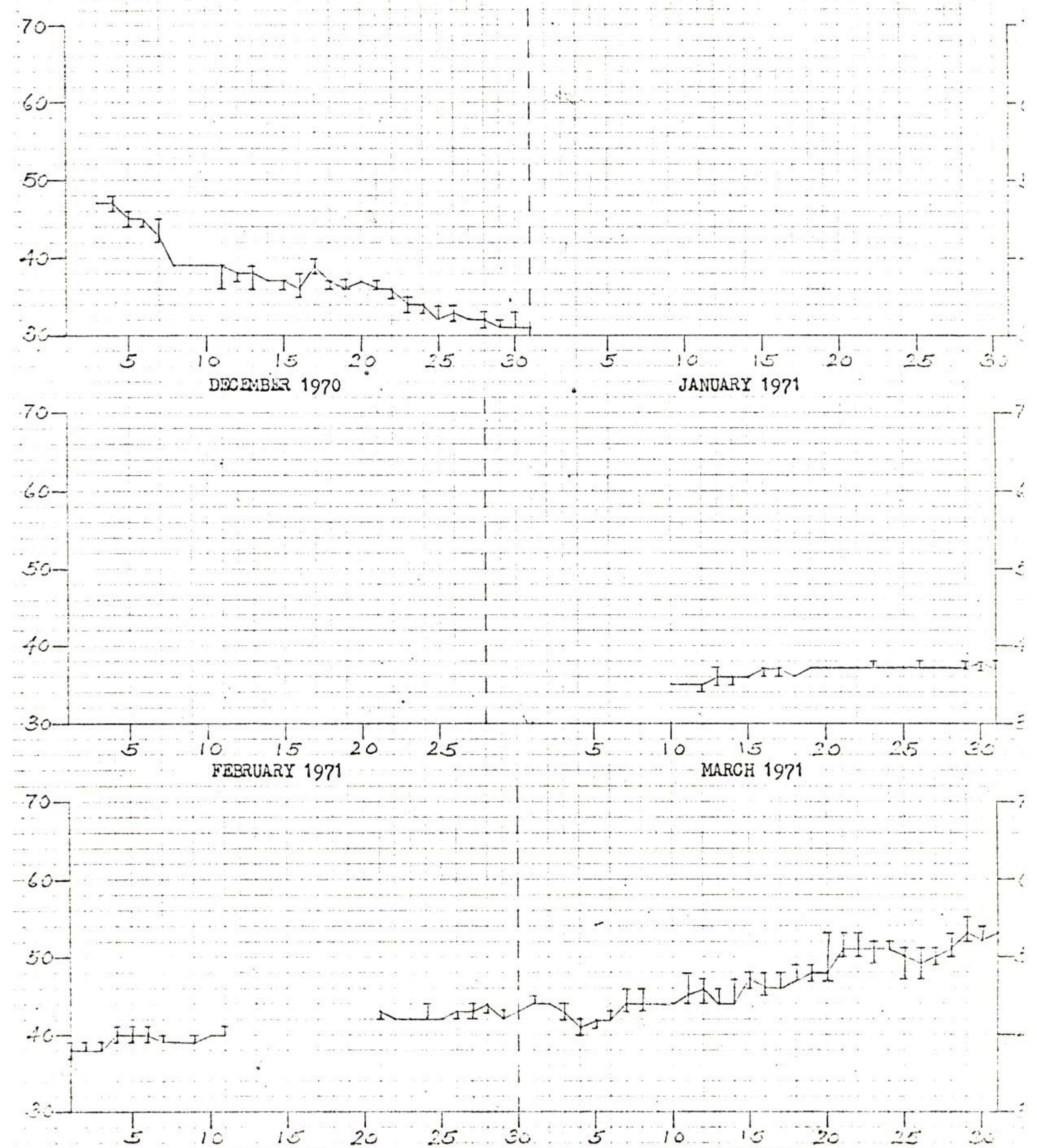
a Only 7-day's data
b Based on 29-day's data
c Based on 26-day's data
d Apparant instrument malfunction
e Based on 18-day's data
f Based on 21-day's data

