SEABROOK STATION

ENVIRONMENTAL REPORT

A.1

VOLUME I

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

1. OBJECTIVES OF THE PROPOSED FACILITY

Request for RMD Services

I. REQUESTOR INFORMATION	(PLEASE PRINT) NAME Bonnie L Bryant	MAIL CODE 01-48

DEPT. Environmental Services PHONE EXT. 7749 CONTROL * NUMBER ~~C704~~ (M. Sullivan) [initials] 7-10-00 (if applicable)

DATE/TIME REQUESTED 7/6/00 / 1230 DATE/TIME REQUIRED 7/12/00 10800

II. CONTROLLED DOCUMENT REQUEST INFORMATION

NOTE: Latest revision and standard size document will be provided unless requestor specifies otherwise below.

WR/RTS NO. ______ (if applicable) ☐ ADDITIONAL INFORMATION ATTACHED

DOCUMENT DESCRIPTION	DOCUMENT NUMBER	REV. NO.	SHEET NO.	QTY.	DISTRIBUTION STATUS (X) ONE				REMARKS
					INFO ONLY	VALID 3 DAYS	VALID RTS/WR	* CON-TROLLED	
Environmental Report-Construction Permit Stage				1	X			~~X~~	Volumes I, II, + III
							[initials]	non-controlled [initials]	7-10-00

III. * - REQUESTS FOR ISSUANCE OF CONTROLLED DOCUMENT REQUIRE REQUESTOR DEPARTMENT SUPERVISOR SIGNATURE/DATE.

*REQUESTOR'S DEPARTMENT SUPERVISOR	DATE	RMD SECTION LEADER	DATE
Bonnie L Bryant for A Legendre	7/6/00	James W West	7/10/00

IV. (RMD USE ONLY)

DATE/TIME RECEIVED ______ / ______ / ______ (initial) DATE/ITEM COMPLETED 7-11-00 / [initials] (initial)

(RECORDS RETRIEVAL REQUEST INFO ON REVERSE SIDE)

1 OBJECTIVES OF THE PROPOSED FACILITY

1.1 Requirement for Power

Coordinated power planning in New England has been an evolving process over the past two decades. Over the past five years, a concerted effort has been underway to formalize a regional New England power pool, commonly referred to as "NEPOOL". This goal was achieved in November, 1971, with the implementation of the New England Power Pool Agreement. This agreement superseded earlier interim agreements, and is now fully effective following its recent acceptance as an effective rate schedule by the Federal Power Commission under Docket No. E-7690. All major generating utilities in the New England region are participants.

NEPOOL provides for common dispatch of all generating units of its member companies, for the establishment of joint maintenance schedules, for necessary pool reserves, and for forward power planning on an integrated, pool-wide basis. Power planning is the responsibility of the NEPOOL Planning Committee, under the direction of the managing committees of the pool organization. The Planning Committee consists of the planning engineers of the member companies, and is backed by full-time professional support. Load and capacity forecasting are directed to total pool requirements, and new generating units are designed to meet pool-wide power requirements. Planning on a pool basis achieves reliability with a minimum of generation reserve and the location of units to minimize transmission requirements. Ownership of generating units is necessarily vested in the individual utility companies, but large units scaled to pool size are increasingly owned jointly by a number of pool members, or are shared through purchase and sale agreements for the capacity and output of individual units. This trend is clearly evident in the joint ownership agreements now being worked out for the nuclear units planned for the 1977-1982 period. The joint ownership arrangement allows the smaller companies to obtain the economies inherent in the larger units and at the same time all companies can spread the economic risk over several units.

Over the years, a number of public policies relating to the availability of electric power have been established in laws and regulations applying to electric utility companies. The more explicit of these policies require a company to provide an adequate and reliable supply of power on demand to anyone in its service area, to provide that power in a safe and economical manner; and, also to plan and construct the generating and transmission facilities required to meet these objectives with the least practicable adverse environmental impact. The statutes of New Hampshire include the following: RSA 374:1 states in part, "Every public utility shall furnish such service and facilities as shall be reasonably safe and adequate and in all other respects just and reasonable." RSA 162-F sets up a generation and transmission siting committee, the purpose of which is to review the electric utilities proposed construction plans so as to assure the State an adequate and reliable supply of electric power in conformance with sound environmental utilization.

Electric power has become a major form of commonly available energy. It also represents an increasing portion of total energy consumed.

It is generally anticipated in New England and New Hampshire that present growth trends and public policies will cause demand for electric energy to continue to increase for at least the next two decades. From 1965 to 1970 the peak load in New England has grown at a rate of slightly over 7 percent per year. During this time the peak load of Public Service Company of New Hampshire has grown at a rate of slightly over 10.5 percent.

The planning of bulk power facilities in New England is undertaken through the New England Power Pool (NEPOOL) to enhance the adequacy, reliability and economy of power supply in these states. As stated in the agreement by which New England's major electric utility systems created NEPOOL in 1971:

> "The objectives of NEPOOL are, through joint planning, central dispatching, cooperation in environmental matters and coordinated construction, operation and maintenance of electric generation and transmission facilities owned or controlled by the Participants, and through the provision of a means for more effective coordination with other power pools and utilities situated in the United States and Canada:

(a) to assure that the bulk power supply of New England and any adjoining areas served by Participants conforms to proper standards of reliability, and

(b) to attain maximum practicable economy, consistent with such proper standards of reliability, in such bulk power supply and to provide for equitable sharing of the resulting benefits and costs."

The obligations of the NEPOOL Participants include, among other things, the central dispatch of all generating units of NEPOOL Participants, maintenance of generating reserves adequate to insure the reliability of the pool, joint use of transmission facilities for specified pool purposes, and joint planning of future generation and transmission. The NEPOOL agreements formalizes arrangements which have been in existence in varying degrees for many years, and its benefits will increasingly emerge as facilities now being planned come into operation late in the 1970's.

To implement its objectives, NEPOOL has formed various committees and working groups to examine specific aspects of regional cooperation. One of these committees, the NEPOOL Planning Committee, has a Generation Task Force charged with investigating the expansion of generation for the New England region. The Generation Task Force has established guidelines for capacity planning within which the NEPOOL Participants coordinate their plans, and the Planning Committee has formulated planning standards to assure reliable system development.

Every major system in New England is dependent to some degree upon its transmission interconnections with neighboring systems within New England and beyond for the reliability of its system. This interdependence between utility systems and between larger regions is an essential ingredient of modern bulk power supply.

NEPOOL provides an organizational framework through which the New England Utility Systems can consummate purchases or sales with each other and neighboring regional systems such as the New Brunswick Electric Power Commission and the New York Power Pool.

Under NEPOOL, each Participant has an obligation to meet its own "Capability Responsibility". This means that each individual system must install or otherwise participate in capacity equal to its share of the total generating capacity required to serve the New England load. The present schedule of planned and committed capacity additions may be found in Table 1.1-5.

1.1.1 Demand Characteristics

Necessity for Accurate Load Forecasts

Forecasts of the demand for electricity are vital to the economic viability of the electric industry, and play an essential role in planning for the most advantageous mix of generation facilities.

At present, long lead times are required for installation of new generating capacity because of the large size and complexity of the equipment and because of the increasing time needed for certification of the facilities at the state and federal levels of government. As a result, the industry is required to commit large sums of capital to projects as long as ten years in advance of operation. If the projections of future load on which these commitments are based are erroneous, the electrical system concerned either has an over-capacity or under-capacity situation, either of which could have serious consequences.

Under-capacity would mean that the power company has not met its legal obligations to its customers and would not be able to furnish a reliable supply of power. This would lead to area blackouts with the resulting loss of industrial production and wages, property damage, effect on public safety, etc.

Over-capacity would lead to a very reliable system but the power company and its rate payers would be forced to carry the costs of the surplus generation until load growth made the capacity necessary.

In planning for new generating units it is essential that: (a) only those units which are needed to fulfill demand are built; (b) that these units be appropriate to the most environmentally and economically desirable mix of base load, intermediate and peaking generation, and (c) that older less efficient units be retired from service and their generation replaced by more appropriate generation to the extent that it is environmentally and economically feasible. Because of the more stringent requirements for emissions and siting of generation units in recent years, the need for careful and accurate planning on a regional basis has become essential, and thus the load forecast is an essential planning tool.

Present Forecasts - Public Service Company of New Hampshire

Table 1.1-1 shows the historic peak hour demand and the projected peak hour demand from 1966 to 1982 for Public Service Company of New Hampshire. Future growth is being projected at a rate of slightly over 10.1 percent. Historic growth over the period from 1966 to 1971 was at a rate of about 10.5 percent.

The projected values for annual peak hour demand shown in Table 1.1-1 were developed by the Power Supply Department of the Company in the following manner. A trend line of future peak loads is determined by first selecting relevant historical values of annual peak hour demands, then adjusting that data for large non-conforming loads or for other unusual circumstances, then applying the least squares regression line technique to the adjusted data to obtain the equation of a best fit line for the selected period. The equation can then be used to obtain the annual peak hour demands for each year of the period of interest. The values determined using the equation may have to be adjusted to incorporate any non-conforming loads or to reflect other unusual circumstances.

After the projected peak loads have been determined in this manner, they are checked for reasonableness by another procedure which is based on a forecast of future annual kilowatt-hour sales prepared by the Research Department of the Company. To obtain the sales forecast, total sales of the Company are separated into six classes; residential, commercial, industrial, public street lighting, other public authorities and other utilities. Historical trends of sales to these various classes are developed in chart form as a guide to future sales estimates. The estimates for each of the classes is prepared using a special procedure developed for that class. Following is a listing of some of the input data which are used in one or more of the class forecasting procedures:

1. State population, historical data and future estimates, related to numbers of customers.

2. Past and projected statistics on residential customer electrical applicance saturations and kilowatt-hour use per applicance.

3. Historical and estimated future data on the number of electrical space heating customers and the kilowatt-hour use per installation.

4. Data on expected future kilowatt-hour use per customer, reflecting past historical trends and based on general information affecting future use patterns, such as 2 and 3 above.

5. Data on present and expected future changes within the Company's service area which is collected from operating division managers. The reports from managers include general information on growth, economic conditions and a subjective evaluation of other factors which might influence sales, together with reports of specific customers' electric load expansions or losses and plans for new customer electric loads.

6. Industrial class kilowatt-hour sales are segregated into many categories by Standard Industrial Classification (S.I.C.) Manual coding. Future estimates of sales to each category are based on the data of 5 above. A second method is also used for the industrial class whereby sales estimates are based on a empirical relationship having as inputs historical and future estimated data on number of production workers, value added by manufacture, capital expenditures for new plant and equipment and several other factors relevant to the level of industrial activity. Checks of the resulting sales estimates are made against the industrial sales forecast published annually in Electrical World by McGraw Hill Inc. and against projections of the Federal Reserve Board Index of Industrial Production by several sources outside the Company.

Other data having significance to the forecast of sales is collected and weighed for its potential impact. This includes statistics and reports on national and state demography, future business or economic conditions, information on potential new uses for electricity, and many other factors which might influence the level of kilowatt-hour sales by the Company.

The total sales forecast, which is the sum of sales to each of the six classes forecast individually, is developed principally for the use of the Company's Accounting Division in preparing a financial forecast. However, this same forecast is next adjusted to include an estimate of kilowatt-hours used by the Company or lost in the system, and is then utilized in conjunction with an estimate of future system load factor to confirm the estimate of peak loads prepared by the Power Supply Department.

In order to demonstrate the reasonableness of the resulting Company forecast, Table 1.1-2 and Figure 1.1-6 have been prepared. For a twelve-year period of historic data, and for a ten-year future period covered by the Company's forecast, the kilowatt-hour annual prime sales and kilowatt annual prime peak hour load have been related to State of New Hampshire population. The table shows a rapid and continual growth in the annual values of kilowatt-hour sales per capita and kilowatts of peak load per capita over the twelve-year historical period. The Table also shows that the Company's forecast has determined that the per capita energy and capacity requirements of its customers will continue to increase into the future. The two curves plotted on Figure 1.1-6 do illustrate that the projected future relationships of energy sales and peak load to population continue the smooth trend lines established in the historical period. The two curves do confirm the reasonableness of the forecast values of energy sales and peak loads.

Present Forecasts - New England

All of the power companies in New England prepare their forecasts in a somewhat similar manner to that of Public Service Company of New Hampshire. A total New England mean load forecast is prepared by summing the individual company peak load projections. This method of forecasting works very well because New England has a great deal of weather-dependent load (winter heating and lighting load creates system peak in December or January) and since New England is a small area all of the utilities will have their winter peak at the same time.

Table 1.1-3 shows the historic peak load in New England from 1966 and the projected peak load through 1982. This table reflects a growth rate of 7.8 percent in the winter peak load.

The New England Energy Policy Staff (NEEPS), an agency of the New England Regional Commission and affiliated with the New England Governors' Conference, has prepared a forecast of winter peak loads for staff use. The study by this public body is in general agreement with the NEPLAN forecast. Their observations on the subject of peak demand projection are as follows:

> "In recent years New England's annual peak demand has occurred at the 6:00 p.m. hour during one of the weekdays of the last week before Christmas. At the current growth rate of heating load, within a few years the December peak will be exceeded in late January or early February of the following year when colder weather and the resulting higher heating load will offset the pre-Christmas commercial activity and lighting load."
>
> "The method used here for projecting peak demands employed the assumption that all loads other than electric heating will maintain their current relationship. In other words, it has been assumed that after the effect of electric heating is discounted the remaining load shapes will remain constant as demands increase."

A comparison of the NEPLAN and NEEPS forecasts for the period from 1972 through 1982 is as follows:

NEW ENGLAND LOAD FORECAST
(Winter Peak Loads - Megawatts)

	NEPLAN	NEEPS		NEPLAN	NEEPS		NEPLAN	NEEPS
1972	13,423	13,250	1976	18,169	17,770	1980	24,459	23,500
1973	14,502	14,240	1977	19,564	19,000	1981	26,345	25,300
1974	15,643	15,300	1978	21,073	20,400	1982	28,378	27,200
1975	16,853	16,450	1979	22,698	21,900			

Energy consumption in New England has increased from 40184 GWH in 1966 to 59072 GWH in 1971. This represents an annual increase of slightly over 8 percent. The NEEPS forecast assumed an average annual growth rate of 7.7 percent for New England and the 1970 National Power Survey of the Federal Power Commission forecast assumed an average annual growth of 7.5 percent on a national basis.

The present shortage of oil and natural gas will cause the nation to rely even more on electric power and in particular nuclear power for its energy needs in the future. This, coupled with the power needed for environmental clean up, assures continued growth in the consumption of electric energy in New England and the nation.

The average annual KWH consumption per residential customer in New Hampshire has increased from 3957 in 1966 to 6145 in 1971. This increase is an annual rate of slightly over 9 percent. It is predicted that the average annual use per residential customer on the Public Service Company's system will reach 12000 KWH by 1980.

The average annual KWH consumption per residential customer in New England has increased from 3953 in 1966 to 5917 in 1971. This is an annual increase of about 8.45 percent. The NEEPS report forecasts an increase of 7.1 percent per year to an average annual energy consumption of 12000 KWH in 1982.

The national average residential energy consumption was 7685 KWH in 1971 with some areas showing an average of 12000 KWH and over.

The NEEPS report comments:

> "Residential use of electrical energy is dependent upon a complex relationship of such factors as family income, availability of alternate energy sources, price of alternate energy sources, personal preferences and ownership of appliances."
>
> "The average use per residential customer increased from just over three thousand KWH per year in 1961 to just under six thousand KWH in 1971. Increased sales of appliances such as quick recovery water heaters, clothes dryers, frostfree refrigerators and no drift colored television contributed to the increase, but electric space heating and air conditioning contributed the most significant impetus to growth in the past several years. The relatively low market saturation of these factors indicates that the rate of increase will continue for several years."

The NEEPS report forecasts approximately 4,200,000 residential electric customers in New England in 1982 in contrast to 3,400,000 in 1972.

Commercial and industrial energy consumption in the Public Service Company of New Hampshire territory has grown from 1016 GWH in 1966 to 1639 GWH in 1971. This is an annual growth rate of about 10 percent.

The increase in energy consumed for industrial and commercial purposes in New England has grown from 24877 GWH in 1966 to 34643 in 1971 for an annual growth rate of about 7 percent.

The NEEPS report forecasts a decrease in the growth rate of energy sales to these classes of service to about 5 percent through the mid-seventies and increasing to a 6 percent rate thereafter. It notes, "This is thought to be a middle-of-the-road forecast reflecting neither economic stagnation nor extensive industrialization in New England."

On the basis of the NEEPS forecast, the residential energy sales will exceed the combined industrial and commercial energy sales within the next 10 to 15 years.

Necessity for Base Load Generation

Figure 1.1-1 shows Public Service Company of New Hampshire's proposed generation dispatch for the peak day of 1982. The generation shown in this chart is as follows:

1. Hydro -- Public Service Company has several small hydro plants that have very limited storage and can produce about 44 mw of base load hydro.

2. Seabrook Units 1 and 2 -- These are the units covered by this application. The dispatch shows Public Service Company of New Hampshire's share of these two units.

3. Purchased nuclear -- This is made up of Public Service Company of New Hampshire's share of Rowe Yankee, Connecticut Yankee, Vermont Yankee, Maine Yankee, Pilgrim 2 and Millstone 3 which totals 188 mw.

4. Base load fossils -- This is PSNH Merrimack Units 1 and 2. These coal burning units have a total capacity of 455 mw of which 100 mw of their capacity is committed to an adjoining utility.

5. Cycling fossil -- This is Public Service Company of New Hampshire's Newington unit which has a capacity of 400 mw.

6. Fossil purchase -- This is made up of a unit purchase from New Brunswick and Maine and totals 86 mw.

7. Old fossil plants -- This is made up of Public Service Company of New Hampshire's Schiller and Manchester Steam Plants and totals 199 mw.

8. Gas turbines and purchase -- This is made up of a 30 mw purchase and 110 mw of gas turbines for a total of 140 mw.

9. Uncommitted Gas Turbines and Purchases are reserves that have not been committed as yet.

Figure 1.1-1 does not show the effect of pumped hydro on the system load and it is probable that the purchased nuclear part of the generation schedule will be used to pump Northfield Mountain and Bear Swamp in 1982 which will raise the load curve in the early hours of the morning.

Without Seabrook, the base load generation available to meet the load is only about 485 mw, where PSNH requires about 1200 mw or approximately 50 percent of the peak load. It is obvious that base load generation is required by Public Service Company of New Hampshire.

1.1.2 Capacity Resources

Table 1.1-4 shows the New England generation capability by type as given in the October 1, 1972 issue of the New England Load and Capacity Report.

This table shows a total generation addition of 18,643 mw and total retirements of 339 mw from 1972 to 1982. The proposed generation additions are as follows:

Nuclear	11612 mw
Conventional Fossil	4765 mw
Gas Turbine	174 mw
Diesel	24 mw
Combined Cycle	437 mw
Conventional Hydro	31 mw
Pumped Hydro	1600 mw

Eight thousand seven hundred and thirty mw of the 11612 mw of proposed nuclear additions do not have construction licenses at the present time and should not be considered as positive capacity additions.

Table 1.1-4 shows sales of approximately 40 mw from Maine Public Service Company to Consolidated Edison Company in New York which expires in 1976. The purchases included 150 mw from Power Authority of the State of New York by the Vermont Utilities and the remainder is the contracted and projected purchases from New Brunswick.

Table 1.1-5 shows a detail of committed and planned changes in generating equipment from 1973 to 1982 and Table 1.1-6 shows a detail of capacity retirement from 1973 to 1982. These are taken from the October, 1972, issue of the New England Load and Capacity Report which is filed with the FPC under Docket No. R 362.

Table 1.1-7 shows Public Service Company of New Hampshire's generation capability by type from 1967 through 1982. This capability is based on the construction of the Seabrook units, Pilgrim No. 2 and Millstone No. 3; none of which has a construction permit. The nuclear additions shown are only Public Service Company of New Hampshire's share of the two Seabrook Units. This table shows additions of 400 mw in a fossil unit and 1150 mw in nuclear capacity from 1972 to 1982.

Reserve Margin

The minimum system reliability criterion used by NEPOOL is based on the probability (calculated monthly) of the loss of load during one day in ten years.

In December 1964, the major utilities in New England established a Generation Planning Task Force which was charged with initiating a generation planning study for the entire New England area. The goal of the study was to provide management with a guide for coordinated expansion of generating facilities on a one system basis.

Progress Report No. 1 was issued by the Task Force in December 1965. This report incorporated a study of the reliability of the New England capacity supply needs for the years 1962 through 1967 to determine the index of reliability achieved during these years. The results indicated that a minimum reliability criteria of one day in 10 years would be proper to use for future studies.

The Northeast Power Coordinating Council was formed in 1966 comprising New England, New York and Ontario, Canada. The object of the Council was to improve the reliability and efficiency on a regional basis for the interconnected power systems in the Northeast. To pursue this objective, basic criteria for the design and operation of the interconnected power system were written. After deliberation, it was concluded that each area within the confines of the Council System (the areas are defined as New England, New York, Ontario and recently New Brunswick) must install generation so that after due allowance for required maintenance and expected forced outage, each area's generating supply will equal or exceed area load at least 99.9615 percent of the time. This is equivalent to a loss of load probability of one day in ten years. Subsequently reliability standards have been adopted for the New England Interconnected Power Systems which are compatible with the NPCC criteria.

The load model used for reliability calculations is based on a computer analysis of the composite New England historical net hourly loads for the most recent five year period available. From this load analysis, deviation of peak loads were determined and seasonal factors established.

Forced outage rates were based on the Edison Electric Institute Prime Movers Committee "Report on Equipment Availability" issued September 1969 and Ebasco Services, Incorporated recommendations included in their report entitled, "Generating Plant Investment Estimates, Heat Rate Data and Forced Outage Rates for New England Power Planning" issued November 1969 coupled with task force modifications based on New England experience.

The capacity model used for determining capacity requirements combines the probability distribution of peak loads with a calculated distribution of available capacity to yield the probability of having insufficient generation to cover load. This probability is then compared with the reliability criteria for New England and capacity is added if needed to meet the criteria.

The method used in this generation planning study was to develop patterns of generation mix and then to determine the total costs (capacity and production) of each pattern for the study period which were then related on a present worth basis. The optimum generation mix (least dollars) was determined by comparing the costs of each of these patterns.

The studies as outlined in Generation Report No. 4 (Reference 1) indicate that nuclear units sized at about 5 percent of the December peak load are the most economical. This represents a balance between the additional reserves required to protect against the outage of large generating units and the "economies of scale" associated with these units. Of course, the larger units make the most efficient use of land and material resources for a specified amount of capacity.

The installed reserve requirements of the New England Power Pool were determined as if the pool were a single, integrated, utility system.

Full credit was taken for interconnections between pool participants, because the generating capacity in the pool is under central dispatch.

The predicted loads, reserve requirements and total capability requirements necessary to meet the one day in ten year criterion is shown in Table 1.1-8. The objective reserves were developed using the forced outage rates shown in Table 1.1-9 and the maintenance schedule shown in Table 1.1-10.

Forced outage rates are currently being reviewed and the effect of interconnections to other pools on required reserves is being studied.

Table 1.1-11 shows Public Service Company of New Hampshire load, required reserves and required capabilities based on reserve margins shown in Table 1.1-8.

1.1.3 System Demand and Resource Capability Comparison*

New England demand and capability data are plotted in graph form in Figure 1.1-2. The curves shown are:

(1) Capability resources with all the proposed units.

(2) The capability resources without the two Seabrook Units.

(3) The annual system peak demand.

(4) The generating capability with all of the proposed units.

(5) The generating capability without the two Seabrook Units.

Figure 1.1-3 is a graph of:

(1) The reserve margin with all of the proposed units.

(2) The reserve margin without the two Seabrook Units.

*Capability resources includes outside purchases and sales. Generating capability excludes outside purchases and sales.

Table 1.1-12 presents the New England System Demand and Resource Capability Comparison in tabular form showing the effect on reserve margin of delays of various combinations of planned nuclear units.

Reserve margins without the Seabrook Units will drop well below the reserve margin required to meet the one day in 10 years criteria.

The Public Service Company of New Hampshire demand and capability data is plotted in graph form in Figure 1.1-4. The curves shown are:

(1) Capability resources with the Seabrook Units.

(2) Capability resources without the Seabrook Units.

(3) Annual system peak demand.

(4) Generating capability with the Seabrook Units.

(5) Generating capability without the Seabrook Units.

Figure 1.1-5 is a graph of:

(1) The reserve margin with the Seabrook Units.

(2) The reserve margin without the Seabrook Units.

Table 1.1-13 presents the above in tabular form and shows the effect on reserve margin of delays in the Seabrook Units.

1.1.4 Input and Output Diagram

The block diagrams requested in this section have not been supplied because:
1. The information requested in the input diagram is presented in tabular form in Tables 1.1-5 and 1.1-8. The information requested in the output diagram is not available.

1.1.5 Report from the Regional Reliability Council

The Northeast Power Coordinating Council (NPCC) is the regional reliability council that NEPOOL and Public Service Company of New Hampshire are accountable to. Each company under NPCC has agreed to abide by certain rules for design and operation of the interconnected power system.

The Planning Committee of the New England Pool (NEPOOL) is responsible for the overall generation planning for New England. The generation plan is published twice a year in a Load and Capacity Report. This report is filed with the NPCC who in turn include it in the R-362 filing to the FPC. The October 1, 1972, issue of the New England Load and Capacity Report is included in Appendix L.

The Seabrook Units are included as part of the overall generation expansion plan for New England, are approved as NEPOOL planned units and are required to help satisfy the reliability criteria of NPCC, as discussed under subsection 1.1.2.

Subsection 1.1.2 discusses the reliability criteria used to design the system and the studies performed to determine the amount and type of generation required to meet the design criteria. Seabrook 1 and 2 are "NEPOOL planned units" and are required to help meet the reliability criteria in 1979 and beyond. Any delay in either of these units will mean that the reliability criteria will not be met.

References

1. Generation Report No. 4 is a report issued by the Generation Task Force of the New England Planning Committee in 1971 which showed the size and type of generation which best fitted the New England picture.

TABLE 1.1-1

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
HISTORIC AND PROJECTED ANNUAL PEAK HOUR DEMAND

YEAR	PEAK-MW	YEAR	PEAK-MW	YEAR	PEAK-MW
1966	488	1972	875	1978	1580
1967	530	1973	975	1979	1740
1968	600	1974	1073	1980	1916
1969	639	1975	1182	1981	2110
1970	739	1976	1302	1982	2324
1971	805	1977	1434		

TABLE 1.1-2

COMPARISON OF HISTORIC AND PROJECTED GROWTH
IN NEW HAMPSHIRE POPULATION
AND COMPANY PRIME SALES AND PEAK LOAD

Year	N.H. Population	Company Prime Sales MWH	KWH Sales Per Capita	Company Peak Load KW	KW Peak Load Per Capita
			Historic		
1961	619,000	1,548,000	2,501	334,500	0.540
1962	631,000	1,663,000	2,635	364,000	0.577
1963	644,000	1,782,000	2,767	381,700	0.593
1964	656,000	1,919,000	2,925	408,000	0.622
1965	669,000	2,066,000	3,088	450,300	0.673
1966	682,000	2,213,000	3,245	488,100	0.716
1967	696,000	2,486,000	3,572	530,500	0.762
1968	709,000	2,834,000	3,997	600,700	0.847
1969	723,000	3,106,000	4,296	639,200	0.884
1970	738,000	3,411,000	4,622	739,300	1.002
1971	758,000	3,764,000	4,966	805,700	1.063
1972	771,000	4,208,000	5,458	875,100	1.135
			Projected		
1973	785,000	4,589,000	5,846	977,000	1.245
1974	799,000	5,081,000	6,359	1,075,000	1.345
1975	813,000	5,596,000	6,883	1,184,000	1.456
1976	828,000	6,180,000	7,464	1,304,000	1.575
1977	842,000	6,805,000	8,082	1,436,000	1.706
1978	857,000	7,483,000	8,732	1,582,000	1.846
1979	873,000	8,233,000	9,431	1,742,000	1.995
1980	888,000	9,036,000	10,176	1,918,000	2.160
1981	904,000	9,926,000	10,980	2,112,000	2.336
1982	920,000	10,877,000	11,823	2,323,000	2.525

"Population projections are those used by the Company in its sales forecast. The 1980 value of 888,000 may be compared with the U. S. Department of Commerce, Bureau of the Census projections I-C and I-E of 902,000 and 878,000 respectively. (Current Population Reports, Series P-25, No. 477, March 1972.) In 1972, the Company served approximately 83% of the State's population with its prime sales (which include sales to ultimate consumers and prime sales to other utilities)."

TABLE 1.1-3

HISTORIC AND PROJECTED PEAK LOAD
FOR NEW ENGLAND

YEAR	PEAK LOAD MW	YEAR	PEAK LOAD MW	YEAR	PEAK LOAD MW
1966	8699	1972	13423	1978	21073
1967	8942	1973	14502	1979	22698
1968	10045	1974	15643	1980	24459
1969	10600	1975	16853	1981	26345
1970	11643	1976	18169	1982	28378
1971	12135	1977	19564		

TABLE 1.1-4

NEW ENGLAND CAPABILITIES
1963 - 1982

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
(a)	CAPABILITY - MW																				
	Fossil: Thermal	6339	6852	7304	7423	7616	8779	9550	9472	9748	10030	10324	11189	12721	12721	14168	14168	14168	14168	14168	14168
	Gas Turbine	165A	173A	175A	181A	383A	485A	772	1248	1361	1475	1475	1475	1475	1475	1519	1519	1519	1519	1519	1519
	Diesel	A	A	A	A	A	A	161	200	227	241	244	243	243	246	249	249	249	249	249	249
	Combined Cycle											110	110	160	160	437	437	437	437	437	437
	Nuclear:	185	185	185	185	608	638	750	948	1410	3163	3163	4229	4262	4292	4292	5472	7772	9822	12122	13022
	Hydro: Conventional	1183	1180	1175	1174	1169	1172	1228	1233	1239	1243	1223	1248	1249	1249	1249	1249	1249	1249	1249	1249
	Pumped	32	32	32	32	32	32	32	32	32	282	1032	1632	1632	1632	1632	1632	1632	1632	1632	1632
(b)	SALES							175			40	40	41	43							
(c)	PURCHASES	359	328	232	487	584	262	275	476	510	497	482	429	238	593	594	595	595	594	594	594
(d)	GENERATION ADDITIONS																				
	Fossil: Thermal										457	400	865	1592		1451					
	Gas Turbines										130					44					
	Diesel										14	3			4		3				
	Combined Cycle											110		50		277					
	Nuclear:										1753		1066	33	30		1180	2300	2050	2300	900
	Hydro: Conventional										5		25	1							
	Pumped										250	750	600								
	TOTAL ADDITIONS										2609	1263	2556	1676	34	1772	1183	2300	2050	2300	900
(e)	GENERATION RETIREMENTS																				
	Fossil: Thermal										175	106		60		4					
	Gas Turbines										16										
	Diesel												1		1						
	Combined Cycle																				
	Nuclear:																				
	Hydro: Conventional										1	20									
	Pumped																				
	TOTAL RETIREMENTS										192	126	1	60	1	4					
(f)	TOTAL CAPABILITY	8263	8750	9103	9482	10392	11368	12593	13609	14527	16891	18013	20514	21937	22368	24137	25321	27621	29670	31970	32870

NOTE: (A) Combined for 1967 and 1968.

TABLE 1.1-5

NEW ENGLAND COMMITTED AND PLANNED CHANGES IN GENERATING EQUIPMENT 1973-1982

RERATINGS

COMPANY	STATION	EQUIPMENT	CHANGE IN NOMINAL MW	DATE MONTH	DATE YEAR
Maine Yankee	Wiscasset	Base Load Nuclear	+ 209.0	March	1974
Vermont Yankee	Vernon	Base Load Nuclear	+ 27.0	April	1974
Maine Yankee	Wiscasset	Base Load Nuclear	+ 33.0	April	1975
Maine Yankee	Wiscasset	Base Load Nuclear	+ 30.0	May	1976

ADDITIONS

COMPANY	LOCATION	MW CAPABILITY NAME-PLATE	MW CAPABILITY NOM. CAP.	**TYPE	NAME OF MANUFACTURER TURBINE	NAME OF MANUFACTURER BOILER	EXPECTED DATE OF OPERATION MONTH	EXPECTED DATE OF OPERATION YEAR
Northeast Utilities	Northfield #1	211.5	250.0	Pump. Stor. Hydro	G. E.	-----	March	1973
Northeast Utilities	Northfield #2	211.5	250.0	Pump. Stor. Hydro	G. E.	-----	May	1973
Northeast Utilities	Middletown #4	375.4	400.0	Int./Peak Fossil	G. E.	-----	June	1973
Northeast Utilities	Northfield #3	211.5	250.0	Pump. Stor. Hydro	G. E.	-----	July	1973
Taunton Mun. Light Plant	B. F. Cleary Station #9	110.0	110.0	Combined Cycle (90 mw Thermal) (20 mw Gas Turbine)	G. E.	Riley	July	1973
*Shrewsbury Elec. Light	Peaking Plant	-----	2.75	Diesel	-----	-----	Sept.	1973
New England Elec. Sys.	New Deerfield #5	15.0	15.0	Conv. Hydro	West.	-----	March	1974
New England Elec. Sys.	Fife Brook	11.0	10.0	Conv. Hydro	West.	-----	April	1974
Northeast Utilities	Millstone #2	860.7	830.0	Nuclear Base Load	G. E.	-----	April	1974
New England Elec.Sys.	Bear Swamp #2	300.0	300.0	Pump. Stor. Hydro	Toshiba	-----	May	1974
Public Ser. Co. of NH	Newington, N. H.	424.0	400.0	Int./Peak Fossil	West.	C. E.	June	1974
New England Elec. Sys.	Bear Swamp #1	300.0	300.0	Pump. Stor. Hydro	Toshiba	-----	July	1974
New England Elec. Sys.	Brayton Point #4	437.0	465.0	Int./Peak Fossil	G. E.	Riley	Dec.	1974
Boston Edison Company	Mystic #7	587.0	587.0	Base/Int. Fossil	G. E.	C. E.	May	1975
United Illuminating	Coke Works	-----	445.0	Base/Int. Fossil	G. E.	C. E.	June	1975
Braintree Elec. Light	Potter Station	-----	50.0	Combined Cycle	-----	-----	July	1975
NEGEA & EUA	Canal #2	-----	560.0	Base/Int. Fossil	West.	B & W	July	1975
MEPCO/NB Purchase #2 (start)	----------------	-----	200.0	Inter. Fossil	-----	-----	Jan.	1976
MEPCO/NB Purchase #2 (start) (Increase)	----------------	-----	200.0	Inter. Fossil	-----	-----	July	1976
*Shrewsbury Elec. Light	Peaking Plant	-----	2.75	Diesel	-----	-----	Fall	1976
Peabody Mun. Light Plant	Peabody	17.3	20.0	Gas Turbine	Turbo Power	-----	-----	1977
New England Gas & Elec. Assn.	Unknown	-----	24.0	Jet Gas Turbine	-----	-----	July	1977
Vermont Group	Undecided	277.0	277.0	Combined Cycle	West.	-----	Aug.	1977
Central Maine Power	W. F. Wyman #4	-----	600.0	Base/Int. Fossil	-----	-----	Nov.	1977
New Eng. Elec. Sys.	North Shore	850.0	850.0	Base/Int. Fossil	G. E.	-----	Nov.	1977

COMPANY	LOCATION	MW CAPABILITY NAME-PLATE	MW CAPABILITY NOM. CAP.	**TYPE	NAME OF MANUFACTURER TURBINE	NAME OF MANUFACTURER BOILER	EXPECTED DATE OF OPERATION MONTH	EXPECTED DATE OF OPERATION YEAR
*Shrewsbury Elec. Light	Peaking Plant	------	2.75	Diesel	----	----	Fall	1978
Boston Edison Company	Pilgrim #2	1180.0	1180.0	Nuclear Base Load		C. E.	Nov.	1978
Northeast Utilities	To be determined	------	1150.0	Nuclear Base Load	G. E.	West.	May	1979
P.S.Co.N.H. & U.I.	Seabrook #1	1150.0	1150.0	Nuclear Base Load	----	West.	Nov.	1979
Boston Edison Company	Pilgrim #3	1180.0	1150.0	Nuclear Base Load			June	1980
**New. Eng. Elec. Sys.	Rome Point #1	900.0	900.0	Nuclear Base Load	----	----	June	1980
Northeast Utilities	To be determined	1150.0	1150.0	Nuclear Base Load	----	----	May	1981
P.S.N.H. & U. I.	Seabrook #2	1150.0	1150.0	Nuclear Base Load	----	----	Nov.	1981
**New Eng. Elec. Sys.	Rome Point #2	900.0	900.0	Nuclear Base Load	----	----	June	1982

*Figures used taken from L & C Report dated March 1, 1972.

**Tentative Location.

TABLE 1.1-6

NEW ENGLAND CAPACITY RETIREMENTS

COMPANY	STATION	EQUIPMENT	CHANGE IN NOMINAL MW	DATE MONTH	DATE YEAR
Fitchburg Gas & Elec. Light Co.	Fitchburg #1, 2, 3, and 5	Conv. Thermal	- 28.0	January	1973
Northeast Utilities	Dwight #2, 3 & 5	Hydro	- 1.2	January	1973
Public Service Co. of N. H.	Kelleys	Hydro	----	March	1973
Public Service Co. of N. H.	Kelleys #1 and 2	Conv. Thermal	- 18.0	March	1973
Public Service Co. of N. H.	Jackman Station	Hydro	- 3.0	March	1973
Montaup	Fall River	Conv. Thermal	- 14.0	April	1973
Montaup	Pawtucket #3, 4 and 5	Conv. Thermal	- 26.0	April	1973
Montaup	E. Bridgewater #2, 3, and 4	Conv. Thermal	- 20.0	April	1973
New England Electric System	Deerfield #5	Hydro	- 15.0	May	1973
Public Service Co. of N. H.	Canaan Station	Hydro	- 1.0	June	1973
MEPCO/NB Purchase #1	------------	Interm Fossil	- 20.0	July	1973
Municipal Electric Dept.	Wolfeboro, New Hampshire	Diesels	- 0.3	January	1974
MEPCO/NB Purchase #1	------------	Interm Fossil	- 40.0	July	1974
Municipal Electric Dept.	Wolfeboro, New Hampshire	Diesels	- 0.3	January	1975
New England Electric System	South Street #8	Conv. Thermal	- 37.0	January	1975
MEPCO/NB Purchase #1 (End of Purchase)		Interm Fossil	-200.0	July	1975
New England Gas & Elec. Assn.	Blackstone #2 and 4	Conv. Thermal	- 8.0	July	1975
New England Gas & Elec. Assn.	Cannon Street #4 and L. P. Boilers	Conv. Thermal	- 15.0	July	1975
Municipal Electric Dept.	Wolfeboro, New Hampshire	Diesels	- 0.5	January	1976
Vermont Group	Milton	Conv. Thermal	- 4.0	August	1977

TABLE 1.1-7

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE CAPABILITIES
1963 - 1982

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
(a) CAPABILITY - MW																					
Fossil:	Thermal	359	359	359	359	359	696	696	696	696	696	678	1078	1078	1078	1078	1078	1078	1078	1078	1078
	Gas Turbines						44	89	111	111	111	111	111	111	111	111	111	111	111	111	111
	Diesel	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Combined Cycle																				
Nuclear:																		575	575	1150	1150
Hydro:	Conventional	48	48	48	48	48	48	48	48	48	48	48	44	44	44	44	44	44	44	44	44
	Pumped																				
(b) SALES						0	160	160	110	100	100	100	100	100	100	100	100	220	220	220	220
(c) PURCHASES		17	42	62	89	181	40	103	106	168	305	367	150	207	387	463	667	417	417	417	417
(d) GENERATION ADDITIONS																					
Fossil:	Thermal						335						400								
	Gas Turbines						44	45	23												
	Diesel																				
	Combined Cycle																				
Nuclear:																		575		575	
Hydro:	Conventional																				
	Pumped																				
TOTAL ADDITIONS							379	45	23				400					575		575	
(e) GENERATION RETIREMENTS																					
Fossil:	Thermal										3	15									
	Gas Turbines																				
	Diesel																				
	Combined Cycle																				
Nuclear:																					
Hydro:	Conventional											4									
	Pumped																				
TOTAL RETIREMENTS											3	19									
TOTAL GENERATION		410	410	410	410	410	791	836	858	858	855	836	1236	1236	1236	1236	1236	1811	1811	2386	2386
TOTAL CAPABILITY		427	452	472	499	591	671	779	854	926	1060	1103	1286	1343	1523	1599	1803	2008	2008	2583	2583

Note: 1979 and 1981 nuclear additions are Public Service Company of New Hampshire's share of the two Seabrook Units.

TABLE 1.1-8

NEW ENGLAND REQUIRED RESERVES AND CAPABILITY

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Predict Winter Peak Load -MW	14502	15643	16857	18169	19564	21073	22698	24459	26345	28378
Reserve Requirements -Percent	20.8	22.4	21.9	20.0	20.0	20.7	23.5	24.1	24.5	23.9
Reserve Requirements -MW	3016	3504	3691	3634	3913	4362	5334	5895	6454	6782
Required Capability -MW	17518	19147	20544	21803	23477	25435	28032	30354	32799	35160

NOTE: (1.) Winter peak loads are from the October, 1972, issue of the New England Load and Capacity Report.

TABLE 1.1-9

FORCED OUTAGE RATES

1. Nuclear and Fossil Base Load Capacity and Intermediate Fossil with Single Boilers:

Unit Size MW	Immature Rates %*	Immature Rates %**	Mature Rates %
10- 89	3.6	2.7	1.8
90- 199	5.0	3.8	2.5
200- 389	9.0	6.8	4.5
390- 499	11.2	8.4	5.6
500- 649	12.2	9.0	6.1
650- 849	13.4	10.1	6.7
850-1049	14.4	10.8	7.2
1050-1249	15.4	11.6	7.7

2. Internal Combustion:

10 percent was used for the life of the unit.

3. Pumped Hydro:

Unit Size MW	Immature Rates %*	Immature Rates %**	Mature Rates %
250	5.0 through 1st 3 Dec. Pks.		1.5

4. Conventional Hydro:

All sizes	2.0	1.5	1.0

*This forced outage rate is held through the 1st. Two December Peaks after the unit is commercial.

**This forced outage rate is held one year (Through the third December Peak after the unit is commercial). After this time period the mature FO rate applies.

TABLE 1.1-10

PLANNED MAINTENANCE SCHEDULES

(Weeks Per Year)

	1st Part Year	2nd Year	3rd Year	All Years After
Nuclear	0	9	5	5
All Fossil	0	4	4	4
Internal Combustion	0	1	1	1
Pump Hydro	0	*	*	*

*Units in a plant are staggered on a cycle with one unit out every five years for four weeks.

TABLE 1.1-11

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

REQUIRED RESERVES AND CAPABILITY

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Predicted Winter Peak Load - MW	977	1075	1184	1304	1436	1582	1742	1918	2112	2323
Required Reserves - Percent	20.8	22.4	21.9	20.0	20.0	20.7	23.5	24.1	24.5	23.9
Reserve Requirements - MW	203	241	259	261	287	327	409	462	517	555
Required Capability - MW	1180	1316	1443	1565	1723	1909	2151	2380	2629	2878

TABLE 1.1-12

NEW ENGLAND SYSTEM DEMAND AND RESOURCE CAPABILITY COMPARISON

1967-1982 (USING COMMITTED OR PLANNED GENERATION ONLY)

		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
New England Load		9222	10045	10962	11643	12135	13423	14502	15643	16835	18169	19564	21073	22698	24459	26345	28378
New England Capability*		10392	11368	12593	13609	14527	16891	18013	20514	21937	22368	24137	25321	27621	29670	31970	32870
New England Generation		9808	11106	12318	13133	14018	16425	17537	20071	21685	21761	23529	24712	27026	29076	31376	32276
New England Reserve Margin	MW	1170	1323	1631	1966	2392	3468	3511	4871	5084	4199	4573	4248	4923	5211	5625	4492
	%	12.7	13.2	14.9	16.9	19.7	25.8	24.2	31.1	30.2	23.1	23.4	20.2	21.7	21.3	21.4	15.8

WITHOUT THE TWO SEABROOK UNITS

		1979	1980	1981	1982
New England Capability		26471	28520	29670	30570
New England Generation		25876	27928	29076	29978
New England Reserve Margin	MW	3773	4061	3325	2192
	%	16.6	16.6	12.6	7.7

WITHOUT ANY OF THE "UNLICENSED FOR CONSTRUCTION" NUCLEAR UNITS

		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
New England Capability													24171	24171	24170	24170	24170
New England Generation													23562	23576	23576	23576	32578
New England Reserve Margin	MW												3098	1473	- 289	-2175	-4208
	%												14.7	6.4	- 1.1	- 8.2	-14.8

*Capability resources include outside purchases and sales.

Generating capability excludes outside purchases and sales.

TABLE 1.1-12

NEW ENGLAND SYSTEM DEMAND AND RESOURCE CAPABILITY COMPARISON

1963-1982 (USING COMMITTED OR PLANNED GENERATION ONLY)

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
New England Load		6987	7477	8115	8699	9222	10045	10962	11643	12135	13423	14502	15643	16835	18169	19564	21073	22698	24459	26345	28378
New England Capability*		8263	8750	9103	9482	10392	11368	12593	13609	14527	16891	18013	20514	21937	22368	24137	25321	27621	29670	31970	32870
New England Generation		7904	8425	8871	8995	9808	11106	12318	13133	14018	16425	17537	20071	21685	21761	23529	24712	27026	29076	31376	32276
New England Reserve Margin	MW	1276	1273	988	783	1170	1323	1631	1966	2392	3468	3511	4871	5084	4199	4573	4248	4923	5211	5625	4492
	%	18.3	17.0	12.2	9.0	12.7	13.2	14.9	16.9	19.7	25.8	24.2	31.1	30.2	23.1	23.4	20.2	21.7	21.3	21.4	15.8

WITHOUT THE TWO SEABROOK UNITS

		1979	1980	1981	1982
New England Capability		26471	28520	29670	30570
New England Generation		25876	27928	29076	29978
New England Reseeve Margin	MW	3773	4061	3325	2192
	%	16.6	16.6	12.6	7.7

WITHOUT ANY OF THE "UNLICENSED FOR CONSTRUCTION" NUCLEAR UNITS

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
New England Capability																	24171	24171	24170	24170	24170
New England Generation																	23562	23576	23576	23576	32578
New England Reserve Margin	MW																3098	1473	-289	-2175	-4208
	%																14.7	6.4	-1.1	-8.2	-14.8

*Capability resources include outside purchases and sales.

Generating capability excludes outside purchases and sales.

TABLE 1.1-13

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

DEMAND AND RESOURCE CAPABILITY COMPARISON

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Public Service Company of New Hampshire Load		381	408	450	488	530	600	639	739	805	875	977	1075	1184	1304	1436	1582	1742	1918	2112	2323
Public Service Company of New Hampshire Capability		427	452	472	499	591	671	799	854	926	1060	1103	1286	1343	1523	1599	1803	2008	2008	2583	2583
Public Service Company of New Hampshire Generation		410	410	410	410	410	791	836	858	858	855	826	1236	1236	1236	1236	1236	1811	1811	2386	2386
Public Service Company of New Hampshire Reserve Margin	MW	46	44	22	11	61	71	140	115	121	188	126	211	159	219	163	221	266	90	471	260
	%	12.1	10.8	4.9	2.3	11.5	11.8	21.9	15.5	15.0	21.4	12.8	19.6	13.4	16.7	11.3	13.9	15.2	4.6	22.3	11.1

WITHOUT THE SEABROOK UNITS

		1979	1980	1981	1982
Public Service Company of New Hampshire Capability		**1433**	**1433**	**1433**	**1433**
Public Service Company of New Hampshire Generation		**1236**	**1236**	**1236**	**1236**
Public Service Company of New Hampshire Reserve Margin	**MW**	**-309**	**-485**	**-679**	**-890**
	%	**-17.7**	**-25.2**	**-32.1**	**-38.3**

Capability equals generation plus purchases minus sales.

Generation is only generation on our system - Yankee's etc., are purchases.

BY ____________ DATE ________ SUBJECT ______________________ SHEET NO. ________ OF _____
CHKD. BY ______ DATE ________ JOB NO. ________________

FIGURE 1.1-1
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
GENERATION SCHEDULE PROPOSED FOR THE
DAY OF THE 1982 PEAK LOAD

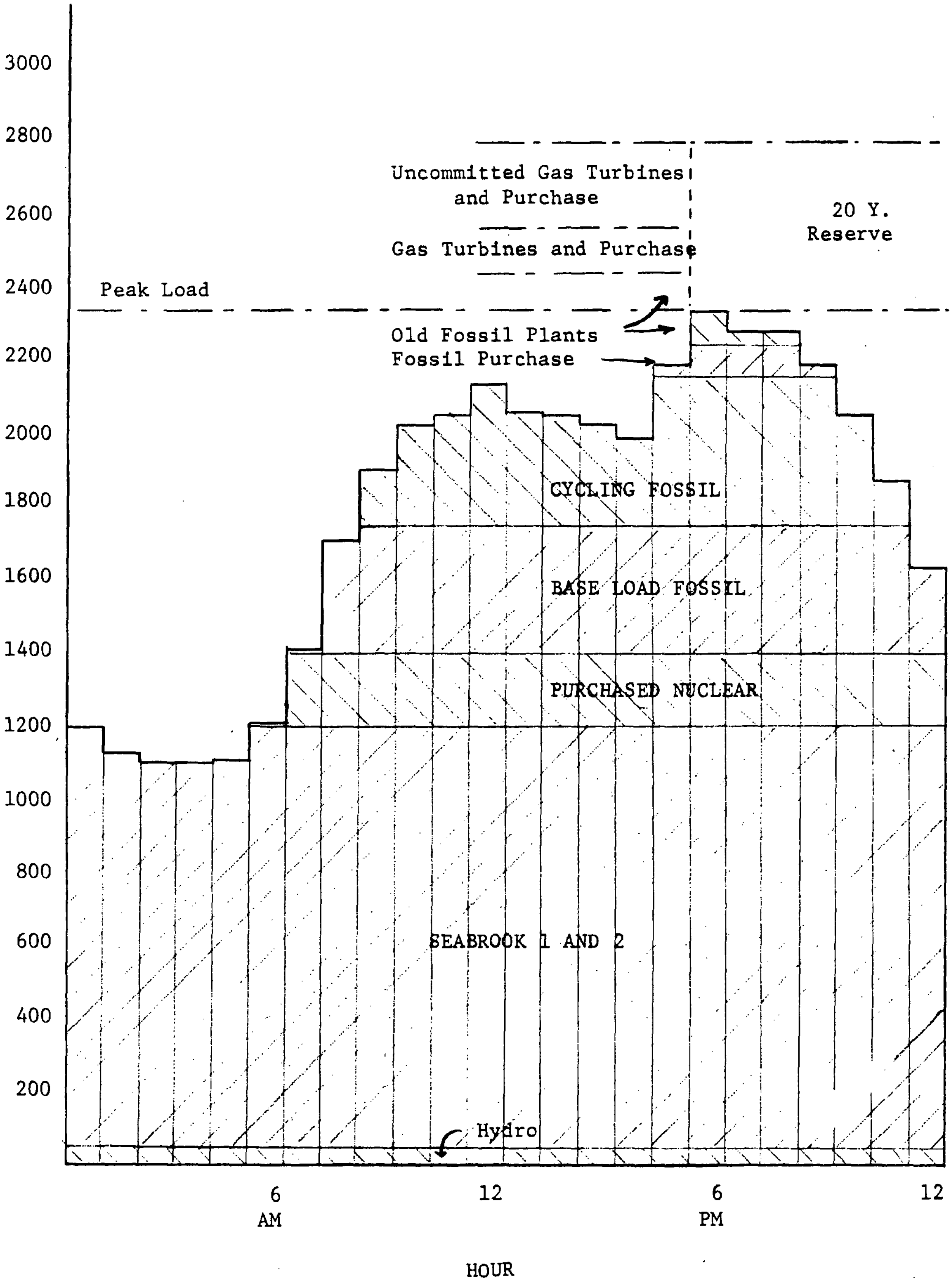


FIGURE 1.1-2
NEW ENGLAND SYSTEM DEMAND
AND
RESOURCE CAPABILITY COMPARISON

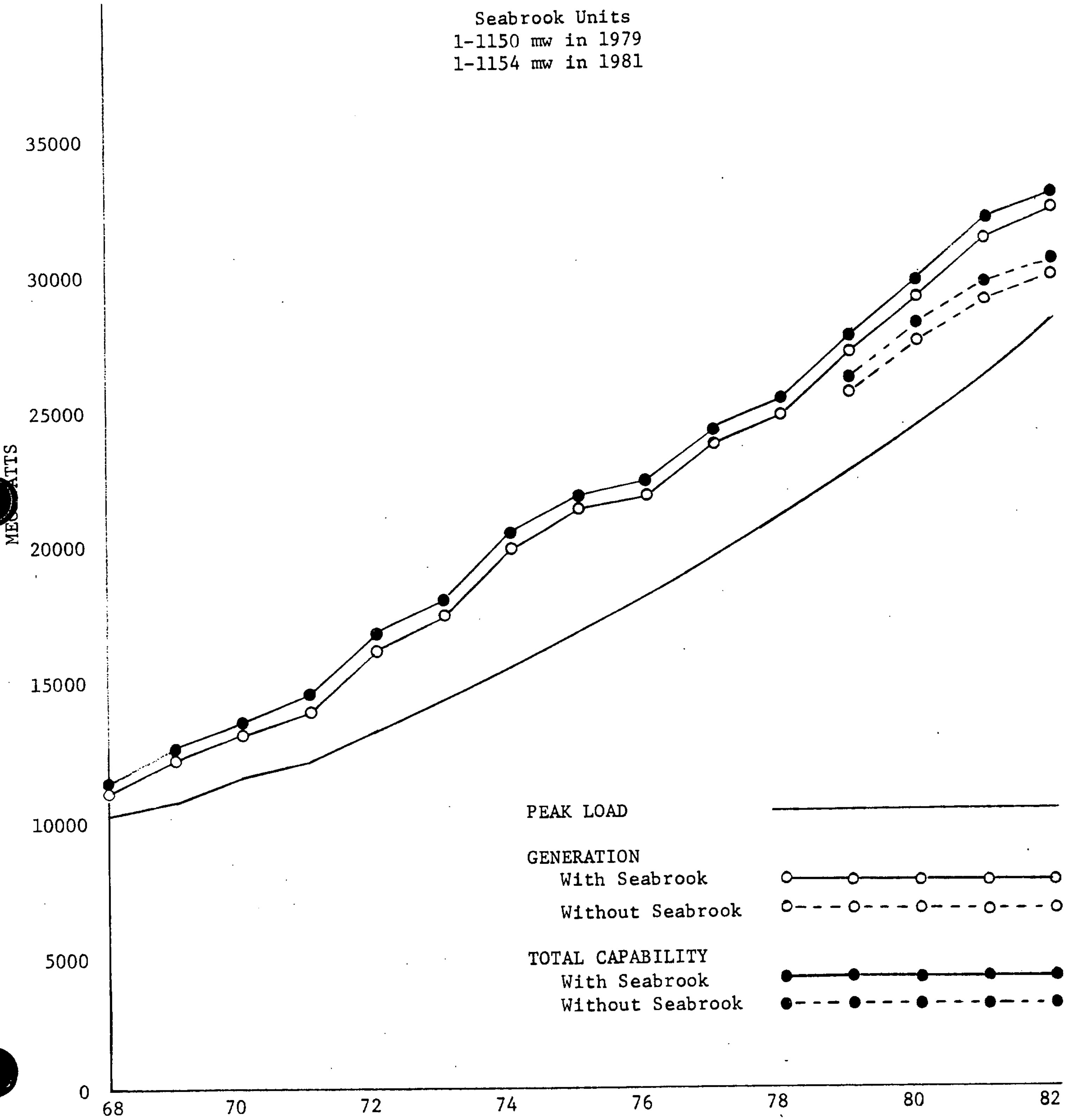


FIGURE 1.1-3
NEPOOL RESERVE MARGIN
AS A PERCENTAGE
OF PEAK SYSTEM DEMAND
(Using Committed Generation Only)

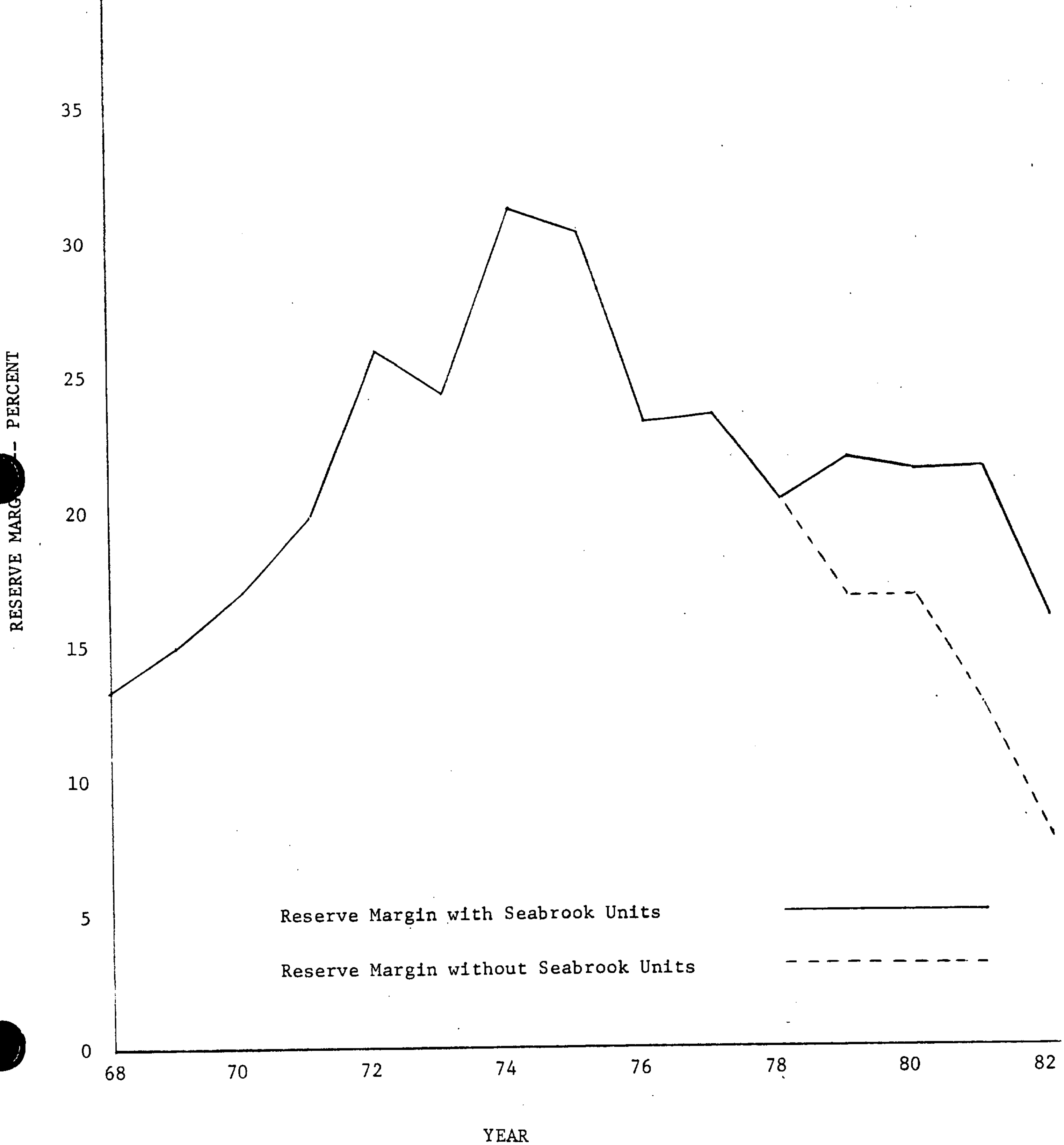
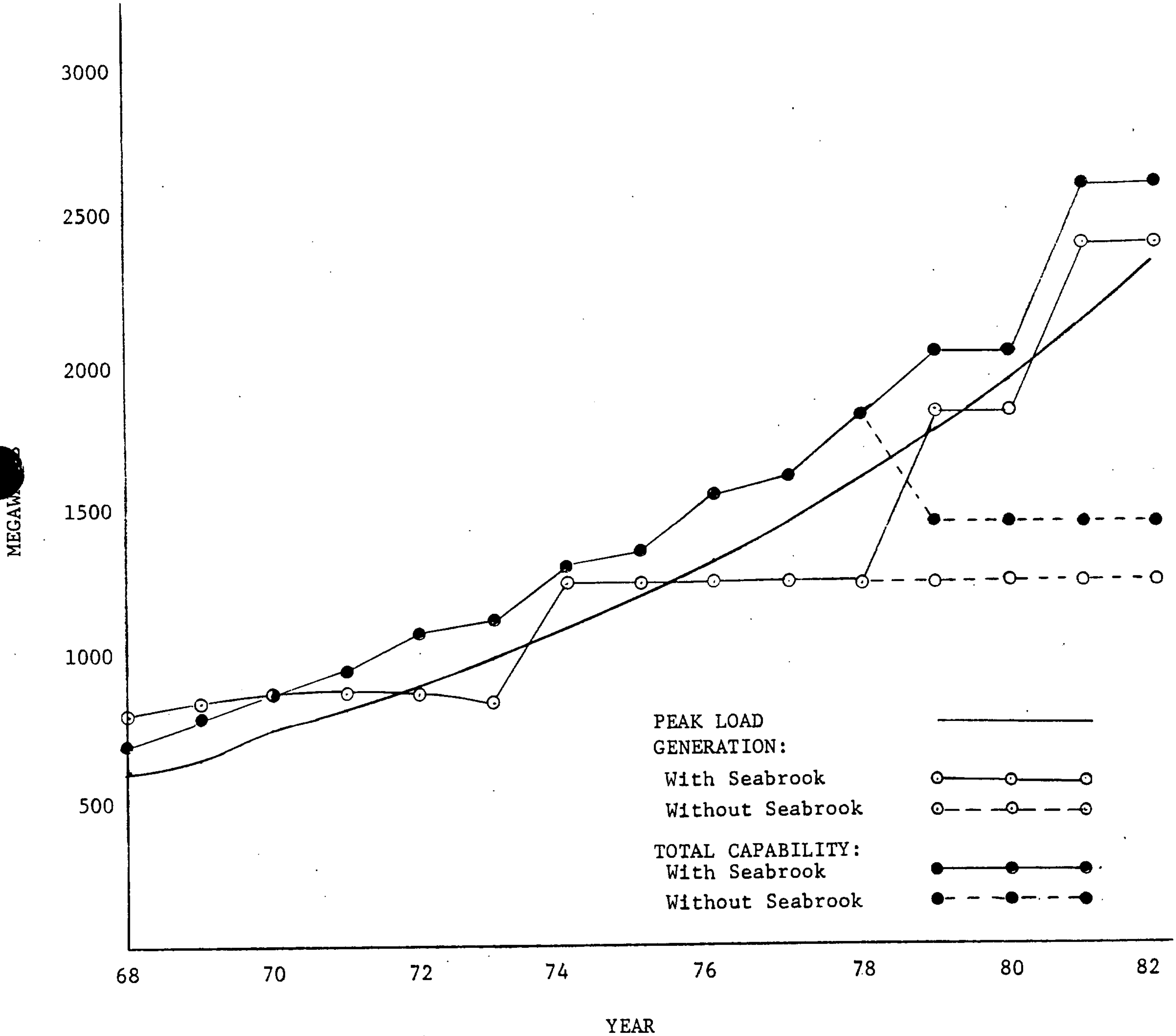
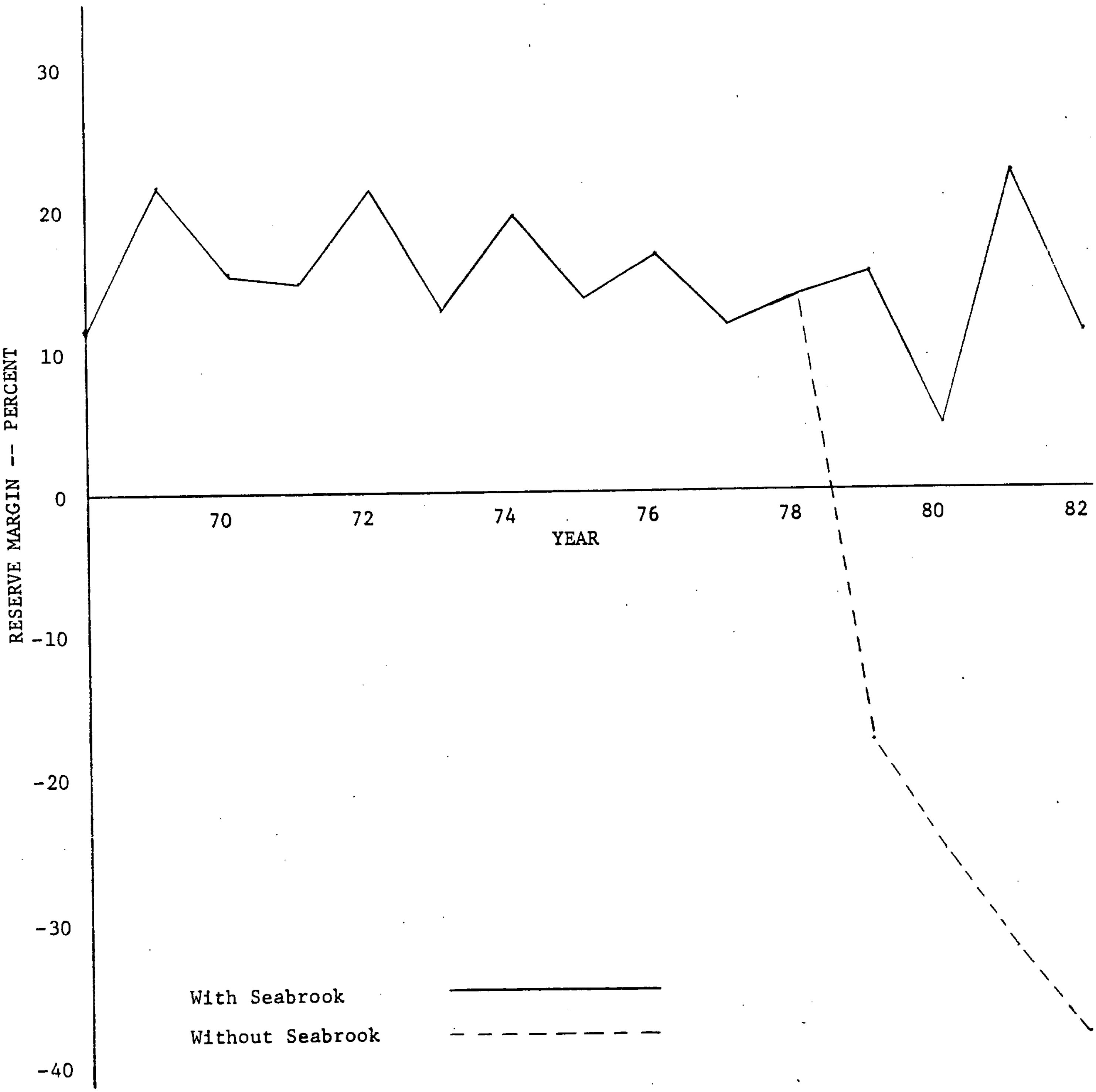


FIGURE 1.1-4
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
SYSTEM DEMAND AND RESOURCE
CAPABILITY COMPARISON



NOTE: Only Public Service Company of New Hampshire's share or Seabrook's is counted.

FIGURE 1.1-5
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
RESERVE MARGIN AS A PERCENTAGE
OF PEAK SYSTEM DEMAND



NOTE: Only Public Service Company of New Hampshire's share or Seabrook's is counted.

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
Comparison of Historic and Projected Growth in Prime Sales and
Peak Load Vs New Hampshire Population
1961-1982

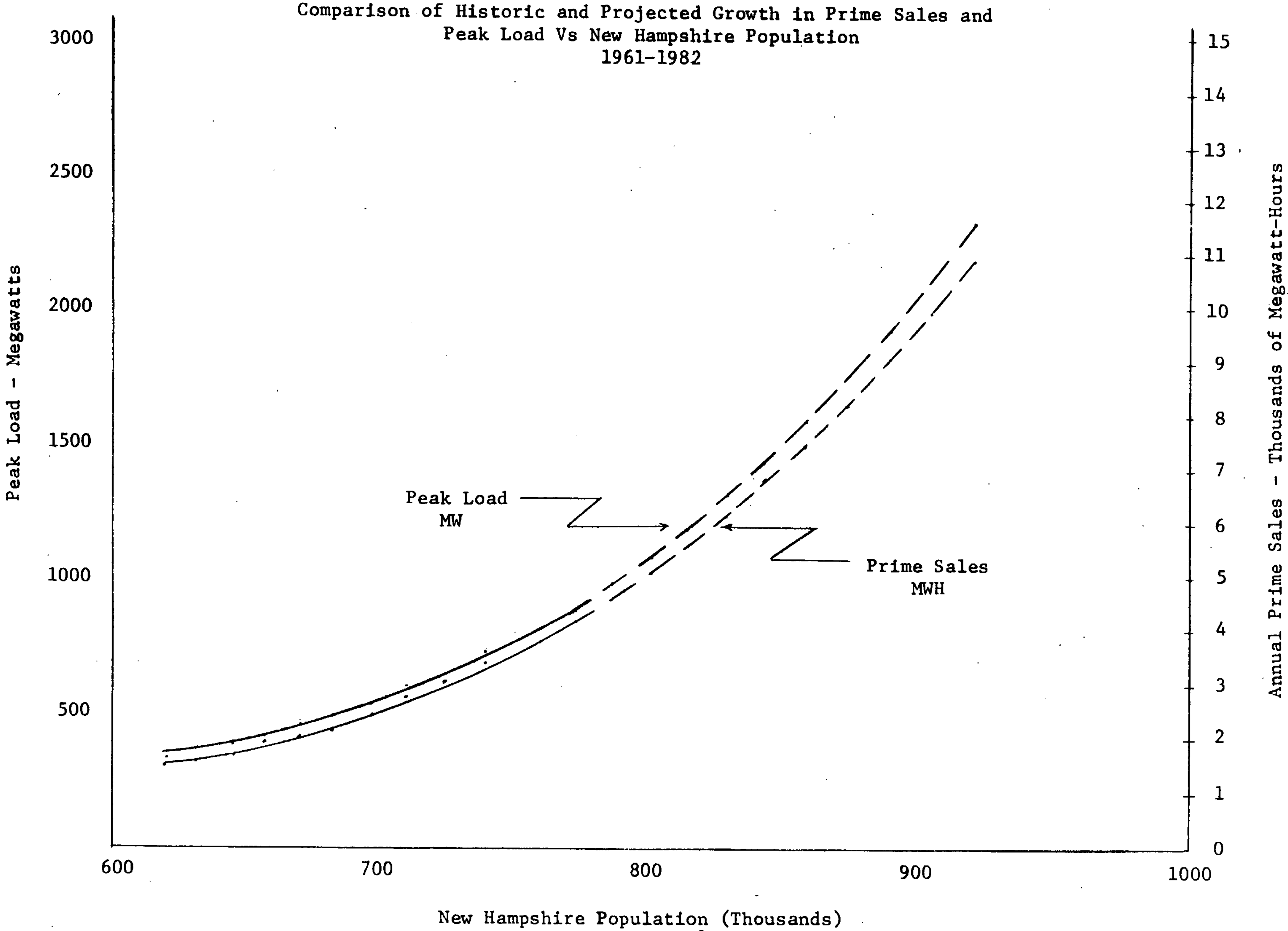


FIGURE 1.1-6

1.2

1.2 Other Primary Objectives

The sole purpose of the proposed facility is to convert nuclear energy into electrical energy. There are no other objectives in constructing the plant.

1.3

1.3 Consequences of Delay

The consequences of delay in granting a Construction Permit for the Seabrook project fall in four categories:

1. Effect on each Applicant's ability to meet demands for electricity;
2. Effect on adequacy and reliability of regional power supply;
3. Economic effects; and
4. Environmental effects

In considering these four matters, it should be kept in mind that the Seabrook units are to be jointly owned in various ownership percentages by a group of at least nine and possibly twenty-two electric systems. The nine committed participants and the thirteen other systems which may become participants, and their respective ownership shares, are set forth below. To the extent that some or all of the other thirteen systems elect to finalize their participation, which they may do at any time prior to June 30, 1974, the maximum percentages of the nine committed participants will be appropriately reduced.

Committed Participants

	Ownership Percentage	
	Maximum	Minimum
Public Service Company of New Hampshire	50.0000	47.58458
The United Illuminating Company	20.0000	20.00000
Central Maine Power Company	2.5505	2.51891
The Connecticut Light & Power Company	11.9776	11.82073
Fitchburg Gas and Electric Light Company	.1716	.16948
Montaup Electric Company	1.9064	1.82791
New Bedford Gas and Edison Light Company	1.3539	1.33714
New England Power Company	8.9430	8.64769
Vermont Electric Power Company, Inc.	3.0970	3.05865
	100.0000	96.96509

Other Possible Participants

	Ownership Percentage
Ashburnham Municipal Light Plant	.01195
Burlington Electric Light Department	.22175
Eastern Maine Electric Cooperative, Inc.	.00256
Holyoke Gas and Electric Department	.09946
Hudson Light and Power Department	.05780
Hull Municipal Lighting Plant	.01345
Marblehead Municipal Light Department	.05565
Middleborough Gas & Electric Department	.05598
Middleton Municipal Light Department	.02563
New Hampshire Electric Cooperative, Inc.	2.41542
North Attleborough Electric Department	.03648
South Norwalk Electric Works	.00855
Templeton Municipal Light Plant	.03023
	3.03491

1.3.1 Effect on Ability to Meet Demands

Capacity and energy supplied by the Applicants to meet demands (directly or indirectly) in their respective areas can be placed in two categories:

1. Sales at retail; and
2. Firm sales at wholesale to other utility systems for resale to ultimate consumers.

Sales at Retail

The obligations of the Applicants to meet demands for electric power are inherent in their status as utilities, whether or not (in the case of municipal or cooperative systems) they are "public utilities" under the applicable law. In general, it may be stated that each participant (or if such participant is solely a generating company, its distribution affiliate) has the obligation to furnish adequate electric service within its retail service territory and that its failure to furnish adequate service subjects such participant to the possibility of customer complaint and regulatory agency investigation and may lead to loss of its franchise or authority to operate. The nature and importance of electricity as a commodity are such that electric systems cannot arbitrarily restrict the use of electricity by their customers or unreasonably refuse to provide service to anyone requesting it. Therefore, they must plan to meet the anticipated demand for electricity caused by projected growth in the number of cutomers and in customer usage.

Firm Sales at Wholesale for Resale

Some of the participants provide electric service to other utility systems for resale to ultimate consumers. The selling system's obligations, whether to supply a fixed or maximum amount of power or to supply the customer's total requirements (or total requirements above power available from other sources) are set forth in applicable tariffs or contracts. In the case of Public Service Company of New Hampshire, contracts of this type are on file with the Federal Power Commission with respect to service to the following New Hampshire systems:

New Hampshire Electric Cooperative, Inc.
Concord Electric Company
Exeter & Hampton Electric Company
Wolfeboro Municipal Department
Ashland Municipal Department
New Hampton Municipal Department

Th purchasing systems' obligations to supply their customers can only be met if the selling systems meet their obligations under such tariffs or contracts.

1.3.2 Effect on Adequacy and Reliability of Regional Power Supply

Up-to-date revisions of the New England Load and Capacity Report are annually filed with the Northeast Power Coordinating Council so that this information may be used for filing this Council's report to the Federal Power Commission under Docket R-362 Order No. 383-2. The latest New England Report, dated October 1972, estimates Load and Capacity requirements through 1982 and incorporates the planning of Seabrook Units I and II scheduled for commercial operation in 1979 and 1981 respectively. Information from this Report was used for projecting future New England peak loads, reserve requirements, and reserve margins presently anticipated based upon generation committed or planned to date. Information from Tables 1.1-8 and 1.1-12 of this report is summarized here for the years 1979 through 1982:

With the Operation of Seabrook Units I and II as Planned

	1979	1980	1981	1982
New England Peak Load (MW)	22,698	24,459	26,345	28,378
New England Reserve Requirements (%)	23.5	24.1	24.5	23.9
New England Reserve Margin (%)	21.7	21.3	21.4	15.8

As shown also in Table 1.1-12, if Seabrook I and II are deleted from the available capability on which the above reserve margins are based, the New England margins would be as follows:

Without Operation of Seabrook Units I and II

	1979	1980	1981	1982
New England Reserve Margin (%)	16.6	16.6	12.6	7.7

These reductions in New England reserve margins would result in inadequate capability to meet the NEPOOL reliability criterion of failure to meet load requirements no more often than "one day in ten years".

Additionally, reserve margins solely for Public Service Company of New Hampshire as an individual participant in Seabrook have been developed and, as shown in Table 1.1-13, are as follows:

Without Operation of Seabrook Units I and II

	1979	1980	1981	1982
P.S. Co. of N. H. Reserve Margins (%)	-17.7	-25.2	-32.1	-38.3

These negative reserve margins indicate that Public Service Company of New Hampshire as a single entity would not only be void of reserves, but would be unable to meet from 17 to 38 percent of its peak load depending on the year selected and the delay anticipated. Without the protection the New England Power Pool provides, this impact on the reliability of the system of Public Service Company would be intolerable. Even though the Company's system reliability will be as good as the reliability of the Pool as a whole, there would be serious economic consequences to the Company, as discussed below.

1.3.3 Economic Effects

Unit I is on a very tight schedule with commercial operation scheduled for November 1, 1979. This requires that fuel loading take place in May 1979. Based on this schedule, any delay in receiving a Construction Permit will create at least an equal delay in the date of commercial operation. If a Construction Permit is received on January 1, 1975, 52 months would be available for field construction prior to fuel loading, and would allow a total construction period to commercial operation of 58 months. This is believed to be the shortest construction schedule feasible. If the Construction Permit is received by September 1, 1974, an additional four months would be available for site preparation before the rigors of New England winter set in. The resulting schedule would be much more realistic and the ability to meet December 1979 peak loads much more assured.

The responsibilities of the participants to meet certain power needs has been previously discussed, and construction of the Seabrook units on schedule is required to allow the participants to meet these responsibilities. As has been discussed, a significant reduction in reserve margins will most certainly occur in New England if delay in the operation of either Seabrook unit occurs. But assuming that power demands will somehow be met from other sources, there will be an adverse financial impact to the participants throughout this period of delay and this will be reflected in reduced income and/or higher electric rates to the consumer. Perhaps the most obvious economic consequence would be caused by the purchase of replacement power during the period of delay.

Quantification of the estimated adverse financial effects during the delay of commercial operation is extremely difficult. The method of determining these costs is to compare the actual replacement power costs that would occur without Seabrook to the costs that would occur with Seabrook in operation as planned, taking into consideration the resulting tax savings. The actual replacement power costs would include the costs of capability and energy charges under Section 9 and 12 of the New England Power Pool Agreement, but determing these charges for nearly seven years in the future is impossible. It is, however, evident that the cost of the required replacement energy, which would be from oil-fired units, when compared to the nuclear energy it will replace, will carry a sizeable penalty; and assuming a plant factor of 70 percent, this penalty will amount to approximately $6,750,000 per year per mill of energy cost difference for each of the two Seabrook units. It is also fairly evident that this energy penalty will be based on a cost differential of several mills. But estimates of that portion of the replacement power costs which are related to replacement capacity are indeterminate because of many unknown factors, including the fact that charges under the Pool agreement are subject to the review and, in some cases, the discretion of the Management Committee during the intervening years. Since the cost related to replacement capacity could vary through a wide range any meaningful estimate of this is presently impossible.

Thus, with no reasonable way to evaluate the capability charge at this time, and because this variable is a major one in the economic penalty equation, any meaningful comparison between the total cost for replacement power and Seabrook power total cost is precluded. But the exposure to this economic penalty is in no way minimized by the fact that its magnitude is presently indeterminate. In fact, considering the practical considerations regarding the variables in light of ascending fuel oil prices, higher capacity costs, environmental requirements, etc., it is concluded that any delay in granting the Construction Permit will create replacement power penalties with adverse economic consequences proportional to the delay.

Adding to the economic consequences discussed above, delay also increases the exposure to inflationary factors which have historically increased the investment in construction. But even more severe than inflation are the economic consequences of delay which disrupt the construction schedule itself. The impact of this delay would create numerous inefficiencies in the coordination and utilization of manpower of the various crafts, and create problems for storing and/or setting in place heavy equipment and materials which, due to their long deliveries, must be ordered far in advance in order to meet the construction schedule. Because of the close coordination the construction schedule requires between Seabrook Unit I and Unit II, any prolonged delay will produce congestion of both manpower and equipment within the limited construction area, and the consequences of this would become more severe for each day the Construction Permit is delayed. These effects will be experienced by both units and will not only increase the severity of the replacement power penalties discussed above, but will add to the construction costs of each project. The resulting increase in the investment of each unit will require higher annual costs which in turn must be borne by the consumer through higher electric rates over the life of the Seabrook units. The magnitude of this economic impact will increase substantially for any extended Construction Permit delay.

1.3.4 Environmental Effects

Because Seabrook Unit I is on the shortest feasible construction schedule, it is expected that any delay in receiving a Construction Permit will extend the construction schedule by an equal amount of time. Accordingly, if the Construction Permit for Seabrook Unit I were delayed one year, the energy to have been furnished by this nuclear unit would have to be provided by existing units in New England, which are those normally operating in the intermediate and peaking ranges of the load curve. All forms of generation including diesels, gas turbines, pumped hydro, oil-fired fossil units, etc., will be called into service for longer hours use to supply this replacement energy, the bulk of which will be supplied by the intermediate oil-fired units existing at this time.

Without overstating the facts, and in order to evaluate the environmental impact due to delay of obtaining a Construction Permit, a conservative and simplified approach was selected to indicate the magnitude of the environmental problems created by increased operation of generation existing in 1979. Studies of Public Service Company indicate that Seabrook Unit I during its first year of operation would generate the equivalent of approximately 6000 hours at full load. It was then assumed that this energy would be replaced from a modern base load oil-fired unit meeting emission standards for particulate matter, sulfur dioxide, and nitrous oxide as specified in 42CFR466, EPA Standards of Performance for New Stationary Sources, and New Hampshire Air Pollution Control Agency Standards. The use of low sulfur fuels, specialized firing processes, precipitators, etc., would be necessary for the plant assumed to meet these standards. Ambient air quality standards have not been considered, because compliance with these standards must be developed separately for each site.

The results of emission calculations based on these assumptions are consistent with the emission calculations in Section 9.3 and are as follows:

Effluent	EPA Standards (lbs/MBTU)	N.H. Air Pollution Standards (lbs/MBTU)	Total Emission** (lbs/hr)	(tons/yr)
Particulate Matter	0.2	.12	1,250	3,700
Sulfur Dioxide	0.8	*	8,250	24,800
Nitrous Oxide	0.3	--	3,100	9,300

* Requires 1% sulfur oil
** Based on the lower of either standard.

This environmental degradation could be avoided provided granting of the Seabrook Construction Permit is not delayed.

Because of the lower thermal efficiency of the nuclear unit relative to an oil-fired one, and because of its resulting larger quantities of waste heat per KWH, it initially would appear that the environmental impact on aquatic ecology due to cooling water would favor the increased use of oil-fired units. But because Seabrook is being designed to meet all water quality criteria imposed, there is ample reason to believe that this ocean-discharge cooling system will have less environmental impact than oil-fired units installed before these criteria were established. Thus, the differences between the environmental impacts caused from the cooling systems of the two types of plants is virtually zero.

Another advantage that might be suggested for the longer hours use of the oil-fired units occasioned by delay of Seabrook, concerns the gaseous and liquid radioactive releases which are eliminated when a nuclear plant is not operated. However, strict radiation monitoring programs will be provided at Seabrook to guarantee compliance with all applicable radiation regulations. Postulating that these regulations restrict releases to amounts that have no significant environmental impact, it can be concluded that no environmental benefit can be attributed to the use of the oil-fired units.

In summary, the environmental impact for longer hours use of oil-fired units resulting from a delay of the Seabrook nuclear generation is totally adverse. Environmental achievements can be made beginning in 1979 if the Construction Permit for Seabrook is granted in time to maintain the construction schedule planned.

2. THE SITE

2.1

2.1 Site Location and Layout

The site for the Seabrook Station is located in the northern part of the town of Seabrook, Rockingham County, New Hampshire. It is approximately 8 miles southeast of the county seat of Exeter and 5 miles northeast of Amesbury, Massachusetts. Portsmouth, New Hampshire, the nearest large population center, is approximately 11 miles north of the site. The site coordinates are approximately 70 degrees, 51 minutes, 05 seconds west longitude, and 42 degrees, 53 minutes, 53 seconds north latitude. The Universal Transverse Mercator coordinates of the site are 348,970 meters East and 4,751,090 meters North (Reference 1). Figure 2.1-1 is a regional map illustrating the location of the site with respect to the southeastern corner of New Hampshire and bordering areas in Massachusetts.

Figure 2.1-2 shows the plant site. The utility property will include a minimum of 3000 feet from the center of either containment to the nearest site boundary. The land on the northern side of Browns River is in the town of Hampton Falls.

All the area within the site boundary will be owned by Public Service Company of New Hampshire with the exception of a railroad easement, owned by the Boston and Maine Railroad, and portions of the Browns River and Hunts Island Creek, which are state waters. Figure 2.1-3 shows the existing site conditions in the general area of the generating units. At the present time, the Seabrook town dump is located within the site boundary; however, it will be deactivated during plant construction. A high voltage electric transmission line runs through the area and will be relocated as necessary to pass around the plant structures. This power line is owned by the Exeter-Hampton Electric Company.

The proposed use of the land within the site boundary is illustrated in Figure 2.1-4 (Reference 3). There are approximately 715 acres within the two 3000 foot overlapping circles that represent the minimum exclusion area boundary. The site area not shown in Figure 2.1-4 is almost totally salt marsh. At the present time there are tentative plans for an education center that would provide educational facilities for the public in the fields of nuclear energy and environmental science (Reference 3).

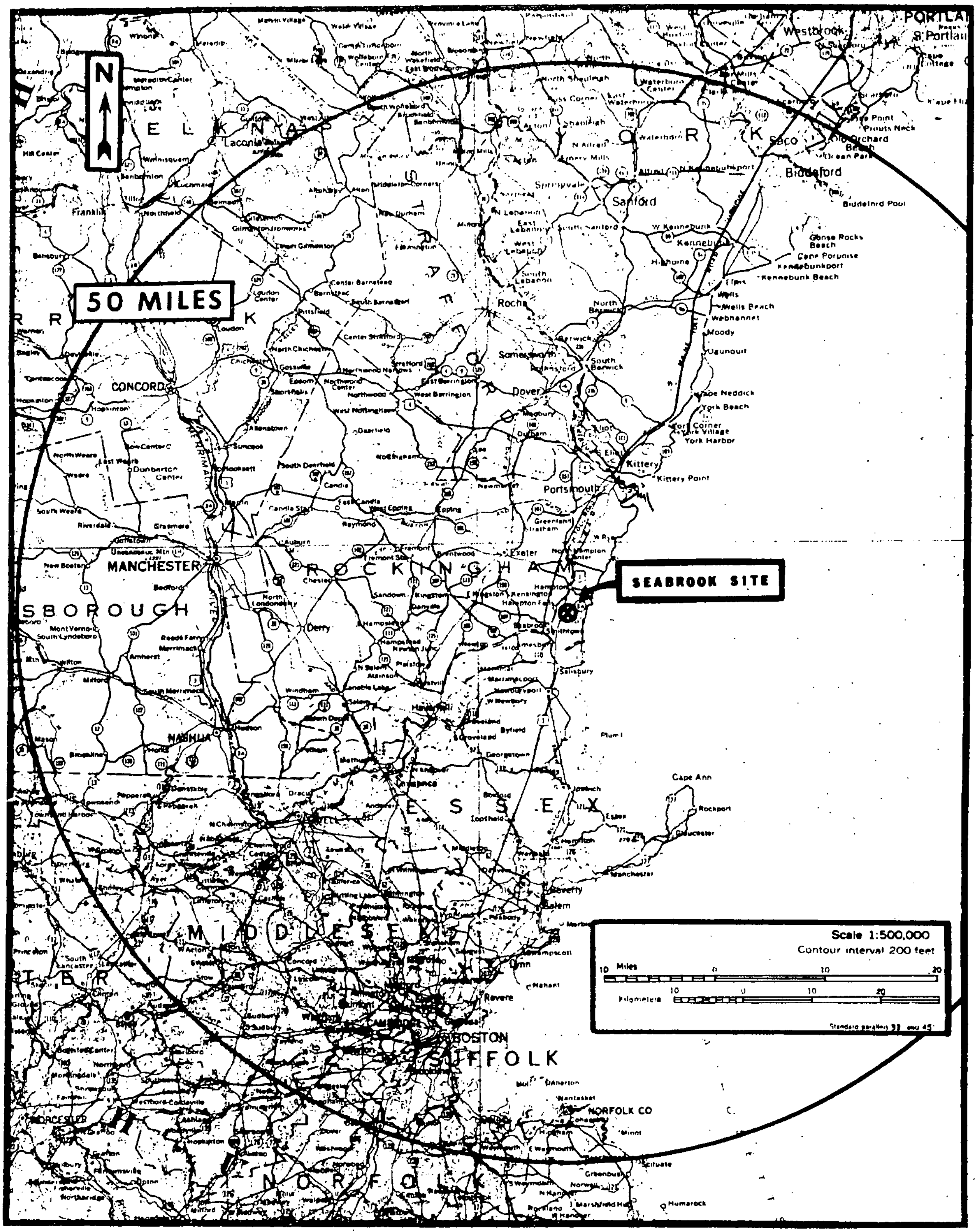
Figure 2.1-5 shows the public facilities within the Southeastern New Hampshire Planning Region (Reference 2). The existing land use in the Southern New Hampshire Planning Region is illustrated in Figure 2.1-6 (Reference 2). Transportation links are shown in Figure 2.1-7 (Reference 2), and a contour map of the site is provided in Figure 2.1-8.

References

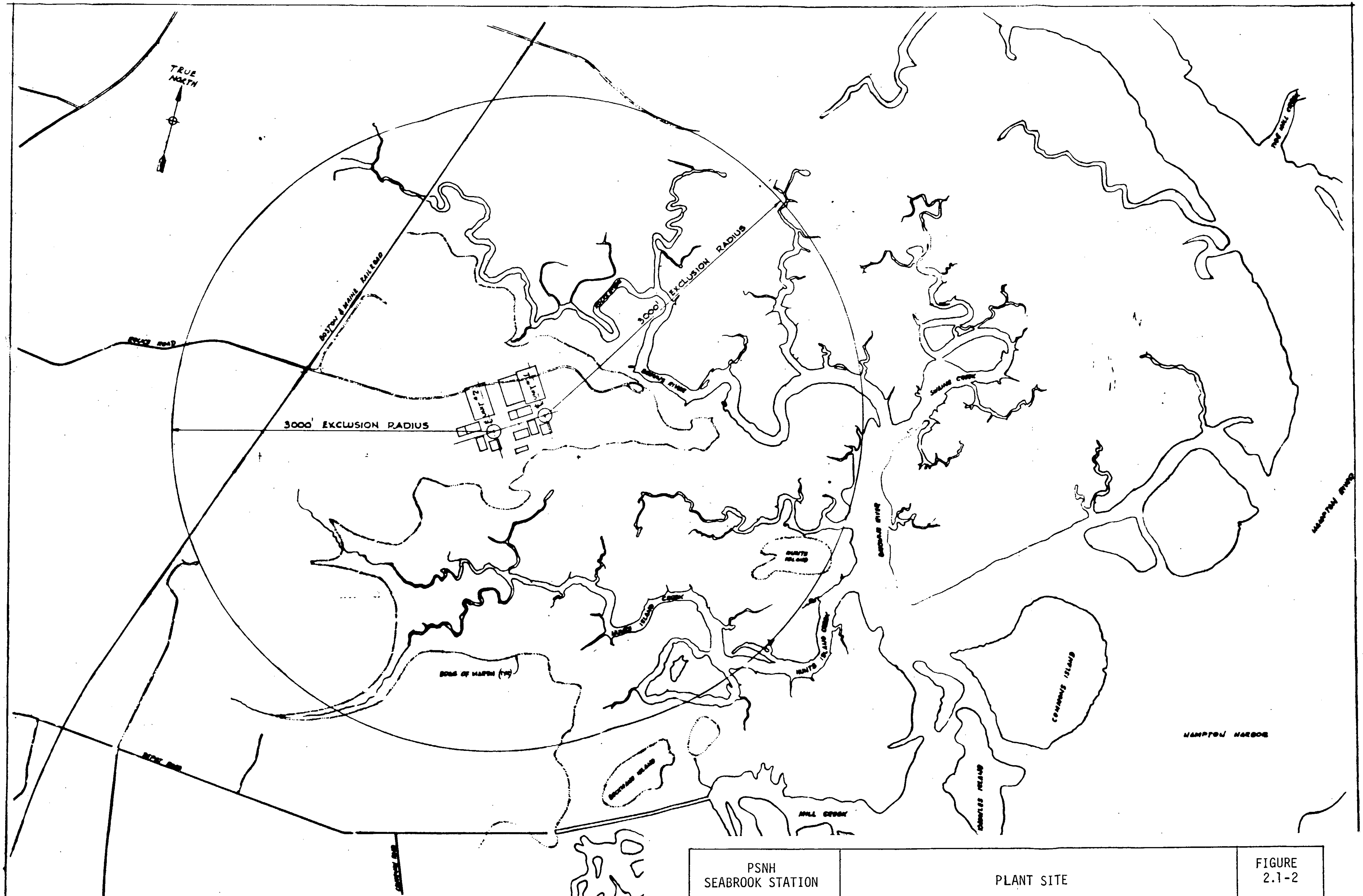
1. United States Department of the Interior, Geological Survey Map, Hampton Quandrangle, New Hampshire - Rockingham County, 7.5 Minute Series (Topographic), 1957.

2. Southeastern New Hampshire Regional Planning Commission Report, "Existing Land Uses (Including Transportation, Public Facilities, Utilities, Open Space and Recreation)", May 1, 1972.

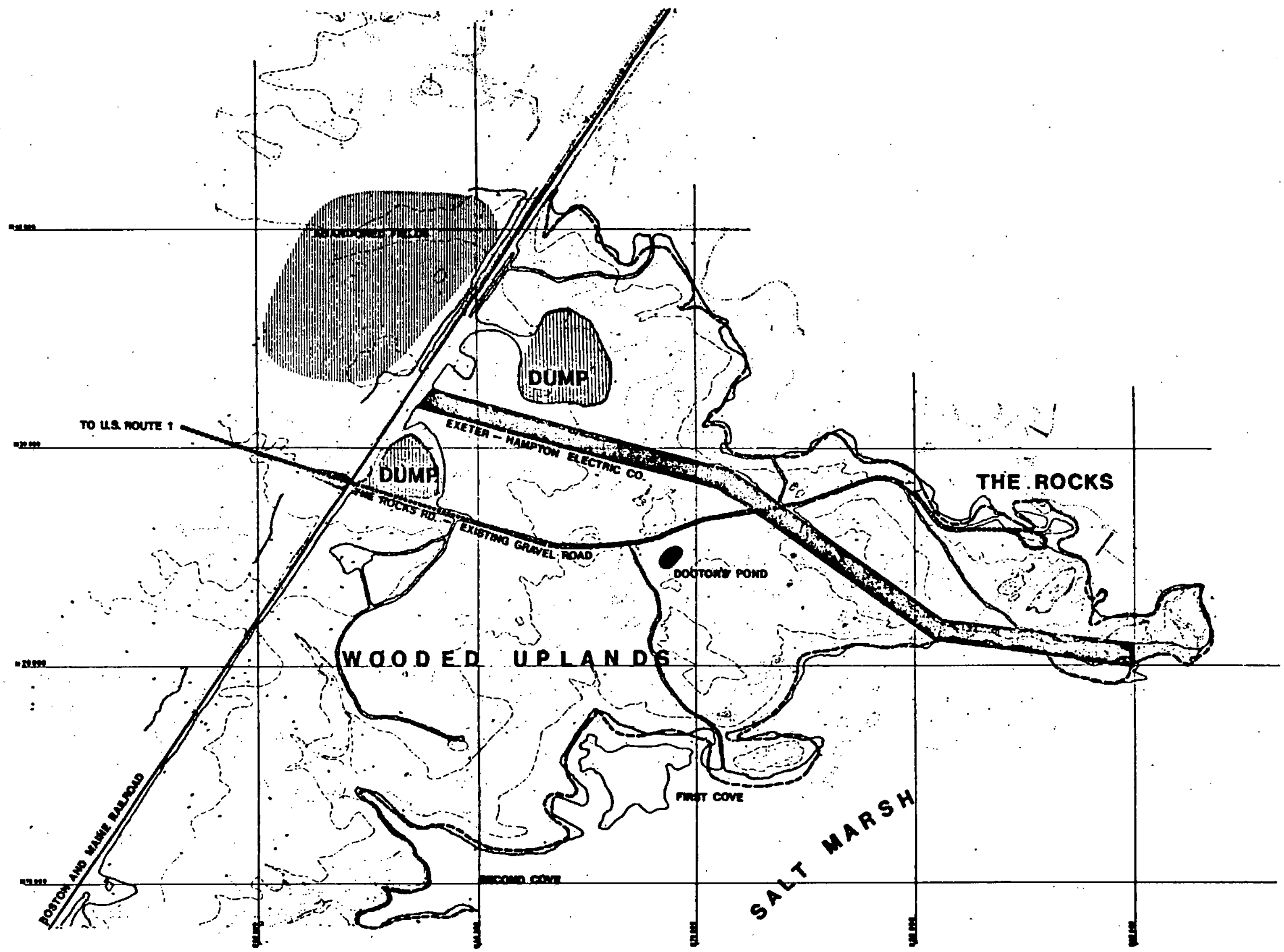
3. Kling/Planning Report, "Seabrook Station Land Planning and Site Design Study", prepared for Public Service Company of New Hampshire by Kling/Planning, Philadelphia, Pennsylvania, November, 1972.