Rec
3/29/72

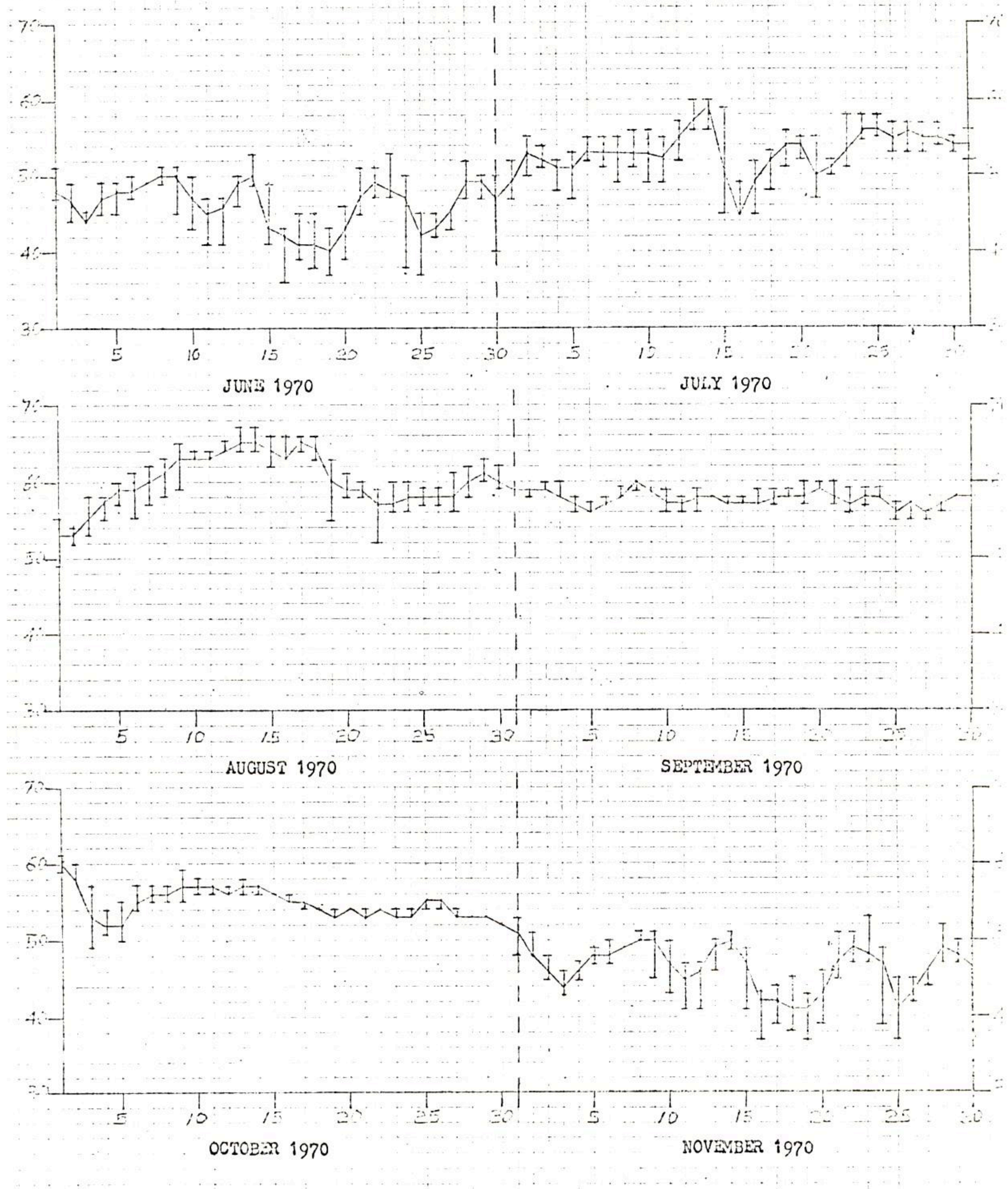
DAILY TEMPER. E RANGES & AVERAGES FROM 2-FC ATION (°F)



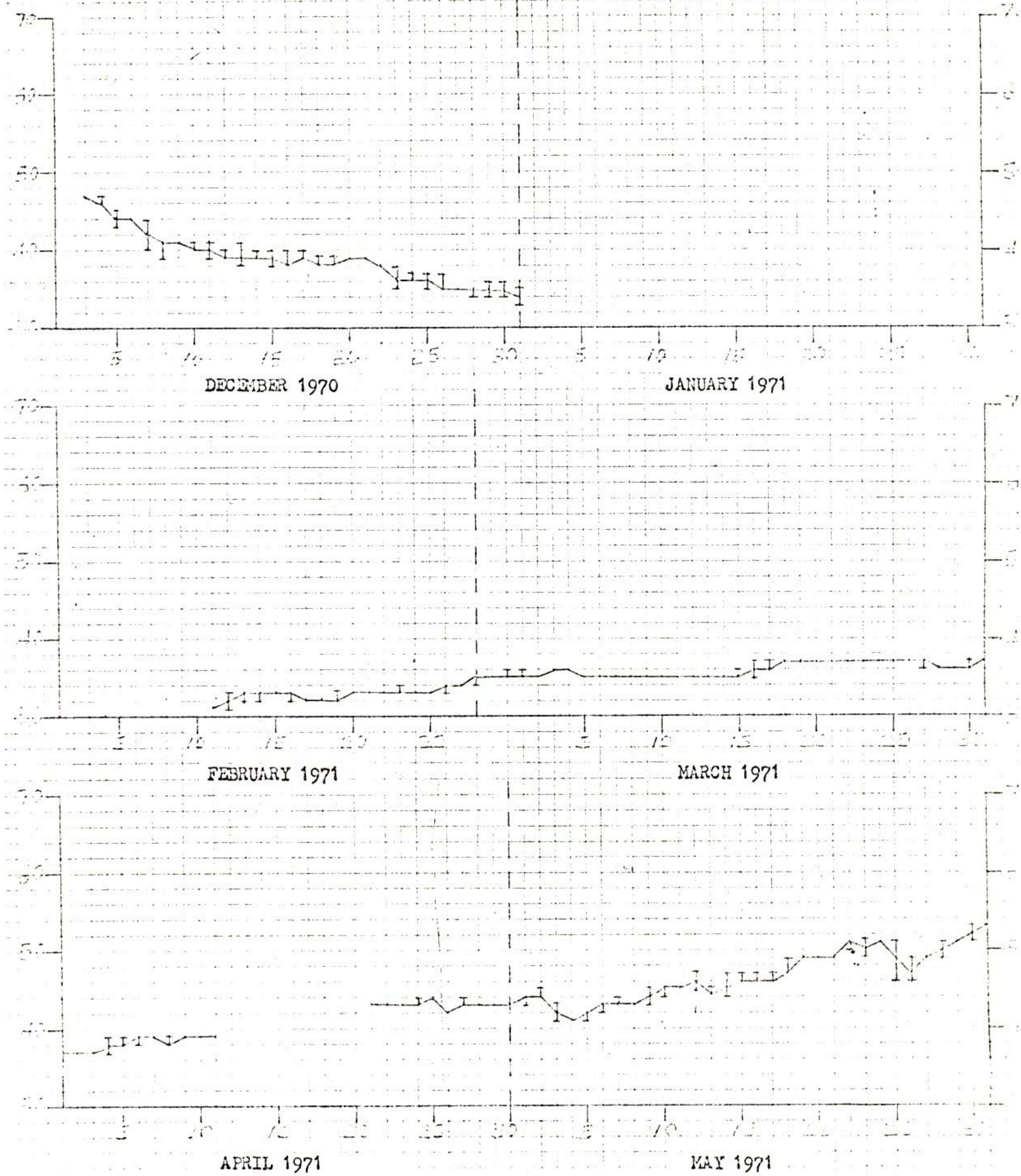
DAILY TEMPE E RANGES & AVERAGES FROM 2-F STATION (°F)