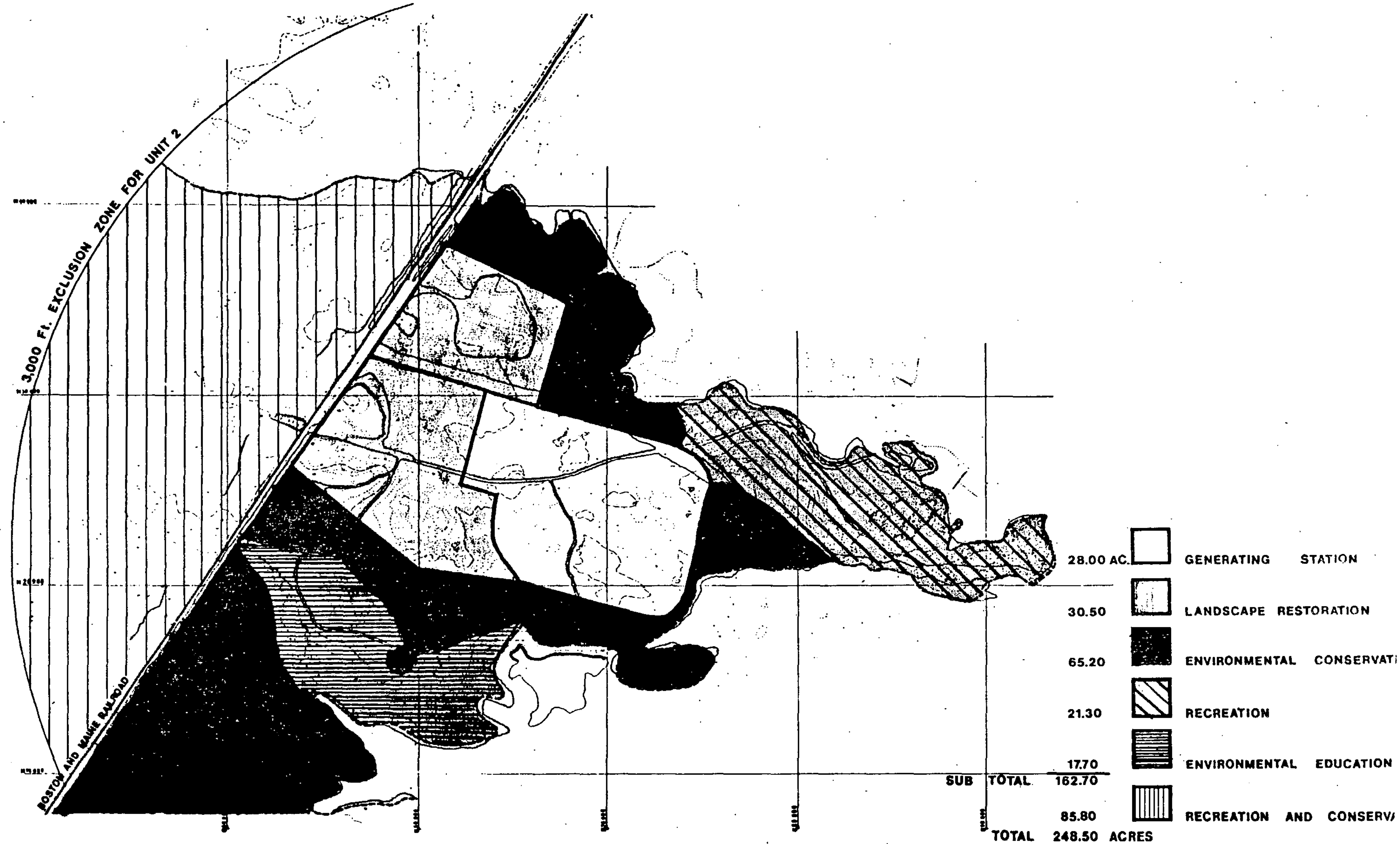
PSNH SEABROOK STATION	LOCATION OF SITE WITHIN SOUTHEASTERN NEW HAMPSHIRE	FIGURE 2.1-1



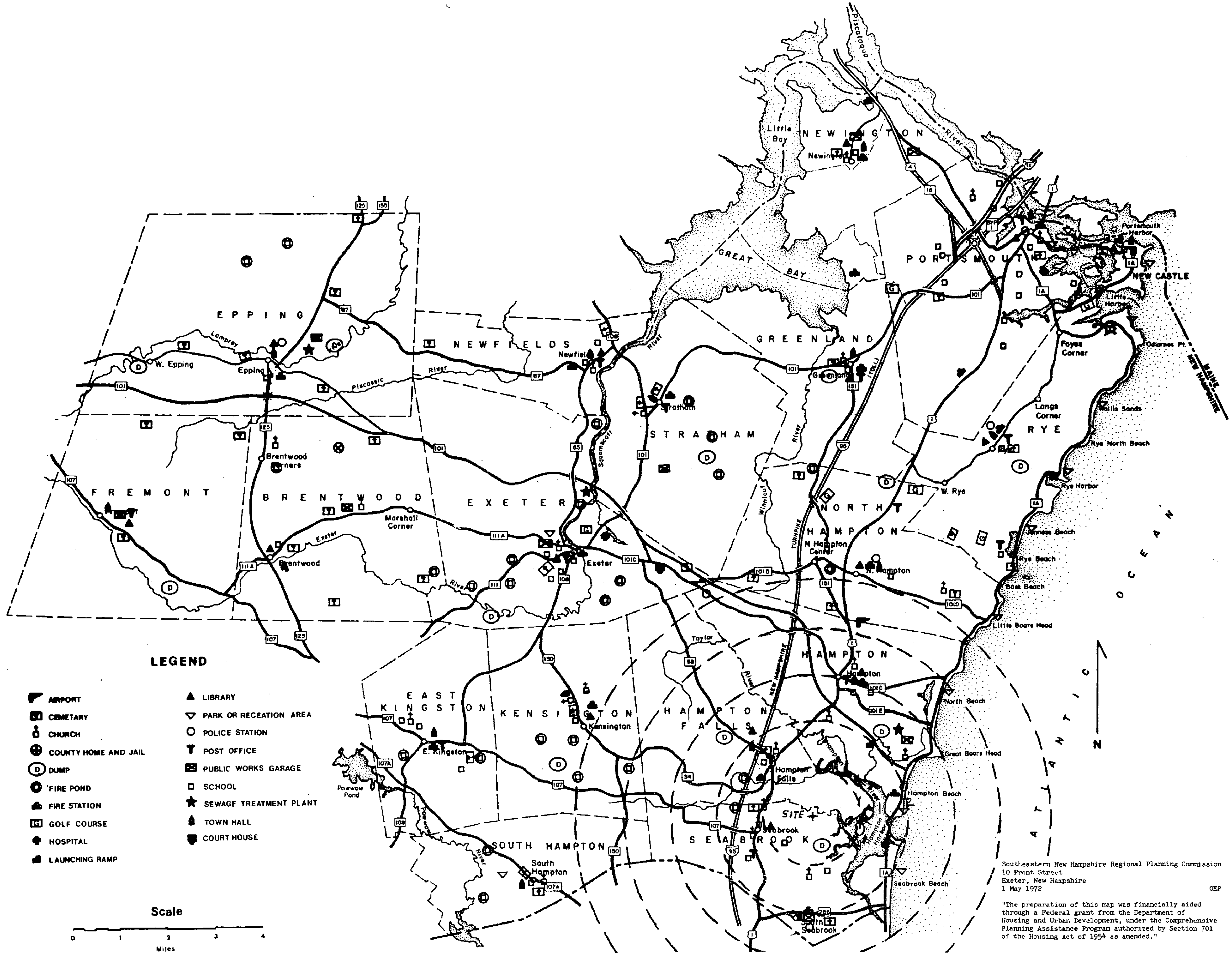
PSNH SEABROOK STATION	PLANT SITE	FIGURE 2.1-2



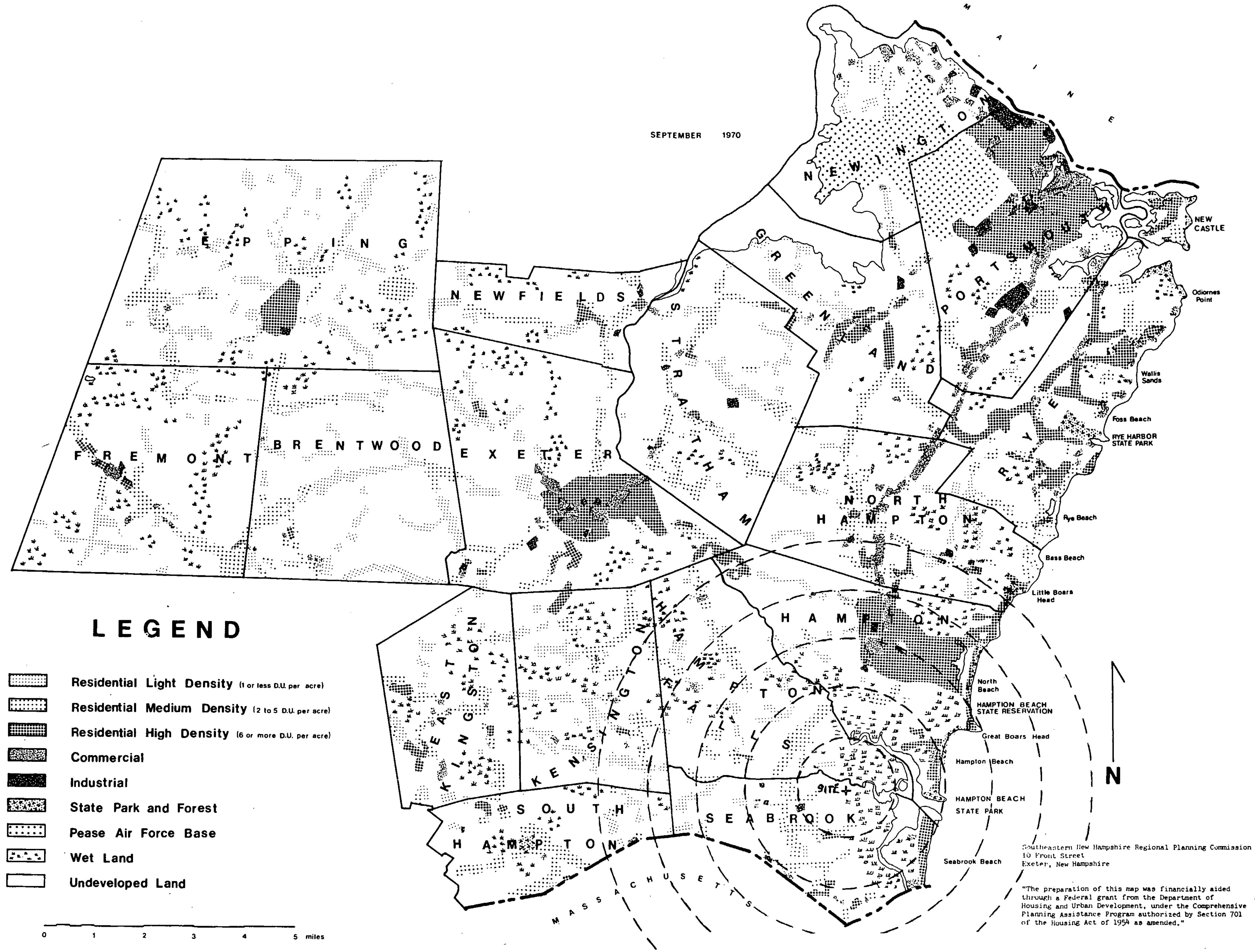
PSNH SEABROOK STATION	EXISTING SITE CONDITIONS	FIGURE 2.1-3



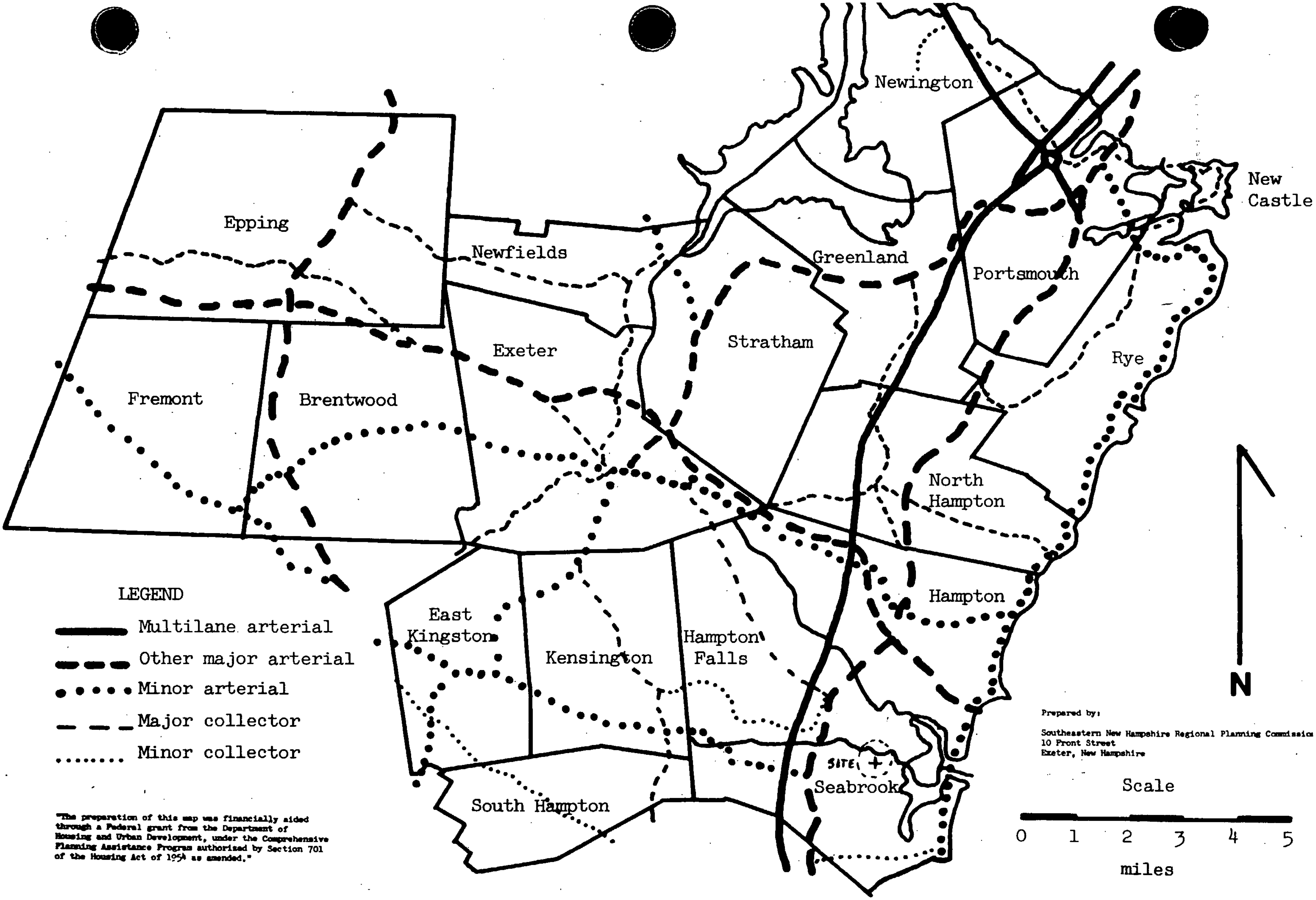
PSNH SEABROOK STATION	LAND USE PLAN	FIGURE 2.1-4



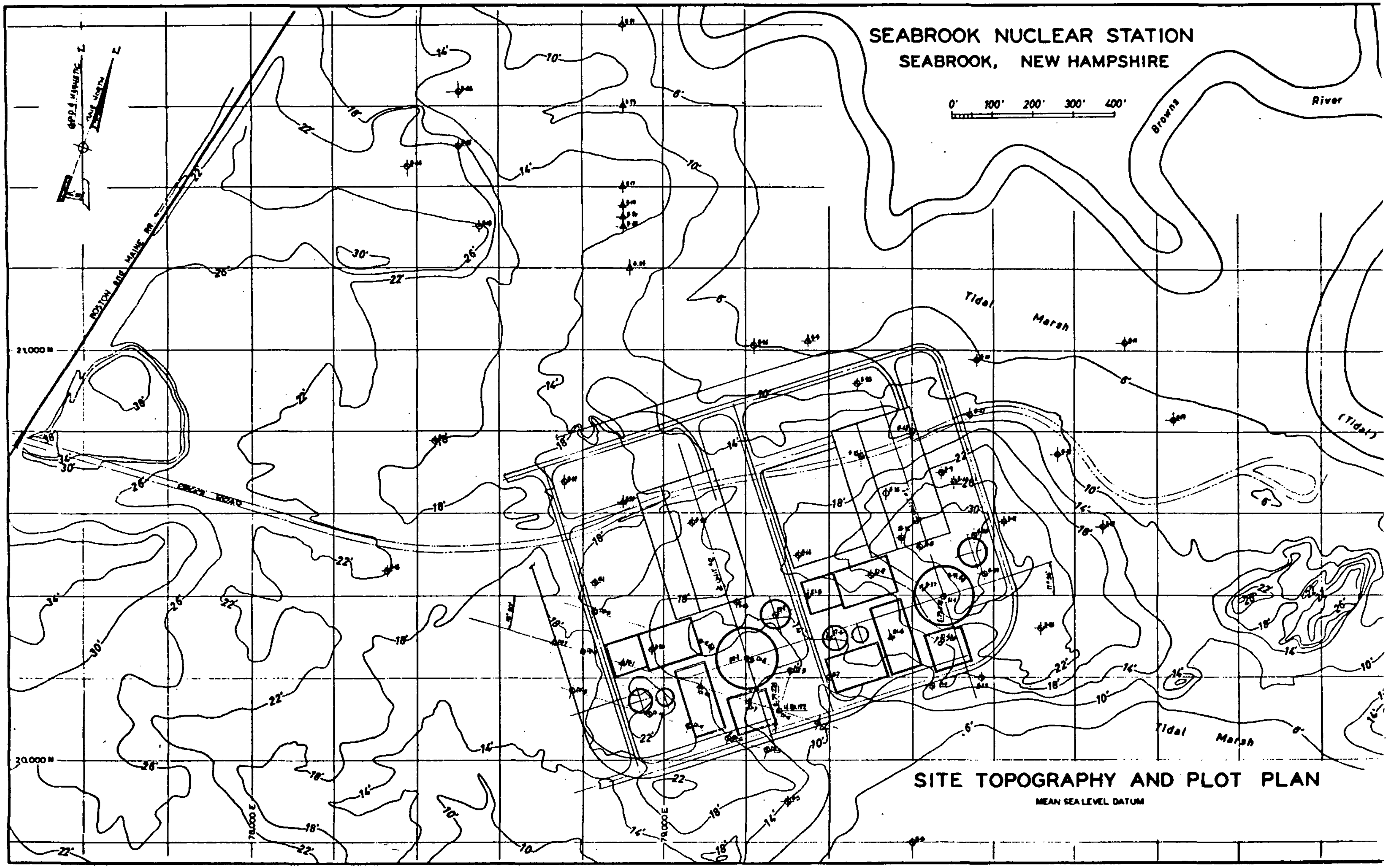
PSNH SEABROOK STATION	PUBLIC FACILITIES	FIGURE 2.1-5



PSNH SEABROOK STATION	EXISTING LAND USE	FIGURE 2.1-6



PSNH SEABROOK STATION	HIGHWAY CLASSIFICATION 1970	FIGURE 2.1-7



PSNH SEABROOK STATION	SITE TOPOGRAPHY	FIGURE 2.1-8

2.2 Regional Demography, Land and Water Use

The locations of the towns and cities within a ten mile radius of the plant are shown in Figure 2.2-1 and the 1970 census population of this area is tabulated by compass direction and distance from the plant in Table 2.2-1. These population figures were prepared by the Bureau of the Census in response to a request from the applicant for a detailed population survey of the area surrounding the site. Figure 2.1-1 and Table 2.2-2 present the location of the towns and cities, and the associated 1970 census population tabulations, respectively, for a fifty mile radius centered at the plant site. The population statistics were found in References (1), (2), (3), and (14).

Table 2.2-3 lists the projected populations, by segment, within a ten mile radius of the reactors for the years 1980, 1990, 2000, 2010 and 2020. The population projections for towns in New Hampshire are based on an Anderson-Nichols study of public water supply requirements (Reference 4). The Anderson-Nichols population projections were compared with projections made by the Southeastern New Hampshire Regional Planning Commission in Reference (5). The projections for the year 2020 agreed within 2 percent in the region of interest, and the independent review resulted in added confidence in the Anderson-Nichols projections.

For the towns in Massachusetts that are located entirely within ten miles of the site (Amesbury, Salisbury, Newburyport) or partly within ten miles of the site (Merrimack, West Newbury, Newbury), the population projections are based on an extrapolation of previous population data, over four decades (References 3 and 6) from a projected population study of similar nearby towns out to 1990 (Reference 7); and from Merrimack Valley Planning Commission data (References 8 and 9). The year 2020 estimate was made by assuming that the 1960 to 1990 rate of increase would continue from 1990 to 2020.

For those segments of Figure 2.2-1 that have a zero current population, but could be made habitable, e.g. marshland that could be filled, the projections maintain a zero population for the segment, since no firm basis for projections in these areas could be established.

Table 2.2-4 lists the projected populations, by segment, within a fifty-mile radius of the reactors for the years 1980, 1990, 2000, 2010 and 2020.

The population distribution and the projections to the year 2020 for a fifty-mile radius surrounding the site were determined in the following manner. The grid system of concentric circles and radial lines, with the reactors at the center, was superimposed on a map that denoted town boundaries within the area. The fraction of a town's area within a segment was estimated and applied to the total town population to determine the population within the segment. For towns in New Hampshire, the population projections were based on the Anderson-Nichols report (Reference 4) obtained from the New Hampshire Office of State Planning.

For metropolitan Massachusetts, the projected population distributions out to 1990 were from a report by the Metropolitan Area Planning Council (Reference 7). This was the latest source available and had not been revised at the time the projection was made. The year 2020 estimate was made in most cases by assuming that the 1960 to 1990 rate of change would continue for 1990 to 2020. The "high" estimate from Reference (7) for the 1990 figures were used. Two types of anomalies were noted using this method. One type occurred with certain large cities that projected a lower population for 1990 than for 1960. In those cases, the largest historic population was used for the 2020 population estimate. The second type of anomalous result occurred with several very small towns where very large increases were projected for the period 1960 to 1990. Continued projection at this rate resulted in unrealistic population projections for the year 2020 that were 10 to 20 times the 1970 population. In these cases, adjoining towns were examined and their extrapolation factors, from 1970 to 2020, were determined. The town in question was then compared in terms of land area, population, and potential for expansion. These comparisons were then used as the basis for a judgement on an appropriate population extrapolation factor.

A small number of northeastern Massachusetts towns were not included in the Metropolitan Area Planning Council projections. For this area, the Merrimack Valley Planning Commission reports (References 8 and 9) were used.

For the State of Maine, the population projections were based on an Arthur D. Little report (Reference 10), prepared as part of a comprehensive planning program for development and conservation of water resources. The population projections contained in this report appeared low when compared with the New Hampshire and Massachusetts projections, and in certain cases the projections were increased accordingly.

The resort character of the coastal area near the site results in a large summer seasonal increase in both the residential population and single-day visitors to the beach areas. York County, Maine, experiences a seasonal influx of approximately 70,000 summer residents, increasing the county population (111,576 in 1970) by approximately 60 percent. The seasonal population growth in Maine is concentrated primarily along the resort beaches, 40 to 50 miles north-northeast of the site. Rockingham and Strafford Counties, in New Hampshire, experience a summer seasonal increase in residential population of approximately 40,000 persons. The total permanent population of these two counties was 210,000 in 1970. This summer increase in resident population has a major effect on population distribution in the immediate vicinity of the site. The seasonal population growth is concentrated in the resort communities at Seabrook Beach, Hampton Beach, and North Hampton Beach. The town of Seabrook's permanent population of 3,053 (1970 census) increases to approximately 5500 during the summer; Hampton (including Hampton Beach and North Hampton Beach) increases from a permanent resident population of 8,011 (1970 census) to approximately 17,000 during this season.

The number of single-day visitors to the beach areas in New Hampshire was estimated using traffic count data covering all access roads to the public beach areas provided by the New Hampshire Department of Public Works and Highways. These estimates indicated a maximum daily beach population of 100,000 to 120,000, and an average seasonal transient population of 30,000, in addition to the maximum seasonal and permanent population in the beach areas of 22,500. This concentrated population would be primarily located at Hampton Beach and North Hampton Beach.

The town of Salisbury, in Essex County, Massachusetts, also experiences a large influx of summer seasonal residents and single-day visitors to the nearby beach areas. The population of the town of Salisbury increases from 4179 (1970 census) to about 20,000 in the summer, and the estimated maximum number of single-day visitors to the beach areas is approximately 60,000.

The annual number of visitors to the New Hampshire resort areas has been increasing at a rate of 1.0 to 1.3 percent per year, comparable to the overall growth rate of the lower New England and Mid-Atlantic states. No significant change is expected in this growth rate. Seasonal variations in other regions around the site do not appreciably affect the overall population distributions listed in Tables 2.2-3 and 2.2-4.

Table 2.2-5 lists all the schools in New Hampshire within ten miles of the site, with their approximate enrollment in September, 1972, and their approximate distance and direction from the site. The school closest to the site is the Seabrook Elementary School, with a Fall 1972 enrollment of 650, located 1.25 miles south of the site. Ackerman Elementary School in Hampton Falls is located 1 1/2 miles northwest of the site, with a Fall 1972 enrollment of 150. Table 2.2-6 shows all the schools in Massachusetts that are located within ten miles of the site, with their approximate enrollment in September, 1972, and their approximate distance and direction from the site.

The hospitals within 10 miles of the site are listed in Table 2.2-7. The nearest hospital to the site is the Amesbury Hospital, on Highland Road, located about 5 1/2 miles southwest of the site.

Table 2.2-8 lists the major parks and recreational areas within 10 miles of the site. The Parker River National Wildlife Refuge is located in the town of Newbury, Massachusetts, approximately nine miles south of the site. The Pow Wow River State Forest is a hunting preserve that occupies approximately 48 acres in the town of South Hampton, N.H., approximately seven miles west of the site. The Audubon Society Nature Park is a privately owned nature preserve that occupies 18 acres in the town of South Hampton, N.H., approximately eight miles west of the site.

The industrial facilities located within approximately five miles of the plant site, within New Hampshire, are listed in Table 2.2-9. Included in the table are the number of employees, the product manufactured or service performed, and the approximate distance and direction from the site. Table 2.2-10 list the same information for industrial facilities located in Massachusetts within approximately five miles of the plant site.

The Seabrook site is bordered on the north, east, and south by marsh land extending to estuarine streams and Hampton Harbor. The land to the west is characterized as second growth and scrub land, as is sixty percent of the land within the town of Seabrook. The active farms in Seabrook occupy less than six percent of the land area. Figure 2.1-6 (Reference 11) shows the existing land use in the Southeastern New Hampshire Planning Region. The "Residential High Density" areas shown along Seabrook Beach in the Figure are mostly seasonal residences. Less than twenty percent of the land area in the town of Seabrook is characterized as residential. Approximately 1.5 percent of the town is designated as industrial. The land use plan for the year 1980 developed by the Southeastern New Hampshire Regional Planning Commission is shown in Figure 2.2-2. The proposed site is located on land designated for industrial use.

The agricultural activity in New Hampshire in the area of the plant site is declining, whereas industrial activity is expected to increase (Reference 12). The main products of this region's agriculture are dairy, poultry, grain, haycrops, and fruit. Statistical data on the five counties within 25 miles of the site are given in Table 2.2-11. The two closest dairy herds to the site are located approximately three miles to the west and northwest.

The major highways in the area run north and south and include:

1. U. S. Route 1, which passes one mile west of the site,

2. Interstate Route 95, the New Hampshire Turnpike, which passes 1.6 miles west of the site, and

3. Route 1A, along the coast line, which passes 1.7 miles east of the site.

The access road to the plant site connects directly into U.S. Route 1. Water transportation in the area is limited to small boats as Hampton Harbor is not a deep water port and there are no shipping lanes in the vicinity of the plant. The nearest airport is Hampton Airport, located 4.5 miles north-northeast of the site, a privately owned General Aviation facility.

Water uses in the area of the plant site are mainly recreational, including the beaches in Salisbury, Seabrook, Hampton, and North Hampton and boat docks in Hampton Harbor. There is no commercial fishing in Hampton Harbor. The harbor is, however, a source of softshell clams which are taken by state licensed individuals for their own consumption. Commercial clamming is prohibited in New Hampshire. Presently there are no onsite water uses and no wells are planned for the site. The water requirements of the plant will be supplied by the Town of Seabrook.

Ground water movement in the site area is toward adjoining tidal areas. Under the hydraulic gradients that exist in nature, the rate of ground water movement is very slow. Anticipated rates of ground water movement at the site are not expected to exceed 100 feet per year. This is based on a water table gradient of 0.06 feet per foot as observed during high water table conditions and an average permeability of 5 and 4 Meinzer units for the till and bedrock respectively. The low permeability of the till and bedrock found on the site is substantiated by the lack or relatively small response in water levels to tidal fluctuation as observed in several borings located along the edge of the tidal marshes (Reference 13).

There is very little evidence to indicate that accidental radioactive liquid discharge at the reactor site could contaminate any existing well supplies in the area since ground water is moving toward neighboring tidal water bodies and away from populated inland areas. Moreover, public supply wells are located in areas at least two miles from the site, and beyond reasonable limits of ground water travel from the site area. Accidental liquid waste discharge on the site could conceivably reach nearby tide water bodies. However, since the ground water is moving at less than 100 feet per year, such liquid wastes would be well diluted before discharging into the tide water. Furthermore, a part of such wastes would be absorbed on clay or silt particles in the till and marine deposits.

It is unlikely that any wells will be located east of the site in the future because the ground water underlying the marsh is brackish. Also, the Seabrook municipal water system is well developed and serves nearly 100 percent of the towns residences. Any future users will be served by this system which draws its water from wells far to the west of the site. The Hampton Beach area is served by the Town of Hampton municipal water system which draws water from wells far to the north of the site.

There are no other commercial nuclear facilities located within a 50 mile radius of the site.

References

1. United States Department of Commerce Publication, PC(1)-A31 N.H., "1970 Census of Population, Number of Inhabitants, New Hampshire", issued March 1971.

2. United States Department of Commerce Publication PC(1)-A21 Maine, "1970 Census of Population, Number of Inhabitants, Maine", issued April 1971.

3. United States Department of Commerce Publication PC(1)-A23, Massachusetts, "1970 Census of Population, Number of Inhabitants, Massachusetts", issued June 1971.

4. New Hampshire Department of Resources and Economic Development Report, "Public Water Supply Study, Phase One Report", Anderson-Nichols and Co., Inc., May 1969.

5. Southeastern New Hampshire Regional Planning Commission Report, "Population Report and Projections", May 1, 1972.

6. United States Department of Commerce Report PC(1)-23A Massachusetts, "United States Census of Population: 1960, Number of Inhabitants, Massachusetts", issued 1961.

7. Metropolitan Area Planning Council Report, "The Population of Cities and Towns in Metropolitan Boston Projected to 1990", April 1968.

8. Central Merrimack Valley Regional Planning District Report, "Population Report", September 1968.

9. "Revised Population Projections (Preliminary)", Merrimack Valley Planning Commission, September 1972.

10. "Projective-Economic Studies of New England", by Arthur D. Little, Inc., 1965.

11. Southeastern New Hampshire Regional Planning Commission Report, "Existing Land Uses (Including Transportation, Public Facilities, Utilities, Open Space and Recreation)", May 1, 1972.

12. New England Region Commission Report, "New England: An Economic Analysis", prepared by Arthur D. Little, Inc., November 1968.

13. "Groundwater Hydrology for the Proposed Nuclear Station - Unit I", Seabrook, New Hampshire, by Weston Geophysical Research, Inc., 1969.

14. U.S. Department of Commerce, Bureau of the Census letter, 1970 Population Figures Near Seabrook, New Hampshire, January 11, 1973.

TABLE 2.2-1

RESIDENT POPULATION DISTRIBUTION 0-10 MILES (1970 CENSUS)

Segment	0-1	1-2	2-3	3-4	4-5	5-10	(Miles)
N	14	24	161	871	424	7,352	
NNE	0	18	1,219	2,905	492	2,886	
NE	0	5	484	788	246	2,096	
ENE	0	211	207	37	0	0	
E	0	126	0	0	0	0	
ESE	0	239	0	0	0	0	
SE	0	17	133	0	0	0	
SSE	11	0	139	170	715	337	
S	50	176	351	566	527	2,419	
SSW	134	459	514	313	357	7,013	
SW	146	425	368	220	2,468	6,274	
WSW	11	187	99	104	1,608	9,958	
W	72	264	127	171	177	2,066	
WNW	21	138	125	67	180	1,872	
NW	0	242	117	123	152	6,575	
NNW	14	179	63	254	126	1,908	

TABLE 2.2-2

Resident Population Distribution 0-50 Miles (1970 Census)

Segment	Population 0-10	10-20	20-30	30-40	40-50 Miles
N	8,846	26,960	28,161	17,941	7,249
NNE	7,520	21,485	5,666	10,343	35,364
NE	3,619	0	0	0	0
ENE	455	0	0	0	0
E	126	0	0	0	0
ESE	239	0	0	0	0
SE	150	564	0	0	0
SSE	1,372	19,283	12,255	0	0
S	4,089	17,374	111,345	8,634	120,565
SSW	8,790	16,105	205,258	800,479	1,023,308
SW	9,901	30,717	145,699	181,867	134,147
WSW	11,967	55,868	87,061	124,733	46,190
W	2,877	9,296	31,773	71,353	15,438
WNW	2,403	4,929	6,299	59,401	29,017
NW	7,209	5,174	2,571	7,782	15,224
NNW	2,544	14,084	17,663	11,268	3,700

TABLE 2.2-3

Projected Resident Population Distribution By Segment And By Decade To 2020
0 to 10 Miles

Segment		Population 1970	1980	Projected Population 1990	2000	2010	2020
0 To 1 Mile	N	14	18	29	54	94	128
	NNE	0	0	0	0	0	0
	NE	0	0	0	0	0	0
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	11	17	24	29	38	53
	S	50	79	108	131	172	238
	SSW	134	210	289	351	461	637
	SW	146	229	315	383	502	694
	WSW	11	17	24	29	38	53
	W	72	113	156	189	248	342
	WNW	21	27	43	78	134	184
	NW	0	0	0	0	0	0
	NNW	14	18	29	54	94	128
1 To 2 Miles	N	24	27	36	50	72	89
	NNE	18	19	24	27	32	34
	NE	5	6	7	8	9	10
	ENE	211	226	277	317	370	401
	E	126	135	166	189	221	240
	ESE	239	376	517	627	823	1136
	SE	17	27	37	45	66	81
	SSE	0	0	0	0	0	0
	S	176	277	381	462	605	836
	SSW	459	721	992	1203	1579	2181
	SW	425	668	918	1114	1462	2019
	WSW	187	294	404	490	644	889
	W	264	415	571	692	909	1254
	WNW	138	189	290	483	799	1094
	NW	242	310	501	927	1622	2220
	NNW	179	230	371	686	1200	1642

TABLE 2.2-3 (Continued)

Segment		Population 1970	1980	Projected Population 1990	2000	2010	2020
2 To 3 Miles	N	161	173	210	242	282	306
	NNE	1219	1305	1597	1829	2134	2316
	NE	484	518	635	726	847	920
	ENE	207	222	272	311	363	394
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	133	214	307	725	1327	2203
	SSE	139	224	324	548	664	973
	S	351	552	760	925	1216	1682
	SSW	514	825	1186	1629	2366	3448
	SW	368	600	891	1322	2024	3025
	WSW	99	159	227	307	442	641
	W	127	200	275	333	437	604
	WNW	125	160	259	479	838	1147
	NW	117	150	243	449	784	1073
	NNW	63	76	109	175	279	368
3 To 4 Miles	N	871	932	1142	1307	1524	3145
	NNE	2905	3109	3806	4358	5084	5520
	NE	788	844	1033	1182	1379	1498
	ENE	37	40	49	56	65	71
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	170	278	412	611	935	1398
	S	566	923	1370	2032	3113	4653
	SSW	313	511	758	1124	1722	2573
	SW	220	345	503	725	1091	1607
	WSW	104	144	196	251	351	480
	W	171	291	557	1048	1685	2333
	WNW	67	109	212	415	686	946
	NW	123	158	255	472	825	1128
	NNW	254	272	333	381	445	483

TABLE 2.2-3 (Continued)

Segment		Population 1970	1980	Projected Population 1990	2000	2010	2020
4 To 5 Miles	N	424	1039	1692	2214	2409	2472
	NNE	492	1034	1629	2104	2304	2378
	NE	246	277	347	403	467	504
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	715	1166	1731	2567	3933	5878
	S	527	860	1276	1892	2899	4332
	SSW	357	582	864	1282	1964	2935
	SW	2468	3050	3903	4403	5511	6598
	WSW	1608	1978	2525	2831	3522	4181
	W	177	271	452	806	1491	2709
	WNW	180	328	690	1379	2241	3104
	NW	152	195	315	583	1019	1394
	NNW	126	135	166	189	221	240
5 To 10 Miles	N	7352	9390	11900	15250	19450	24940
	NNE	2886	3790	5010	6620	8750	11600
	NE	2096	2820	3810	5190	7020	9510
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	337	393	461	540	632	740
	S	2419	2820	3305	3880	4530	5310
	SSW	7013	8580	10600	13100	16100	19980
	SW	6274	7520	9110	11100	13500	16390
	WSW	9958	12800	16600	21600	27900	36010
	W	2066	3110	4730	7220	11000	16960
	WNW	1872	2860	4390	6700	10300	15810
	NW	6575	7350	8280	9290	10450	11650
	NNW	1908	2820	4190	6200	9170	13640

TABLE 2.2-4

Projected Resident Population Distribution By Segment And By Decade To 2020
0 To 50 Miles

Segment		Population 1970	Projected Population 1980	1990	2000	2010	2020
0 To 10 Miles	N	8846	11579	15009	19117	23831	31080
	NNE	7520	9257	12066	14938	18304	21848
	NE	3619	4465	5832	7509	9722	12442
	ENE	455	488	598	684	798	866
	E	126	135	166	189	221	240
	ESE	239	376	517	627	823	1136
	SE	150	241	344	770	1393	2284
	SSE	1372	2078	2952	4295	6202	9042
	S	4089	5511	7200	9322	12535	17051
	SSW	8790	11429	14689	18689	24192	31754
	SW	9901	12412	15640	19047	24090	30333
	WSW	11967	15392	19976	25508	32897	42254
	W	2877	4400	6741	10288	15770	24202
	WNW	2403	3673	5884	9534	14998	22285
	NW	7209	8163	17757	11721	14700	17465
	NNW	2544	3551	5198	7685	11409	16501
10 To 20 Miles	N	26960	32000	38000	45000	54000	64500
	NNE	21485	24000	27000	30500	34000	38900
	NE	0	0	0	0	0	0
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	564	780	1100	1550	2150	3000
	SSE	19283	23500	28200	34000	42000	49600
	S	17374	22500	29000	38000	49000	64000
	SSW	16105	23500	35000	51000	76000	111400
	SW	30717	42000	58000	79000	108000	147800
	WSW	55868	68000	84000	102000	125000	155200
	W	9296	14000	21000	32000	48000	73500
	WNW	4929	8500	14000	24000	40000	66900
	NW	5174	7800	11500	17500	26000	38800
	NNW	14084	19000	25500	34500	47000	64300

TABLE 2.2-4 (Continued)

Segment		Population 1970	Projected Population 1980	1990	2000	2010	2020
20 To 30 Miles	N	28161	33000	38500	45000	53000	63300
	NNE	5666	6400	7300	8200	9400	10600
	NE	0	0	0	0	0	0
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	12255	14000	16000	18000	20000	23000
	S	111345	135000	145000	167000	190000	221000
	SSW	205258	240000	285000	335000	400000	476000
	SW	145699	175000	215000	260000	320000	389000
	WSW	87061	108000	135000	170000	210000	263000
	W	31773	45000	64000	88000	125000	174500
	WNW	6299	11000	19500	34000	60000	104900
	NW	2571	4400	7200	12000	20000	34300
	NNW	17663	26000	37000	53000	76000	108000
30 To 40 Miles	N	17941	20000	23000	26000	29000	32700
	NNE	10343	11500	13200	15000	17000	19400
	NE	0	0	0	0	0	0
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	0	0	0	0	0	0
	S	8634	9400	10500	11500	13000	14200
	SSW	800479	880000	910000	945000	975000	1028700
	SW	181867	210000	250000	290000	340000	399500
	WSW	124733	145000	165000	190000	215000	249400
	W	71353	89000	110000	135000	165000	204000
	WNW	59401	67000	77000	88000	100000	114100
	NW	7782	10300	13500	18000	23500	30700
	NNW	11268	15000	21000	28000	38500	52200

TABLE 2.2-4 (continued)

Segment		Population 1970	Projected Population 1980	1990	2000	2010	2020
40 To 50 Miles	N	7249	8200	9400	10500	12200	14100
	NNE	35364	39000	45000	51000	59000	67100
	NE	0	0	0	0	0	0
	ENE	0	0	0	0	0	0
	E	0	0	0	0	0	0
	ESE	0	0	0	0	0	0
	SE	0	0	0	0	0	0
	SSE	0	0	0	0	0	0
	S	120565	150000	190000	240000	305000	382000
	SSW	1023308	1080000	1150000	1230000	1320000	1405900
	SW	134147	170000	220000	290000	370000	476100
	WSW	46190	63000	86000	115000	160000	217100
	W	15438	20000	25000	32000	42000	53000
	WNW	29017	38000	48000	62000	80000	103900
	NW	15224	19000	24000	31500	40000	51700
	NNW	3700	4800	6400	8400	11000	14300

TABLE 2.2-5

Schools Within Ten Miles of the Seabrook Site
In New Hampshire

Town	School	Distance (Miles) and Direction	Fall 1972 Enrollment
East Kingston	Bakie Elementary School	7 W	355
Exeter	Elementary Schools (4)	7-8 NW	949
	Exeter Area Junior High School	8 NW	839
	Exeter Area High School	8 NW	1033
	Rockingham School for Special Children	8 NW	58
	Phillips Exeter Academy	7 NW	960
Greenland	Greenland Elementary School	9 N	340
Hampton	Center Elementary School	2 1/2 NNE	550
	Marston Elementary School	3 NNE	437
	Sacred Heart Elementary School	3 NNE	240
	Hampton Academy Junior High School	3 NNE	541
	Winnacunnet High School	2 1/2 NNE	1155
Hampton Falls	Lincoln-Ackerman Elementary School	1 1/2 NW	150
Kensington	Kensington Elementary School	5 WNW	142
North Hampton	North Hampton Elementary School	5 NNE	591
Rye	Rye Elementary School	8 NNE	358
	Rye Junior High School	8 NNE	220
Seabrook	Seabrook Elementary School	1 1/4 S	650
South Hampton	Barnard Elementary School	6 WSW	97
Stratham	Memorial Elementary School	8 NNW	242

TABLE 2.2-6

Schools Within Ten Miles Of The Seabrook Site In Massachusetts

Town	School	Distance (Miles) and Direction	Fall 1972 Enrollment
Amesbury	Amesbury Elementary School	5 SW	761
	Amesbury Middle School	5 1/2 SW	925
	Amesbury High School	5 1/2 SW	820
	St. Joseph's School	5 SW	123
	Sacred Heart School	5 SW	228
	Seventh Day Adventist School	5 SW	29
Merrimac	Helen R. Donahue School	10 WSW	339
	Red Oaks School	10 WSW	324
Newbury	Byfield School	10 SSW	72
	Woodbridge School	7 S	92
	Newbury Elementary School	7 1/2 S	355
Newburyport	Belleville School	6 SSW	664
	Davenport School	6 SSW	123
	Kelly School	6 1/2 SSW	123
	Brown School	6 1/2 S	332
	R. A. Nock School	6 1/2 SSW	1108
	Newburyport High School	6 SSW	987
Salisbury	Salisbury Memorial School	4 S	653
	Salisbury Plains School	3 SW	93
West Newbury	Central Elementary School	10 SW	409

TABLE 2.2-7

Hospitals Within Ten Miles Of The Site

Town	Hopsital	Distance (Miles) and Direction	Bed Capacity
Amesbury	Amesbury Hospital	5 1/2 SW	63
Newburyport	Anna Jacques Hospital	6 1/2 SSW	80
Exeter	Exeter Hospital	8 NW	98

TABLE 2.2-8

Parks And Recreational Areas Within Ten Miles Of The Site

Area	Town	Distance (Miles) and Direction
Rye Beaches	Rye	5-9 NE
North Hampton Beach	North Hampton	4 NE
Hampton Beach State Park	Hampton	2 E
Seabrook Beach	Seabrook	2 ESE
Salisbury Beach State Reservation	Salisbury	3 SE
Plum Island Beach	Newbury	6 SE
Park River National Wildlife Refuge	Newbury	9 SSE
Pow Wow River State Forest	South Hampton	7 WSW
Audubon Society Nature Park	South Hampton	8 WSW

TABLE 2.2-9

Industrial Firms Within Five Miles Of Seabrook Site In New Hampshire

Firm Name	Distance (Miles) and Direction	Number of Employees	Product or Service
Town of Seabrook:			
Bailey Division of USM Corp.	1 WSW	1000	Molded rubber products
Cargocaire Engineering Corp.	3 WSW	13	Research, development, & testing
D. T. Quin & Co., Inc.	2 SSW	25	Industrial organic chemicals
Rockingham Fireworks Mfg. and Display Co., Inc.	1 1/4 SW	3	Aerial fireworks
Spherex, Inc.	2 SSW	24	Fabricated wire products
Circle Machine Co.	1 1/2 WSW	35	Shoe fitting equipment
Welpro, Inc.	1 1/2 WSW	400	Footwear
Ornsteen Chemical Co.	2 SSW	13	Hot melt adhesives
Tower Press, Inc.	2 SSW	37	Print national magazines
Town of Hampton:			
J. D. Cahill Co.	3 NNE	40	Plastics materials
Charles E. Greenman Co.	3 NNE	N.A.*	Boot and shoe cut stock
Hampton Metal Shop	2 NNE	5	Plumbing and heating
New Tool Co., Inc.	2 1/2 NNE	3	Special dies and tools
Palmer and Sicard, Inc.	3 NNE	30	Sheet and metal work
Pearse Chemical Co.	3 N	5	Dyes & organic pigments
S & H Precision Mfg. Co.	3 NNE	25	Sheet metal work
Seacoast Mfg. Corp.	2 1/2 NNE	5	Wood products
White's Welding Co.	3 N	3	Fabricated metal products
Woodbury Press, Inc.	3 N	7	Commercial printing
Town of North Hampton:			
Arc-way Steel Boiler and Welding Co.	5 N	2	Fabricated plate work
Hampton Pattern Works	4 NNW	5	Industrial patterns mfg.
Hendry Pine Shop	5 NNW	N.A.*	Wood household furniture

*Not Available

TABLE 2.2-10

Industrial Firms Within Five Miles of Seabrook Site
In Massachusetts

Firm Name	Distance (Miles) and Direction	Number of Employees	Product or Service
Town of Salisbury:			
Vaughn Corp.	4 SSW	60	Electric water heaters
Town of Amesbury:			
Amesbury Chair Co. & R & G Mfg. Co.	4 1/2 WSW	104	Dining room sets; metal cabinets
Amesbury Metal Products	5 WSW	65	Metal machining
Amesbury Plastic Co.	5 WSW	166	Shoes
Amesbury Tool & Die Co.	5 WSW	8	Machine tools
Aqua Laboratories	5 SW	3	Chemical treatment of industrial water
The Bailey Company	5 SW	290	Auto channels
Bartley Machine and Mfg.	5 SW	20	Metal products
Cado Fabrications	4 1/2 SW	14	Sheet metal
Cargocaire Corp.	5 WSW	90	Dehumidifier units for ships
Champion Foils Co.	5 WSW	3	Gold leaf stamping
Country kitchens	5 SW	2	Kitchen Cabinets
Dalton Mfg. Co.	5 WSW	7	Machine Shop
Durasol Drug & Chemical	5 WSW	13	Chemical specialities
Flexaust Co.	5 WSW	43	Flexible hose
Henschel Corp.	4 1/2 WSW	100	Navy instruments
LeBarron Bonney Co.	5 WSW	18	Auto restoring
Louis Shoe Co.	5 WSW	200	Shoes
M.A.T. Corp.	4 1/2 SW	7	Boats, snowmobiles covers
Merrimac Valley Brass Foundry	5 WSW	2	Cast Brass products
Oakland Industries	5 WSW	25	Metal and wood products
Reid Foundry	5 WSW	16	Metal castings
Sagamore Industrial Finish Corp.	5 SW	8	Paints
Scandia Plastics	5 WSW	4	Shaped extrusions
Surfaces Coating	5 WSW	4	Shoe lacquers
Sydell Plastics Corp.	5 WSW	10	Plastic bags

TABLE 2.2-11

Regional Agricultural Activites

New Hampshire Counties:

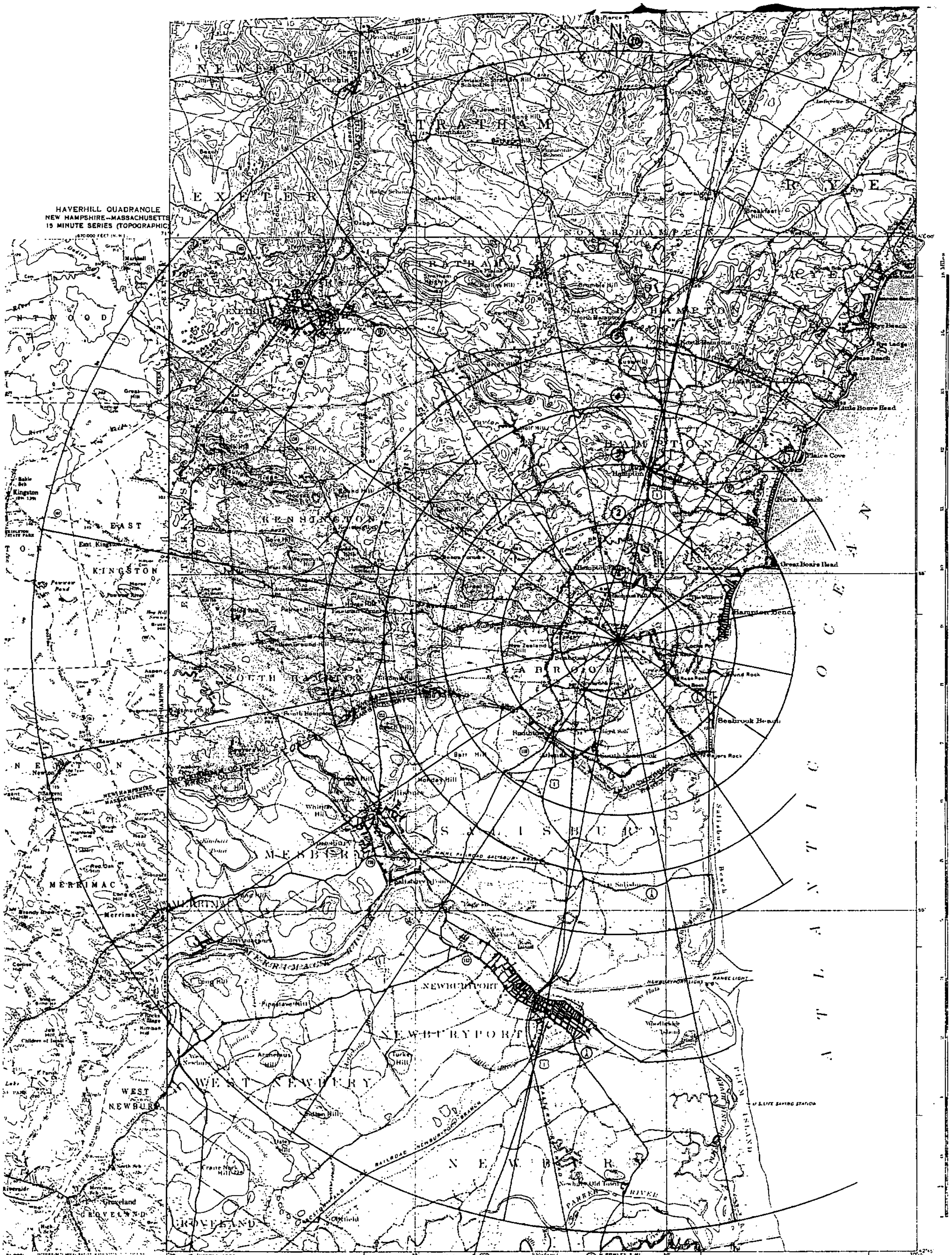
	Rockingham	Strafford
Number of Farms (1968)	735	380
(1959)	1076	494
Percent of County (1964)	21.5	23.9
Areas in Farms (1959)	26.1	29.4
Milk Producing Farms (1964)	181	113
Number of Milk Cows (1964)	4600	2800
Acres Under Cultivation (1964)	22000	11000

Massachusetts Counties:

	Essex	Middlesex
Number of Farms (1968)	634	956
(1959)	785	1346
Percent of County (1964) Areas in Farms	15.3	12.6
Milk Producing Farms (1964)	138	160
Number of Milk Cows (1964)	4600	5900
Acres Under Cultivation (1964)	14000	19000

Maine Counties:

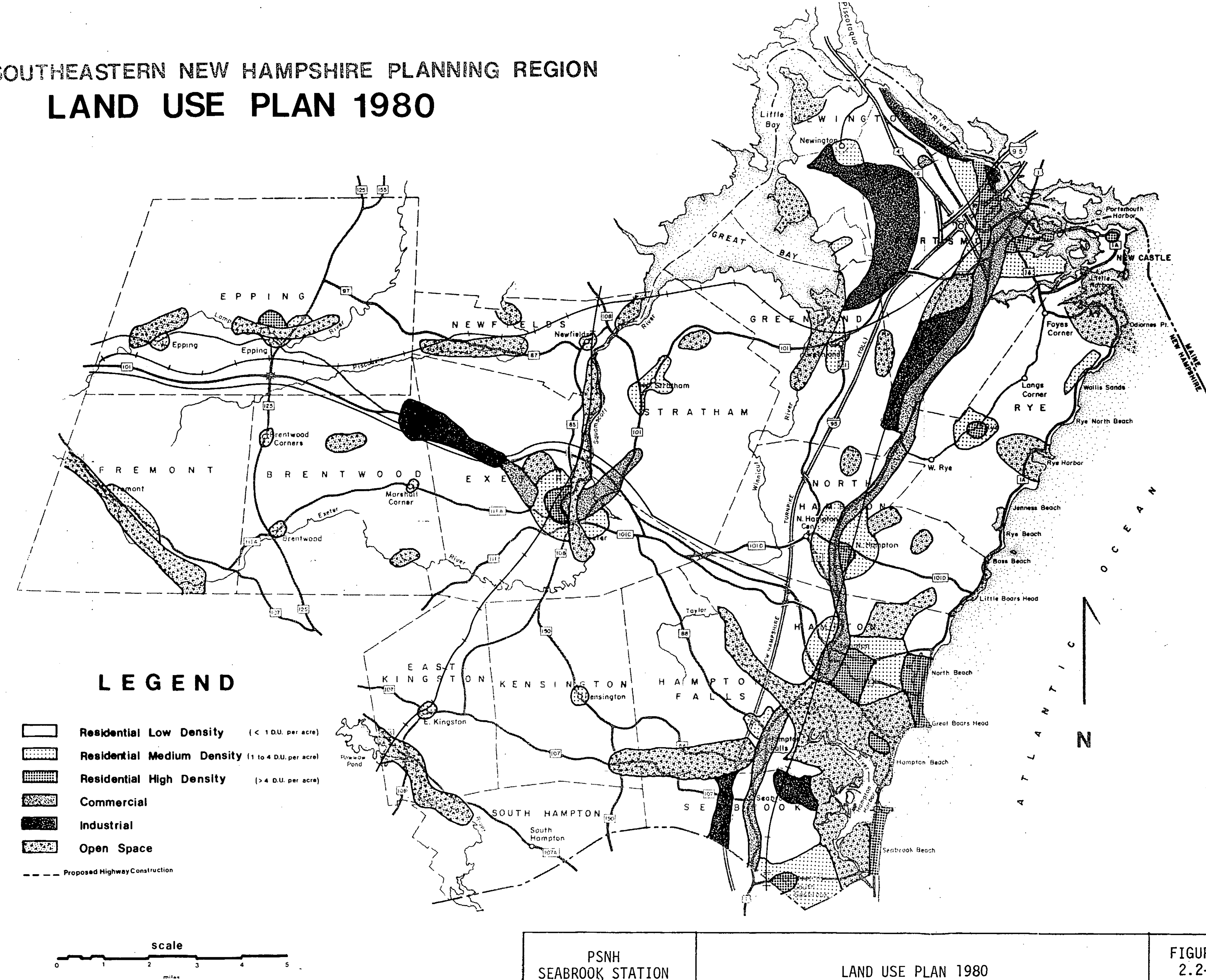
	York
Number of Farms (1968)	877
(1959)	1283
Percent of County (1964) Areas in Farms	20.8
Milk Producing Farms (1964)	198
Number of Milk Cows (1964)	5700
Acres Under Cultivation	21000



PSNH SEABROOK STATION	LOCAL MAP	FIGURE 2.2-1

SOUTHEASTERN NEW HAMPSHIRE PLANNING REGION

LAND USE PLAN 1980



PSNH SEABROOK STATION	LAND USE PLAN 1980	FIGURE 2.2-2

2.3

2.3 Regional Historic and Natural Landmarks

The following is a listing of historic, natural and scenic areas in Seabrook and the towns through which the transmission lines pass as noted in publications entitled "An Appraisal of Potential for Outdoor Recreational Development - Rockingham County, New Hampshire" published by Rockingham County Conservation District assisted by the Soil Conservation Service and other agencies of U. S. Department of Agriculture and the New Hampshire Department of Resources and Economic Development; pamphlet entitled "A Tour of New Hampshire's Historic Landmarks" by Philip Marston published by New Hampshire Division of Economic Development; Land, Water, Recreation Report No. 13, The New Hampshire Outdoor Recreation Plan: National Register of Historic Places - U. S. Department of Interior, National Parks Service.

Location - New Hampshire

Seabrook	- Bound Rock	--Seabrook Beach, A Historic marker noting the Boundary Marker between New Hampshire and Massachusetts dated 1657.
Hampton Falls	- Gristmill & Dam	--Located 1/2 mile from Route 1 on Kensington Road
	- George Washington Visit	--Marker at Junction of Routes 88 and 1
Hampton	- First Public School	--Marker, Toll Plaza of N. H. Turnpike near the Information Booth
North Hampton	- Breakfast Hill	--Marker, The Rye-Hampton Town Line on U. S. Route 1
Portsmouth	- Strawberry Banke	--Restoration project within downtown Portsmouth involving 27 historic houses and buildings.
	- Great Bog	--A natural area - boggy area within Portsmouth and Greenland.
Greenland	- Great Bog	--A natural area - boggy area contiguous with City of Portsmouth
Kingston	- Rock Rimmon State Forest	--A State Forest with a State Forest Fire Lookout

	- Cedar Swamp	--A natural area - certain stands of dense cedar growth, also contains water course between two water bodies and swamp grass.
Danville	- Old Cemetery	--A historic site, cemetery established in 1774 with handcut gravestones.
Chester	- Walnut Hill	--A scenic overlook to the southeast towards Hampton
	- Pulpit Rock	--A natural area consisting of an overhang, shelf-type rock.

Location - Massachusetts

Merrimack & West Newbury	- Merrimack River	
Haverhill & Methuen	- Merrimack River	Scenic area - crossings of Merrimack are areas where existing transmission lines now cross.
Dracut & Andover	- Merrimack River	

None of the historic sites in Seabrook or Hampton Falls is visible from the plant. Nor will any site be affected by the plant. There are no known or expected points of archaeological significance on or near the site.

None of the historic markers or sites will be affected by the proposed transmission lines. The natural area of Great Bog will be crossed through the hardwood portion of the Bog using the selective feathering trimming without chemical treatment. The Cedar Swamp natural area will be crossed by the proposed line. Screening and buffer strips will be maintained on each edge of the swamp. The route is being proposed so that the line will not cross or go through the major stands of cedar in and around the swamp. The clearing will be by selective feathering to disrupt the area as little as possible. No chemicals will be used through the swamp portion of this area. The Pulpit Rock natural area will be close by the proposed line. Selective feathering will be used in this area also.

The structures at the Merrimack River Crossings will be situated well back from the bank of the river so that vegetation screens will be maintained. If necessary additional screening will be planted.

2.4

2.4 Geology

The bedrock basement within 200 miles of the Seabrook site ranges in geological age from Late Precambrian to Upper Mesozoic, and consists predominantly of hard, crystalline metamorphic and igneous rock types. Mildly metamorphosed to unmetamorphosed well-consolidated sedimentary and volcanic bedrock types of Carboniferous and Triassic age occur locally in basin structures in the crystalline basement in the Connecticut River valley, the Narragansett and Boston Basins, and in other apparently isolated basins within the Gulf of Maine area. Loosely-consolidated Coastal Plain sediments of Upper Mesozoic and Lower Cenozoic age blanket the crystalline basement rocks and successor basins in wide areas on the Continental Shelf and in scattered patches near-shore within the Gulf of Maine. The entire area is widely covered by a thin veneer of loose, unconsolidated sediments of Quaternary age, derived from continental glaciation and post-glacial deposition.

The geologic structure of this broad province is characterized essentially by northeast-trending foldbelts of metamorphic rocks, predominantly steeply-dipping schistose rocks, intruded by large sub-concordant, commonly folidated plutonic masses. Major fault structures strike through the region, trending sub-parallel with the structural fabric of the older basement rocks. The primary regional northeasterly structure was initiated early in the Paleozoic era, and the rocks were then compressed, folded, metamorphosed, recrystallized and faulted, largely to their present configuration, by the Acadian orogeny in Upper Devonian time, around 350 million years ago. Superimposed on the characteristic northeasterly-trending foldbelt structure of the region are northeast- to east-trending rift basins formed by post-orogenic crustal adjustment in Late Paleozoic time, and north- to northeast-trending rift basins formed during renewed crustal uplift and tensional separation in Lower Mesozoic time. Finally, during Middle and Upper Mesozoic time, the last major structural modification of the area occurred with the emplacement of scattered plutonic intrusives within a northwesterly-striking zone which transected normal regional structure from the Gulf of Maine to Montreal, Quebec. For roughly the last 100 million years since the close of the Mesozoic era, the region has experienced only minor structural adjustment, in the limited form of successive broad isostatic uplifts followed by depression and rebound under continental glaciation and deglaciation.

Numerous major fault structures of great lateral extent are found throughout the region, commonly reflecting the northeasterly pattern of the folded bedrock structure. Faulting in the region ranges in age of development from early Paleozoic to Upper Mesozoic; Paleozoic faulting is commonly characterized by low-angle thrusts associated with regional orogenic compression, while Late Paleozoic and Mesozoic faulting is more frequently defined as high-angle normal faulting associated with post-orogenic crustal uplift and tensional separation. There are no known or inferred tectonic faults displacing Quaternary glacial deposits or post-glacial and Recent sediments, nor has any tectonic fault structure been reported or inferred to have occurred in the region in the past 100 million years since the close of the Mesozoic era.

Bedrock formations in the area of the Seabrook Station include schistose rocks of the Merrimack Group of Ordovician-Silurian age, intruded by dioritic igneous rocks of the Newburyport and Exeter plutons of Upper Devonian age. In addition to the larger plutons, small granitic intrusive also invaded the area during the time of folding, faulting and igneous activity of the Acadian orogeny. Thin diabase dikes were emplaced, largely along northeast-trending tensional joint openings, during periods of crustal uplift in Late Paleozoic and Mesozoic time. The Seabrook Station production facilities will be placed in or on a gneissoid phase of the Newburyport quartz diorite intrusive, a few hundred feet to the south of the contact between the Newburyport and the Kittery formation quartzitic schist. The Newburyport is a hard, strong crystalline igneous rock consisting of a medium-to coarse-grained quartz diorite matrix intimately enclosing inclusions of dark gray, fine-grained diorite. The Kittery formation in the area is a fine-grained, evenly-foliated quartzitic schist to slaty quartzite. The intrusive contact between the Newburyport and Kittery rocks is welded, tight and interfingering; locally, lens-like remnants of the Kittery formation occur enclosed as isolated blocks within the Newburyport intrusive mass.

The bedrock structure at the Station site is controlled by the attitude of Acadian folding along the south-plunging nose of the Rye anticline, and is characterized by steep south-dipping schistosity in the Kittery formation and sub-parallel foliation in the gneissoid Newburyport quartz diorite. The contact between the Newburyport and Kittery trends irregularly east-west and is interpreted to dip steeply south, roughly conforming with the layering of the adjacent bedrock structure. The bedrock is characteristically cut by numerous high-angle joints at intervals spaced from a few inches to greater than 10 feet. Both northeast- and northwest-striking joints are common, while north-striking joints occur less frequently. East-striking joints are occasionally noted in the quartz diorite, possibly reflecting a minor tendency for that rock to part along foliation planes.

No evidence or inferrence of surface faulting is known for the area, and extensive drilling on the site has not revealed the presence of any subsurface structures or conditions suggestive of recent tectonic activity. Welded micro-faults are noted occasionally in drill core, and within a few miles of the site some faults of significant displacement have been inferred to occur within the bedrock; both features are associated with the major structural development of the region during the Paleozoic era.

The degree of bedrock weathering in the site area is commonly slight, consisting of thin rusty coatings on high-angle joint surfaces. The bedrock material between the weathered surfaces is normally fresh at or within a few feet below the bedrock surface, although slight to moderate weathering effects associated with joints extend locally to 100 feet or more below ground surface. No discrete continuous zones or wide-area masses of severely weathered bedrock are known or inferred to exist in the site area. Pre-Quaternary subaerial weathering in the area affected the Kittery schist to greater depths than it did the Newburyport quartz diorite. Subsequent Pleistocene glacial scouring removed the residual soils derived from the earlier period of weathering to leave an undulating bedrock surface underlain by essentially fresh rock. Because of its relative resistance to the earlier weathering, the Newburyport quartz diorite subsequent to glacial scouring is found commonly to form topographic highs, knobs and ridges on the bedrock surface, while the less resistant Kittery schist underlies topographic lows, depressions, and valleys on the bedrock surface. Drilling data in the site area suggest that the bedrock surface commonly lies below elevation -30 to -50 feet in areas where the country rock is predominantly Kittery formation, and above that general elevation where the country rock is Newburyport quartz diorite.

The physiographic configuration of the site area is characterized by broad open areas of level tidal marshes, dissected by numerous meandering tidal creeks and man-made linear drainage ditches, and interrupted locally by wooded "islands" or peninsulas which rise to elevations of 20 to 30 feet above sea level. The site is located on a wooded peninsula held up by quartz diorite bedrock to a maximum of about 30 feet above sea level. The groundwater table conforms with the topography, normally lying 5 to 10 feet below ground surface. No major groundwater aquifers are inferred for the area, and groundwater migration is slow. Current information suggests that changes in ocean tide levels have little effect on water table levels within the bedrock at the site.

2.5

2.5 Hydrology

Described in this Section are the known physical, chemical and hydrological characteristics (and their seasonal variations) of the above-ground and below-ground bodies of water adjacent to the proposed Seabrook Station. The Section is sub-divided into separate descriptions for these water bodies as is appropriate.

2.5.1 Above-ground Adjacent Bodies of Water

The location of the proposed Seabrook Station on the sea coast of New Hampshire is in close proximity to the estuary of Hampton Harbor. The estuary and associated drainage basin is therefore described apart from the coastal waters of the nearby Gulf of Maine from which and into which the plant circulating water will interact in a once-through system. Where appropriate, the communication between the estuary and the Gulf of Maine will be described.

2.5.1.1 Estuarine Waters

The following subsections summarize the pertinent state of knowledge of the hydrology of the Hampton Harbor estuary as obtained from studies found in the academic literature, governmental studies, and studies commissioned directly by Public Service Company of New Hampshire.

2.5.1.1.1 Estuarine Physical Characteristics

The proposed plant site abuts the Hampton Harbor estuary near Browns River. In order to describe the physical characteristics of this estuary, it may be well to define an estuary in general. According to Pritchard, Reference (12):

> "An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage."

According to Pritchard's classification of estuaries, the Hampton Harbor estuary could be considered from a geomorphological standpoint as a bar-built estuary with some of the features of a drowned river valley since barrier beaches form the seaward bound. A precise classification of the estuary is difficult to make since fresh water runoff is quite variable from season to season thus the estuary may range from positive where runoff plus precipitation exceeds evaporation to negative where evaporation is dominant, causing a hyperhaline condition to exist. Seasonally, the estuary at times appears as a lagoon.

There is some uncertainty in the distinction between an estuary and a lagoon. Caspers, Reference (2), suggests that the distinction can be made on the basis of stability. If the inflow of fresh water in a separated basin develops a stable body of brackish water, one may consider it a lagoon. If the mixing of fresh and marine waters is not stable but shows periodic changes (a poikilohaline biotope) one may consider the basin an estuary. The question may be raised as to how periodic is periodic. Dramatic seasonal variability of fresh water inflow may be accompanied with no change in inflow over a month or more.

Further classification of Hampton Harbor estuary may be made on the basis of the physical character of the water circulation (Bowden, Reference 1). The estuary based on fresh water flow falls into Type 4 of Table 2.5-1. There may be instances during the spring runoff or during storms when the estuary falls into Type 3.

From a physiographic viewpoint, this estuarine complex is simply described as a body of water bordered by land masses and occupying the mouth of a series of streams.

On a large scale, the Hampton Harbor estuary is part of the New Hampshire Coastal Area as shown on the Basin Map of Figure 2.5-1 (re-drawn from NENYIAC, Reference 7). Pictorial representations of the Hampton Harbor estuary are readily available on several maps and charts, most notable of which are: the U. S. Geological Survey 7.5 Minute Series Topographic Hampton Quadrangle Map, the National Ocean Survey Chart C&GS 1206 (Portsmouth to Cape Ann), and the National Ocean Survey Chart C&GS 613-SC (Portsmouth Harbor to Boston Harbor).

The New Hampshire Coastal Area is a 47,000 acre triangular-shaped drainage basin at the eastern end of Rockingham County, in the extreme southeastern corner of New Hampshire (Wilson, Reference 15). It includes all of the drainage entering the Atlantic Ocean between Odiornes Point in Rye (the south entrance point to the Piscataqua River) and the southern end of Seabrook Beach at the Massachusetts state line, 16 miles to the southward. It is bounded by the Piscataqua River Basin on the north and west, by the Merrimack River Basin on the southwest and by a narrow strip of the Massachusetts North Coastal Area to the south, the latter is the small coastal area located immediately north of the mouth of the Merrimack River. The base of this triangular area extends about 10 miles westward from the town of Seabrook to the extreme southwestern corner of the town of Kensington.

The topography consists of a gently rolling plain with a very indistinct divide separating this drainage area from the adjoining basins. Except for extensive tidal marshes at the southeastern end of the basin, the typical elevation near the coast is about 40 feet. Elevations along the divide range from 60 feet at Rye village in the north to 283-foot Hog Hill in Kensington at the southwestern end of the basin, where a series of 200-foot high drumlins rise above the coastal plain. Numerous fresh and salt water marshes occupy nearly one-third of the surface, especially in the five tidewater towns (in north to south order) of Rye, North Hampton, Hampton, Hampton Falls and Seabrook. Except for a few coastal drumlins and the cluster of drumlins at the southwestern end of the basin, most of the surficial deposits consist of marine sands and clays which were uplifted following glacial retreat (Reference 3).

Geographically, the Hampton Harbor tidal marsh - estuary complex extends across the boundaries of four Atlantic coastal towns; --- Hampton on the north, Hampton Falls and Seabrook on the West, all in New Hampshire; and Salisbury, Massachusetts on the south. About 80 percent of the area is within Southeastern New Hampshire. The complex is nearly 5.5 miles long (along its north-south axis) and varies in its east-west width from a maximum of about 2.7 miles at the northward end to a minimum of 0.7 miles at the southward end. The Hampton Harbor estuary drainage area is roughly 47.4 square miles in extent (Reference 4) and accommodates 3/4 of the drainage within the New Hampshire Coastal Area.

Hampton Harbor is located about 13 miles south of Portsmouth Harbor, 8 miles south of Rye Harbor, 1.5 miles north of the Massachusetts state line and 5 miles north of Newburyport Harbor at the mouth of the Merrimack River.

Hampton Harbor itself is a shallow rectangular lagoon behind the barrier beach villages of Hampton Beach north of the harbor entrance and Seabrook Beach south of the entrance. The harbor is roughly 1.2 miles wide by 1.5 miles long. It is situated at the confluence of several rivers. These are shallow tidal streams emptying into the harbor from three drainage areas.

The Hampton River is tidal for two miles to the northwestward, where it is fed largely by the Taylor and Hampton Falls Rivers. The Taylor River rises in the east-central part of Kensington and flows northeastward through extensive marshes in the northern part of Hampton Falls before turning southeastward to form the major segment of the Hampton Falls-Hampton boundary line. It has a total length of 10 miles and a total fall of only 75 feet. This river has a safe yield of between 1 and 10 million gallons per day within a length of 1 mile above the Hampton Falls River (Wilson, Reference 15).

The Hampton Falls River rises in the southeastern corner of Kensington and flows generally easterly through the northern part of Seabrook and the southern part of Hampton Falls before joining the Taylor River to form the Hampton River. It has a total length of nearly 7 miles and a total fall of nearly 120 feet. The lower of two series of small falls in the river has been developed by three small dams near the village of Hampton Falls, about two miles upstream from the mouth of the river. The impounded water bodies, Dodge Ponds, have a total surface area of roughly 20 acres.

A third tributary of the Hampton River is the 8-mile long Tide Mill Creek which drains the south-central part of North Hampton and the eastern part of Hampton. It flows southward through extensive marshes into the Hampton River about one mile north of Hampton Harbor.

The Blackwater River terminates in a 4-mile long tidal inlet which extends two miles southward from Hampton Harbor to the Massachusetts state line, plus an additional two miles southward in the eastern part of Salisbury, Massachusetts. The river rises about five miles westward in the western part of Salisbury. Together with two small brooks to the northward, it drains an 8-square mile section of the Massachusetts North Coastal Area, all within Salisbury.

In addition Browns River, Hunts Island Creek and Mill Creek flow into the confluence from the west. Mill Creek has as its main tributary Cains Brook. Although there is a discernible watershed, it is still small and the attendant fresh water runoff is not particularly significant. Thus overall, the several streams and their branches serve primarily as tidal streams directing the inward and outward flow of saline water twice daily.

Estimates of the areal extent of the salt marsh and the harbor are found in several sources. The variance in the estimation is high, probably reflecting the difference in interpretation of what constitutes marshland and harbor. Whether or not planimetry was used on Geological Survey maps, Coast and Geodetic Survey charts or aerial photographs may also cause differences in values of areal extent.

The New England River Basins Commission in Reference (8) estimates the total acreage of marsh and open water as 5700 acres of which some 4990 acres are tidal marshes. They state further that there are several hundred acres of intertidal flats fringing the mouths of the tidal streams and the harbor.

Normandeau Associates, Inc. in Reference (10) estimates the tidal marsh area to be approximately 3800 acres as obtained from planimetry of a U.S.G.S. Topographical Map.

The Corps of Engineers in Reference (4) estimates the tidal marsh to be about 8 square miles (5120 acres) in extent.

The New England - New York InterAgency Committee in Reference (7) estimates the open water harbor area at high tide to be 300 acres in extent.

The New Hampshire Fish and Game Department in Reference (9) estimates the salt marsh to be 2784 acres in extent although a check of their figures indicates 3085 acres of tidal marsh and 23 acres of dunes and flats.

Finally, Ebasco Services, Inc. in Reference (5) estimates the water surface area in the estuary arms at mean low water to be 24 million square feet (550.9 acres). This result was arrived at by planimetry of aerial photographs.

The entrance to Hampton Harbor is crossed by highway U. S. Route 1 A. This includes a highway bridge about 1800 feet in shore from the entrance over the bar. Constructed by the State of New Hampshire in 1949, the bridge is a single leaf bascule type having a horizontal clearance of 42.7 feet and a closed vertical clearance of 18.8 feet at high water.

State Route 286 crosses the Blackwater River about 2 miles south of the harbor entrance on a fixed bridge and a branch of the Boston and Maine

Railroad crosses Mill Creek, Browns River and Hampton Falls River about 2 miles west of the harbor entrance on small bridges. The rivers are somewhat navigable up to these latter bridges. The river confluence is marked by shifting sandbars.

The entrance to the harbor has numerous unmarked rocks, shoal waters and sand bars. Two contiguous large rock outcrops are near the entrance and are called rather decriptively Inner Sunk Rocks and Outer Sunk Rocks. The harbor entrance was formerly a migrating inlet, shifting alternately to the north and to the south. Accompanying each northward migration, Seabrook Beach grew in the direction of migration and attached itself to White Rocks, a rock outcrop, and the south end of Hampton Beach eroded and receded northward. During southward migration of the inlet, Hampton Beach attached itself to White Rocks and Seabrook Beach eroded and receded southward.

During 1934-35, the State of New Hampshire constructed a series of dikes and jetties to stabilize the inlet and reclaimed about 50 acres of land north of the north jetty by pumping hydraulic fill from Hampton Harbor, thus creating a State Park. The White Rocks outcrop is now adjacent to the south jetty.

In 1941, 1955, and 1956, the State performed additional dredging in the entrance channel. The present entrance is long and has widths ranging from 900 to 1500 feet with depths, after the bar at the channel outfall is crossed ranging from 5 to 20 feet at mean low water.

An existing Federal navigation project, authorized under Section 107 of the 1960 River and Harbor Act, was approved in 1964 by the Chief of Engineers for the purpose of increasing stabilization of the inlet, and improving navigation conditions at the entrance of Hampton Harbor. The existing project provides for a 4000 foot long entrance channel, 8 feet deep and 150 feet wide, across the entrance bar from deep water to the Route 1A highway bridge; an extension of the existing State-built, stone jetty 1000 feet seaward with a top elevation of 12 feet above mean-low water; and provides for raising the outer 300 feet of the south jetty, and construction of a 180-foot spur to high ground, all to an elevation of 16 feet above mean low water.

On February 15, 1972, the New England Division of the Corps of Engineers issued a Draft Environmental Statement, EIS-COE-35016-02 Maintenance and Jetty Repair, Hampton Harbor, New Hampshire describing a proposed dredging project in the estuary, Reference (4). This document is publicly available from the National Technical Information Service (NTIS) under accession number PB-207-563-D.

The bathymetry of Hampton Harbor is shown on Figure 2.5-2. Depths are referenced to mean sea level and represent the bottom topography as of the years 1968-1969. It is evident that the bottom of the estuary is relatively flat and shallow at mean low water except in the navigation channels.

2.5.1.1.2 Estuarine Hydrological Characteristics

Siting of Seabrook Station with respect to the Hampton Harbor estuary will be at the westward side on a peninsula of land which is bordered on the north by the Browns River and on the south by Hunts Island Creek. Surface drainage of natural precipitation from this peninsula is into these two streams.

Data sources for the hydrological characteristics of Hampton Harbor estuary complex are few in number. Surface water records for the Hampton Harbor estuary complex are not given in the annual Water Resources Data for Massachusetts, New Hampshire, Rhode Island, Vermont - Part 1. Surface Water Records, U. S. Department of the Interior, Geological Survey. This comprehensive record is prepared in cooperation with the New Hampshire Water Resources Board, the U. S. Army Corps of Engineers and the Environmental Protection Agency among others. No official gaging stations are located in the Hampton Harbor estuary.

Neither the National Estuarine Pollution Study of 1969 conducted by the U. S. Department of Interior Federal Water Pollution Control Administration (now the Water Quality Office of the Environmental Protection

Agency) under the Clean Water Restoration Act of 1966 (P. L. 89-753) nor the National Estuary Study of 1970 conducted by the U. S. Department of Interior Fish and Wildlife Service under the Estuary Protection Act (P.L. 90-454) specifically considered the Hampton Harbor estuary hydrology.

A. Water Elevations

Astronomical tide data for Hampton Harbor is given in the Tide Tables, High and Low Water Predictions; East Coast of North and South America, published annually by the National Ocean Survey, National Oceanic and Atmospheric Administration, U. S. Dept. of Commerce. Tidal current information for Hampton Harbor is not offered in these tables. The 1972 tidal height tables indicate that the mean tide range, spring tide range and mean tide level are 8.3, 9.5 and 4.1 feet respectively.

An extensive analysis of normal and abnormal waves and tides in the Hampton Harbor estuary is found in Section 2.4 of the Seabrook Station Preliminary Safety Analysis Report. Table 2.5-2 summarizes the predicted astronomical tide parameters for Hampton Harbor. Astronomical tides in this area are mixed semi-diurnal with usually two highs and two lows occurring daily. The periodicity is in the order of 24.5 hours.

Section 2.4.3.3 of the Seabrook Station PSAR analyzes the freshwater surface runoff into Hampton Harbor estuary from natural precipitation under normal and abnormal conditions. It is indicated therein that for a 24 hour standard project storm over the Hampton River drainage basin (area = 47.4 square miles) that the rise in water level in the estuary would be 0.26 feet assuming a runoff of 9.7 inches. This is relatively small compared to normal tidal excursions.

B. Volumetric Considerations

An investigation involving field studies and analytical calculations was performed by Ebasco Services, Inc. for the first Seabrook PSAR during

1968-69 to determine the existing hydrological conditions in the Hampton Harbor estuary.

The field study program included a bathymetric survey of Hampton Harbor, a current meter monitoring program at Hampton Harbor Bridge, installation of recording tide gages at the Hampton Harbor Bridge and at the Hampton River Boat Club, and a current velocity measurement study in the Browns River.

The field studies and analytical calculations yielded the following results:

1) The mean tidal range in Hampton Harbor is about 8.6 feet and varies from about 4 feet below to 4.6 feet above mean sea level. This is depicted on Figure 2.5-3.
2) Extreme high tide during the study period was 7.5 feet above mean sea level and extreme low tide was 6.2 feet below mean sea level.
3) Tidal amplitude does not vary materially within the estuary.
4) Within the Hampton Harbor estuary the volume in the tidal prism (between mean low water and mean high water) is approximately 470 million cubic feet.
5) The residual volume of water in the estuary at mean low tide is about 80 million cubic feet. This is depicted in Figure 2.5-4.
6) The calculated maximum average tidal velocity through the inlet section at Hampton Harbor Bridge is about 1.0 knots or 1.7 feet per second as shown on Figure 2.5-5.
7) The measured maximum average tidal velocity through the Hampton Harbor Bridge navigation bay is about 1.55 knots or 2.60 feet per second. The inlet profile at this point is shown on Figure 2.5-6.

Normandeau Associates, Inc. in the Seabrook Ecological Study - Phase II, 1970-1971, Reference (11), expands further on this subject by converting from cubic feet per second to gallons per minute and adds the following pertinent facts.

Under natural conditions water flow velocity at the estuary inlet ranges from about zero to six or seven feet per second on spring tides, and maximum flow through the inlet may reach nearly 18,000,000 gallons per minute. The average flow on a typical flooding tide is about 9,800,000 gallons per minute. Over a period of 12 hours and 30 minutes, under typical conditions, about 3,700,000,000 gallons of water enter and leave the estuary on one flood and ebb tide cycle. At ebb slack tide, a mean of approximately 500,000,000 gallons of water is estimated to remain in the estuary. Thus, the total average flood tide volume of the estuary is approximately 4,200,000,000 gallons of water. Expressed on a percentage basis, about 88 percent of the estuary volume leaves and returns on each ebb and flood tide cycle. At ebb slack tide the estuarine residual is approximately 12 percent that of the total volume of the basin. These figures indicate, then that the Hampton Harbor estuary exhibits a substantial tidal exchange rate under natural conditions.

2.5.1.1.3 Estuarine Thermal and Chemical Characteristics

Several studies of the thermal and chemical structure of Hampton estuarine waters have been made. These investigations, with the exception of specific wet chemical and spectrographic water analyses, have been conducted by Normandeau Associates, Inc. The exception has been performed by Sheppard T. Powell Associates, Inc. and will be discussed separately.

Normandeau Associates investigations commenced in June 1969 and the results of their surveys in this area are delineated here. Figures 2.5-7 and 2.5-8 show the location of their sampling stations for the years 1969 and 1970 respectively.

For the year 1969, measurements were made from mid-July to early November. Temperature and salinity were periodically profiled. Only thermal structure is reported for 1970.

A. Temperature

Temperature profiles were taken at in-harbor stations on July 18, 22, 23, 29, 31, 1969 and August 6, 8, 25, 27, 29, 1969. Readings taken from August 6 on were limited to Stations H-1, C-8, B-11, and A-11.

Ordinarily, profiles were made on the flooding tide one week and the ebbing tide the following week. On August 29, however, temperature readings were taken at Stations H-1, C-8, B-11, and A-11 over a complete tidal cycle.

The temperature recorder at the Hampton Harbor Bridge produced continuous surface water temperature readings from August 15 to August 26, 1969. Bottom temperature at the Bridge was monitored from August 15 to November 7, 1969, except for fourteen days (September 26 to October 9). The recorder at the Hampton Harbor Boat Club gave an uninterrupted record of temperature from July 14 to November 3, 1969, when it was removed for the season. The records of daily maximum and minimum temperature at these two stations are shown in Figures 2.5-9 and 2.5-10.

The highest summer temperature recorded at the Hampton River Boat Club was 25.8°C (78.4°F) on August 9, 1969. Although the recorder at the Hampton Harbor Bridge was not operating on this date, a temperature profile taken on August 8 at Station H-1 gave a surface temperature of 24.0°C (75.2°F). Other weekly temperature profile data provided further evidence that the seasonal high temperature occurred at or near this date. Stations A-11 and B-11 had seasonal surface water temperature peaks of 27.2°C (81.0°F) and 26.2°C (79.2°F) respectively on August 8, 1969.

Throughout July and August, temperatures were consistently higher at the Hampton River Boat Club and other upper estuary stations (e.g., A-11, B-11, C-8) than at the Hampton Harbor Bridge. As seawater entered the shallow, branching channels of the estuary, the surface to volume ratio changed from that existing offshore (less depth per unit surface). Consequently, this incoming water experienced more local warming by solar radiation than occurred offshore. With the onset of cooler atmospheric temperatures in September and October, temperatures in the upper reaches of the estuary were slightly cooler than those recorded at the Harbor mouth (see Figures 2.5-9 and 2.5-10). This was caused by a reversal of the phenomenon mentioned above. With less depth per surface area, cooling occurred faster in the shallow estuarine waters than in the offshore deeper waters.

As shown in Figures 2.5-9 and 2.5-10, the greatest daily fluctuations in water temperature occurred during the period of maximum or peak temperatures in July and August. The maximum temperature fluctuation for any day sampled at the Harbor station was 8.0°C (14.4°F) on August 2, 1969. Daily fluctuations of 7.0 to 7.5°C (12.6 to 13.5°F) were common during much of August 1969. The daily maximum temperature fluctuation at the Hampton River Boat Club was 10.6°C (19.1°F) on August 9, 1969. Seventeen additional days in July and August showed maximum - minimum differences of at least 7.0°C (12.6°F). During the autumn months, daily temperature fluctuations became progressively smaller. In later September, the daily differential at any station rarely exceeded 3°C (5.4°F). By early November the daily fluctuations were down to 2°C (3.6°F).

In an estuarine system such as the Hampton Harbor estuary, the tidal cycle is extremely important in bringing about regular fluctuations in temperatures. In the summer months the flooding tide brings relatively cold ocean water into the estuary. The subsequent receding tide draws some of the warmed water out of the estuary to the adjacent ocean.

The influence exerted by the tidal cycle on daily temperature in the Hampton Harbor estuary is graphically shown in Figures 2.5-11 through 2.5-14. These graphs present temperature data taken over the course of a tidal cycle at Stations H-1, A-11, B-11, and C-8 on August 29, 1969. In each case there is a decrease in water temperature on the flooding tide (decreases of 4.1°F at H-1, 4.9°F at C-8, 6.3°F or more at B-11 and 5.0°F or more at A-11; in the last two cases peaks were not recorded).

On the ebbing tide there was an even larger change (which probably occurred to some extent before the previous flood tide, but was not sampled in this study effort). Increases were recorded of 9.1°F for H-1, 11.2°F for B-11, 5.0°F for A-11 and 4.5°F at C-8.

Temperature profiles taken throughout the summer at stations within the estuary confirmed the observations made from the recorded data. Because this estuary is relatively shallow (most of the estuary is covered by less than eight feet of water at mean low tide), there is considerable mixing of its waters and there are no excessive differences in temperature with depth.

Summer temperature trends during 1970 of surface and bottom water during ebb and flood tides for selected plankton stations are illustrated in Figures 2.5-15 through 2.5-20. Examination of these graphs reveal some pertinent information about temperature/tide/time relationships within the estuary. Surface and bottom temperature trends shown in these figures indicate the existence of a relatively consistent surface-to-bottom temperature differential for each tide phase and at each station.

B. Salinity

Inasmuch as the Hampton Harbor estuary does not have a large watershed, the freshwater runoff is usually small. Thus salinity fluctuations would not be expected to be large. They are, indeed, not excessive but they do occur and are apparently tied closely to the tidal cycle. Presumably during and following heavy rains and the spring runoff period, greater salinity fluctuations might be observed.

The lowest salinity value recorded was 12.01 $^{o}/oo$ (parts per thousand) on August 8, 1969 at Station A-11. On the ebbing tide this station is usually subject to some freshwater runoff from the upper Taylor River. Several other stations in the upper reaches of the estuary had their lowest recorded salinities on this same day (Station B-11 had a reading of 19.78 $^{o}/oo$ and C-8 a reading of 23.43 $^{o}/oo$) reflecting some amount of recent precipitation. The upper estuarine stations apparently were not subject to as much turbulent mixing as generally occurred in the mouth and harbor of the estuary, and in several instances distinct stratification of saline layers was observed. For example, on August 6 the salinity at Station A-11 was 14.14 $^{o}/oo$ on the surface and 20.54 $^{o}/oo$ six feet below the surface. The highest recorded estuarine salinity was 31.10 $^{o}/oo$ on the flooding tide at Station B-11 on August 25, 1969. On the same day Station H-1 had a high of 30.80 $^{o}/oo$ on the ebbing stage of the same tide.

In the Hampton Harbor estuary there is generally a slightly higher salinity level on the flooding tide as ocean water flows in and a slightly lower level on the ebbing tide as a portion of the freshwater runoff is carried seaward. The freshwater inflow into the estuary is small compared to the total tidal volume (Ebasco Services, Inc., Reference 5), but it appears to be adequate to produce this perceptible salinity differential. Figure 2.5-21 shows salinity changes occurring over a complete tidal cycle on August 29, 1969, at four different stations. In every case the surface salinity readings were less than the bottom salinities. On the flooding tide the differences between top and bottom were very slight (rarely more than 0.3 $^{o}/oo$), but the differences were more pronounced on the ebbing tide. The surface - bottom differential is typical of most estuarine situations where lighter, less saline water tends to float up over the heavier, more saline ocean water. As inferred above, the addition of even small amounts of freshwater from the watershed tends to augment this surface - bottom differential during ebb tide stages.

C. Dissolved Oxygen

The variation of dissolved oxygen and current with time over a tidal cycle on October 9, 1969, at Station C-9 is shown on Figure 2.5-22. For comparative purposes, the coincident temperature and salinity variation is shown on Figure 2.5-23.

It is seen that dissolved oxygen levels are above 5 ppm at all stages of the tidal cycle. A low of 5.5 ppm is shown near low slack tide and a high of 8.5 ppm near high slack tide. The corresponding temperatures at these extremes indicate that at 5.5 ppm the water is roughly half saturated with dissolved oxygen and at 8.5 ppm the water is almost saturated.

D. Water Chemistry

Wet chemical and spectrographic analyses were performed on sea water samples taken from the estuary. The results of the analysis for a sea water sample taken from the Browns River at low tide on July 1, 1969, is shown in Table 2.5-3. The results of the analysis for sea water samples taken from the Hampton Harbor inlet at flood tide on August 18, 1969, and on November 8, 1972, is shown in Table 2.5-4. The firm of Sheppard T. Powell Associates, Baltimore, Maryland, was retained to perform these analyses.

Constituent spectrographic analyses are reported in percent by weight of the dry residue of total dissolved solids as given by the wet chemical analysis.

2.5.1.2 Ocean Waters

The hydrography of the New Hampshire coastal waters is quite variable with the fields of temperature, salinity, and density showing strong seasonal changes. The variability is typical of coastal waters, where wind, tides, waves (surface and internal), topography, river runoff, evaporation, precipitation, insolation, proximity to land, and advection all affect the hydrography to varying degrees in time and space (Beardsley, Reference 16). The various mean hydrographic features are characteristic of temporate coastal waters. The water nearshore is generally fresher than offshore, due to river discharge and seasonal freshening of the nearshore waters occurring in the spring from increased runoff, which may be ten times the summer freshwater flow.

Often coastal waters are isothermal and vertically well mixed in winter, but develop a transient seasonal thermocline in summer. Surface water temperature generally increases offshore in winter and decreases offshore in summer because of the large heat capacity of water relative to land, and the heat transport by local winds. This pattern is modified by the extent of mixing, upwelling, advection, and by depth. Mixing and the large heat capacity of water also result in a smaller seasonal temperature fluctuation of the water than on land and in a moderating effect of the sea on coastal climate (Beardsley, Reference 16).

The site for the proposed Seabrook Station along the southeastern coast of New Hampshire is fronted by a portion of the western North Atlantic Ocean known as the Gulf of Maine. This water body will be both the primary source of cooling water for the proposed power plant as well as the receiving water mass for its heated effluent.

2.5.1.2.1 Oceanic Physical Characteristics

A. Physiography

The Gulf of Maine forms a roughly rectangular embayment about 200 miles across from east to west and 120 miles from north to south stretching from Cape Cod and Nantucket Island, Massachusetts northeastward along about 600 miles of shoreline excluding local perturbations to Cape Sable, Nova Scotia (Figure 2.5-24 from Cotton, Reference 19). It is bordered to the south by two shallow bank areas -- Georges Bank and Browns Bank -- which apparently restrict water circulation with the North Atlantic and essentially enclose the Gulf as a coastal sea. The Gulf itself comprises an estimated surface area of about 49,000 square miles.

South of Cape Elizabeth, Maine, the shoreline is characterized by a succession of sand beaches and barrier islands (such as Hampton Beach) alternating with bold headlands and rocky stretches (such as Cape Ann). North and east of Cape Elizabeth the coast is almost continuously rocky with numerous embayments formed by estuaries and rivers extending landward and a labyrinth of islands, large and small, extending in places 10 to 20 miles seaward from the mainland.