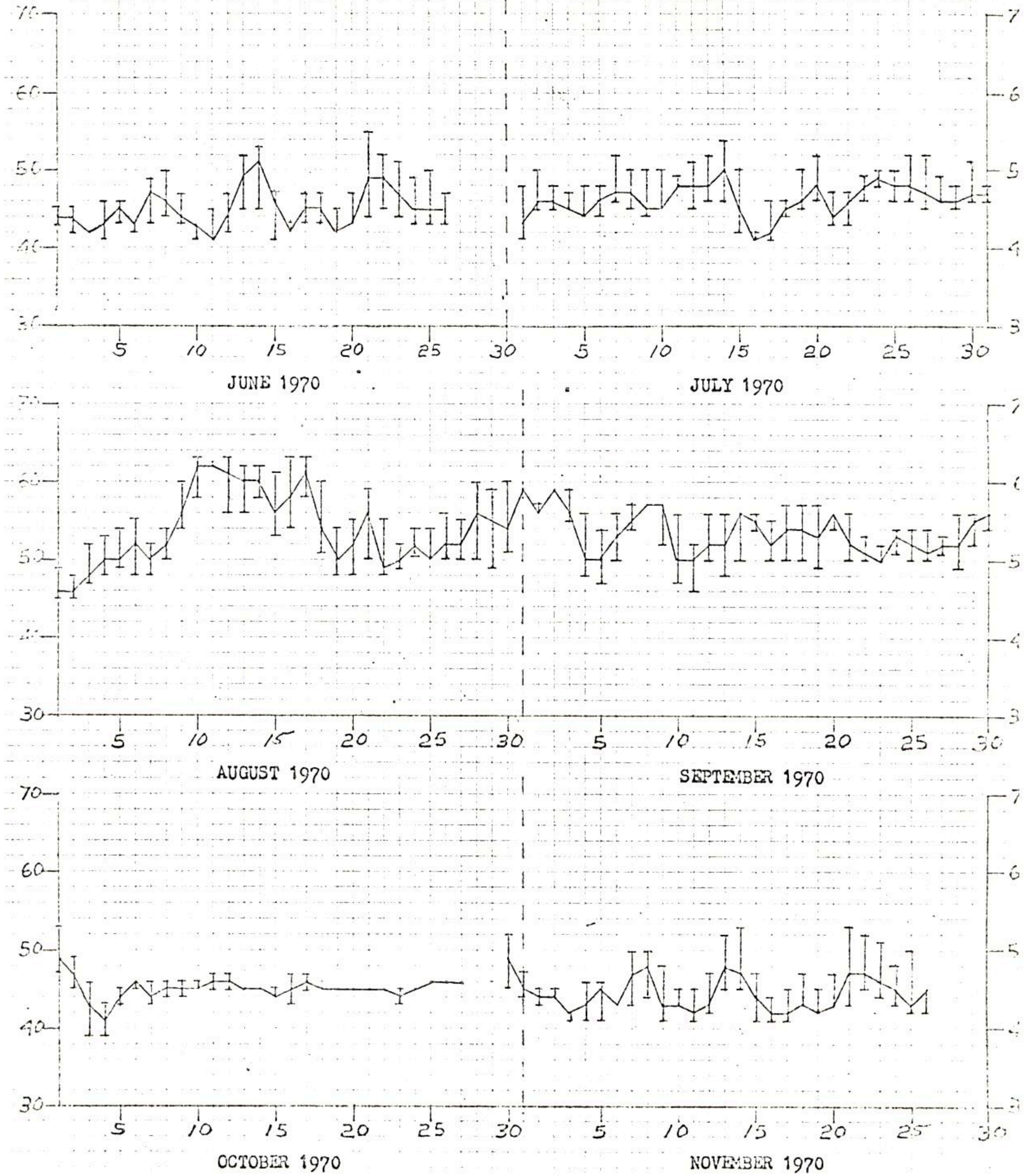
DAILY TEMPERA RANGES & AVERAGES FROM 10-F(TATION (°F)



DAILY TEMPER/ RANGES & AVERAGES FROM 10_F(TATION (°F)



DAILY TEMPERATURE R & AVERAGES FROM BOTTOM (-30 LW) STATION (°F)



ORIGIN OF LIQUID DISCHARGE COMPONENTS

Thermal - Cooling water to condense steam (same as in any thermal - electric generating station)

Radioactivity -
(a) Neutron activation products
   (1) originating in water
   (2) originating in reactor equipment

(b) Fission Products
   (1) minor leakage from fuel
   (2) tramp uranium

THERMAL DISCHARGE

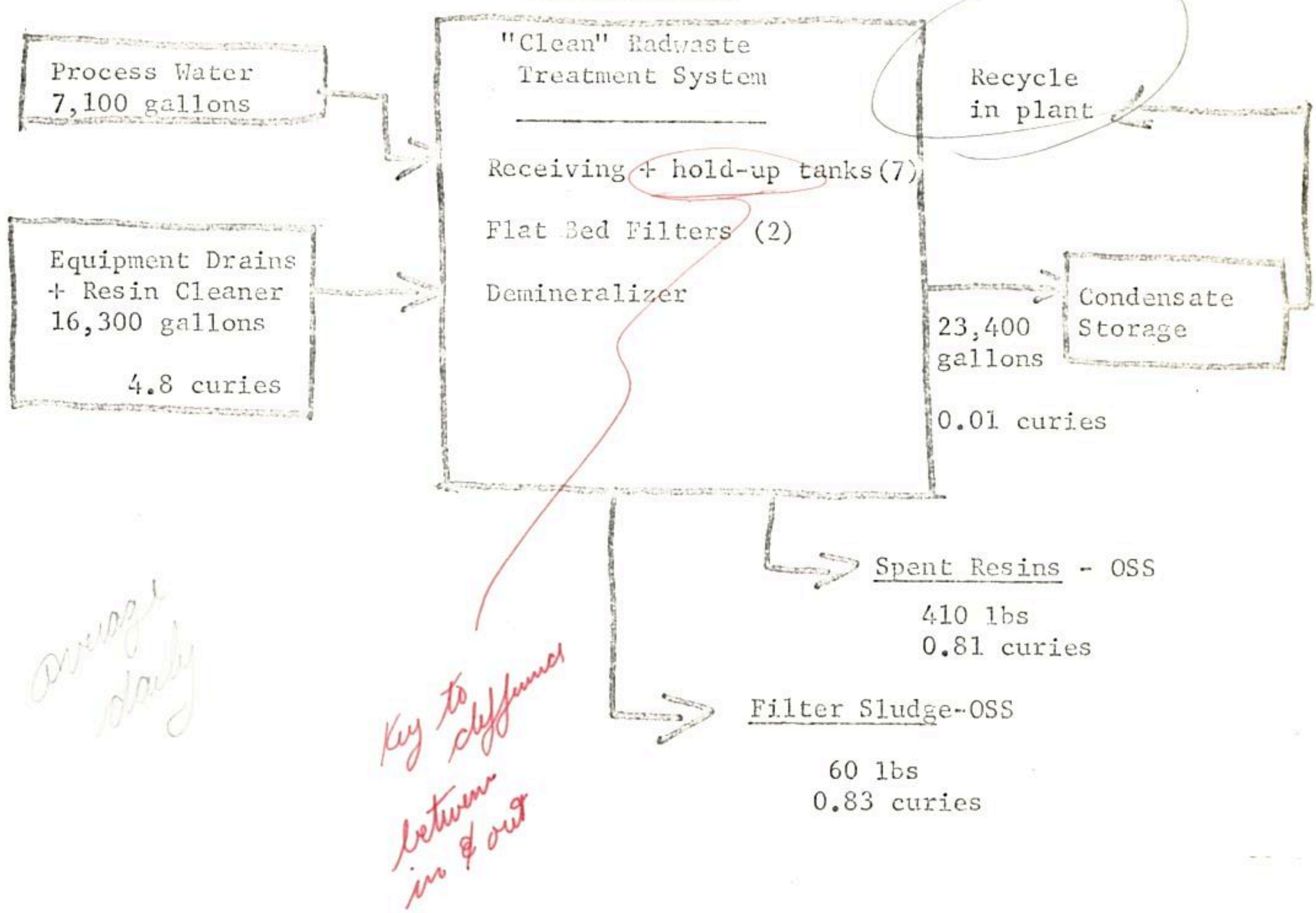
1. Leakage of process streams into Sea Water cooling system is virtually impossible due to Δ p effects.