B. Bathymetry

The Gulf of Maine has a generally irregular bottom topography with numerous banks and sinks. A narrow, gently sloping shelf up to 15 miles wide rings much of the periphery of the Gulf but the Gulf is dominated by three deep basins -- Wilkinson Basin, located in the western half of the Gulf (maximum depth about 930 feet); Jordan Basin, in the northeastern portion (about 810 feet deep); and Crowell Basin, in the southeastern section (about 1,240 feet deep) -- shown in Figure 2.5-24. The seaward edge of the Gulf consists of a nearly continuous series of shallow sills extending from Nantucket to Cape Sable -- Georges Bank which is between 90 and 210 feet deep, but in places is almost out of water at low tide, and Browns Bank which is between 100 and 300 feet deep. There are three narrow passages which breech this sill, connecting the deeper basins of the Gulf to the open coast -- Great South Channel between Nantucket and Georges Bank (about 210 feet deep); the Eastern Channel between Georges Bank and Browns Bank (about 680 feet deep); and the Northern Channel separating Browns Bank and the mainland of Nova Scotia (about 420 feet deep).

The bathymetry of the western Gulf of Maine adjacent to the coast of New Hampshire is dominated by two deep basins -- Jeffreys Basin which is about 600 feet deep and Scantum Basin which is about 420 feet deep. Between these basins and the coast is a broad gently-sloping shelf area with numerous local bottom irregularities, especially in the vicinity of the Isles of Shoals (Figure 2.5-25 from NOS Chart No. 1106). These basins are somewhat separated from the main Gulf by a shallow rise known as Jeffreys Ledge. A rough approximation for the volume of the Gulf of Maine, based on published hydrographic charts, is about 3,925 cubic miles or 1.2×10^{15} gallons. This figure does not include any part of the Bay of Fundy.

2.5.1.2.2 Oceanic Hydrological Characteristics

A. Tides

The tides in the Gulf of Maine are of a mixed semi-diurnal type with a small (1 foot) diurnal inequality. In general the mean tidal range increases as one moves clockwise around the Gulf. It ranges from several feet at Nantucket Island to almost 20 feet along the eastern coast of Maine; from the Bay of Fundy southeastward they gradually decrease to about 5.4 feet near Cape Sable. At Hampton Harbor the mean tidal range is about 8.3 feet; spring tides may be as high as 12.4 feet (relative to mean low water) whereas neap tides may be as small as 4.3 feet (relative to mean low water). Tidal current flow offshore show a clockwise rotary motion due to Coriolis forces whereas nearshore the current tend to be more elliptical in the horizontal plane.

B. Circulation Patterns

The circulation in the Gulf of Maine is very strongly influenced by tides and at most locations the tidal currents comprise the greater part of the total water movement. However, this tidal movement is superimposed on a more general scheme of surface circulation (Figures 2.5-26 through 2.5-29 from Bumpus and Lauzier, Reference 18) which undergoes an annual cycle. This circulation pattern is largely influenced by regional river runoff, horizontal temperature gradients, frictional drag of the wind, atmospheric pressure gradients, and the effects of the Coriolis force on tidal motions in restricted waters (Bumpus and Lauzier, Reference 18).

Looking at the winter circulation, the chief characteristic is an indraft of water off of Cape Sable, Nova Scotia across Browns Bank and the eastern Gulf of Maine (Figure 2.5-26). This water flows into the southern portion of the Bay of Fundy. A southerly flow develops along the western side of the Gulf of Maine and continues past Cape Cod through Great South Channel. Between the Bay of Fundy and the southerly flow along the western side of the Gulf, several irregular eddies develop by February.

At about the same time north of Georges Bank, an area of divergence forms which has a persistent offshore component across the bank with water apparently spilling out into the Atlantic. In the early spring the runoff from rivers along the coast flows into the Gulf and helps to form an eddy which rapidly develops into a huge counterclockwise gyre (Figure 2.5-27). This gyre encompasses the entire Gulf of Maine by the end of May. On the eastern side of the gyre an indraft from the Scotian shelf and Browns Bank occurs and is carried either northward into the Bay of Fundy or westward toward the coast of Maine. The less saline waters from the Bay of Fundy move down the eastern side of the bay and join the westward flow of the gyre. In the western part of the Gulf the gyre flows southward toward Massachusetts Bay where it is diverted either into Cape Cod Bay or toward the east and north of Georges Bank. In the summer the pattern of the spring gyre persists but its drift rate gradually slows down (Figure 2.5-28). By autumn the southern side of the Gulf's counter-clockwise current pattern breaks into a southerly drift across Georges Bank (Figure 2.5-29). The net non-tidal drift ranges from a few tenths of a mile per day to as much as seven miles per day throughout the Gulf, depending upon surface wind conditions (Bumpus & Lauzier, Reference 18). In the western Gulf of Maine Graham (Reference 24) found an average rate of residual drift of approximately 1.9 miles per day. According to the findings of Bigelow in Reference (17), surface waters in the Gulf take about three months to circuit the basin.

The pattern of bottom circulation is similar to surface circulation but appears to move at a much slower rate. Currents move from east to west along the coast and in the vicinity of Cape Ann move offshore and southward (Figure 2.5-30 from Graham, Reference 24). The net drift of bottom waters as inferred by releases during different seasons, 1962-1965, is substantially less than surface waters and in the western Gulf of Maine average rates of bottom drift range from 0.06 to 0.33 miles per day (Graham, Reference 24). However, as bottom waters in the Gulf approach the shore they appear to pick up velocity very quickly.

The New Hampshire coastal region is subject to active tidal currents which flow northward and southward during a tidal cycle at a velocity of several tenths of a knot. The maximum velocity measured to date by Normandeau Associates, Inc. was 0.6 knots during flood tide in late November, 1972. Preliminary data from glass drift bottles and polyethylene drift envelopes released by NAI in September 1972 indicate a predominant south to southwesterly drift off the New Hampshire coast (Figures 2.5-31 and 2.5-32), which is imposed on the tidal currents. However, close to shore off Hampton Beach and Rye Beach, New Hampshire, the data indicate a northward drift and possible presence of a local coastal eddy current. By mid-November seven bottles had been recovered on Cape Cod having been swept along by the Gulf of Maine gyre.

Bottom drift is somewhat variable due to irregularities in bottom topography. In general, the flow is southwestward in Jeffreys Basin and Scantum Basin, and then northwestward up onto the coastal shelf (Graham, Reference 24). Recent drifter recoveries from releases in September 1972 by Normandeau Associates showed a northwestward and westward drift on shore from coastal release sites but a southeastward drift off of Cape Ann as part of the Gulf of Maine gyre (Figure 2.5-33). In the same figure data from spring 1972 releases by workers from the University of New Hampshire north of the Isles of Shoals are shown (Ward, Reference 36). These drifters came south to southwestward except for two which came northwestward onto Boon Island out of Jeffreys Basin.

In summary, the waters of the Gulf of Maine are derived from several sources: 1) high salinity (35 ^{o}/oo), cold (6-8° C; 42.8-46.4°F) slope water which flows intermittently into the Gulf as a bottom current; 2) the Nova Scotian current of cold low-salinity water which flows into the Gulf at the surface from around Cape Sable in the spring (this current generally slackens later in the year); 3) a surface drift into the Gulf, offshore from Cape Sable which is made up of a mixture of cold banks water, slope water, and tropic water; 4) occasional overflows of tropic water across Georges Bank into the Gulf, particularly during the late autumn or winter when the Gulf of Maine gyre is at a minimum; and 5) rainfall and river discharge which contribute freshwater from a watershed of roughly 64,000 square miles. The Gulf of Maine does not appear to receive water from the Labrador Current (Bigelow, Reference 17). Thus the immediate sources of water for the coastal shelf in the Seabrook area (90 to 300 feet deep) are: estuarine discharges, waters from the western basin of the Gulf of Maine, and waters from the Bay of Fundy. After the water moves across the coastal shelf, it is carried offshore, generally in the vicinity of Cape Ann. Surface waters move along the coast whereas bottom waters tend to move shoreward, resulting in an upwelling along much of the coast (Graham, Reference 24).

C. Wind and Wave Conditions

The annual wind conditions in the Gulf of Maine area are summarized in Table 2.5-5 (from U.S. Naval Weather Service Command, Reference 35). The predominant winds are from the south to west quadrant (about 51.1% frequency). Under these conditions surface waters tend to move offshore and toward the northeast. When winds are from the east and north, the surface waters are moved to the southwest and onshore. It should be noted that surface currents may be deflected to the right of the wind direction by the Coriolis force in the northern hemisphere.

The "northeaster", which develops as a low-pressure center over the southwestern or southeastern United States and swings in a northeasterly course along the Atlantic coast, is the most important storm type affecting the northern New England coast in terms of coastal processes of erosion and deposition on sand beaches and in shallow nearshore waters (Hayes and Boothroyd, Reference 27). Such storms usually generate large, long period waves. The percent frequency of wind speed and direction versus sea heights for the Boston coastal area from 1963 to 1968 are shown in Tables 2.5-6(a) and 2.5-6(b) from the U.S. Naval Weather Services Command, Reference (35).

D. Currents in the Vicinity of the Proposed Intake and Discharge Pipes

Currents in coastal waters can be conceptually separated by their characteristic time scales, i.e., mean currents, tidal currents, and higher frequency currents associated with waves and turbulence. Mean currents are flows with time scales of weeks to months such as the net drift of the Gulf of Maine. Mean flows are usually very weak whereas tidal flows are considerably stronger (Beardsley, Reference 16).

Data from several 13-hour anchor stations undertaken by Normandeau Associates, Inc. during October 1972 indicate that current patterns in the vicinity of the proposed intake and discharge pipes for the Seabrook Station are very complex. On October 12, 1972 during a neap tide of about 6.7 feet flood tidal currents were primarily to the northeast and northwest; during ebb tide the currents flowed mostly to the east with a slight southeasterly component (Figure 2.5-34). During a spring tide of about 11.1 feet on October 25, 1972 flood tidal currents were primarily to the northeast and northwest in the upper part of the water column, whereas at depth they reversed into a strong southwesterly current. During ebb tide the currents were northeastward and eastward near the surface but to the south and southwest in the lower part of the water column (Figure 2.5-35). Maximum current velocities generally occurred in the middle part of the water column on both days.

Additional data on surface current patterns is contained in a study of dye releases made by Webster Martin, Inc. in December 1968 and April-May 1969. In general their data showed a northward component of net drift and dye dispersal, but that winds could strongly influence the movement of surface waters along the coast (Ebasco Services, Inc., Reference 22).

Studies of current patterns off Salisbury Beach, Massachusetts south of the study area indicate a southward component of net drift during at least part of the year. Occasionally the water mass seems to stop and reverse itself with a net northward drift for several days before returning to its original flow pattern (Dean Bumpus, personal communication, November 6, 1972). This phenomenon may be related to upwelling along the coast and seems to be similar to the flow patterns observed on October 12, 1972. Additional studies of flow patterns off Hampton Beach are in progress by Normandeau Associates, Inc.

2.5.1.2.3 Oceanic Thermal and Chemical Characteristics

A. Temperature

Temperature of Gulf of Maine water is due to the interaction of several factors, the principal ones being its location leeward of the continent and the severe climate of the adjacent land and, to a lesser extent the influx of currents. However, in spite of its latitude and the land climate, the Gulf waters are not abnormally cold and should not be described as "arctic" (Bigelow, Reference 17). Solar warming is the chief source of heat for the surface waters. In the coastal waters, tidal stirring mixes the water fairly well from surface to bottom.

In winter, water temperature is nearly uniform at all depths, surface water being slightly cooler than the deeper water (Table 2.5-7 from EPA, Reference 23). Figures 2.5-36 to 2.5-41 (from Colton and Stoddard, Reference 20) show the horizontal distribution of the surface temperature in the Gulf of Maine based on data from 1940-1959. During January and February (Figure 2.5-36), the surface temperatures are at their lowest throughout the area. It is interesting to note that in addition to the expected north-south temperature gradient, there is also a tendency for low temperatures to occur near shore (2-3° C; 35.6-37.4°F). Figure 2.5-37 shows the beginning of a gradual warming trend in March and April.

In spring and summer the surface water warms only slightly more rapidly than the deeper water, so that the period of a strong thermocline is only two or three months, instead of five to six months as in more southerly locations (Bigelow, Reference 17). Figure 2.5-38 shows average monthly surface water temperatures for May and June. The low surface temperature of the region is thus due to local causes rather than to arctic waters. Heat is also contributed by warm winds, surface water drifting from over Browns Bank and the Cape Sable area, and from periodic overflows of tropic water into the Gulf. Vernal warming is opposed by the Nova Scotian current flowing in past Cape Sable, and by river discharge in the early spring. During periods of strong stratification, active vertical mixing associated with tidal stirring along the shore and local weather can produce a zone of cool water (11-12°C; 51.8-53.6°F) close to shore (Hulburt, Reference 30). Figure 2.5-39 shows the overall distribution of mean monthly surface temperature in the Gulf of Maine for July and August which is near the end of the heating season. Here areas of intense tidal mixing, such as Georges Shoal and the Bay of Fundy are clearly shown by their low surface temperatures. Where vertical mixing is at a minimum (off Cape Ann for example), high surface temperatures are found. It should be noted that along the western shoreline of the Gulf of Maine in general, surface temperatures are lower than in the central portion. This band of relatively cool water along the western shore results from a combination of tidal mixing and possible upwelling caused by the prevailing offshore winds.

Autumn and winter chilling is mainly due to heat loss by radiation as the air temperature falls below the water temperature. Average monthly surface temperatures in September and October are shown in Figure 2.5-40. Snowfall and ice also contribute to cooling, as does evaporation throughout the year. Figure 2.5-41 shows the surface temperatures for November and December. Typical minimum, average, and maximum temperature profiles from the Gulf of Maine during the summer and the winter are shown in Figure 2.5-42 (from the EPA, Reference 23).

The annual cycle of sea surface temperature changes in percent frequency of occurrence for the years 1876 to 1968 offshore of Boston, Massachusetts is shown in Table 2.5-8 (from U.S. Naval Weather Services Command, Reference 35). Figure 2.5-43 from the University of Massachusetts Marine Station shows the annual cycle of surface temperature change at Hodgkins Cove, Cape Ann, Massachusetts which is located about 15 miles south of the Hampton Harbor estuary. Figure 2.5-44 shows the temperature variations at a station off of Cape Ann over several years, as a function of season and depth as measured by Bigelow, Reference (17). Figures 2.5-45 and 2.5-46 (redrawn from Ward, Reference 36) show temperature profiles from October 1971 through September 1972 from a station located northeast of the Isles of Shoals at latitude 43° 1.5' N and longitude 70° 18.1' W. Profile "J" is from data of Shevenell, Reference (34).

Figures 2.5-47, 2.5-48, and 2.5-49 show temperature cross-sections made on September 12-13, 1972 by Normandeau Associates along three east-west transects off of the New Hampshire coast. The western end of the transect in Figure 2.5-48 is located in the vicinity of the proposed intake and discharge site for the Seabrook Station. Note the temperatures show a general decrease as one moves seaward.

These preceeding figures all illustrate the same series of annual events in the offshore waters. Beginning with the winter minimum temperature in February, the water warms during the spring months. At first, the warming proceeds slowly because the incoming solar heat is mixed throughout the water column, however the surface layers soon become warmed and the resulting density gradient forms a transient thermocline zone -- which restricts mixing to a certain degree. After this thermocline is established, usually in late March or early April, warming proceeds rapidly. Warming continues throughout the summer, reaching a maximum in late August or early September inshore. Following this, the temperature declines very rapidly to a winter minimum. Because of the great heat capacity of water, the summer maximum in temperature lags the time of maximum heat input (June) by about two months. A similar lag is seen between the time of minimum heat input (December) and the time of minimum temperature (February).

Although the same events are seen both at Hodgkins Cove (Figure 2.5-43) and off of Cape Ann (Figure 2.5-44), it is interesting to note that the summer maximum offshore is about 2°C (3.6°F) higher than at Hodgkins Cove. Similarly, the winter minimum is about 2°C (3.6°F) lower at Hodgkins Cove than offshore. The lower summer temperatures inshore are a result of the upwelling of cooler water caused by the prevailing offshore winds. The lower winter temperature at Hodgkins Cove results from the fact that shallower water will cool faster and reach a lower temperature than deep water.

The limited temperature data available to date from the offshore waters in the vicinity of the proposed discharge pipes about one mile NE of Hampton Harbor show these same basic seasonal characteristics. Figure 2.5-50 shows temperature profiles taken in April and May, 1969 by Webster Martin, Inc. (Ebasco Services, Inc., Reference 22). On April 14 during early flood (Profile A), there was a pronounced gradient from 43.9°F on the surface to 38.7°F on the bottom whereas by April 21st during early flood (Profile B) the water column had warmed slightly and was more homogeneous at depth (surface 43.2°F and bottom 41°F; Figure 2.5-50). Profile C during late flood on April 25 and Profile D on May 2 (mid flood) both show a continuing warming trend. By May 6th bottom waters reached 44.6°F (Profile E during early ebb); however, they became cooled again by May 17th (Profile F taken during early flood) possibly due to intrusion of cold offshore waters. Data of 1969 from Normandeau Associates, Inc., Reference (28), show that by August 10th surface temperatures in this same area were up to 61.7°F and bottom temperatures were 53.4°F (Figure 2.5-51). On August 26th surface waters cooled slightly to 58.3°F whereas on September 23rd they were nearly isothermal (surface 61.5°F and bottom 57.9°F; Figure 2.5-51), reflecting strong vertical mixing. It should be noted that at no time did these temperature ranges approach the much higher range of temperatures observed in the estuary (Normandeau Associates, Inc., Reference 28).

Surface temperature data from July to September 1970 measured by Normandeau Associates, Inc., Reference (29), show pronounced variations between flood and ebb tides on the same day. Figure 2.5-52 shows that on July 17th surface waters offshore ranged from 46.4° to 48.2°F during flood whereas during ebb they were considerably warmer (49.6° to 55.4°F), reflecting the large volume of heated water which is discharged northward and southward out of the estuary by the ebbing tide. On August 12th and 13th similar temperature patterns were observed during flood (68.0° to 72.0°F) and ebb (70.2° to 72.9°F, Figure 2.5-53), however the temperature variation between tidal phases was smaller than in July due to normal seasonal warming of offshore waters by solar radiation. On September 24th flood tide surface temperatures were 60.1° to 62.4°F, whereas during ebb tide they were only 58.5° to 61.0°F (Figure 2.5-54), probably due to night-time cooling and insolation effects during the ebb tide when the water was ponded across shallow tidal flats. The temperature variations between flood and ebb tides from July through October, 1970 at an offshore station located about 1/2 mile east of the mouth of Hampton Harbor estuary are shown in Figure 2.5-55. Warmest temperatures were measured on August 13th (72°F) during flood tide and then decreased gradually through the last measurement on October 15th (56.7°F).

Several potential sources of anomalous temperature patterns in the New Hampshire coastal area are present. Because of the close proximity of the plant site to the Merrimack River estuary and the Hampton Harbor estuary, it is possible that freshened warm water masses discharged from the estuary (Hartwell, Reference 26) could maintain their identity long enough to be carried offshore and impart anomalously high temperature readings to surface waters offshore. Another source is wave disturbances which can develop along a density gradient such as a thermocline, causing vertical mixing of stratified water masses. A more regular form of internal wave has been reported from the Gulf of Maine by Halpern, Reference (25). Finally, the temperature structure offshore can be expected to change dramatically in response to changes in wind strength and direction. An easterly wind will cause warm water to pile up near the shore with result that the transient seasonal thermocline will deepen. If the wind shifts to westerly, the warm surface water will be blown away and replaced by cooler, deeper upwelled water. At such times, the surface temperature may fall 5° to 7°F.

These annual cycles of temperature are superimposed on a longer term variation in the temperature of the Gulf of Maine. Figure 2.5-56 shows a plot of five-year mean sea surface temperatures at Boothbay Harbor, Maine from 1905 to 1964 (Dow, Reference 21). From this curve it is apparent that from 1905 to 1944, there was a general upward trend in sea surface temperatures. Beginning in 1944, the rate of increase became much greater -- reaching a peak in 1954. From 1954 to 1967

(Figure 2.5-57) the mean sea surface temperatures declined to about 1940 levels (Colton, Reference 19). It appears that these fluctuations are largely due to changes in the relative positions of the Gulf of Maine water mass and the warm edge of the Gulf Stream or slope water (Colton, Reference 19). Years when the slope water borders on the 600 foot isobath are warm years; when the warm slope water is displaced by cold coastal water originating near Labrador, a cold year results.

B. Salinity

The salinity of the Gulf of Maine is low (32 to 33 $^{o}/oo$) in comparison with other enclosed seas and with the Gulf Stream seaward to the Gulf (35 $^{o}/oo$). Tidal stirring minimizes the vertical range of salinity in the coastal waters (generally less than 1 $^{o}/oo$). Seasonal variations are typical of coastal areas with coastal waters freshening with spring runoff, and then increasing in salinity again slowly through the summer and fall. Figure 2.5-58 (redrawn from Bigelow, Reference 17) shows the general areal distribution of sea surface salinity in the Gulf of Maine in mid-winter, February 22 to March 24, 1920. The general picture is that there is only about 1 $^{o}/oo$ variation throughout the Gulf; most of the variations observed are along the western side of the Gulf where river runoff is concentrated. Figure 2.5-59 (redrawn from Bigelow, Reference 17) shows the areal distribution of sea surface salinity in summer, July to August, 1914. The principal change from winter conditions is that there is much less variation; the tendency toward reduced salinity on the western border of the Gulf is apparent, but much less pronounced (also, see Table 2.5-7). It should be noted that the spring runoff from large rivers along the coast, especially the Merrimack, may cause a rapid decrease in salinity in offshore waters out to about 20 miles (from about 32.8 to 31.6 $^{o}/oo$, Bigelow, Reference 17); however, its effect is mostly confined to the immediate surface waters. In regions such as this where a local supply of freshwater is mixed with more saline water, there is an outflow at the surface and a compensating inflow at the bottom (Watson, Reference 37).

A limited amount of salinity data is available from New Hampshire coastal waters. During April and May, 1969, measurements by Webster Martin, Inc. taken in the vicinity of the proposed discharge pipes about one mile NE of Hampton Harbor showed freshened water near the surface during early flood on April 14th and 21st (27.7 to 28.7 $^{o}/oo$) and a small gradient at depth (29.2 to 29.8 $^{o}/oo$; Profiles A and B in Figure 2.5-60 redrawn from Ebasco Services, Inc., Reference 22). During late April and early May a pronounced freshening occurred lowering salinities to 24.2 to 25.8 $^{o}/oo$ near the surface and 27.5 to 28.0 $^{o}/oo$ on the bottom (Profiles C and D; Figure 2.5-60). Later in May salinities rose again and were uniformly distributed in the water column reflecting strong mixing (Profiles E and F; Figure 2.5-60). By late summer in 1969 salinity measurements in the same area made by Normandeau Associates, Inc. ranged from 29.8 to 31.0 $^{o}/oo$ on the surface with little change at depth (Figure 2.5-61). Salinity data from August 1970 from a station located about 1/2 mile offshore of Hampton Beach showed generally lower salinities during ebb (30.6 to 30.7 $^{o}/oo$) than during flood (31.2 to 32.1 $^{o}/oo$), but more similar salinities during phases of the tide in September (Figure 2.5-62).

A series of three west to east transects out to a distance of about 26 miles off the New Hampshire coast were made on September 12-13, 1972 by Normandeau Associates, Inc. The northern transect which ran through the Isles of Shoals along 42° 58.7' N latitude showed two pockets of freshened water -- one near shore (29.9 $^{o}/oo$) and one east of the Isles (28.0 $^{o}/oo$), both of which may have been carried offshore from the Piscataqua River estuary (Figure 2.5-63). The middle transect off Hampton Harbor estuary near 42° 54' N latitude showed one freshened pocket near the shore and generally stratified salinities offshore ranging from 30.1 to 31.0 $^{o}/oo$ on the surface down to 34.4 $^{o}/oo$ on the bottom (Figure 2.5-64). The southern transect off Plum Island along 42° 46' N latitude was also stratified but had no observable pockets of freshened water (Figure 2.5-65).

C. Density

Limited data on density of offshore waters in the vicinity of the proposed discharge pipes about one mile NE of Hampton Harbor was published by Ebasco Services, Inc., Reference (22). In April 1969 water densities ranged from about 1.022 to 1.024 gr/cc (Figure 2.5-66 redrawn from Ebasco Services, Inc., Reference 22) but in early May they dropped to 1.019 - 1.022 reflecting the decreased salinities during the same period (see Figure 2.5-60).

Later in the month they rose again to about 1.024 (Profile F). Similar data is also shown in Table 2.5-7. These data all show that the water column is fairly well mixed and that even the greatest density gradient observed (May 2, 1969; Profile D) is only 0.003 gr/cc which is not enough to oppose any vertical mixing processes. Thus, because density, salinity, and temperature are uniform with depth in these coastal waters, one can conclude that these waters are subject to fairly complete vertical mixing.

D. Dissolved Oxygen and Other Gases

Redfield (Reference 31) estimated the seasonal variation in the magnitude of oxygen exchange across the sea surface as it occurs in the Gulf of Maine and evaluated the factors responsible for this exchange. He determined the quantity of dissolved oxygen to a depth of 650 feet and inorganic phosphate to a depth of 325 feet at stations in a 35-mile square area in the western basin of the Gulf from July 1933 through September 1934. He established that about 30 x 10^4 cc of oxygen per square meter leaves the surface of the Gulf of Maine between the end of March and the latter part of October and that a similar amount enters during winter. Of the annual exchange across the sea surface he attributed only two-fifths to net production or consumption of oxygen by organisms. The remainder presumably resulted from the effects of temperature on the solubility of oxygen. In spring the production of oxygen in photosynthesis was sufficient to account for the entire surface exchange; during summer the exchange was attributable to decreasing solubility because of warming; in late fall and winter, excess oxygen consumption and increasing solubility caused the exchange. He estimated the exchange coefficient of oxygen to be 13 x 10^6 cc per m^2 per atmosphere per month into the water in winter and 2.8 x 10^6 cc per m^2 in summer. These seasonal differences were attributed to differences in sea surface conditions (Colton, Reference 19).

Concentrations of dissolved oxygen measured by Normandeau Associates, Inc. in the vicinity of the proposed intake and discharge ports on October 12, 1972 ranged from about 9.0 mg/L in surface waters to about 7.2 mg/L at the 40 foot depth. On October 25, 1972 they ranged from 10.0 mg/L on the surface to 7.0 mg/L near the bottom in 39 feet of water. Typical profiles of dissolved oxygen as a function of depth during September 1972 in offshore waters are shown in Figure 2.5-67, from Shevenell, Reference (34).

Redfield and Keys (Reference 32) presented results on the occurrence of ammonia in various sections of the Gulf of Maine in September 1933 and May 1934. They showed that in the deeper basin of the Gulf of Maine in May, ammonia occurred in maximal concentration in a definite substratum between 100 and 200 feet, while in September the concentration of ammonia was uniform at all depths. In the strong tide ways of the deep channels ammonia was distributed uniformly with depth, and in the shallow water over Georges Bank its occurrence showed no regularity. The distribution of ammonia paralleled the distribution of organic phosphorus compounds, nitrate, and zooplankton, indicating that its distribution marked the location and intensity of organic decomposition (Colton, Reference 19).

E. Nutrients

Redfield, Smith, and Ketchum (Reference 33) determined the distribution of phosphorus present as inorganic phosphorus, as dissolved organic compounds, and as particulate matter for specific depths at a standard station in the western part of the Gulf of Maine during May, August, and November, 1935 and February and May 1936. They reported on the cycle of phosphorus throughout the year and on the methods for analyzing quantitatively the factors producing seasonal changes in the distribution of such a compound (Colton, Reference 19).

Table 2.5-9 shows the gradient of dissolved phosphate as a function of distance offshore in the vicinity of the Isles of Shoals for various times of the year (data from Shevenell, Reference 34).

F. Suspended Sediments

The suspended load of particulate matter in offshore waters is largely due to the discharge of suspended sediment from freshwater runoff, re-suspension of tidal-flat sediments by wind, wave activity and subsequent seaward transport out of estuaries, and biological growth. Total particulate concentrations off the New Hampshire coast from the mouth of the Piscataqua River to the 500 foot contour in Jeffreys Basin, as measured during 1971 and 1972, showed large fluctuations, but in general, the winter months had the highest concentrations and the summer months the lowest (Ward, Reference 36). This is associated with the stormy weather prevailing in the winter while the summer months experiences the calmer sea. Other increases in total particulate concentrations were seen near the mouth of the Piscataqua River and the lowest in the most seaward sampling sites in Jeffreys Basin. Organic analysis indicated a great deal of variation in concentrations. Highest organic concentrations were often seen during increases in total particulate concentrations, excluding the phytoplankton blooms. This indicates the increase in particulate concentrations can largely be attributed to inorganic sources. Generally about 35 percent of the total particulate matter was of an organic source. Annual variations in suspended sediment concentration in waters near the Isles of Shoals is shown in Figure 2.5-68 (from Ward, Reference 36). The average monthly variation in milligrams per liter near the surface and six feet above the bottom is shown for two general areas between October, 1971 and May, 1972. One area is several miles north of the Isles of Shoals and the other area is located in Jeffreys Basin. In each area, the data from three stations were used.

Figure 2.5-69 (redrawn from Shevenell, Reference 34) shows typical profiles of percent tranmission and temperature as a function of depth at a station about three miles southeast of the Isles of Shoals during August 1, 1972. The near-surface and near-bottom zones are generally turbid during the summer, whereas the middle zone has much less suspended material. From initial observations it appears that the surface turbid layer is primarily due to phytoplankton and to a lesser extent to particulate matter from estuarine discharge. This latter component was not readily noticeable during the summer months. The bottom turbid zone is primarily due to re-suspension of bottom sediments either by current activity or long-period wave action. It occurs in a relatively isothermal region of the water column. It may be as thick as 130 feet in 260 feet of water (Shevenell, Reference 34), but in shallower waters turbidity may be entirely absent. In the immediate area of the proposed intake and discharge pipes for the Seabrook Station a layer of suspended material several feet thick has been observed along the bottom by SCUBA divers on several occasions, especially following stormy periods. Visibility within this layer has been observed to be less than a foot at these times.

2.5.1.3 Inland Surface Waters

The surface water characteristics of southeastern New Hampshire and northeastern Massachusetts in the general region of Seabrook Station are described in this section.

2.5.1.3.1 Inland Surface Water Physical Characteristics

The region surrounding the Seabrook Station includes portions of the Merrimack River drainage basin and New Hampshire coastal drainage basin. Figure 2.5-70 shows the boundaries of these basins superimposed upon the political boundaries of the region. The entire New Hampshire coastal basin is within the seacoast region, whereas only about 4 percent of the Merrimack River basin is included in this region. Table 2.5-10 summarizes the area of each basin considered to be within the seacoast region (References 38 and 43).

These basins are bordered by the Piscataqua River basin to the north and west, the Atlantic Ocean to the east, the Parker and Rowley River basins to the south, and the inland reaches of the Merrimack River basin to the west.

The eastern sections of the Merrimack River basin and the New Hampshire coastal basin consist of moderately shallow river basins characteristic of coastal low-lands. Inland to the west these basins gradually change to a hilly and gently rolling topography with occasional level areas and marshes.

Records from the stream gaging stations located within these drainage basins indicate that run-off varies between 20 and 23 inches which is about 50 percent of the annual rainfall (References 38 and 43).

2.5.1.3.2 Hydrological Characteristics of Surface Waters

1. Merrimack River Drainage Basin

The Merrimack River drainage basin (Figure 2.5-70) is a large drainage basin with an area of nearly 5,010 square miles of which nearly 80 percent is in New Hampshire and the remainder in Massachusetts. The Merrimack River, which is the fourth largest river in New England, is formed by the junction of the Pemigewasset and Winnepesaukee Rivers in Franklin, New Hampshire. From this junction the river flows in a southerly direction to Lowell, Massachusetts, where it turns abruptly through an angle of about 110° and flows in an east-northeasterly direction to tidewater at Haverhill and thence to the Atlantic Ocean near Newburyport, Massachusetts, 35 miles north of Boston. The total distance thus covered is 186.2 miles, through a total fall of 2,700 feet at an average rate of 14.5 feet per mile. The mean discharge flow recorded in the Lawrence, Massachusetts area is about 7000 cfs. The average annual run-off of the entire basin is 4,900 mgd. Only a small portion of this basin involving some 134,000 acres or 200 square miles is in the southeastern New Hampshire and northeastern Massachusetts coastal region. There are five watersheds included in this region. They are the Powwow River, the Artichoke River, the East Meadow River, the Little River, and the Spickett River watersheds. The Artichoke River and East Meadow River watersheds are totally within the boundaries of Massachusetts, whereas the other three begin in New Hampshire and extend into Massachusetts. The major rivers associated with each watershed all drain into the Merrimack River. Table 2.5-11 summarizes the area of these watersheds in New Hampshire and the area within the seacoast region (References 39, 41 and 43).

There are no figures available on the surface water storage of this drainage basin, but the area includes over 2400 acres of lakes and ponds of greater than 10 acres size and an estimated 38 miles of streams having safe yields of between 1 and 10 million gallons per day. The rainfall in this area is about 40 inches per year and the estimated run-off would be 50 percent or about 20 inches. Serious flooding and erosion have not been a problem in this area owing to the generally flat terrain which slows down the run-off. The natural surface waters are soft (10-50 ppm) due to low mineral content and suspended material.

A. Powwow River Watershed

This watershed which extends into Massachusetts contributes an area of 31,400 acres to the seacoast region.

The principal river of this watershed is the Powwow River which rises in Great Pond and Country Pond in Kingston, New Hampshire. It then flows a short northerly distance into Powwow Pond which extends from Kingston into East Kingston. From the outlet of Powwow Pond in East Kingston the river flows on a generally southeasterly but winding course into Massachusetts to its confluence with the Merrimack River. While figures on the storage capacity of ponds in the Powwow River watershed are unavailable, Table 2.5-12 tabulates the individual acreage for each pond which amounts to a total of over 1600 acres. There are an estimated eight miles of the Powwow River in the seacoast region with a flow of between 1 and 10 million gallons per day. The fall of the river to the point where it crosses the state line is approximately 18 feet.

Most of the surface water bodies of the seacoast region part of the Merrimack River drainage basin are located in this watershed. These are summarized in Table 2.5-12 (References 40, 41 and 43).

B. Artichoke River Watershed

The Artichoke River watershed is entirely within the borders of Massachusetts. The Artichoke River, which flows in a generally northerly direction through West Newbury, is the principal river within this watershed. The river begins at the Upper Artichoke Reservoir from where it flows to the Lower Artichoke Reservoir and eventually into the Merrimack River a distance of about 3 miles. The watershed of this river encompasses a drainage area of 4200 acres.

The two main bodies of surface water in the Artichoke River watershed are summarized in Table 2.5-13 (Reference 41).

C. East Meadow River Watershed

The East Meadow River watershed is predominantly located in Haverhill, Massachusetts. The area drained by this watershed is about 5900 acres, most of which is in Haverhill, however, its northern reaches extend into Merrimack, Massachusetts. The watershed's principal river, the East Meadow River, begins in Merrimack at Neat Pond, which is largely marsh. Direction of flow of the river from this point is generally southerly through Haverhill into the Millvale Reservoir and eventually into the Merrimack River approximately 2 miles east of downtown Haverhill. The East Meadow River travels a distance of about 4.5 miles between Neat Pond and the Merrimack River. The mean discharge flow for the East Meadow River calculated from data taken between October, 1969 and September, 1970 was 11 cfs.

The two main bodies of surface water in the East Meadow River watershed are summarized in Table 2.5-14 (References 40 and 41).

D. Little River Watershed

The Little River watershed begins in New Hampshire and extends across the state line into Massachusetts. This drainage area contributes 18,200 acres of relatively low lying or gently sloping land to the seacoast region. There are about seven miles of streams in the watershed with safe yields of between 1 and 10 million gallons per day. Lake Pentucket is the only significant body of surface water in this watershed. It has a surface area of 38 acres. The principal river, the Little River, rises in a swampy area in South Kingston, New Hampshire, and flows along a generally southerly course into Haverhill, Massachusetts, where it joins the Merrimack River (References 40, 41, and 43).

E. Spickett River Watershed

This watershed with an estimated total area in Massachusetts and New Hampshire of 50,000 acres contributes 9000 acres to the seacoast region. There are no significant lengths of streams having dependable yields in excess of 1 million gallons per day, and the principal surface water bodies of this watershed within the seacoast region are Wash Pond and a part of Island Pond both located in Hampstead. It is from these ponds, described in Table 2.5-15 that the Spickett River flows (References 40, 42 and 43).

2. The New Hampshire Coastal Drainage Basin

This drainage basin is a large watershed which includes those lands that drain into the Atlantic Ocean along the New Hampshire coast. It covers an area of 47,000 acres or 73.5 square miles and is shown in Figure 2.5-71. The principal outlet to the sea is Hampton Harbor which occupies about one-half square mile of the salt water marsh area in the southeastern part of the seacoast region.

Hampton Harbor serves as a tidal basin for two rivers: The Blackwater River which flows north out of Massachusetts and the Hampton River which enters from the northwest.

The Hampton River is tidal throughout its two mile length. It is formed by the confluence of the Taylor and Hampton Falls Rivers. The tidal range at the mouth of the Hampton River is 8.3 feet. The Taylor River has a safe yield of between 1 and 10 million gallons per day for a length of about 1 mile above its confluence with the Hampton Falls River (Reference 44).

The drainage basin is divided into four watersheds. They are the Blackwater River, Hampton Falls River, Taylor River, and the Little River watersheds. The Blackwater, Hampton Falls and Taylor Rivers all empty into Hampton Harbor and the Little River into Plaice Cove at the North Hampton-Hampton line. Table 2.5-16 summarizes the area of these watersheds.

A. Blackwater River Watershed

The Blackwater River terminates in a 4 mile long tidal inlet which extends four miles southward from Hampton Harbor (Figure 2.5-71). The river rises about 5 miles westward in the western part of Salisbury. Together with Cains Brook and Sheperd Brook which empty into Mill Creek this watershed drains an eight square mile section of Massachusetts and a 5.5 square mile area of New Hampshire to the southward and westward of Hampton Harbor. This watershed is the smallest of the four with an area of only 5500 acres (Reference 44).

B. Hampton Falls River Watershed

The Hampton Falls River watershed is entirely within the boundaries of New Hampshire. The Hampton River is tidal two miles to the northwestward, where it is fed largely by the Taylor and Hampton Falls Rivers. The Hampton Falls River rises in the southeastern corner of Kensington and flows generally easterly through the northern part of Seabrook and the southern part of Hampton Falls before joining the Taylor River to form the Hampton River (Figure 2.5-71). The Hampton Falls River has a total length of nearly seven miles and a total descent of nearly 120 feet. The Hampton Falls River watershed drains an area of 10,000 acres (Reference 44).

C. Taylor River Watershed

The Taylor River watershed is also located entirely in New Hampshire. The Taylor River is the primary river in this watershed. It rises in the east-central part of Kensington and flows northeastward through salt marshes in the northern part of Hampton Falls before turning southeastward to form the major segment of the Hampton Falls-Hampton boundary line (Figure 2.5-71). It has a total length of 10 miles and a total fall of only 75 feet. The 8 mile long Tide Mill Creek which drains the south-central part of North Hampton and the eastern part of Hampton is also part of the Taylor River watershed. Tide Mill Creek flows through salt marshes into the Hampton River about one mile north of Hampton Harbor (Reference 44). This watershed drains a total area of 16,000 acres, the greatest of the four watersheds of the New Hampshire Coastal Drainage Basin.

D. Little River Watershed

The Little River watershed drains the entire northern section of the New Hampshire Coastal Drainage Basin to the north of Great Boars Head. The Little River is the primary river in this watershed. It is about 4 miles long and has a total fall of 100 feet. It rises in central North Hampton and flows southeastward into Plaice Cove at the North Hampton-Hampton town line (Figure 2.5-71). Other significant water bodies in the watershed are Bailey Brook and Nilus Brook discharging into Eel Pond in Rye and Meadow Pond in Hampton, respectively. The Little River watershed covers a total area of about 14,000 acres.

2.5.1.3.3 Thermal and Chemical Characteristics

Information concerning the thermal and chemical characteristics of the lower Merrimack River and surface waters in the New Hampshire coastal region is somewhat limited. Of these two areas the U. S. Department of Interior, Geological Survey conducts an on-going program of limited scope for only the lower Merrimack River in the vicintiy of West Newbury, Massachusetts. The information collected from this program is published annually by the Geological Survey.

Four parameters are measured and recorded. They are specific conductance, pH, dissolved oxygen (DO), and temperature. Table 2.5-17 tabulates the high, low and mean values of these four parameters for the period October 1969 to September 1970.

2.5.2 Groundwater

The Seabrook Station is located in what is termed by Meinzer (Reference 45) as the Northeastern Drift Province. Principal groundwater supplies in the area come from glacial drift. The average annual temperature in the area is 50°F. Mean annual precipitation is about 43 inches and annual loss to evaporation from water bodies is approximately 25 inches. Seepage into the groundwater body is extremely variable due to the variations in the permeability of the surficial deposits.

The hydrologic boundaries of the site are Hampton Harbor, the local drainage courses and impervious subsurface materials.

2.5.2.1 Description and Hydrological Characteristics

2.5.2.1.1 Regional Aquifers, Formations, Sources and Sinks

The study area comprises the drainage basins of Hampton River, Browns River, Blackwater River and Hampton Harbor. It includes the towns of Hampton, Hampton Falls, Kensington and Seabrook in New Hampshire and Salisbury, Massachusetts. Throughout the area groundwater is found in the bedrock and in overlying glacial and recent deposits. The seaward limit of the fresh groundwater body does not extend greatly beyond the tidewater margins of Hampton Harbor. Infiltration of precipitation is retarded in places by the impermeable marine sediments which overlie much of the area. The shallow unconsolidated surficial deposits overlying bedrock are the principal aquifers in the area. These are composed of beach deposits, swamp deposits and glacial drift. The latter includes: till, ice contact, marine and outwash deposits. Groundwater in the underlying bedrock is limited to fractures which become less frequent at increasing depths. The effective depth for fractures to transmit water is about 300 feet.

Aquifers and Formations

The largest quantities of groundwater are obtained from coarse grained sediments in the ice contact deposits which consist primarily of stratified sand and gravel. These are the coarsest in texture of all the local deposits and average about 50 feet in thickness. As shown in Figure 2.5-72, their areal extent is small, except in the vicinity of Hampton and Salisbury. These deposits are a source of public water supply for the towns of Seabrook, Salisbury and Hampton.

Lesser amounts of groundwater, adequate for meeting the needs of homes, farms and small industries are available from the outwash deposits. Well yields from them generally do not exceed 100 gpm (Reference 46). In the study area, the outwash is mostly made up of fine sand, commonly less than 25 feet thick and is a source for small domestic supplies.

Some small wells are also developed in the till and in beach sands. The till which is an assorted mixture of rock particles in a matrix of clay and silt, generally yields only a few gpm to a well in this area (Reference 47). Groundwater development from permeable beach sands in the Hampton and Seabrook Beach areas is limited by a thin freshwater lens, in many places only a few feet thick, which is floating on saline water. Recharge to the lens is from infiltrating precipitation which originates in the beach areas. These till deposits are not considered an important source of water for the region.

Impermeable marine deposits largely consisting of silt and clay are widely distributed in the area. They are not a source of well supplies but locally confine groundwater in ice contact deposits, till or bedrock (Reference 46).

Bedrock which underlies the unconsolidated materials is composed of the Newburyport quartz diorite and the metamorphosed sediments of the Merrimack group. There is no apparent difference in the water bearing properties of the different types of rock and they are not an important water source. Most bedrock wells yield less than 10 gpm from depths up to 300 feet (Reference 48).

Swamp deposits almost wholly occupy the tidal marshes and contain brackish or salty water. These deposits are impermeable and are not sources of well supplies.

Sources and Sinks

The groundwater body in the area occurs under water table conditions except in some places where it is confined by marine sediments. It is principally sustained by infiltrating precipitation which in the region averages about 43 inches per year. The infiltration capacities of soils in the area vary considerably and where the soil is composed of marine clays groundwater recharge is greatly retarded.

The regional water table approximates the configuration of the topography and frequently occurs within 10 feet of the ground surface. Groundwater movement is limited to drainage areas where streams intersect the water table and in areas where streams are tributary to tidewater. Because these drainages are relatively small, groundwater flow paths from points of recharge to discharge generally do not exceed one mile (Reference 46).

Recharge to the aquifers in the region is accomplished by the infiltration of precipitation. The places immediately underlaid by ice-contact deposits and by outwash and shore deposits are the principal recharge areas (see Figure 2.5-72). These deposits are sufficiently permeable to absorb water readily. They commonly form terraces and plains whose flat surfaces retard surface runoff and thereby afford ample storage space to accommodate the additional water (Reference 49).

Many places immediately underlain by till also serve as recharge areas, but here the rate of recharge is comparatively small. Not only is the till less permeable than the outwash and the ice-contact deposits, but it commonly forms hills whose slopes shed water rapidly.

Recharge occurs intermittently and usually follows a seasonal pattern. During the growing season, most of the precipitation that enters the soil is retained there to satisfy soil-moisture requirements and recharge therefore is small. During the rest of the year, when plants are dormant, the soil-moisture requirement usually is small and recharge is great whenever there is much rain or snowmelt. The peak usually accompanies snowmelt during the spring season.

Groundwater is discharged naturally through springs, by seepage to streams and other bodies of surface water, and by evapotranspiration. It is discharged artificially through wells and artificial drains. Discharge to streams, called ground-water runoff, usually is greatest soon after periods of dry weather and sustains the flow of the streams when there is little or no surface runoff. Discharge by evapotranspiration is greatest during the growing season.

Under natural conditions the principal discharge areas in the Seacoast Region are stream channels, the swamps, and the coastline. The water table normally slopes toward the streams, and groundwater enters them wherever they flow on permeable material. Groundwater is discharged in swamps and other low areas by seepage whenever the water table is high enough to intersect the land surface and by evaporation and transpiration at times when the water table is only a short distance below the land surface. Along the coastline some of the groundwater evaporates and some of it seeps directly into the ocean.

Changes in groundwater storage take place as a result of changes in the ratio between recharge and discharge. In general, periods when recharge is greater than natural discharge occur in late fall, winter, and early spring while evapotranspiration is ineffective. During late spring, summer, and early fall, however, when most of the rainfall that infiltrates into the soil is evaporated or transpired by plants and does not reach the zone of saturation, recharge and natural discharge continue, though at a reduced rate, and the amount of ground water in storage declines.

Changes in groundwater storage are reflected by fluctuations in groundwater levels; these levels rise when recharge exceeds discharge and decline when discharge exceeds recharge.

In general, the greater the permeability of a deposit, the smaller the water-level fluctuations. In till, for example, fluctuations ranging from 10 to 20 feet are not unusual, especially in wells located on hills or slopes. During periods of recharge, the low permeability of the till prevents rapid lateral percolation of groundwater to areas of discharge and the water level rises considerably. However, during periods of little recharge, the groundwater continues to drain and discharge slowly; thus, the water level declines. In contrast, fluctuations of only a few feet are common in wells in ice-contact deposits. These deposits are sufficiently permeable to transmit groundwater laterally at rates approximating those of recharge and large rises in water levels ordinarily do not occur (Reference 49).

2.5.2.1.2 Local Aquifers, Formations, Sources, Sinks

The information presented in this subsection is adapted from Reference 46.

No major aquifers underlie the site or its vicinity. Locally, the most productive aquifers are in the outwash deposits which are widely distributed just west and southwest of the site (Figure 2.5-72). The outwash, however, is made up mostly of predominantly fine silty sand of low permeability. In the site area, it is up to 35 feet thick and generally overlies marine sediments.

Local occurrences of coarser grained glacial and/or recent deposits are evident both to the northwest and under the tidal marshes east of the site (Figure 2.5-73). These deposits, however, contain either brackish or salty water or would be subject to salt water contamination under pumping conditions because of their proximity to salt water bodies.

On the site property, bedrock occurs at or near the surface becoming deeper under the tidal marshes to the south and north where it is 70 feet or more below sea level. On the site, the bedrock forms an irregularly buried ridge trending in an approximately easterly direction. It is overlain by a sandy textured but well compacted till up to 62 feet thick. A sequence of marine and recent marsh deposits normally rests on the till along or just north of the Browns River near the northern site boundary and also in adjoining areas to the south (Figure 2.5-72). West of the site, thin outwash deposits overlie either till or marine silts and clays. To the east, toward Hampton Beach, medium to fine sands, 50 feet or more in thickness, occur just below ground level or below recent marsh deposits (Figure 2.5-73). The sands, which appear permeable are essentially saturated with salt water. They probably are outwash or older shore deposits with beach sands overlying them in the Hampton Beach area.

In the site area the water table is found at depths no greater than 17 feet and generally less than 10 feet. West of the site area in the sandy outwash material it is usually within 5 feet of the ground surface.

Predominant groundwater movement is toward the tidal areas, however, local flow lines are modified by variations in permeability of water bearing materials and by topography. A plot of available water table levels in the plant area is shown on Figure 2.5-74. Rate of groundwater movement is expected to range from a few feet to several tens of feet per year. Based on available information the average permeability of both the till and bedrock is less than 10 gpd per ft^2 (gallons per day per square foot). Permeability of the marine deposits is less than 1 gpd per ft^2.

2.5.2.1.3 Utilization of Groundwater by the Plant

Groundwater used by the plant will be supplied by the town of Seabrook. The present Seabrook water supply system is supplied by 5 wells (Figure 2.5-75). A sixth well will be added to supply the plant's needs which are not expected to exceed 400 gpm during startup and considerably less during normal operation. Presently no wells are planned for the site.

The groundwater will be utilized in the plant makeup water system which will have a makeup water storage tank. It will also be used for fire protection.

2.5.2.2 Sources

2.5.2.2.1 Public and Private Groundwater Use

Present Regional Use

Most water supplies in the area are dependent on groundwater sources. Public supplies in the towns of Seabrook and Salisbury are taken from wells which tap aquifers in ice-contact deposits. These wells yield from about 300 to 700 gpm and range from 22 to 54 feet deep (Reference 46). The town of Seabrook at the present uses five wells for its public water supply and all of these are located at least two miles from the site. Most homes as well as commercial and industrial users in Seabrook are supplied by the town's municipal water system (Reference 46). The Salisbury Water Supply Company uses five wells to supply water to most homes and industries in Salisbury, Massachusetts.

Other wells supplying mostly domestic and farm needs are scattered throughout the area including the town of Hampton Falls and Kensington which are both without public water supply systems. In the site vicinity a few private wells supply homes. All of these are less than 15 feet deep and tap the shallow outwash deposits to the west and southwest of the site area (Reference 46).

Tabulation of Existing Users

Figure 2.5-75 shows the location of all known active wells in the region (Reference 50). Data for each of these wells and for many test borings is presented in Table 2.5-18 and Table 2.5-19. The information provided in these tabulations includes names of owners, location, year completed, depth, diameter, type, geologic characteristics, water level and type of use.

Town of Seabrook Municipal Water System

The town of Seabrook is served by its own Municipal Water Works System whose source is groundwater wells. The basic system, first put into use in 1956 with two wells, now consists of five active high yield groundwater wells, each with a pump and pump house. Present storage capacity is provided by a 720,000 gallon storage standpipe, with a 1,000,000 gallon tank scheduled for construction in the next few years.

The system with approximately twenty miles of 6, 8, 10 and 12 inch diameter distribution pipe is outstanding in size and service in comparison to the small population of the town and to the water systems of adjacent towns.

The quality of the groundwater drawn in Seabrook is of good quality as it generally is throughout the whole southeastern New Hampshire region (Table 2.5-20).

The water consumption rate in Seabrook has been steadily increasing over the past decade. Figure 2.5-76 plots this annual trend which now shows an average increase of about 70,000,000 gallons per year (References 51 and 52).

Town of Salisbury, Massachusetts Water Supply System

The town of Salisbury at present is served by the privately owned Salisbury Water Supply Company which draws its supply from 5 wells in the northwestern corner of Salisbury (Figure 2.5-75). The five wells draw from 400 gpm to 700 gpm to supply the town's residential and industrial users. A 200,000 gallon elevated storage tank is also in use.

Projected Future Use

The demand for water in this region is expected to grow at an accelerating rate over the projection period (1980-2020). This increase in water can be attributed to the shifting industrial trends and increasing suburbanization of New Hampshire. More supply wells and inter-municipal distribution systems are anticipated to satisfy the region's increased demand for water.

Table 2.5-21 presents the water use projections through the year 2020 for towns in Rockingham County and Salisbury, Massachusetts through 1990. It is expected that both surface and groundwater sources will be developed to provide the required supply. Specific data for the town of Seabrook are included in Table 2.5-21.

Groundwater Levels

The pattern of water-level fluctuations in the region is irregular, reflecting variations in precipitation and temperature. This is illustrated in Figure 2.5-77 which correlates the hydrographs of selected wells in southeastern New Hampshire with monthly precipitation records (Reference 53).

The water table in the site area is mostly in till or bedrock at depths no greater than 17 feet and usually less than 10 feet below the ground surface. In the outwash deposits west of the site (Figure 2.5-72) it occurs mostly within 5 feet of the surface. Some partially confined groundwater is found at depth in bedrock fractures. Evidence of this is found along the edge of tidal marshes where fresh groundwater with a chloride content ranging from 38 to 144 ppm is encountered in bedrock borings under sufficient hydrostatic head to cause flowing conditions (Reference 46).

2.5.2.2.2 Flow Directions and Gradients

In southeastern New Hampshire, groundwater generally moves from the interstream areas, where much of the recharge takes place, toward nearby streams or other bodies of surface water into which some of the groundwater is discharged. During warm weather some groundwater also is discharged directly to the atmosphere by evaporation and transpiration in areas such as swamps or marshes where the water table is at or near the surface. Under the hydraulic gradients that exist in nature, the rate of groundwater movement is very slow. In the aquifers of the report area, groundwater moves at rates that range from a few inches per year to a few feet per day.

Groundwater movement in the site area is toward adjoining tidal areas and essentially normal to the water table contours shown on Figure 2.5-74. Local modifications in flow lines are the results of variations in permeability of water bearing materials and of topography. Rates of groundwater movement at the site do not exceed 100 feet per year (Reference 46). This is based on a water table gradient of 0.06 feet per foot as observed during high water table conditions and an average permeability of 5 and 4 Meinzer units (gallons per day per square foot at prevailing groundwater temperatures) for the till and bedrock respectively. The low permeability of the till and bedrock is substantiated by the lack or relatively small response in water levels to tidal fluctuations as observed in several borings located along the edge of the tidal marshes. Table 2.5-22 lists the range and mean values of field permeabilities of glacial and bedrock materials. These were determined by falling head and packer tests made in the test borings on the site area. The listed values for the outwash material are representative for the finer sands more commonly found to the west of the site, whereas, the coarser outwash and beach sands to the east (Figure 2.5-72) appear to be much more permeable and values of 1,000 gpd per square foot or more are probably not uncommon.

2.5.2.2.3 Recharge Area Within the Influence of the Site

Under natural conditions nearly all recharge to aquifers in southeastern New Hampshire is accomplished by the infiltration of precipitation within the area. The principal recharge areas are the places immediately underlain by ice-contact deposits and by outwash and shore deposits. These deposits are sufficiently permeable to absorb water readily. They commonly form terraces and plains whose flat surfaces retard surface runoff and thereby afford ample opportunity for infiltration. They generally also provide sufficient storage space to accommodate the additional water.

Many places immediately underlain by till also serve as recharge areas, but here the rate of recharge is comparatively small. Not only is the till less permeable than the outwash and the ice-contact deposits, but it commonly forms hills whose slopes shed water rapidly. Furthermore, because till generally is thin, it may at some places become so fully saturated during prolonged periods of wet weather that potential recharge is rejected.

The site is primarily underlain by well compacted till up to 62 feet thick and therefore it is not an important recharge area (Reference 46).

List of Agencies Contacted

New Hampshire Department of Resources and Economic Development

New Hampshire Office of State Planning

Seabrook Water Department

Salisbury Water Supply Company

Southeastern New Hampshire Regional Planning Commission

University of New Hampshire Water Resources Board

United States Geologic Survey

References

1. Bowden, K. F., 1967, Circulation and Diffusion. (In: Estuaries, ed. by G. H. Lauff, Pub. No. 83, AAAS, Washington, D. C., 1967, 757 p.) pp. 15-36.

2. Caspers, Hubert, 1967, Estuaries: Analysis of Definitions and Biological Considerations. (In: Estuaries, ed. by G. H. Lauff, Pub. No. 83, AAAS, Washington, D. C., 1967, 757 p.) pp. 6-8.

3. Corps of Engineers, 1971, Water Resources Development in New Hampshire, New England Division, U. S. Army Corps of Engineers, Waltham, Massachusetts, 60 p., 1 January 1971.

4. Corps of Engineers, 1972, Environmental Impact Statement: Maintenance Dredging and Jetty Repair, Hampton Harbor, New Hampshire. New England Division, U. S. Army Corps of Engineers, Waltham, Massachusetts, 15 February 1972, 11 p. (Avail. NTIS PB-207-563-D).

5. Ebasco Services, Inc., 1969, Thermal Discharge Application Report, Circulating Water System, Seabrook Nuclear Station Unit No. 1 for Public Service Company of New Hampshire, Ebasco Services, Inc., New York, New York, October 1969, 11 p., 44 Figs.

6. National Ocean Survey, 1972, Tide Tables High and Low Predictions, East Coast of North and South America, U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, D. C., 1972, 290 p.

7. New England-New York Inter-Agency Committee, 1955, The Resources of the New England - New York Region, Part Two, Chapter XXIV, Special Subjects Subregion "B", New Hampshire-Massachusetts-Connecticut-Rhode Island-Vermont, Volume 1, Section 1. pp. 60-72.

8. New England River Basins Commission, 1971, Power and the Environment Report No. 2. Environmental Evaluation of Seabrook, New Hampshire Nuclear Power Plant, New England River Basins Commission, Boston, Massachusetts, January 1971, 4 sect.

9. New Hampshire Fish and Game Department, 1964, Salt Marshes of New Hampshire, N.H.F.&G. Dept., Concord, New Hampshire, 1964, 24 p.

10. Normandeau Associates, Inc., 1971, Seabrook Ecological Study: Phase I, 1969-1970, Hampton-Seabrook Estuary, New Hampshire for Public Service Company of New Hampshire, Normandeau Associates, Inc., Manchester, New Hampshire, 1971, 313 p.

11. Normandeau Associates, Inc., 1971, Seabrook Ecological Study - Phase II, 1970-1971, Hampton-Seabrook Estuary, New Hampshire for Public Service Company of New Hampshire, Normandeau Associates, Inc., Manchester, New Hampshire, 1971, 8 sections.

12. Pritchard, Donald W., 1967, What is an Estuary: Physical Viewpoint. (In: Estuaries, ed. by G. H. Lauff, Pub. No. 83, AAAS, Washington, D. C., 1967, 757 p.) pp. 3-5.

13. Public Service Company of New Hampshire, 1969, Seabrook Nuclear Station Unit No. 1. Preliminary Safety Analysis Report, Public Service Company of New Hampshire and the United Illuminating Company, Manchester, N. H., 1969, 3 Vol.

14. U. S. Geological Survey, 1970, Water Resources Data for Massachusetts, New Hampshire, Rhode Island, Vermont, U.S. Dept. of the Interior, Geological Survey, Water Resources Division, Boston, Massachusetts, 1970, 373 p.

15. Wilson, John A., 1969, Regional Planning: New Hampshire - Maine. Part 2. Surface Water Resources, Ground Water Resources, Climate. University of New Hampshire, Durham, New Hampshire, and New Hampshire Department of Resources and Economic Development, Concord, New Hampshire, May 1969. 3 sections.

16. Beardsley, R. C. 1972. Hydrography and currents in Massachusetts Bay, (pages 3-1 to 3-24) in Mollo-Christensen, Erik L. and Arthur T. Ippen, (eds.), Methods of Observations and Analysis of Harbor and Coastal Pollution, Dept. of Civil Engr. & Dept. of Meteorology, M.I.T., Cambridge, Mass., 489 pp.

17. Bigelow, H. B. 1927. Physical Oceanography of the Gulf of Maine. Bull. of the U.S. Bur. of Fish., Vol. 40, 511-1027.

18. Bumpus, D. F. and Lauzier, L. M. 1965. Surface Circulation on the Continental Shelf off eastern North American between Newfoundland and Florida. Serial Atlas of the Mar. Environ. Folio 7: Amr. Geo. Soc., New York. 25 pp.

19. Colton, J. B., Jr. 1969. Temperature conditions in the Gulf of Maine and adjacent waters during 1968. J. Fish. Res. Bd. Canada. Vol. 26, No. 10, 27466-2751.

20. Colton, and Stoddard, R. H. 1972. Average monthly sea-water temperatures, Nova Scotia to Long Island. Serial Atlas of the Mar. Environ. Folio 21: Amr. Geo. Soc., New York.

21. Dow, R. L. 1967. The influence of temperature on Maine lobster supply. Maine Sea and Shore Fish. Res. Bull. No. 30.

22. Ebasco Services, Inc. 1969. Thermal Discharge Application Report, Circulating Water System, Seabrook Nuclear Station, Unit No. 1. A report to Public Service Company of New Hampshire.

23. Environmental Protection Agency. 1971. Potential environmental effects of an offshore submerged nuclear power plant, Vol. No. 2. Water Quality Res. Office, Washington, D.C., 11-21.

24. Graham, J. J. 1970. Coastal currents of the western Gulf of Maine. International Commission for the Northwest Atlantic Fish. Res. Bull. No. 7, 19-31.

25. Halpern, D. 1971. Semidurnal internal tides in Massachusetts Bay. Jr. of Geophysical Res., Vol. 76, No. 27, 6573-6584.

26. Hartwell, A. D. 1970. Hydrography and Holocene sedimentation of the Merrimack River Estuary, Massachusetts. Contri. No. 50CRG, Dept. of Geology, U. Mass., Amherst, Mass. 166 pp.

27. Hayes, M. O. and Boothroyd, J. C. 1969. Storms as modifying agents in the coastal environment (245-265), in: Coastal Environments, NE Mass. and N.H., Coastal Res. Group, Dept. of Geology, U. Mass., Amherst, Mass. 462 pp.

28. Normandeau Associates, Inc. 1971. Seabrook Ecological Study - Phase I studies for Public Service Company of New Hampshire, 312 pp.

29. Normandeau Associates, Inc. 1972. Seabrook Ecological Study - Phase II studies for Public Service Company of New Hampshire, 97 pp.

30. Hulburt, E. M. 1968. Stratification and mixing in coastal waters of the western Gulf of Maine during summer. Jr. Fish. Res. Brd., Canada. Vol. 25, 2609-2621.

31. Redfield, A. C. 1948. The exchange of oxygen across the sea surface. Jr. of Mar. Res., Vol. 7, No. 3, 347-361.

32. Redfield, A. C., and Keys, A. B. 1938. The distribution of ammonia in the waters of the Gulf of Maine. Bio. Bull., Vol. 74, No. 1, 83-92.

33. Redfield, A. C., Smith, H. P., and Ketchum, B. K. 1937. The cycle of organic phosphorus in the Gulf of Maine. Biol. Bull., Vol. 73, No. 3, 421-443.

34. Shevenell, T. C. 1972. Dispersal and distribution of suspended sediment in an estuarine coastal shelf complex as related to physical and climatic parameters. (Unpublished Progress Report), Univ. of N.H., Durham, N.H. 28 pp.

35. U. S. Naval Weather Service Command. 1970. Summary of synoptic meteorological observations for North American coastal marine areas. Vol. 2, 1-158.

36. Ward, L. G. 1972. Seasonal variations in suspended sediments and hydrographic parameters in the waters of coastal New Hampshire. (Unpublished Progress Report), Univ. of N.H., Durham, N.H. 29 pp.

37. Watson, E. E. 1936. Mixing and residual currents in tidal waters as illustrated in the Bay of Fundy. Jr. of the Bio. Brd. of Canada, Vol. 2, No. 2, 141-208.

38. Water Resources of New England, Publication No. 51, December 1, 1937 New England Regional Planning Commission.

39. Survey of Merrimack River, Massachusetts and New Hampshire, April 1, 1938 War Department, United States Engineer Office.

40. Water Resources Data for Massachusetts, New Hampshire, Rhode Island and Vermont, 1970 United States Department of the Interior, Geological Survey.

41. House No. 1300, The Commonwealth of Massachusetts, Report of the Special Commission Directed to Study the Use of Certain Lands and Waters in the Commonwealth for Recreational Purposes, December 6, 1933.

42. Environmental Evaluation of Seabrook, New Hampshire Nuclear Power Plant, New England River Basins Commission, January 1971.

43. Regional Planning: New Hampshire - Maine; Surface Water Resources, Ground Water Resources, Climate, University of New Hampshire, Durham, N. H., 1969.

44. Water Resources Development in New Hampshire, U. S. Army Corps of Engineers, January 1971.

45. Groundwater in the United States - A Summary, by O. E. Meinzer, Survey, WSP 836-D, 1939.

46. Groundwater Hydrology for the Proposed Nuclear Station - Unit No. 1 by Weston Geophysical Research Inc., 1969.

47. Clays of Southeastern New Hampshire by J. W. Goldthwait, New Hampshire State Planning Development Commission, Mineral Resources Survey, Part 15, 1953.

48. Progress Report, Rock Well Survey in New Hampshire, New Hampshire Department of Resources and Economic Development, 1964.

49. Regional Planning: New Hampshire - Maine, Surface Water Resources, Ground Water Resources Climate - by John A. Wilson, University of New Hampshire, Durham, New Hampshire, 1969.

50. New Hampshire Basic Data Report No. 1 Groundwater Series, Southeastern Area by Edward Bradley and Richard Peterson, State of New Hampshire Water Resources Board, 1962.

51. Comprehensive Town Plan for Seabrook, New Hampshire by Hans Klunder Associates, Hanover, New Hampshire, 1967.

52. Annual Reports of the Town of Seabrook, New Hampshire by the Town Officers, 1969 - 1971.

53. Geology and Groundwater Resources of Southeastern New Hampshire by Edward Bradley, Geological Survey Water Supply Paper No. 1695, 1964.

TABLE 2.5-1

TYPES OF ESTUARINE CIRCULATION

Type	Physical Processes	Forces
1. Salt wedge	River-flow dominant	Pressure gradients, field accelerations, Coriolis effect, interfacial friction
2. Two-layer flow with entrainment, including fjords	River-flow, modified by tidal currents	Pressure gradients, field accelerations, Coriolis effect, entrainment
3. Two-layer flow with vertical mixing	River-flow and tidal mixing	Pressure gradients, field accelerations, Coriolis effect, turbulent shear stresses
4. Vertically homogeneous (a) with lateral variation (b) laterally homogeneous	Tidal currents predominating	Pressure gradients, field accelerations, turbulent shear stresses, Coriolis effect in (a)
5. Exceptional cases: intensive mixing in restricted sections tributary estuaries, sounds, straits, etc.		

TABLE 2.5-2

ASTRONOMICAL TIDE ELEVATIONS

	Hampton Harbor
Mean tidal range	8.3 feet
Spring tidal range	9.5 feet
Highest predicted astronomical tide	10.6 feet MLW
Mean high water (MHW)	8.3 feet MLW
Mean sea level (MSL)	4.15 feet MLW
Mean low water (MLW)	0.00 feet MLW
Lowest Predicted Astronomical tide	-2.2 feet MLW

TABLE 2.5-3

CONSTITUENT ANALYSIS OF SEA WATER SAMPLE FROM BROWNS RIVER, LOW TIDE, JULY 1, 1969

Wet Chemical Analysis

CONSTITUENTS	As	ppm
Turbidity		3
pH		6.9
Free CO_2	CO_2	20.5
Phenolphthalein Alk.	$Ca\ CO_3$	0
Total Alkalinity	$Ca\ CO_3$	124.0
Total Hardness	$Ca\ CO_3$	5305
Total Dissolved Solids		28,500
Chloride	Cl	15,475
Sulfate	SO_4	2,190
Sulfide	S	None detected
Ammonia	N	Less than 0.01
Manganese	Mn	Less than 0.01
Iron	Fe	0.09

Spectrographic Analysis	Percent By Weight of TDS
Sodium	23.%
Magnesium	10.
Potassium	1.2
Boron	0.067
Silicon	0.012
Calcium	0.14
Copper	0.00036
Strontium	0.026
Iron	trace
Chromium	less than 0.008

TABLE 2.5-4

CONSTITUENT ANALYSIS OF SEA WATER SAMPLES FROM HAMPTON HARBOR INLET, HIGH TIDE

Wet Chemical Analysis

CONSTITUENTS	As	August 18, 1969 ppm	November 8, 1972 ppm
Turbidity		2	< 5
pH		7.00	7.90
Free CO_2	CO_2	-	24
Phenolphthalein Alk.	$CaCO_3$	0	0
Total Alkalinity	Ca CO_3	115.0	114.0
Total Hardness	Ca CO_3	5985	5600
Total Dissolved Solids		33,132	32080
Chloride	Cl	17,545.6	16985
Sulfate	SO_4	2,491.2	2383
Sulfide	S	None detected	None detected
Ammonia	N	0.06	0.16
Manganese	Mn	None detected	0.01
Iron	Fe	0.10	0.08

Spectrographic Analysis

CONSTITUENTS	Percent By Weight of TDS: August 18, 1969	Percent By Weight of TDS: November 8, 1972
Sodium	31.	34.
Magnesium	4.4	4.9
Potassium	3.0	2.5
Boron	0.024	0.036
Silicon	Trace	0.054
Calcium	0.23	0.47
Copper	Trace	0.0019
Strontium	0.051	0.050
Iron	0.0025	< 0.001
Chromium	0.00029	-

TABLE 2.5-5

PERCENT FREQUENCY OF WIND DIRECTION BY SPEED AND BY HOUR FOR THE GULF OF MAINE

Wind Direction	Wind Velocities (knots)					Number of Observations	Percentage of Frequency	Mean Speed
	0-6	7-16	17-27	28-40	41+			
N	1.7	4.8	2.8	0.8	0.1	3024	10.2	15.1
NE	1.4	3.6	1.8	0.5	0.1	2169	7.3	14.4
E	1.6	3.2	1.3	0.5	0.1	1974	6.7	13.5
SE	1.6	4.2	1.7	0.3	0.1	2375	8.0	13.0
S	2.8	9.0	4.1	0.6	*	4915	16.6	13.4
SW	2.7	9.9	4.4	0.8	0.1	5269	17.8	13.8
W	2.4	7.9	4.9	1.7	0.2	5070	17.1	15.9
NW	1.6	5.8	4.4	1.5	0.2	3990	13.5	16.8
Variable	*	*	0.0	0.0	0.0	9	*	2.9
Calm	2.7					784	2.7	0.0
Number of Observations	5469	14348	7500	2020	242	29579		14.2
Percentage	18.5	48.5	25.4	6.8	0.88	100.0	100.0	(Mean Total)

* Frequencies between 0.0% and 0.05%

Data from 1864 - 1968

TABLE 2.5-6(a).

PERCENT FREQUENCY OF WIND SPEED AND DIRECTION VS. SEA HEIGHTS FOR THE GULF OF MAINE

	N						
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL
<1	.2	1.1	.1	*	.0	.0	104
1-2	.1	1.3	1.5	*	.0	.0	211
3-4	.0	.5	1.9	.5	.0	.0	205
5-6	.0	.2	.7	.5	*	.0	103
7	.0	*	.3	.4	.2	*	65
8-9	.0	*	*	.2	.1	.0	25
10-11	.0	.0	.1	.1	.1	.0	20
12	.0	.0	.0	.1	*	*	7
13-16	.0	.0	.0	*	.1	*	10
17-19	.0	.0	.0	.0	*	.0	2
20-22	.0	.0	.0	.0	*	*	2
23-25	.0	.0	.0	.0	.0	.0	0
26-32	.0	.0	.0	.0	.0	.0	0
33-40	.0	.0	.0	.0	.0	.0	0
41-48	.0	.0	.0	.0	.0	.0	0
49-60	.0	.0	.0	.0	.0	.0	0
61-70	.0	.0	.0	.0	.0	.0	0
71-86	.0	.0	.0	.0	.0	.0	0
87+	.0	.0	.0	.0	.0	.0	0
TOTAL	22	228	333	135	30	6	754
PCT	.3	3.2	4.6	1.9	.4	.1	10.4

	NE						
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL
<1	*	.7	.1	.0	.0	.0	56
1-2	.1	1.0	.6	*	*	*	128
3-4	*	.3	.9	.2	.0	.0	103
5-6	*	.1	.3	.3	*	.0	51
7	.0	*	.1	.2	*	.0	25
8-9	.0	*	.1	.1	*	.0	18
10-11	.0	.0	*	.1	*	*	9
12	.0	.0	.0	*	.0	*	3
13-16	.0	.0	.0	*	.0	*	2
17-19	.0	.0	.0	.0	*	.0	2
20-22	.0	.0	.0	*	*	.0	2
23-25	.0	.0	.0	.0	.0	.0	0
26-32	.0	.0	.0	.0	.0	.0	0
33-40	.0	.0	.0	.0	.0	.0	0
41-48	.0	.0	.0	.0	.0	.0	0
49-60	.0	.0	.0	.0	.0	.0	0
61-70	.0	.0	.0	.0	.0	.0	0
71-86	.0	.0	.0	.0	.0	.0	0
87+	.0	.0	.0	.0	.0	.0	0
TOTAL	12	156	152	64	11	4	399
PCT	.2	2.2	2.1	.9	.2	.1	5.5

	E						
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL
<1	.2	1.0	.1	.0	.0	.0	87
1-2	.1	1.0	.6	*	.0	.0	118
3-4	*	.4	.8	.2	*	*	112
5-6	.0	.1	.3	.3	*	.0	45
7	.0	.0	.2	.2	.1	.0	31
8-9	.0	.0	.0	.1	.1	*	15
10-11	.0	.0	*	.1	.1	.0	10
12	.0	.0	.0	.1	*	.0	7
13-16	.0	.0	*	.1	*	*	12
17-19	.0	.0	.0	.0	*	.0	1
20-22	.0	.0	.0	.0	.0	.0	0
23-25	.0	.0	.0	.0	*	.0	1
26-32	.0	.0	.0	.0	.0	.0	0
33-40	.0	.0	.0	.0	.0	.0	0
41-48	.0	.0	.0	.0	.0	.0	0
49-60	.0	.0	.0	.0	.0	.0	0
61-70	.0	.0	.0	.0	.0	.0	0
71-86	.0	.0	.0	.0	.0	.0	0
87+	.0	.0	.0	.0	.0	.0	0
TOTAL	17	174	143	76	25	4	439
PCT	.2	2.4	2.0	1.1	.3	.1	6.1

	SE						
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL
<1	.2	1.7	.3	.0	.0	.0	162
1-2	.1	1.4	1.7	*	.0	.0	231
3-4	.0	.6	1.5	.4	.0	.0	176
5-6	.0	.1	.3	.5	.1	.0	68
7	.0	.0	*	.2	*	*	23
8-9	.0	.0	*	.1	*	.0	7
10-11	.0	.0	.0	*	*	.0	4
12	.0	.0	*	.0	*	.0	2
13-16	.0	.0	.0	.0	.0	.0	0
17-19	.0	.0	.0	.0	.0	.0	0
20-22	.0	.0	.0	.0	.0	.0	0
23-25	.0	.0	.0	.0	.0	.0	0
26-32	.0	.0	.0	.0	*	.0	1
33-40	.0	.0	.0	.0	.0	.0	0
41-48	.0	.0	.0	.0	.0	.0	0
49-60	.0	.0	.0	.0	.0	.0	0
61-70	.0	.0	.0	.0	.0	.0	0
71-86	.0	.0	.0	.0	.0	.0	0
87+	.0	.0	.0	.0	.0	.0	0
TOTAL	24	267	279	89	14	1	674
PCT	.3	3.7	3.9	1.2	.2	*	9.3

*Indicate mean frequencies between 0.00% and 0.05%.
Speed in knots, height in feet.

TABLE 2.5-6(b).

PERCENT FREQUENCY OF WIND SPEED AND DIRECTION VS. SEA HEIGHTS FOR THE GULF OF MAINE

	S							SW						
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL	1-3	4-10	11-21	22-33	34-37	48+	TOTAL
<1	.3	3.0	.4	*	.0	.0	267	.1	2.6	.5	.0	.0	.0	233
1-2	.1	2.8	2.9	.1	.0	.0	420	.1	2.5	2.5	.1	.0	.0	375
3-4	*	.9	3.7	.5	.0	.0	370	*	.8	3.4	.4	.0	.0	338
5-6	.0	.1	1.0	.5	.0	*	121	.0	.1	.9	.6	.0	.0	117
7	.0	*	.3	.4	.1	.0	59	.0	*	.5	.5	*	.0	71
8-9	.0	.0	.1	.2	*	.0	18	.0	.0	.2	.2	.1	.0	33
10-11	.0	.0	.1	.1	*	.0	16	.0	.0	*	.2	.0	.0	15
12	.0	.0	*	*	*	.0	5	.0	.0	.0	.1	*	.0	12
13-16	.0	.0	.0	*	.0	.0	2	.0	.0	.0	.1	*	.0	9
17-19	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	*	.0	1
20-22	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
23-25	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
26-32	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
33-40	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
41-48	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
49-60	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
61-70	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
71-86	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
87+	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0
TOTAL	26	491	611	139	9	2	1278	18	443	572	159	12	0	1204
PCT	.4	6.8	8.5	1.9	.1	*	17.7	.2	6.1	7.9	2.2	.2	.0	16.7

	W							NW							
HGT	1-3	4-10	11-21	22-33	34-37	48+	TOTAL	1-3	4-10	11-21	22-33	34-37	48+	TOTAL	GRAND TOTAL
<1	.2	2.4	.3	.0	.0	.0	212	.1	1.7	.2	*	.C	.0	146	1267
1-2	*	2.7	2.5	.1	*	.0	384	*	1.7	1.4	*	.0	.0	228	2095
3-4	*	.9	3.0	.2	.0	*	304	.0	.7	2.4	.4	*	.0	251	1859
5-6	.0	.1	1.5	.9	.1	.0	189	.0	.1	1.1	1.0	.1	.0	164	858
7	.0	*	.6	1.0	.3	.0	136	.0	.0	.5	1.0	.3	*	128	538
8-9	.0	.0	.2	1.0	.2	.0	93	.0	.0	.2	.7	.1	*	67	276
10-11	.0	.0	.1	.4	.2	.0	43	.0	.0	*	.2	.1	*	25	142
12	.0	.0	*	.1	.1	.0	21	.0	.0	.1	.1	.1	.0	24	81
13-16	.0	.0	*	.1	.2	*	22	.0	.0	*	.1	.2	.1	23	80
17-19	.0	.0	.0	*	*	*	3	.0	.0	.0	.0	*	.0	3	12
20-22	.0	.0	.0	.0	.0	*	1	.0	.0	.0	.0	.0	.0	0	5
23-25	.0	.0	.0	.0	*	*	3	.0	.0	.0	.0	*	*	2	6
26-32	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	1
33-40	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
41-48	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
49-60	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
61-70	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
71-86	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
87+	.0	.0	.0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	0	0
TOTAL	22	443	594	272	74	6	1411	10	300	425	252	64	10	1061	7220
PCT	.3	6.1	8.2	3.8	1.0	.1	19.5	.1	4.2	5.9	3.5	.9	.1	14.7	100.0

*Indicate mean frequencies between 0.00% and 0.05%.
Speed in knots, height in feet.

TABLE 2.5-7

PHYSICAL PROPERTIES OF WATERS IN THE WESTERN GULF OF MAINE

DEPTH (m)	DENSITY (σ_t)			TEMPERATURE (°F)			SALINITY (°/oo)		
	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.
					WINTER				
0	25.68	26.16	25.12	42.6	46.9	36.0	32.61	33.10	31.83
10	25.74	26.16	25.12	42.8	47.7	36.9	32.69	33.10	31.92
20	25.77	26.15	25.08	43.2	48.0	37.0	32.76	33.11	32.34
30	25.79	26.15	25.11	43.2	47.8	37.0	32.79	33.13	32.88
50	25.83	26.17	25.30	43.3	47.3	37.2	32.86	33.15	32.52
75	25.92	26.20	25.64	43.3	47.1	37.2	33.95	33.17	32.72
100	26.04	26.22	25.86	43.0	46.8	37.8	33.08	33.30	32.82
125	26.12	26.22	25.99	42.6	43.9	41.4	33.15	33.32	32.88
					SUMMER				
0	23.48	24.52	22.49	57.6	65.8	50.0	31.55	32.66	30.48
10	24.09	24.87	22.71	53.4	64.0	45.1	31.76	32.80	30.68
20	24.74	25.41	23.37	49.1	59.0	42.1	32.03	32.94	31.20
30	25.10	25.62	23.86	46.0	55.2	40.6	32.18	33.06	31.36
50	25.41	25.99	24.95	43.5	53.2	39.2	32.36	33.29	31.60
75	25.68	26.29	25.19	42.3	50.5	38.5	32.54	33.52	31.89
100	25.91	26.42	25.43	41.5	47.8	38.1	32.75	33.70	32.20
125	26.11	26.58	25.35	41.4	46.2	39.9	33.00	33.82	32.10

Temperature is given in degrees Fahrenheit, salinity in parts per thousand (°/oo), and density in sigma-t units (where, *e.g.*, 24.39 represents a specific gravity of 1.02439).

TABLE 2.5-8.

PERCENT FREQUENCY OF OCCURRENCE OF SEA SURFACE TEMPERATURES BY MONTH FOR THE GULF OF MAINE

SEA TMP DEG F	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	PCT
96+	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
95/96	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
93/94	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
91/92	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
89/90	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
87/88	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
85/86	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
83/84	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	3	*
81/82	.0	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	4	*
79/80	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	2	*
77/78	.0	.0	.0	.0	.0	.0	.0	*	.0	.0	.0	.0	1	*
75/76	.0	.0	.0	.0	.0	.1	*	.3	*	.1	.0	.0	12	*
73/74	.0	.0	.0	.0	.0	*	.2	.7	.3	.0	.0	.0	29	.1
71/72	.0	.0	.0	.0	.0	.1	1.0	1.6	.6	.0	.0	.0	83	.3
69/70	.0	.0	.0	.0	.0	.1	3.4	4.8	1.2	.4	.0	.0	250	.9
67/68	.0	.0	.0	.0	.0	.7	5.1	8.0	3.0	.2	.0	.0	426	1.6
65/66	.0	.0	.0	.0	.0	1.2	7.6	10.7	5.1	.7	.0	.0	630	2.4
63/64	.0	.0	.0	.0	.0	2.0	10.2	9.9	9.0	1.4	.1	.0	801	3.0
61/62	.0	.0	.0	.0	.3	3.6	8.7	9.8	11.1	2.3	.1	.0	873	3.3
59/60	.0	.0	.0	.0	.4	4.3	11.0	9.0	14.7	5.6	.8	.1	1095	4.1
57/58	.0	.0	.0	.0	.8	6.1	6.7	6.3	11.7	11.8	2.2	.1	1045	4.0
55/56	*	.0	.0	.1	2.0	7.3	5.4	4.6	10.2	18.6	3.4	.4	1157	4.4
53/54	.3	.0	.0	.5	2.5	9.7	5.0	4.2	6.3	18.1	8.0	.9	1216	4.6
51/52	.4	.3	.1	1.1	3.8	9.4	5.0	5.1	6.6	13.6	11.5	2.3	1299	4.9
49/50	1.1	1.2	.7	1.3	6.8	10.5	8.9	13.0	10.3	11.7	21.5	6.7	2082	7.9
47/48	1.9	1.2	1.4	2.1	9.6	8.9	11.3	9.8	8.9	9.5	19.4	11.9	2125	8.0
45/46	6.6	2.4	1.4	3.7	14.5	10.6	8.0	1.7	.4	5.1	20.0	18.1	1995	7.5
43/44	13.8	4.2	3.5	8.5	15.1	11.5	1.9	.1	.2	.6	10.5	25.7	2042	7.7
41/42	23.1	12.1	9.1	16.8	18.0	11.7	.3	*	.2	.1	2.2	23.4	2509	9.5
39/40	25.3	15.6	16.4	17.6	14.5	2.0	.2	.0	.0	.1	.2	7.3	2136	8.1
37/38	16.4	21.8	23.7	28.4	10.0	.2	.0	.0	.0	.1	.1	1.9	2184	8.3
35/36	6.9	27.7	32.8	16.4	1.1	.0	.0	.0	.0	.1	.1	.6	1777	6.7
33/34	2.3	8.7	8.2	3.0	.3	.0	.0	.0	.0	.1	.0	.5	475	1.8
31/32	.8	3.1	2.1	.3	.3	.0	.0	.0	.0	.0	.0	.2	140	.5
29/30	.8	1.3	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	54	.2
27/28	.1	.2	*	.0	.0	.0	.0	.0	.0	.0	.0	.0	7	*
<27	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
TOTAL	2254	1884	2158	2148	2344	2304	2493	2603	2337	1948	1983	1946	26452	100.0
MEAN	40.4	37.9	37.6	39.5	44.0	50.1	56.7	58.6	57.1	53.4	48.6	44.1	47.8	

*Indicate frequencies between 0.00% and 0.05%.

TABLE 2.5-9

CONCENTRATION OF DISSOLVED PHOSPHATE VS DEPTH ALONG A TRANSECT EXTENDING SE FROM RYE BEACH

DISTANCE OFFSHORE, (STATUTE MILES)	3.9	7.5	11.7	15.6	.9.1	22.8
WATER DEPTH, (FT.)	60	115	205	270	297	495
APRIL 14, 1972						
Surface:	0.35	1.3	0.75	0.21	0.47	0.5
Bottom:	0.68	0.94	1.1	0.68	0.79	0.99
MAY 11, 1972						
Surface:	0.11	0.20	0.25	0.17	0.13	0.13
Bottom:	0.32	0.43	0.52	0.72	0.83	0.80
JUNE 21, 1972						
Surface:	0.20	0.16	--	--	--	--
Bottom:	0.55	0.56	0.96	--	--	--
JULY 19, 1972						
Surface:	0.28	0.24	--	--	--	--
Bottom:	0.49	0.63	0.61	--	--	--

Concentration in microgram atoms per liter.

TABLE 2.5-10

DRAINAGE BASIN AREAS

Basin Name	Area in Seacoast Region (Acres)
Merrimack River Basin	134,000
New Hampshire Coastal Basin	47,000
	181,000

TABLE 2.5-11

AREA OF WATERSHEDS IN MERRIMACK DRAINAGE BASIN IN
NEW HAMPSHIRE AND MASSACHUSETTS SEACOAST REGION

Watershed Title	Watershed Area (NH)	Total Area in Seacoast Region
Powwow River	29,000 acres	31,400 acres
Artichoke River		4,200
East Meadows River		3,200
Little River	14,500	18,600
Spickett River	44,500	47,500

TABLE 2.5-12

WATERBODIES OF POWWOW RIVER WATERSHED

Name	Seacoast Municipality	Acreage
Long Pond	Danville, N. H.	89
Country Pond	Kingston, N. H.	255
Great Pond	Kingston, N. H.	204
Greenwood Pond	Kingston, N. H.	50
Halfmoon Pond	Kingston, N. H.	16
Powwow Pond	Kingston, N. H.	247
Angle Pond	Sandown, N. H.	150
Cub Pond	Sandown, N. H.	56
Gardiner Lake	Amesbury, Mass.	91
Tuxbury Pond	South Hampton, N. H.	109
Lake Attitash	Amesbury, Mass.	360

TABLE 2.5-13

WATERBODIES OF THE ARTICHOKE RIVER WATERSHED

Name	Seacoast Municipality	Acreage
Upper Artichoke Reservoir	West Newbury, Mass.	126
Lower Artichoke Reservoir	West Newbury, Mass.	49

TABLE 2.5-14

WATERBODIES OF THE EAST MEADOW RIVER WATERSHED

Name	Seacoast Municipality	Acreage
Millvale Reservoir	Haverhill, Mass.	47
Kenoza Lake	Haverhill, Mass.	255

TABLE 2.5-15

WATERBODIES OF SPICKETT RIVER WATERSHED

Name	Seacoast Municipality	Acreage
Wash Pond	Hampstead, N. H.	151
Island Pond (1)	Hampstead, N. H.	250

(1) Approximately 50 percent of this pond is in Derry, N. H.

TABLE 2.5-16

AREA OF WATERSHEDS IN NEW HAMPSHIRE COASTAL DRAINAGE BASIN

Watershed Title	Watershed Area
Blackwater River	5,500 acres
Hampton Falls River	10,000
Taylor River	16,000
Little River	14,000

TABLE 2.5-17

LOWER MERRIMACK RIVER CHEMICAL AND THERMAL PROPERTIES

Property	High	Low	Mean
Specific Conductance (Micromohos at 25C)	1000.0	50.0	138.0
pH (Units)	8.2	5.4	6.6
Dissolved Oxygen (Milligrams per liter)	16.2	0.1	8.4
Temperature (C)	29.5	0.0	14.5

TABLE 2.5-18

From Reference 50

RECORDS OF SELECTED WELLS AND TEST HOLES IN SOUTHEASTERN NEW HAMPSHIRE

Well no. *	Location *	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well (inches)	Water-bearing material: Character	Water-bearing material: Geologic unit	Water level: Depth	Water level: Date	Type of pump	Use	Remarks
								SEABROOK						
1	W16-9	Town of Seabrook	1956	100	54	Dr	24	Sand and gravel	Ice-contact deposits	5.76	4-25-56	T	PS	Reported yield 450 gpm. T 47.
2	W16-9	do.	1956	105	49	Dr	24	do.	do.	5	-56	T	PS	Reported yield 350 gpm.
3	W16-9	L. R. Matthews	1930	105	110	Dr	6	-	Bedrock	35	-30	F	D	
4	W16-9	R. E. Bergeron	1952	100	26.5	Dg	36	Sand and gravel	Ice-contact deposits	17.92	5- 9-56	J	D	
5	W16-9	Joseph Neves	1900	63	12.4	Dg	30	-	Till	3.00	5- 9-56	S	D	Not in use in 1956.
6	X16-7	Parkman Clinic	-	45	13.3	Dg	36	Sand	Outwash and shore deposits	3.93	5- 9-56	S	D	
7	X15-1	Lloyd Property	1900	63	22.0	Dg	36	do.	do.	16.08	4-25-56	S	D	
8	X16-8	Town of Seabrook	1955	14	15.0	Dg	96	do.	Beach deposits	9.26	4-25-56	None	PS	Fire protection well. Reported yield 60 gpm.
9	X15-1	Carroll F. Randall	1946	65	150	Dr	6	-	Bedrock	-	-	J	D	
10	X16-7	T. L. Boyd	1930	25	9.0	Dg	18	Sand	Outwash and shore deposits	2.35	5- 9-56	S	D	
11	X16-7	Dearbon Academy Assoc.	1900	58	10.8	Dg	36	do.	do.	7.15	5- 9-56	None	U	
12	W16-9	Town of Seabrook	1955	45	16.5	Dn	2½	-	-	-	-	None	T	
13	W16-9	do.	1955	47	28.7	Dn	2½	-	-	4	-55	None	T	
14	W16-9	do.	1955	50	43.0	Dn	2½	-	-	+2	-55	None	T	
15	W16-9	do.	1955	54	45.0	Dn	2½	-	-	1.9	-55	None	T	
16	X16-7	do.	1955	45	94.3	Dn	2½	-	-	2.8	-55	None	T	
17	W16-9	do.	1955	40	33.5	Dn	2½	-	-	+2.8	-55	None	T	Reported natural flow 7 gpm.
18	X16-7	do.	1955	43	37.3	Dn	2½	-	-	9.3	-55	None	T	
19	X15-1	do.	1955	48	41.5	Dn	2½	-	-	2	-55	None	T	
20	X15-1	do.	1955	18	53.5	Dn	2½	-	-	4.3	-55	None	T	
21	W16-9	do.	1955	100	54.8	Dn	2½	-	-	6.7	-55	None	T	At same location as Seabrook 1.
22	W16-9	do.	1955	50	41.0	Dn	2½	-	-	Flowing	-55	None	T	Reported natural flow 6 gpm.
23	X15-1	do.	1955	60	61.3	Dn	2½	-	-	2	-55	None	T	
24	W16-9	do.	1955	65	38.9	Dn	2½	-	-	+4	-55	None	T	
25	W16-9	do.	1955	70	52.7	Dn	2½	-	-	2.8	-55	None	T	
								SOUTH HAMPTON						
1	W16-7	Guy E. Kenerson	1938	188	75	Dr	6	-	Bedrock	-	-	F	D	Reported yield 7 gpm.
2	W16-7	do.	1900	190	19.0	Dg	36	Sand and gravel	Ice-contact deposits	4.92	5-14-56	None	U	
3	W15-1	R. E. Lowry	1935	87	53	Dr	6	-	Bedrock	-	-	F	D	
4	W16-8	Edith M. Spurr	1945	250	200	Dr	6	-	do.	17	-45	J	D	Reported yield 12 gpm.
5	W16-7	Albert E. Gray	1948	130	123	Dr	6	-	do.	Flowing	-48	S	D	Reported yield 10 gpm. T 50.
6	W16-7	Edmund Roy	1955	110	19.8	Dg	24	Sand	Outwash and shore deposits	4.33	5-18-56	S	D	
7	W16-8	Adam J. Mazur	1900	185	13.0	Dg	36	-	Till	5.30	5-18-56	S	D	Not in use in 1956.
								NORTH HAMPTON						
1	X17-8	Paul Kelley	1954	110	138	Dr	8	-	Bedrock	20	-54	J	D	Reported yield 3 gpm.
2	X17-7	Lora Booker	1900	100	42.3	Dg	36	-	Till	35.31	4-13-56	L	D	Not in use in 1956.
3	X16-1	Charles Black	1900	70	23.8	Dg	36	-	do.	17.61	4-12-56	S	D	
4	X16-1	K. D. Bowers	1956	105	105	Dr	6	-	Bedrock	12	-56	J	D	Reported yield 4 gpm.
5	X16-1	R. A. Wright	1935	100	32.9	Dg	24	Sand and gravel	Ice-contact deposits	25.22	4-12-56	L	D	
6	X16-2	Wallace P. Hale	1954	122	100	Dr	8	-	Bedrock	45	-54	J	D	
7	X16-2	Hampton Water Works	1919	65	22	Dg	240	Sand and gravel	Ice-contact deposits	4.07	4-11-56	C	PS	Reported yield 450 gpm.
8	X16-2	do.	1919-1937	65	42	Dg-Dr	240-18	do.	do.	3.27	4-11-56	T	PS	Reported yield 450 gpm; 18-inch casing installed inside 240-inch dug well in 1937.
9	X16-2	Hinckle Property	1900	30	18.5	Dg	36	-	Till	3.11	4-17-56	S	D	
10	X16-2	Mrs. J. Marshall	1953	83	175	Dr	6	-	Bedrock	Flowing	-53	J	D	Reported yield 8 gpm.
11	X16-1	Mrs. Irving Marsten	1948	85	74	Dr	6	Sand and gravel	Ice-contact deposits	32	-48	F	D	Reported yield 20 gpm.
12	X16-1	F. S. Snow	1947	95	179	Dr	6	-	Bedrock	23	-47	J	D	Reported yield 5½ gpm. T 55.
13	X16-1	Kenneth S. Ellingwood	1947	65	50	Dr	6	-	do.	12	-47	J	D	Reported yield 6 gpm.
14	X16-1	Abraham Lampert	1948	108	170	Dr	6	-	do.	26	-48	J	D	Reported yield 10 gpm. T 48.

TABLE 2.5-18 (cont.)

Well no. *	Location *	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well (inches)	Water-bearing material: Character	Water-bearing material: Geologic unit	Water level: Depth	Water level: Date	Type of pump	Use	Remarks
		HAMPTON												
1	W16-3	Charles Mathews	1900	142	28.0	Dg	42	-	Till	18.82	12- 8-53	S	U	T 51,
2	X16-5	Otis Garland	1900	47	30.0	Dg	36	Sand and gravel	Ice-contact deposits	27.95	12-11-53	L	U	T 51,
3	X16-5	Hampton Water Works	1937	75	54	Dr	18	do.	do.	8	-37	T	PS	Reported yield 460 gpm. T 52.
4	X16-1	Mrs. O. D. Colvin	1900	100	15.0	Dg	36	-	Till	5.89	4-11-56	S	D	
5	X16-4	Robert F. Walker	1952	60	32	Dg	42	Sand	Ice-contact deposits	7.04	4-12-56	S	D	
6	X16-5	Hampton Water Works	1956	75	45.0	Dn	2½	Sand and gravel	do.	1.77	4-11-56	None	O	Reported yield 100 gpm.
7	X16-5	do.	1950	45	54	Dr	36	do.	do.	2	-50	T	PS	Reported yield 720 gpm.
8	X16-4	Godfrey Dearbon	1926	85	19.0	Dg	24	do.	do.	4.05	4-17-56	S	D	
9	X16-4	Ernest Woodburn	1900	60	14.0	Dg	24	-	Till	4.18	4-19-56	S	D	
10	X16-3	Deborah G. Bryer	1937	125	160	Dr	6	-	Bedrock	36	-37	F	D	Reported yield 15 gpm.
11	X16-1	Edwin L. Batchelder	1940	70	232	Dr	6	-	do.	11	-40	T	D	Reported yield 4 gpm.
12	X16-5	Gordon Yeaton	1913	77	90	Dr	6	-	do.	20	-13	J	D	Reported yield 5½ gpm.
		HAMPTON FALLS												
1	W16-9	J. M. Goodwin	1900	85	8.5	Dg	48	Sand	Ice-contact deposits	1.91	12- 4-53	S	D	T 49,
2	X16-7	R. P. Merrill	1945	68	20.0	Dg	18	do.	Outwash and shore deposits	11.45	4-17-56	S	D	
3	X16-7	E. J. Payne	1955	67	101	Dr	6	-	Bedrock	9	-55	J	D	Reported yield 16 gpm.
4	W16-6	Oscar McKenney	1900	90	25.3	Dg	28	-	Till	4.47	4-19-56	S	U	
5	W16-6	do.	1951	90	95	Dg	6	-	Bedrock	-	-	J	D	Reported yield 7½ gpm.
6	W16-6	Mark Kelly	1900	112	38.2	Dg	42	Sand and gravel	Ice-contact deposits	21.00	4-17-56	F	D	
7	W16-6	Ralph M. Farley	1954	60	120	Dr	6	-	Bedrock	5	-54	J	D	Reported yield 25 gpm.
8	W16-6	Donald Merchant	1955	65	17	Dg	48	Sand and gravel	Ice-contact deposits	15	8- -55	S	D	
9	W16-3	Alfred L. Binnette	1900	115	21.0	Dg	36	-	Till	5.65	4-19-56	S	D	
10	W16-6	V. L. Yeaton	1947	103	100	Dr	6	-	Bedrock	19	-47	F	D	Reported yield 2½ gpm.
11	W16-6	J. W. Elton	1942	110	150	Dr	6	-	do.	45	-42	J	D	Reported yield 45 gpm. Additional use, orchard.
12	X16-4	Eugene Whittemore	1948	65	140	Dr	6	-	do.	13	-48	J	D	Reported yield 25 gpm.
13	X16-7	C. M. Wellington	1948	60	120	Dr	6	-	do.	8	-48	F	D	Reported yield 15 gpm.
14	X16-7	Nicholas A. Natale	1947	30	94	Dr	6	-	do.	15	-47	J	D	Reported yield 20 gpm.
15	W16-6	William H. Coburn	1952	115	250	Dr	6	-	do.	-	-	L	D	Reported yield 35 gpm.
		KENSINGTON												
1	W16-4	Gordon Swift	1953	217	13.0	Dg	40	-	Till	9.56	7-13-54	None	U	
2	W16-4	Betsy J. Monahan	1900	270	25.0	Dg	30	-	do.	10.52	7-13-54	None	U	
3	W16-5	J. W. York	1953	75	108	Dr	6	-	Bedrock	-	-	J	D	Reported yield 6 gpm.
4	W16-5	F. E. Toothacre	1926	107	84	Dr	6	-	do.	22	-26	J	D	Reported yield 2½ gpm.
5	W16-4	Charles Matthews	1954	225	120	Dr	6	-	Till and bedrock	28	-54	L	D	Reported yield 5 gpm.
6	W16-4	C. R. Hutchinson	1952	250	220	Dr	6	-	do.	30	-52	J	D	Reported yield 20 gpm.
7	W16-5	Kensington School	1952	128	50	Dr	6	Sand and gravel	Ice-contact deposits	17	-52	J	PS	Reported yield 30 gpm.
8	W16-5	Mrs. Alice E. Bragg	1931	123	60	Dr	6	do.	Ice-contact deposits and bedrock	-	-	L	D	Reported yield 20 gpm.
9	W16-4	Amos S. Gove	1900	223	25.0	Dg	36	-	Till	7.53	5-21-56	H	D	T 52.
10	W16-8	A. Mertinooke	1915	170	23.0	Dg	36	-	do.	10.95	5-21-56	S	D	
11	W16-8	Leavitt Brown	1910	90	23.5	Dg	36	Sand and gravel	Ice-contact deposits	6.15	5-21-56	S	D	

* Well numbers and locations are shown on Figure 2.5- 75 An explanation of the legend is as follows:

TABLE 2.5-19

BORING LOGS OF SELECTED WELLS AND TEST HOLES

	Thickness (Feet)	Depth (Feet)
SEABROOK 14. W16-9. Alt. 50 ft.		
Lat. 42°53'29". Long. 70°52'41".		
Outwash and shore deposits:		
Peat	1.7	1.7
Sand, light brown; some gravel, fine	7.3	9.0
Marine deposits:		
Clay, hard, brown	4.0	13.0
Sand, fine, brown	1.3	14.3
Sand, fine, and clay, gray; changing to clay, gray	8.2	22.5
Clay, soft, gray	18.5	41.0
Till:		
Sand and gravel, sharp, and clay, gray	2.0	43.0
Refusal		43.0
SEABROOK 15. W16-9. Alt. 54 ft.		
Lat. 42°53'34". Long. 70°52'35".		
Outwash and shore deposits:		
Sand and gravel, brown	14.0	14.0
Marine deposits:		
Sand, fine, and clay, gray	9.8	23.8
Sand, fine, and clay, gray; changing to clay	10.2	34.0
Till:		
Sand and gravel, sharp, and clay, blue	10.3	44.3
Unreported	0.7	45.0
Refusal		45.0
SEABROOK 16. X16-7. Alt. 45 ft.		
Lat. 42°53'37". Long. 70°51'54".		
Outwash and shore deposits:		
Gravel, small	8.0	8.0
Sand, fine, brown	5.0	13.0
Sand, fine, and clay, brown	5.3	18.3
Sand and clay, red-brown	1.5	19.8
Marine deposits:		
Clay, light gray, and sand, fine	12.2	32.0
Clay, dark brown	3.5	35.5
Sand, medium-fine, brown	1.5	37.0
Sand, fine, and clay, gray	5.0	42.0
Sand, fine, and clay in layers, gray	28.0	70.0
Till:		
Sand, gravel, sharp, and clay, gray	7.9	77.9
Gravel, sharp, gray, and boulders; some clay	9.6	87.5
Sand and gravel, sharp, and clay, gray	6.8	94.3
Refusal		94.3
SEABROOK 17. W16-9. Alt. 40 ft.		
Lat. 42°53'01". Long. 70°52'48".		
Outwash and shore deposits:		
Sand and gravel, light brown	3.5	3.5
Marine deposits:		
Clay, gray	18.2	21.7
Sand, fine, and clay, gray	11.8	33.5
SEABROOK 18. X16-7. Alt. 43 ft.		
Lat. 42°52'50". Long. 70°51'48".		
Outwash and shore deposits:		
Sand, fine, brown	10.1	10.1
Marine deposits:		
Sand, fine, brown, and clay, gray	5.2	15.3
Clay, gray	14.8	30.1
Clay, gray, and sand	7.2	37.3
Refusal		37.3
SEABROOK 19. X15-1. Alt. 48 ft.		
Lat. 42°52'07". Long. 70°51'35".		
Outwash and shore deposits:		
Loam	1.0	1.0
Sand, brown	2.0	3.0
Sand and gravel	3.0	6.0
SEABROOK 19.--Continued		
Marine deposits:		
Sand, fine, and clay, brown	2.0	8.0
Sand, gray, changing to sand, fine, and clay	14.6	22.6
Clay, hard, brown	3.4	26.0
Ice-contact deposits:		
Sand, medium, gray; some gravel, fine	15.0	41.0
Till:		
Sand, gravel, and clay, gray	2.5	43.5
Refusal		43.5
SEABROOK 20. X15-1. Alt. 18 ft.		
Lat. 42°52'19". Long. 70°50'37".		
Outwash and shore deposits:		
Sand, medium-coarse	10.0	10.0
Sand and gravel; cemented layer at 19 feet	9.0	19.0
Marine deposits:		
Sand, fine, and clay, gray	28.5	47.5
Till:		
Sand, fine, and gravel, gray	6.0	53.5
SEABROOK 21. W16-9. Alt. 100 ft.		
Lat. 42°53'42". Long. 70°54'44".		
Ice-contact deposits:		
Sand and gravel	23.3	23.3
Sand and gravel, fine	10.6	33.9
Sand, coarse, and gravel	5.0	38.9
Sand and gravel, fine	10.2	49.1
Till:		
Sand and gravel, some clay	5.7	54.8
Refusal		54.8
SEABROOK 22. W16-9. Alt. 50 ft.		
Lat. 42°53'52". Long. 70°54'07".		
Marine deposits:		
Clay, brown	8.0	8.0
Clay, gray	27.9	35.9
Ice-contact deposits:		
Sand and gravel, blue	5.1	41.0
SEABROOK 23. X15-1. Alt. 60 ft.		
Lat. 42°52'29". Long. 70°51'18".		
Ice-contact deposits:		
Sand and gravel, brown	7.1	7.1
Sand, fine, brown	5.2	12.3
Sand, fine to medium, tight, brown	44.0	56.3
Till:		
Sand, fine to medium, and clay	5.0	61.3
Bedrock		61.3
SEABROOK 24. W16-9. Alt. 65 ft.		
Lat. 42°53'58". Long. 70°54'31".		
Marine deposits:		
Clay	7.1	7.1
Clay, gray	10.8	17.9
Clay, gray, and sand, fine	16.6	34.5
Ice-contact deposits:		
Gravel, blue, sand, fine, and clay, gray	4.4	38.9
SEABROOK 25. W16-9. Alt. 70 ft.		
Lat. 42°53'33". Long. 70°54'28".		
Outwash and shore deposits:		
Sand, fine, brown	19.5	19.5
Marine deposits:		
Sand, fine; a little clay, brown	10.3	29.8
Ice-contact deposits:		
Sand, fine, brown	10.7	40.5
Till:		
Sand, gravel, and clay, gray	12.2	52.7
Refusal		52.7
SOUTH HAMPTON 1. W16-7. Alt. 188 ft.		
Lat. 42°52'56". Long. 70°57'52".		
Unconsolidated deposits, undifferentiated:		
Sand, fine, yellow, and gravel	40	40
Bedrock	35	75
SOUTH HAMPTON 3. W15-1. Alt. 87 ft.		
Lat. 42°52'25". Long. 70°57'41".		
Marine deposits:		
Silt and clay	52	52
Bedrock	1	53
SOUTH HAMPTON 4. W16-8. Alt. 250 ft.		
Lat. 42°53'52". Long. 70°56'06".		
Till:		
Clay and boulders	100	100
Bedrock	100	200
SOUTH HAMPTON 5. W16-7. Alt. 130 ft.		
Lat. 42°53'29". Long. 70°58'56".		
Till:		
Gravel and clay	56	56
Bedrock	67	123
HAMPTON 3. X16-5. Lat. 42°57'29".		
Long. 70°49'35". Alt. 75 ft.		
Ice-contact deposits:		
Sand and gravel	9.0	9.0
Clay and sand, fine	0.5	9.5
Sand and gravel	48.5	58.0
Refusal		58.0
HAMPTON 7. X16-5. Lat. 42°56'31".		
Long. 70°48'46". Alt. 45 ft.		
Ice-contact deposits:		
Sand and gravel	54	54
HAMPTON 10. W16-3. Lat. 42°57'43".		
Long. 70°53'12". Alt. 125 ft.		
Unconsolidated deposits, undifferentiated	60	60
Bedrock:		
Gneiss	100	160
HAMPTON 11. X16-1. Lat. 42°57'32".		
Long. 70°51'55". Alt. 70 ft.		
Till:		
Sand, gravel, and clay	30	30
Bedrock	202	232
HAMPTON 12. X16-5. Lat. 42°56'42".		
Long. 70°49'07". Alt. 77 ft.		
Ice-contact deposits:		
Sand	30	30
Bedrock:		
Gneiss	60	90
HAMPTON FALLS 3. X16-7. Alt. 67 ft.		
Lat. 42°54'58". Long. 70°51'48".		
Ice-contact deposits:		
Sand	35	35
Bedrock	66	101
HAMPTON FALLS 5. W16-6. Alt. 90 ft.		
Lat. 42°55'28". Long. 70°52'47".		
Till	35	35
Bedrock	60	95
HAMPTON FALLS 7. W16-6. Alt. 60 ft.		
Lat. 42°55'07". Long. 70°53'35".		
Outwash and shore deposits:		
Sand	30	30
Till	30	60
Bedrock	60	120
HAMPTON FALLS 8. W16-6. Alt. 65 ft.		
Lat. 42°56'08". Long. 70°54'42".		
Ice-contact deposits:		
Sand and gravel	17	17
Bedrock		17
HAMPTON FALLS 10. W16-6. Alt. 103 ft.		
Lat. 42°57'27". Long. 70°54'18".		
Till:		
Gravel	11	11
Bedrock	89	100
HAMPTON FALLS 11. W16-6. Alt. 110 ft.		
Lat. 42°55'48". Long. 70°54'23".		
Till:		
Sand and gravel	6	6
Clay, yellow; gravel and rocks.	33	39
Clay, blue; gravel and rocks	38	77
Bedrock	73	150
HAMPTON FALLS 15. W16-6. Alt. 115 ft.		
Lat. 42°55'32". Long. 70°53'57".		
Till	120	120
Bedrock	130	250
NORTH HAMPTON 1. X17-8. Alt. 110 ft.		
Lat. 43°00'02". Long. 70°48'41".		
Outwash and shore deposits:		
Gravel	20	20
Marine deposits:		
Clay and silt, gray	60	80
Bedrock	58	138
NORTH HAMPTON 4. X16-1. Alt. 105 ft.		
Lat. 42°57'56". Long. 70°50'21".		
Ice-contact deposits:		
Sand and gravel, silty	40	40
Bedrock	65	105
NORTH HAMPTON 6. X16-2. Alt. 122 ft.		
Lat. 42°59'22". Long. 70°49'16".		
Unconsolidated deposits, undifferentiated:		
Gravel	45	45
Clay	29	74
Not recorded	6	80
Bedrock	20	100
NORTH HAMPTON 8. X16-2. Alt. 65 ft.		
Lat. 42°57'32". Long. 70°49'24".		
Unconsolidated deposits, undifferentiated	7	7
Ice-contact deposits:		
Sand and gravel	35	42
NORTH HAMPTON 10. X16-2. Alt. 83 ft.		
Lat. 42°48'26". Long. 70°49'49".		
Unconsolidated deposits, undifferentiated	1	1
Bedrock:		
Rock	174	175
NORTH HAMPTON 11. X16-1. Alt. 85 ft.		
Lat. 42°59'28". Long. 70°50'42".		
Ice-contact deposits:		
Sand and gravel	74	74
NORTH HAMPTON 12. X16-1. Alt. 95 ft.		
Lat. 42°58'17". Long. 70°50'43".		
Unconsolidated deposits, undifferentiated:		
Gravel and bouldery material	29	29
Bedrock	150	179
NORTH HAMPTON 13. X16-1. Alt. 65 ft.		
Lat. 42°58'27". Long. 70°50'11".		
Unconsolidated deposits, undifferentiated:		
Clay and boulders	10	10
Bedrock	40	50
NORTH HAMPTON 14. X16-1. Alt. 108 ft.		
Lat. 42°52'51". Long. 70°50'10".		
Ice-contact deposits:		
Sand and boulders	20	20
Bedrock	150	170
NORTH HAMPTON 15. X16-2. Alt. 85 ft.		
Lat. 42°58'07". Long. 70°49'26".		
Till	19	19
Bedrock	53	72
NORTH HAMPTON 16. X16-2. Alt. 85 ft.		
Lat. 42°59'36". Long. 70°53'20".		
Outwash and shore deposits:		
Sand and gravel	12	12
Marine deposits:		
Clay and gravel	7	19
Refusal		19
NORTH HAMPTON 17. X16-2. Alt. 85 ft.		
Lat. 42°59'39". Long. 70°53'24".		
Outwash and shore deposits:		
Sand and gravel	6	6
Marine deposits:		
Clay	19	25
Refusal		25
NORTH HAMPTON 18. X16-2. Alt. 87 ft.		
Lat. 42°59'42". Long. 70°53'28".		
Outwash and shore deposits:		
Sand and gravel	12	12
Till:		
Clay, sand, and gravel	17	29
Refusal		29
NORTH HAMPTON 19. X16-2. Alt. 95 ft.		
Lat. 42°59'46". Long. 70°53'31".		
Outwash and shore deposits:		
Sand and gravel	12.3	12.3
Marine deposits:		
Clay	5.5	17.8
Till:		
Clay, sand, gravel, and disintegrated bedrock	15.0	32.8
Refusal		32.8
NORTH HAMPTON 20. X16-2. Alt. 105 ft.		
Lat. 42°59'54". Long. 70°53'31".		
Outwash and shore deposits:		
Sand	12.3	12.3
Marine deposits:		
Clay	5.0	17.3
Clay and gravel	4.5	21.8
Refusal		21.8
NORTH HAMPTON 21. X16-2. Alt. 95 ft.		
Lat. 42°59'52". Long. 70°53'16".		
Ice-contact deposits:		
Clay and gravel	11.3	11.3
Till:		
Sand, gravel, and broken ledge	6.9	18.2
Refusal		18.2
SEABROOK 9. X15-1. Alt. 65 ft.		
Lat. 42°52'14". Long. 70°51'49".		
Ice-contact deposits:		
Gravel	12	12
Bedrock	138	150
SEABROOK 12. W16-9. Alt. 45 ft.		
Lat. 42°53'26". Long. 70°52'36".		
Outwash and shore deposits:		
Loam and subsoil	4.0	4.0
Sand, coarse, brown	0.5	4.5
Sand and clay, light brown	6.0	10.5
Marine deposits:		
Clay, hard, gray	5.2	15.7
Clay, gray, and broken stones.	0.8	16.5
Bedrock		16.5
SEABROOK 13. W16-9. Alt. 47 ft.		
Lat. 42°53'27". Long. 70°52'39".		
Outwash and shore deposits:		
Loam	0.5	0.5
Sand, coarse; some gravel, fine	4.0	4.5
Sand and clay, gray	1.2	5.7
Sand and gravel, light brown	2.8	8.5
Marine deposits:		
Clay, brown	2.0	10.5
Sand, fine, and clay, gray	14.5	25.0
Till:		
Sand, gravel, and clay, gray	3.7	28.7
Refusal		28.7

SYMBOLS AND LEGEND FOUND IN TABLES 2.5-18 and 2.5-19

Well No.: For location of wells, see Figure 2.5-74.

Owner or user: Name of present owner or agency responsible for installation or operation of well.

Year completed: Year when well was completed, if known. Wells completed prior to 1900 are not specifically dated unless exact year is known.

Altitude: Altitude expressed in feet and tenths, or in feet, tenths, and hundredths are instrumentally determined; those in whole feet are interpolated from topographic maps. Datum is mean sea level.

Depth: Depths expressed in feet and tenths are measured; those in whole feet are reported. Depths are below land-surface datum.

Type of well and diameter of well: Dg, dug; Dn, driven; Dr, drilled; Dg-Dr, dug and drilled.

Water-bearing material: For explanation of geologic units from which water is drawn, see Table 1 and accompanying text.

Water level: Water levels expressed in feet and tenths, or in feet, tenths, and hundredths are measured; those in whole feet are reported. Depths are below land-surface datum, except when preceded by + indicating they are above land-surface datum.

Type of pump: C, centrifugal pump; F, force pump; H, hand drawn; J, jet pump; L, lift pump; S, suction; Sb, submersible pump; T, turbine pump.

Use: C, use in cemetery; D, domestic or domestic and farm; I, Industrial or commercial; Ir, irrigation; O, well installed as an observation or test well; PS, public supply; S, use for stock only; T, test hole or test well, now abandoned and casing removed; U, unused.

Remarks: Other available data are indicated as follows: D, destroyed; dd, drawdown; gpm, gallons per minute; T, temperature in degrees Fahrenheit.

Table 2.5-20

Summary of Chemical Analyses of Groundwater,

Seacoast Region

Characteristic or Constituent	Seacoast Values Range PPM	U.S. Public Health Service Drinking Water Standards PPM
Silica	6.6 - 18	-
Iron	.01 - 3	.3
Manganese	00 - .04	.05
Calcium	1.4 - 39	-
Magnesium	.5 - 15	125.
Sodium	2.5 - 28	-
Potassium	0.6 - 11.0	-
Bicarbonate	4. - 110.	-
Sulfate	1.6 - 54	250
Chloride	1.2 - 96	250
Fluoride	0 - 1.0	.7-1.2
Nitrate	0.05 - 26	45
Dissolved solids	36 -197	500
Hardness	13 - 188	150
pH	5.6 - 8.5	
Color	Generally free of color in objectionable amounts	15

Reference: Report on the Water Supply of Southeastern New Hampshire prepared by Southeastern New Hampshire Regional Planning Commission.

TABLE 2.5-21

PAST, PRESENT AND PROJECTED WATER USE
SOUTHEASTERN NEW HAMPSHIRE REGION AND SALISBURY, MASSACHUSETTS*

Community	1964	1971	1980	1990	2000	2010	2020
Exeter	0.5		1.4	1.7	2.3	2.6	3.3
Hampton	1.0		1.6	1.9	2.2	2.8	3.2
Hampton Falls	-	-	-	0.3	0.7	1.3	2.2
Kensington	-	-	0.1	0.5	0.8	1.3	2.3
North Hampton			0.4	1.1	2.0	2.9	3.6
Rye			0.9	1.3	2.0	3.2	4.8
Salisbury (Mass.)		0.7	2.2	4.0			
Seabrook	0.3	0.6	0.7	1.1	1.8	2.4	3.2
South Hampton	-	-	-	-	0.1	0.4	1.3
Stratham	-	-	-	0.3	0.9	2.1	3.7

*These figures are for Groundwater and Surface Water requirements in million gallons per day.

References: Water Supply by The Southeastern New Hampshire Regional Planning Commission, August 31, 1972.

Water Supply and Sewerage Planning in Central Merrimack Valley Region by Metcalf & Eddy, Inc.

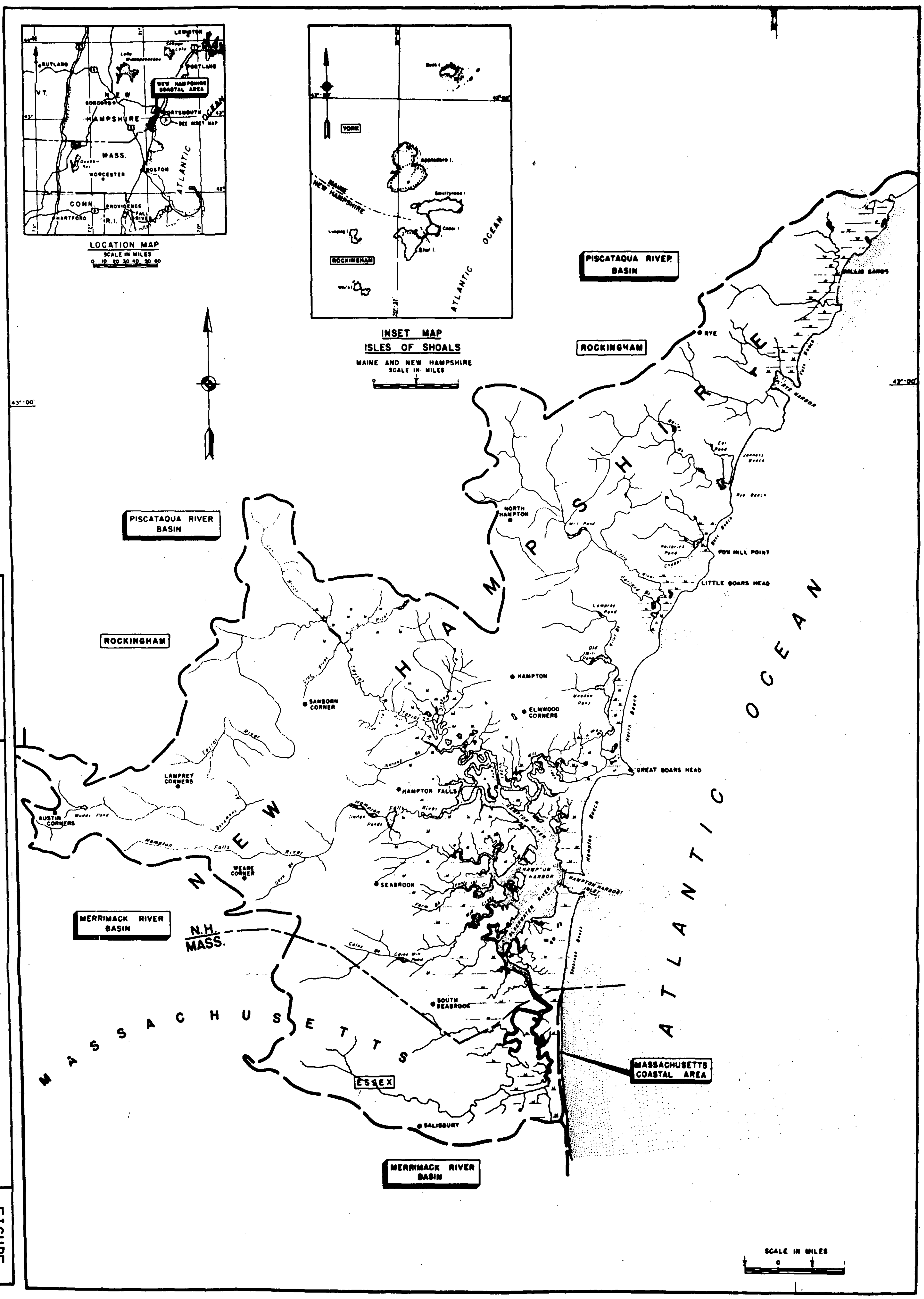
TABLE 2.5-22

SUMMARY OF FIELD PERMEABILITY
FOR GLACIAL AND BEDROCK MATERIALS
IN THE SEABROOK AREA

Type of Material	Number of Samples	Permeability in gpd/sq. ft. Range	Mean
Outwash	6	17 - 130	50
Marine (silty phase)	2	0.3 - 0.6	0.4
Till	21	0.3 - 25	5
Bedrock	9	1 - 51*	4

*Large fracture, not used in Mean

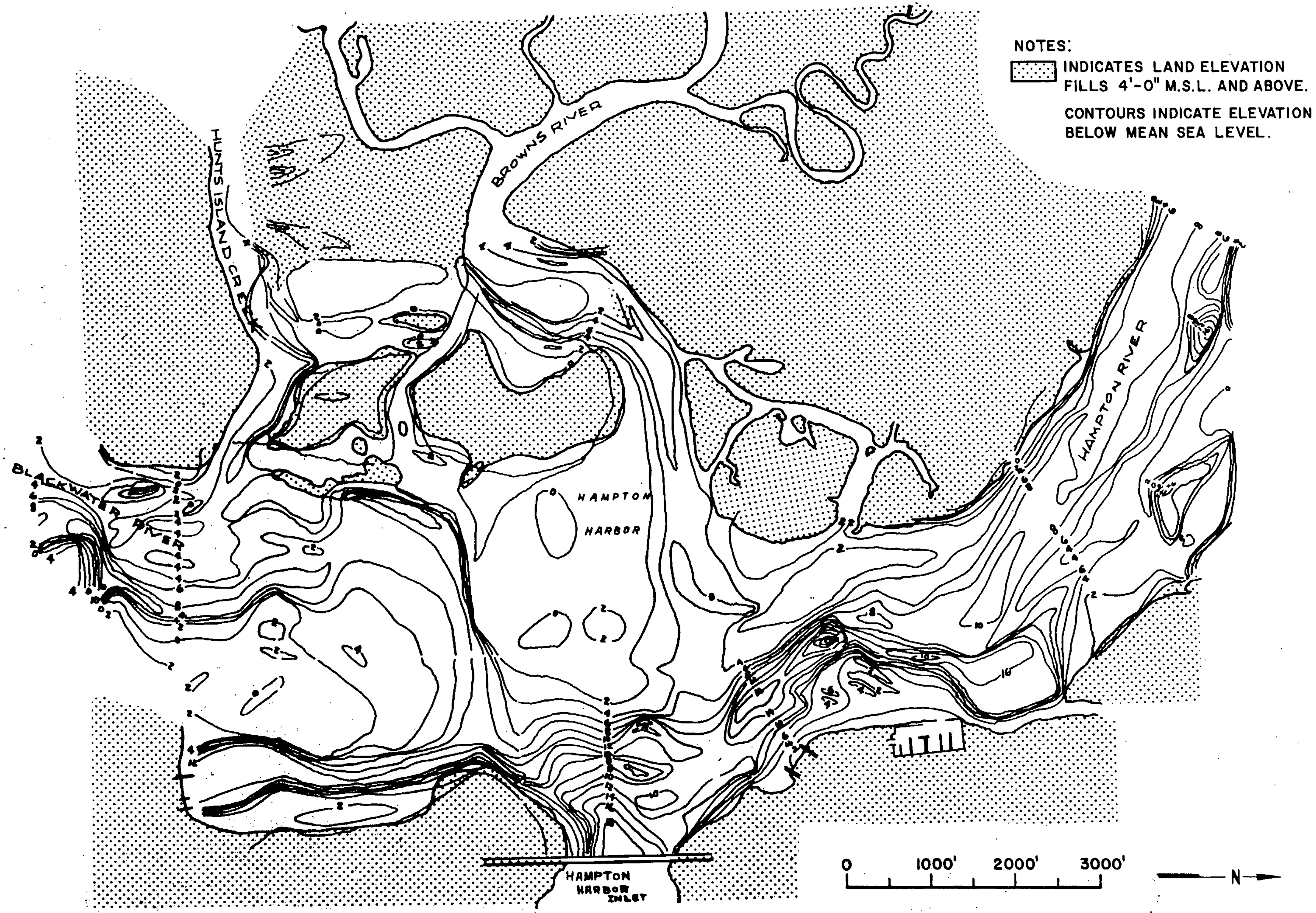
Reference: Groundwater Hydrology for the Proposed Seabrook Nuclear Station, by Weston Geophysical Research, Inc., 1969.



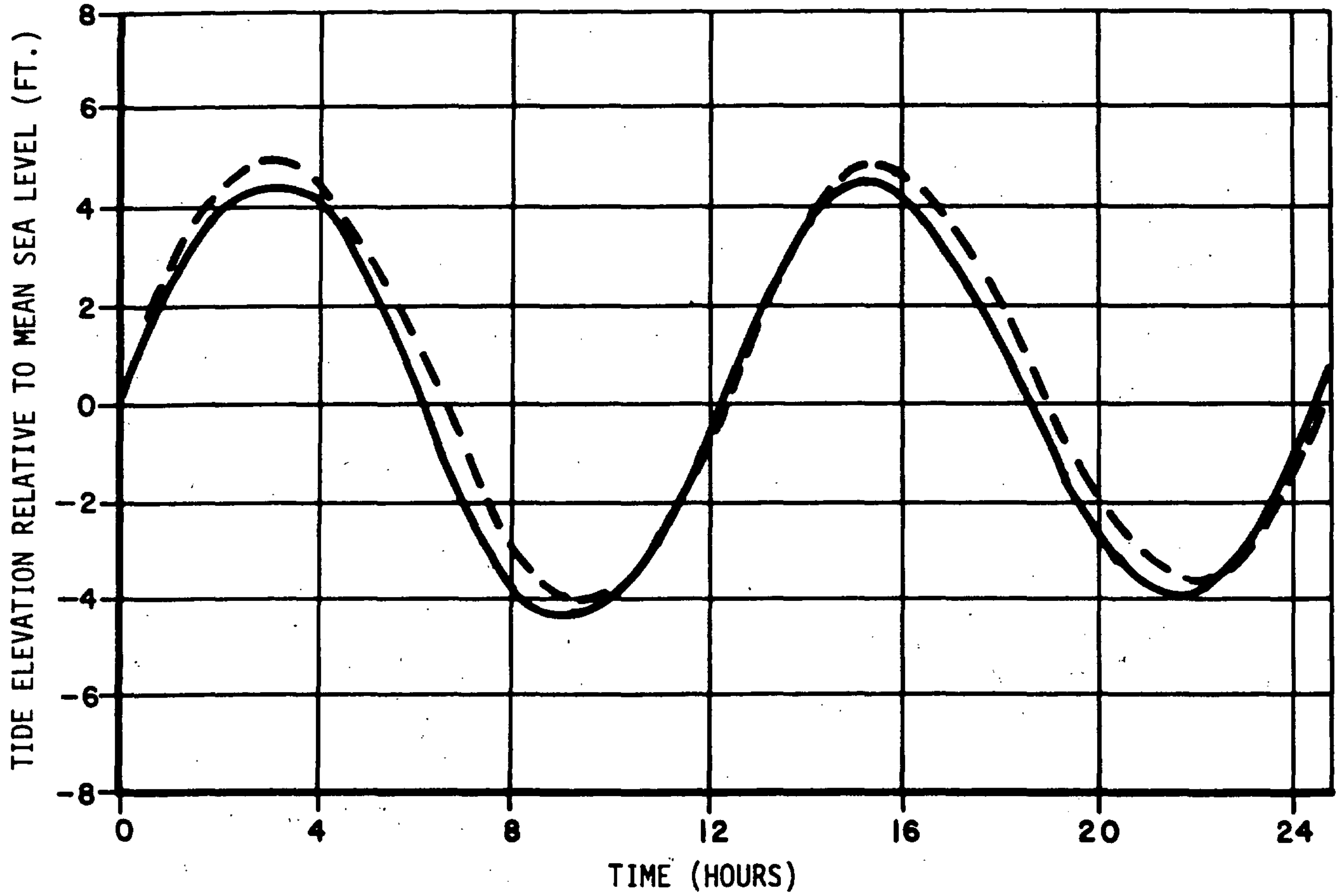
PSNH
SEABROOK STATION

NEW HAMPSHIRE COASTAL AREA

FIGURE 2.5-1



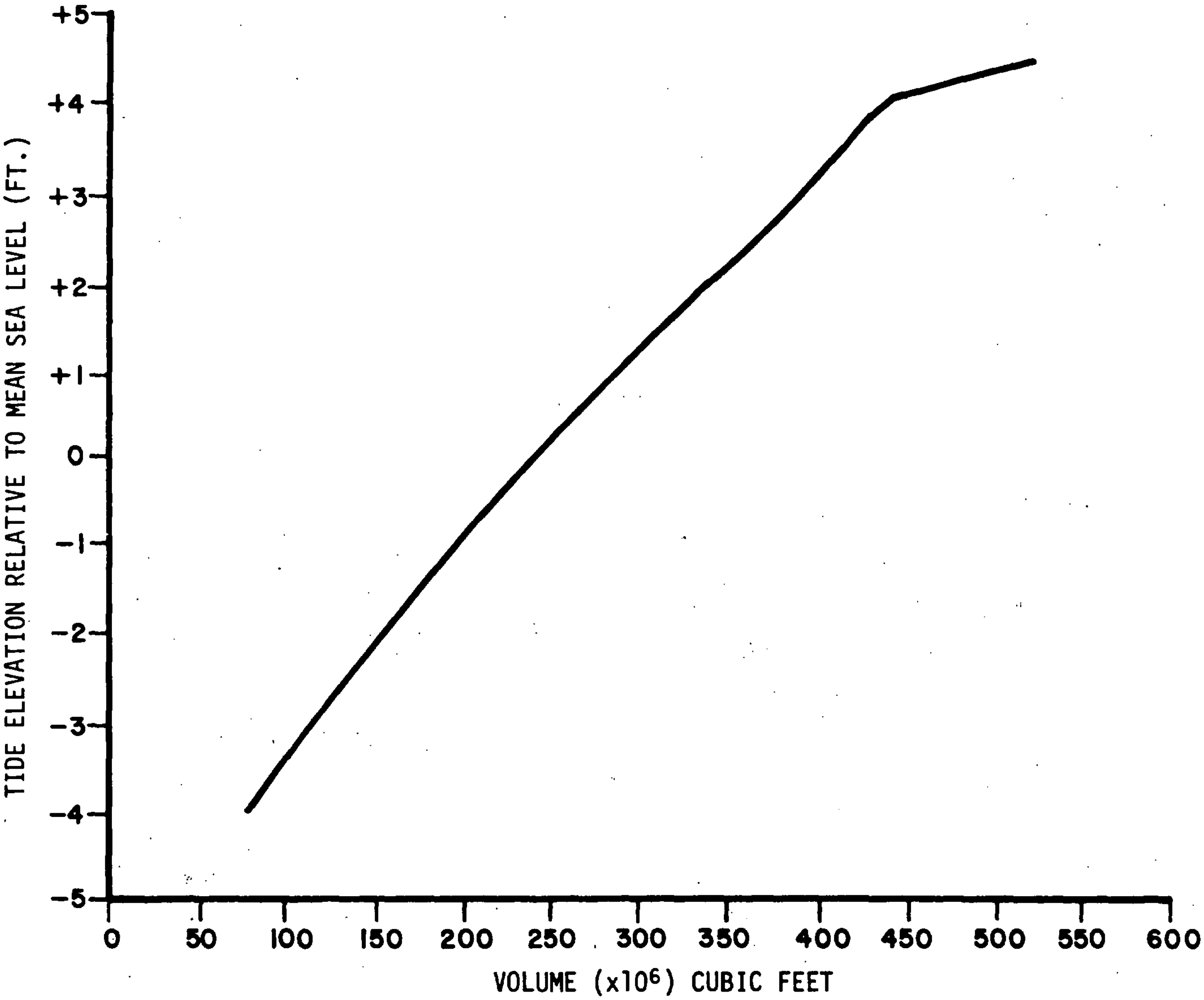
PSNH SEABROOK STATION	HAMPTON HARBOR BATHYMETRY	FIGURE 2.5-2



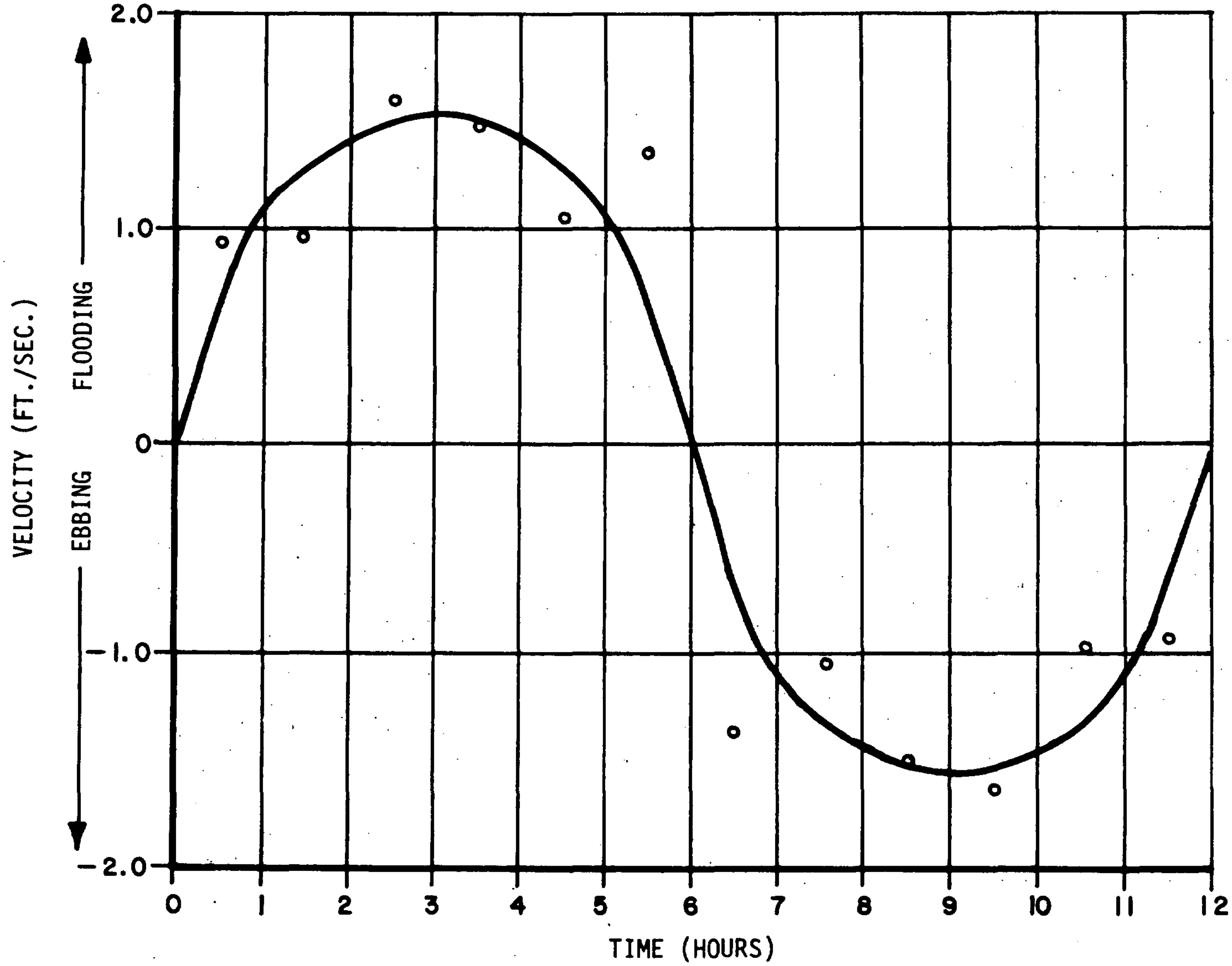
LEGEND:

—— TIDE GAGE LOCATED AT HAMPTON HARBOR BRIDGE
- - - - TIDE GAGE LOCATED IN UPPER SECTION OF ESTUARY

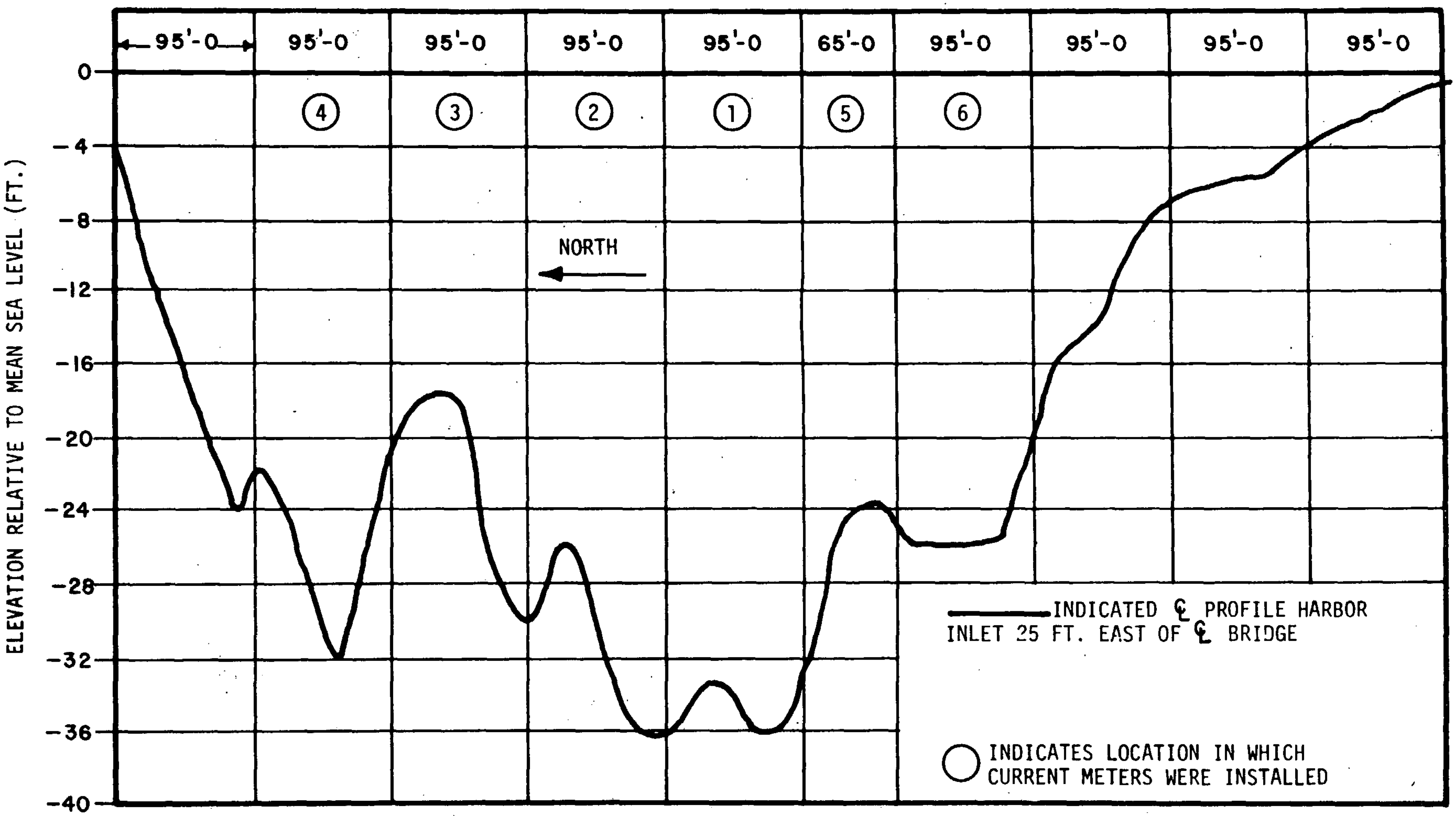
PSNH SEABROOK STATION	TIDE GAGE MEASUREMENTS	FIGURE 2.5-3



PSNH SEABROOK STATION	HAMPTON ESTUARY ELEVATIONS VS. VOLUME	FIGURE 2.5-4



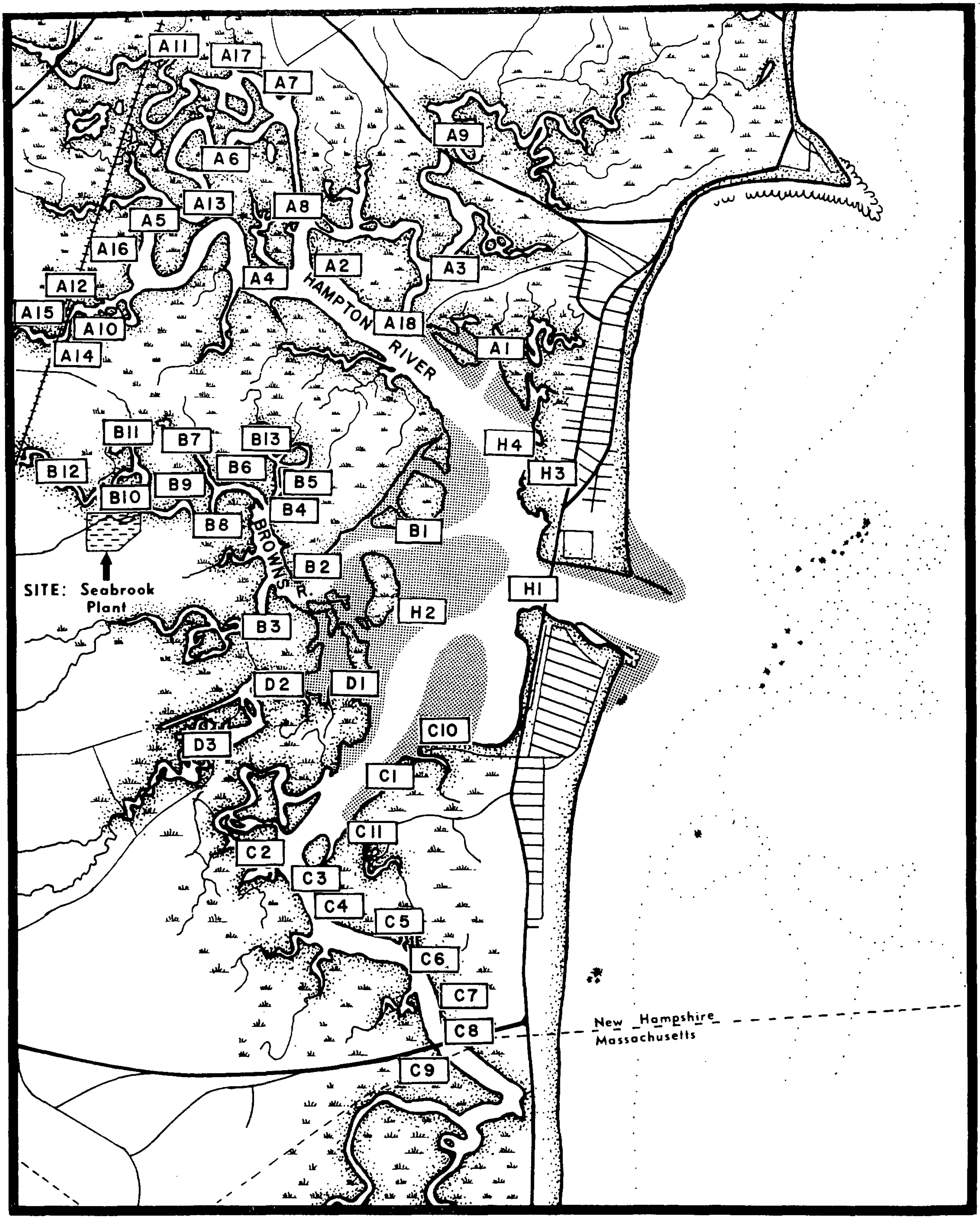
PSNH SEABROOK STATION	AVERAGE VELOCITIES AT HAMPTON BRIDGE	FIGURE 2.5-5



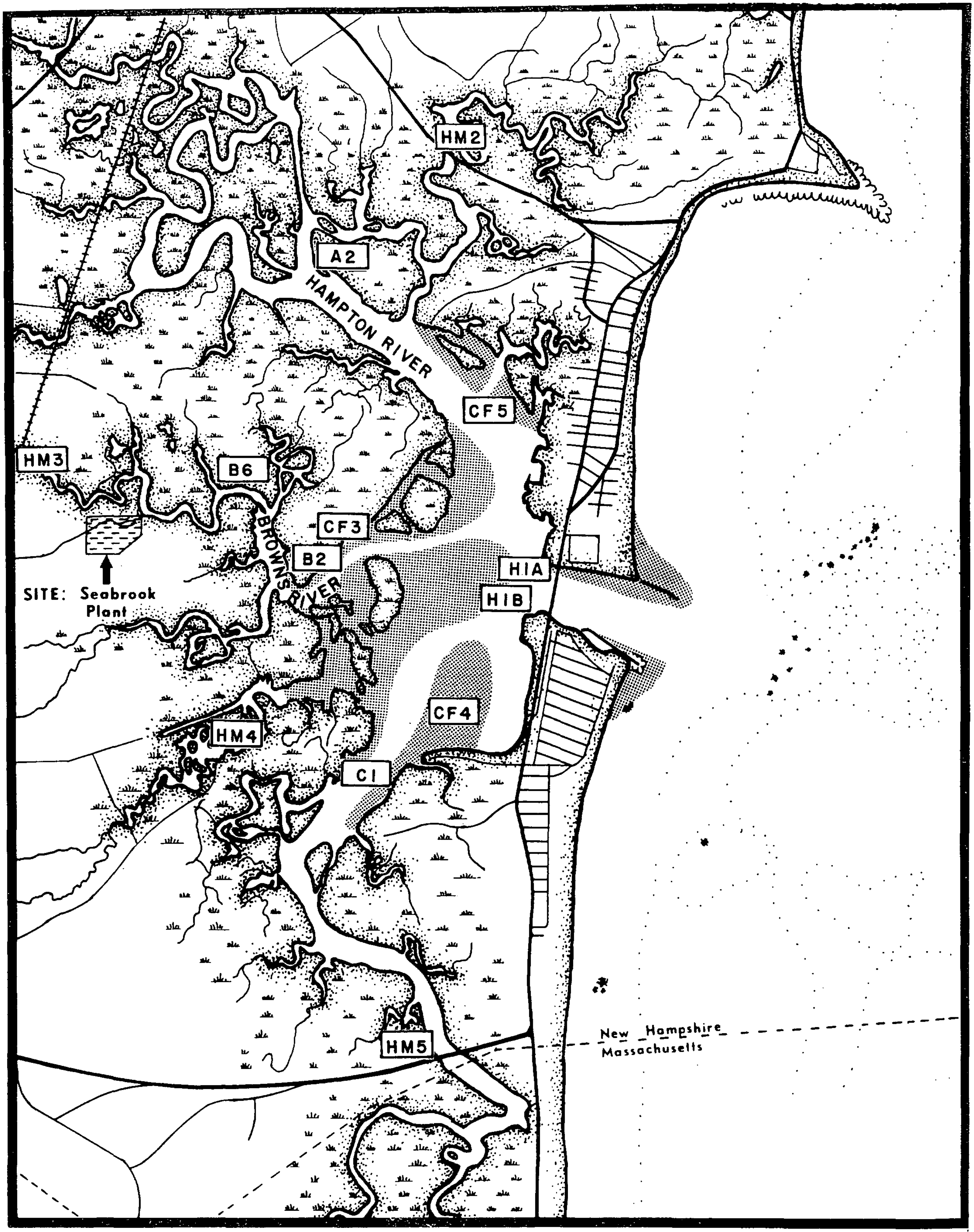
PSNH
SEABROOK STATION

HAMPTON HARBOR INLET PROFILE

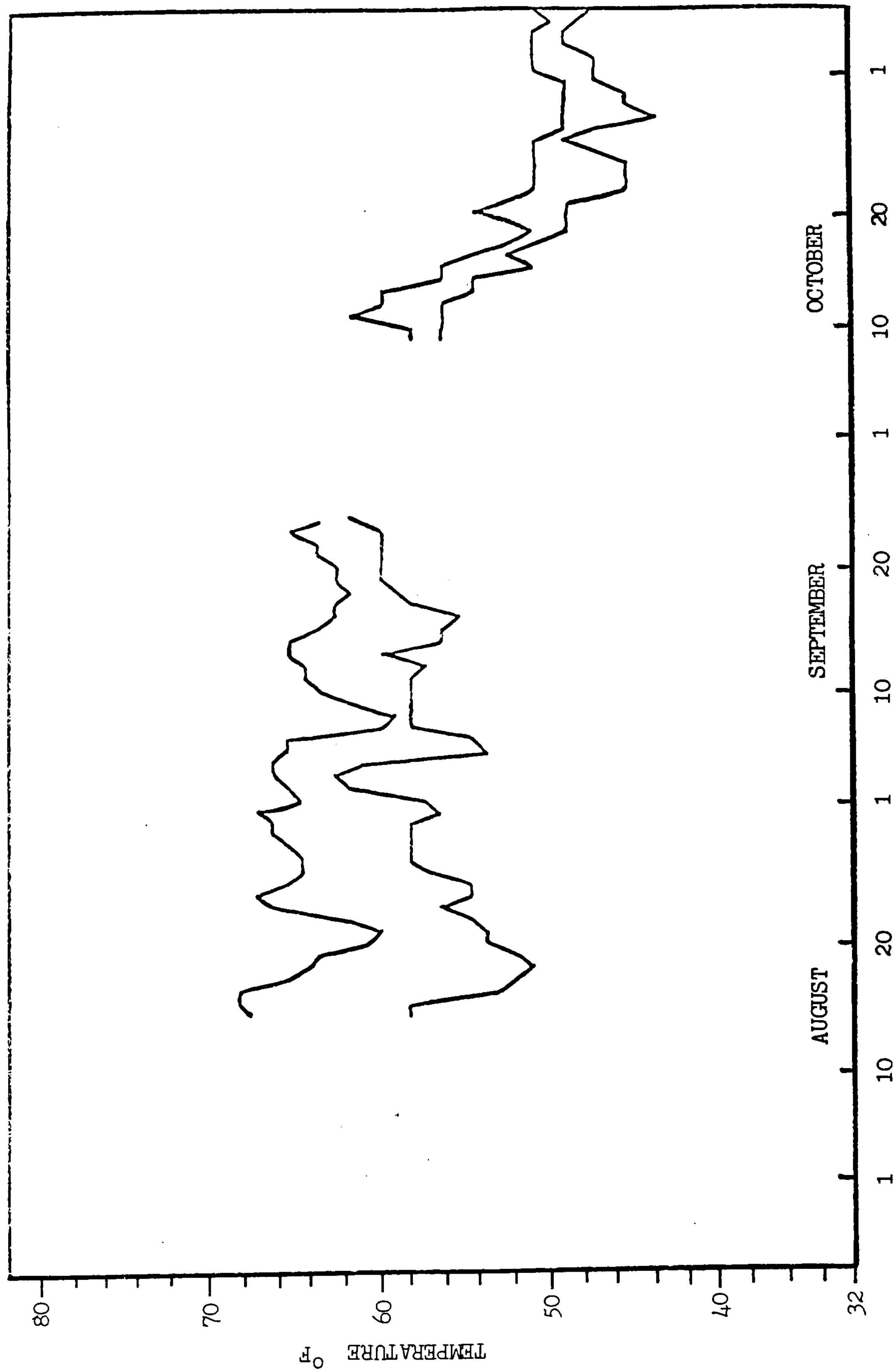
FIGURE 2.5-6



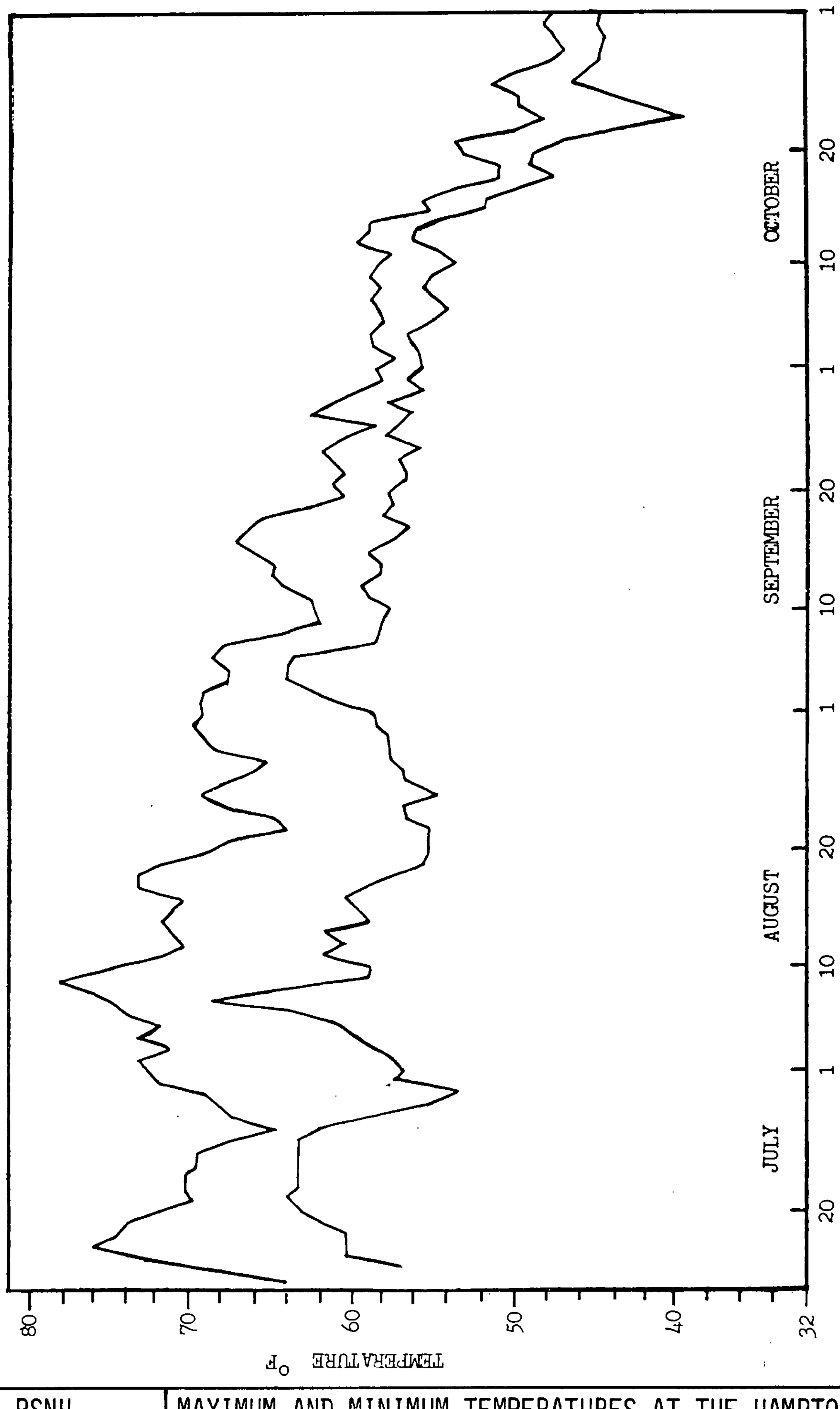
PSNH SEABROOK STATION	ESTUARINE SAMPLING STATIONS, 1969	FIGURE 2.5-7



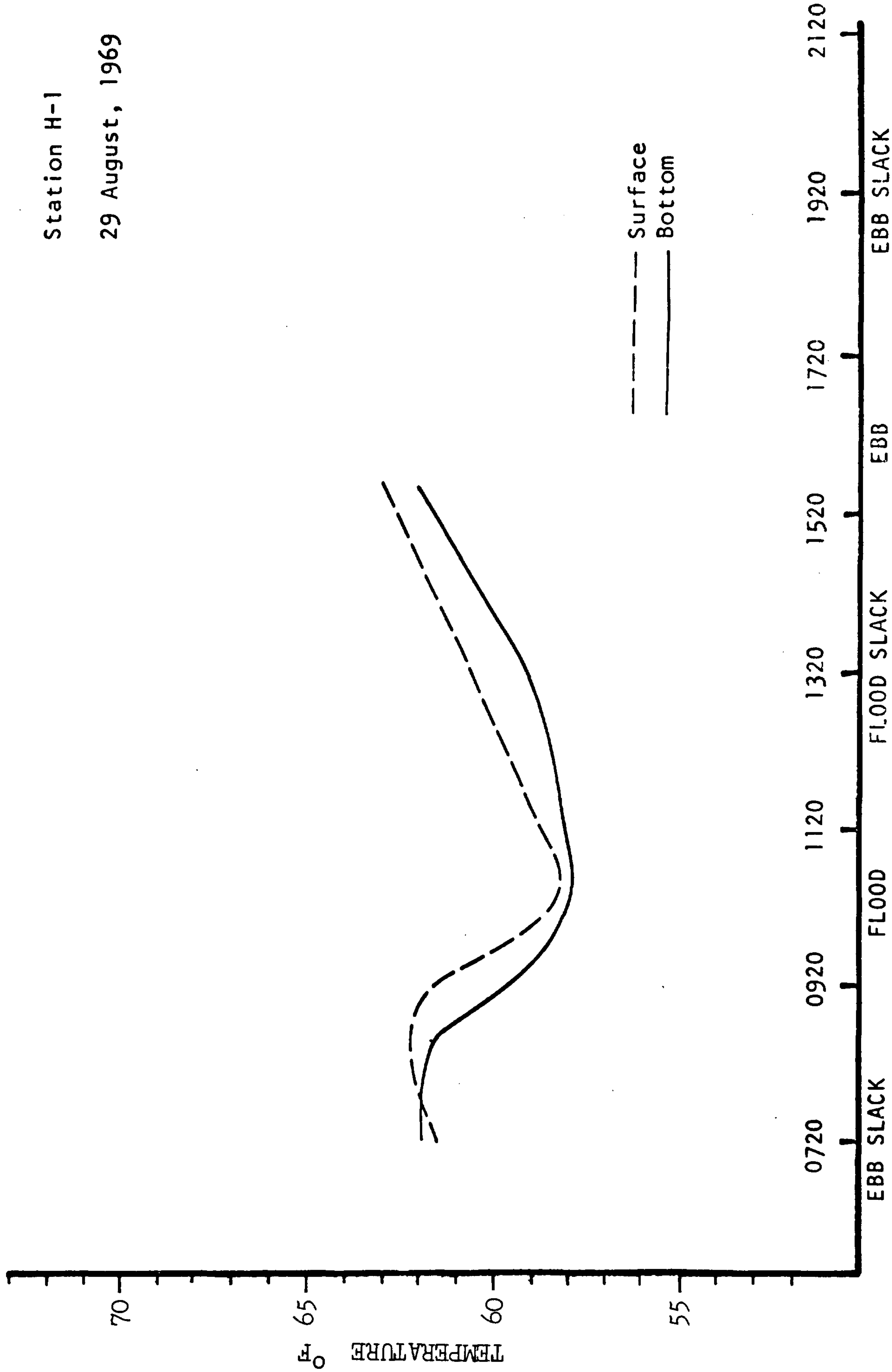
PSNH SEABROOK STATION	ESTUARINE SAMPLING STATIONS, 1970	FIGURE 2.5-8



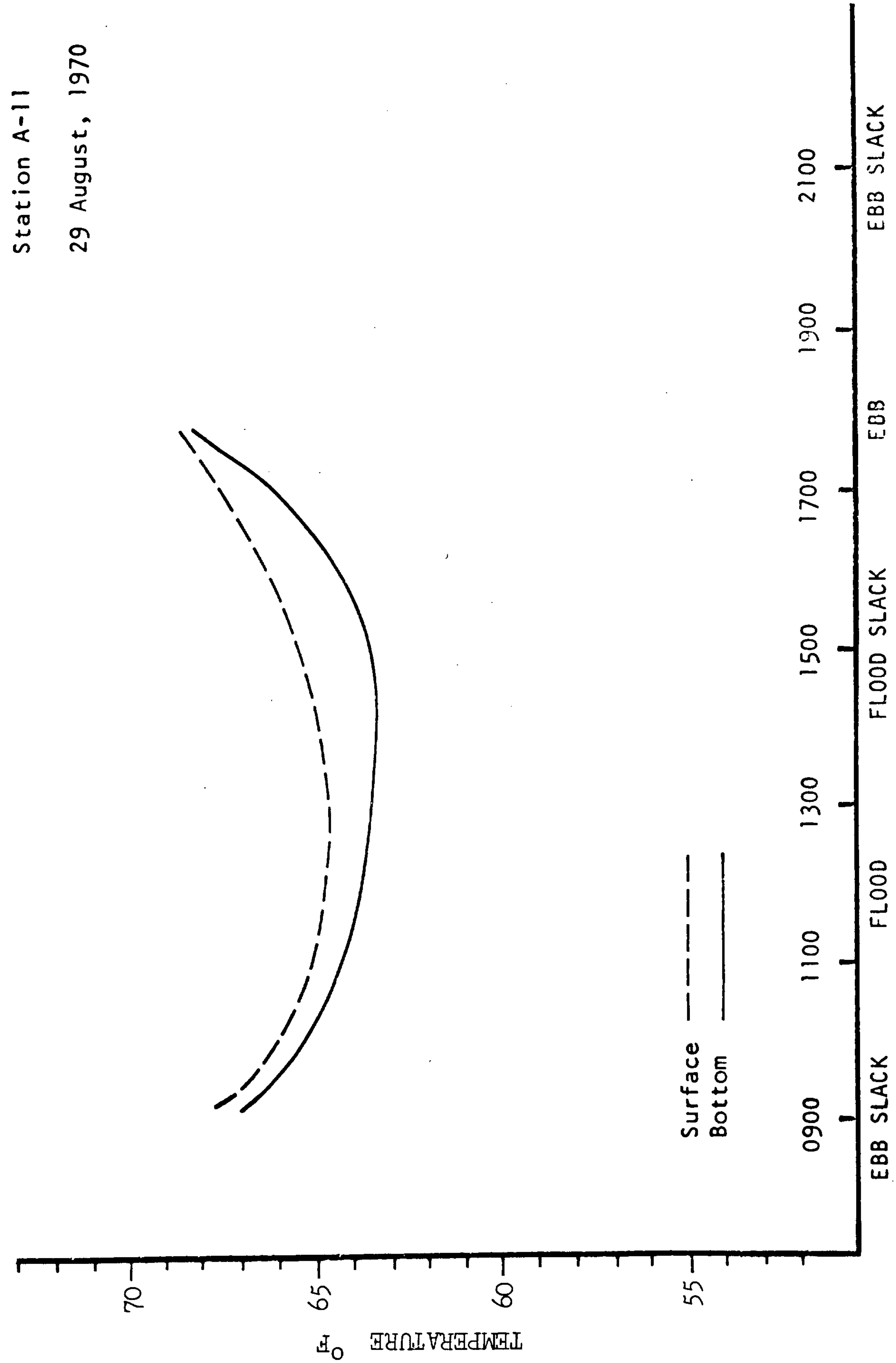
PSNH SEABROOK STATION	MAXIMUM AND MINIMUM BOTTOM TEMPERATURES AT THE HAMPTON HARBOR BRIDGE	FIGURE 2.5-9



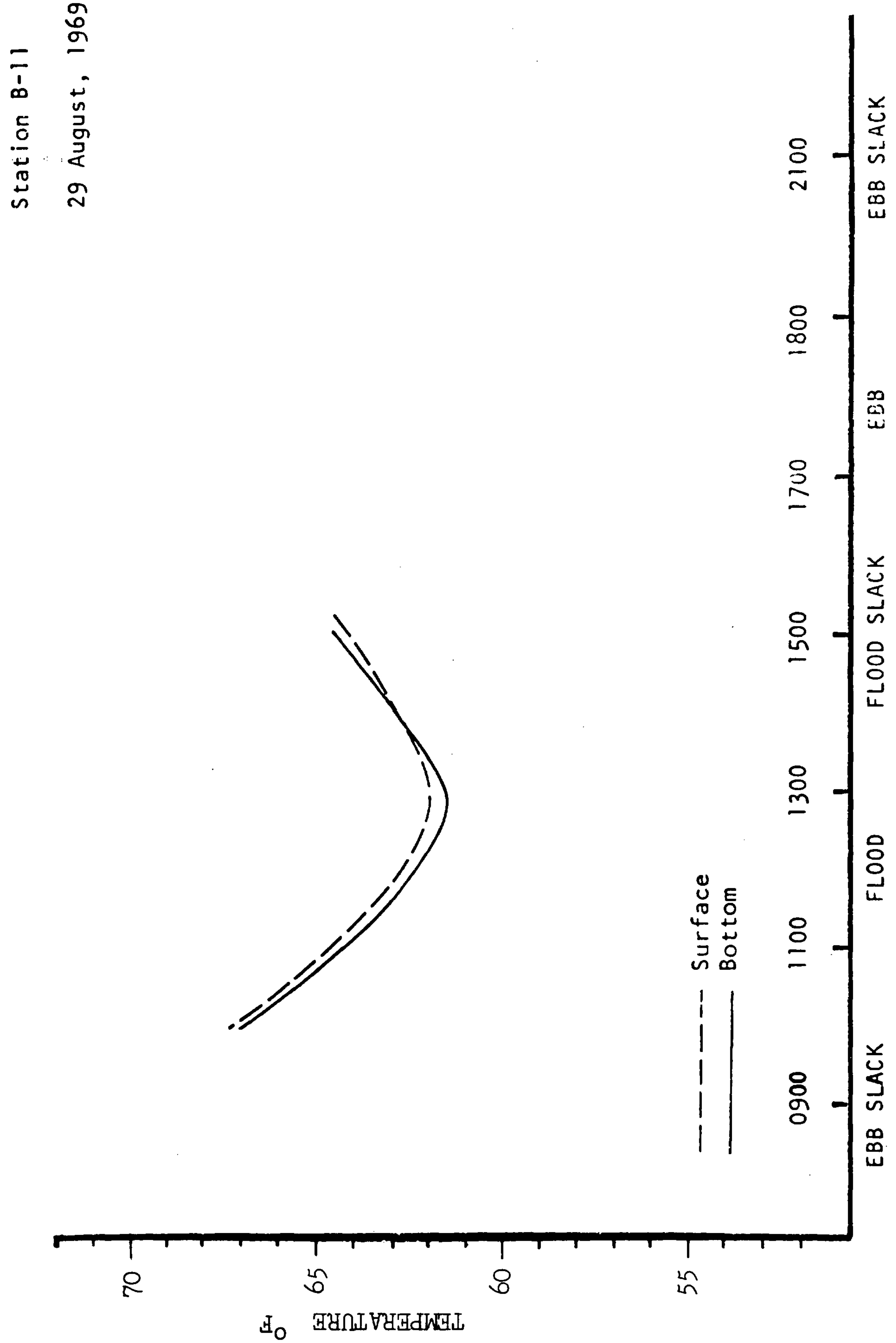
PSNH	MAXIMUM AND MINIMUM TEMPERATURES AT THE HAMPTON	FIGURE
SEABROOK STATION	RIVER BOAT CLUB	2.5-10



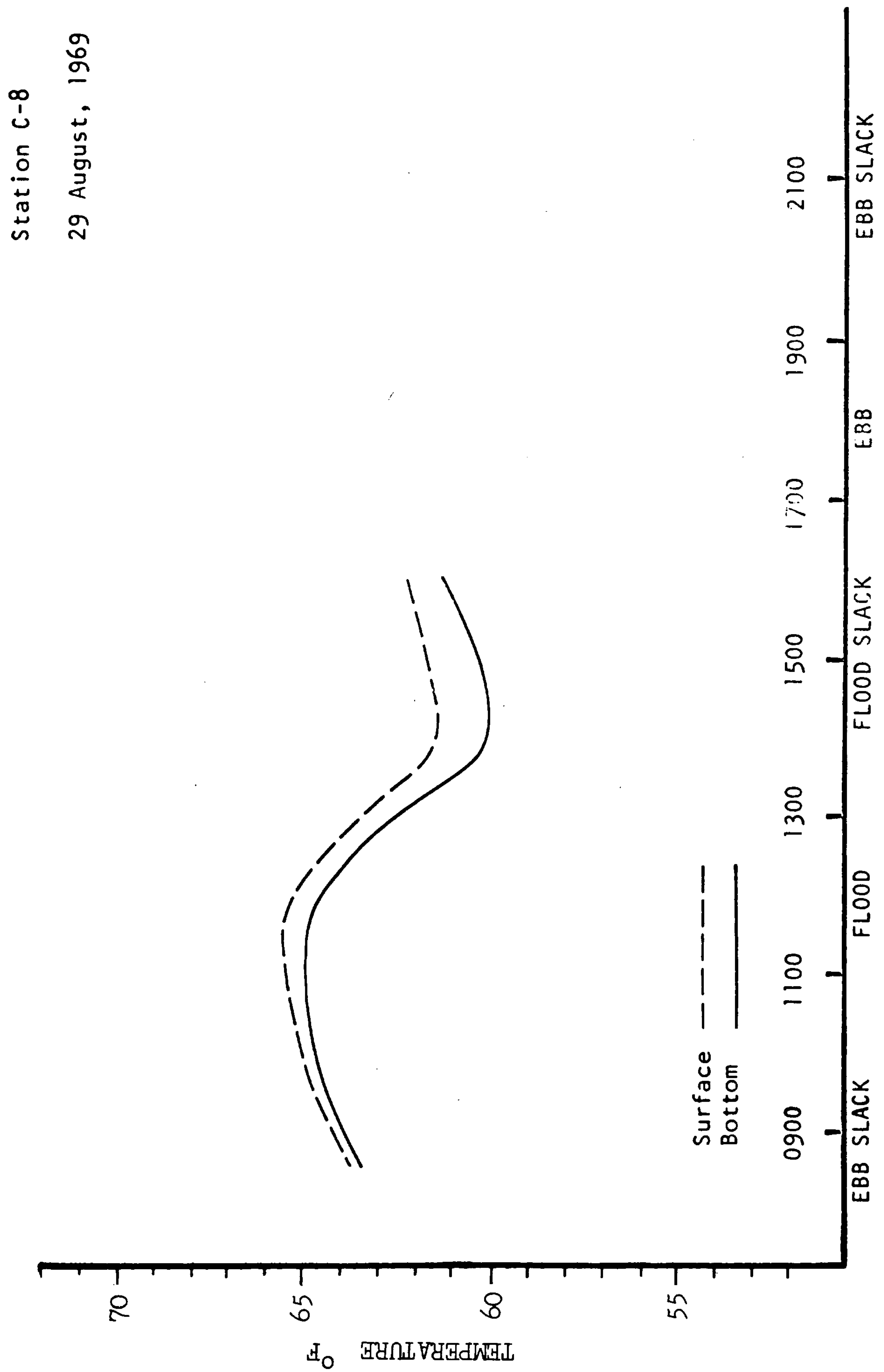
PSNH	TEMPERATURE AS RELATED TO TIDAL CYCLE - STATION	FIGURE
SEABROOK STATION	H-1	2.5-11



PSNH SEABROOK STATION	TEMPERATURE AS RELATED TO TIDAL CYCLE - STATION A-11	FIGURE 2.5-12



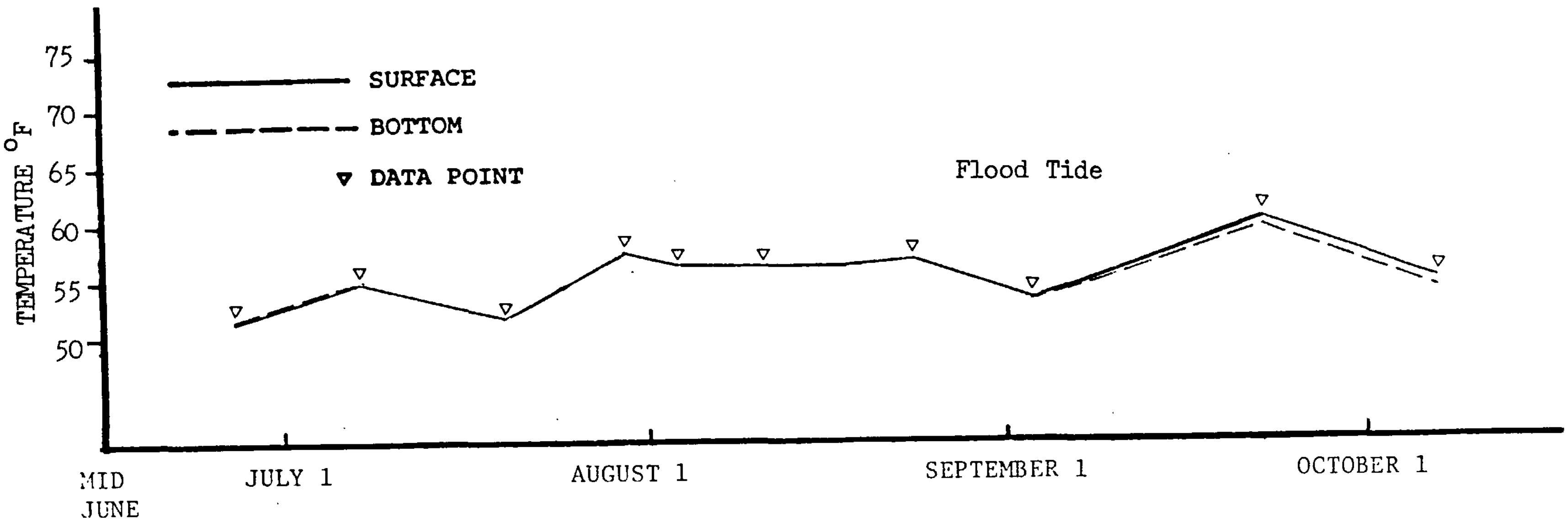
PSNH SEABROOK STATION	TEMPERATURE AS RELATED TO TIDAL CYCLE - STATION B-11	FIGURE 2.5-13



PSNH SEABROOK STATION	TEMPERATURE AS RELATED TO TIDAL CYCLE - STATION C-8	FIGURE 2.5-14

PSNH
SEABROOK STATION

STATION H-1A SURFACE AND BOTTOM TEMPERATURES



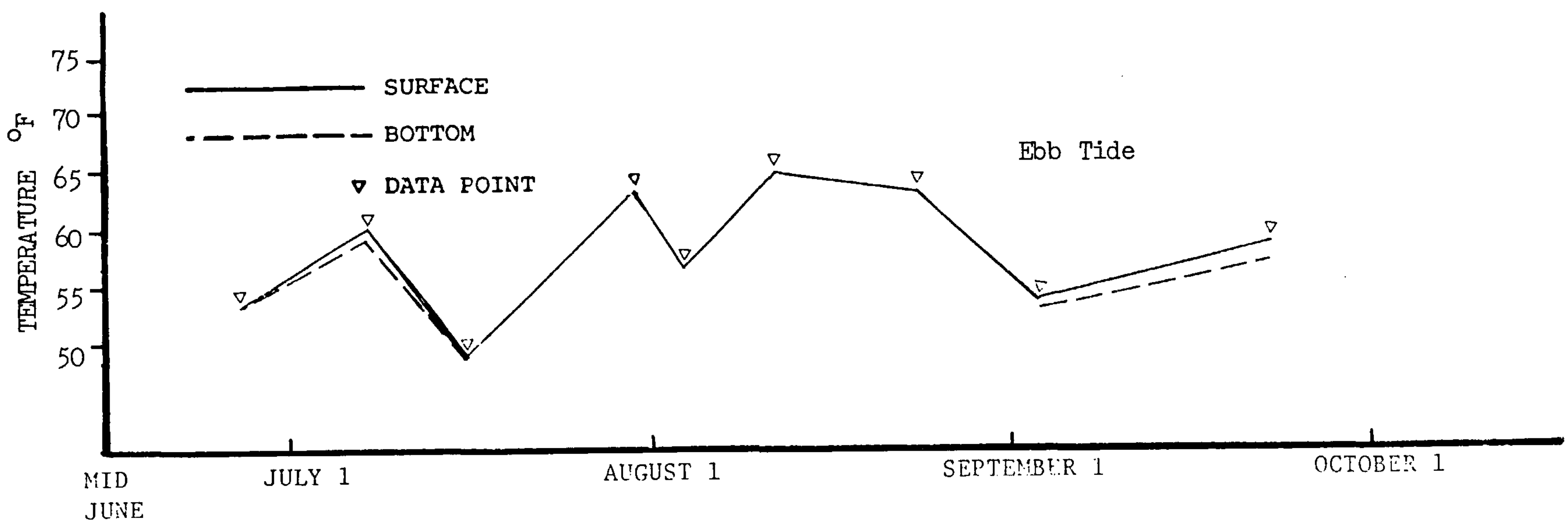
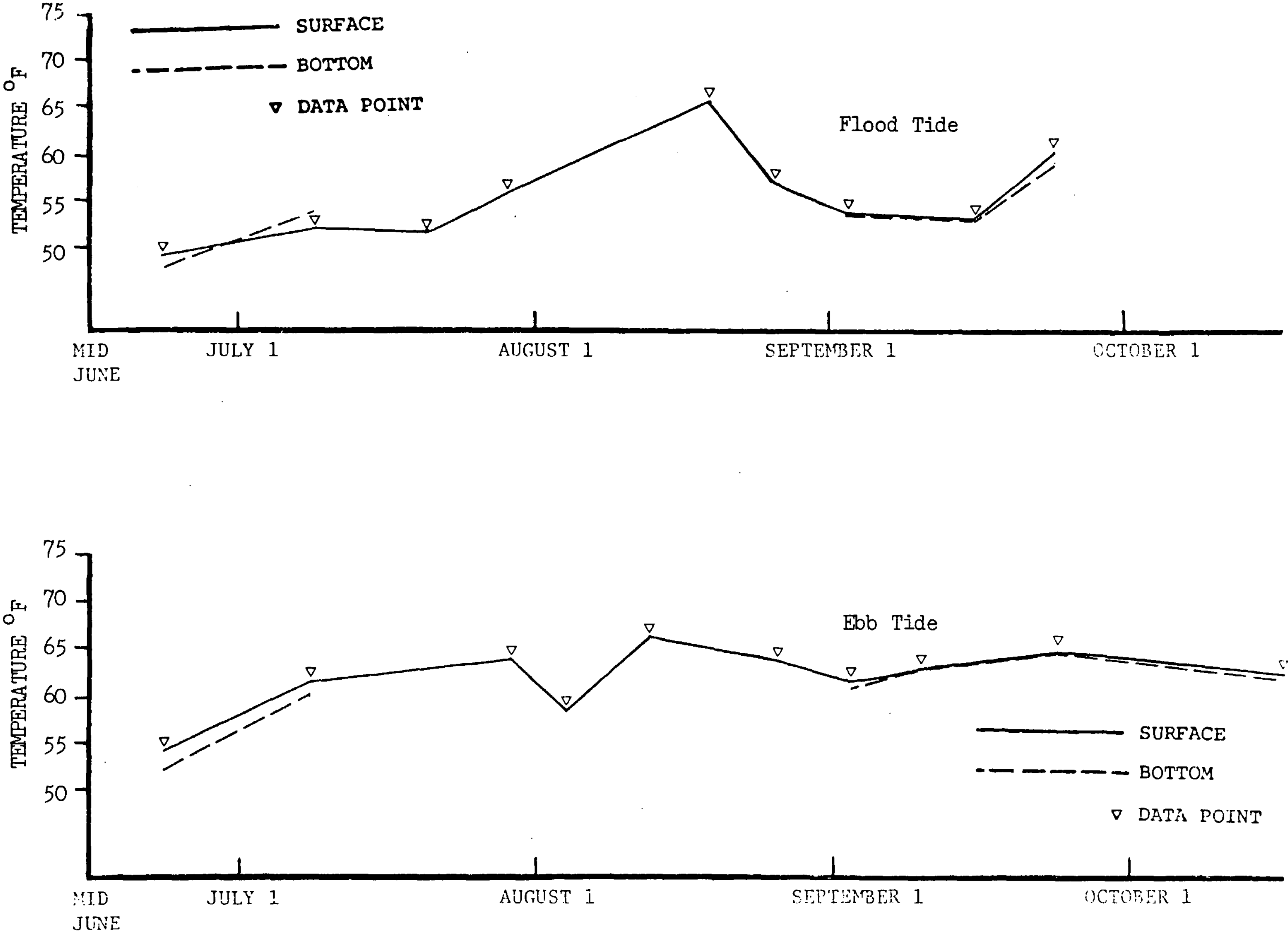