2. Discharge system designed to promote rapid mixing of heated effluent with ambient bay water and minimize bottom effects:

   - High exit velocity
   - Short discharge canal
   - Surface discharge
   - Provides 3-sided entrainment of cold water
   - Minimizes time at ΔT max. for entrained organisms

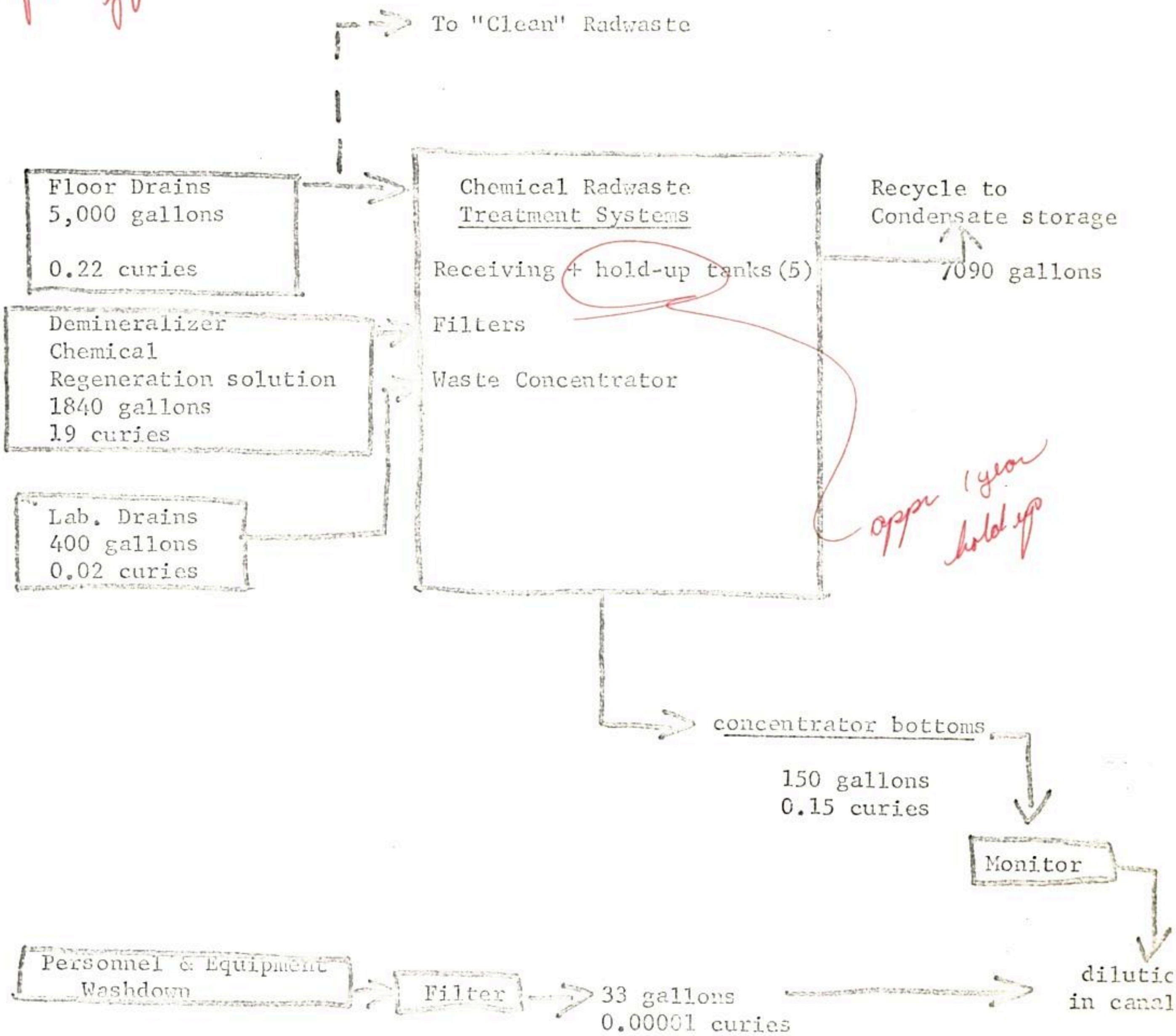
LIQUID RADWASTE TREATMENT SYSTEM

A. "CLEAN" RADWASTE



LIQUID RADWASTE TREATMENT SYSTEM

B. "CHEMICAL" RADWASTE



Attachment 4

Principal Chemical Additions in Liquid Discharge

	Chemical	Amount Discharged (lbs./yr.)	Annual Average Concentration (mg/liter)
1.	Sodium Pentaborate (Boron)	2.5×10^2	1.9×10^{-4}
2.	Sodium Nitrite	4×10^4	3×10^{-2}
3.	Sodium Hydroxide (NaOH)	-	Trace Amounts
4.	Sulfuric Acid (H_2SO_4)	-	Trace Amounts
5.	Dissolved Solids (Na_2SO_4)	4.2×10^5	0.3
6.	Sodium Hypochlorite (Free Chlorine Algicide)	Not Applicable	< 0.1

ATTACHMENT 4

B-4 REMARKS

(1) The values listed at the top of the fill-in space in Parts A and B-2 were derived from laboratory analyses performed on grab samples taken weekly in the time period August 18, 1971 through September 8, 1971. The values in parentheses at the bottom of the space are predictions of the quantities that will be added to the sea water in the discharge after full power operation is initiated (currently scheduled for April, 1972).

(2) Parts A and B-2, Columns (4), (5) and (7) -

No chemicals other than sodium sulfate and sodium hypochlorite have been added to date. The differences between values listed in Columns (1) and (6) are due primarily to uncertainties in the analyses and/or normal sea water variations as indicated by the standard deviations in the measured values reported in Column 1.

(3) Parts A and B-2, Column 4 -