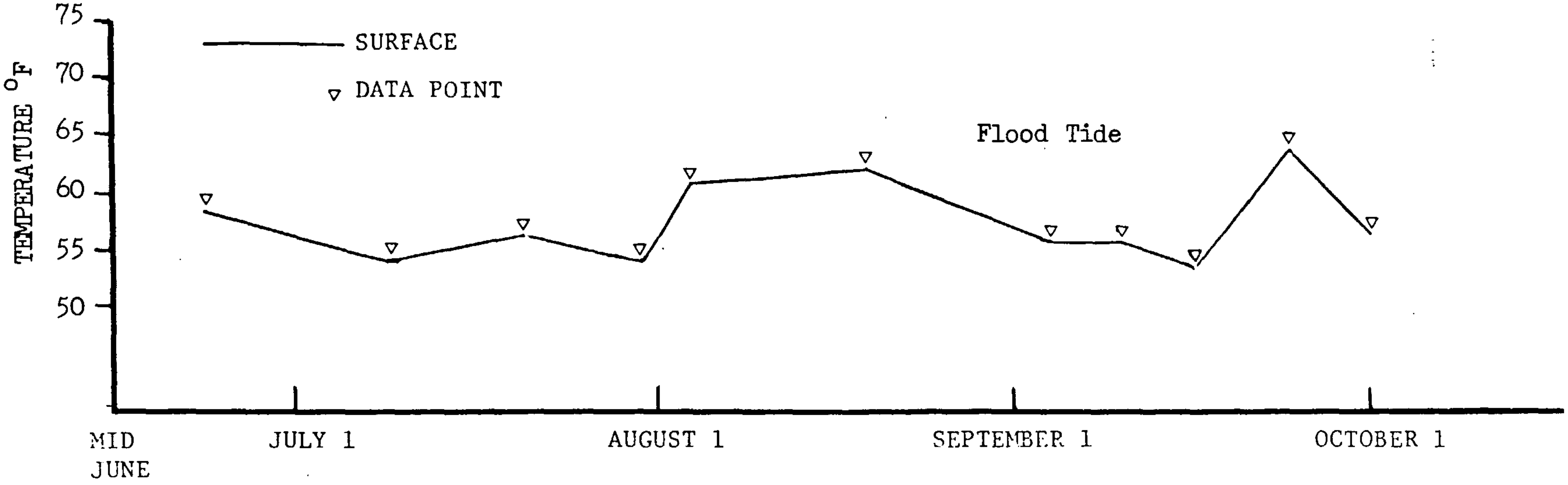
FIGURE 2.5-15

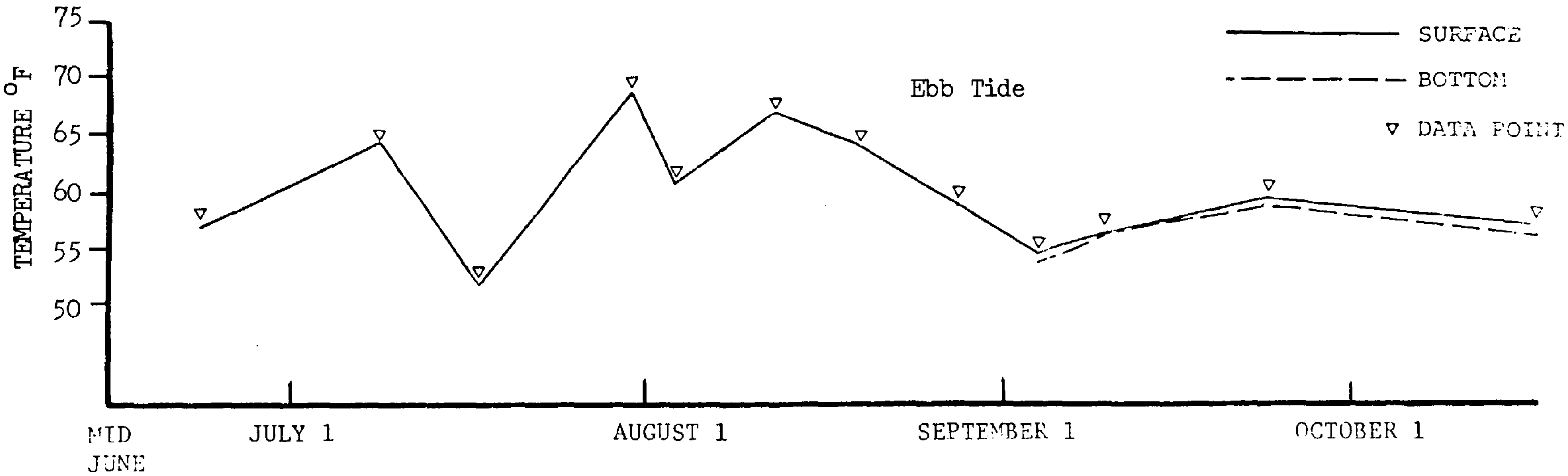


PSNH
SEABROOK STATION

STATION H-1B SURFACE AND BOTTOM TEMPERATURES

FIGURE 2.5-16





PSNH
SEABROOK STATION

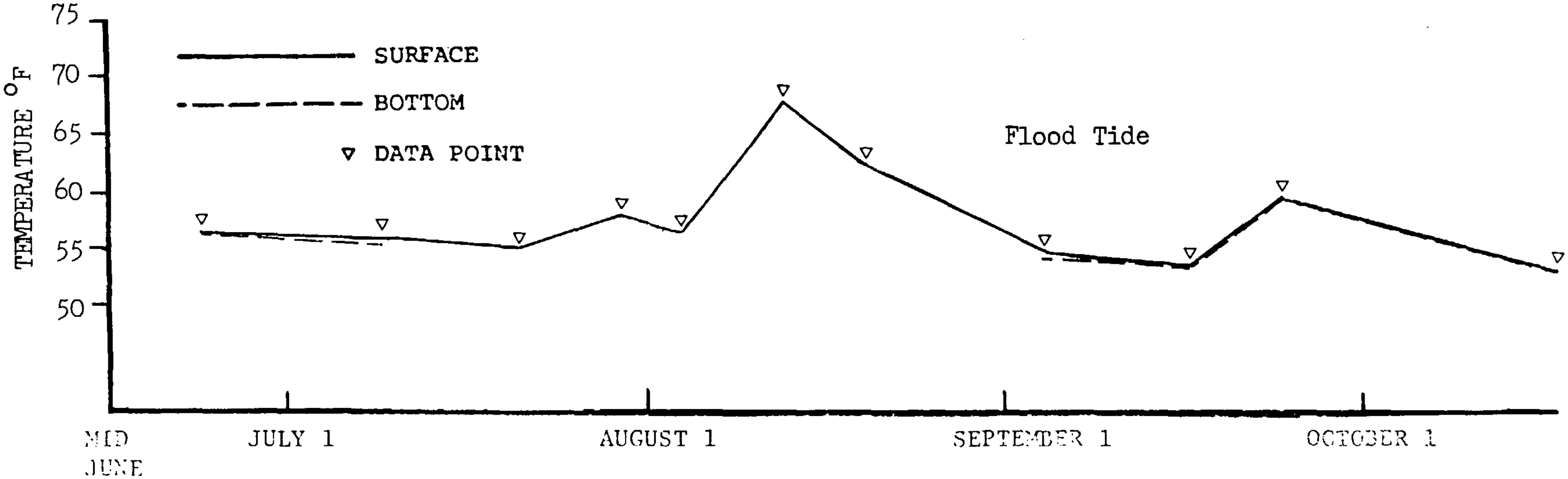
STATION C-1 SURFACE AND BOTTOM TEMPERATURES

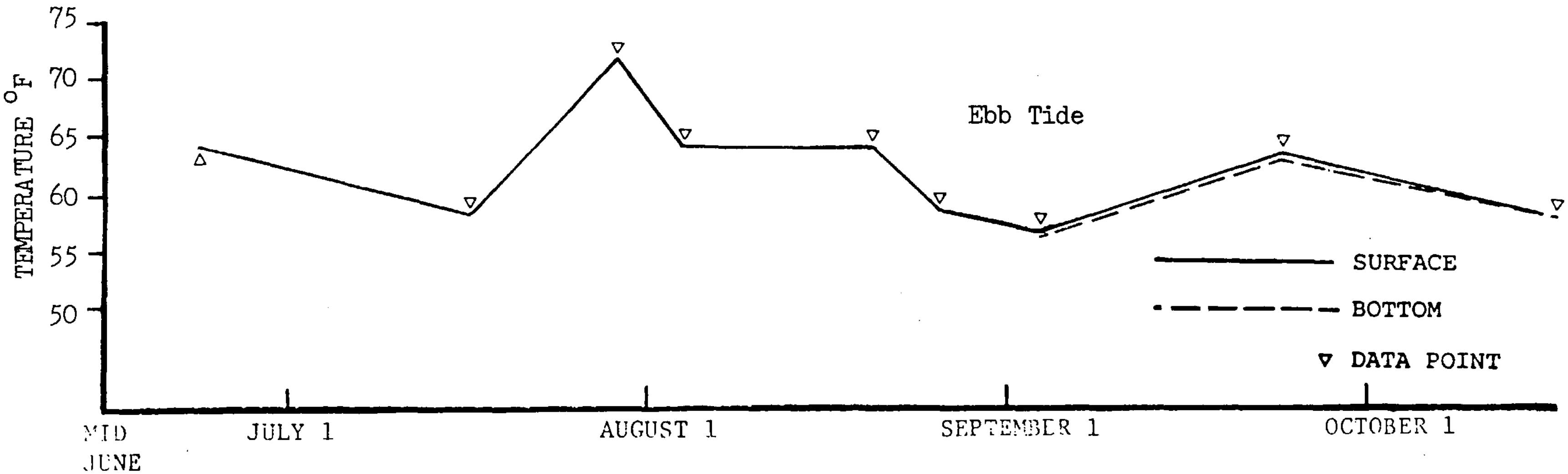
FIGURE
2.5-17

PSNH
SEABROOK STATION

STATION B-2 SURFACE AND BOTTOM TEMPERATURES

FIGURE
2.5-18

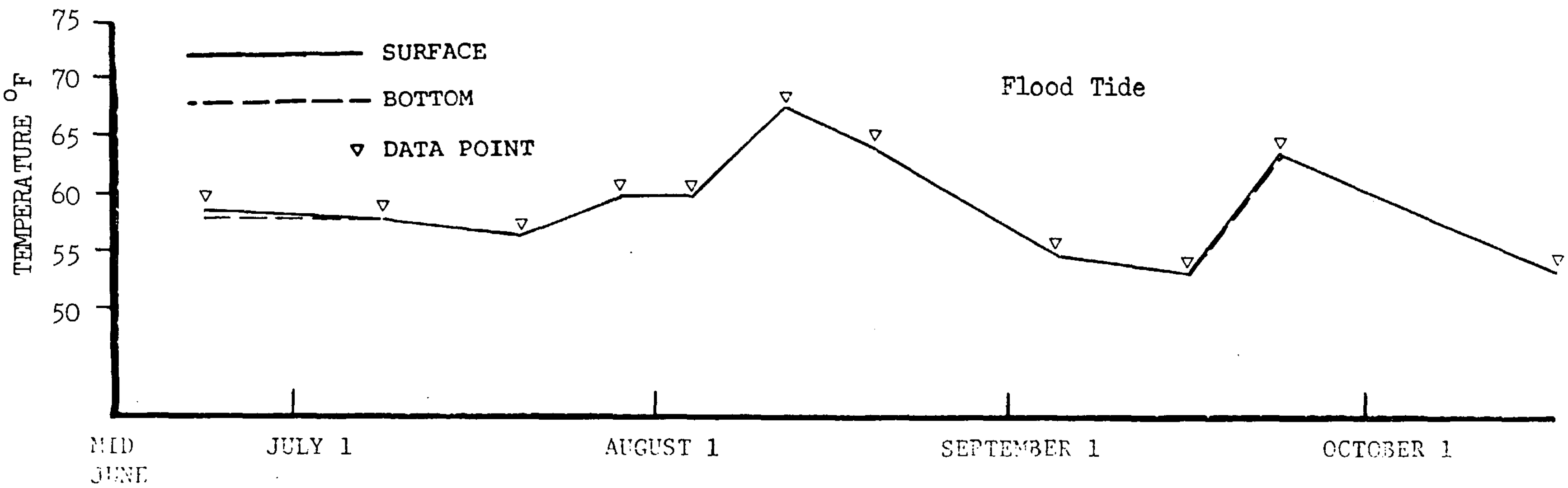


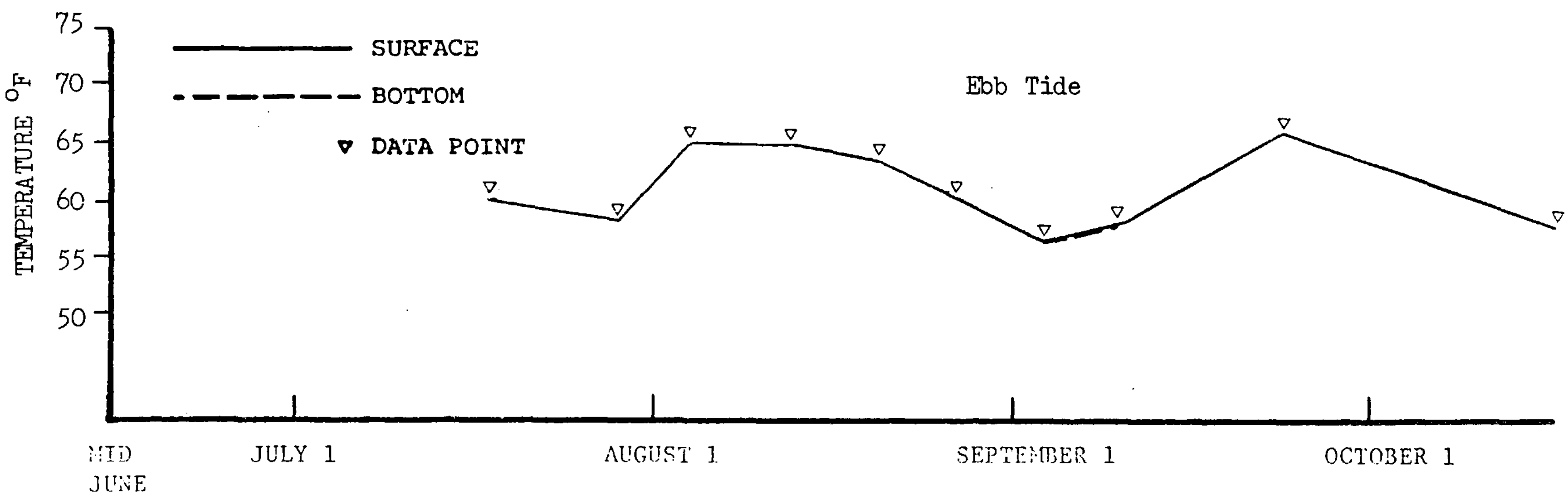


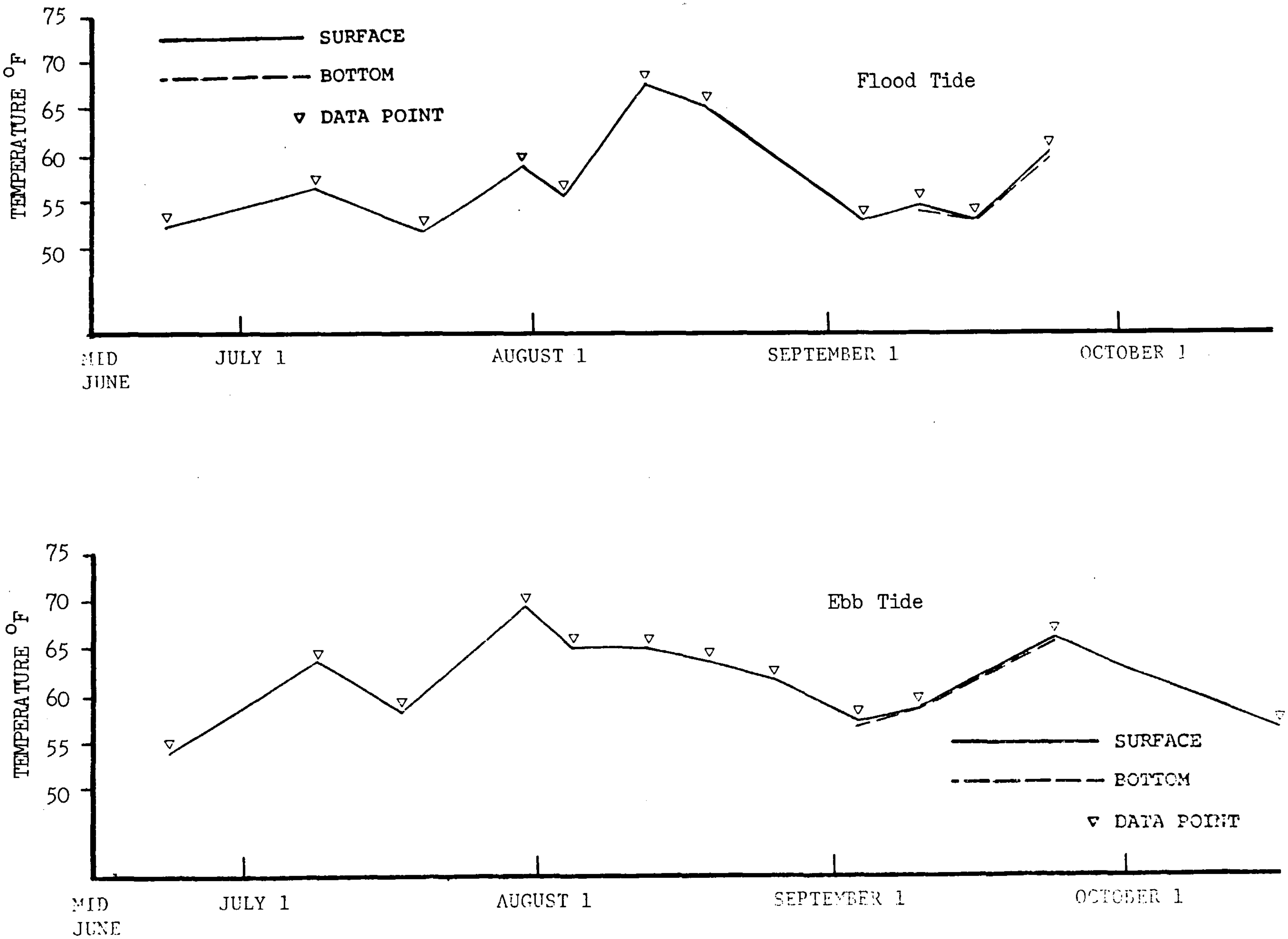
PSNH
SEABROOK STATION

STATION B-6 SURFACE AND BOTTOM TEMPERATURES

FIGURE 2.5-19



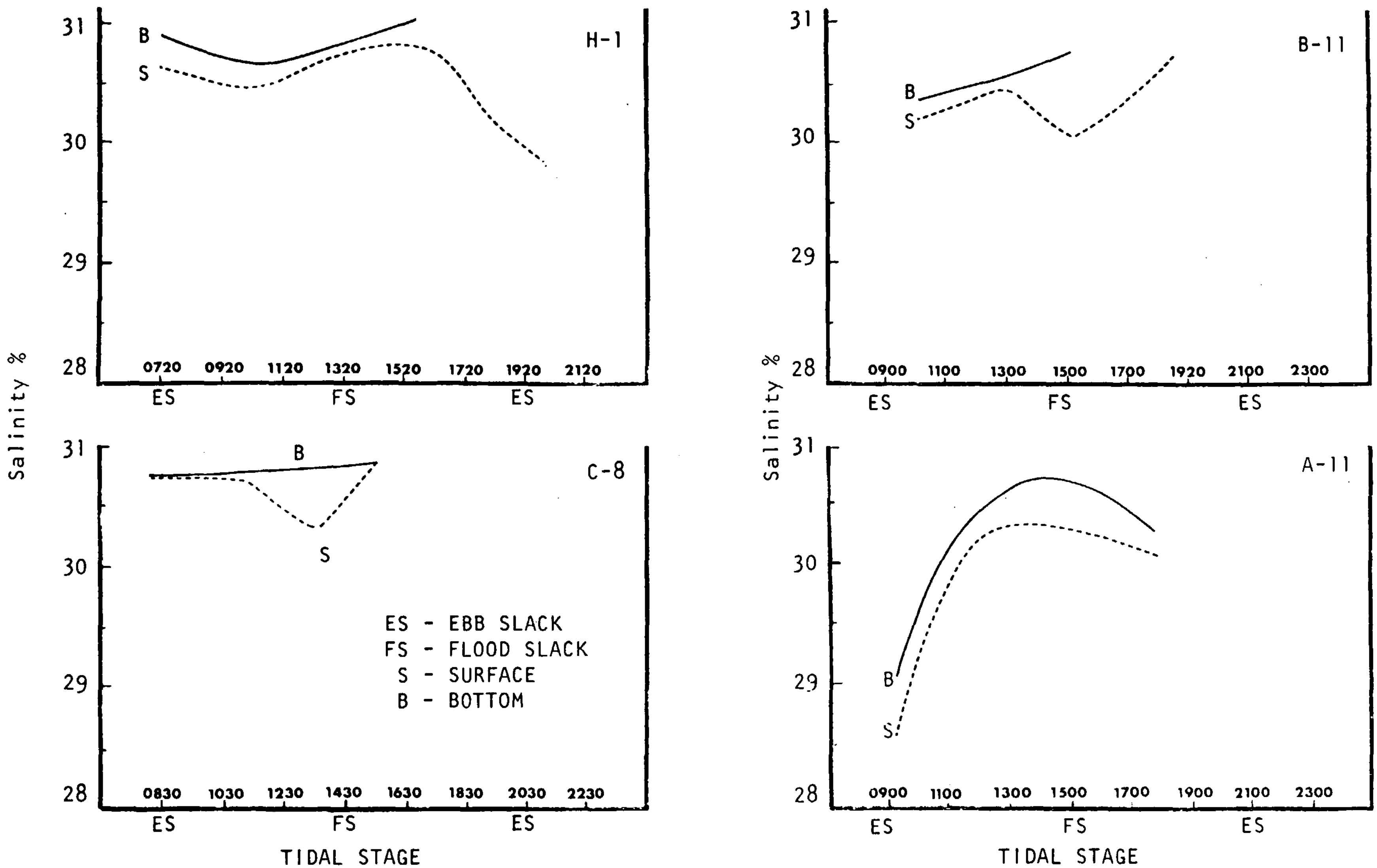




PSNH
SEABROOK STATION

STATION A-2 SURFACE AND BOTTOM TEMPERATURES

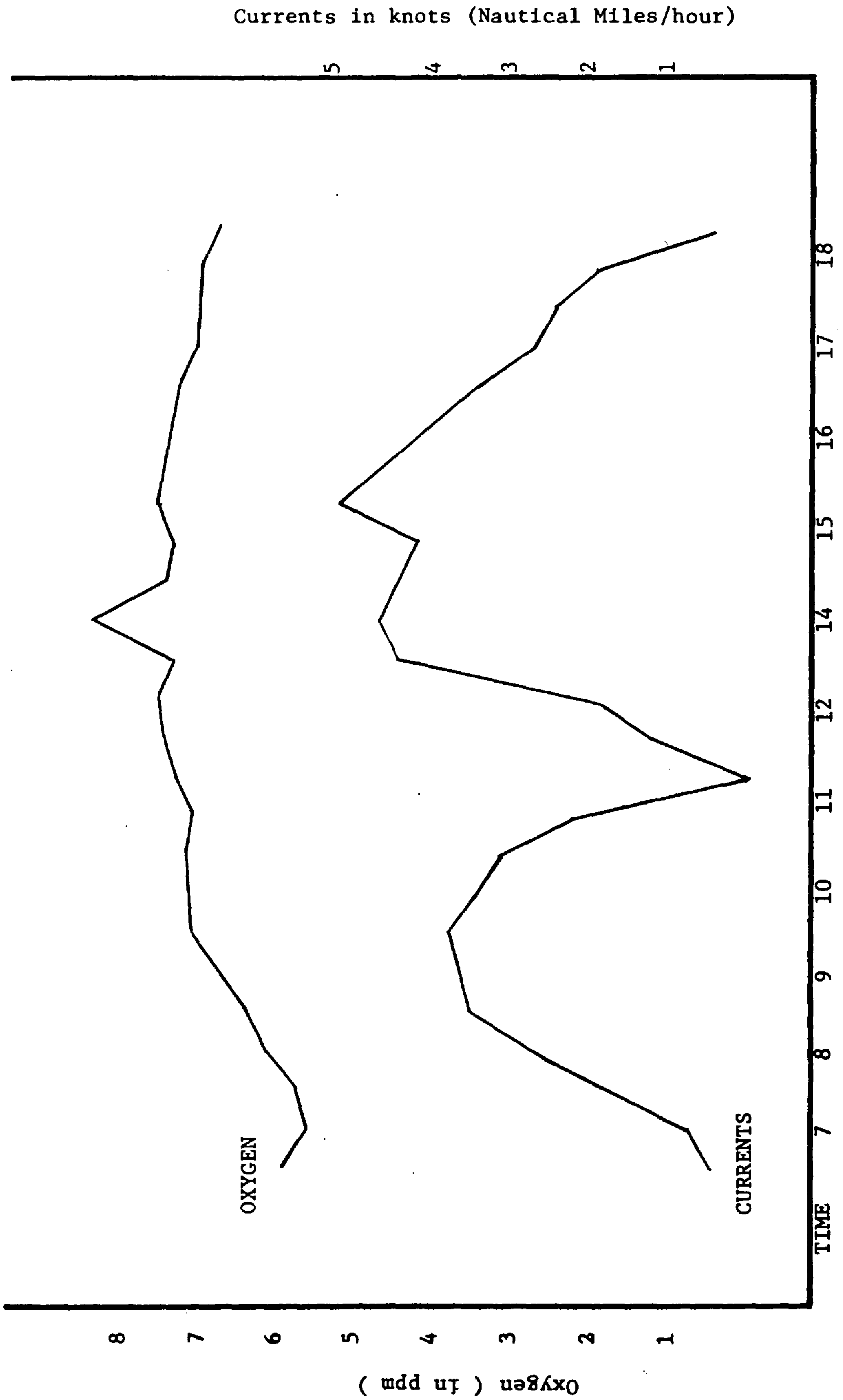
FIGURE
2.5-20



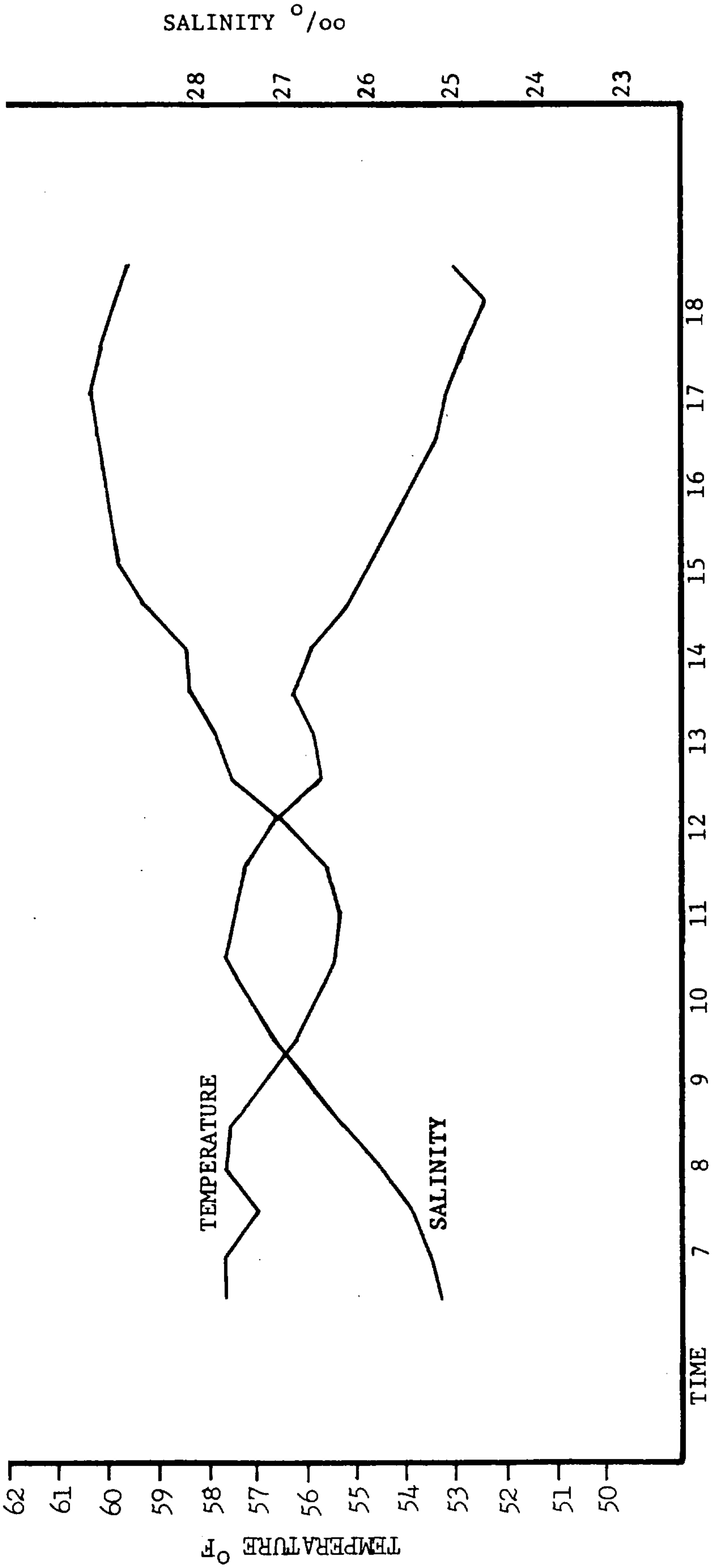
PSNH
SEABROOK STATION

SALINITY CHANGES WITH TIDAL PHASE

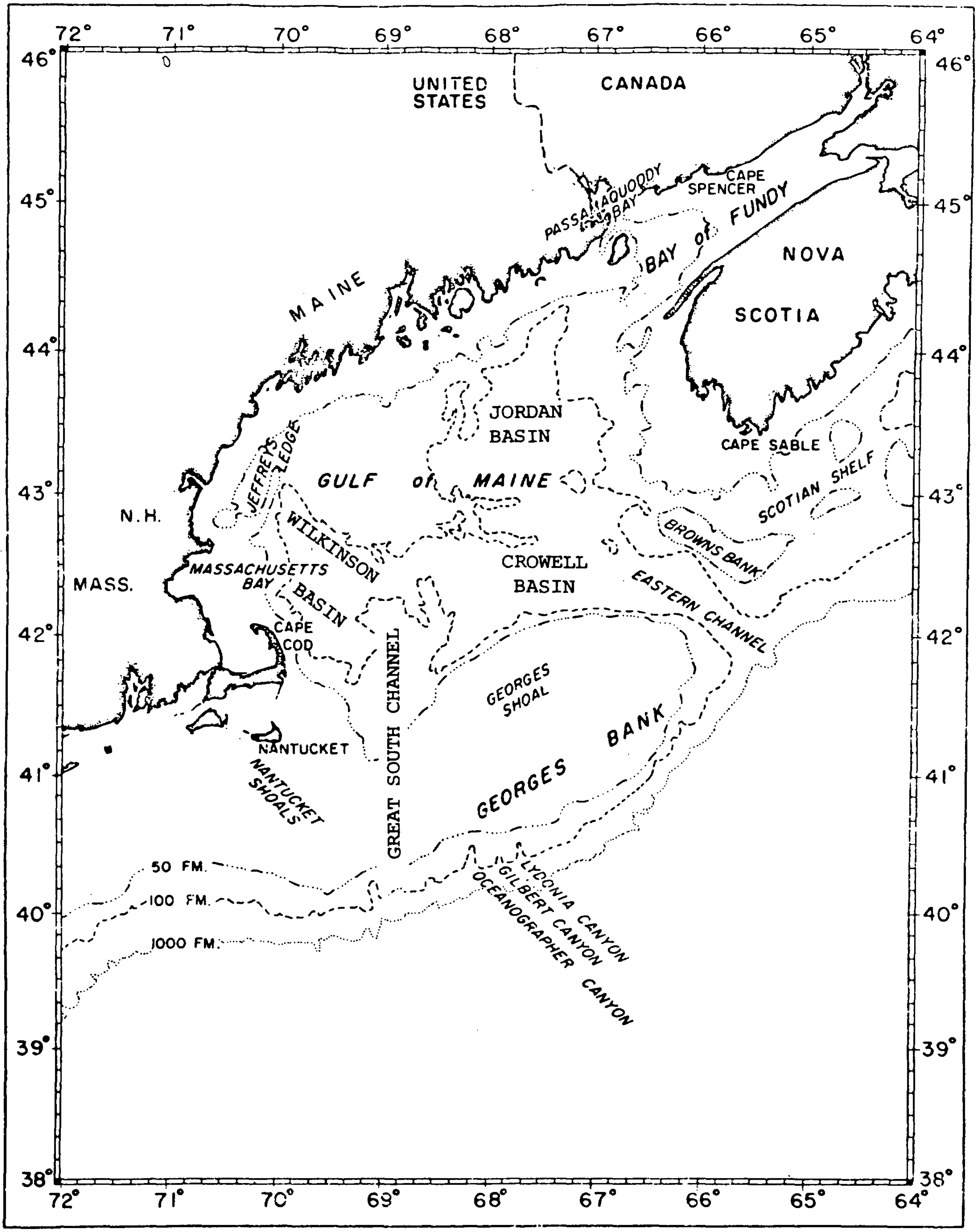
FIGURE
2.5-21



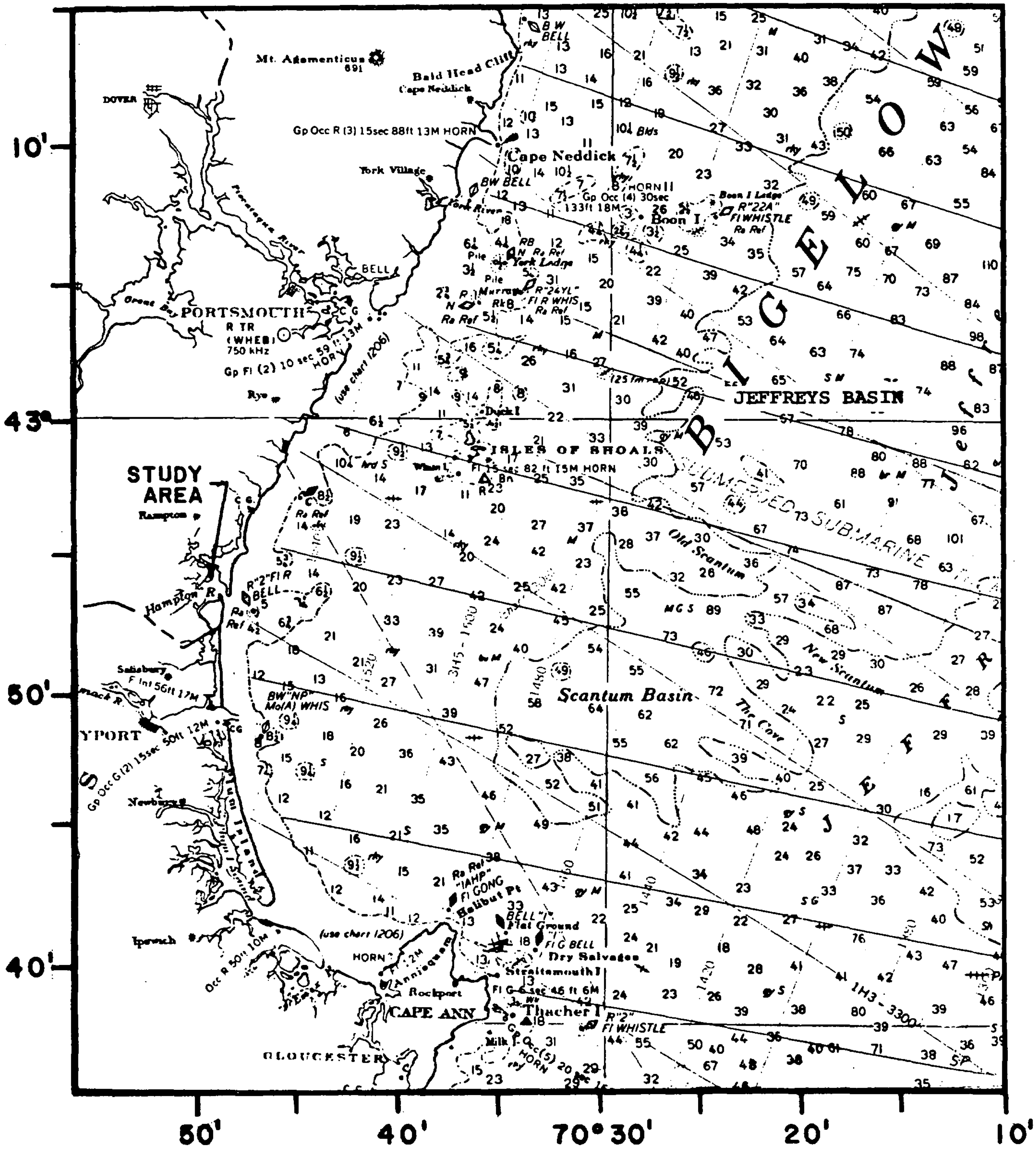
PSNH SEABROOK STATION	DIURNAL VARIATIONS OF OXYGEN AND CURRENTS AT C-9	FIGURE 2.5-22



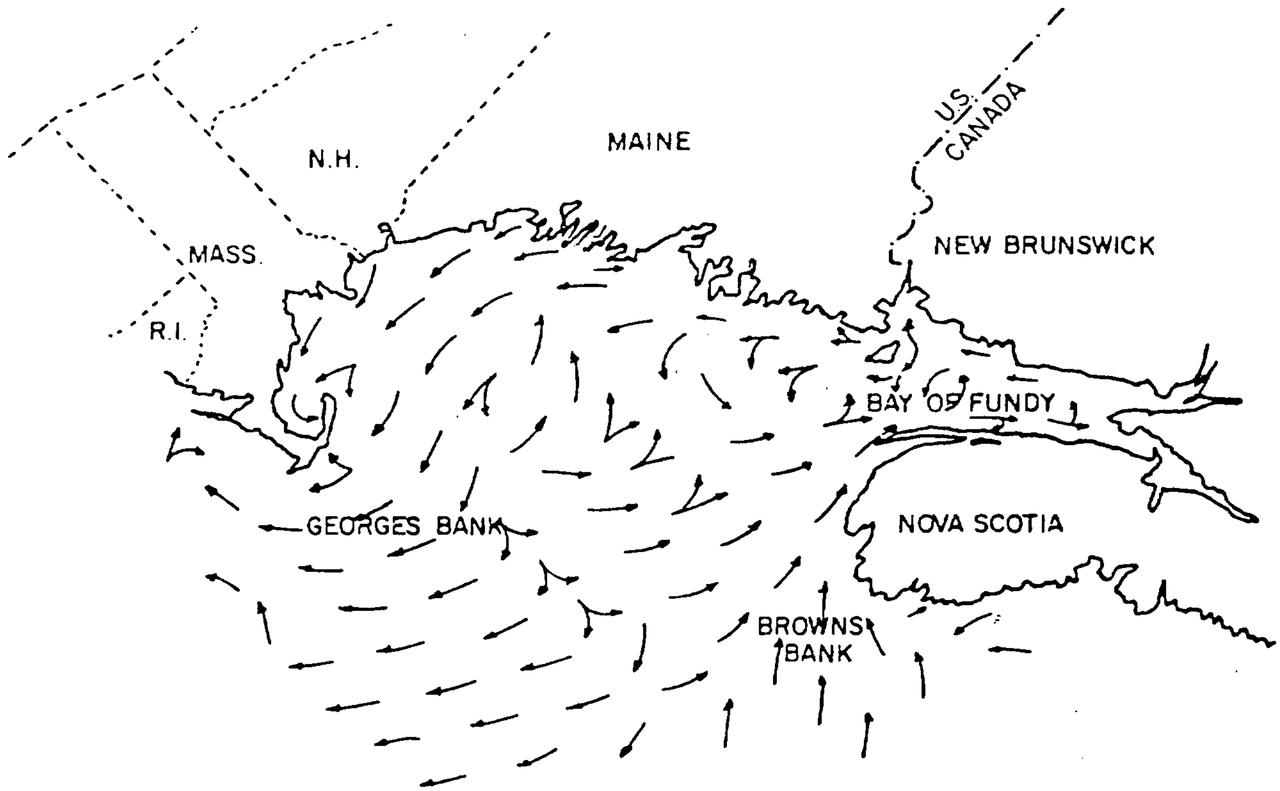
PSNH	DIURNAL VARIATIONS OF TEMPERATURE AND SALINITY	FIGURE
SEABROOK STATION	AT C-9	2.5-23



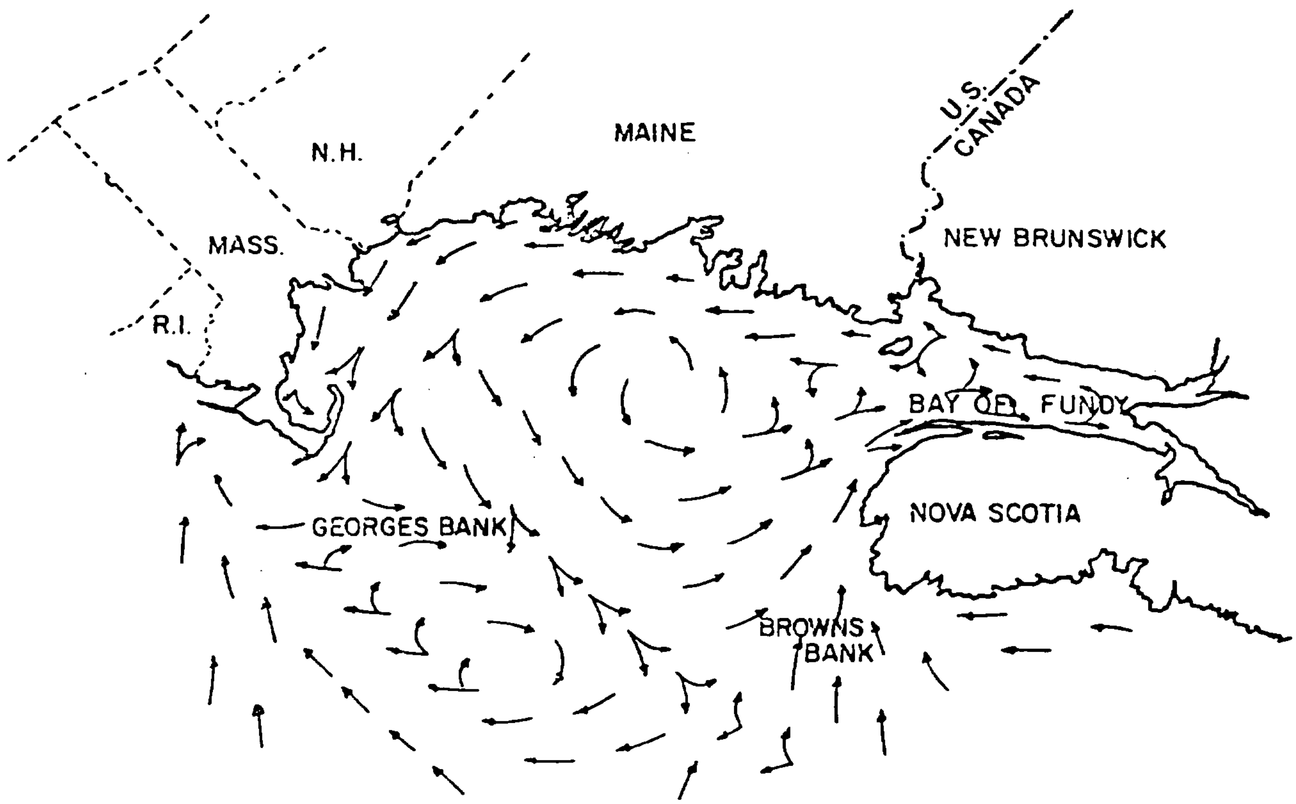
PSNH SEABROOK STATION	LOCATION MAP OF THE GULF OF MAINE	FIGURE 2.5-24



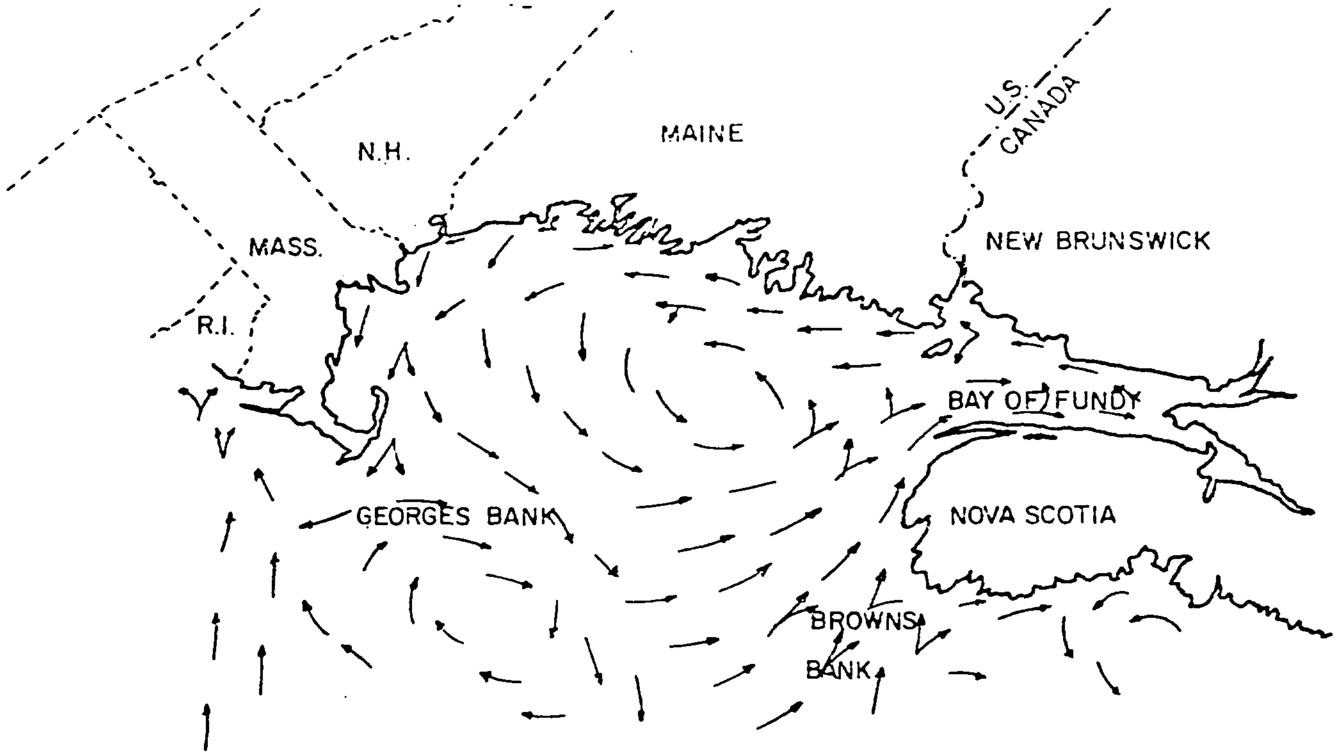
PSNH SEABROOK STATION	BATHYMETRY OF NEW HAMPSHIRE COASTAL WATERS	FIGURE 2.5-25



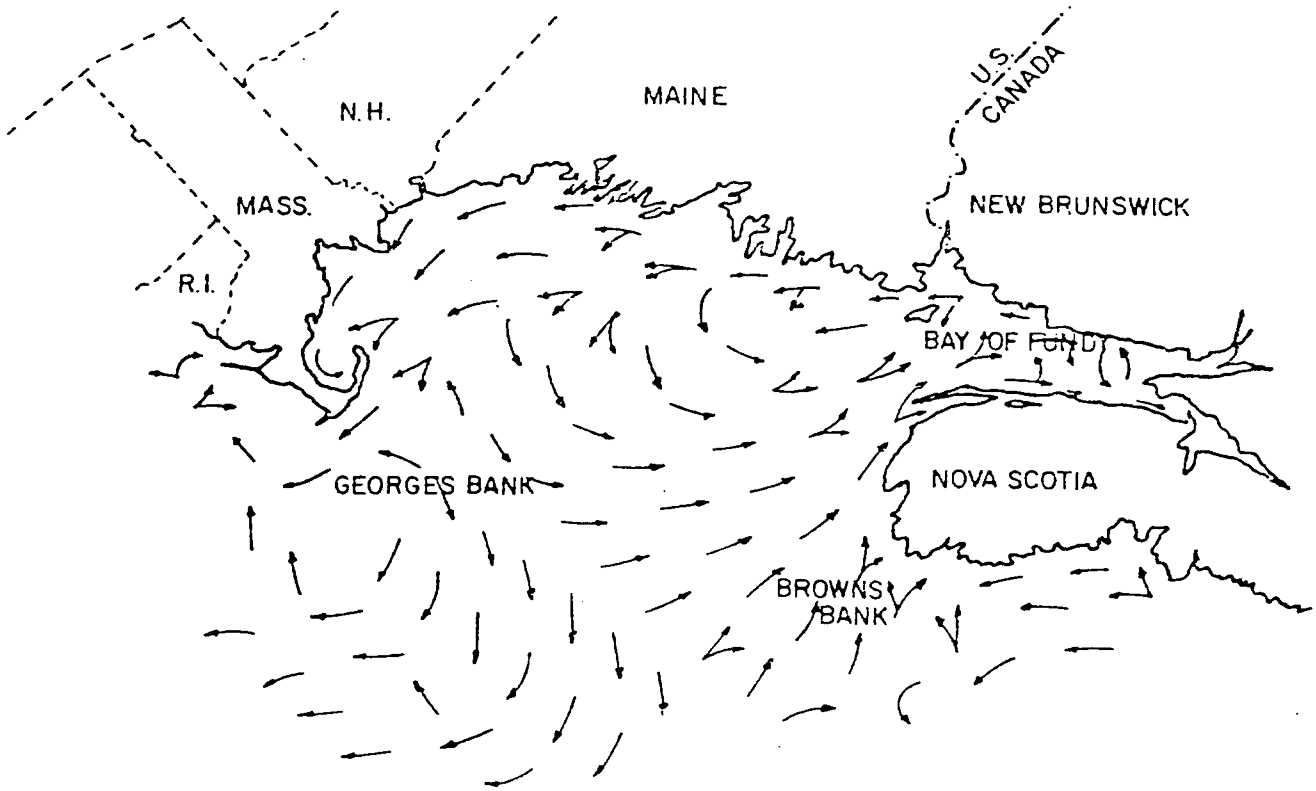
PSNH SEABROOK STATION	WINTER CIRCULATION PATTERN OF SURFACE WATERS IN THE GULF OF MAINE	FIGURE 2.5-26



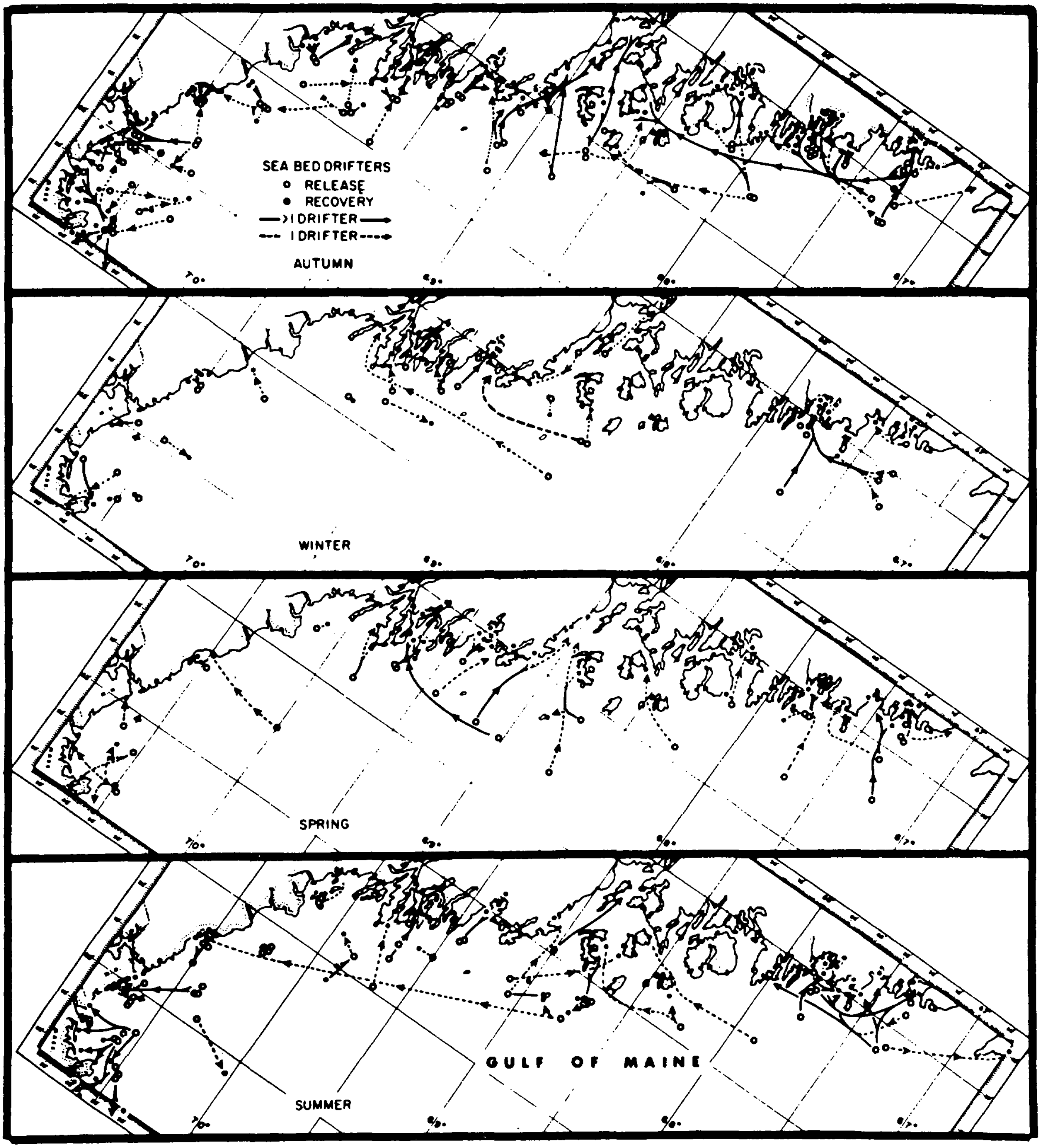
PSNH SEABROOK STATION	SPRING CIRCULATION PATTERN OF SURFACE WATERS IN THE GULF OF MAINE	FIGURE 2.5-27



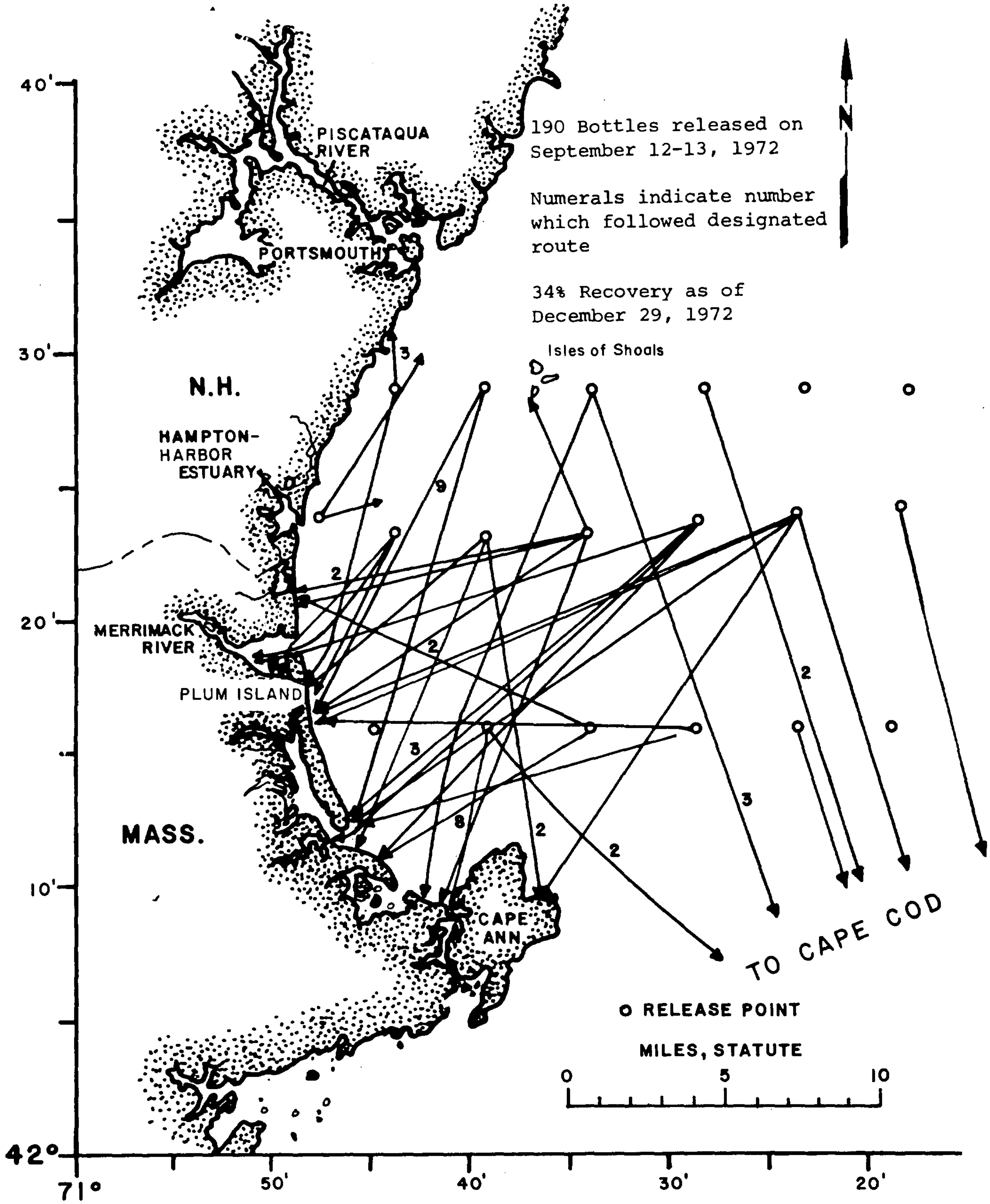
PSNH SEABROOK STATION	SUMMER CIRCULATION PATTERN OF SURFACE WATERS IN THE GULF OF MAINE	FIGURE 2.5-28



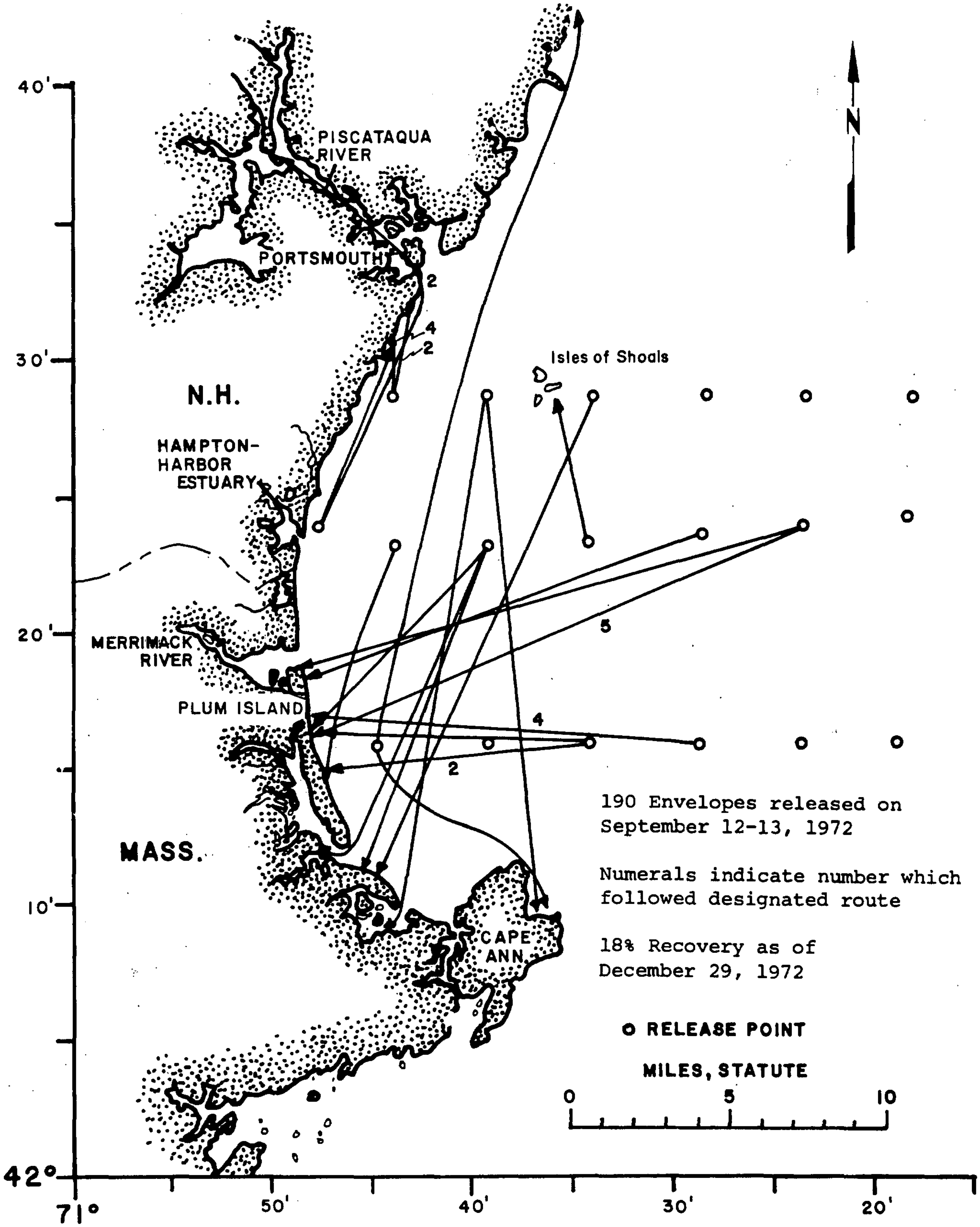
PSNH SEABROOK STATION	AUTUMN CIRCULATION PATTERN OF SURFACE WATERS IN THE GULF OF MAINE	FIGURE 2.5-29



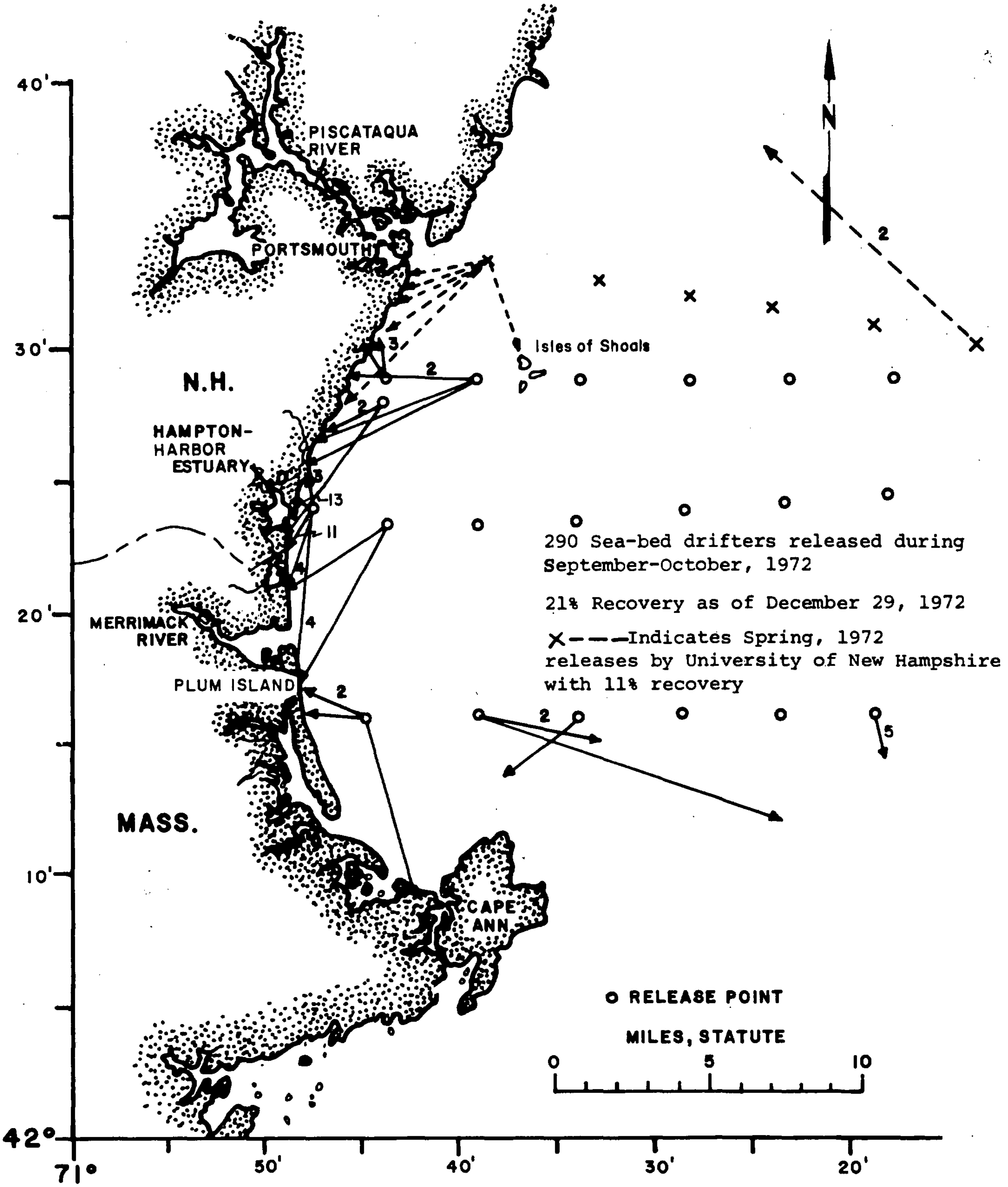
PSNH SEABROOK STATION	ASSUMED ROUTES OF SEABED DRIFTERS	FIGURE 2.5-30



PSNH SEABROOK STATION	ASSUMED DRIFT ROUTES OF DRIFT BOTTLES	FIGURE 2.5-31



PSNH SEABROOK STATION	ASSUMED DRIFT ROUTES OF POLYETHYLENE DRIFT ENVELOPES	FIGURE 2.5-32

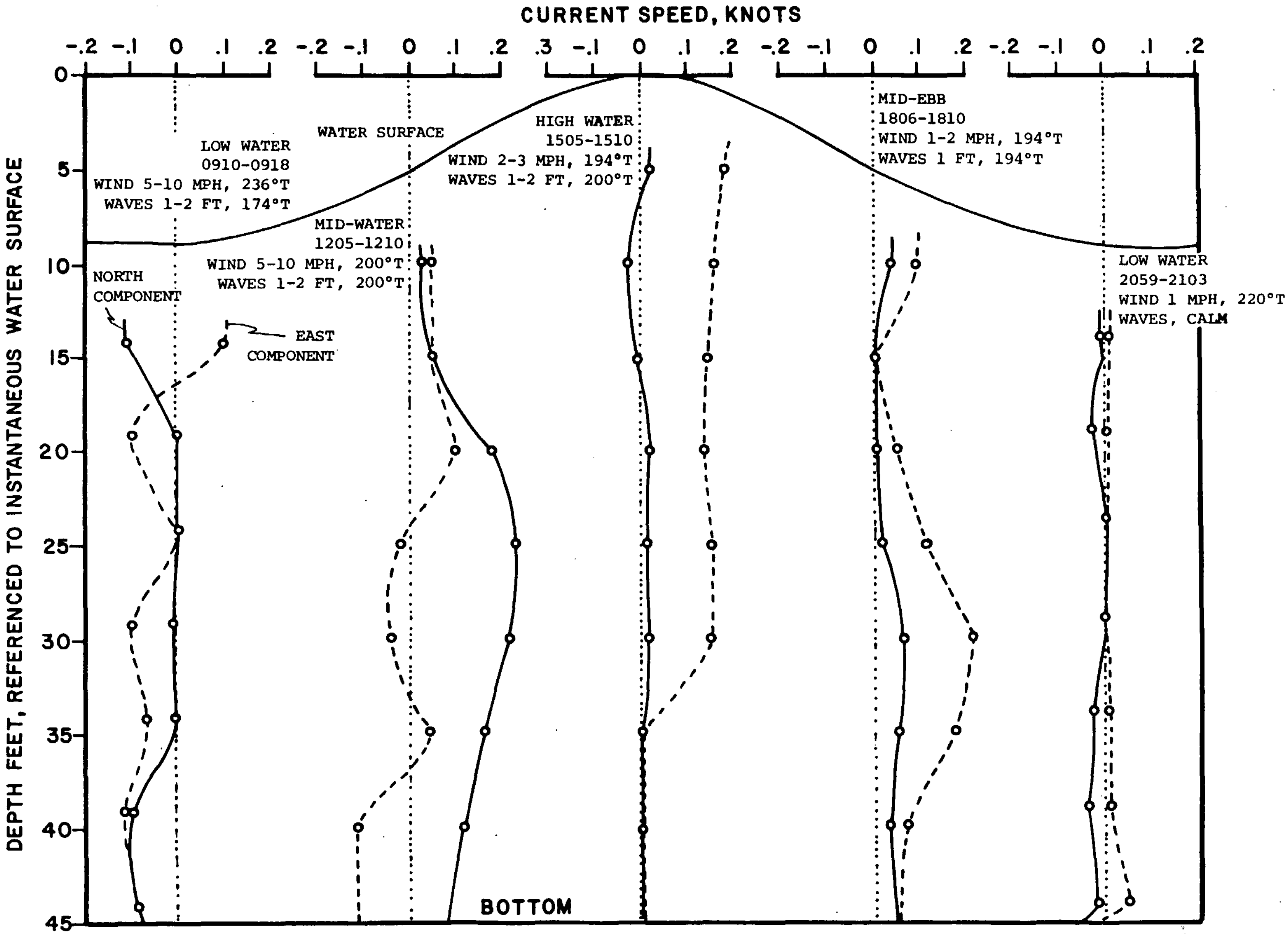


PSNH SEABROOK STATION	ASSUMED DRIFT ROUTES OF SEABED DRIFTERS	FIGURE 2.5-33

PSNH
SEABROOK STATION

CURRENT VELOCITY PROFILE NEAR PROPOSED DISCHARGE
POINT NEAP TIDE

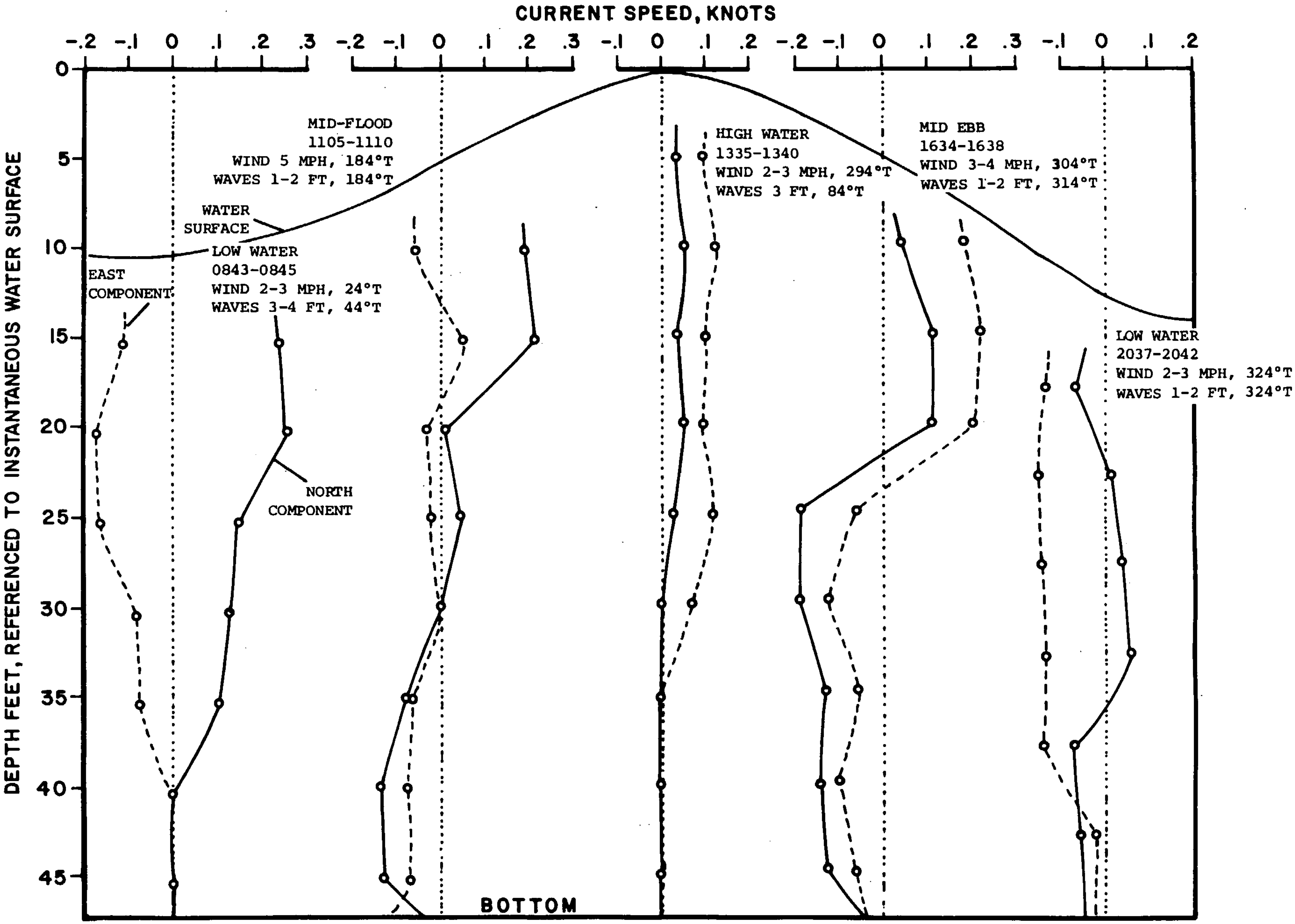
FIGURE
2.5-34

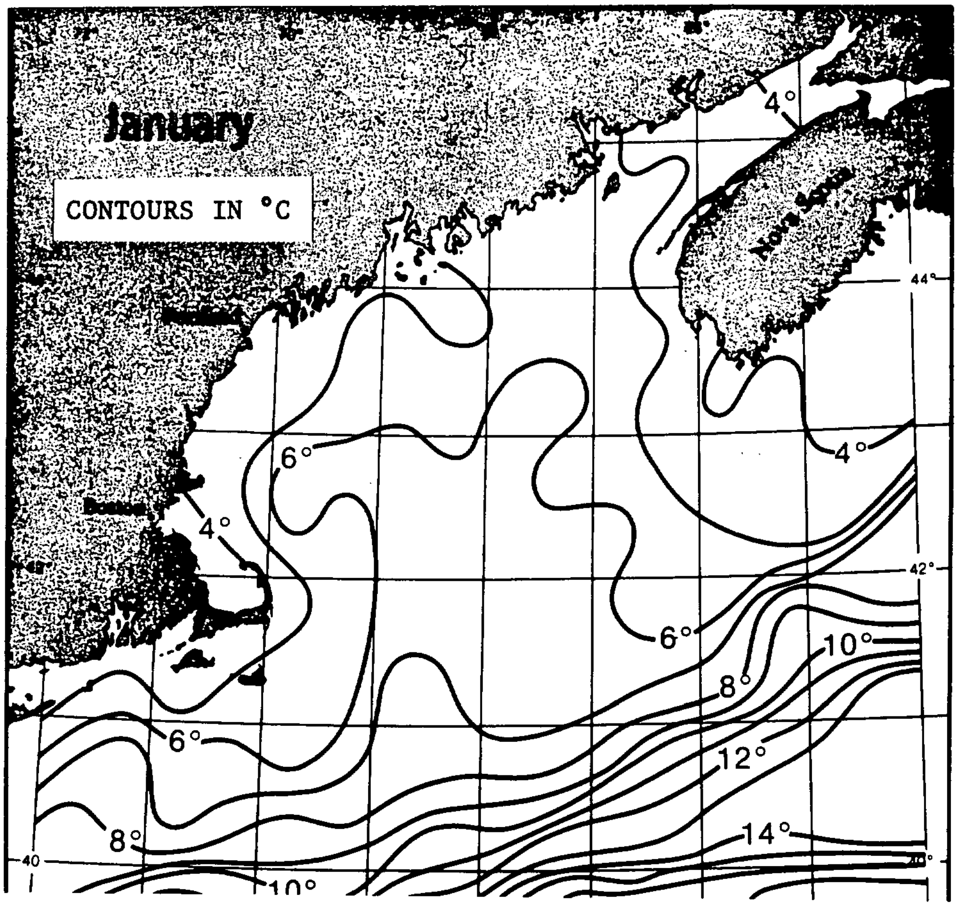


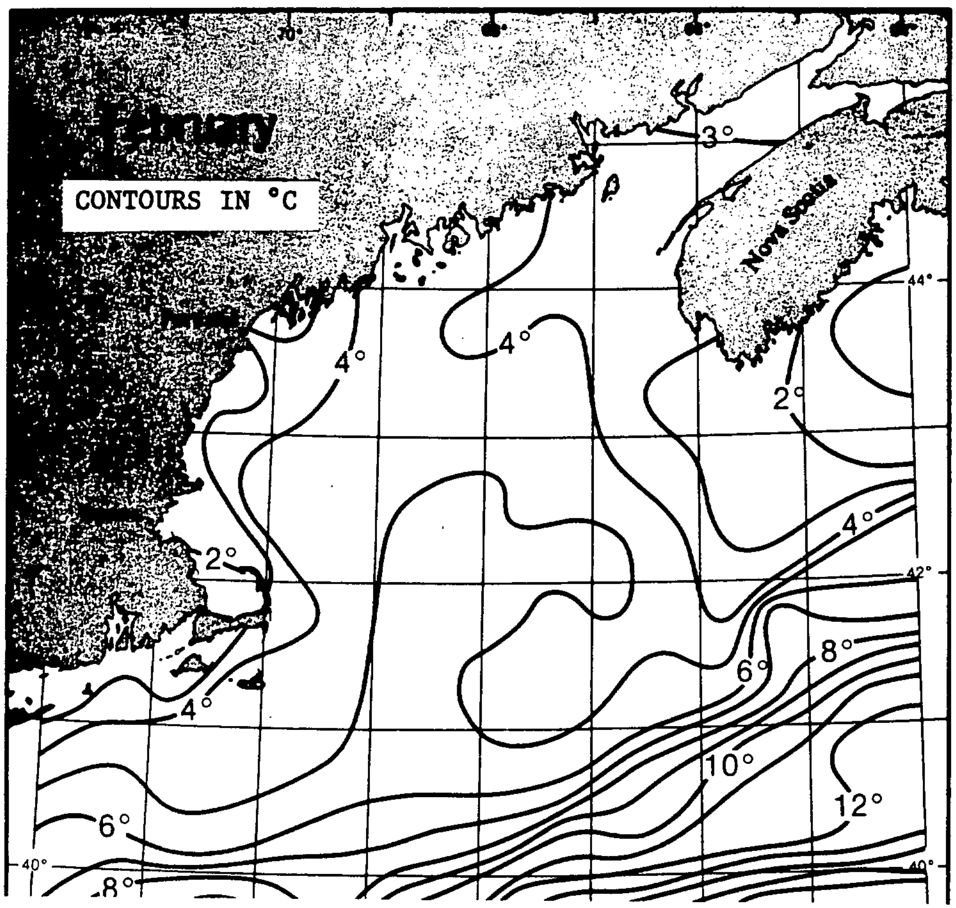
PSNH
SEABROOK STATION

CURRENT VELOCITY PROFILE NEAR PROPOSED DISCHARGE POINT SPRING TIDE

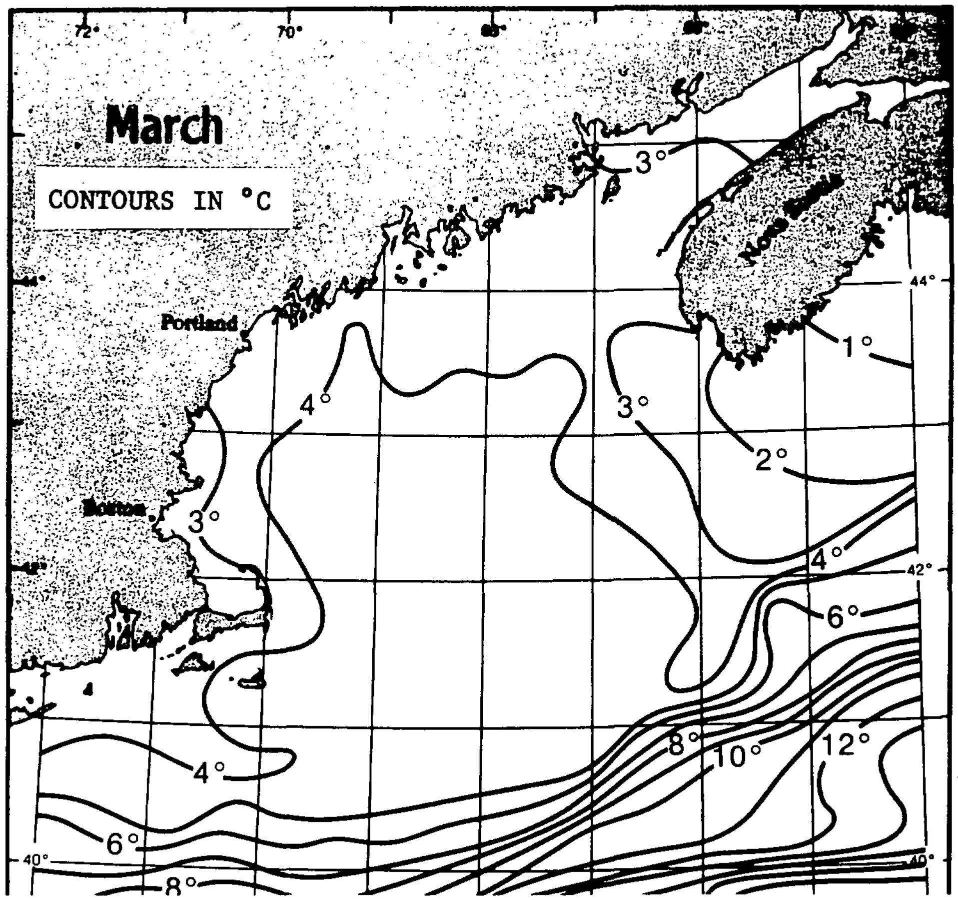
FIGURE 2.5-35

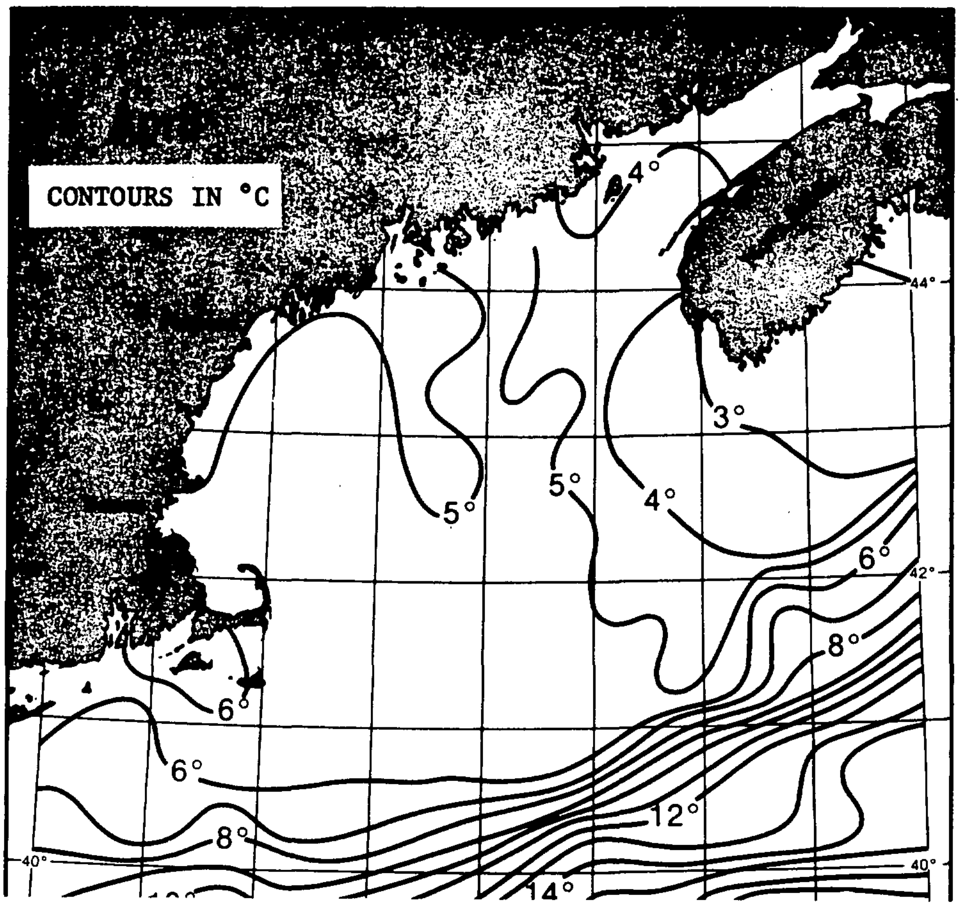




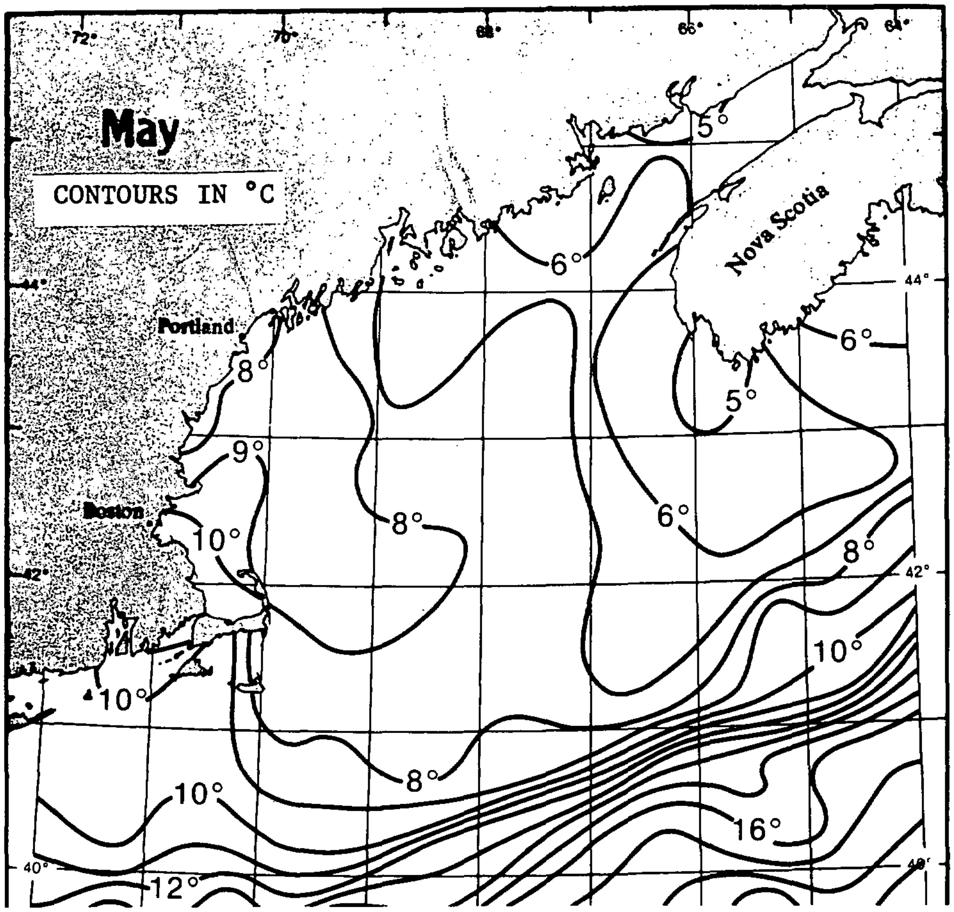


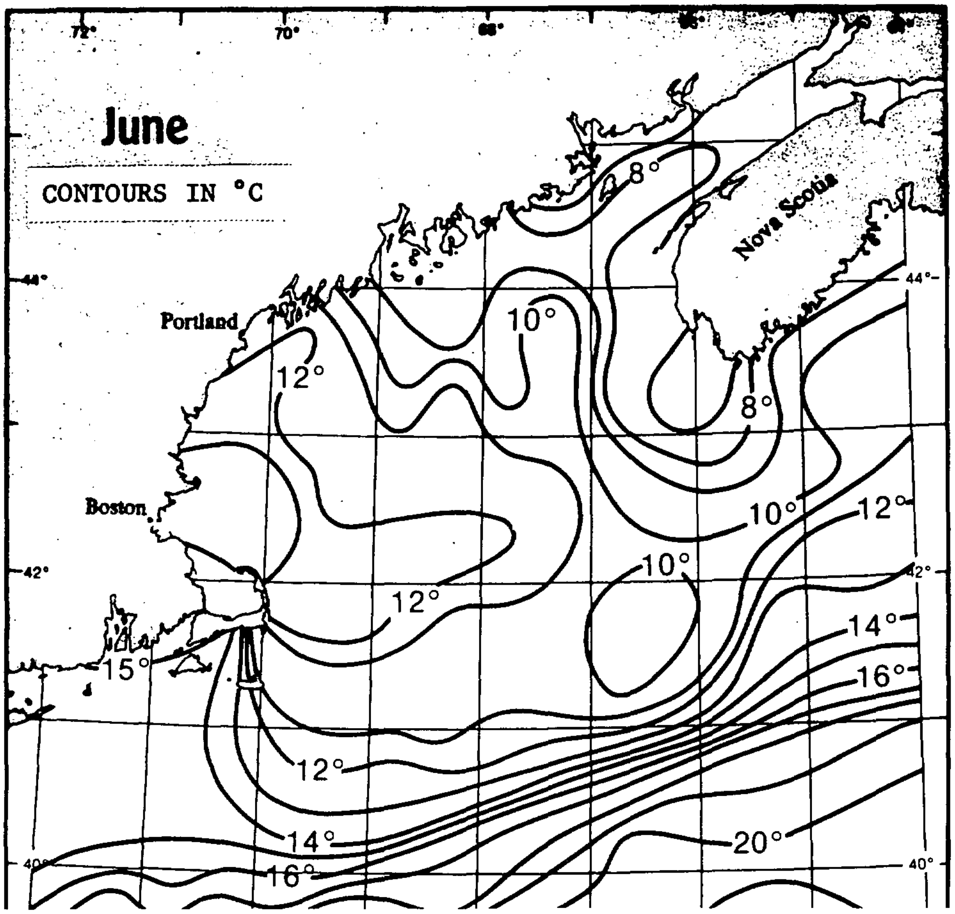
PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-36



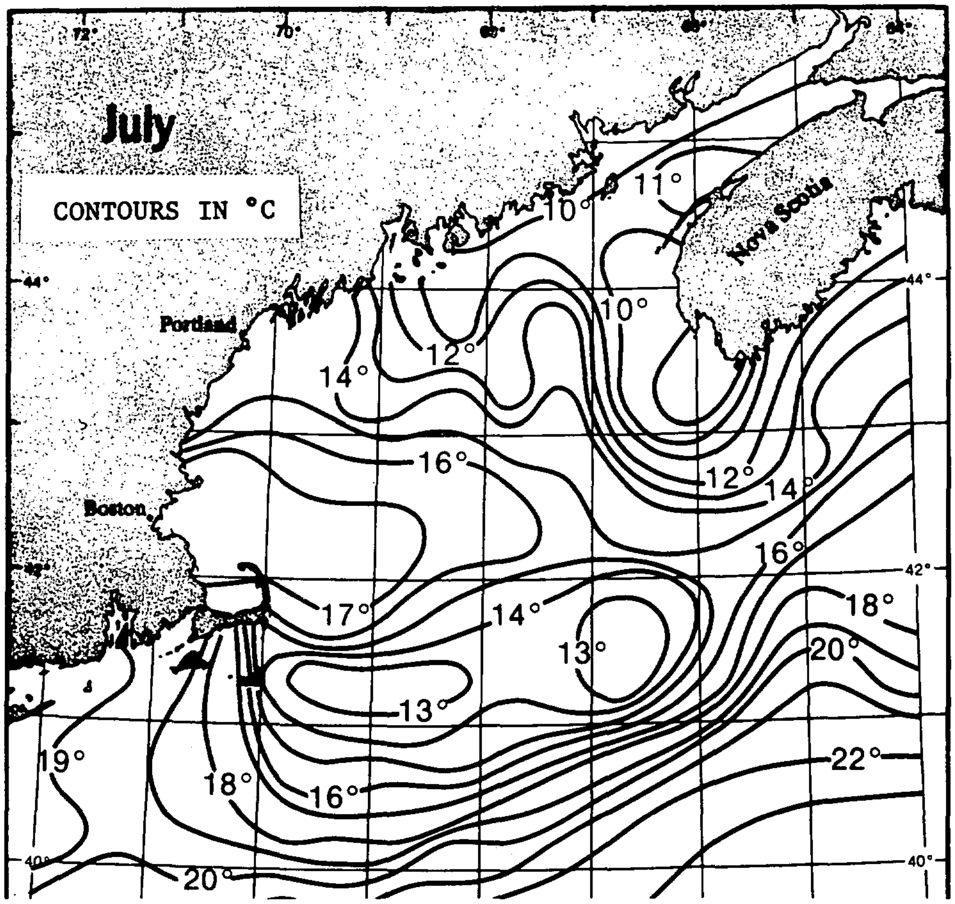


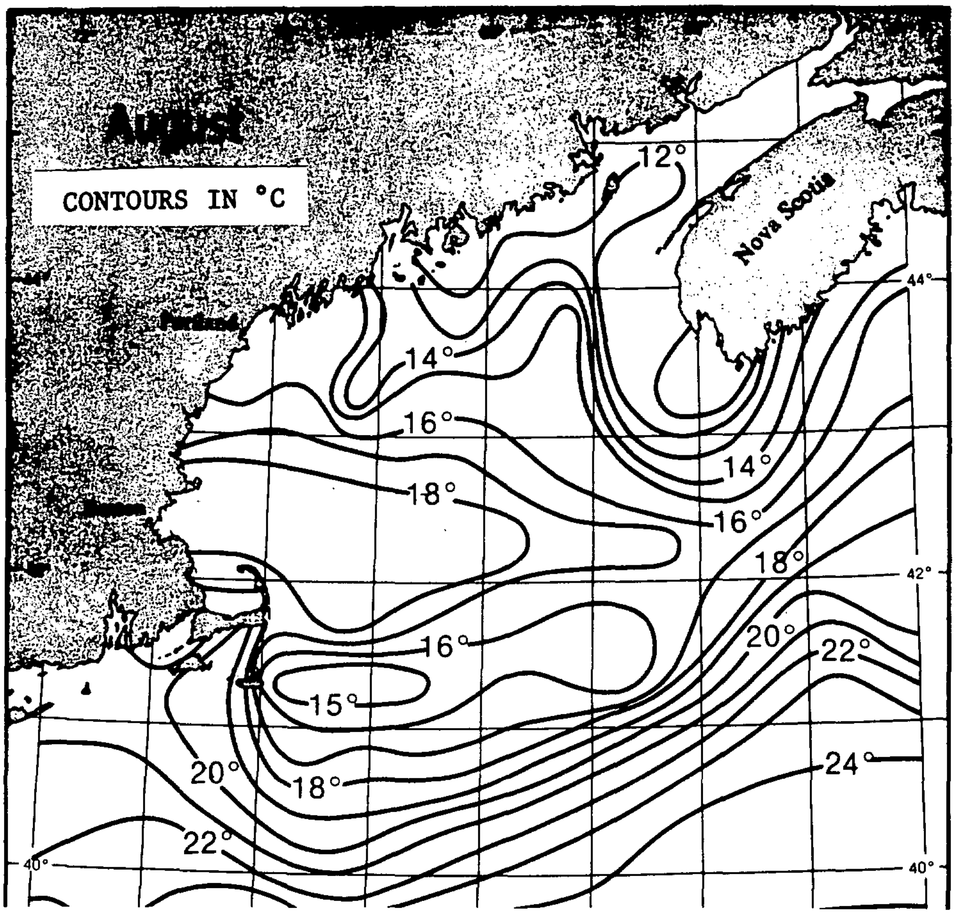
PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-37



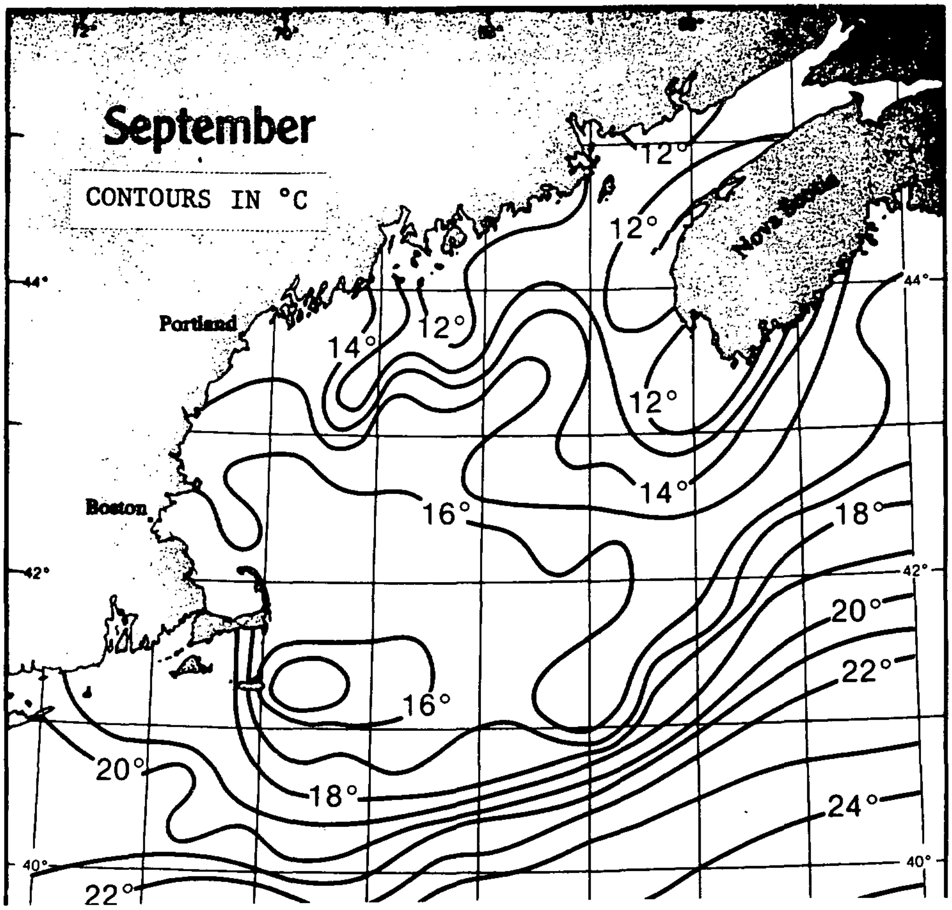


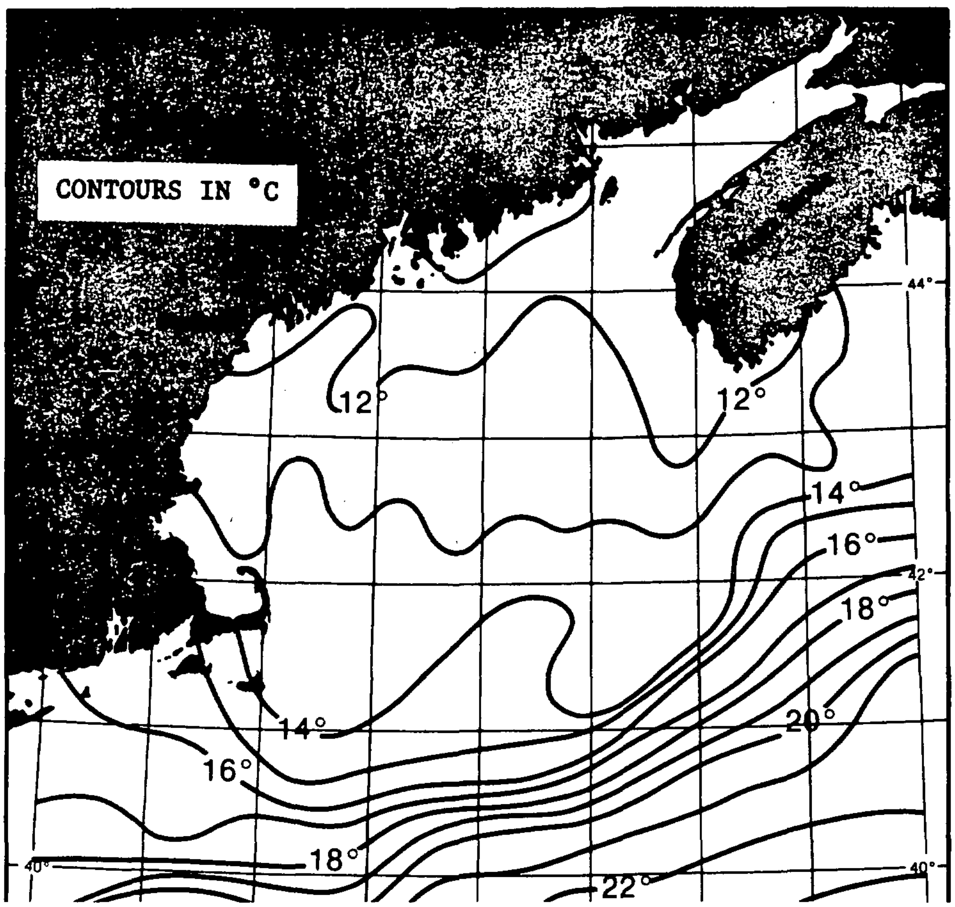
PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-38



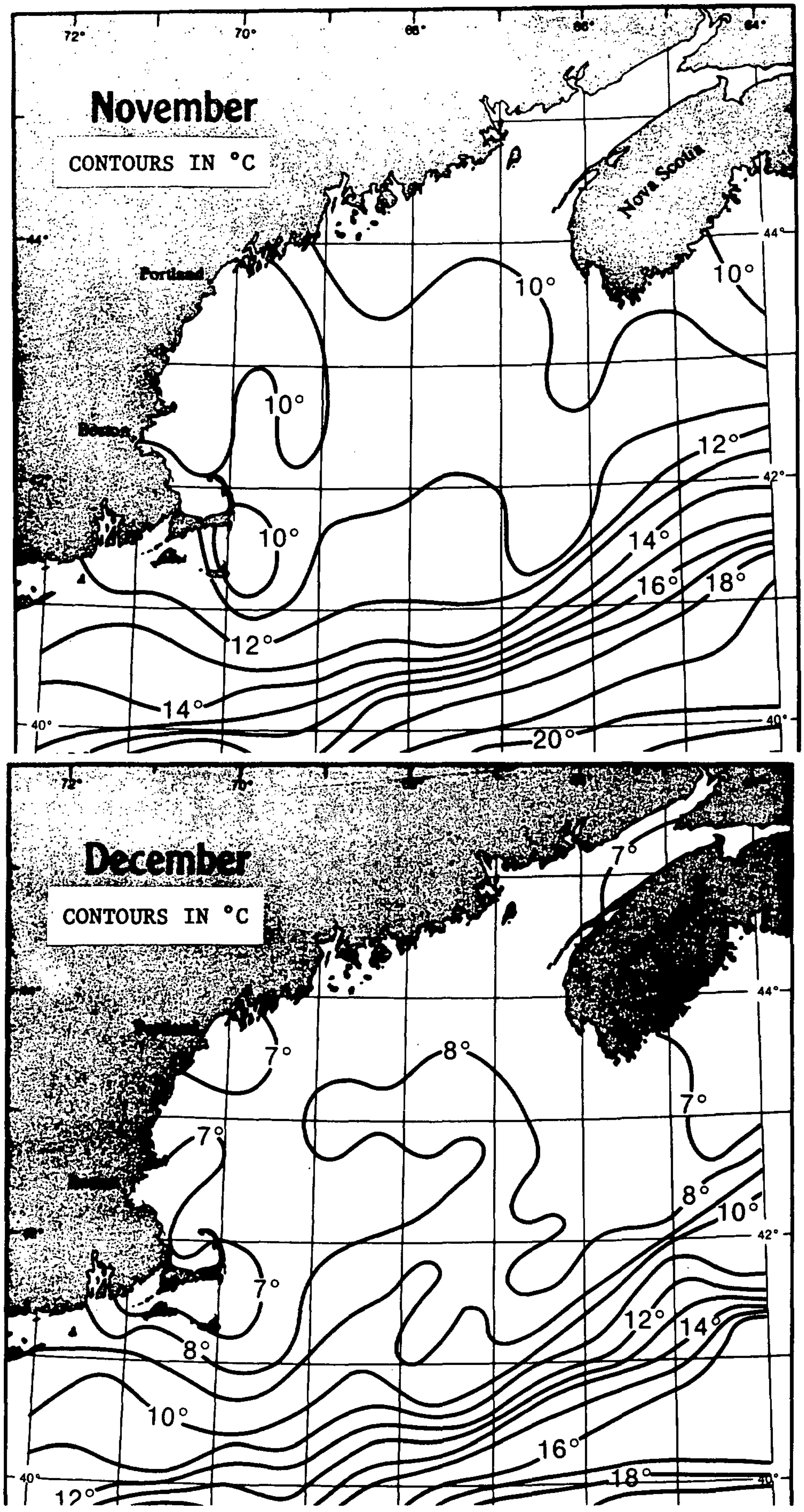


PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-39

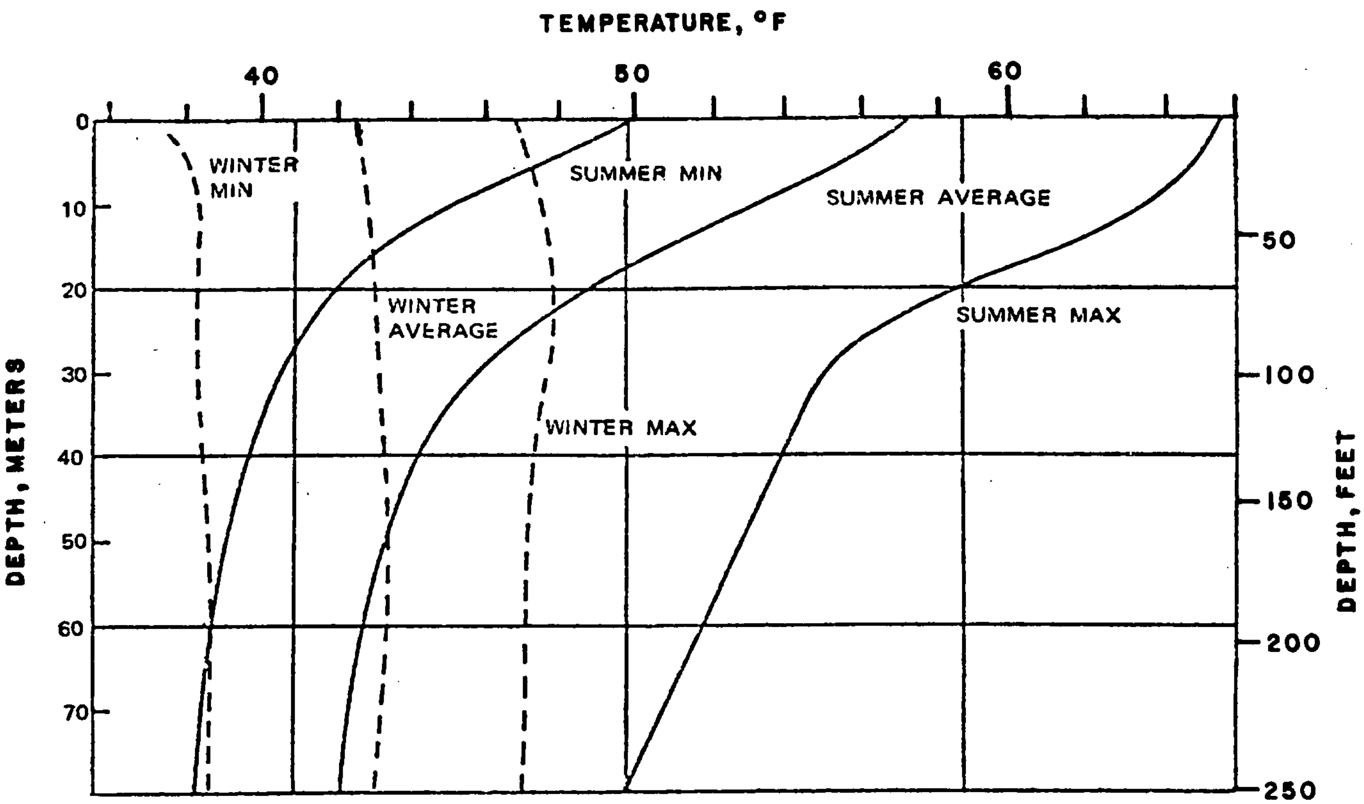




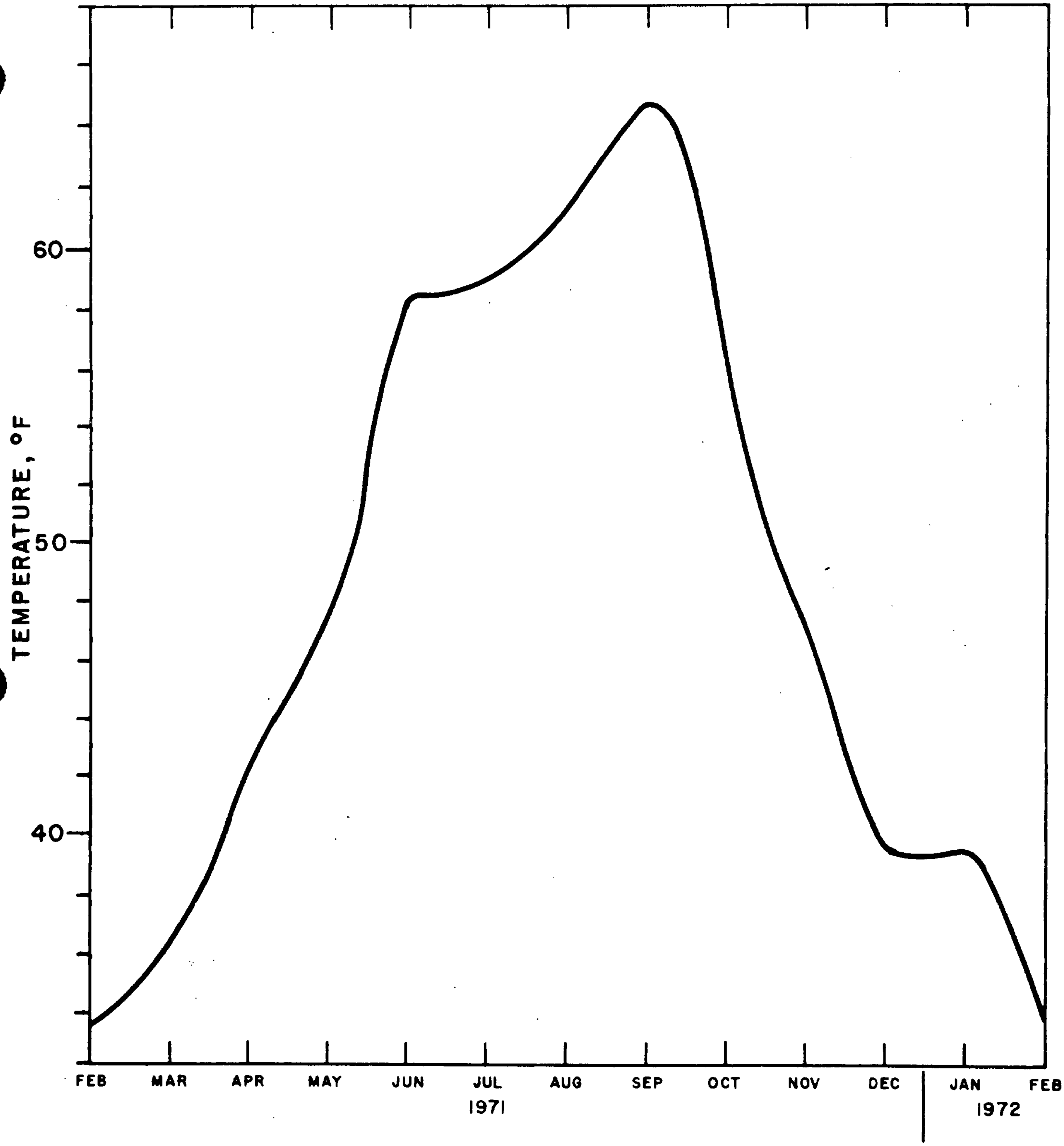
PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-40



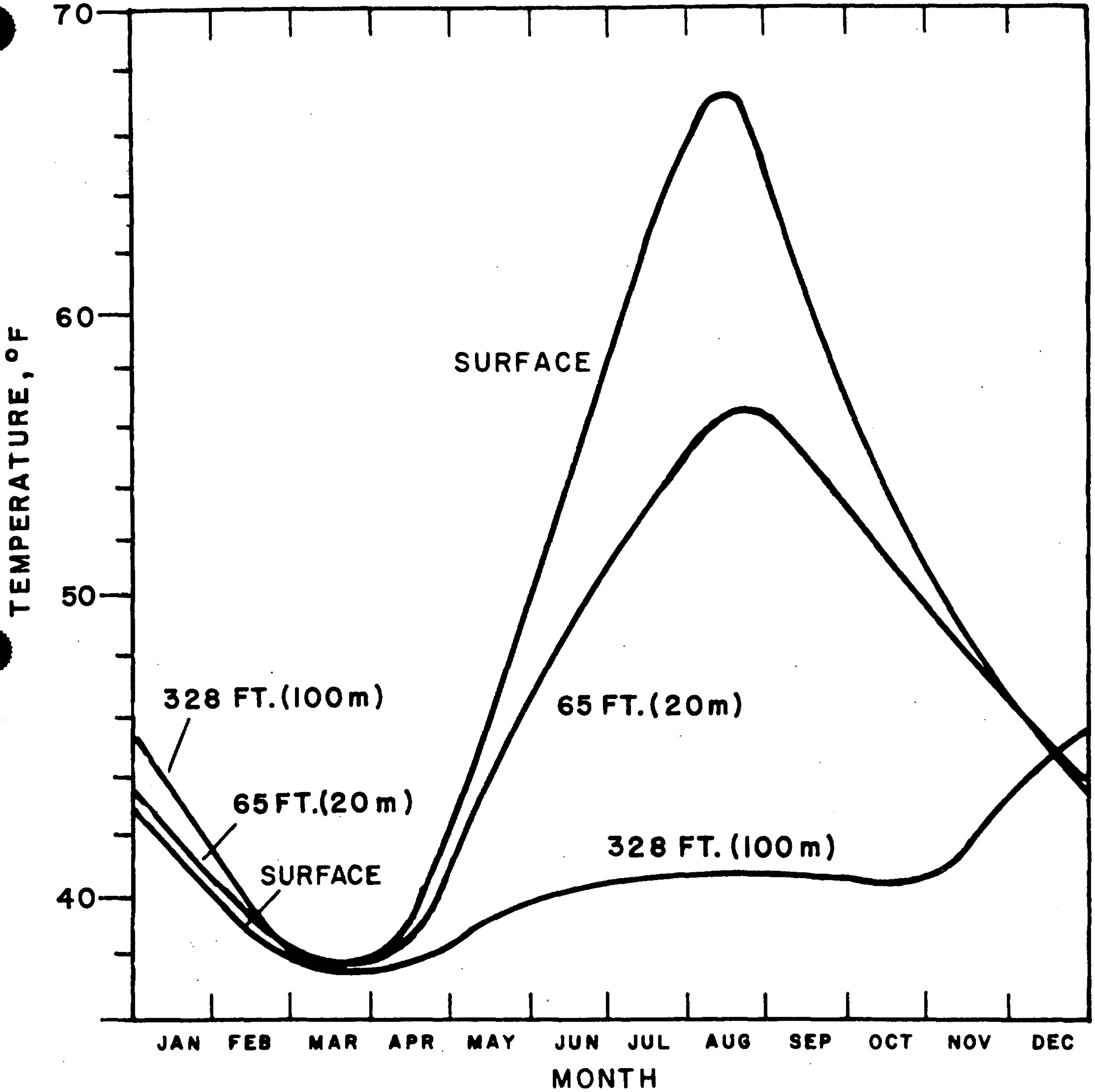
PSNH SEABROOK STATION	AVERAGE MONTHLY SURFACE WATER TEMPERATURES IN THE GULF OF MAINE	FIGURE 2.5-41



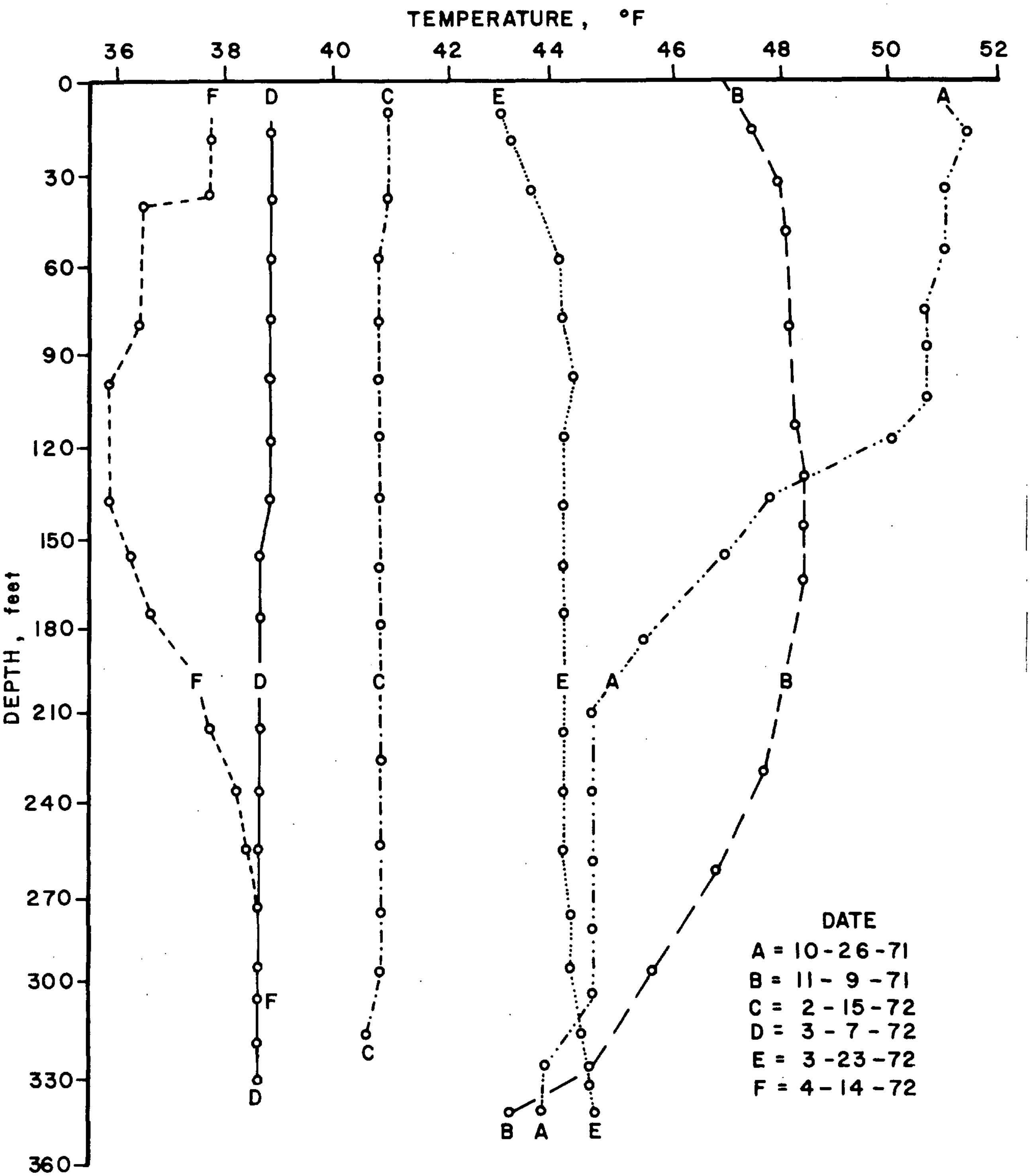
PSNH SEABROOK STATION	SUMMER AND WINTER TEMPERATURE PROFILES IN THE GULF OF MAINE	FIGURE 2.5-42



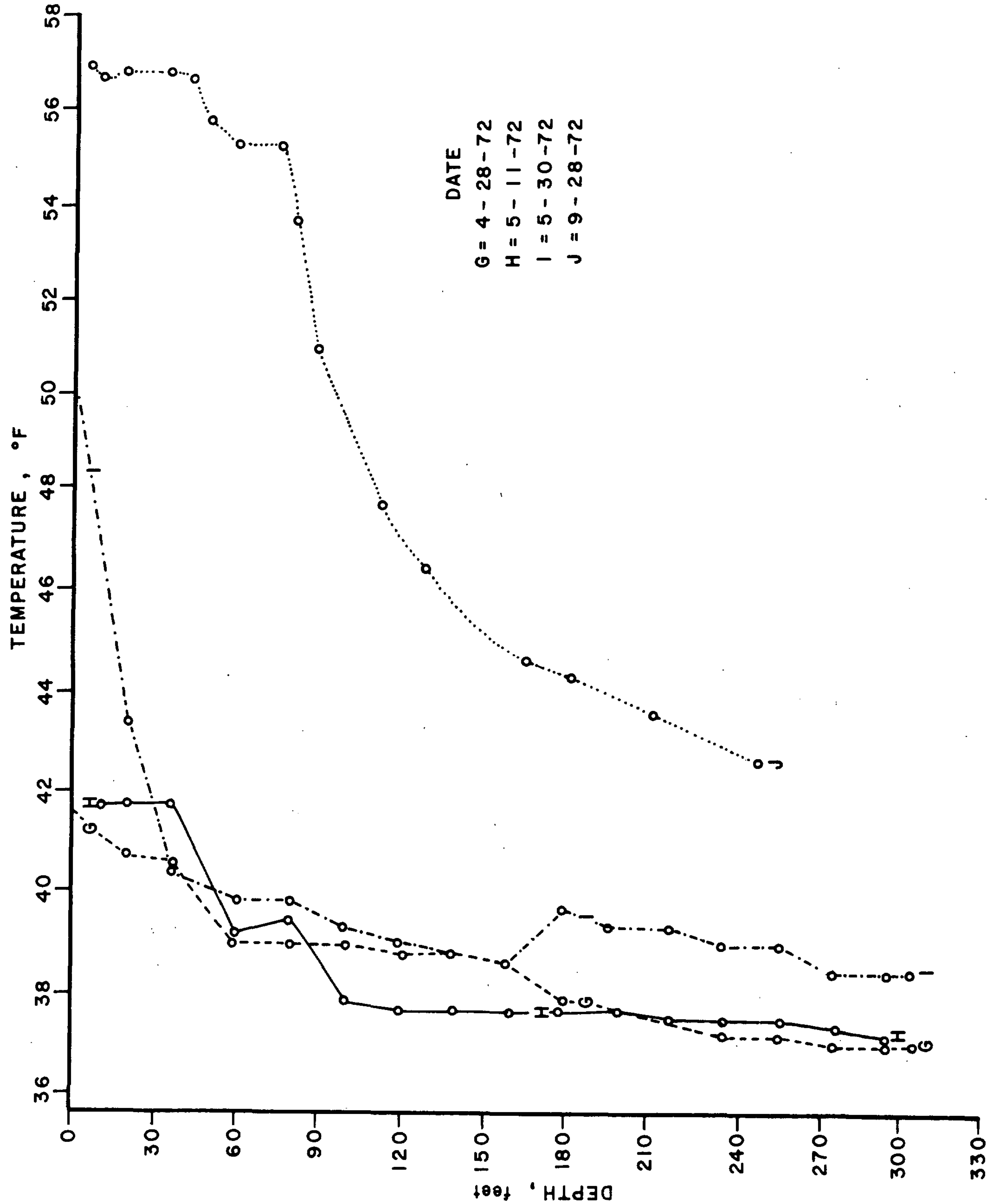
PSNH SEABROOK STATION	SEA-SURFACE TEMPERATURE VERSUS MONTHS AT HODGKINS COVE	FIGURE 2.5-43



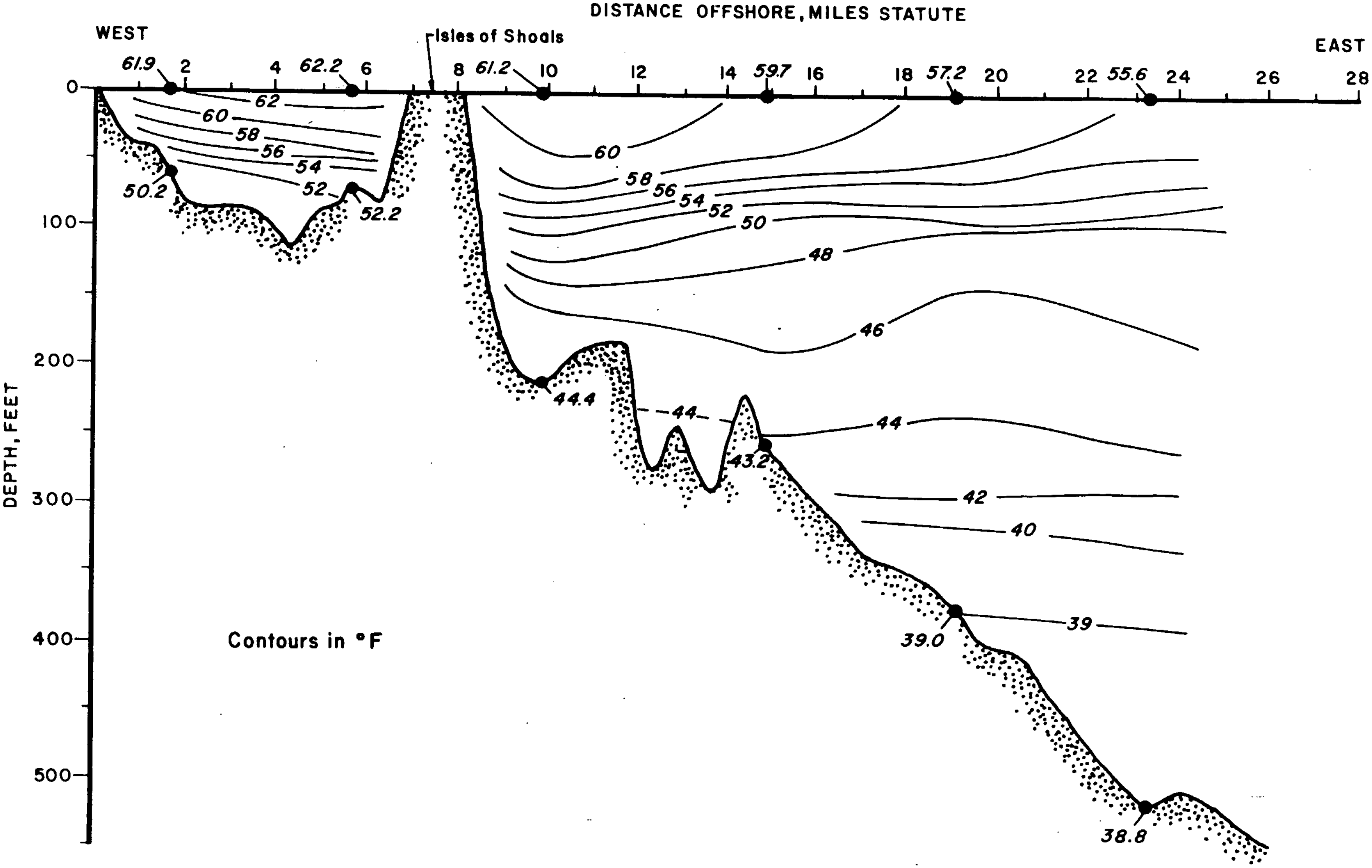
PSNH SEABROOK STATION	SEASONAL VARIATIONS IN WATER TEMPERATURE OFF CAPE ANN	FIGURE 2.5-44



PSNH SEABROOK STATION	TEMPERATURE PROFILES NORTHEAST OF THE ISLES OF SHOALS	FIGURE 2.5-45



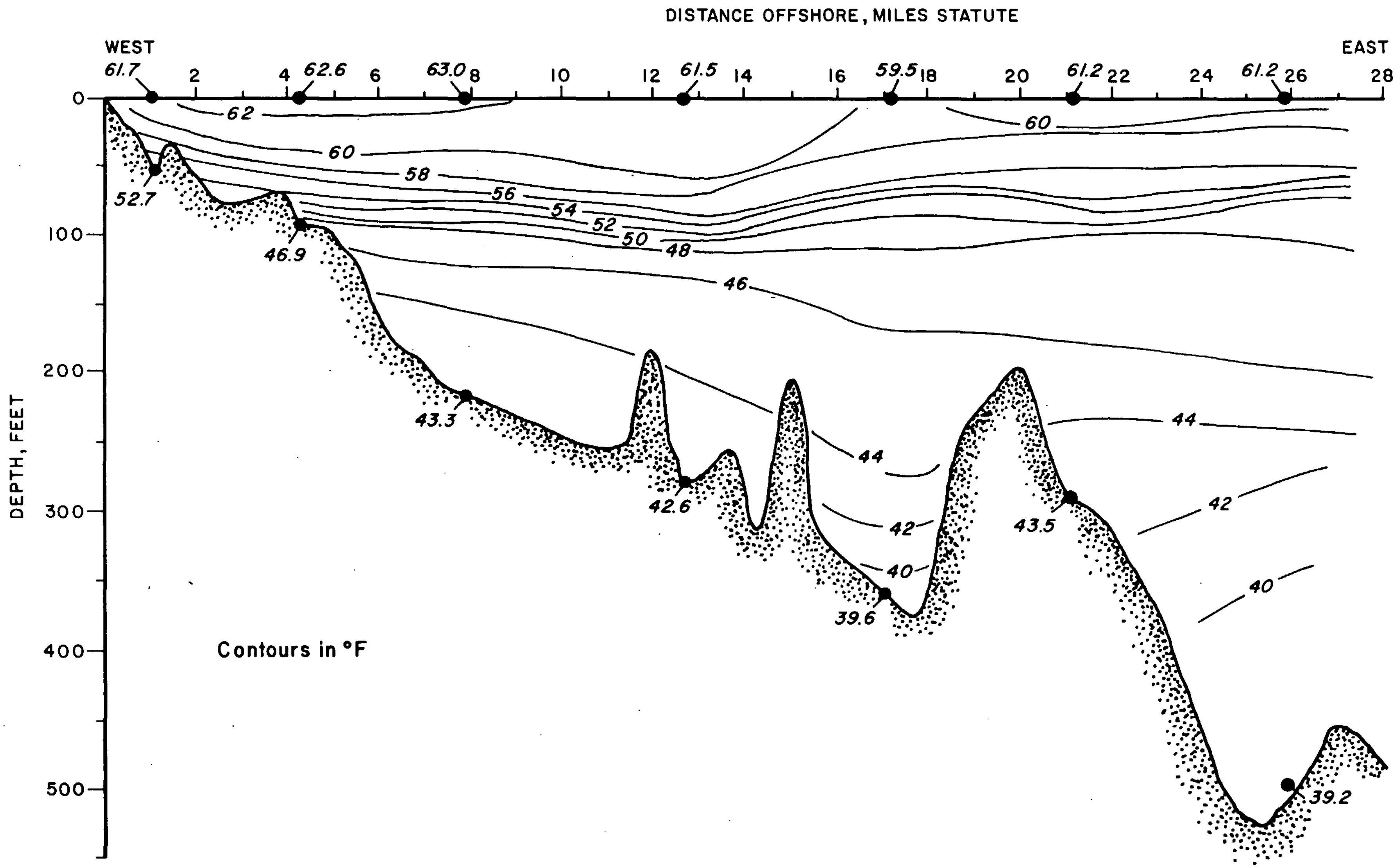
PSNH SEABROOK STATION	TEMPERATURE PROFILES NORTHEAST OF THE ISLES OF SHOALS	FIGURE 2.5-46



PSNH
SEABROOK STATION

CROSS-SECTION OF WATER TEMPERATURES IN A TRANSECT THROUGH THE ISLES OF SHOALS

FIGURE 2.5-47



PSNH
SEABROOK STATION

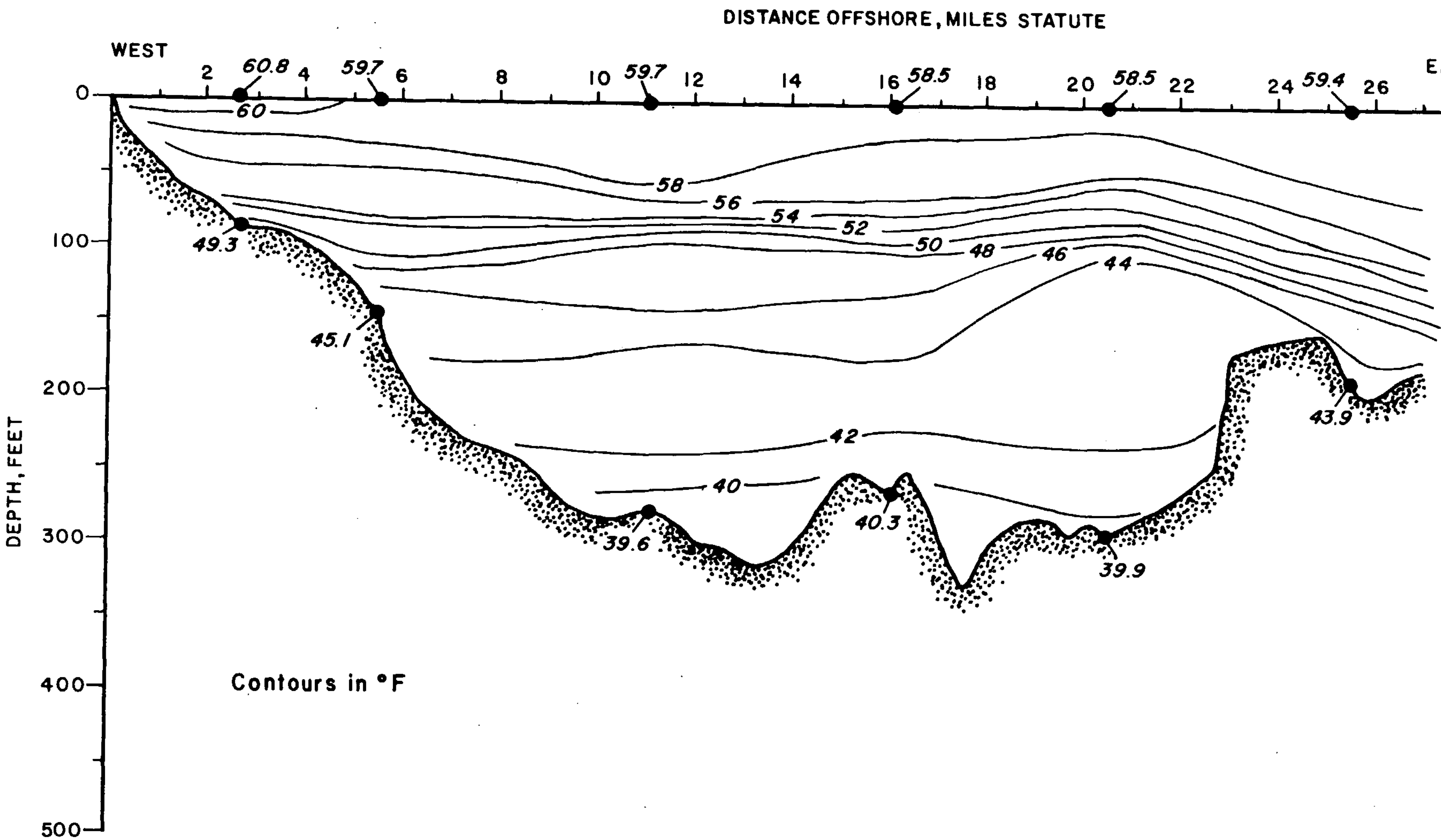
CROSS-SECTION OF WATER TEMPERATURES IN A TRANSECT OFF HAMPTON HARBOR ESTUARY

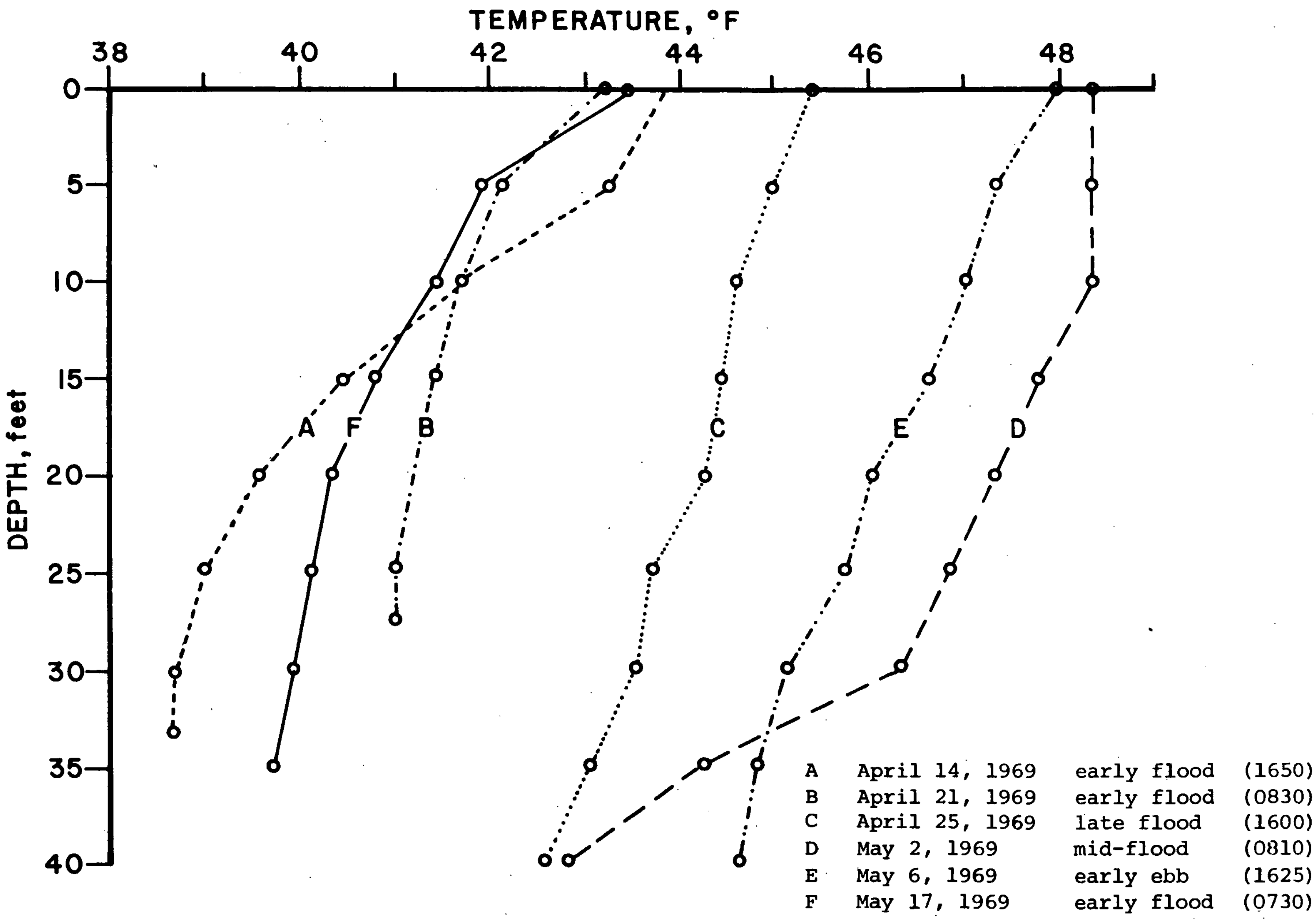
FIGURE 2.5-48

PSNH
SEABROOK STATION

CROSS-SECTION OF WATER TEMPERATURES IN A TRANSECT OFF PLUM ISLAND

FIGURE 2.5-49

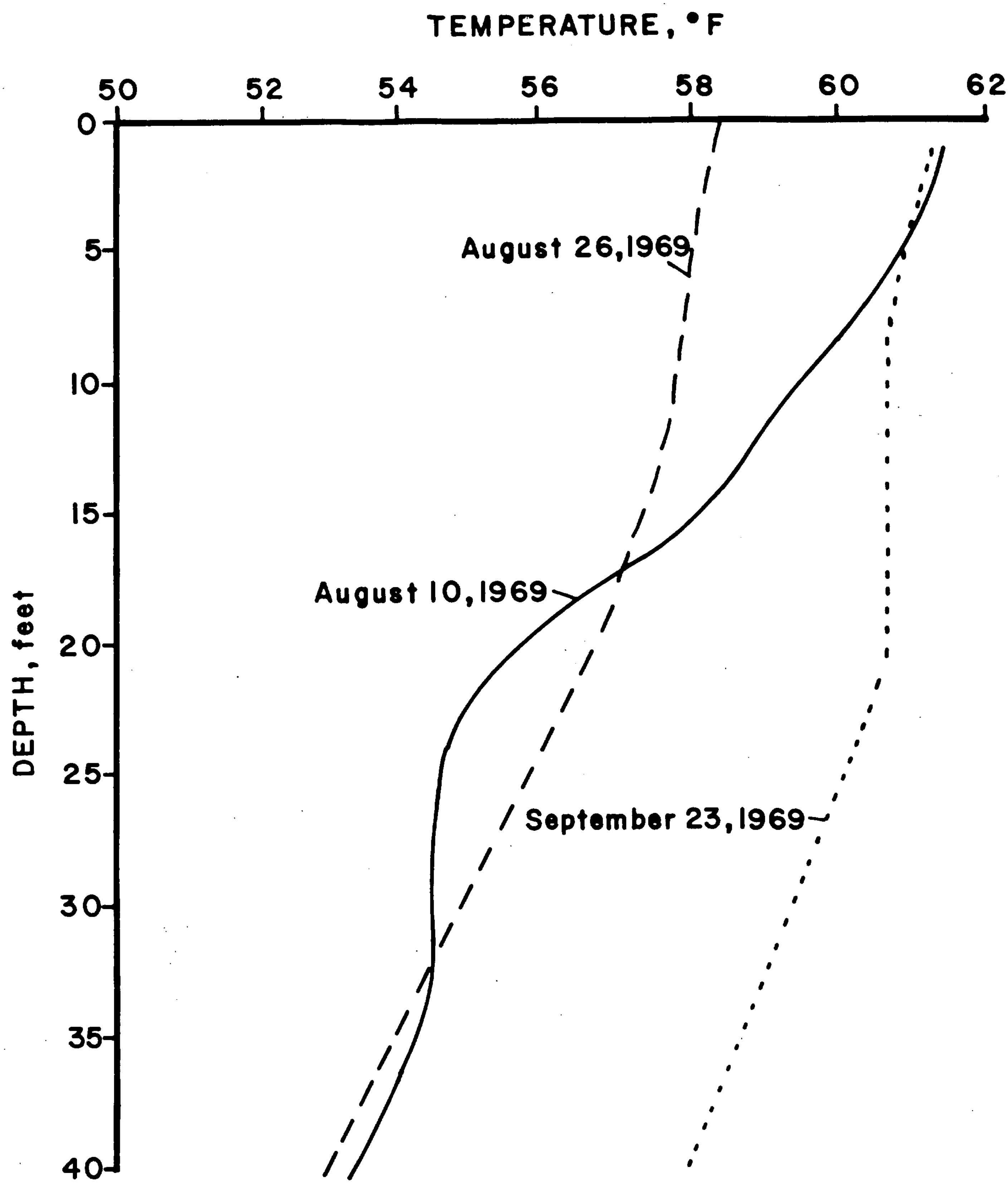




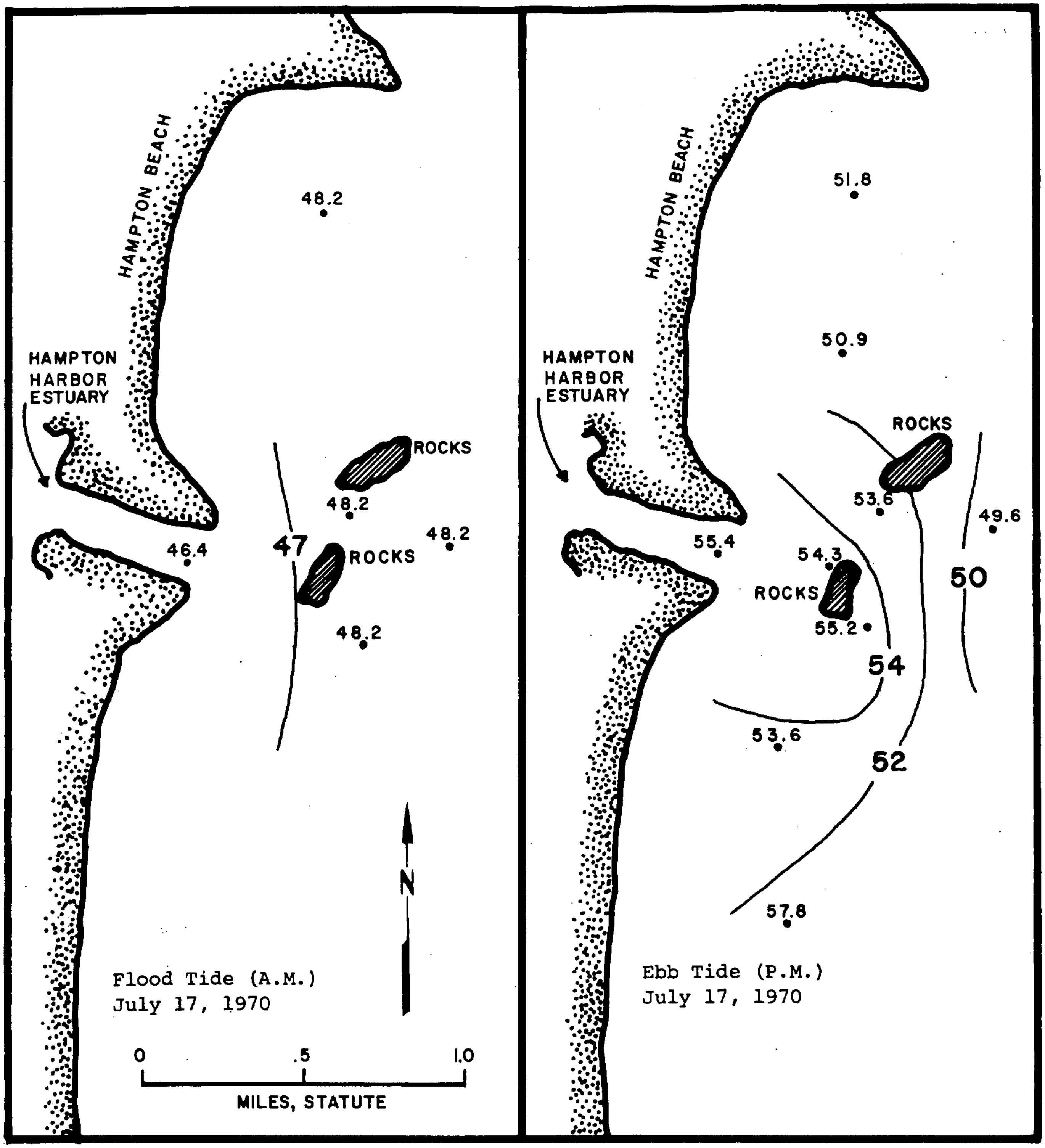
PSNH
SEABROOK STATION

TEMPERATURE PROFILES NEAR PROPOSED DISCHARGE AREA

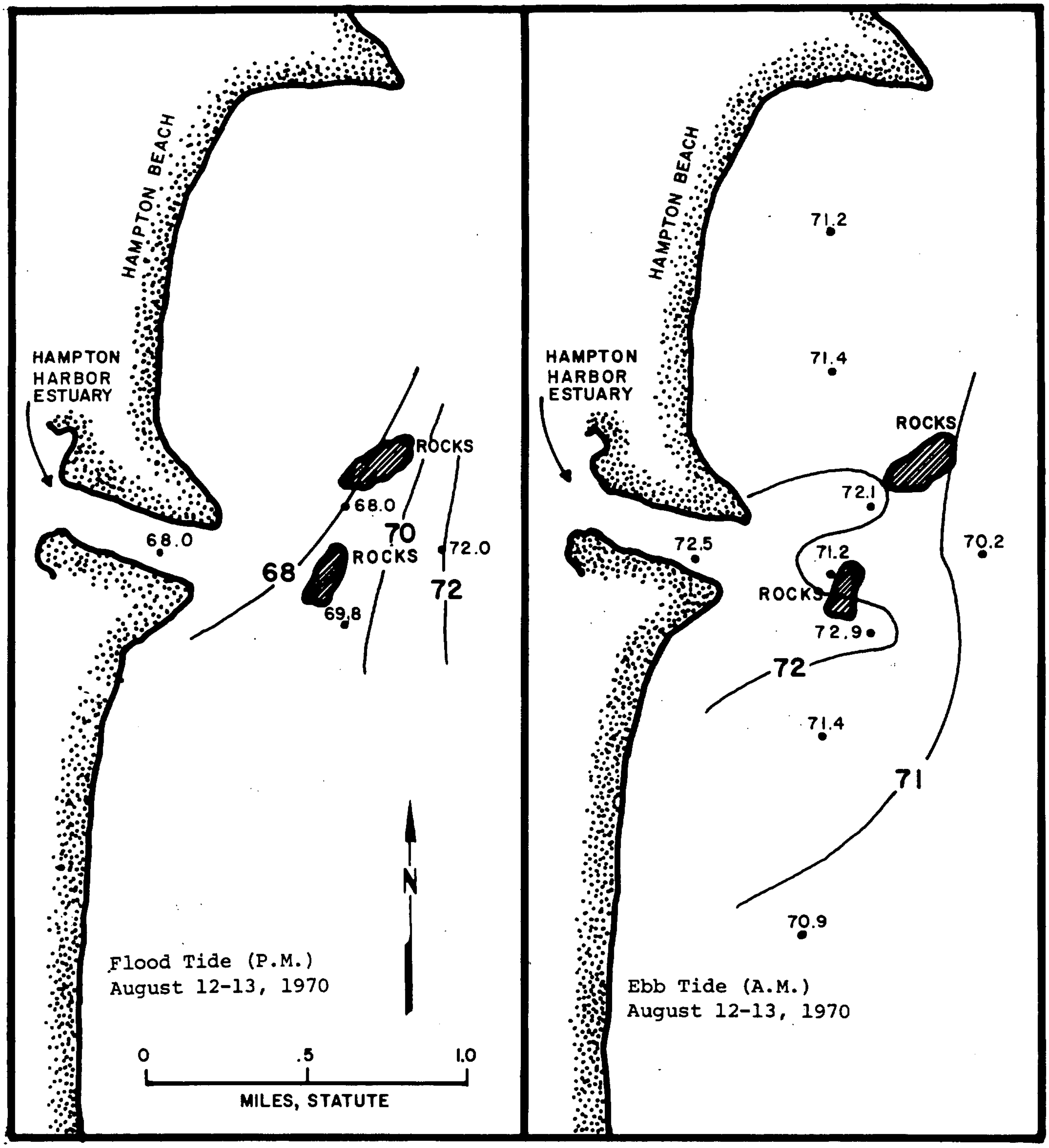
FIGURE 2.5-50



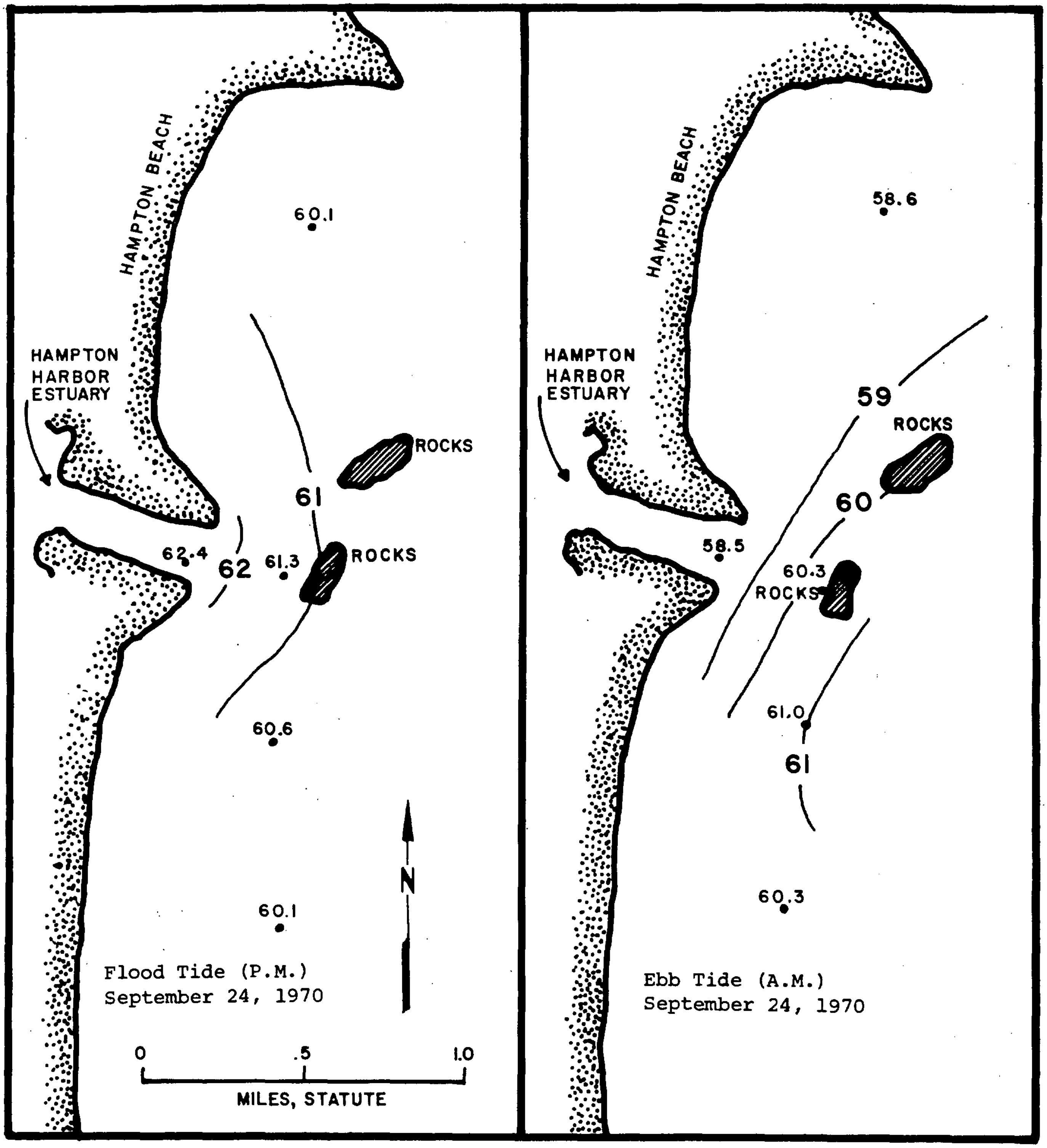
PSNH SEABROOK STATION	TEMPERATURE PROFILES NEAR PROPOSED DISCHARGE AREA	FIGURE 2.5-51



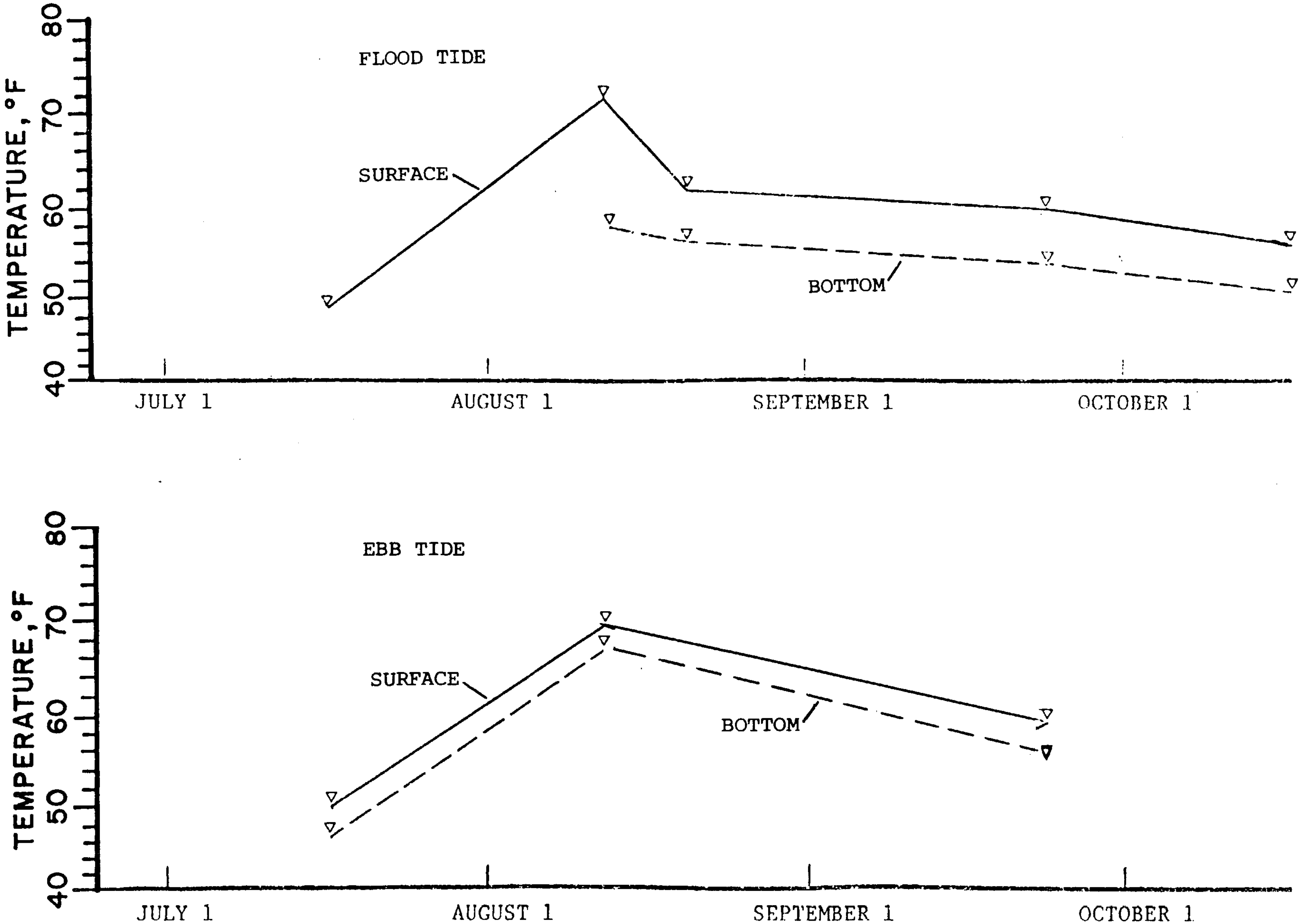
PSNH SEABROOK STATION	SURFACE WATER TEMPERATURES DURING A TIDAL CYCLE	FIGURE 2.5-52



PSNH SEABROOK STATION	SURFACE WATER TEMPERATURES DURING A TIDAL CYCLE	FIGURE 2.5-53



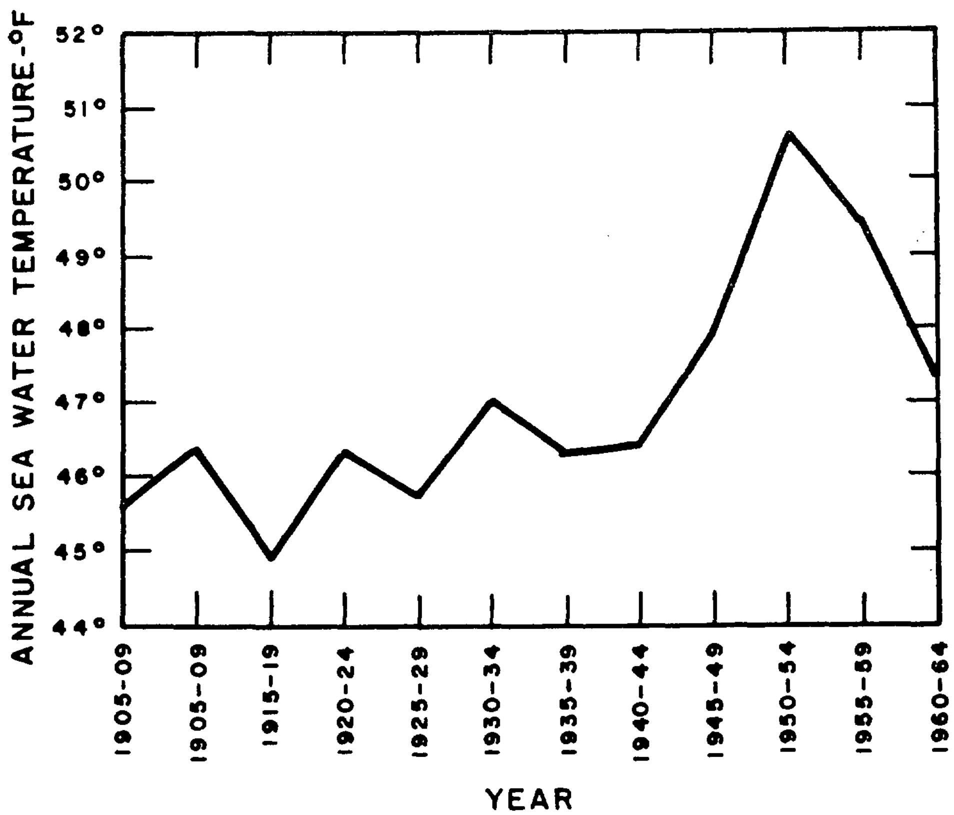
PSNH SEABROOK STATION	SURFACE WATER TEMPERATURES DURING A TIDAL CYCLE	FIGURE 2.5-54



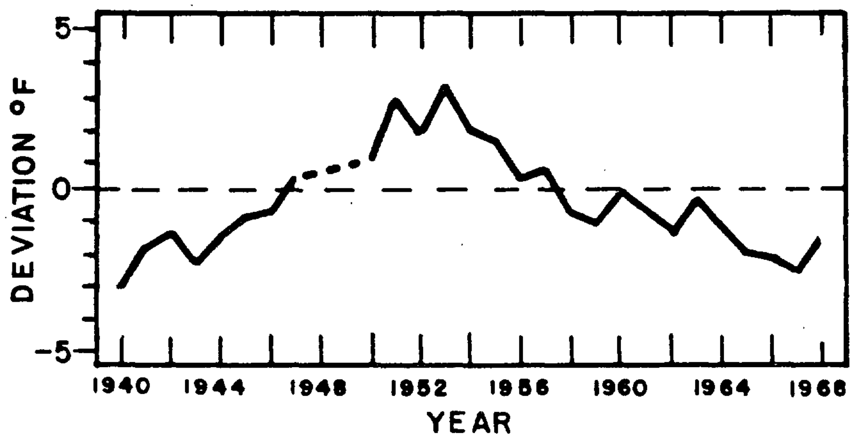
PSNH
SEABROOK STATION

TEMPERATURE VARIATIONS BETWEEN SURFACE AND BOTTOM WATERS

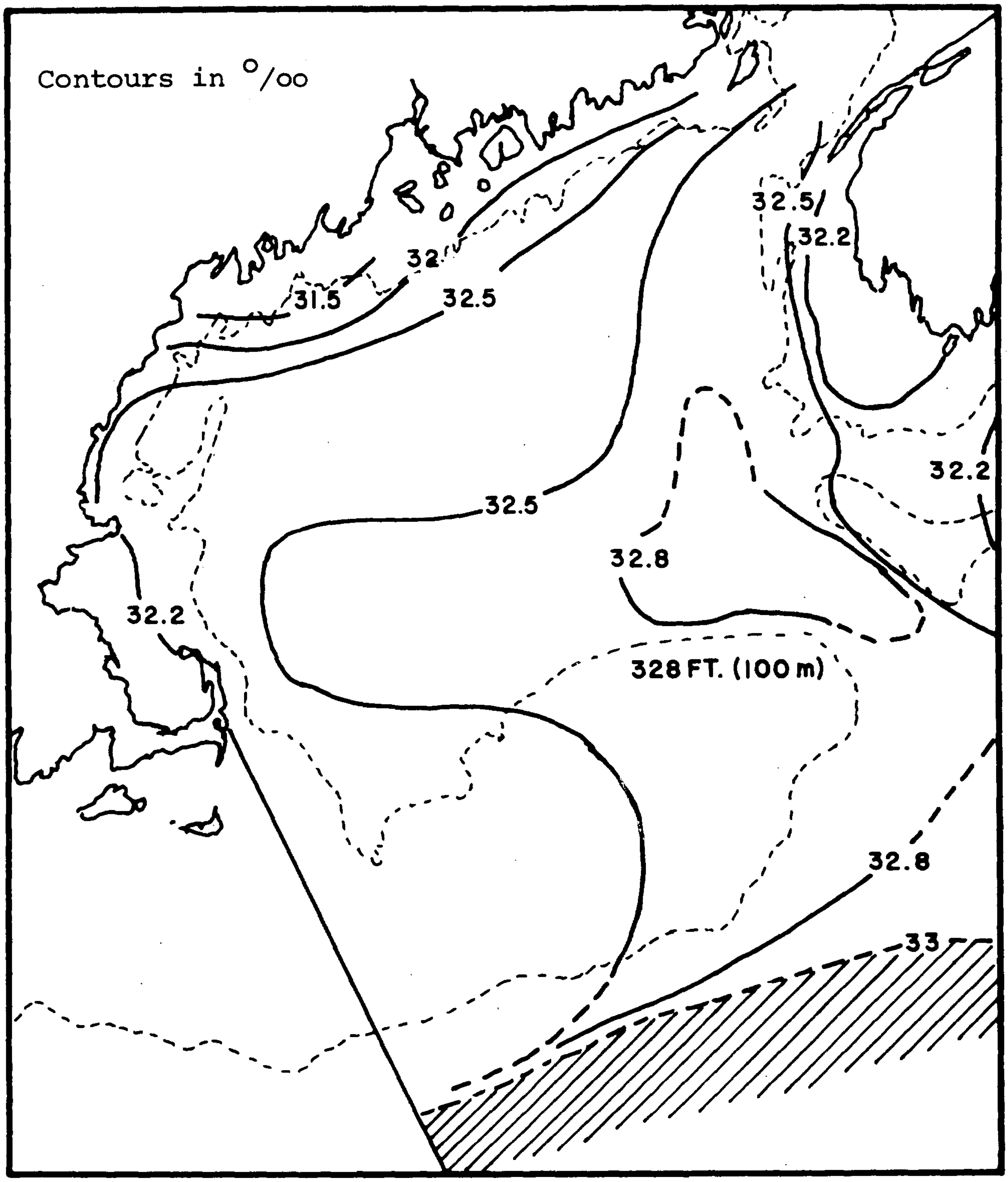
FIGURE 2.5-55



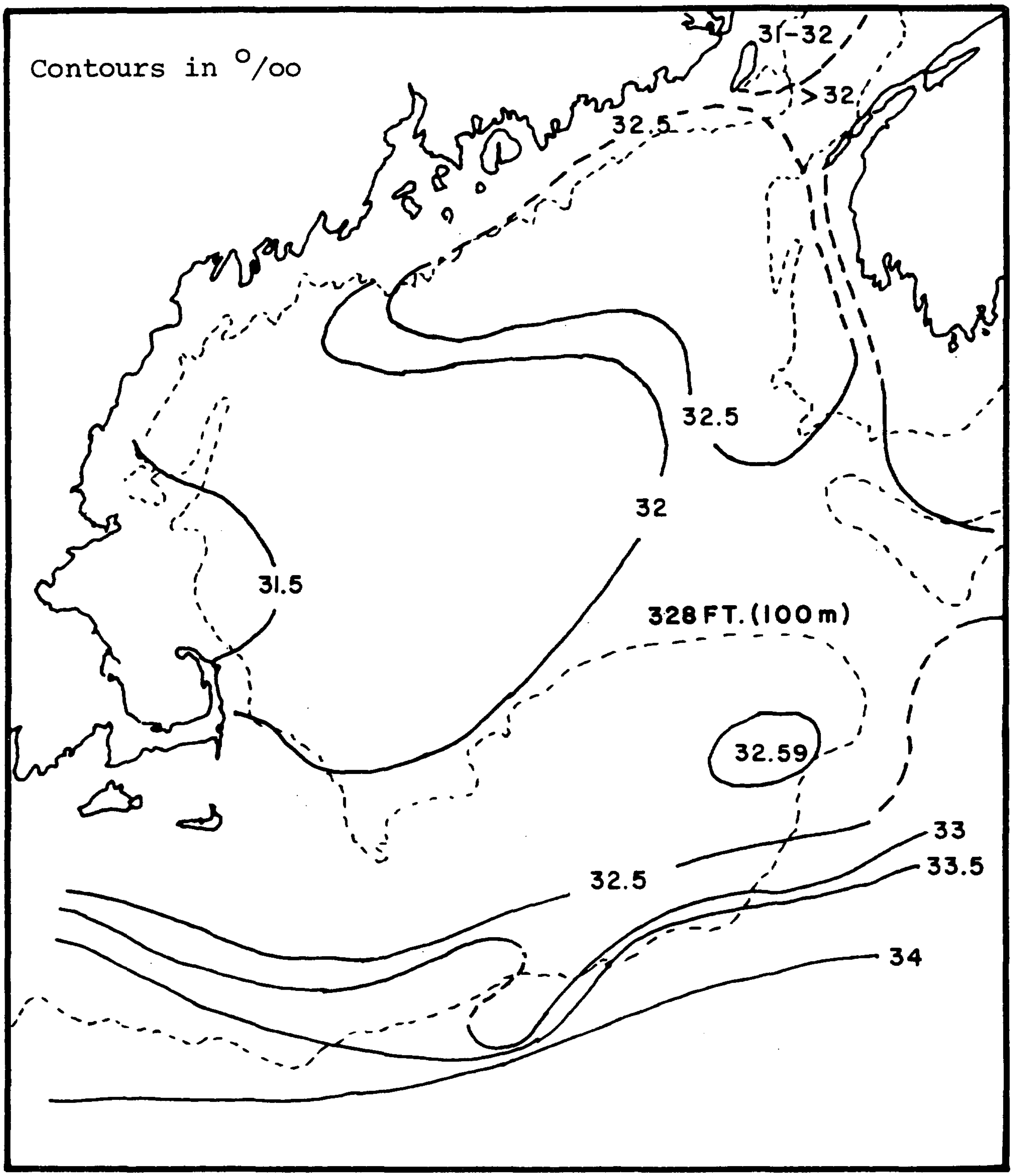
PSNH SEABROOK STATION	AVERAGE OF SEA WATER TEMPERATURE AT BOOTHBAY HARBOR, MAINE	FIGURE 2.5-56



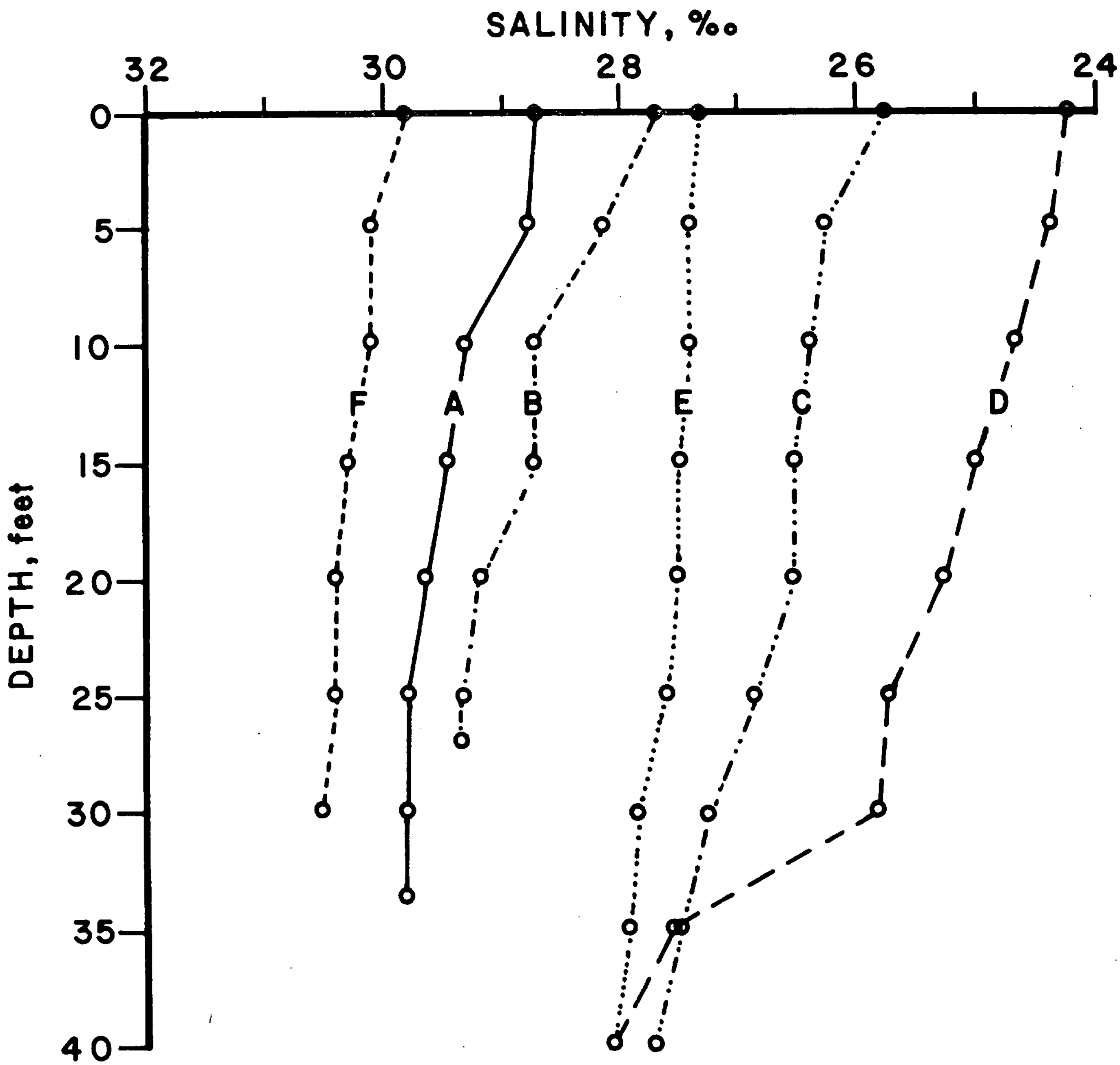
PSNH SEABROOK STATION	ANNUAL DEVIATIONS FROM THE 1940-1959 MEAN SEA-SURFACE TEMPERATURE AT BOOTHBAY HARBOR	FIGURE 2.5-57



PSNH SEABROOK STATION	SALINITY OF SURFACE WATERS IN THE GULF OF MAINE FOR MID-WINTER	FIGURE 2.5-58

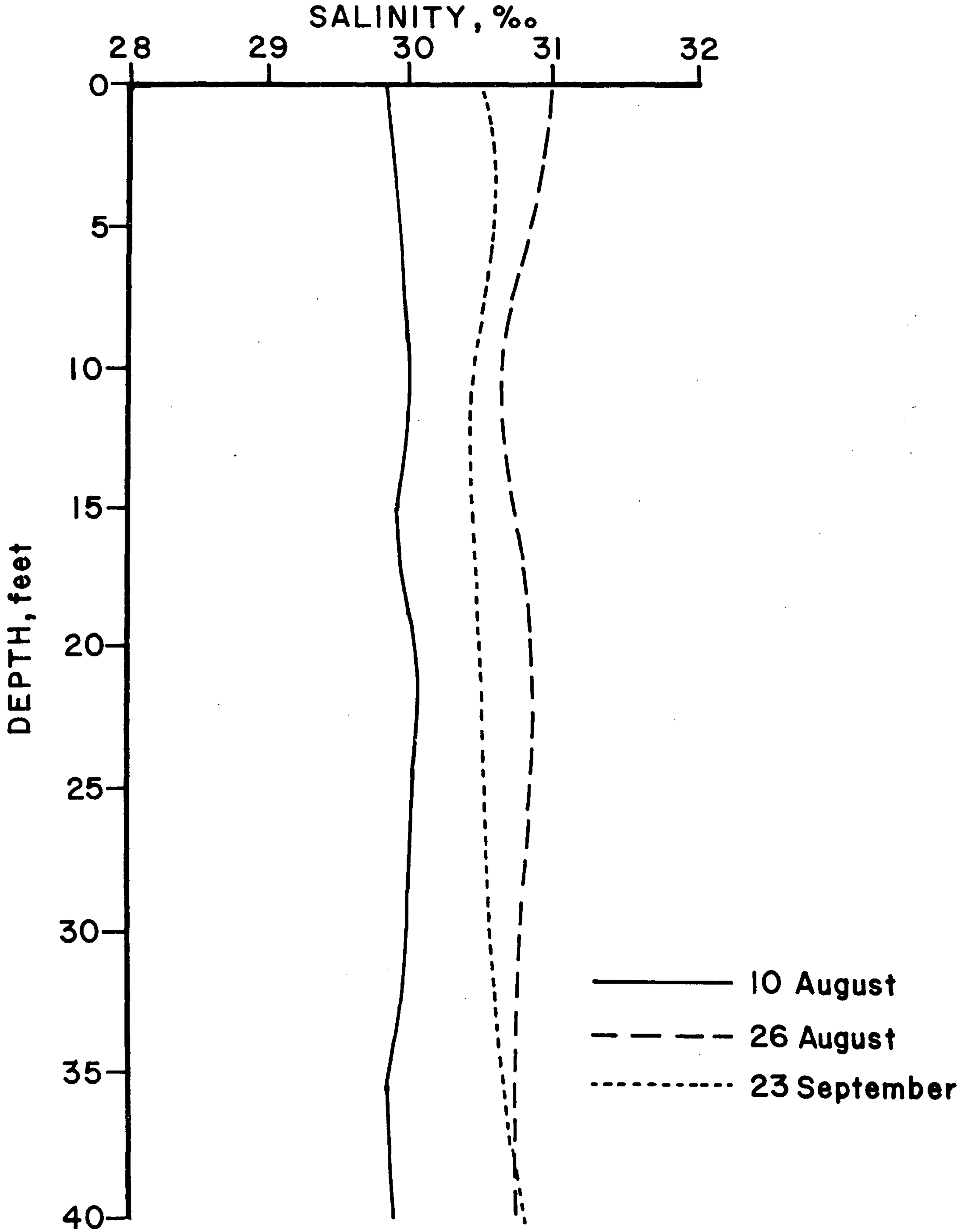


PSNH	SALINITY OF SURFACE WATERS IN THE GULF OF MAINE	FIGURE
SEABROOK STATION	FOR SUMMER	2.5-59

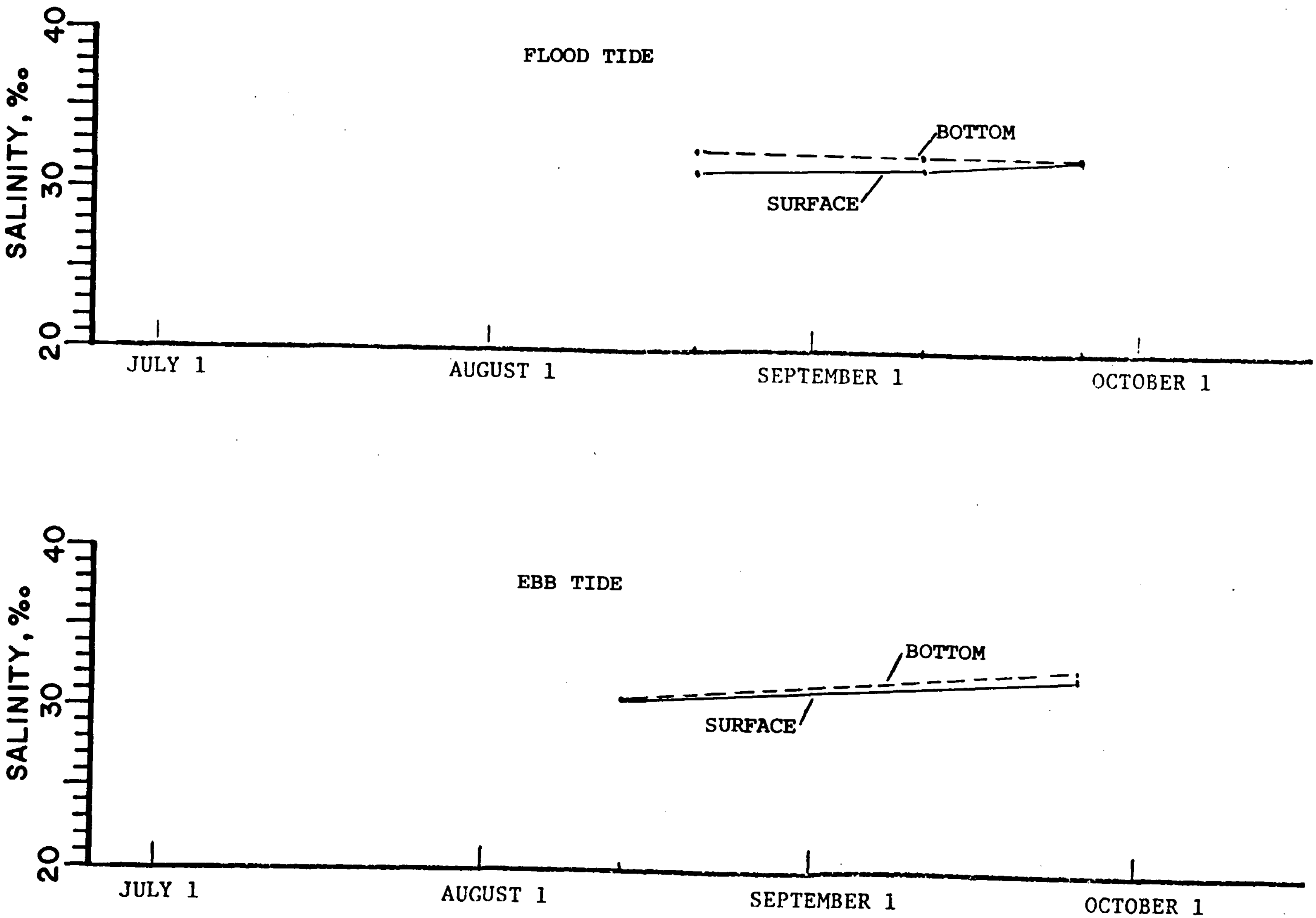


A	April 14, 1969	early flood	(1650)
B	April 21, 1969	early flood	(0830)
C	April 25, 1969	late flood	(1600)
D	May 2, 1969	mid-flood	(0810)
E	May 6, 1969	early ebb	(1625)
F	May 17, 1969	early flood	(0730)

PSNH SEABROOK STATION	SALINITY PROFILES NEAR THE PROPOSED DISCHARGE AREA	FIGURE 2.5-60



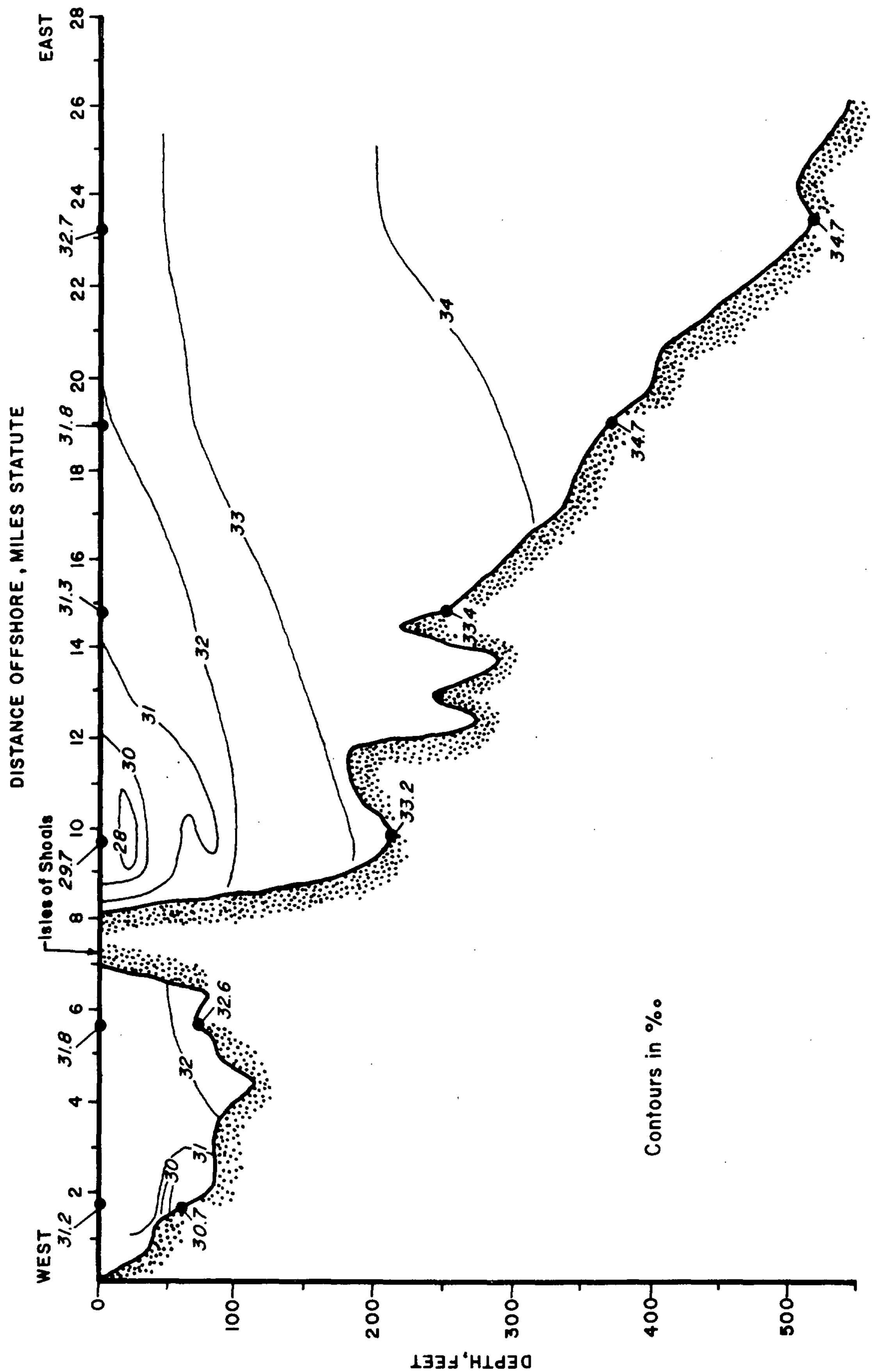
PSNH SEABROOK STATION	SALINITY PROFILES NEAR THE PROPOSED DISCHARGE AREA	FIGURE 2.5-61



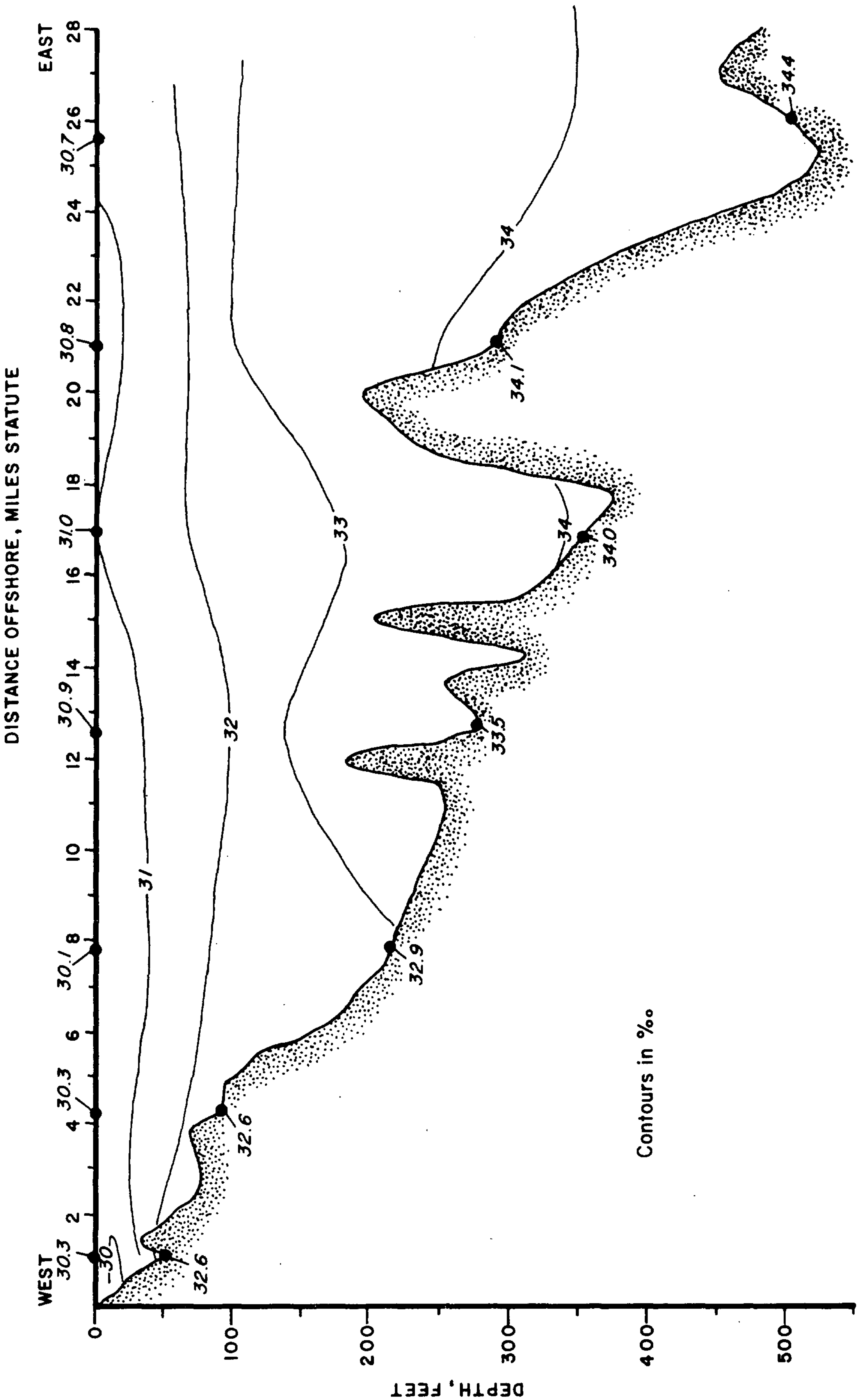
PSNH
SEABROOK STATION

SALINITY VARIATIONS BETWEEN SURFACE AND BOTTOM WATERS

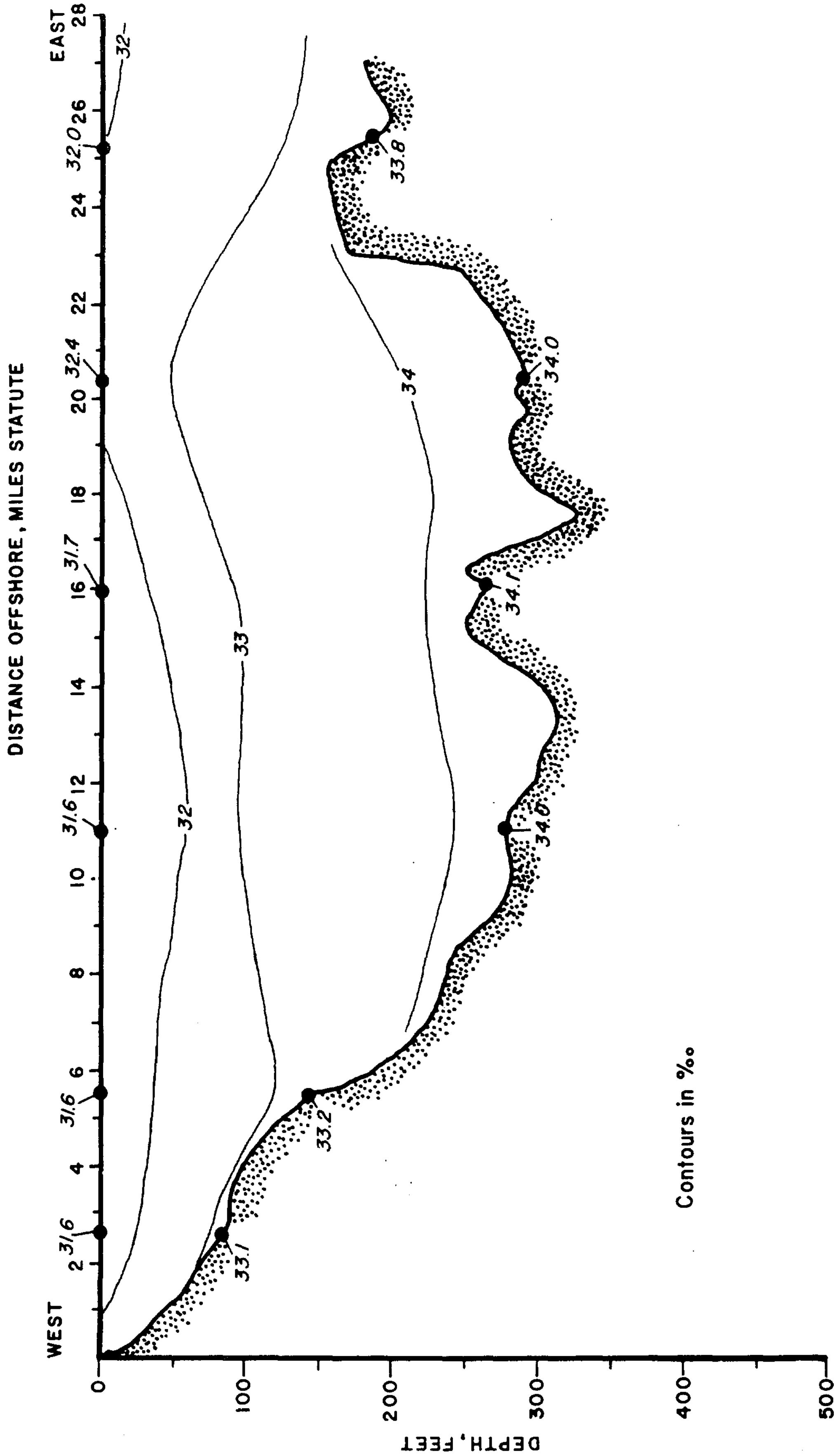
FIGURE 2.5-62



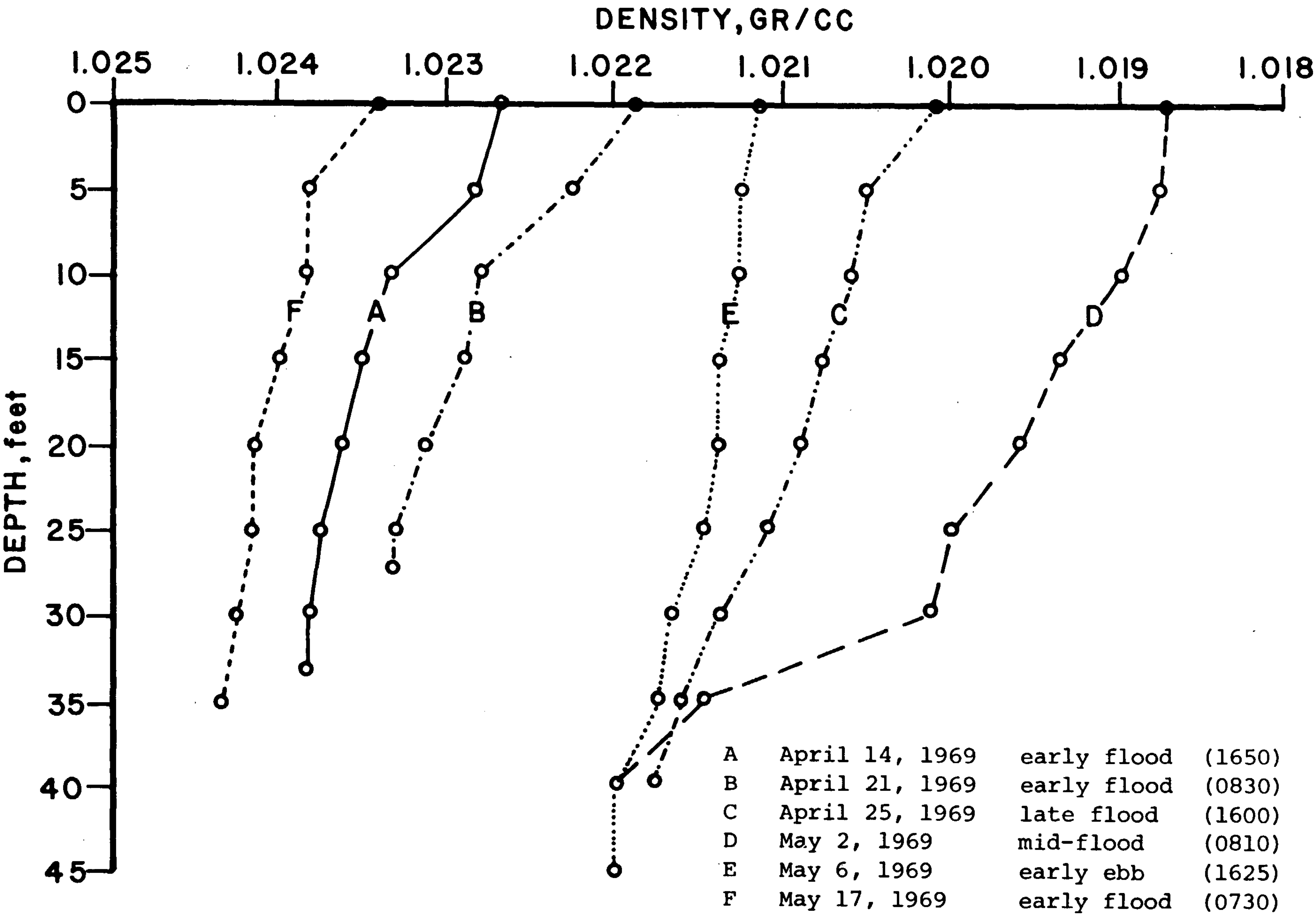
PSNH SEABROOK STATION	CROSS-SECTION OF WATER SALINITY IN A TRANSECT THROUGH THE ISLES OF SHOALS	FIGURE 2.5-63



PSNH SEABROOK STATION	CROSS-SECTION OF WATER SALINITY IN A TRANSECT OFF HAMPTON HARBOR ESTUARY	FIGURE 2.5-64



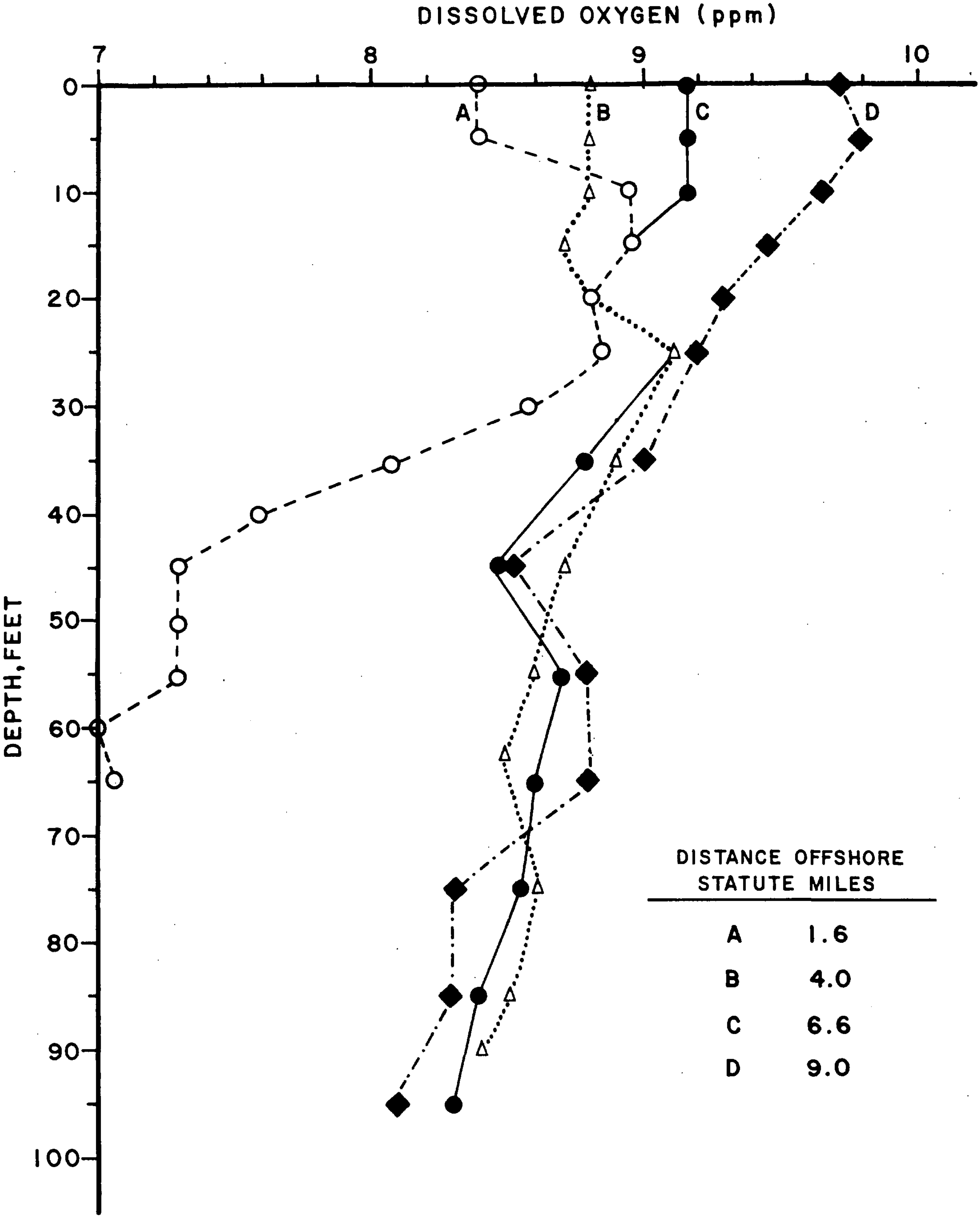
PSNH SEABROOK STATION	CROSS-SECTION OF WATER SALINITY IN A TRANSECT OFF PLUM ISLAND	FIGURE 2.5-65