Values listed are based on 16.45 process units, where 1 process unit equals 10^6 kilowatthours, and maximum pounds per day added to the discharge.

(4) Parts A and B-2, Column (7) -

Predicted values of average pounds per day added to the discharge apply for days in which that particular parameter is added to the discharge. Yearly averages will, of course, be lower than the reported values in column 7 for those parameters whose discharge frequency is less than one per day (see Attachment 3).

(5) Part B-2 -

Residual chlorine in discharge could result from addition of sodium hypochlorite and is monitored continuously during and after periods of hypochlorite addition using a Wallace and Ternin Residual Chlorine Analyzer, Series 50-236.

(6) Part B-3 -

Present discharge contains no added radioactivity (see Attachment 2). Measurements listed for radioactivity in intake water were obtained as part of pre-operational test program during the period September 1970 through September 1971. Meaningful predictions of radioactive parameters prior to full power operation cannot be made. The plant will be operated to maintain all radioactive effluents as low as practicable and, in all cases, will be less than the maximum permissible levels specified in 10 CFR 20 (Title 10 of the Code of Federal Regulations, Part 20).

(7) Part B-3 -

Beta activity reported is the summation of fractional gross beta activities.

(8) Part B-3 -

Gross gamma activity reported is based on assumption that gamma activity is due entirely to cesium-137.

(9) Part B-3, Column (6)

Alpha activity measurement is based on a single sample of intake water taken on August 18, 1971. Alpha measurements of sea water are not normally performed due to the large counting error associated with such measurements.