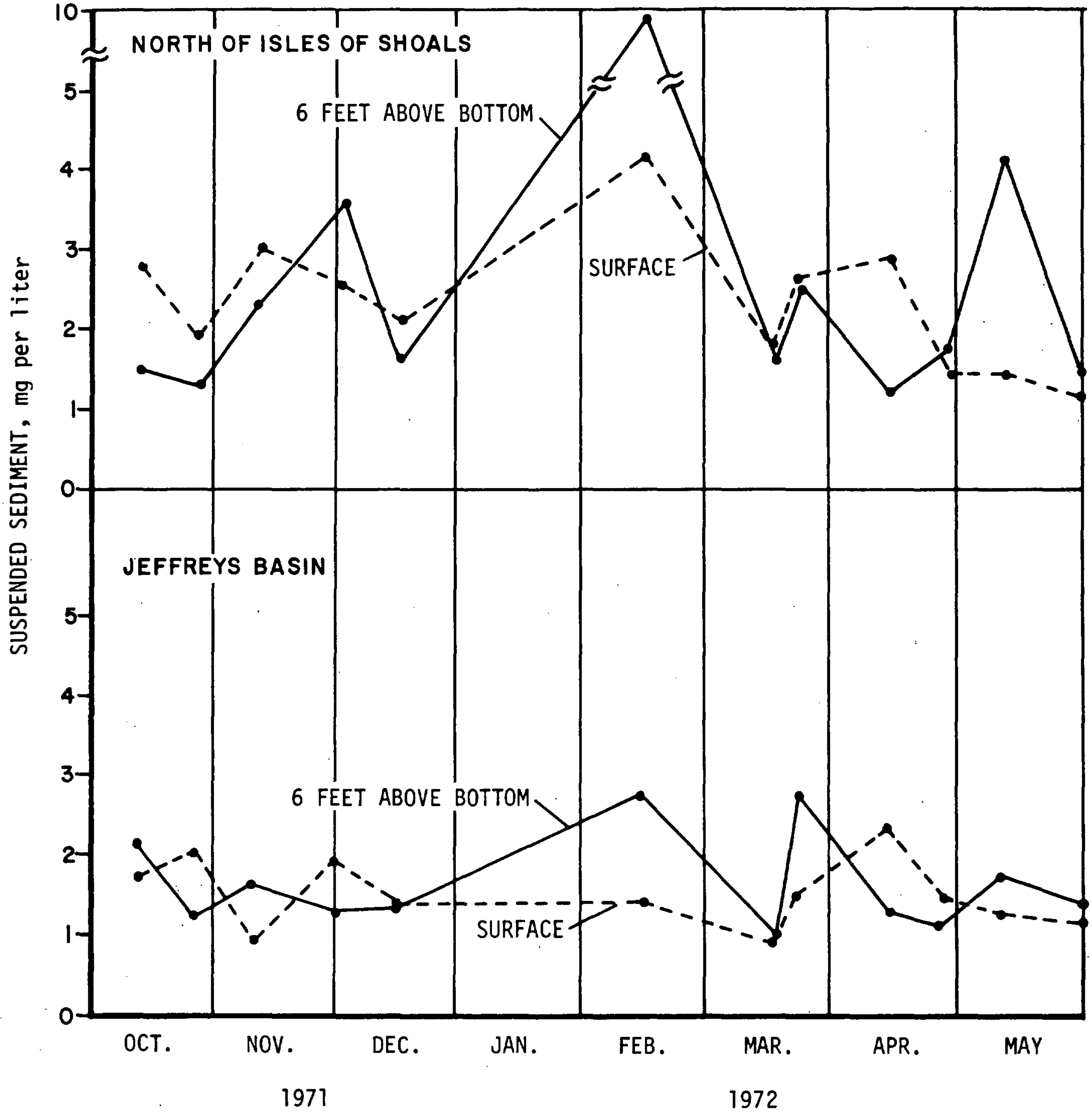
PSNH
SEABROOK STATION

WATER DENSITY PROFILES NEAR THE PROPOSED DISCHARGE AREA

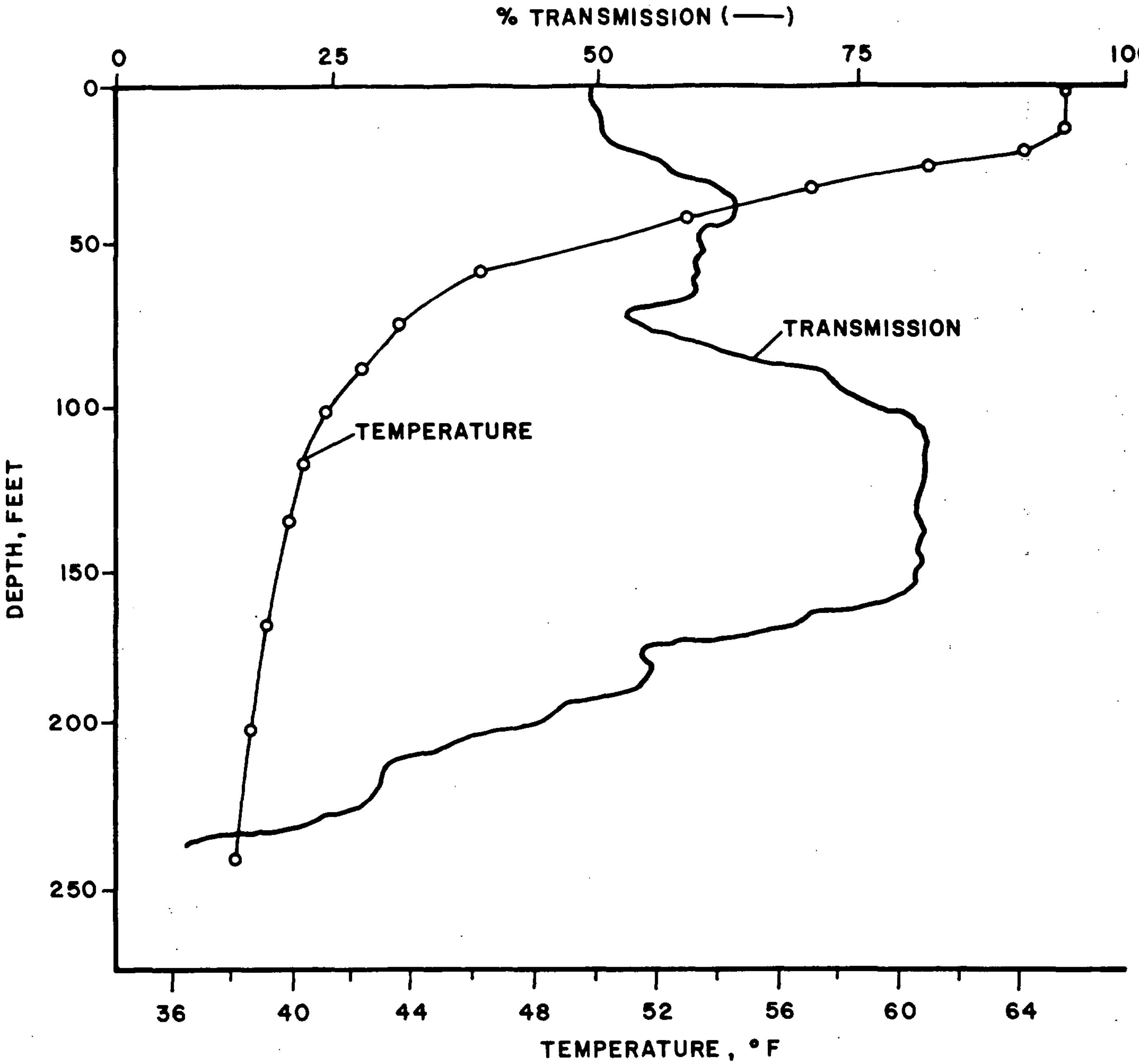
FIGURE 2.5-66



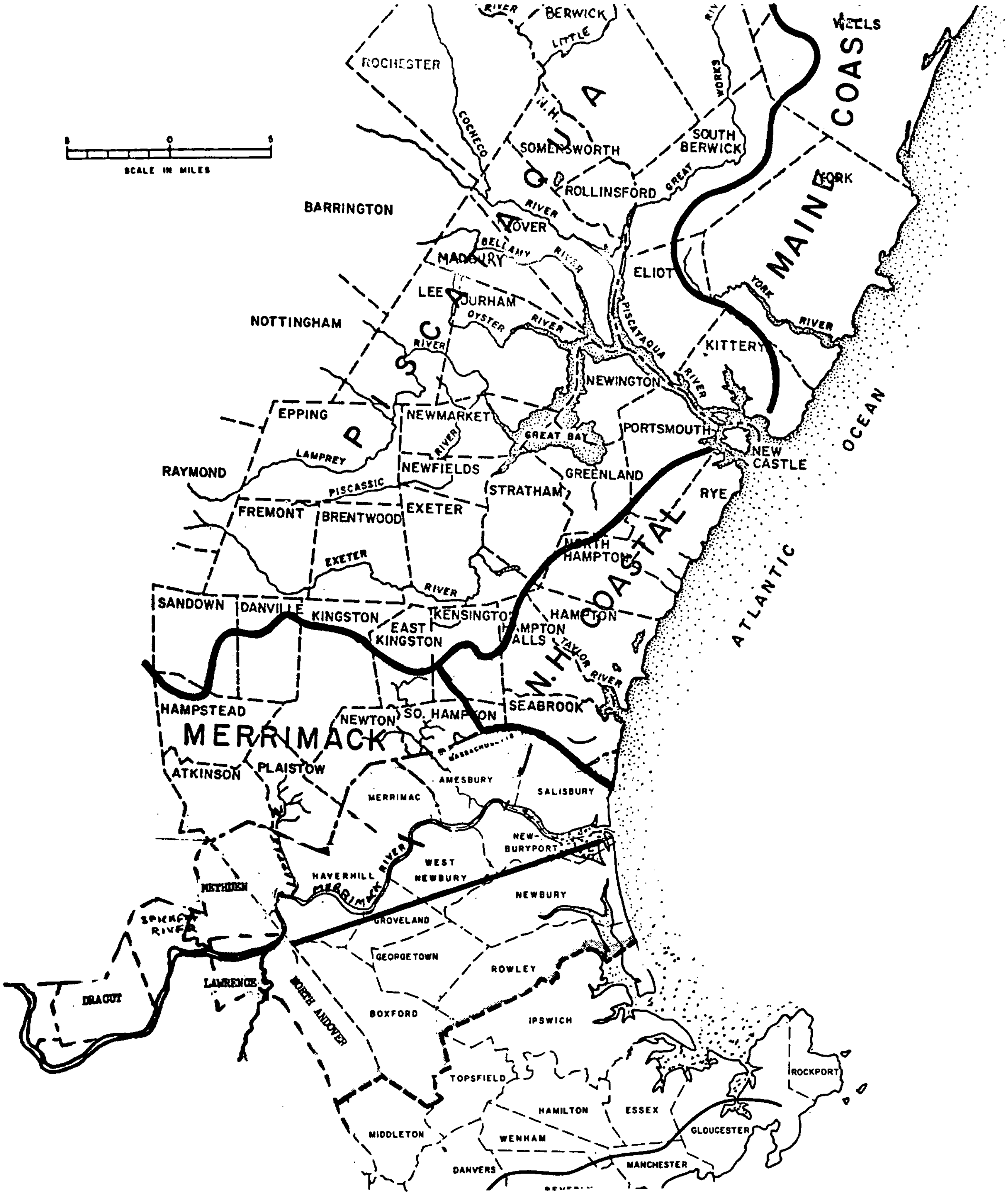
PSNH SEABROOK STATION	PROFILES OF DISSOLVED OXYGEN IN A NW TO SE TRAN- SECT OFF RYE BEACH, NEW HAMPSHIRE	FIGURE 2.5-67



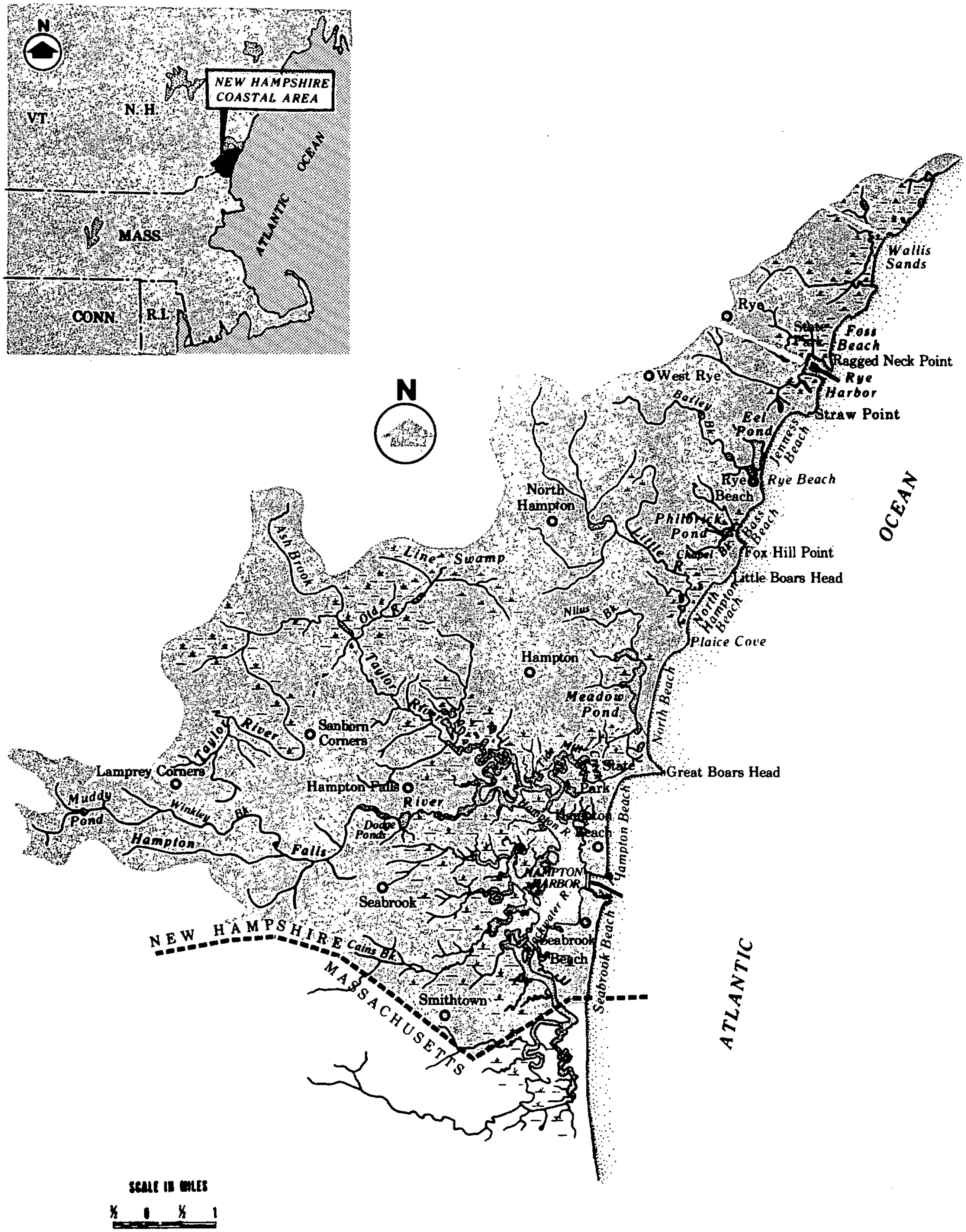
PSNH SEABROOK STATION	AVERAGE MONTHLY SUSPENDED SEDIMENT CONCENTRATIONS AT TWO DEPTHS IN TWO AREAS	FIGURE 2.5-68



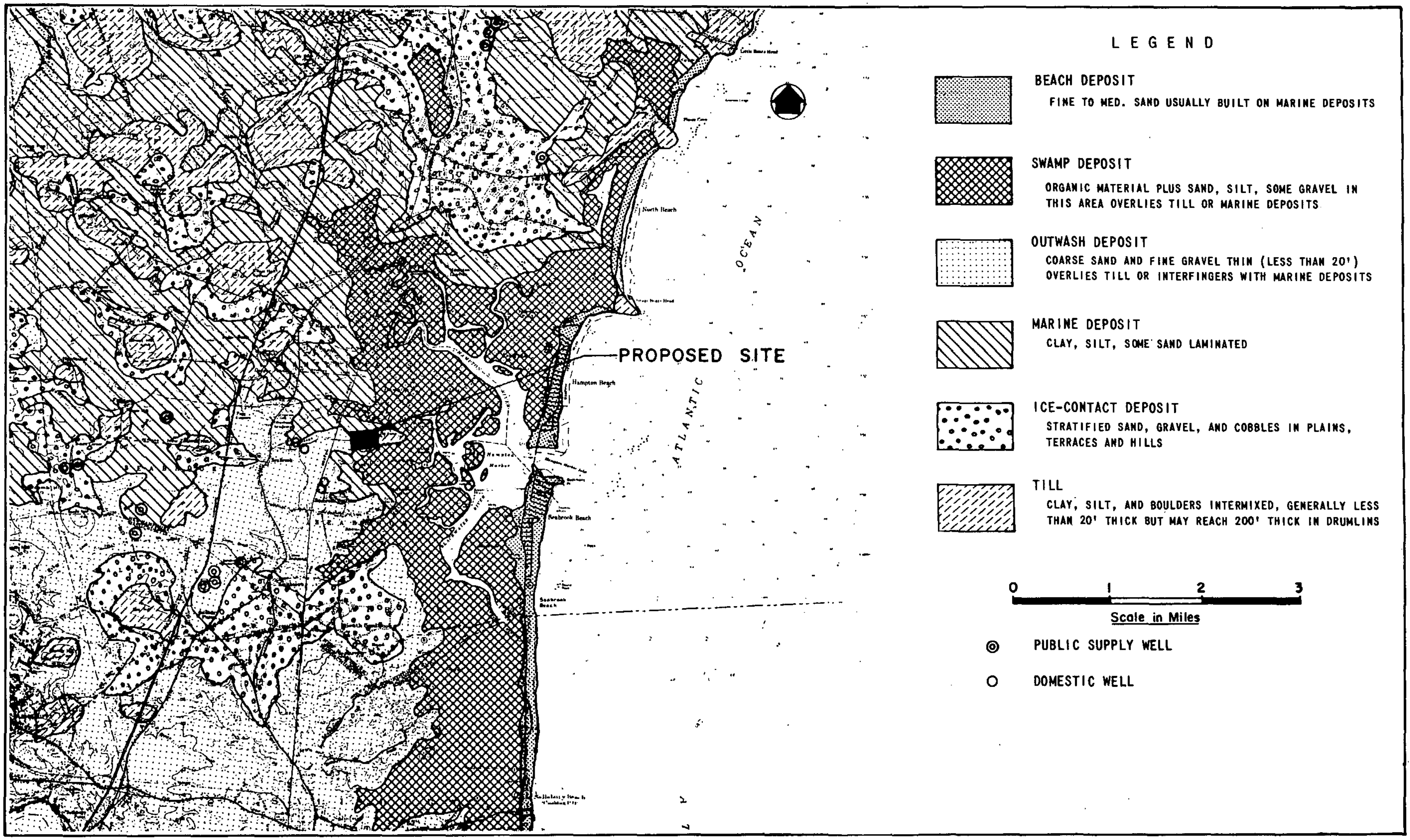
PSNH	PROFILES OF PERCENT TRANSMISSION AND TEMPERATURE	FIGURE
SEABROOK STATION	VERSUS DEPTH	2.5-69



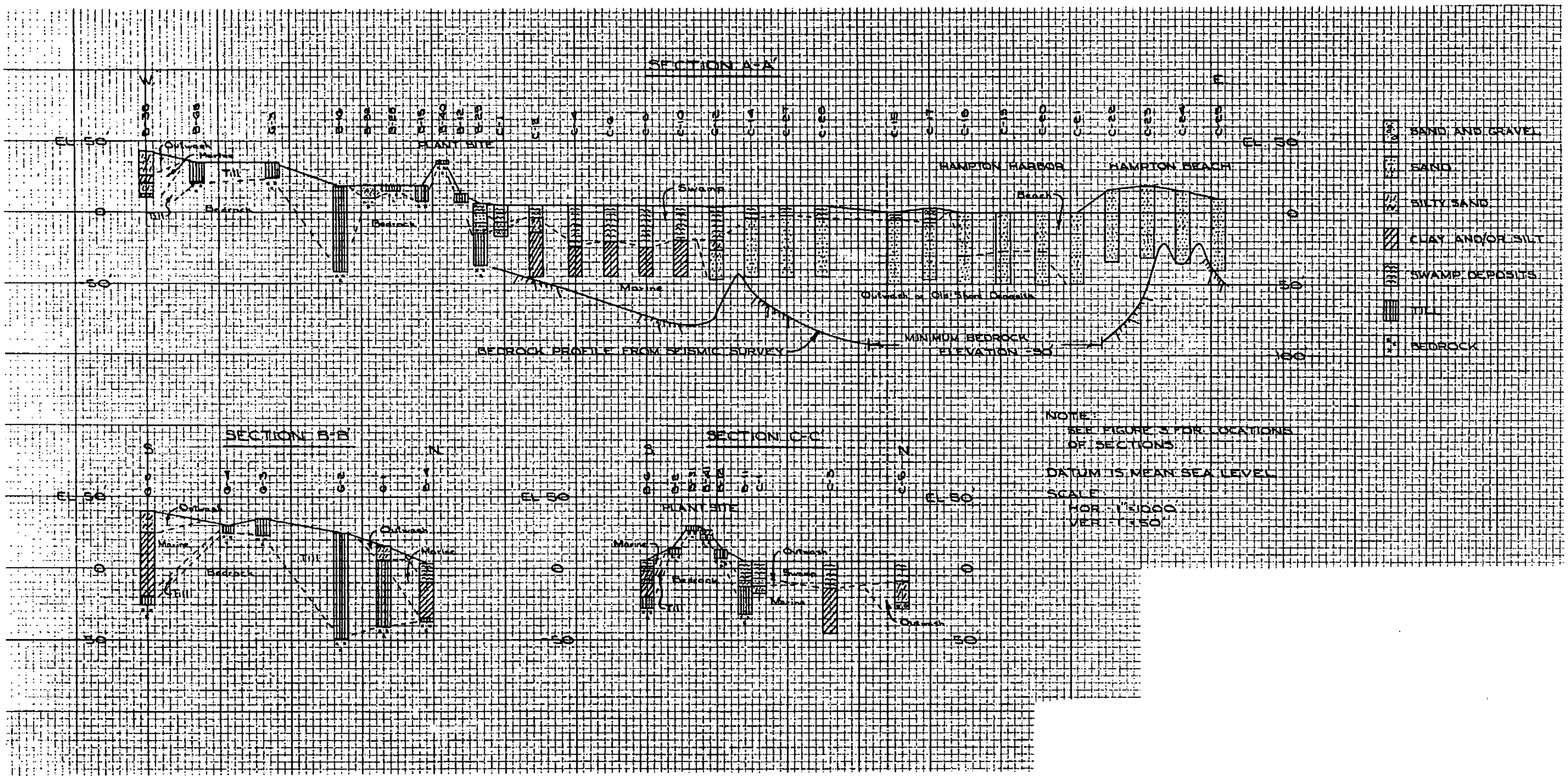
PSNH SEABROOK STATION	SEACOAST REGION DRAINAGE BASINS	FIGURE 2.5-70



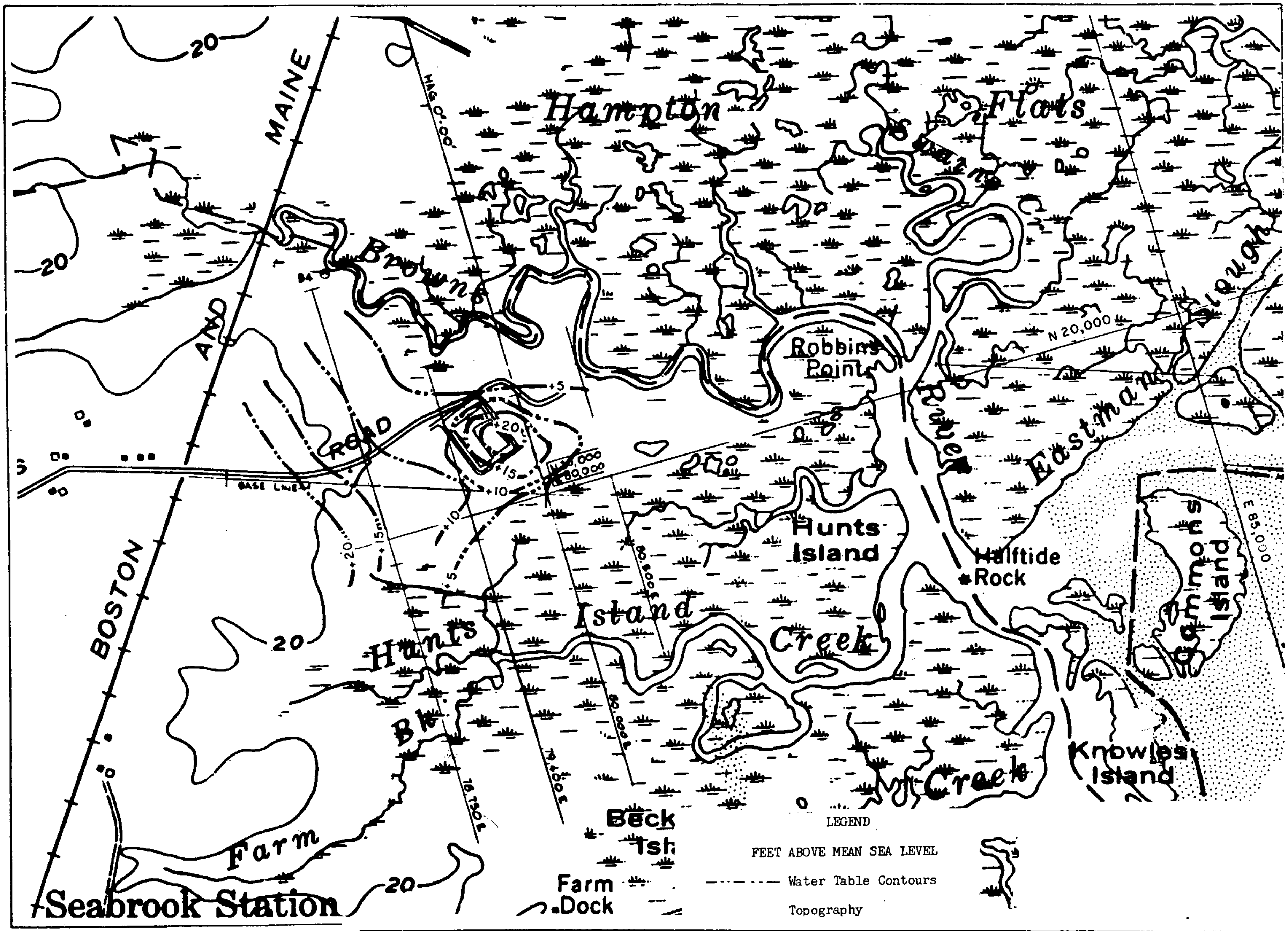
PSNH SEABROOK STATION	NEW HAMPSHIRE COASTAL DRAINAGE BASIN	FIGURE 2.5-71



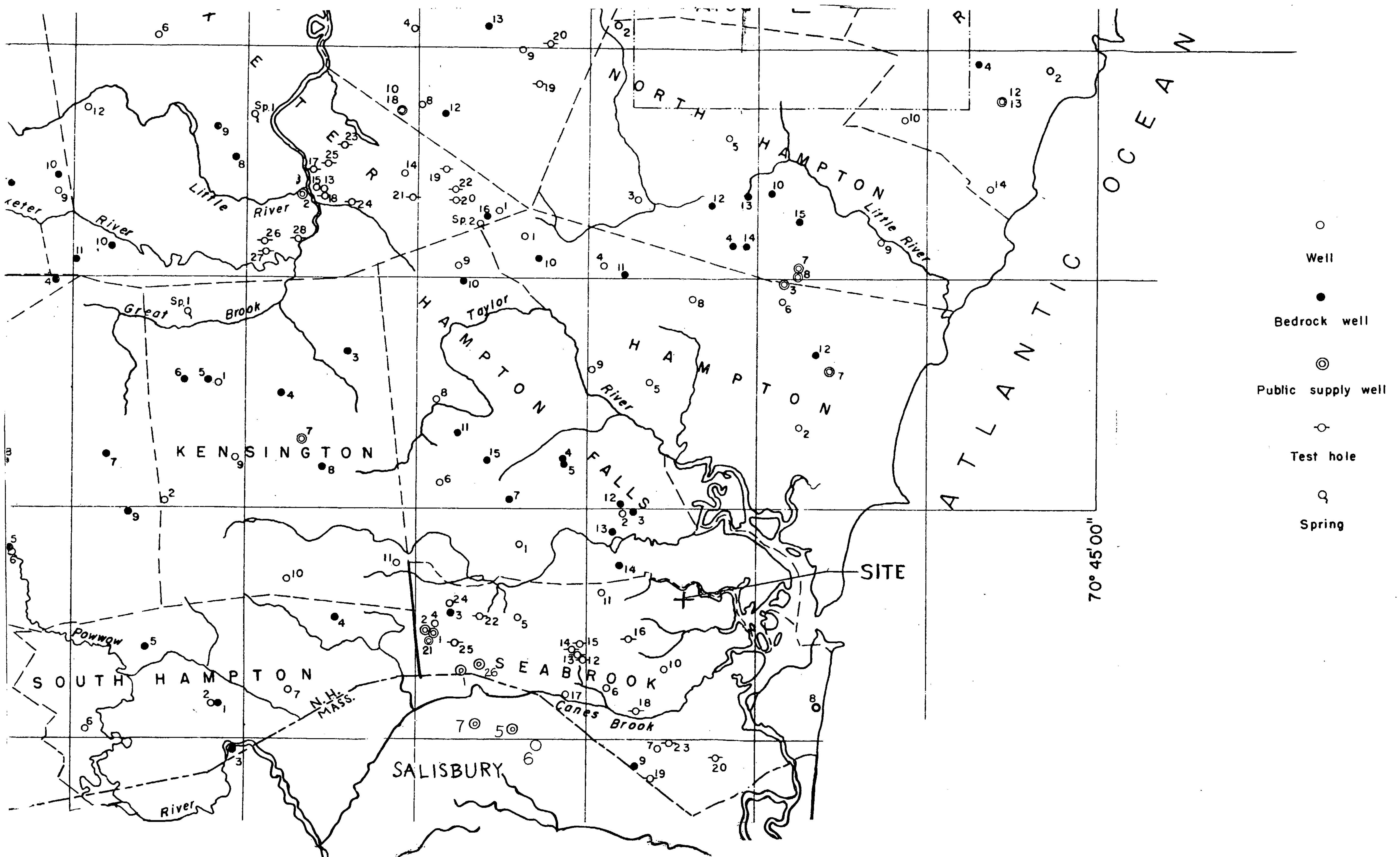
PSNH SEABROOK STATION	SURFICIAL GEOLOGY IN THE SEABROOK AREA	FIGURE 2.5-72



PSNH SEABROOK STATION	GEOLOGIC PROFILES OF SEABROOK AREA	FIGURE 2.5-73



PSNH SEABROOK STATION	WATER-TABLE CONTOURS	FIGURE 2.5-74



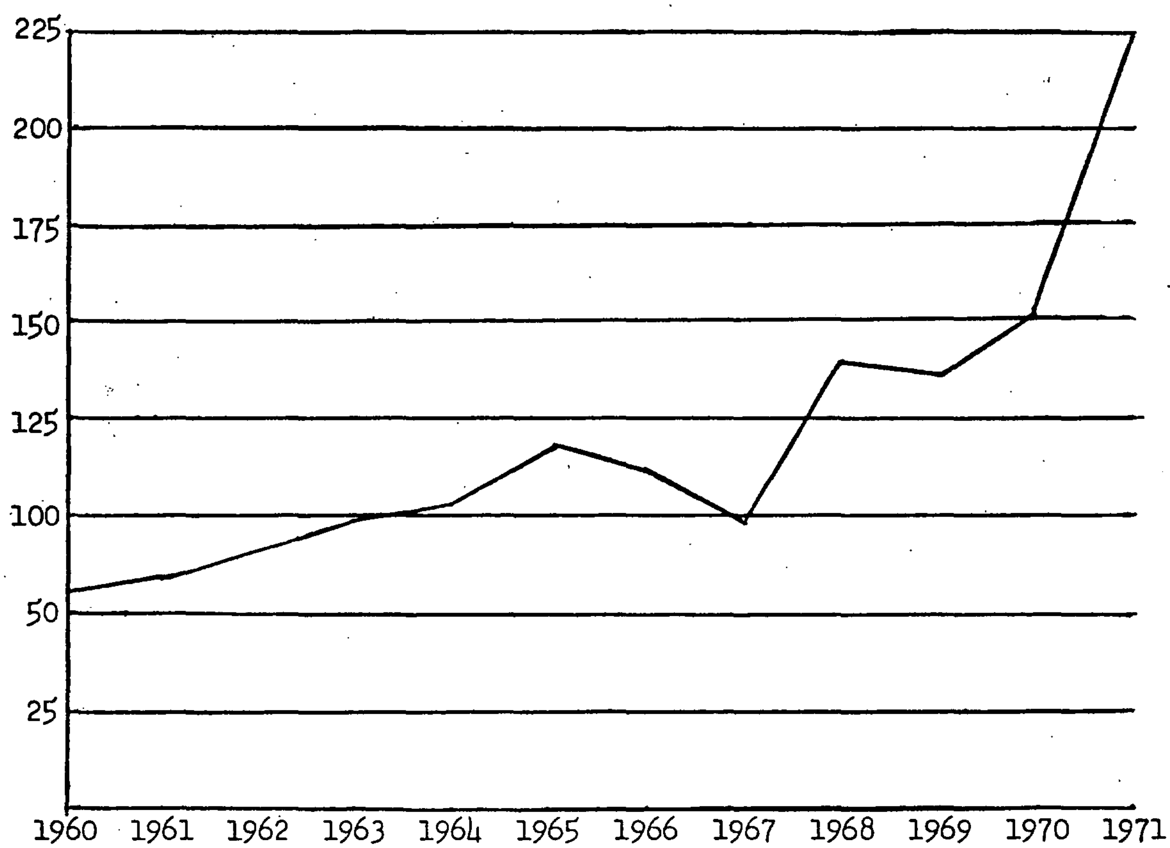
PSNH
SEABROOK STATION

SEABROOK AREA WELLS

FIGURE 2.5-75

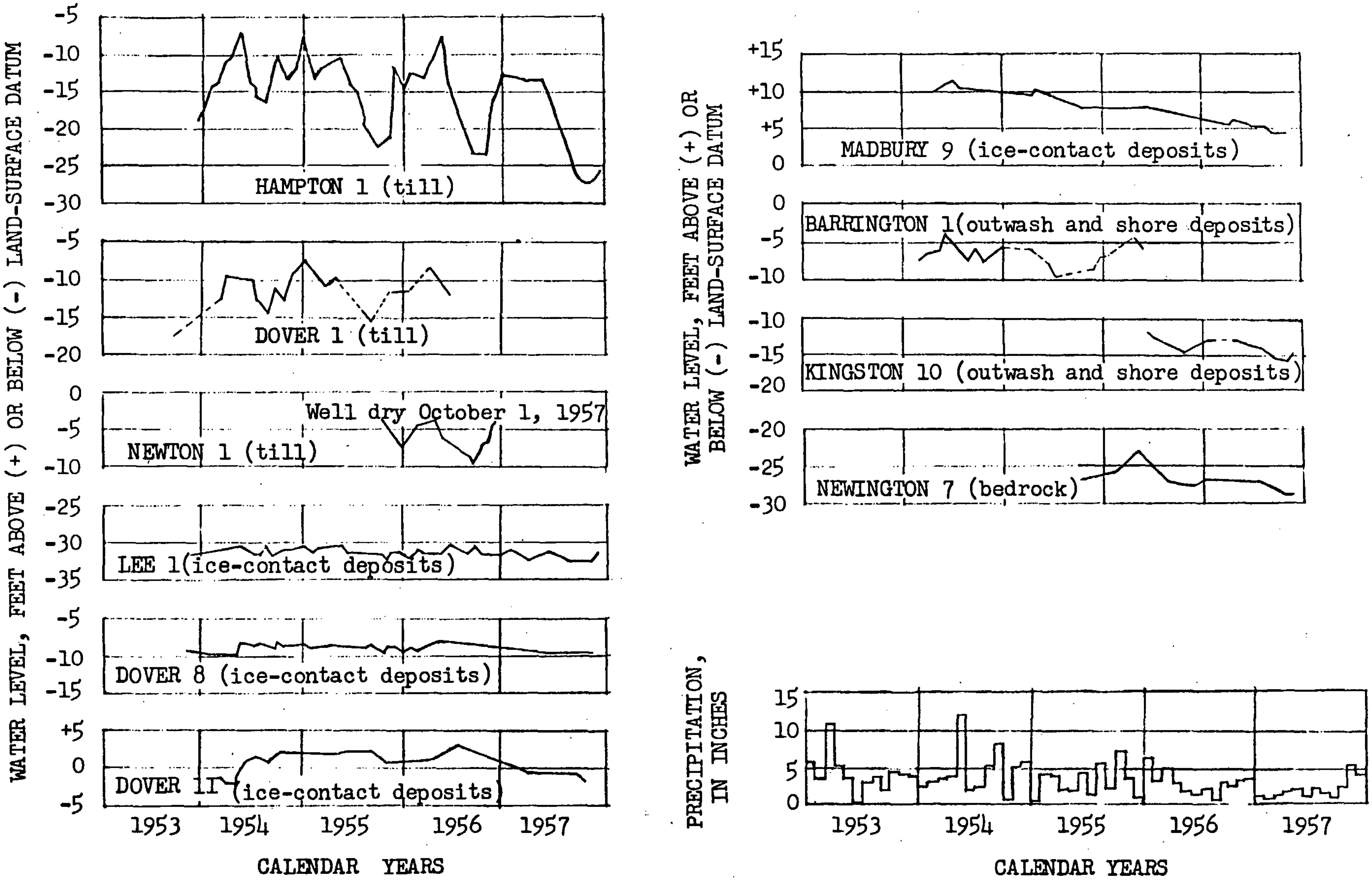
YEAR	GALLONS OF WATER PUMPED ANNUALLY FOR DOMESTIC, INDUSTRIAL AND COMMERCIAL USES FROM SEABROOK MUNICIPAL WATER SUPPLY
1960	56,433,660 gallons
1961	63,417,190 gallons
1962	71,399,710 gallons
1963	93,947,720 gallons
1964	105,581,720 gallons
1965	114,037,320 gallons
1966	111,838,520 gallons
1967	97,317,820 gallons
1968	139,859,380 gallons
1969	133,115,780 gallons
1970	150,915,940 gallons
1971	221,141,340 gallons

Reference: Comprehensive Town Plan for Seabrook New Hampshire by Hans Klunder Associates



PSNH SEABROOK STATION	GALLONS OF WATER PUMPED ANNUALLY FROM SEABROOK MUNICIPAL WATER SUPPLY	FIGURE 2.5-76

ference: Geology and Groundwater Resources of theastern New Hampshire, Geological Survey Water-Supply Paper 95, by Edward Bradley, U.S. Government Printing ice, Washington, D.C., 1964.



PSNH SEABROOK STATION	WATER LEVEL VARIATIONS IN THE SEABROOK AREA	FIGURE 2.5-77

2.6

2.6 Meteorology

2.6.1 General Climate

The Seabrook site can be characterized as a typical seacoast location in the northeastern United States. It is subjected to storms that track not only across the continental United States and southern Canada, but also to east coast cyclones that move northeastward along the U. S. coast. Occasionally, the site is affected by low pressure systems that stall off shore in the vicinity of Newfoundland and cause several days of cloudy, unsettled weather with north to northwesterly winds.

The site is located about two miles from the open Atlantic Ocean. This proximity permits a definite maritime influence on the general climate. Winter temperature extremes are tempered by the relatively warmer water while summer temperatures are moderated by a seabreeze.

Precipitation amounts are quite uniform throughout the year. Heavy precipitation occurs occasionally, usually as a result of a "nor'easter" moving up along the east coast.

Thunderstorms may occur during the summer, although they are very seldom in the severe category.

It is unusual for the area to be subjected to the full strength of an east coast hurricane or tropical storm. Such storms usually move inland well before they reach the Seabrook latitude or curve to the east and subject the site to just fringe effects of the storm.

The terrain near the site causes no special phenomena on a climatic basis. The mountains of New Hampshire, Vermont, Massachusetts and upstate New York do temper, to varying degrees, storms that reach the coast from the west. The site is generally between predominant storm tracks which is a much more significant factor than the surrounding terrain.

The Seabrook site is located between two National Weather Service Class A airport stations. The Boston, Massachusetts Logan International Airport is 38 miles to the south-southwest, while the Portland Maine International Jetport is 59 miles to the north-northeast. The Boston Airport is on a land fill that extends into Boston Harbor, which is part of the Atlantic Ocean. The Portland Airport is located just inland from the Atlantic Ocean.

Data from these stations were used to obtain climatological means and extremes for the Seabrook area. Climatological data from Portsmouth, N. H. and Pease AFB have also been used. Both stations are about 13 miles NNE of the site. Portsmouth data is from the Department of Public Works, a cooperative weather observer.

2.6.2 Temperature, Moisture Deficit and Fog

A. Temperature

Temperature extremes are moderated by the proximity of the site to the Atlantic Ocean. This effect is more pronounced during the summer when the sea breeze counters inland heating. Cold air outbreaks can produce low minimum temperatures, but the persistence of extreme values along the coast is less than for inland stations.

Table 2.6-1 presents mean and extreme temperatures for Boston, Portland and Portsmouth (References 2, 3, 4). Considerable variation in temperatures is noted between these three stations. The Portsmouth data is representative of the Seabrook temperatures.

B. Moisture Deficit

Equipment to record dewpoint data was installed 30 feet above grade on the meteorological tower at Seabrook on March 17, 1972. From these data, moisture deficit frequency distributions have been prepared for each atmospheric stability by computing the additional moisture required for the air to reach saturation. Table 2.6-2 shows the occurrences of six categories of moisture deficit. Note that for the annual data in this table, moisture deficits greater than 1.0 g/m^3 occurred 70 percent of the time and that deficits less than this value occurred 75 percent of the time with stability category D or E.

C. Fog

The cool Atlantic waters can produce extensive advection fog when warmer, moist air is carried over the cool water. With any persistent eastern component in the wind direction, the fog that often lies just off shore during the summer can reach the Seabrook site. This situation is supported during the summer by local heating and a resulting sea breeze.

All months of the year have a fairly consistent frequency of occurrence of fog. This is shown in the following table which lists the occurrence of fog at Pease AFB (Reference 4), about 5 miles inland. Although localized and contiguous fog is seen at Pease AFB about 15 percent of the time, it is dense enough to restrict visibility to one mile or less about 3.5 percent of the time.

ANNUAL FREQUENCY OF FOG AT PEASE AFB

1956-1961

Month	Percent of Hours
January	13.5
February	12.3
March	13.3
April	16.6
May	13.9
June	18.1
July	15.3
August	12.2
September	16.9
October	19.0
November	17.0
December	14.2
Annual	15.2

2.6.3 Winds and Stability

On-site wind and stability data have been collected at Seabrook since November 1, 1971. Details on the on-site meteorological program and the meteorological tower instrumentation are presented in subsection 6.1.3. Joint frequency distributions of these parameters are presented in tabular form in Appendix H for the four seasons and the 12 months of collected data. Figures 2.6-1 through 2.6-5 present the seasonal and annual wind roses for all stabilities combined as derived from the on-site data at 30 feet above grade. The data was prepared in terms of stability categories determined from the vertical temperature gradient as defined in Safety Guide 23 of the Atomic Energy Commission.

Wind directions were from sectors around WNW during the year of collected data. During the winter, 55.6 percent of all winds at 30 feet above ground were from the W through NW sectors. This peak is reduced to 35.2 percent during the spring when 25.3 percent of the winds come from the NNE through E. Winds from the west and northwest predominate, even during the summer, with winds from NE through SE accounting for only 27.1 percent. On-shore winds are at a minimum during the winter months. Northeast winds, usually associated with a nor'easter moving up along the New England coast, show a peak during the spring.

During the year, the maximum wind direction persistence in a 22.5 percent sector was 20 hours with a WNW wind. There were ten occurrences of the wind direction remaining within a 45 percent sector over 48 hours. These occurred with winds from the SW westward through the NNW.

Highest hourly wind speeds during the year occurred with winds from the ENE and the NW.

2.6.4 Precipitation

A. Rain

A mean monthly precipitation between 3 and 4 inches each month is expected for Seabrook, with a mean annual total close to 43 inches. Most summer rain is from showers and thunderstorms, which are less frequent along the coast than farther inland. Heavy precipitation between December and March is usually associated with stormy conditions caused by nor'easters moving up along the coast.

On the average, there are about 130 days per year with more than a trace of precipitation (Reference 4) and 79 days with over 0.1 inch. At Pease Air Force Base, October, the driest month, averages 9 days with measurable precipitation, while November, the wettest month, averages 12 days.

Heavy precipitation at Seabrook usually occurs only with storm centers that form along the east coast and move northeastward toward New England. These nor'easters usually have a small, intense circulation and move rapidly through the New England area. If the center passes sufficiently close to the site, considerable rain or snow can occur. A maximum monthly precipitation amount close to 10 inches could be expected at the site. Maximum 24 hour precipitation amounts will occur with thunderstorms during the summer or as a result of nearby hurricanes during the fall.

Table 2.6-3 presents the mean and extreme values for Boston, Portland and Portsmouth (References 1, 2, 3, 4). Data for Portsmouth are representative of the values expected for Seabrook.

B. Snow

Snowfall amounts vary in the Seabrook area, normally decreasing in the immediate vicinity of the shore. The following table lists the average number of occurrences per season of various depths of 24-hour snowfalls at Portsmouth (Reference 4):

AVERAGE OCCURRENCES OF 24-HOUR SNOWFALLS
PORTSMOUTH, N. H., 1954-1967

Snowfall Equal to or Greater Than	Average Occurrences per Season
1 inch	17
2	11
4	5
6	4
8	2
12	1

During the period 1954 to 1967, the number of snowfalls of one inch or more has varied from 10 to 29 per season, and snowfalls occurred as early as November and as late as April. The frequency at Seabrook would not exceed the values in this table.

The ground is normally covered with snow from late December until well into March, although it may remain bare for several weeks during this period in a milder winter. A continuous snow cover of at least one inch lasts 30 to 45 days in a usual winter, but continued for 87 days in the snowy winter of 1955-1956. The average maximum snow depth is about 18 inches although periods of nearly twice that amount may exist after a nor'easter late in the season.

Table 2.6-4 presents snowfall data for Boston, Portland and Portsmouth (References 2, 3, 4). It should be noted that the maximum snowfall amounts have normally been recorded in different years for the three stations, indicating a substantial spatial variation in the snowfall in the region. The topographic features and climatology of the area indicate the Seabrook snowfall data is best represented by the data for Portsmouth.

2.6.5 Severe Weather

A. Strong Winds

The Boston and Portland climatology show that wind speeds over 40 mph can occur during any month of the year. During the winter these high winds are normally caused by nor'easters that move up along the coast and are normally accompanied by moderate to heavy precipitation. During the warmer months, high winds are normally the result of thunderstorms or squall lines that move through the area. Hurricanes could produce high wind speeds during the late summer and early fall.

The table below lists the fastest-mile wind speeds recorded at Boston and Portland (References 2, 3). The Boston wind data are considered to be representative for the Seabrook area due to comparable exposure.

FASTEST MILE WIND SPEED (MPH)

	Boston	Portland
January	52	52
February	56	58
March	57	76
April	56	57
May	58	50
June	63	44
July	64	45
August	65	69
September	61	62
October	58	45
November	58	76
December	49	62
Years	1926-1971	1941-1971

The annual extreme-mile at 30 feet above ground for four recurrence intervals is as follows (Reference 9):

ANNUAL EXTREME-MILE FOR 30 FEET ABOVE GROUND
SEABROOK AREA

Return Interval (years)	Speed (mph)
10	70
25	80
50	90
100	95

B. Hurricanes

A review of all tropical cyclone events for the period 1886 through 1970 (Reference 11) shows that no tropical storms or hurricanes have come onshore within the 100 mile strip of coast line from 42.08° N, 69.90° W north to 43.52° N, 70.32° W. The Seabrook site is located at 42.9° N, 70.9°W. While no tropical storms or hurricanes have come ashore in the Seabrook area, such storms that reach the New England area usually pass northward west of the site or on a northeast track south of the site. Since, to date, the only hurricanes or tropical storms to reach the Seabrook area have had to travel a substantial distance overland, the potential impact of such storms is significantly reduced. The expected high wind speeds from such storms are within those values given in subsection 2.6.5 (A).

One of the more critical aspects of tropical storms passing south of the site is the possibility of flooding caused by a substantial on-shore fetch. The record high tide for the New Hampshire coast associated with a hurricane was 7.7 ft. MSL recorded at Newburyport (Reference 12). The U. S. Army Corps of Engineers has estimated the 100 year high water mark for the Newburyport-Hampton area to be 9.0 ft. above mean sea level (Reference 12). The 50 year record level for the New Hampshire coast is estimated to be 8.4 ft. This value is based on record high water marks recorded by storms in November 1944, December 1959, and January 1961 (Reference 12).

C. Tornadoes

Minor tornadoes have occurred in all of the New England states. The average annual number of tornadoes for the entire State of New Hampshire is 2.2 (Reference 8). The 1° square from 42 - 43° N and 71 - 72° W that contains this Seabrook site shows a total number of only

MEAN NUMBER OF DAYS WITH THUNDERSTORMS

	Boston	Portland	Pease AFB
January	*	0	0
February	*	*	0
March	*	*	0
April	1	1	0.8
May	2	2	2.5
June	4	4	3.2
July	5	4	5.4
August	4	4	3.4
September	2	2	1.5
October	1	1	0.4
November	*	*	0.1
December	*	*	0
Annual	19	18	17.3
Years	36	31	10

*Less than 0.5

Hail associated with thunderstorm activity is seldom of the severe type in the Seabrook region. The table below lists the total number of days with hail over a 40-year period for Boston and Portland (Reference 7). Data for Concord, New Hampshire, an inland station 40 miles northwest of the site, are also presented.

DAYS WITH HAIL

	Total Possible Days	Hail Days	Ratio	Years
Boston	14,610	28	0.0019	40
Portland	14,610	33	0.0023	40
Concord	12,783	29	0.0023	35

A number of reports of hail with a diameter over 1.5 inches have been logged by the National Severe Storm Forecast Center for New Hampshire, Massachusetts and Maine over a 13 year period (Reference 8). An average of 0.4 storms per year with hail 0.75 inches in diameter or larger have been reported for the 1° square that includes the Seabrook area.

2.6.6 Atmospheric Dispersion Estimates

The meteorological data collected at the site were also used to obtain dispersion estimates for assessing the consequences of routine and accidental gaseous releases from the plant.

The accident dispersion data were based on cumulative frequency distributions of hourly dilution factors (χ/Q) averaged over selected time intervals. The hourly χ/Q, in turn, were evaluated by two different models depending on the time interval of concern. Details on the analytical models are presented in subsection 6.1.3. The results obtained for the various time intervals are summarized in the following table for the exclusion radius (3000 ft) and the outer boundary of the low population zone (1.5 miles).

REALISTIC ESTIMATES OF
ACCIDENT DILUTION FACTORS FOR SELECTED
TIME INTERVAL

Time Interval	χ/Q (sec/m^3) at 3000 feet	χ/Q (sec/m^3) at 1.5 mile
0 - 1 hour	7.60×10^{-5}	1.93×10^{-5}
0 - 2 hours	5.51×10^{-5}	1.39×10^{-5}
0 - 8 hours	3.00×10^{-5}	7.65×10^{-6}
8 - 24 hours	1.14×10^{-5}	2.25×10^{-6}
1 - 4 days	8.03×10^{-6}	1.62×10^{-6}
4 - 30 days	8.96×10^{-6}	1.85×10^{-6}

These values represent the time-averaged relative concentrations a receptor could be exposed to if the duration of his exposure to an accidental release of gaseous effluents from the plant is as indicated. Based on one year's worth of on-site meteorological data, these concentrations may be exceeded 50 percent of the time.

Accident dilution factors as functions of distance for population dose computations are given in Table 2.6-5.

Routine diffusion estimates, or annual χ/Q averages, were computed from the on-site hourly data for each sector for distances out to 50 miles. The models used to compute these values are described in subsection 6.1.3. The results are presented in Table 2.6-6. It is seen that the highest annual average dilution factor at the exclusion radius is equal to 3.00×10^{-5} (sec/m^3); it is in the ESE sector and reflects the high frequency of light winds from the WNW.

References

1. Climatological Data National Summary, ESSA, Environmental Data Services, Asheville, N. C., Annual 1969 and Others.

2. Local Climatological Data Annual Summary with Comparative Data, Boston, Mass., NOAA, Environmental Data Service, Asheville, N. C., 1971, 1954 and Others.

3. Local Climatological Data Annual Summary with Comparative Data, Portland, Maine, NOAA, Environmental Data Service, Asheville, N. C., 1971, 1965 and Others.

4. Lautzenheiser, Robert E., Climatological Summary, Portsmouth, N. H., Climatography of the United States No. 20-27, ESSA, Asheville, N. C., 1967.

5. Bennett, Iven, Glaze, Its Meteorology and Climatology, Geographical Distribution, and Economic Effects, Tech. Report EP-105, Hqtrs, Quartermaster Research and Engineering Command, U. S. Army, Natick, Mass., 1959.

6. U. S. Naval Weather Service World-Wide Airfield Summaries, Vol. VIII, Part 7, AD 703606, p. 409, Washington, D. C., March 1970.

7. Hull, Blanche B., Hail Size and Distribution, Tech. Report EP-83, Hqtrs, Quartermaster Research and Engineering Command, U. S. Army, Natick, Mass., 1957.

8. Pautz, Maurice E., Severe Local Storm Occurrences, 1955-1967, ESSA Tech. Memo WBTM FCST 12, Weather Analysis and Prediction Division, Silver Springs, Md., 1969.

9. Thom, H.C.S., New Distributions of Extreme Winds in the United States, Journal of the Structural Division, ASCE, Vol. 94, No. ST7, Proc. Paper 6038, pp. 1787-1801, 1968.

10. Wolford, Laura V., Tornado Occurrences in the United States, Weather Bureau Tech. Paper No. 20, Supplements 1960-1965, U. S. Dept. of Commerce, Washington, D. C., 1960.

June 1973

11. Simpson, R. H. and Miles B. Lawrence, Atlantic Hurricane Frequencies Along the U. S. Coastline, NOAA Technical Memorandum NWS TM SR-58, Fort Worth, Texas (June 1971).

12. New Hampshire Coastal and Tidal Area, House of Representatives Document Number 249, U. S. Army Corps of Engineers, Sept. 24, 1965.

TABLE 2.6-1

MEAN TEMPERATURES AND EXTREMES (^{o}F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean Daily Maximum														
Boston	37	37	45	56	68	76	82	80	73	63	52	40	59.0	1931 - 1960
Portland	32	34	41	52	64	73	80	78	70	60	48	35	55.6	1931 - 1960
Portsmouth	32	34	42	53	66	75	80	78	70	61	49	35	56.4	1954 - 1967
Mean Daily Minimum														
Boston	23	23	31	40	50	59	65	63	57	47	38	26	43.6	1931 - 1960
Portland	12	12	22	32	42	51	57	55	47	37	29	16	34.4	1931 - 1960
Portsmouth	13	13	22	32	41	51	56	54	46	37	29	17	34.4	1954 - 1967
Record Lowest														
Boston	-13	-18	-8	11	31	41	50	46	34	25	-2	-17		1872 - 1972
Portland	-26	-39	-21	8	23	33	40	33	23	18	5	-21		1941 - 1972
Portsmouth	-23	-15	-8	10	22	35	40	33	26	14	11	-12		1954 - 1967
Mean No. of Days with Minimum 0^{o} or Below														
Boston	0	1	0	0	0	0	0	0	0	0	0	*		1954 - 1971
Portland	6	5	1	0	0	0	0	0	0	0	3	15		1941 - 1971
Portsmouth	4	5	*	0	0	0	0	0	0	0	2	11		1954 - 1967

---

* = less than 1 day

TABLE 2.6-2
(Sheet 1)

MOISTURE DEFICIT BY STABILITY CATEGORY
PERCENT OF COLLECTED DATA

Moisture Deficit (g/m^3)	Pasquill Stability A	B	C	D	E	F	G	All
April 1972								
< 0.5	0.0	0.3	0.3	9.3	3.8	1.7	3.1	18.5
0.5 - 1.0	0.7	0.2	1.2	5.1	2.5	0.7	0.8	11.1
1.0 - 2.0	1.2	0.5	1.7	9.0	8.1	1.7	1.7	23.7
2.0 - 4.0	1.8	2.7	2.0	8.6	8.3	1.3	1.7	26.4
4.0 - 8.0	2.2	1.7	2.7	4.3	2.8	0.5	0.3	14.4
> 8.0	1.2	1.2	0.8	1.8	0.7	0.0	0.2	5.8
May 1972								
< 0.5	0.0	0.0	0.0	3.8	0.9	0.0	1.3	6.0
0.5 - 1.0	0.0	0.0	0.0	9.1	1.9	0.2	0.8	12.0
1.0 - 2.0	0.3	0.3	0.2	6.9	4.9	3.0	2.8	18.5
2.0 - 4.0	1.6	0.8	0.2	6.3	5.8	1.4	1.3	17.4
4.0 - 8.0	1.7	1.3	2.2	11.8	7.7	1.4	0.3	26.5
> 8.0	1.6	1.9	2.4	9.9	3.8	0.2	0.0	19.7
June 1972								
< 0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
0.5 - 1.0	0.0	0.0	0.0	4.6	4.3	0.4	1.7	11.0
1.0 - 2.0	0.3	0.6	0.8	16.8	10.2	3.4	4.1	36.0
2.0 - 4.0	0.7	1.3	1.8	9.4	6.4	2.0	1.0	22.5
4.0 - 8.0	2.5	1.3	1.4	10.8	3.4	1.3	0.1	20.7
> 8.0	1.1	0.8	1.5	5.2	1.0	0.0	0.0	9.6
July 1972								
< 0.5	0.0	0.3	0.4	1.1	0.8	1.0	0.8	4.4
0.5 - 1.0	0.1	0.1	0.1	2.6	4.4	2.7	2.9	12.9
1.0 - 2.0	0.4	0.3	0.1	7.1	4.9	3.0	2.9	18.7
2.0 - 4.0	0.5	0.7	0.8	7.8	7.1	2.5	2.6	21.9
4.0 - 8.0	2.3	1.1	2.0	12.1	7.2	1.6	0.5	27.0
> 8.0	1.5	1.1	1.8	8.7	1.5	0.5	0.0	15.1

TABLE 2.6-2
(Sheet 2)

MOISTURE DEFICIT BY STABILITY CATEGORY
PERCENT OF COLLECTED DATA

Moisture Deficit (g/m^3)	Pasquill Stability A	B	C	D	E	F	G	All
August 1972								
< 0.5	0.0	0.0	0.0	0.3	1.1	0.3	1.7	3.3
0.5 - 1.0	0.0	0.0	0.0	0.7	4.8	1.7	2.7	9.8
1.0 - 2.0	0.0	0.0	0.0	3.9	6.9	3.1	3.5	17.4
2.0 - 4.0	0.0	0.0	0.3	7.8	9.0	5.6	2.4	25.1
4.0 - 8.0	1.4	1.1	2.5	9.7	8.0	2.2	1.5	26.5
> 8.0	2.1	1.3	3.6	7.8	2.2	0.6	0.3	17.9
September 1972								
< 0.5	0.0	0.0	0.0	0.6	2.0	1.5	2.2	6.3
0.5 - 1.0	0.0	0.0	0.0	2.8	4.3	0.8	5.2	13.1
1.0 - 2.0	0.0	0.1	0.3	11.2	6.3	4.9	4.0	26.8
2.0 - 4.0	1.7	0.6	0.1	7.7	8.1	2.5	1.8	22.5
4.0 - 8.0	2.5	1.8	1.8	9.9	5.6	1.4	0.6	23.6
> 8.0	0.3	0.7	2.2	4.2	0.4	0.0	0.0	7.8
October 1972								
< 0.5	0.0	0.0	0.0	2.9	3.2	1.1	7.6	14.8
0.5 - 1.0	0.0	0.0	0.0	2.3	5.2	2.9	2.7	13.2
1.0 - 2.0	0.0	0.4	0.4	3.8	11.9	3.1	2.2	21.7
2.0 - 4.0	0.7	2.0	0.7	10.6	13.2	2.2	1.3	30.7
4.0 - 8.0	2.2	2.0	2.3	8.3	3.2	0.4	0.2	18.6
> 8.0	0.0	0.0	0.4	0.5	0.2	0.0	0.0	1.1
November 1972								
< 0.5	0.1	0.1	0.2	6.4	2.8	2.0	4.6	16.5
0.5 - 1.0	0.3	0.4	0.6	9.8	7.8	2.1	1.5	22.5
1.0 - 2.0	0.6	0.7	0.9	16.3	16.1	1.9	0.7	37.3
2.0 - 4.0	0.9	1.0	0.9	7.2	7.2	0.6	0.0	17.9
4.0 - 8.0	0.4	0.6	0.0	1.9	2.5	0.0	0.0	5.5
> 8.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.4

TABLE 2.6-2
(Sheet 3)

MOISTURE DEFICIT BY STABILITY CATEGORY
PERCENT OF COLLECTED DATA

Moisture Deficit (g/m³)	Pasquill Stability A	B	C	D	E	F	G	All
December 1972								
< 0.5	0.3	0.4	0.0	20.0	7.8	0.5	0.5	29.6
0.5 - 1.0	0.4	0.1	0.1	14.9	11.0	2.2	0.7	29.5
1.0 - 2.0	1.3	0.4	0.8	12.4	13.2	2.0	0.4	30.6
2.0 - 4.0	0.1	0.9	0.9	3.9	3.6	0.1	0.0	9.7
4.0 - 8.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.7
> 8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
January 1973								
< 0.5	0.0	0.0	0.0	3.1	2.0	0.5	3.9	9.5
0.5 - 1.0	0.3	0.1	0.3	11.8	12.2	2.0	2.7	29.4
1.0 - 2.0	0.1	0.1	1.5	11.8	11.2	2.6	2.6	29.8
2.0 - 4.0	0.1	0.3	0.9	9.1	12.0	2.6	1.5	26.5
4.0 - 8.0	0.1	0.0	0.0	1.6	2.3	0.7	0.0	4.7
> 8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
February 1973								
< 0.5	0.0	0.3	0.3	12.1	4.9	1.5	0.8	19.8
0.5 - 1.0	1.1	0.3	0.5	15.6	9.2	1.4	0.5	28.4
1.0 - 2.0	1.5	1.1	1.1	14.7	10.5	1.1	0.0	29.9
2.0 - 4.0	0.6	0.6	1.2	8.7	8.1	0.5	0.2	19.8
4.0 - 8.0	0.0	0.0	0.2	1.5	0.3	0.0	0.0	2.0
> 8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
March 1973								
< 0.5	0.0	0.0	0.0	12.1	5.9	1.6	2.2	21.8
0.5 - 1.0	0.0	0.3	0.3	9.7	4.7	1.1	2.6	18.5
1.0 - 2.0	1.1	1.3	0.8	10.6	5.2	2.6	1.6	23.3
2.0 - 4.0	0.9	1.1	1.7	9.1	6.6	2.0	2.0	23.5
4.0 - 8.0	2.0	0.9	1.3	4.0	1.9	1.7	0.5	12.5
> 8.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.4

TABLE 2.6-2
(Sheet 4)

MOISTURE DEFICIT BY STABILITY CATEGORY
PERCENT OF COLLECTED DATA

Moisture Deficit (g/m³)	Pasquill Stability A	B	C	D	E	F	G	All
Spring (Mar 73, Apr - May 72)								
< 0.5	0.0	0.1	0.1	8.5	3.7	1.2	2.2	15.8
0.5 - 1.0	0.2	0.2	0.5	8.1	3.1	0.7	1.5	14.2
1.0 - 2.0	0.9	0.8	0.9	8.9	6.0	2.4	2.0	21.9
2.0 - 4.0	1.4	1.5	1.3	8.1	6.9	1.6	1.7	22.4
4.0 - 8.0	2.0	1.3	2.0	6.6	4.0	1.3	0.4	17.6
> 8.0	0.9	1.0	1.0	3.7	1.5	0.1	0.1	8.2
Summer (Jun 72 - Aug 72)								
< 0.5	0.0	0.1	0.1	0.5	0.6	0.4	0.8	2.7
0.5 - 1.0	0.0	0.0	0.0	2.6	4.5	1.6	2.4	11.3
1.0 - 2.0	0.2	0.3	0.3	9.2	7.3	3.1	3.5	24.0
2.0 - 4.0	0.4	0.6	1.0	8.3	7.5	3.3	2.0	23.2
4.0 - 8.0	2.1	1.2	2.0	10.9	6.2	1.7	0.7	24.7
> 8.0	1.6	1.1	2.3	7.3	1.6	0.4	0.1	14.2
Fall (Sep 72 - Nov 72)								
< 0.5	0.1	0.1	0.2	3.2	2.7	1.6	4.6	12.2
0.5 - 1.0	0.1	0.2	0.2	5.1	5.8	1.8	3.2	16.4
1.0 - 2.0	0.2	0.4	0.5	10.8	11.3	3.3	2.4	29.0
2.0 - 4.0	1.1	1.1	0.6	8.4	9.2	1.7	1.0	23.2
4.0 - 8.0	1.7	1.4	1.3	6.7	3.9	0.6	0.3	15.9
> 8.0	0.1	0.3	0.9	1.7	0.3	0.0	0.0	3.3
Winter (Dec 72 - Feb 73)								
< 0.5	0.1	0.2	0.1	11.7	4.9	0.8	1.8	19.9
0.5 - 1.0	0.6	0.2	0.3	14.1	10.9	1.9	1.3	29.1
1.0 - 2.0	1.0	0.5	1.1	12.9	11.7	1.9	1.0	30.1
2.0 - 4.0	0.3	0.6	1.0	7.2	7.9	1.1	0.6	18.6
4.0 - 8.0	0.0	0.0	0.0	1.2	0.9	0.2	0.0	2.5
> 8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 2.6-2
(Sheet 5)

MOISTURE DEFICIT BY STABILITY CATEGORY
PERCENT OF COLLECTED DATA

Moisture Deficit (g/m^3)	Pasquill Stability A	B	C	D	E	F	G	All
Annual (Apr 72 - Mar 73)								
< 0.5	0.0	0.1	0.1	6.0	3.0	1.0	2.3	12.5
0.5 - 1.0	0.2	0.1	0.2	7.5	6.1	1.5	2.1	17.8
1.0 - 2.0	0.6	0.5	0.7	10.5	9.1	2.7	2.2	26.2
2.0 - 4.0	0.8	0.9	1.0	8.0	7.9	2.0	1.3	21.8
4.0 - 8.0	1.4	1.0	1.3	6.3	3.7	1.0	0.4	15.1
> 8.0	0.7	0.6	1.1	3.2	0.8	0.1	0.0	6.5

TABLE 2.6-3

PRECIPITATION (INCHES)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean Monthly														
Boston	3.9	3.3	4.2	3.8	3.3	3.5	2.9	3.7	3.5	3.1	3.9	3.6	42.8	1931 - 1960
Portland	4.4	3.8	4.3	3.7	3.4	3.2	2.9	2.4	3.5	3.2	4.2	3.9	42.9	1931 - 1960
Portsmouth	4.2	4.0	3.4	3.6	2.8	2.7	3.4	2.7	3.8	4.1	4.6	3.5	42.6	1954 - 1967
Maximum Monthly														
Boston	9.5	7.1	11.0	9.1	13.4	9.1	11.7	17.1	10.9	8.8	11.3	9.7		1871 - 1972
Portland	9.4	6.8	10.0	6.5	7.7	6.3	5.9	8.3	9.8	12.3	9.8	9.7		1941 - 1972
Portsmouth	13.8	5.8	6.2	6.5	6.4	6.3	5.4	6.7	9.1	10.8	9.7	6.4		1954 - 1967
Minimum Monthly														
Boston	0.9	0.4	T	0.9	0.2	0.3	0.5	0.4	0.2	0.1	0.6	0.7		1872 - 1971
Portland	0.8	1.3	0.8	0.7	0.5	0.7	0.6	0.3	0.3	0.3	2.1	1.0		1941 - 1971
Portsmouth	0.9	1.3	1.7	1.4	1.0	0.8	1.3	1.4	1.5	1.9	2.4	1.0		1954 - 1961
Maximum 24 Hour Total														
Boston	3.2	4.4	4.1	3.2	5.7	5.4	6.0	8.4	5.6	4.9	5.4	4.2		1871 - 1972
Portland	2.0	3.2	3.5	2.4	2.3	5.6	2.2	4.2	7.5	7.7	3.4	3.8		1941 - 1972
Portsmouth	2.6	3.4	1.8	1.7	1.8	2.4	2.4	2.2	6.6	5.6	2.8	2.0		1954 - 1967

T = less than 0.01 inches

TABLE 2.6-4

SNOWFALL (INCHES)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean Monthly														
Boston	12.4	12.1	8.4	0.7	T	0	0	0	0	T	1.3	8.1	43.0	1936 - 1971
Portland	18.4	21.0	14.1	3.0	0.3	0	0	0	T	0.3	3.1	15.2	75.4	1941 - 1971
Portsmouth	17.7	18.9	16.3	1.9	T	0	0	0	0	T	1.8	15.6	72.2	1954 - 1967
Maximum Monthly														
Boston	36	41	33	28	T	T	T	T	T	1	18	28		1872 - 1972
Year	1904	1969	1916	1874	1953	1952	1954	1954	1948	1884	1898	1970		
Portland	59	61	47	16	7	0	0	0	T	4	16	55		1926 - 1972
Year	1935	1969	1956	1967	1945				1959	1969	1938	1970		
Portsmouth	48	38	54	10	T	0	0	0	0	T	6	42		1954 - 1967
Year	1966	1967	1956	1956	1963					1963	1961	1956		
Maximum 24 Hour Total														
Boston	15	20	18	9	T	T	T	T	T	1	12	13		1872 - 1972
Year	1897	1958	1960	1917	1953	1952	1954	1954	1948	1884	1898	1960		
Portland	14	22	12	9	7	0	0	0	T	4	9	23		1941 - 1972
Year	1944	1969	1964	1971	1945				1959	1969	1961	1970		
Portsmouth	15	15	15	8	T	0	0	0	0	T	5	22		1954 - 1967
Year	1966	1966	1956	1956	1963					1963	1961	1954		

T = less than 0.1 inches

TABLE 2.6-5

Accident Dilution Factors as a Function of Distance
For Selected Time Intervals

χ/Q (sec/m^3)

Distance (Miles)	0 - 1 hrs.	0 - 2 hrs.	0 - 8 hrs.	8 - 24 hrs.	1 - 4 days	4 - 30 days
.5	9.08E-05	6.53E-05	3.54E-05	1.42E-05	9.98E-06	1.11E-05
1.5	1.93E-05	1.39E-05	7.65E-06	2.25E-06	1.62E-06	1.85E-06
2.5	9.43E-06	6.88E-06	3.78E-06	9.98E-07	7.24E-07	8.42E-07
3.5	5.79E-06	4.22E-06	2.33E-06	5.93E-07	4.32E-07	5.09E-07
4.5	4.08E-06	2.95E-06	1.63E-06	4.05E-07	2.97E-07	3.52E-07
7.5	2.02E-06	1.48E-06	8.14E-07	1.89E-07	1.40E-07	1.70E-07
15.0	1.05E-06	7.59E-07	4.18E-07	7.08E-08	5.33E-08	6.61E-08
25.0	8.56E-07	6.22E-07	3.42E-07	3.51E-08	2.70E-08	3.41E-08
35.0	7.61E-07	5.51E-07	3.02E-07	2.24E-08	1.74E-08	2.24E-08
45.0	7.00E-07	5.09E-07	2.80E-07	1.62E-08	1.27E-08	1.65E-08

Note: 1.23E-4 = 1.23×10^{-4}

TABLE 2.6-6
(Sheet 1 of 3)

SEABROOK ANNUAL (NOV 71 - OCT 72)

MEAN ANNUAL CHI/Q BY SECTOR GROUND LEVEL RELEASE
SECTOR AVERAGE AND/OR LIMITED MIXING MODEL L=900 M

DOWNWIND SECTOR	NBR	DOWNWIND DISTANCE (MILES) 0.5	0.57	1.50	2.50
SSW	208	0.348E-05	0.280E-05	0.573E-06	0.258E-06
SW	282	0.305E-05	0.246E-05	0.502E-06	0.226E-06
WSW	393	0.237E-05	0.191E-05	0.389E-06	0.174E-06
W	325	0.372E-05	0.300E-05	0.621E-06	0.282E-06
WNW	351	0.303E-05	0.243E-05	0.491E-06	0.220E-06
NW	369	0.463E-05	0.372E-05	0.766E-06	0.347E-06
NNW	315	0.518E-05	0.417E-05	0.855E-06	0.386E-06
N	256	0.639E-05	0.515E-05	0.106E-05	0.485E-06
NNE	344	0.649E-05	0.523E-05	0.108E-05	0.490E-06
NE	587	0.963E-05	0.777E-05	0.162E-05	0.742E-06
ENE	762	0.162E-04	0.130E-04	0.274E-05	0.125E-05
E	940	0.196E-04	0.158E-04	0.334E-05	0.153E-05
ESE	1427	0.371E-04	0.300E-04	0.640E-05	0.297E-05
SE	1238	0.154E-04	0.124E-04	0.260E-05	0.119E-05
SSE	416	0.516E-05	0.416E-05	0.855E-06	0.387E-06
S	336	0.427E-05	0.344E-05	0.701E-06	0.315E-06
ALL	8549	0.145E-03	0.117E-03	0.246E-04	0.112E-04

8784 HRS EXAMINED

TABLE 2.6-6
(Sheet 2 of 3)

SEABROOK ANNUAL (NOV 71 - OCT 72)

MEAN ANNUAL CHI/Q BY SECTOR GROUND LEVEL RELEASE
SECTOR AVERAGE AND/OR LIMITED MIXING MODEL L=900 M

DOWNWIND SECTOR	NBR	DOWNWIND DISTANCE (MILES) 3.5	4.50	7.50	15.00
SSW	208	0.155E-06	0.107E-06	0.513E-07	0.198E-07
SW	282	0.136E-06	0.936E-07	0.448E-07	0.172E-07
WSW	393	0.104E-06	0.721E-07	0.344E-07	0.132E-07
W	325	0.170E-06	0.118E-06	0.573E-07	0.225E-07
WNW	351	0.131E-06	0.901E-07	0.428E-07	0.162E-07
NW	369	0.209E-06	0.144E-06	0.697E-07	0.272E-07
NNW	315	0.232E-06	0.160E-06	0.771E-07	0.298E-07
N	256	0.293E-06	0.203E-06	0.983E-07	0.385E-07
NNE	344	0.296E-06	0.204E-06	0.990E-07	0.386E-07
NE	587	0.450E-06	0.313E-06	0.152E-06	0.605E-07
ENE	762	0.764E-06	0.532E-06	0.260E-06	0.103E-06
E	940	0.939E-06	0.655E-06	0.323E-06	0.129E-06
ESE	1427	0.182E-05	0.127E-05	0.634E-06	0.258E-06
SE	1238	0.726E-06	0.505E-06	0.247E-06	0.987E-07
SSE	416	0.233E-06	0.161E-06	0.777E-07	0.303E-07
S	336	0.189E-06	0.130E-06	0.620E-07	0.237E-07
ALL	8549	0.685E-05	0.476E-05	0.233E-05	0.928E-06

8784 HRS EXAMINED

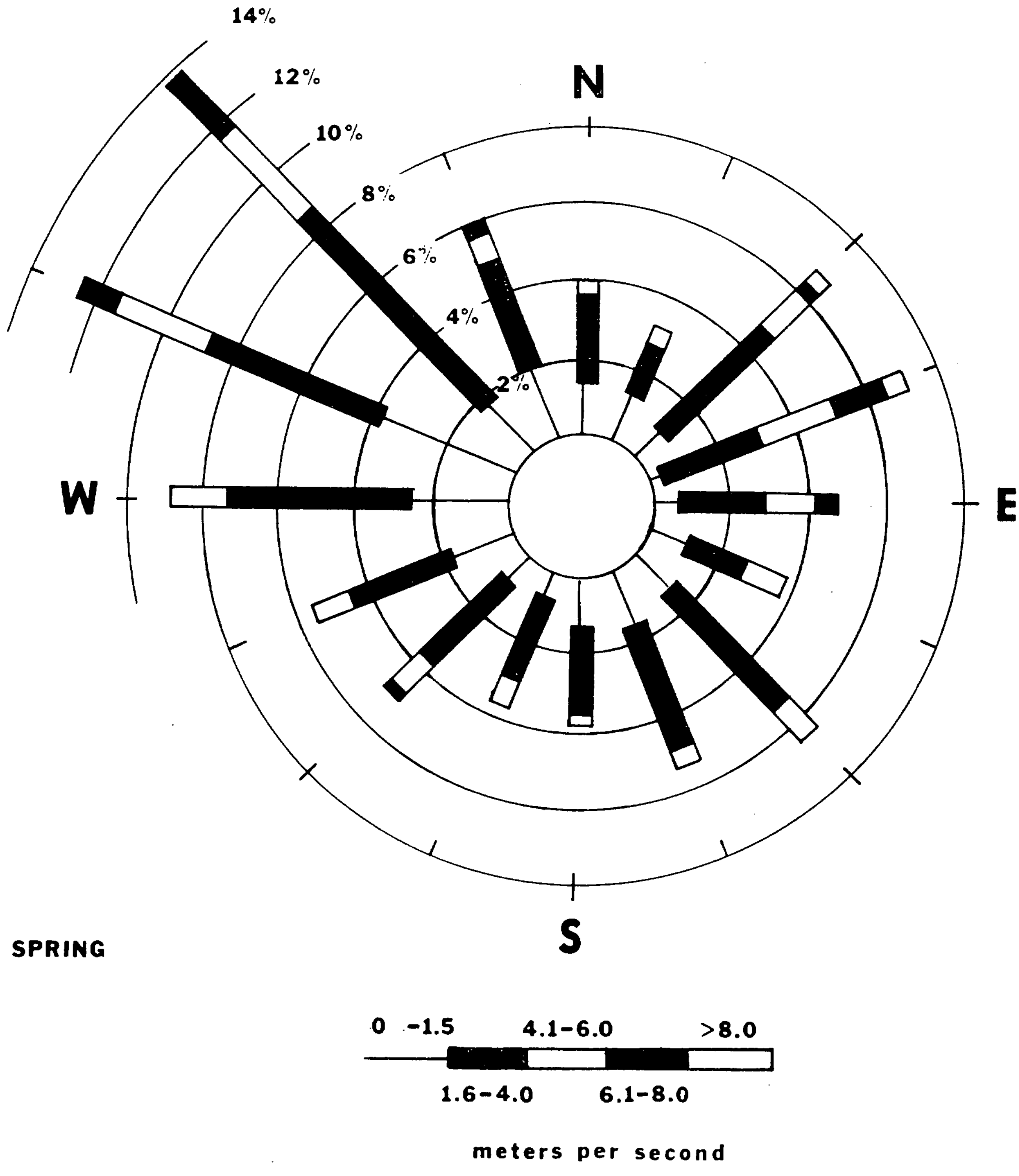
TABLE 2.6-6
(Sheet 3 of 3)

SEABROOK ANNUAL (NOV 71 - OCT 72)

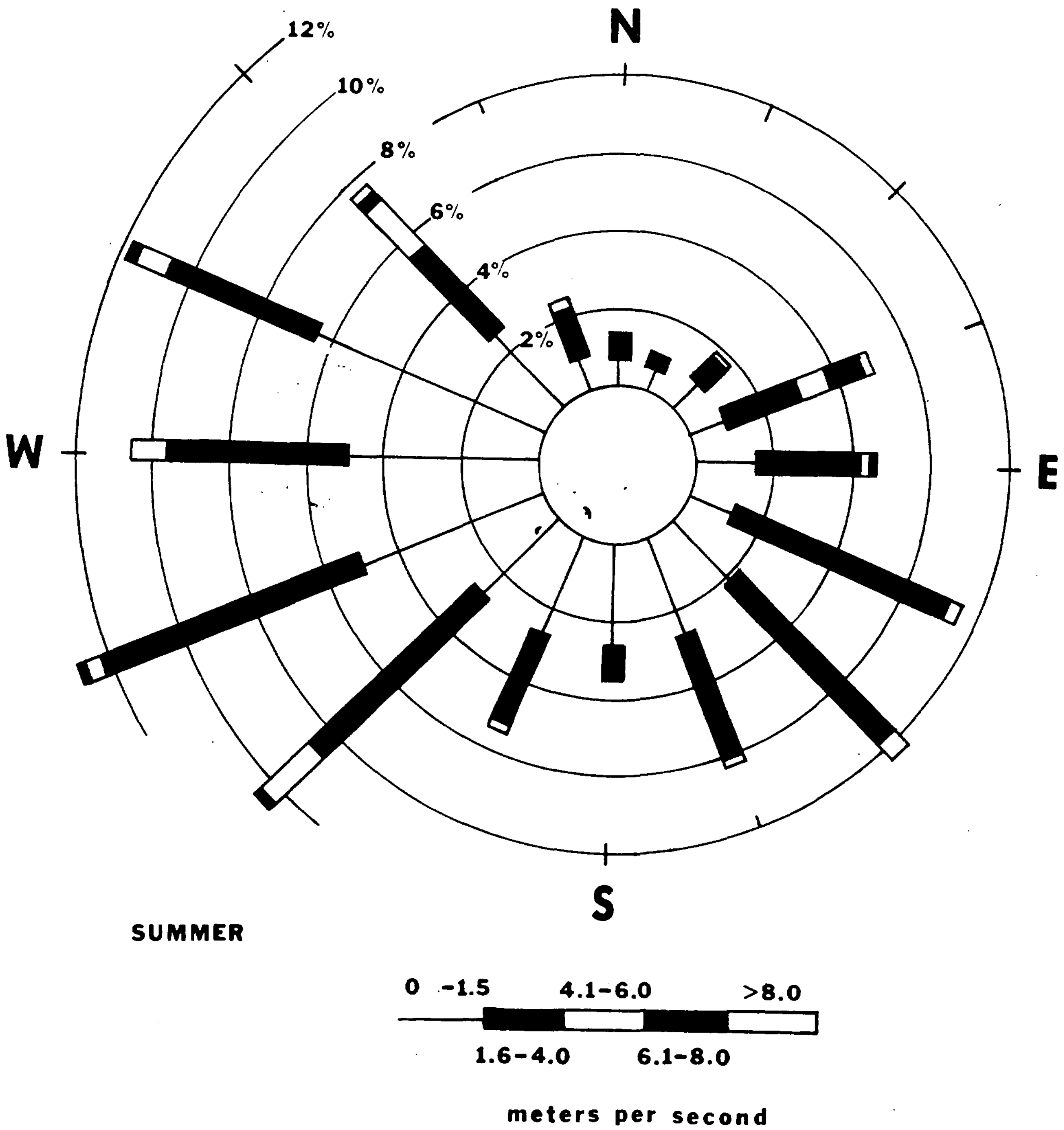
MEAN ANNUAL CHI/Q BY SECTOR GROUND LEVEL RELEASE
SECTOR AVERAGE AND/OR LIMITED MIXING MODEL L=900 M

DOWNWIND SECTOR	NBR	DOWNWIND DISTANCE (MILES) 25.0	35.00	45.00	50.00
SSW	208	0.101E-07	0.668E-08	0.492E-08	0.434E-08
SW	282	0.886E-08	0.581E-08	0.427E-08	0.377E-08
WSW	393	0.676E-08	0.442E-08	0.325E-08	0.286E-08
W	325	0.117E-07	0.776E-08	0.576E-08	0.509E-08
WNW	351	0.825E-08	0.537E-08	0.393E-08	0.345E-08
NW	369	0.141E-07	0.932E-08	0.690E-08	0.609E-08
NNW	315	0.153E-07	0.101E-07	0.746E-08	0.658E-08
N	256	0.200E-07	0.132E-07	0.981E-08	0.867E-08
NNE	344	0.200E-07	0.132E-07	0.978E-08	0.864E-08
NE	587	0.318E-07	0.211E-07	0.157E-07	0.139E-07
ENE	762	0.548E-07	0.365E-07	0.273E-07	0.242E-07
E	940	0.690E-07	0.462E-07	0.346E-07	0.307E-07
ESE	1427	0.138E-06	0.935E-07	0.704E-07	0.626E-07
SE	1238	0.521E-07	0.348E-07	0.259E-07	0.230E-07
SSE	416	0.157E-07	0.103E-07	0.766E-08	0.677E-08
S	336	0.121E-07	0.795E-08	0.584E-08	0.514E-08
ALL	8549	0.489E-06	0.326E-06	0.243E-06	0.216E-06

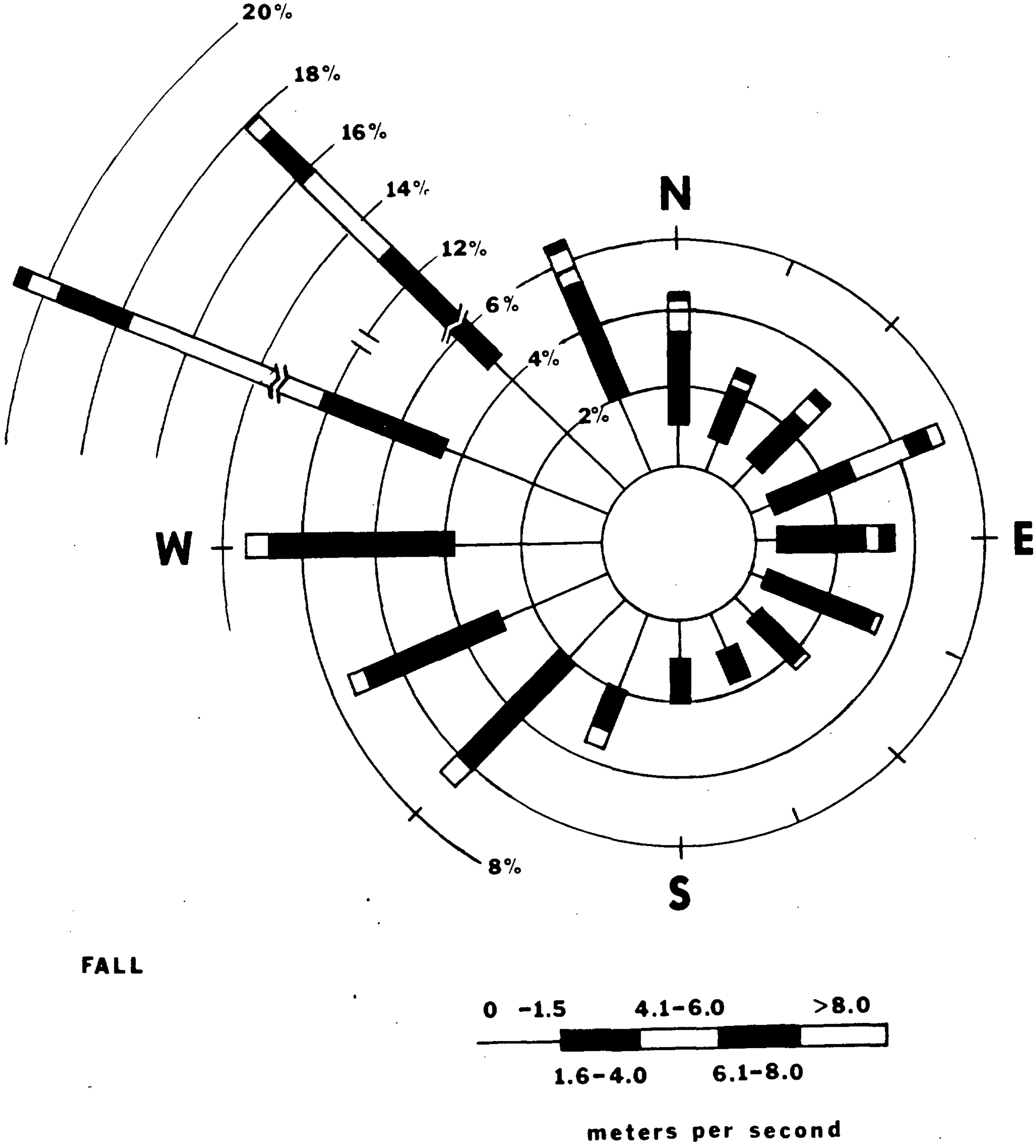
8784 HRS EXAMINED



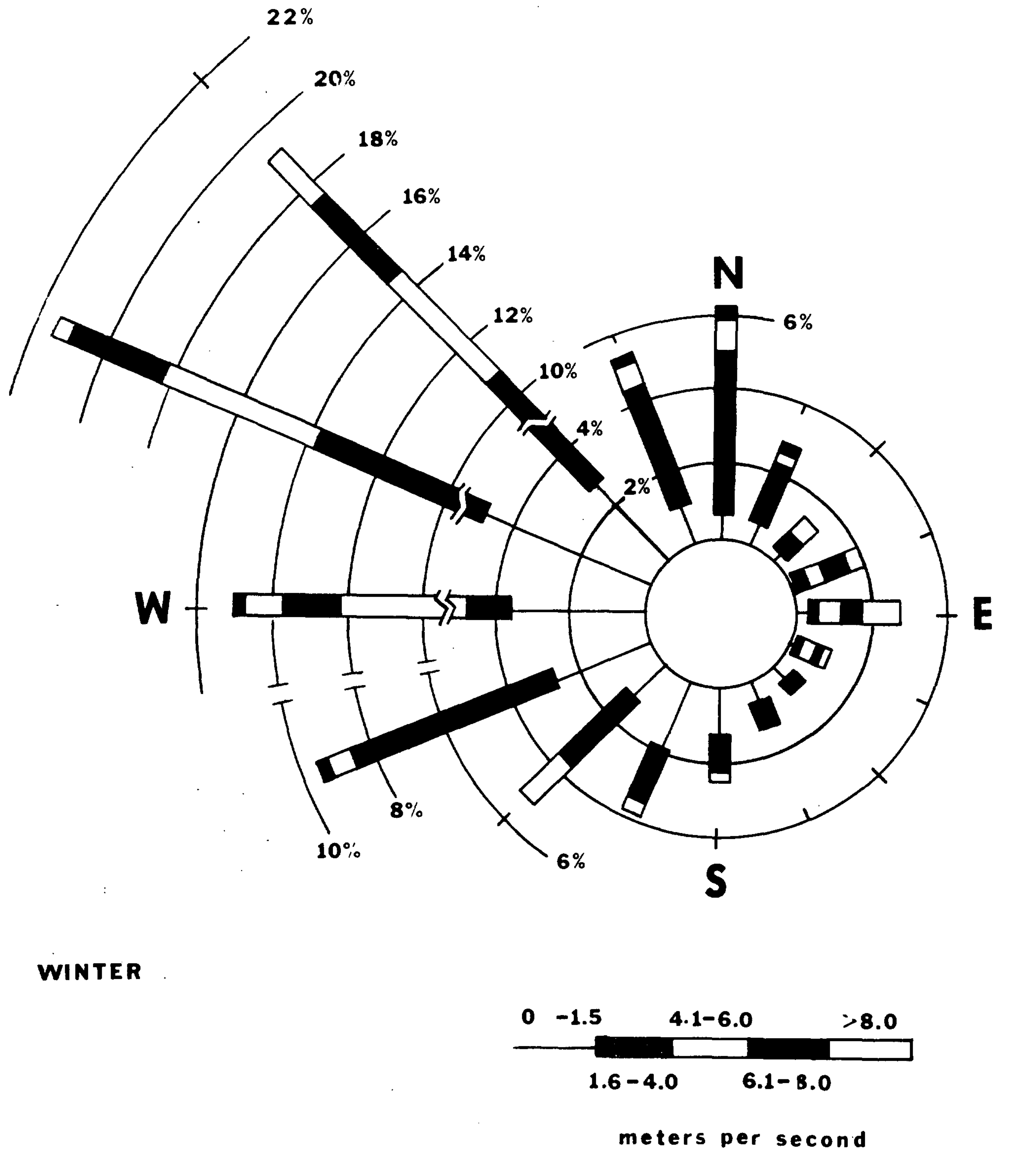
PSNH SEABROOK STATION	SPRING WIND ROSE (30 FT LEVEL)	FIGURE 2.6-1



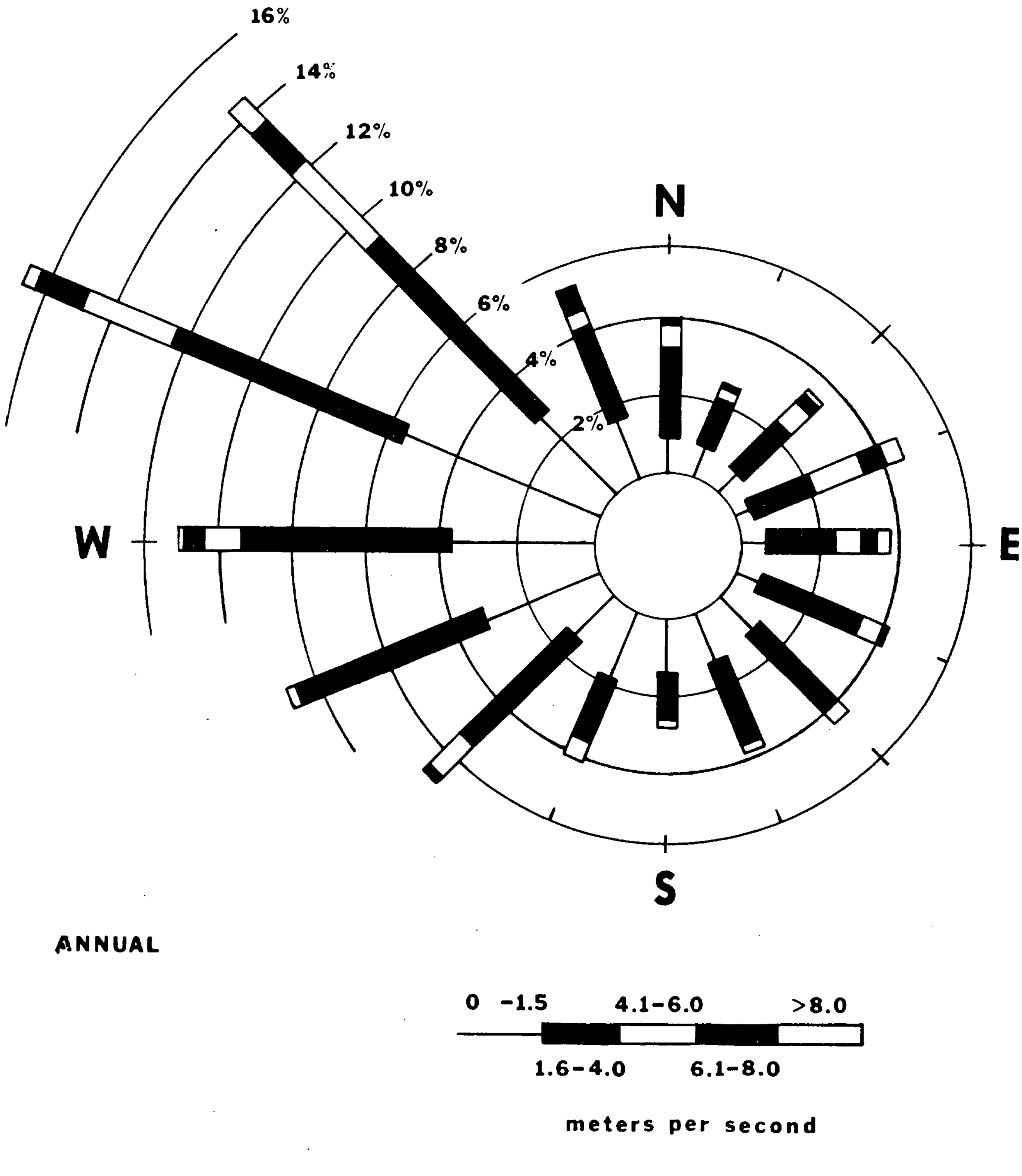
PSNH SEABROOK STATION	SUMMER WIND ROSE (30 FT LEVEL)	FIGURE 2.6-2



PSNH SEABROOK STATION	FALL WIND ROSE (30 FT LEVEL)	FIGURE 2.6-3



PSNH SEABROOK STATION	WINTER WIND ROSE (30 FT LEVEL)	FIGURE 2.6-4



PSNH SEABROOK STATION	ANNUAL WIND ROSE (30 FT LEVEL) (NOVEMBER 1971 - OCTOBER 1972)	FIGURE 2.6-5

2.7

2.7 Ecology

2.7.1 Terrestrial Ecology

Vegetation of the Seabrook site may be generally described as a diverse assemblage of plant types and associations caused by variations in terrain and no doubt reflecting the many uses of this land by man in the past.

Natural topographic features certainly regulate vegetative types to some extent. Most prominent of these regulators is elevation which influences soil water content and has been in part responsible for the establishment of distinct upland hardwood, swamp hardwood and hemlock ravine forest communities. Salt spray is another natural feature which has influenced plant distribution. The fringe bordering the salt marsh has been populated by relatively salt tolerant forms compared to more inland plants. Certain salt-intolerant species such as sugar maple and juniper are absent from the site entirely but whereas others, similarly intolerant, are found (hemlock, poison ivy, white pine). This absence is viewed as a matter of chance.

In addition to natural factors, the actions of man have done much to shape the existing vegetative associations. Such actions as selective cutting of commercially valuable species, clear cutting for roads, dwellings, powerlines, and dump sites and herbicide applications for power line maintenance have occurred at specific locations over the years resulting in successional sere of many types and stages.

Despite the heterogeneity of plant types and associations it is possible to identify and map six major types of forest vegetation. These forest communities are characterized as follows:

1. Hardwood - (Red Cedar)
   On ledges adjoining the salt marsh, Red and White Oaks, Shagbark and Pignut-Hickories, Red Maple, Red Cedar, Black Oak, Basswood,

and Pitch Pine tend to be the most abundant trees while, on moister shores, Red Maple and oaks, including Swamp White Oak, become more common. Shrub species tend to be less specialized and several kinds of Shadbush occur widely on rocky or wetter marsh edges. Sassafras is abundant on some rocky shores and nearly absent from wet sites. Bayberry, Catbrier and Sumac are common as well as Poison Ivy. On moister shores an abundance of Arrow-wood, Smooth Alder, Shadbush and Chokeberry is found.

2. Upland Oak - Hickory
   Areas dominated by Red, White and Black Oak and both Shagbark and Pignut Hickory with occasional Black Birch, Black Cherry and Red Maple. Catbrier, Huckleberry, species of Low Blueberry, Gray Dogwood, Poison Ivy, Chokeberry, Bayberry and Shadbush species are common.

3. Swamp Hardwoods
   Dominated by Red Maple and often with abundant Red and White Oak and occasional Tupelo. Shrubs present include Shadbush, Winterberry, Sweet Pepperbush, abundant Highbush Blueberry, occasional Maleberry and tangles of Catbrier. Herbaceous plants often include Cinnamon Fern, Hay-scented Fern, Lady-Fern and Shield Ferns often in great abundance.

4. Upland Hardwood - Evergreen
   This represents an older type of forest in an ecological sense having acquired both Hemlocks and Beech trees in addition to early arrivals such as White Pine, aspens and Gray and White Birches. The groundcover species often include an abundance of Starflower, Canada Mayflower, Partridge-berry and Wild Sarsaparilla with frequent Layd's-slipper orchids and Wild Cucumber-root.

5. Hemlock Ravine
   A very specialized vegetational type with Hemlocks abundant and White Pine common. Along the moist banks of the stream grow luxuriant Shield Ferns, False Hellebore and Jack-in-the-Pulpits.

6. Old Field Pine

This type of forest has grown up recently on land formerly cleared for field or pasture. White Pine is the principal species but often intermixed with many broad-leaved species but rarely with either Beech or Hemlock. Shrub species are usually not very abundant except for those which persist from the pasture shrub stage. Thus Highbush Blueberry may be common as well as various other species that previously thrived when the area was open.

The location and areal extent of these forest communities are shown on page 7 in Appendix A.

Several plants considered rare to coastal New Hampshire have been found on the site. One of these, wild coffee (Triosteum aurantiacum), had been previously unkown to New Hampshire until its discovery on the southern side of "The Rocks" within the area cleared and maintained for power lines. Records show that wild coffee has been found also in Maine and in southern New England. Three other unusual plants are located near the wild coffee, namely a Bush-Clover (Lespedeza), Venus' Looking-Glass (Specularia) and Wild Licorice (Galium circaezans). It is possible that herbicide application along the power line has in fact promoted the continuation of these uncommon plants by preventing encroachment of certain more common types.

For a more complete description of the flora of the Seabrook Station site including a plant inventory refer to the survey report entitled "Botanical Survey of Seabrook Nuclear Project Site" by Hodgdon and Wicks in Appendix A.

Mammals

Mammals of the site can generally be correlated with distinct plant communities. This preferential selection of plant community may be based on food requirements or their needs for cover with both sometimes inextricably joined. Shrews and moles are found among the understory vegetation where they feed primarily on insect adults and sub-adults. In addition worms, isopods, slugs, arachnids, rodents and plant materials may enter their diet. Based on collected data, the most common insectivore here seems to be the short-tailed shrew (Blarina brevicauda). This locally abundant mammal may be found in a variety of habitats, the field where they frequent microtine rodent runways and the forest litter in shallow burrows of their own construction or those of moles or microtines. The short-tailed shrew, because of its abundance and feeding preference, undoubtedly is of value as an insect predator. The star-nosed mole (Condylura cristata), noted to prefer swampy low areas, has been observed by local residents and no doubt could be found on the site.

Bats are commonly observed in this area during the crepuscular hours. Although no specimens have been collected on site it is certain that two species are represented here, namely the little brown bat (Myotis lucifugus) and big brown bat (Eptesicus fuscus). Such a prediction is based on review of catch records in adjacent locales. Both bat species are solitary in their habits leaving their roosts at dusk for nightly forays on local flying insect populations. Because of this dietary preference their role in nature as viewed by man is one of beneficence.

Rodents of many types are well represented on the site. Around the dump Norway rats (Rattus norvegicus) and house mice (Mus musculus) are particularly abundant. Both feed on dumped refuse material and are considered undersirable inhabitants.

Certainly the most obvious rodents of the area are the squirrels (both gray and red) and chipmunk. The flying squirrels (Glaucomys spp.) are within range and probably present but because of their nocturnal habits are not seen. In addition to nuts the squirrels feed on buds, mushrooms, and birds eggs. The flying squirrels are particularly noted as opportunistic carivores feeding occasionally on birds and nocturnal insects as well as plant materials. The gray squirrel (Sciurus carolinensis) is of value as a game species. The State of New Hampshire has a one month season (October 1 to November 1) in all but two northern counties, with a daily limit of five. The method of hunting generally involves reconnaissance of oak, beech and hickory stands and the shooting of the animal from the tree. Compared with other native game species, the gray squirrel is unimportant being hunted by about 11 percent of the resident license holders according to a survey conducted in 1947 through 1951. A similar follow-up survey in 1964 showed that 12 percent hunted squirrel. Their preferred habitat at Seabrook site is the mixed hardwood stands where they forage for food and construct nests. Although the gray squirrel has a locally rare melanistic phase, none have been seen in this area. All of the squirrels are considered beneficial in their roles as planters of nut trees and because of the pleasure they afford to people who watch them.

The woodchuck (Marmota monax) is commonly reported by local residents and several typical burrows are found on the site. Because of its depredations on local gardens its reputation locally is that of a noxious and troublesome rodent. In truth woodchucks are of value as primary consumers in the food chain converting plant tissue to animal tissue which in turn is utilized by carnivorous species.

Three microtine rodents are certain inhabitants of the site, namely, the white-footed mouse (Peromyscus leucopus), meadow vole (Microtus pennsylvanicus) and muskrat (Ondatra zibethicus). The first two mentioned, although economically unimportant, are extremely valuable to the food chain. Both the white-footed mouse and the meadow vole are prolific breeders whose numbers serve as food for such predators as raptorial birds, weasel, and fox. The two are similar in their ecological niche but differ in habitat preference with Peromyscus inhabiting the woodlands and Microtus the fields. The muskrat is far less abundant than other microtines but of greater direct economic value due to the price paid for its pelt. Muskrat are well known by the local residents and their signs are found on the site. Their food consists chiefly of stems and roots of aquatic vegetation although at times they are known to feed upon frogs and fish. They are preyed upon by mink, raptorial birds, fox and, of course, man.

In the course of a small mammals sampling program, several meadow jumping mice (Zapus hudsonius) were taken. The numbers trapped during this brief period suggests an abundance of these small rodents.

Although none have yet been observed it is possible, based on knowledge of range and habitat, that porcupine (Erethizon dorsatum) are present on the site.

The weasel-like mammals (Family Mustelidae) are represented for certain on the site by the short-tailed weasel (Mustela erminea), mink (Mustela vison) and skunk (Mephitis mephitis). It is possible that fisher (Martes pennanti) long-tailed weasel (Mustela frenata) and otter (Lutra canadensis) may also be present. Of these mustelids all but the skunk is of potential value for its pelt although trapping records show few engage in this pursuit in the coastal region. Disregarding the potential economic value of mustelids they are of certain ecological benefit in that they, as carivores, regulate the populations of small herbivorous mammals such as rodents and in so doing represent a distinct link in the food chain.

Red fox (Vulpes fulva) are well known by the local residents and their dens and scats can be found on the site. Although not a game species, fox are hunted by an estimated 3 percent of the licensed resident hunters. They are also sought by New Hampshire trappers for their pelts. The role of the red fox within the ecosystem is similar to that of other carnivores, controlling prey species populations and converting energy to a higher trophic level. In addition to small mammals, and birds they feed on berries and fruits in season.

Raccoons (Procyon lotor) are certain inhabitants of the Seabrook site especially so because of the presence of the dump. They are omnivorous in their diet, eating a great variety of nuts, fruits, grains, invertebrates, frogs and bird eggs. Raccoons are economically important as a game species. A 1964 hunter preference survey showed that 8 percent of the resident license holders pursue this animal. This ranks the raccoon tenth in relative species popularity among hunters.

The ecological role of raccoon is, because of their omnivorous diet, a dichotomy of carnivore and herbivore.

The New England cottontail rabbit (Sylvilagus transitionalis) has been observed on the site and is well known by local residents. Cottontails are herbivorous and are therefore important as primary consumers and as prey species for such carnivores as fox, raptorial birds and fisher. Tularemia or "rabbit fever" is a disease affecting both cottontails and hares which may in turn be transmitted to man. Although it is recorded in New Hampshire it is not considered widespread, rather of sporadic occurrence. There is no evidence of tularemia in the local population of cottontails at this time.

From the point of view of local residents the most important mammalian inhabitant of the Seabrook site is the white-tailed deer (Odocoileus virginianus). This opinion, no doubt, reflects the overwhelming popularity of deer hunting among hunters as well as a recognition of their importance to the State's significant recreation-based economy. A cursory survey of the site shows their presence as indicated by tracks and deer hair. The deer hair was found near a fox den probably resulting from carrion feeding since deer are much too large to be taken by fox. The site affords ample browse and cover for white-tailed deer and based on known population densities and range requirements it might support several although it is more likely that deer range through the site rather than reside there. Complete dependency on an area the size of Seabrook site might occur at one point within the life of a white tail. Should the doe select a spot on the site for parturition and subsequent raising of fawn(s) then this area would be crucial to the existence of at least the fawn(s). The predators of local deer are domestic dogs and man. Over the past few years a combination of severe winters and predation has reduced the deer herd. Such herd reduction has been responded to by the shortening of the legal hunting season. These measures have not been in effect long enough to determine its success in restoring deer numbers.

There are no rare or endangered mammals known present on the site.

For additional information on area mammals a report entitled "A Survey of the Mammals of the Proposed Nuclear Project Site, Seabrook, New Hampshire" prepared by E. N. Francq is found in Appendix B.

Birds

The site has a mixed avifauna as might be expected considering its variety of plants and plant communities. In addition, the proximity of the marsh, rivers and ocean further contribute to the variety of bird species which may be found there. Numerous species are decidedly transient to the site merely passing over or temporarily alighting before moving on. These transients include loons, grebes, cormorants, herons and egrets, geese and ducks, shore birds, gulls and terns. Present exceptions to this statement are two nesting pairs of green heron in the woods of the site and large numbers of herring gulls which regularly feed at the dump site. These two bird species are obviously dependent in some part on the site.

Raptorial birds, no doubt, are temporarily present here during their migration periods in spring and fall. During these times they would prey largely upon resident rodent populations thereby being of certain ecological benefit as secondary consumers. There is no evidence of hawk, falcon osprey or eagle nesting on the site.

Occurrence of gallinaceous birds is restricted to stocked ring-necked pheasant. These pen-raised cocks are released prior to and during the pheasant hunting season (October 1 to November 9). It is apparent from the numbers seen on the site during late September and October that the New Hampshire Fish and Game Department released cock pheasant either on or immediately adjacent to the Seabrook site. Hunters with bird dogs are seen pursuing these game birds throughout the month of October. There is no indication of breeding pheasant in the spring or summer. Further evidence of the lack of local breeding is demonstrated by a total absence of female and juvenile birds during the hunting seasons. Ruffed grouse have been seen within wooded areas several miles of the site but none are as yet reported on-site.

American woodcock, another upland game bird, has not yet been seen on the site but because of its migration flights, which commonly follow the coast, they are considered a likely transient.

The perching birds are by far the best represented group on the Seabrook site. Those which use the site for nesting include:

Great Crested Flycatcher
Eastern Phoebe
Eastern Wood Pewee
Blue Jay
Black-Capped Chickadee
Brown Creeper
Catbird
Brown Thrasher
Robin
Starling
Red-eyed Vireo
Black and White Warbler
Ovenbird
Yellowthroat
American Redstart
Redwinged Blackbird
Baltimore Oriole
Common Grackle
Brown-Headed Cowbird
American Goldfinch
Rufous-Sided Towhee
Song Sparrow

Those individuals who rely on this habitat for nesting serve generally as primary consumers in the case of the finches and sparrows and as secondary consumers with the insectivorous species. It is of course true that most birds are opportunistic feeders and therefore at times plant eaters and at other times flesh eaters. Perching birds are in turn preyed upon by accipiter hawks, squirrel and fox.

During periods of migration many other perching birds may be expected to use the site as a temporary resting area. For a more complete list of all birds which are believed to use the site as well as the surrounding environs refer to the report entitled "Inventory of birds of Seabrook-Hampton Falls Nuclear Power Plant Site" prepared by R. W. Lawrence appearing in Appendix C.

Reptiles and Amphibians

Observations of local reptiles are limited. Therefore statements of reptile presence on the site are based upon information on range, habitat preference and known abundance. The small pond on the site (Doctor's Pond) could serve as habitat for the Eastern Painted Turtle (Chrysemys picta picta) or perhaps the Stinkpot (Sternotherus odoratus). Both are omivorous feeders utilizing a variety of carrion, insects and plant stuffs. Snake residents may include the Eastern Garter Snake (Thamnophis sirtalis sirtalis), Eastern Milk Snake (Lampropeltis doliata triangulum), Brown Snake (Storeria dekayi), Red-Bellied Snake (Storeria occipitomaculata), Eastern Ringneck Snake (Diadophis punctatus) and Northern Black Racer (Coluber constrictor constrictor). Although two poisonous snakes, namely the Timber Rattlesnake (Crotalus horridus) and Copperhead (Agkistrodon contortrix) are within range they are not believed to be present.

For further information on native New Hampshire reptiles one should consult the "Checklist of New Hampshire Reptiles" in Appendix D.

As with reptiles the amphibians of the site have not been inventoried and therefore the presence of certain species is speculative. Based upon known range, habitat preference and abundance the following amphibians are believed to be present:

Dusky Salamander (Desmognathus fuscus)
Red-Backed Salamander (Plethodon cinereus)
Two-lined Salamander (Eurycea bislineata)
Spotted Salamander (Ambystoma maculatum)
American Toad (Bufo americanus)
Spring Peeper (Hyla crucifer)
Wood Frog (Rana sylvatica)
Leopard Frog (Rana pipiens)

Additional information is available in the appended "Checklist of New Hampshire Amphibians" Appendix E.

Prominent invertebrates of the site include earthworms, slugs, arachnids, and insects. Most notable are the salt marsh mosquito (Aedes sollicitans), Green head fly (Tabanus costalis) and the muscoid flies which frequent the dump.

Terrestrial Communities of the Seabrook Station Site and Their Relationships

The terrestrial environs of the Seabrook Station is considered to have three distinct biotic communities. Each of these is composed of its own particularly unique assemblage of plant and animal populations organized such that it functions as a unit through coupled metabolic transactions. The exact boundaries of such communities are, of course, not absolute but rather they are based on typical organismic interrelationships. Exchange of energy between communities may, at times, occur particularly with organisms of the higher trophic levels.

The three recognized biotic communities on the Seabrook Station site are differentiated as the dump community, the field community and the woodland community.

Dump Community

This community is located within the confines of the Seabrook Town Dump; an area of approximately fifteen acres. The primary energy source is the accumulated organic refuse which is replenished periodically. Dominant consumers are muscoid flies, the Norway rat (Rattus norvegicus), herring gull (Larus argentatus) and common grackle (Quiscalus quiscula). The numerous flies in the area attract a variety of insectivorous birds from adjacent woodlands which in turn may fall prey to their predators (raptorial birds, fox, domestic cat etc.) Occasional burning of dumped material occurs and no doubt profoundly affects the inhabitants of this community.

Field Community

The cleared areas of the Seabrook Station site are the result of past agricultural endeavors, electric transmission line routes and recent cutting to accommodate the meteorological monitoring station. Here the dominant vegetation is an assemblage of various grasses and sedges. The plant material is consumed by orthorpteran, hemipteran and lepidopteran insects as well as the meadow vole (Microtus pennsylvanicus) meadow jumping mouse (Zapus hudsonius) and woodchuck (Marmota monax). Secondary consumers would include insectivorous birds (e.g. fly catchers, thrushes and warblers), short-tailed shrew (Blarina brevicauda), bats (e.g. Myotis lucifugus), red fox (Vulpes fulva) and short-tailed weasel (Mustela erminea). Certainly the secondary consumers of this community are as adaptable to the woodlands as to fields thus providing an energy link between the two.

Woodland Community

Dominant primary producers here are the deciduous trees, coniferous trees, shrubs and herbaceous plants. These plants serve as food sources for insects (e.g. beetle and moth larvae), birds of the family Fringillidae, squirrels, (Tamias striatus, Tamiasciurus hudonius, Sciurus carolinensis, white-footed mouse (Peromyscus leucopus), and white-tailed deer (Odocoileus virginiana). A variety of birds prey upon the woodland insects. These would include woodpeckers, flycatchers, swallows, mimids, thrushes, vireos and warblers. Predators on the rodent herbivores and raptorial birds, short-tailed weasel and red fox. Man may serve as a top-carnivore within this community preying on the large herbivores (deer) as well as secondary consumers.

2.7.2 Aquatic Ecology

The ecology of the Hampton-Seabrook estuary, associated salt marsh, and nearby offshore waters has been the subject of continuing studies by Normandeau Associates, Inc., an independent biological consulting firm. These studies have been conducted on an annual basis since 1969 at the request of Public Service Company of New Hampshire. The main emphasis of the studies has been to provide an adequate baseline of biological information. The secondary objective of these studies has been oriented towards answering specific questions concerning potential ecological effects of construction and operation of the proposed Seabrook Station. Specifically, the studies conducted in 1969-70 as reported in Seabrook Ecological Study: Phase I, 1969-70 (Normandeau Associates, Inc., 1971) consisted of the following:

1) A survey of temperature and salinity of the Hampton-Seabrook estuary, 1969.

2) Physical and biological survey of the proposed discharge location in the offshore waters.

3) Studies of the soft-shelled clam, Mya arenaria, including density and distribution, sediment relationships, reproductive biology and larval ecology.

4) A survey of the benthos in the Hampton-Seabrook estuary.

5) A survey of the epibenthos in the Hampton-Seabrook estuary.

6) A survey of the finfish in the Hampton-Seabrook estuary.

7) A botanical survey of the Hampton-Seabrook estuary, salt marsh, and nearby offshore waters.

Studies conducted during 1970, reported in Seabrook Ecological Study: Phase II, 1970-71 (Normandeau Associates, Inc., 1971) emphasized environmental factors thought to impinge significantly upon stability and maintenance of the soft-shelled clam, Mya arenaria, population and recreational fishery.

Phase III studies conducted in 1971 and early 1972 reported on in a series of technical reports (Seabrook Ecological Study - 1971, Technical Reports III-1 through III-8) dealt with several aspects of the ecology of the marsh, estuary, and offshore waters. Specifically, they reported on:

Technical Report III-1 -- Soft-shelled Clam Spat Density

Technical Report III-2 -- An Assessment of Zooplankton Abundance and Exchange (between) Hampton-Seabrook Estuary and Nearby Offshore Waters

Technical Report III-3 -- Soft-shelled Clam Density

Technical Report III-4 -- Marsh Disturbance Study

Technical Report III-5 -- Primary Productivity in Hampton-Seabrook Estuary

Technical Report III-6 -- Day/Night Zooplankton Study

Technical Report III-7 -- Fish Larvae and Eggs of the Hampton-Seabrook Estuary - 1971

Technical Report III-8 -- Soft-shelled Clam (Mya arenaria) Larval Studies.

In addition, the Phase III document included a Progress Report on the preliminary bioassay of marsh peat extract.

Studies currently being conducted are discussed in "Environmental Study Program, Hampton-Seabrook Estuary and Near Offshore Waters, 1972" (Normandeau Associates, Inc., 1972) and consisted of:

1) Ecological Survey of the Benthos Offshore of the Hampton-Seabrook Estuary in the Area of the Proposed Intake and Discharge.

2) Studies of the Soft-shelled Clam in the Hampton-Seabrook Estuary Including Density and Distribution, Age-Growth, Recruitment, and Larval Ecology.

3) Studies of the Effects of Marsh Peat Extract on Estuarine Animals.

4) A Census of Finfish Offshore of the Hampton-Seabrook Estuary in the Area of the Proposed Intake and Discharge.

5) A Study of the Lobster Fishery in the Area of the Proposed Intake and Discharge Lines.

6) A Study of Estuarine and Nearby Offshore Plankton in the Hampton-Seabrook Area.

7) A Hydrographic Survey and a Survey of Plankton in the Neritic Zone Along the Coast of New Hampshire with Emphasis on the Area of the Proposed Intake and Discharge Pipelines.

Data from the above reports and pertinent literature cited in the Bibliography to this section provides the basis for the following discussion.

2.7.2.1 Communities of the Hampton-Seabrook Estuary and Their Relationships

A biotic community has been defined by Odum (Reference 30) as an assemblage of populations of animals and plants living in a prescribed area or physical habitat, and organized to the extent that it functions as a unit through coupled metabolic transactions. While hundreds of kinds of organisms may be present in a community, usually only a few species are considered dominant -- that is, controlling the community on the basis of size, numbers, production, or other activities (Odum, Reference 30).

Such associations of animals are useful to ecologists concerned with monitoring an environment and estimating possible effects of disruption due to pollution or alteration.

In the Hampton-Seabrook estuary several different communities can be differentiated (see Figure 2.7-1). In the offshore area there is a community of the sandy substrate and one of the rocky outcrops. These two interact with the portion of the pelagic community of the surrounding waters. In the estuary itself both subtidal and intertidal communities can be distinguished and in limited areas a hard substrate intertidal community exists. Moving up the estuary, the banks of the marsh form a third intertidal community, the low marsh community, and finally there is a transition zone, or ecotone community, the high marsh which is intermediate between the aquatic and the terrestrial communities.

Pelagic Community

The pelagic community in the offshore region is similar to that described by Dexter (Reference 13) for Ipswich Bay, Massachusetts, and by Clements and Shelford (Reference 8) for large sections of the North Atlantic Ocean. This Scomber - Calanus biome is characterized by Calanus finmarchicus and other copepods, jellyfishes (Aurelia aurita and Cyanea capillata), mackerel (Scomber scombrus), herring (Clupea harengus), and other pelagic fishes.

Calanus finmarchicus dominates the zooplankton from the coast to the continental shelf edge in the Gulf of Maine (Dexter, Reference 13). It and other copepods (*Acartia*, *Temora*, etc.) feed of phytoplankton, especially diatoms. They, in turn, become food for pelagic fishes. The herring and other clupeids feed mainly on *Calanus*, or sometimes sand eels (*Ammodytes*) which have themselves fed on *Calanus* (Russel-Hunter, Reference 36). Mackerel are also zooplankton feeders, but may feed on phytoplankton in the early spring, while in the summer they feed on small fishes, herring, sand eels, and even smaller mackerel (Bigelow and Schroeder, Reference 3).

The pollock, a voracious predator, feeding on all the smaller fishes, as well as on pelagic shrimp and crustaceans, and occasionally on bottom-dwelling crustaceans can also be considered part of the pelagic community (Bigelow and Schroeder, Reference 3).

Subtidal Soft-Bottom Community and Subtidal Hard-Substrate Community

On the sandy sediments of the offshore area are found many vagile organisms -- *Cancer irroratus*, *Cancer borealis*, *Homarus americanus*, *Lunatia heros*, *Nassarius trivittatus*, and a number of bottom fishes, *e.g.*, the flounders, *Liopsetta putnami*, *Pseudopleuronectes americanus*, and sculpin, *Myoxocephalus octodecemspinosus*.

The majority of the infauna consists of sand dollars (*Echinarachnius parma*), amphipods (*Typhosella* sp., *Haustorius canadensis*), annelids (*Nereis* and *Nephthys* spp., *Clymenella torquata*, *Scoloplos fragilis*, and *Scolecolepides viridis*), bivalves (*Ensis directus*, *Tellina agilis*, *Spisula solidissima*, *Arctic islandica*, and *Siliqua costata*).

On hard substrates, around rock outcrops and boulders, starfish (*Asterias vulgaris*) and a few sea urchins (*Strongylocentrotus drobachiensis*) move slowly over the surface, while some of the more active animals (*e.g.*, *Homarus* and *Cancer* spp.) make their way among the rocks. The kelps and other algae growing in this area provide refuge and attachment space for the smaller plant and animals species. Hydroids, bryozoans, serpulid annelids, and the snail, Lacuna vincta, are found on the Laminaria blades, while the holdfasts house tunicates, bryozoans, small sponge colonies, mussel seed, gammarid amphipods, isopods, scaleworms, brittle stars, small crabs, periwinkles, and even fish fry (Dexter, Reference 14). These large sea weeds play an important role as well in slowing the currents, reducing light intensity, and holding sediment, wherever they occur. The other dominant algae species which occur in the rocky areas -- Chondrus crispus, Agarum cribrosum, Phyllophora spp., etc. -- also provide space and protection for animals.

The pelagic and subtidal benthic communities cannot really be considered separately because their dynamics overlap. Their seasonal relations probably remain the same, with the exception of the migrating species of fish, e.g., dogfish (Squalus acanthias), mackerel (Scomber scombrus), and pollock (Pollachius virens), which migrate through the area in the summer, and some of the estuarine fish which move out into the offshore area to escape cold winter temperatures, e.g. winter flounder (Pseudopleuronectes americanus).

In the rocky areas the algae (Laminaria, Chondrus, Ulva, etc.) provide food for many snails (littorinids, Lacuna), crustaceans (Cancer, Pagurus), and fishes. The herbivorous snails are preyed upon by Lunatia and Nassarius trivittatus, while crabs and fish eat both herbivourous and carnivorous snails. The small fish, longhorn sculpin (Myoxocephalus octodecimspinosus), cunner (Tautogolabrus adspersus), etc. are eaten by the larger predaceous fish, striped bass, Morone, and pollock, Pollachius, as well as by diving birds. Sea ducks utilize the area in the fall and winter months, feeding on small mollusks, worms, and amphipods (Stott, Reference 42). Figure 2.7-2 illustrates food relationships of the offshore subtidal community.

In the sandy substrate, most of the bivalves are suspension feeders, filtering out plankton and detritus from the water column. These mollusks fall prey to Lunatia, Cancer spp., Asterias vulgaris, annelids, flounder, sculpin, skates, and spiny dogfish (Dexter, Reference 14).

Subtidal and Intertidal Flats Within the Estuary

Within the estuary the communities are mainly determined by the character of the substrate. In the harbor area, where strong tidal currents result in an unstable substrate of shifting bars and shoals, benthic life is scarce. Where the substrate changes to a more stable sand or muddy-sand substrate, the nature of the subtidal and intertidal flats is similar, including motile species such as Pagurus, Lunatia, Cancer, Carcinus, Liopsetta, and Pseudopleuronectes, which move into intertidal areas to feed when the tide is in and retreat to the subtidal channels and harbor when the tide is out. The lobster, Homarus americanus, occurs within the estuary, mainly in the harbor and the lower part of the Hampton River.

Further up the estuary in the tidal rivers, the substrate changes from coarse to fine sand to mud and peat, with a corresponding change in the benthos.

It is generally recognized that suspension-feeding infauna are more abundant in sandy sediments, due both to lack of negative biotic reactions with deposit feeders, which prefer the higher organic content of mud or muddy sand, and to the greater physical stability of well-sorted sediment, which enables the infaunal suspension feeder to retain the connection of its feeding organs with the surface at all times (Levinton, Reference 26). This general relationship seems to hold true for the Hampton-Seabrook estuary. The dominant suspension-feeding bivalve, Mya arenaria, occurred most densely in substrates of well-sorted sand with a minimal admixture of mud near the harbor, while Macoma balthica, Gemma gemma, and Clymenella torquata have their densest populations further up the estuary where the substrate consists of muddy sand and silt. Nereis and Nephthys polychaetes were found abundantly in both subtidal and intertidal environments, although Nereis spp. were able to penetrate into lower salinity regions than Nephthys.

The food web of the estuary (see Figure 2.7-3) begins with the production of plant material. The salt marsh grass, Spartina spp., and other marsh grass are responsible for much of this, as phytoplankton production can be quite variable and is usually low. However, very few animals feed directly on the Spartina itself. The vegetation goes through its annual cycle of growth and decay and becomes broken down into detritus, which forms a substrate for bacterial growth, providing in its suspended form an important source of food for filter-feeders, and when settled and mixed into the sediment, a major food source for deposit-feeders (Green, Reference 19).

The most important suspension-feeders are the soft-shelled clam, Mya arenaria, the gem clam, Gemma gemma, and the blue mussel, Mytilus edulis (which occurs in dense aggregations, especially in the intertidal flats of the Blackwater River and near the Hampton Marina).

The majority of the infauna of the subtidal and intertidal sediments are deposit feeders. Clymenella torquata, the abundant tube-dwelling polychaete, has been shown by Sanders, et al (Reference 37) to feed mainly on benthic diatoms and organic particles which it gathers by means of currents generated in its ciliated buccal cavity. It is also important in reworking and grading the sediment of the areas in which it occurs in large concentrations (Rhoads, Reference 33). Other common small polychaetes, like Scoloplos viridis and Spio setosa, are also deposit-feeders, ingesting sand, detritus, diatoms, filamentous and macro-algae fragments, and possibly animal material (Sanders, et al, Reference 37). The larger Nereis and Nephthys have been described as carnivores (Clark, Reference 7), but are probably more or less omnivorous in diet. They prey on the other worms, clams, and small crustaceans they come across as they burrow, but also seem to ingest plant material, diatoms, and detritus (Sanders, et al, Reference 37).

The most abundant deposit-feeding clam is Macoma balthica, which moves its siphons in a circle over the surface of the sediment surrounding its burrow, thus coming in contact with the maximum area for feeding (Brafield and Newell, Reference 5).

All these deposit and suspension-feeders may eventually serve as food for the predaceous moon snails, larger crustacians, and the horseshoe crab, *Limulus*, as well as for various fishes and shore birds.

The smaller estuarine fish, subsist on a diet of diatoms, small Crustacea (copepods, amphipods, cladocerans, etc.), small mollusks and worms. *Fundulus*, the most abundant of these small fish, is omnivorous, feeding on diatoms, eelgrass, shrimps and other small crustaceans, small mollusks, and tiny fish. *Pungitius pungitius*, the nine-spined stickleback, and *Gasterosteus aculeatus*, the three-spined stickleback, are also omnivorous, eating diatoms, the smaller invertebrates, especially the crustaceans and fish fry. The silversides, *Menidia menidia*, and the sand eel, *Ammodytes americanus*, have approximately the same diet, as does the pipefish, *Syngnathus fuscus*, though it prefers copepods and amphipods (Bigelow and Schroeder, Reference 3).

Of the larger fish, the smooth flounder, *Liopsetta putnami*, and the winter flounder, *Pseudopleuronectes americanus*, are omnivorous bottom-feeders, ingesting larvae, diatoms, small crustaceans, crabs, shrimp, worms, mollusks, and bits of seaweed (Bigelow and Schroeder, Reference 3).

The striped bass, *Morone saxatilis*, is the most important predatory fish, entering the estuary during the summer to feed on all the smaller fish that are available, as well as a wide variety of invertebrates. Among its food organisms are included alewives, eels, flounders, sculpins, smelt, sand eels, squid, crabs, lobster, nereids, shrimp, *Mya*, and mussels (Bigelow and Schroeder, Reference 3).

Intertidal Hard Substrate Community

Intertidal hard substrate communities provide another subdivision of the estuary, with a structure quite different from that found on the soft bottoms and somewhat similar to that of the offshore rocky area. Here, wherever there are rocks or pilings *Mytilus*, *Balanus*, *Fucus*, and *Ascophyllum* become attached. Associated with them are the herbivorous snails, *Littorina littorea*, *L. obtusata*, and *L. saxatilis*; the carnivorous snail, *Thais lapillus*, Amphipods *Gammarus* spp., starfish *Asterias vulgaris*;

and the crab, Carcinus maenas. At low tide there is little activity, save feeding by some terrestrial and aerial vertebrates; the active species take refuge under the algae, the others remain tightly closed against desiccation and extremes of temperature. When the tide comes in the animals become active, filtering food from the water or hunting prey, taking advantage of the relatively short time that conditions favor their activity.

Low Marsh Community

The portion of the salt marsh between mean low water and mean high water is characterized by Spartina alterniflora, Ascophyllum nodosum f. scorpioides and Fucus vesiculosus var. spiralis. These species are found at the base of the marsh grass stems; Littorina littorea and L. obtusata occur on the algae, while L. saxatilis clings to the stems and lower leaves of the Spartina. Gammarus species hide under the algae or burrow into the bank while the marine insect (Anurida maritima) is common, and other insects begin to occur. Modiolus demissus lives half-embedded in the banks and a few blue mussels and barnacles attach to any suitable surface (Dexter, Reference 14).

During low water the snails remain more or less quiescent, but some amphipods and the Anurida may feed. Marsh insects feed on debris and plants and are in turn fed upon by marsh spiders, visiting passerine birds, (e.g., swallows, redwing blackbirds, sparrows, starlings, etc.) while shore birds and herons collect the various invertibrates among the grasses. As the water returns, the Littorina snails become active, the mussels and barnacles begin to feed, and the Gammarus are able to swim about, while the insects return to the high marsh. Small fishes, e.g., Fundulus, and fish fry return to swim among the Spartina, and Carcinus and Cancer crabs move in to scavenge for debris or feed on the invertebrates (Dexter, Reference 14).

High Marsh Community

The high marsh represents a transitional stage or ecotone between the aquatic and terrestrial communities. It is characterized by Spartina patens, the pulmonate snail, Melampus bidentatus, and amphipods, isopods, and insects (Dexter, Reference 14).

While the high marsh is dry, shore birds and song birds are found walking or flying over the grasses, searching for snails, crustaceans, and insects. The insects and the *Melampus* are active, but the marine snails, *Littorina littorea* and *Littorina saxatilis*, which may be found here, remain rather dormant except during the times of spring tides. The spring tides occurring every two weeks drive the terrestrial fauna back and allow the incursion of *Carcinus*, *Fundulus*, *Limulus*, *Crangon*, and fish fry into the flooded grasses (Dexter, Reference 14). In the high marsh tide pools are found semipermanent populations of *Carcinus*, *Crangon*, *Pungitius*, and *Fundulus*, etc. that are stranded there until the next spring tide. These animals are able to carry on their lives feeding on microfauna and microflora, detritus, and the estuarine insects, (*e.g.*, Corixids) that live there.

2.7.2.2 Flora

A total of 117 taxa of benthonic marine algae have been collected from the estuary and the adjacent open coast, including 30 Chlorophyceae, 35 Phaeophyceae, and 52 Rhodophyceae. Detailed examination of the Cyanophyceae, Bacillariophyceae, and Xanthophyceae was not attempted but general observations were noted in Appendix D of the Seabrook Ecological Study: Phase I (Normandeau Associates, Inc., 1971). The largest number of taxa were found on the open coast and on the Inner and Outer Sunken Rocks with fewer numbers present towards the head of the estuary. Gross fluctuations of species numbers occur at different locations within the estuary primarily because of lack of stable substrate and presence of severe hydrographic conditions. Appendix D of the Seabrook Ecological Study: Phase I (Normandeau Associates, Inc., 1971) contains biological and physical notes for each station sampled in the botanical studies.

Macroalgae in the Offshore Area Adjacent to the Hampton-Seabrook Estuary

The macroalgae in the offshore area is predominantly restricted to the regions of hard substrate, *i.e.*, Inner and Outer Sunken Rocks and the gravel and cobble bottom immediately adjacent to them. There was a positive correlation between the amount of algal cover and the firmness of the substratum. The species dominant in the mixed sand and gravel bottom near the rocks are the so-called psamophytes or "sand-loving" forms. These included Polyides rotundus and Ahnfeltea plicata. Additionally, Desmarestia aculeata was most abundant attached to small boulders or large gravel that were surrounded by sand. The dominant species on the rocky substrate were Agarum cribrosum, Laminaria digitata, Laminaria saccharina, Chondrus crispus, Cystoclonium purpureum var. cirrhosum, Phyllophora spp., Polysiphonia urceolata, Rhodymenia palmata, Chaetomorpha melagonium, and Ulva lactuca. Beneath these foliose forms the rocks were covered with crustose algae. The dominant crustose algae in the area were Clathromorphum circumscriptum and Lithothamnion glaciale. Chondrus crispus, Laminaria spp., and Agarum cribrosum, composed an estimated 80 percent of the biomass in the rocky areas. Although there is no commercial harvesting of any of these species, there is probably enough of the Irish moss, Chondrus crispus, on the Inner and Outer Sunken Rocks to sustain a small commercial operation.

Macroalgae in the Hampton-Seabrook Estuary

The dominant macroalgae of the estuary were the following species: Bryopsis plumosa, Enteromorpha erecta, Enteromorpha intestinalis, Percursaria percursa, Rhizoclonium ripariumm, Ulva lactuca, Ascophyllum nodosum, Ascophyllum nodosum f. scorpiodes, Fucus vesiculosus var. spiralis, Petalonia fascia, Ceramium strictum, and Chondrus crispus. Of these species Ascophyllum nodosum, A. nodosum f. scorpiodes, and Fucus vesiculosus var. spiralis make up the greatest part of the biomass. The distribution by station of these species can be found in Appendix D of Seabrook Ecological Study: Phase I (Normandeau Associates, Inc., 1971).

Species List

Algal species found in the estuary and offshore area (see Figure 2.7-4) and habitat notes for each species:

Chlorophyceae

Bryopsis plumosa (Hudson) C. Agardh: Locally abundant in the estuary (A-3, A-5, A-9, A-15, A-17, B-1, B-2, B-4 to B-6, B-8 and H-3) on muddy surfaces in the sublittoral and lower eulittoral zones. Not found on the open coast.

Chaetomorpha aerea (Dillwyn) Kuetzing: Collected three times from the lower eulittoral (in tide pools) at Beckman's Point.

Chaetomorpha linum (O. F. Mueller) Kuetzing - (including *Chaetomorpha atrovirens* Taylor, in Taylor, 1957): According to our interpretation *C. atrovirens* and *C. linum* are not distinct for there is a continuous gradient of size and color between the two. *Chaetomorpha linum* is the older name and it should be retained. The plant is common as an entangled mass amongst various algae in the lower eulittoral and sublittoral zones of the estuary (A-2, A-11, A-18, B-1, B-2, B-4 to B-6, B-9, B-10, B-12, C-1, C-2, C-6, C-7, and C-9) and the exposed open coast Beckman's Point, (HB-1 and HB-4).

Chaetomorpha melagonium (Weber *et* Mohr) Kuetzing: Occasional on rocks in the lower eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1, and HB-4). Not found in the estuary.

Cladophora sericea (Hudson) Kuetzing sensu van den Hoek, 1963: Locally abundant in high tide pools in the estuary (A-6, A-7, A-9, A-10, B-3, B-7, B-10, B-12, C-3 to C-5, and H-3) and on the exposed open coast (Bound Rock).

Codiolum pusillum (Lyngbye) Kjellman in Foslie: Locally abundant on rocks in the upper littoral zone of the exposed open coast (Bound Rock). Often mixed with *Bangia fuscopurpurea* and various blue green algae. It may be the sporophyte stage of one or more local species of *Urospora* (Scagel, 1966).

Enteromorpha compressa (L.) Greville: Found once on rocks in the lower eulittoral zone at Beckman's Point.

Enteromorpha erecta (Lyngbye) J. Agardh: Abundant on muddy surfaces of the eulittoral zone throughout the estuary (A-1 to A-9, A-13, A-14, A-16, A-17, B-1 to B-7, B-9, B-13, C-1 to C-6, H-1, and H-3); occasionally present as an epiphyte on fucoid algae and *Spartina alterniflora*. Uncommon on the exposed open coast.

Enteromorpha intestinalis (L.) Link: Common on rocks and muddy surfaces of the eulittoral zone throughout the estuary (A-1, A-2, A-4, A-6 to A-10, A-13, A-17, B-1 to B-5, B-8, C-1, C-3, C-5 to C-7, C-9, and H-3) and on the open coast.

Enteromorpha linza (L.) J. Agardh: Found sporadically in the estuary (C-9 and H-1) and on the exposed open coast (Beckman's Point and HB-1); present on mud, rocks, and as an epiphyte in the lower eulittoral and upper sublittoral zones.

Enteromorpha marginata J. Ajardh; equals Blidingia marginata J. Agardh, P. Bangeard): Found once on rocks in the lower eulittoral zone at Bound Rock.

Enteromorpha minima Naegeli; equals Blidingia minima, Naegeli ex Kuetzing, Kylin): Found once in the estuary (B-9) on a muddy bank in the upper littoral zone. More abundant on the exposed open coast where it forms a conspicuous zone on boulders in the upper eulittoral-littoral fringe zones.

Enteromorpha plumosa Kuetzing: Found twice in the estuary (A-18 and B-12) on muddy surfaces in the lower eulittoral zone.

Enteromorpha prolifera (O. F. Mueller) J. Agardh: Infrequent in the estuary (B-2, C-2, C-3, C-5, C-6, and C-11); present on muddy surfaces of the eulittoral zone. Mixed with Enteromorpha erecta but never occurring as abundantly.

Monostroma fuscum (Postels et Ruprecht) Wittrock: Found sporadically throughout the estuary (A-15, B-2, B-4, B-6, B-8, C-1, and C-3) on mud and rocks in the lower eulittoral and sublittoral zones. Abundant in localized areas on the exposed open coast (Beckman's Point and HB-4) and with the same vertical distribution.

Monostroma grevillei (Thuret) Wittrock: Infrequent on rocks in the mid and lower eulittoral zones of the estuary (A-5, A-15, B-6, and B-10). In contrast it is abundant on the exposed open coast and with the same vertical distribution.

Monostroma leptodermum Kjellman: Found once adrift at Station A-3.

Monostroma oxyspermum (Kuetzing) Doty: Locally abundant throughout the estuary (A-2 to A-4, A-9, B-1, B-4, B-6, B-8, C-1, C-2, and C-4 to C-7), particularly in areas of low salinity. It forms a distinct band of high vertical (muddy) banks and occasionally occurs as an epiphyte on Spartina alterniflora and other vascular plants.

Monostroma pulchrum Farlow: Common (during the summer) on rocks and on various algae in the lower eulittoral zones of the exposed open coast.

Percursaria percursa (C. Agardh) Rosenvinge: Locally abundant in the estuary (A-1, A-2, A-16, B-1, B-3, B-6, B-7, and C-3 to C-5) as free-floating masses in tide pools and attached to muddy surfaces in the upper eulittoral zone. Often mixed with Rhizoclonium riparium and Cladophora sericea.

Pseudendoclonium marinum (Reinke) Aleem et Schulz; equals Protoderma marinum Reinke in Taylor, 1957: Abundant on rocks from the mid eulittoral to the sublittoral zones on the exposed open coast; found once in the estuary (A-11).

Rhizoclonium riparium (Roth) Harvey: Abundant throughout the estuary (A-1 to A-5, A-7 to A-9, A-15, B-1 to B-4, B-6, B-8 to B-10, B-11 to B-13, C-1 to C-6, C-8, C-10, C-11, and H-3) as free-floating masses in tide pools and attached to muddy surfaces in the upper littoral zone. Often mixed with Cladophora sericea and Percursaria percursa.

Rhizoclonium tortuosum Kuetzing: Abundant during the summer on the exposed open coast; found once in the estuary (C-9). Present as entangled masses amongst various algae (particularly Chondrus crispus and Gigartina stellata) in the lower eulittoral and sublittoral zones.

Spongomorpha arcta (Dillwyn) Kuetzing: Abundant on rocks (rarely as an epiphyte) in the mid-lower eulittoral zones of the exposed open coast; most conspicuous in the late winter and spring.

Spongomorpha spinescens Kuetzing: Abundant on rocks in the mid to lower eulittoral zones of the exposed open coast; most conspicuous in the late spring and summer.

Ulothrix flacca (Dillwyn) Thuret in Le Jolis: Locally abundant (during winter and spring) on rocks in the upper littoral zone of the exposed open coast.

Ulva lactuca L: Ubiquitous throughout the estuary (being found at all stations except A-6, A-11, A-15, A-16, C-8, D-2, D-3, H-2, and H-4) on mud and any solid substrates in the lower eulittoral and sublittoral zones. Present on the exposed open coast (Beckman's Point and HB-2 and HB-4) but not as abundant as in the estuary.

Urospora collabens (C. Agardh) Holmes et Batters: Locally abundant (particularly during the winter and spring) on rocks in the upper littoral zone at Beckman's Point.

Urospora penicilliformis (Roth) Areschoug: The abundance and distribution (both seasonal and vertical) of this species is essentially similar to that of U. collabrens, except that it tends to appear later than U. collabrens.

Urospora speciosa (Carmichael et Harvey in Hooker) Leblond et Hamel: Occasional (particularly during winter and spring) on rocks in the upper littoral zone at Beckman's Point.

Phaeophyceae

Agarum cribrosum (Mertens) Bory: Common on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1, HB-3, and HB-4): occasionally found in the estuary subtidally in the Harbor.

Alaria esculenta (L.) Greville: Locally abundant on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-2, and HB-3); not found in the estuary.

Ascophyllum nodosum (L.) Le Jolis: Common throughout the estuary (A-2, A-4, A-11, A-13, A-14, A-17, A-18, B-1, B-2, B-9, B-10, C-1 to C-4, C-10, C-11, and H-3) on any solid substrate from the upper sublittoral to the mid eulittoral zones. It is a rare plant on the exposed open coast at Beckman's Point.

Ascophyllum nodosum (L.) Le Jolis f. scorpioides (Hornemann) Reinke: Common on high muddy banks throughout the estuary (A-1 to A-3, A-5 to A-7, A-12 to A-14, A-17, B-1 to B-3, B-5, B-6, B-8, B-9, B-13, C-1 to C-3, C-5, C-6, C-11, D-2, and D-3); entangled amongst Spartina alterniflora and other vascular plants.

Chorda filum (L.) Stackhouse: Found once on pier pilings in the estuary (H-3); another time on rocks and shells on the exposed open coast (Beckman's Point). In both cases the plants were present in the sublittoral zone.

Chorda tomentosa Lyngbye: Locally abundant (during the summer) on scattered rocks in the sublittoral zone of the exposed open coast (Beckman's Point and HB-3).

Chordaria flagelliformis (O. F. Mueller) C. Agardh: Found twice in the estuary (H-1 and H-3); in both cases it was growing on pier pilings in the lower eulittoral-sublittoral zones. The plant is common (during the summer) on the exposed open coast (Beckman's Point and HB-2) and has the same vertical distribution as in the estuary.

Desmarestia aculeata (L.) Lamouroux: Common on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-2 to HB-4); not present in the estuary.

Desmarestia viridis (O. F. Mueller) Lamouroux: Occasional on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1, HB-3, and HB-4); not present in the estuary.

Dictyoyosiphon foeniculaceus (Hudson) Greville: Found once on mud covered rocks in the lower eulittoral zone of the estuary (C-5).

Ectocarpus confervoides (Roth) Le Jolis; equals E. siliculosus (Dillwyn) Lyngbye in Parke and Dixon, 1968: Occasional on rocks and larger algae in the eulittoral and sublittoral zones of the estuary (A-14, A-17, B-9, C-9 to C-11, and H-1), and the exposed open coast (Beckman's Point, HB-1 to HB-4). The estuarine plants were more robust in stature than the plants from the open coast.

Ectocarpus siliculosus (Dillwyn) Lyngbye: Found once as an epiphyte on Spartina alterniflora in the upper littoral zone of the estuary (C-5).

Elachista fucicola (Velley) Areschoug: An occasional epiphyte on Ascophyllum nodosum and Fucus vesiculosus var. spiralis in the estuary (A-1, B-12, C-1, C-3, C-5, and H-3); very common on Fucus vesiculosus on the exposed open coast.

Fucus distichus (L.) emend Powell subsp. distichus Powell: Locally abundant in high tide pools of the exposed open coast (Beckman's Point); never found in the estuary.

Fucus distichus (L.) emend Powell subsp. edentatus (De la Pylaie) Powell: Common on rocks in the lower eulittoral-sublittoral zones of the exposed open coast (Beckman's Point and HB-2). Found once in a similar habitat near the mouth of the estuary (H-1).

Fucus distichus (L.) emend Powell subsp. evanescens (C. Agardh) Powell: Locally abundant on rocks in the lower eulittoral-sublittoral zones of the exposed open coast.

Fucus vesiculosus (L.): Abundant on semi-exposed rocks from the mid to lower eulittoral at Bound Rock. According to our interpretation the typical species is not found in the estuary, but it is replaced by the variety spiralis.

Fucus vesiculosus (L.) var. spiralis Farlow: Ubiquitous throughout the estuary (at all stations except A-12, A-15, A-16, C-8, H-1, H-2, and H-4) on mud, rocks, shells, and any other solid substrates in the mid to the upper eulittoral zone. It is one of the most conspicuous species on the upper banks of the salt marshes, where it is associated with Ascophyllum nodosum f. scorpioides, Spartina alterniflora and various other vascular plants.

Giffordia granulosa (J. E. Smith) Hamel: Found once in the estuary (A-7) on mud covered rocks in the lower eulittoral zone.

Laminaria digitata (Hudson) Lamouroux: Present on rocky substrate in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1, HB-3, and HB-4) and at the mouth of the estuary (H-1). Each specimen had a consistent ± anatomy (i.e., mucilage ducts are present in the blade and absent from the stipe, Wilce, 1965).

Laminaria saccharina (L.) Lamouroux sensu Wilce, 1965: Its distribution was essentially similar to that of L. digitata except that it was found at one other coastal (HB-2) and estuarine location (A-18). All of the specimens were the ecotype of Wilce, 1965 (i.e., L. agardhii Kjellman in Taylor, 1957).

Leathesia difformis (L.) Areschoug: A common epiphyte (during the summer) on Chondrus crispus and other algae in the lower eulittoral-upper sublittoral zones of the exposed open coast (Beckman's Point and HB-2).

Petalonia fascia (O. F. Mueller) Kuntze: Common throughout the estuary (A-4, A-5, A-7, A-9, A-14, A-15, A-17, B-2, B-4, B-6, B-10, B-13, C-2, C-6, C-11, D-2, and D-3) and on the exposed open coast (Beckman's Point). It is present in the eulittoral zone on rocks (often in tide pools), mud, and occasionally as an epiphyte on large algae.

Pylaiella littoralis (L.) Kjellman: Common on rocks and as an epiphyte on Fucus vesiculosus in the mid-lower eulittoral zones of the exposed open coast. Occasionally present in the estuary (C-1, C-5, and C-6) and with the same vertical distribution.

Pseudolithoderma extensum (Crouan frat.) S. Lund; equals Lithoderma extensum (Crouan) Hamel in Taylor, 1957): Occasional on sublittoral stones and boulders of the exposed open coast (HB-2 and HB-4).

Ralfsia borneti Kuckuck: Occasional on stones and boulders in the lower eulittoral-sublittoral zones of the estuary (A-8, A-10, B-10, B-11, and C-1). According to Edelstein, Chen, and McLachlan (1970) R. borneti is a stage in the life history of Petalonia fascia, and it is not a valid taxa.

Ralfsia clavata (Harvey in Hooker) Crouan frat.: Found once in the estuary (A-8) on mud covered rocks in the lower eulittoral zone. It is also described (Edelstein, Chen, and McLachlan, 1970) as a stage in the life history of Petalonia fascia.

Ralfsia fungiformis (Gunner) Stechell et Gardner: Found once on rocks in the sublittoral zone of the exposed open coast (HB-4).

Ralfsia verrucosa (Areschoug) J. Agardh: Found twice on rocks and shells in the upper sublittoral and eulittoral zones of the estuary (B-3 and C-1). Abundant in the same zones on the exposed open coast.

Saccorhiza dermatodea (De la Pylaie) J. Agardh: Occasional on rocks in the sublittoral zone of the exposed open coast (HB-1 and HB-3).

Scytosiphon lomentaria (Lyngbye) Link: Present on rocks (often in tide pools), mussels, shells, mud, and occasionally epiphytic on various plants in the eulittoral zone of the estuary (A-5, A-14, A-15, A-17, B-1, B-2, B-4, B-10, C-9, C-11, and D-3) and the exposed open coast.

Sorapion kjellmanii (Wille) Rosenvinge: Found once on rocks in the sublittoral zone of the exposed open coast (HB-2).

Sphacelaria plumosa Lyngbye; equals Chaetopteris plumosa (Lyngbye) Kuetzing in Taylor, 1957: Occasional and sand-covered rocks in the mid-lower sublittoral zone of the exposed open coast (HB-1).

Sphacelaria radicans (Dillwyn) J. Agardh: Occasional on muddy or sandy surfaces in the mid-lower eulittoral zone of the estuary (A-9, B-1, and B-10); also present on sand-covered rocks in the sublittoral zone of the exposed open coast (HB-1, HB-3, and HB-4).

Spongonema tomentosum (Hudson) Kuetzing: Found once as an epiphyte on Laminaria saccharina in the sublittoral zone of the exposed open coast (HB-3).

Rhodophyceae

Ahnfeltia plicata (Hudson) Fries: Locally abundant on sand-covered rocks and boulders in the lower eulittoral-sublittoral zones of the exposed open coast (Beckman's Point, HB-1, HB-2, and HB-4).

Antithamnion floccosum (O. F. Mueller) Kleen: Found once on sand-covered rocks in the sublittoral zone of the exposed open coast (HB-3).

Audouinella membranaceae (Magnus) Papenfuss: Epiphytic on species of Sertularia, which in turn may be epiphytic (commonly on fucoid algae) or saxicolous in the eulittoral zone of the exposed open coast.

Asterocystis ramosa (Thwaites in Harvey) Gobi ex Schmitz: Found once as an epiphyte on Cladophora sericea in a high marsh tide pool (C-4). Growing in association with Percursaria percursa and various blue green algae.

Bangia ciliaris Carmichael: Found once as an epiphyte or Cladophora sericea in a high marshy tide pool (C-5) in the estuary.

Bangia fuscopurpurea (Dillwyn) Lyngbye: Abundant (particularly during the winter and spring) on rocks in the upper littoral zone of the exposed open coast. Probably missed in the estuary, since most collections were made in the summer.

Callithamnion baileyi Harvey: Found once in the estuary (H-3) on a styrofoam float.

Callithamnion corymbosum (J. E. Smith) C. Agardh: Found once in the estuary (A-17) on rocks in the upper sublittoral zone.

Ceramium rubrum (Hudson) C. Agardh: Present on rocks and epiphytic on large macroscopic algae in the lower eulittoral and sublittoral zones. Occasional within the estuary (B-1 to B-3, B-7, C-2, C-5, and H-3), but more abundant on the exposed open coast (Beckman's Point, HB-1 to HB-4).

Ceramium strictum Harvey: Abundant throughout the estuary (A-1 to A-4, A-7, A-8, A-10, A-12, A-17, B-1 to B-6, B-9, C-1, C-3 to C-7, C-11 and H-1) on muddy surfaces in the lower eulittoral-sublittoral zones. Uncommon on the exposed open coast.

Chondrus crispus Stackhouse: Common throughout the estuary (A-1 to A-3, A-5, A-9 to A-15, A-17, A-18, B-2, B-4 to B-6, B-8 to B-11, C-1, C-9, C-11, D-3, and H-1) and the exposed open coast (Beckman's Point, HB-2 to HB-4); present on any solid substrate in the lower eulittoral and sublittoral zones. The stature of the estuarine plants is much larger than the plants from the open coast.

Clathromorphum circumscriptum (Stroemfelt) Foslie; as Phymatolithon compactum (Kjellman) Foslie in Taylor, 1957): Abundant on rocks and shells in the lower eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1 to HB-4). Found once in the estuary (A-10) on a subtidal population of mussels.

Corallina officinalis L.: Locally abundant on rocks and boulders (often in tide pools) in the eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1 to HB-4).

Cystoclonium purpureum (Hudson) Batters var. cirrhosum Harvey: Present on rocks and as an epiphyte on larger algae in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1 to HB-4).

Dermatolithon pustulatum (Lamouroux) Foslie: An occasional epiphyte on various algae (particularly Chondrus crispus and Gigartina stellata) in the lower eulittoral-sublittoral zones of the exposed open coast (Beckman's Point, HB-2, and HB-4).

Dumontia incrassata (O. F. Mueller) Lamouroux: Abundant on rocks in the mid and lower eulittoral zones of the exposed open coast. Occasional throughout the estuary (A-5, A-14, A-15, A-17, A-18, B-6, B-10, and D-3) and with the same vertical distribution as on the open coast.

Euthora cristata (C. Agardh) J. Agardh: Present on rocks and occasionally epiphytic on various plants (e.g., Phyllophora spp.) in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1, HB-3 and HB-4).

Gigartina stellata (Stackhouse) Batters: On rocks in the lower eulittoral and sublittoral fringe zones of the exposed open coast.

Gloiosiphonia capillaris (Hudson) Carmichael ex Berkeley: Found twice on rocks in the sublittoral zone of the exposed open coast (HB-1 and HB-4).

Hildenbrandia prototypis Nardo: Common on rocks in the eulittoral and sublittoral zones of the exposed open coast. Less common in the estuary (A-8, A-10, A-11, and B-10) but with the same vertical distribution.

Kylinia secundata (Lyngbye) Papenfuss: A common epiphyte on various algae in the eulittoral zone of the exposed open coast.

Lithothamnium glaciale Kjellman: Common on shells and rock (often in tide pools) in the lower eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1 to HB-4).

Lithophyllum corallinae (Crouan frat.) Heydrich: Found once in the sublittoral zone of the exposed open coast (HB-4); a specific epiphyte on Corallina officinalis.

Melobesia lejolisii Rosanoff: An occasional epiphyte on *Phyllophora* spp. in the sublittoral zone of the exposed open coast (Beckman's Point and HB-3).

Membranoptera alata (Hudson) Stackhouse: A common epiphyte on the various algae (occasionally on rock) in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1, HB-3, and HB-4).

Namalion helminthoides (Velley in Withering) Batters: Uncommon on rocks in the lower eulittoral zone of the exposed open coast.

Petrocelis middendorfi (Ruprecht) Kjellman: Present on rocks and shells in the sublittoral zone of the exposed open coast (HB-2 and HB-4).

Peyssonelia rosenvingii Schmity in Rosenvinge: Occasional on rocks in the sublittoral zone of the exposed open coast (HB-1 and HB-4).

Phycodrys rubens (L.) Batters: Common on rocks and as an epiphyte on various algae in the lowest eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1, HB-3, and HB-4) and at the mouth of the estuary (H-1).

Phyllophora brodiaei (Turner) Endlich: Common on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1 to HB-4).

Phyllophora membranifolia (Goodenough *et* Woodward) J. Agardh: The vertical and horizontal distribution of *P. membranifolia* is essentially similar to that of *P. brodiaei*. It was found at Stations HB-2, HB-3, and Beckman's Point.

Phymatolithon laevigatum (Foslie) Foslie: Present on rocks and shells in the sublittoral zone of the exposed open coast (HB-2 to HB-4).

Phymatolithon lenormandi (Areschoug) Adey: Present on rocks in the sublittoral zone of the exposed open coast (HB-4).

Plumaria elegans (Bonnemaison) Schmitz: Common on vertical rock faces under overhanging fucoids in the lower eulittoral zone of the exposed open coast (Beckman's Point). It was found once in the estuary (A-14) with the same vertical distribution.

Polyides rotundus (Hudson) Greville: Occasional on sand-covered rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-2 to HB-4).

Polysiphonia denudata (Dillwyn) Greville ex Harvey in Hooker: Found twice in the estuary (B-6 and B-10) on muddy surfaces in the sublittoral zone.

Polysiphonia elongata (Hudson) Sprengel: Found twice in the sublittoral zone of the estuary (A-7 and H-3).

Polysiphonia fibrillosa (Dillwyn) Sprengel: Common throughout the estuary (A-1, A-2, A-4, A-10, B-2 to B-6, C-2, C-4 to C-6, C-9, and H-3) on muddy surface in the lower eulittoral and sublittoral zones.

Polysiphonia lanosa (L.) Tandy: Hemiparasitic on Ascophyllum nodosum on the open coast and at the mouth of the estuary (A-2 and A-4).

Polysiphonia nigra (Hudson) Batters: Present on rocks in the lower eulittoral and sublittoral zones of the estuary (A-15, B-2, B-3, B-6, B-7, and H-3) and on the exposed open coast.

Polysiphonia nigrescens (Hudson) Greville: On rocks and shells in the lower eulittoral and sublittoral zones of the estuary (A-4, A-7, A-11, A-12, A-15, B-2, B-4, B-5, B-10, C-1, C-2, C-5, H-1, and H-3) and the exposed open coast (HB-1 and HB-4).

Polysiphonia novae-angilliae Taylor: Present on rocks in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1 and HB-2).

Polysiphonia subtilissima Montagne: Found once in the estuary (A-12); growing on mud in the lower eulittoral zone.

Polysiphonia urceolata (Lightfoot *ex* Dillwyn) Greville: Common on rocks in the lower eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1 to HB-4). Found once in the estuary at Station B-6 with the same vertical distribution.

Porphyra miniata (C. Agardh) C. Agardh: Common (particularly during the summer) on rocks and epiphytic on various plants in the upper sublittoral zone of the exposed open coast (HB-1 to HB-4).

Porphyra umbilicalis (L.) J. Agardh: Common on rocks, mud, and on various algae in the eulittoral zone of the estuary (A-1, A-3 to A-5, A-8, A-12, A-14, A-17, C-3, CC-5, C-6, C-9, H-1, and H-3) and the exposed open coast (Beckman's Point). The form *epiphytica* Collins was only found at Beckman's Point.

Ptilota serrata Kuetzing: Present on rocks and epiphytic on various algae in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1 and HB-3).

Rhodochorton purpureum (Lightfoot) Rosenvinge: Present on vertical rock faces under overhanging fucoids in the mid-lower eulittoral zone of the exposed open coast.

Rhodophysema elegans (Crouan frat. *ex* J. Agardh) Dixon: Occasional on rocks and shells in the sublittoral zone of the exposed open coast (HB-2 and HB-4).

Rhodomela confervoides (Hudson) Silva: Locally abundant on sand-covered rocks in the lower eulittoral and sublittoral zones of the exposed open coast (Beckman's Point, HB-1 and HB-3).

Rhodophyllis dichotoma (Lepeschkin) Gobi: Found once adrift at Bound Rock.

Rhodymenia palmata (L.) Greville: Relatively common on rocks and various algae (particularly *Laminaria* spp.) in the sublittoral zone of the exposed open coast (Beckman's Point, HB-1 to HB-4) and the mouth of the estuary (H-1).

Flowering Plants in the Hampton-Seabrook Estuary

The most conspicuous flowering plants found in the salt marsh were as follows: Atriplex patula var. hastata, Distichlis spicata, Limonium nashii, Plantago oliganthos, Ruppia maritima, Salicornia europaea, Spartina alterniflora, Spartina patens, Suaeda maritima, Triglochin maritima, and Zostera marina. In addition, several other species (Puccinellia maritima, Salicornia bigelovii, Suaeda linearis, Suaeda richii, Spergularia canadensis, and Zannichellia palustris) were occasionally found at some stations.

Vertical Zonation

Figures 2.7-5 and 2.7-6 illustrate the vertical distribution of the conspicuous plants and some associated animals at Beckman's Point, Seabrook, New Hampshire and a "typical" estuarine site, which is near Station A-10 on the Hampton Falls River (Figure 2.7-4). Critical tide levels are summarized as follows:

LLLW - lowest of the lower low waters;
MLLW - mean of the lower low waters;
MHLW - mean of the higher low waters;
HHLW - highest of the higher low waters;
LLHW - lowest of the lower high waters,
MLHW - mean of the lower high waters;
MHHW - mean of the higher high waters;
HHHW - highest of the higher high waters;

The horizontal lines indicate the range of vertical distribution of the various species.

2.7.2.3 List of Animal Species Found in the Hampton-Seabrook Estuary Area (*represents dominants).

Cnidaria

Campanularia sp.: Collected once at Station A-2 (see Figure 2.7-4) on Fucus sp.

*Edwardsia sipunculoides (Simpson): This burrowing anemone was found in large numbers in fine sand in the offshore area.

Plathyhelminthes

Notoplana atomata (O. F. Mueller): Occurred in subtidal area; on the under-surfaces of rocks and in kelp holdfasts.

Nemertea

Cerebratulus lacteus (Leidy): Commonly found burrowed in sand or muddy sand, both in the offshore and the estuarine stations.

Lineus ruber (O. F. Mueller): Another nemertean occasionally found in estuarine and offshore stations.

Micrura leidyi (Verrill): Present at Stations A-3 and A-7 in the estuary and common in the offshore area burrowed into fine sand.

Procephalothrix spiralis (Coe): Found at Station B-10 only, in fine sand and mud.

Annelida

Clitellio arenarius (Verrill): This oligochaete was present at several stations within the estuary (A-9, B-9, B-12, C-7, and C-8) in mud and fine sand and under stones.

Amphitrite sp.: Found once at Station B-4, forming a mounded burrow in the sand of the intertidal flat. Found occasionally in the offshore area.

*Clymenella torquata (Leidy): A dominant polychaete, the tubes of the "bamboo worm" occur in dense aggregations at many of the stations sampled within the estuary (A-1, A-4, A-5, A-8, A-11, B-1 to B-7, B-9, B-12, C-1 to C-5, C-7, and C-8) where the substrate ranged from coarse to fine sand to mud. Also found in dense concentrations in the offshore sands.

Glycera sp. The bloodworm was found at only four stations in the estuary (B-7, B-8, B-9, and B-10), burrowing in sand and mud in the upper reaches of the Browns River.

Harmothoe imbricata (Linnaeus): This species was collected at only two stations within the estuary (A-8 and A-11), under stones and algae.

Hypaniola grayi (Pettibone): Found only at one station (A-11), far up a tributary of the Hampton River where the salinity was low.

*Nephthys bucera (Ehlers): These "shimmy" worms were found at many stations within the estuary, harbor mouth, and offshore areas, where they burrow through sand and mud in search of prey.

*Nephthys caeca (Ehlers): Collected at the same stations as N. Bucera (A-1, A-2, A-4, A-9, B-1 to B-10, B-12, C-1 to C-7, H-1, and H-2), and in fine sand at the offshore stations. These two species were the most abundant polychaetes found.

*Nereis virens (Sars): One of the dominant forms in the estuary, the "Clam worm" occurred in fine sand and mud at Stations H-1, A-1, A-3, A-5, A-6, A-8, A-9 to A-11, B-3, B-5 to B-8, B-10 to B-12, C-2 to C-8.

*Nereis spp.: Though not quite as abundant as the Nephthys worms, Nereis spp. were more widely distributed in the estuarine regions as they are able to tolerate lower salinities.

Pectinaria gouldii (Verrill): The "ice-cream cone" worm was collected at Stations A-4 and A-5, where it builds conical open-ended tubes in fine sand in the intertidal flat; also found occasionally at offshore stations.

Scolecolepides viridis (Verrill): Collected at only one station in the Hampton-Seabrook estuary (C-8) in mud. This species is known to be tolerant of quite reduced salinities.

*Scoloplos fragilis (Verrill): This polychaete was quite abundant in the estuary, occurring at Stations A-5, A-6, A-8 to A-11, B-3, B-7, B-9 to B-12, C-3, C-4, and C-6, in substrates of fine sand and mud. Abundant in the offshore region in fine sand.

*Spio setosa (Verrill): Also common in the estuary; it was collected from Stations A-1, A-3, A-4, A-6 to A-9, A-11, B-1, B-2, B-4, B-5, B-7, B-8 to B-12, C-1 to C-5, and C-7, where it builds fragile sandy tubes in intertidal and subtidal areas.

Mollusca

Acmaea testudinalis (Mueller): The common "tortoise-shell" limpet was found on hard substrates in the lower littoral and sublittoral regions of the estuary and offshore areas; a sub-dominant species.

Buccinum undatum (Linnaeus): The "waved whelk" was found at one estuarine station (C-5) on a substrate of fine sand and mud and offshore on rocks.

Elysia Chlorotica (Gould): This nudibranch is characteristic of salt and brackish water marshes; in the Hampton-Seabrook estuary it was collected at Station C-7.

Hydrobia spp.: Several species of this tiny snail may occur. They were collected at Stations A-3, A-8, and A-11 on substrates ranging from coarse sand to mud, clay, and algae.

*Lacuna vincta (Montagu): The "Atlantic chink shell" was found abundantly at estuarine Stations A-1, A-4, A-5, B-3, B-5, B-9 to B-11, C-3, C-5 and C-8, on rocks, algae, and eelgrass, and from algae (especially kelps) and rocks in the offshore area.

*Littorina littorea (Linnaeus): This "periwinkle" was collected both intertidally and subtidally, occurring at Stations A-3, A-5, A-6, A-8 to A-11, B-3 to B-6, B-8, B-10 to B-12, C-2, C-7, and C-8 in the estuary and from the intertidal and subtidal regions of the harbor and offshore areas, where it is a sub-dominant species. It is also very abundant intertidally throughout the salt marsh.

Littorina obtusata (Linnaeus): Found in the lower intertidal region, usually associated with Fucus spp. and Ascophyllum nodosum.

Littorina saxatilis (Olivi): More able to resist dessication than the other littorinids, this species is found on rocks and in rock crevices in the upper littoral.

*Lunatia heros (Say): The "northern moon snail" was found on sandy and muddy sand bottoms both intertidally and subtidally from within the estuary to offshore. Collected at Stations H-2, A-1, B-4, B-5, B-10, and B-12. A dominant member of the epifauna of the soft and hard bottoms of the offshore area, where it feeds on the local burrowing bivalves, e.g., Spisula solidissima, Arctica islandica, and Siliqua costata.

*Nassarius trivittatus (Say): This "mud snail" is found at Stations A-7 and B-6 within the estuary and also subtidally offshore, where the substrate is fine sand.

Polinices duplicatus (Say): Less common than its close relative, the northern moon snail, Lunatia heros, this sand-collar snail has been recorded from the vicinity of the Hampton Harbor Marina.

Thais lapillus (Linnaeus): The dog whelk is a sub-dominant animal on rocks in the subtidal offshore area; it also occurs on hard substrates of the intertidal region.

*Arctica islandica (Linnaeus): Another dominant infaunal clam of the offshore area, the mahogany quahog is found in fine sand.

*Ensis directus (Conrad): The razor clam is adapted for rapid burrowing in sandy substrates; it is a dominant infaunal species in the offshore subtidal region.

intertidal and subtidal regions of the harbor and offshore areas, where it is a sub-dominant species. It is also very abundant intertidally throughout the salt marsh.

Littorina obtusata (Linnaeus): Found in the lower intertidal region, usually associated with Fucus spp. and Ascophyllum nodosum.

Littorina saxatilis (Olivi): More able to resist dessication than the other littorinids, this species is found on rocks and in rock crevices in the upper littoral.

*Lunatia heros (Say): The "northern moon snail" was found on sandy and muddy sand bottoms both intertidally and subtidally from within the estuary to offshore. Collected at Stations H-2, A-1, B-4, B-5, B-10, and B-12. A dominant member of the epifauna of the soft and hard bottoms of the offshore area, where it feeds on the local burrowing bivalves, e.g., Spisula solidissima, Arctica islandica, and Siliqua costata.

*Nassarius trivittatus (Say): This "mud snail" is found at Stations A-7 and B-6 within the estuary and also subtidally offshore, where the substrate is fine sand.

Polinices duplicatus (Say): Less common than its close relative, the northern moon snail, Lunatia heros, this sand-collar snail has been recorded from the vicinity of the Hampton Harbor Marina.

Thais lapillus (Linnaeus): The dog whelk is a sub-dominant animal on rocks in the subtidal offshore area; it also occurs on hard substrates of the intertidal region.

*Arctica islandica (Linnaeus): Another dominant infaunal clam of the offshore area, the mahogany quahog is found in fine sand.

*Ensis directus (Conrad): The razor clam is adapted for rapid burrowing in sandy substrates; it is a dominant infaunal species in the offshore subtidal region.

*Gemma gemma (Totten): One of the most abundant animals in the Hampton-Seabrook estuary, the gem clam was found at 85 percent of the sampling Stations (A-1 to A-8, A-10, A-11, B-1 to B-12, and C-2 to C-7) occurring in sand and mud substrates, often in great numbers.

*Macoma balthica (Linnaeus): The deposit-feeding clam, Macoma balthica, was widespread, occurring at Stations A-1 to A-11, B-1 to B-12, C-1 to C-8, and H-2. It was most abundant in substrates of muddy sand.

Mesodesma arctatum (Conrad): The arctic wedge clam was found at Stations B-1, B-2, B-4, B-6, C-4, and C-5, burrowing in coarse to fine sand.

Modiolus demissus (Dillwyn): The ribbed mussel occurs throughout the estuary region in salt marshes and the upper littoral.

Modiolus modiolus (Linnaeus): The horse mussel is commonly found from the very low intertidal to the subtidal areas of the offshore region.

*Mya arenaria (Linnaeus): Collected at Stations A-1, A-3 to A-11, B-1 to B-12, and C-1 to C-8, the soft-shelled clam was widely and abundantly distributed throughout the estuary, wherever a stable bottom of fine sand and mud was available.

*Mytilus edulis (Linnaeus): The blue mussel occurred at estuarine stations A-2 to A-5, A-7 to A-11, B-2 to B-10, B-12, C-1, C-2, C-4, C-7, and H-2, and also in intertidal and subtidal areas offshore wherever a hard substrate or some other surface for attachment was available. It was a sub-dominant species in the offshore area.

Petricola pholadiformis (Lamarck): This "rock boring clam" was collected at Station A-8 only, where it bores into peat.

Spisula solidissima (Dillwyn): In the estuary the surf clam occurred only at Station A-1 where the substrate was coarse sand; also found in sandy substrates in the offshore area.

*Siliqua costata (Say): A dominant form in sandy areas of the offshore region, this razor clam also burrows vertically into the sand.

Tellina agilis (Stimpson): Collected at Stations A-1 to A-4, A-7, B-2, B-4, C-1, C-2, C-7, H-1, and H-2, and in the offshore area where the substrate ranged from coarse to muddy sand.

Tonicella ruber: This chiton was common in the rocky sections of the offshore area.

Arthropoda

*Balanus balanoides (Linnaeus): The acorn barnacle was collected in the estuary at Stations A-3, A-5, A-11, B-2, B-4, C-1, C-2, C-7, H-1, and H-2, wherever there were rocks, shells, wood or other solid surfaces for attachment. Also found in the rocky intertidal and subtidal areas where it was a sub-dominant species.

Balanus balanus (Linnaeus): Collected from A-6, A-9, A-10, B-5, and B-12, as well as in the rocky subtidal and intertidal offshore area, but much less abundant than B. balanoides.

*Cancer borealis (Stimpson): The "Jonah crab" was found in the offshore subtidal areas, on both rocky and sandy bottoms, where it was one of the dominant species.

*Cancer irroratus (Say): The common rock crab was also a dominant species, though more characteristic of the rocky offshore areas. However, it was collected at Stations H-1 and H-2 within the harbor, and in the area of the marina.

*Carcinus maenas (Linnaeus): The "green crab" was collected at Station B-4 in the estuary, and H-1 and at the Hampton Beach Marina, probably more common than collections indicate because it is a vagile species.

Cirolana polita (Stimpson): This isopod has been recorded from sandy bottoms in the offshore area.

Corophium sp.: Occurred at Station A-1 -- these amphipods live in soft tubes which they construct in fine sand and mud. Other species of this genus found commonly offshore.

*Crangon septemspinosa (Say): Appeared in only a few grab samples, but collected in large numbers while seining in the shallow inshore areas. The sand shrimp is abundant throughout the estuary and offshore areas.

Cyathura polita (Stimpson): Collected from Stations A-9, A-10, A-11, and C-6, this isopod is semi-tubiculous, sometimes building its own "U"-shaped tubes in fine sand and mud, and sometimes inhabiting the tubes of other animals.

Gammarus spp.: Unidentified species of this amphipod were collected at Stations A-1, A-8, A-11, and C-8, in coarse and fine sand, and muddy substrates.

*Haustorius canadensis: This amphipod was collected from Stations A-2, A-3, A-7, A-8, B-1, B-2, B-8, C-1 to C-4, C-6, C-7, H-1, and H-2 and in the offshore area, burrowing in sandy substrates.

*Homarus americanus (Milne-Edwards): Especially important from a commercial-recreational standpoint, the lobster occurs in the harbor and offshore subtidal area.

Idotea balthica (Pallas): This isopod occurs offshore in rocky areas.

Idotea phosphorea (Harger): Collected at Stations A-3, B-10, and C-7, it also occurs in rocky offshore areas among seaweeds.

*Limulus polyphemus (Linnaeus): The horseshoe crab occurs mainly in the lower salinity waters of the tributaries of the Browns and Hampton Rivers; particularly dense concentrations were observed near Station A-11.

*Pagurus longicarpus (Say): Commonest hermit crab. This scavenger is a sub-dominant species in both the estuary and offshore waters.

Pagurus acadiensis: Another species of hermit crab, occurring on sandy and rocky bottoms in the offshore area.

Echinodermata

*Asterias vulgaris (Verrill): Collected from Station B-3 in the estuary, H-1 in the harbor, and from rocky intertidal and subtidal communities, the northern star-fish is a sub-dominant species.

*Echinarachnius parma (Lamarck): Sand dollars are dominant species in the infaunal sand communities of both the harbor and offshore regions.

Henricia sanguinolenta (O. F. Mueller): The blood starfish is found in rocky lower intertidal and subtidal regions of the offshore area.

Strongylocentrotus drobachiensis (O. F. Mueller): Sea urchins have been found in both rocky intertidal and subtidal areas in the offshore region.

Chordata (Urochordata)

Molgula arenata (Stimpson): Collected from Station A-8 only. This species is found unattached and buried in fine sand, its tunic covered with a coat of sand grains.

Vertebrata

*Alosa pseudoharengus (Wilson): Alewives are known to spawn in the Taylor River each spring.

*Ammodytes americanus (DeKay): Though observed only at Station H-2, schools of sand eels probably also extend up the river channels.

Anguilla rostrata (LeSeur): The American eel was observed at Station A-8.

Cycolopterus lumpus (Linnaeus): The lumpfish was observed only occasionally in the estuary.

*Fundulus heteroclitus (Linnaeus): The most abundant fish species in the estuary, the mummichog are numerous in the smaller, more protected tributaries, though rare in the main harbor area.

Gadus morhua (Linnaeus): The cod is reported to be caught by local fishermen in the offshore area.

*Gasterosteus aculeatus (Linnaeus): One of the most commonly encountered fish in the Hampton-Seabrook estuary, the three-spined stickleback occurs along the shore and in salt creeks and marshes.

*Liopsetta putnami (Gill): The smooth flounder is the second most common flounder encountered in the estuary. It was observed at Station A-2, A-5, A-7, A-11, and B-8.

*Menidia menidia (Linnaeus): The Atlantic silversides is caught with shoreline seines at almost all stations within the estuary.

*Microgadus tomcod (Walbaum): The tomcod is observed occasionally within the estuary, moves offshore in warmer months, but occurs in harbors and estuaries and may run up into freshwater in the winter.

*Morone saxatilis (Walbaum): Migrating striped bass move into the estuary in mid-June and stay until autumn. They do not spawn in the Hampton-Seabrook estuary, however.

Myoxocephalus aeneus (Mitchell): The little sculpin, or grubby, was occasionally observed within the estuary.

*Myoxocephalus octodecimspinosus (Mitchell): The longhorn sculpin or toadfish occurs abundantly in the offshore area.

*Osmerus mordax (Mitchell): The smelt is caught by local fishermen in the Hampton-Seabrook estuary, when the adults are making their spawning runs up into freshwater.

*Pollachius virens (Linnaeus): Pollock are caught in the harbor area of the Hampton-Seabrook estuary when they enter it during the summer months to feed. They are also abundant among the rocks in the offshore area in the warmer months.

Prionotus carolinus (Linnaeus): The northern sea-robin is occasionally observed in the estuary in summer, though they move offshore in winter to escape the colder shallow water temperatures.

*Pseudopleuronectes americanus (Walbaum): The most common flounder in the estuary, it is also the species most sought after by fishermen. In summer it may move to cooler water in the channels or offshore where it is also a dominant species.

*Pungitius pungitius (Linnaeus): The nine-spined stickleback is commonly encountered in the estuary; it is a permanent resident, living and spawning there.

Raja sp.: Skates are occasionally observed or caught in the estuary and offshore areas.

Scomber scombrus (Linnaeus): Mackerel are caught by fishermen from the Hampton Harbor Bridge and the Seabrook shoreline of the harbor. They are abundant in the summer in the offshore area.

*Squalus acanthias (Linnaeus): Dogfish are found in the offshore area in the summer months, when large numbers of them migrate into the Gulf of Maine.

Syngnathus fuscus (Storer): The pipefish has been only occasionally observed within the estuary, though it should occur among eelgrass and salt marsh grasses, in marshes, harbors, and river mouths.

*Tautogolabrus adspersus (Walbaum): The cunner occurs around the mouth of the estuary, and is a dominant form near the rocks of the offshore area.

2.7.2.4 Biology of Important Invertebrates

Edwardsia sipunculoides Simpson

Habits: Edwardsia sipunculoides is a small, slender, solitary sea-anemone which lives buried in sand with only the oral disc protruding and burrows by means of its tapering, almost pointed foot (Miner, Reference 24). Its abundance probably makes it valuable in reworking the sediment.

Breeding: No information available.

Geographic Ranges: Cape Cod, Massachusetts - northward to the Bay of Fundy.

Temperature Tolerance: No information available.

Clymenella torquata (Leidy) "Bamboo worm"

Habits: This deposit-feeding polychaete is very common in the Seabrook-Hampton estuary and adjacent offshore waters. Its distribution there seems to be rather discontinuous, being absent from some samples, but present in dense aggregations in many others. Clymenella builds long, straight tubes of mucus and sand in which it lives head down, feeding by ingesting sediment at a depth of around 6-9 cm. It has been reported to have a negative interaction with Mya; it may be that the conditions that are best for Clymenella are not satisfactory for Mya (Sanders, et al, Reference 37). It also appears to have a positive association with Gemma gemma which also has a negative association with Mya, but there was no evidence of this at Seabrook.

Breeding: April-May, larvae are somewhat bottom-dwelling and attach to substrate within four days, thus there is little chance for them to be washed away.

Geographic Ranges: Gulf of St. Lawrence to Louisiana.

Temperature Tolerance: LD50 - acclimated to summer temperature at Beaufort - 40.5°C; acclimated to 5°C - 35.7°C; acclimated to 10°C - 37.5°C (Kenny, Reference 24).

Nephthys bucera (Ehlers) and *Nephthys caeca* (Ehlers) "Shimmy worms"

Habits: Polychaetes of the genus *Nephthys* occur at 85% of the sampling stations in the Seabrook area. These carnivorous polychaetes do not construct permanent burrows, but instead move through the sand and mud in search of prey -- probably mostly other polychaetes. Though more abundant at most stations than the Nereids, they were not found at any of the upper estuarine stations due to their low tolerance to reduced salinities.

Breeding: No information available.

Geographic Ranges: *Nephthys bucera* -- New Hampshire to Rhode Island. *Nephthys caeca* -- Labrador to S. New England.

Temperature Tolerance: No information available (like other burrowing animals, probably not exposed to such extremes of temperature as epifaunal intertidal animals because of insulating effects of sediment).

Nereis virens (Sars) "Clam worm or Sea worm"

Habits: The seaworm, *Nereis virens*, is one of the dominant species of the Hampton-Seabrook estuary, occurring in 44% of the bottom samples. *N. virens* is omnivorous seizing worms, *Gemma gemma*, and other marine animals in its powerful jaws and also ingesting diatoms and algae as it burrows (Bass and Brafield, Reference 2).

Breeding: *N. virens* breeds during the spring (May in Great Britain) and a temperature rise of 5° to 22°C has been shown to produce spawning in the organisms. Larvae remain close to the substrate with a short planktonic stage (approx. 1/2 day), which allows limited distribution without danger of drifting into unsuitable areas of the estuary.

Geographic Ranges: Boreal and north temperate -- on Atlantic coast from Labrador to S. New England.

Temperature Tolerance: Temperatures above 80° F may be harmful if not lethal (Reference 48).

Scoloplos fragilis (Verrill)

Habits: Scoloplos fragilis is another polychaete commonly found in the estuary and offshore where it lives in fine sand and silt, "eating" the mud by protrusion and retraction of its proboscis (Green, Reference 19).

Breeding: Produces egg capsules anchored in the ground by a stalk. Larvae have no planktonic stage.

Geographic Ranges: Bay of Fundy to Cape Hatteras.

Temperature Tolerance: No information available.

Lacuna vincta (Montagu) "Atlantic chink shell"

Habits: This snail is often abundant on the holdfast, stipes, and fronds of Laminaria, other algae, and eelgrass, or attached to stones and shells from the intertidal and subtidal regions. They are able to penetrate into quite brackish waters, apparently to 8-9 $^{0}/00$ (Remane and Schlieper, Reference 32). The snails are vegetarians, feeding on algae. This species apparently has undergone considerable population fluctuations in the New England area, especially after the eelgrass epidemic in 1932. Apparently some were able to move to brown algae or other substrates and the populations eventually recovered (Stauffer, Reference 40; Dexter, Reference 14).

Breeding: In European waters, said to breed from January to June (Costello, et al, Reference 9). This species lays its ring-shaped gelatinous egg cases (each containing 1,000 or more eggs) on the kelp, fucus, or eelgrass); eggs hatch as veligers after 26 days.

Geographic Ranges: Labrador to New Jersey.

Temperature Tolerance: No information available. It appears that the eggs are sensitive to rising temperatures, but can stand quite rigorous experimental treatment (Costello, et al, Reference 9).

Littorina littorea (Linnaeus) "Common periwinkle"

Habits: While collected both subtidally and intertidally, L. littorea was most abundant in the intertidal areas of the estuary; large numbers were constantly seen on the steep banks bordering tidal streams and tributaries; it is quite tolerant of lowered salinities down to 10 $^0/00$. Like the other species of the genus, it feeds on detritus, diatoms, and other small algae which it scraps from the surfaces of stones, eelgrass, etc. (Green, Reference 19).

Breeding: L. littorea produces small capsules each containing from 2 to 4 eggs which float in the plankton; veliger larvae emerge in 6 days, but may remain in the plankton up to a month (Thorson, Reference 44).

Geographic Ranges: Originally European -- has spread across the North Atlantic and now occurs from Canada to New Jersey.

Temperature Tolerance: (Fraenkel, Reference 17) LD50 in 24 hours after one hour exposure - 40°-41°C.

Lunatia heros (Say) "Northern Moon snail" and Polinices duplicatus (Say) "Shark-eye"

Habits: Both moon snails occur in the Hampton-Seabrook estuary and the offshore waters, but the northern species, L. heros, is the more abundant. These snails are predators, using their radula to drill the shells of other mollusks, especially Mya arenaria, Spisula, Artica, and probably Siliqua. They were found near low water and subtidally, and as they are fairly active animals, were probably more abundant then grab samples indicated.

Breeding: The "sand dollars" containing the eggs of these species are found from June to August.

Geographic Ranges: L. heros -- Gulf of St. Lawrence to North Carolina.
P. duplicatus -- S. New Hampshire to Gulf of Mexico.

Temperature Tolerance: No information available -- but according to Woods Hole Key (Smith, Reference 38), P. duplicatus is more tolerant of increased temperatures and lower salinities than L. heros.

Nassarius trivittatus (Say) "New England Nassa"

Habits: This snail is found intertidally and in shallow water in sandy or muddy bottoms; they spend much time burrowed in the flats and have considerable ability to inhabit a low oxygen environment (Kushins and Mangum, Reference 25). It usually prefers sheltered localities, but is found at Hampton in the offshore area. This species is probably a scavenger like N. obsoletus.

Breeding: Eggs laid in capsules and larvae emerge as planktonic veligers.

Geographic Ranges: Nova Scotia to South Carolina.

Temperature Tolerance: No information available.

Ensis directus (Conrad) "Common razor clam"

Habits: The razor clam occurs in the offshore subtidal region, where it is a common vertical burrower in sand; it usually keeps its foot partially protruded from the shell and burrows extremely rapidly when disturbed. This clam is a suspension feeder -- filtering phytoplankton and other small particles from the surrounding water (Yonge, Reference 46).

Breeding: Breeding season is unknown. This species does have a pelagic larval stage. Young clams have ability to swim and may change position after a short time if conditions are not suitable (Drew, Reference 16).

Geographic Ranges: Labrador to Florida Keys.

Temperature Tolerance: Unknown -- must be quite eurythermal to be so widely distributed.

Gemma gemma (Totten) "Gem clam" or "Duck clam"

Habits: This tiny (1/8") clam is extremely abundant in the Hampton-Seabrook estuary where it occurred at 85 percent of all sampling stations, often in huge densities (up to $8000/m^2$). It is a suspension feeder, feeding at night with great efficiency, on diatoms and organic detritus. Large numbers of *Gemma*'s may almost completely exploit the food resources in the water passing over them, this, plus the fact that their densely packed siphons may allow no room for the settlement of *Mya* larvae, may account for the negative correlation which has been observed between *Mya* and *Gemma* (Bradley and Cooke, Reference 4; Sanders, *et al*, Reference 37).

Breeding: Clams retain their young within gills until they mature; the young clams are liberated in the summer to settle around the adults.

Geographic Ranges: Labrador to Cape Hatteras.

Temperature Tolerance: LD50 (48 hours) - 35°C. The greater tolerance of *Gemma* to increased temperature may mean that *Gemma* could live and reproduce at temperatures which would weaken or kill *Mya arenaria*, and the *Gemma* could then prevent settlement of new *Mya* spat, thus changing the makeup of the community (Kennedy and Mihursky, Reference 23).

Macoma balthica (Linnaeus) "Balthic macoma"

Habits: The deposit-feeding bivalve, *Macoma balthica*, was widely distributed throughout the estuary, occurring in densities more than $800/m^2$ in some subtidal samples, but also abundant in the intertidal flats. It preferred a muddy sand substratum where its siphons could sweep detritus from the substrate surface.

Breeding: Occurs during the spring whenever temperature reach the necessary minimum level (in a Netherlands population it was 10°C).

Geographic Ranges: Arctic Seas to off Georgia; Bering Sea to off Monterey, California.

Temperature Tolerance: Large adults at acclimation temperatures:
5°C LD50 (24 hrs.) = 30.3°C
30°C LD50 (24 hrs.) = 32.5°C
Small adults at acclimation temperatures:
5°C LD50 (24 hrs.) = 31.2°C
30°C LD50 (24 hrs.) = 34.1°C
(Kennedy and Mihursky, Reference 23).

Modiolus modiolus (Linnaeus) "Horse mussel"

Habits: The horse mussel is found from the lower intertidal zone to 80 fathoms depth. It burrows in sand and gravel or finds secure byssal attachment in rocky crevices. Like its relative, the blue mussel, it is a suspension feeder. In the Hampton-Seabrook area, the horse mussel is found infrequently in the harbor and more commonly in the offshore areas.

Breeding: Spawning season unknown -- larvae found in plankton during summer months.

Geographic Ranges: Bay of Fundy to Cape Hatteras.

Temperature Tolerance: Acclimation temperature of 15°C, with 1°C rise per 5 min., LD50 = 36.3°C (Henderson, Reference 21). Acclimation temperature -1.7°C, 100 percent mortality occurred at 26°C in 24 hrs. Natural limits of distribution -- correlated with maximum sea water temperature of 23°C.

Mya arenaria (Linnaeus) "Soft-shell clam"

Habits: The soft-shell clam, Mya arenaria, was abundant and widely distributed throughout the estuary. Mya were found most abundantly on stable bottoms and intertidal flats of well-sorted sand, but were absent entirely only from station H-2 where coarse unstable sand provided an unsuitable habitat. The clams live buried in the substrate, extending their siphons to feed on suspended phytoplankton and organic material; in addition to providing food for various other invertibrates and fishes they are the most important commerical and recreational resource in the estuary.

Breeding: For soft-shell clams north of Cape Cod, only one seasonal reproductive season occurs (Ropes and Stickney, Reference 35). The spawning season in the Hampton-Seabrook estuary begins in April and concludes by late September or early October, with a peak sometime in June. The larvae have two planktonic stages of several weeks duration and are found in the plankton primarily in June and July.

Geographic Ranges: Arctic Seas to North Carolina.

Temperature Tolerance: Larval optimum temperature 17°-23°C (Stickney, Reference 41). LD50 (over 24 hours) 30.3° to 32.5°C (Kennedy and Mihursky, Reference 23).

Mytilus edulis (Linnaeus) "Blue Mussel" or "Edible mussel"

Habits: The common blue mussel, Mytilus edulis, was collected subtidally throughout most of the estuary, but was most abundant on the intertidal flats of the Blackwater River and near the Hampton Marina. A filter-feeder, like the soft-shell clam, these bivalves occur in dense aggregations, each attaching by its byssus to hard substrates, or to stones or other shells in muddy substrates. They can have an adverse effect on Mya populations by covering what would otherwise be a good Mya substrate. They are also important fouling organisms.

Breeding: Spawning occurs during the early months of the year. Larvae appear consistently in the plankton of the estuary between July and October.

Geographic Ranges: Widely distributed on European coasts and the east and west coasts of North America.

Temperature Tolerance: It is restricted in its natural distribution by an upper limiting temperature of 27°C. In the laboratory a 1°C per day rise from 7°C resulted in 100 percent mortality at 30°C (Read and Cumming, Reference 31).

Siliqua costata (Say) "Ribbed pod shell"

Habits: *Siliqua costata* is a common suspension-feeding clam found in the offshore area. This bivalve has a compressed ovate-elongate shell, adapted for rapid vertical burrowing into sand. Though its shell is fragile, it is strengthened by a diagonal rib, and its ability to burrow rapidly enables the clam to survive even in exposed surf-beaten areas. It is an important food for sea ducks (Stott, Reference 42).

Breeding: No information available.

Geographic Ranges: Gulf of St. Lawrence to North Carolina.

Temperature Tolerance: No information available.

Arctica islandica (Linnaeus) "Mahogany quahog"

Habits: *Arctica islandica* is found in sandy and muddy bottoms in 30 feet or more of water. In the offshore region of the Hampton-Seabrook area, it is patchily distributed, burrowed shallowly into the substrate wherever found. Like the other clams of the offshore area, it is a suspension feeder.

Breeding: Spawning probably occurs in July or August (DeWolf and Loosanoff, Reference 12).

Geographic Ranges: Arctic Ocean to Cape Hatteras.

Temperature Tolerance: 0.7° to 18.4°C (DeWolf and Loosanoff, Reference 12). 20°C -- lethal (Turner, Reference 45).

Balanus balanoides (Linnaeus) "Common rock barnacle"

Habits: The most common barnacle occurring in the Hampton-Seabrook estuary was Balanus balanoides. This animal is found intertidally, attached to rocks, shells, wood, and other solid substrates. It is a plankton feeder also, using its feathered cirri to comb the water for particles. The barnacle is important as a fouling organism and as food for several invertebrates and fish.

Breeding: Barnacles spawn in the early spring of their second year, and larval development occurs in a series of planktonic stages, ending with the cypris which settles and attaches after searching out suitable conditions.

Geographic Ranges: Arctic Ocean to Delaware Bay.

Temperature Tolerance; A 1°C/per minute rise in temperature resulted in heat comma at 35°-37°C and an LD50 of 44.3°C (Southward, Reference 39). Adult -- 42.3°-44.0°C; that of larval stages varies between 39° and 44°C (Crisp and Ritz, Reference 10).

Cancer borealis (Stimpson) "Jonah crab" or "Northern crab" and Cancer irroratus (Say) "Common rock crab"

Habits: Both of these scavengers and predators are commonly found roaming across the intertidal and subtidal areas, both among the rocks and in the sand, offshore and in the estuary. Both species are of limited commercial importance in this area.

Breeding: No information available.

Geographic Ranges: Bay of Fundy to Cape Hatteras.

Temperature Tolerance: C. irroratus -- 1°C per 5 min. rise LD50 - 32.0° - 33.2°C acclimated to 20°C (Huntsman and Sparks, Reference 22). C. borealis -- No information available.

Carcinus maenas (Linnaeus) "Green crab, mud crab, or shore crab"

Habits: The green crab, Carcinus maenas, is ubiquitously distributed within the estuary. This hardy euryhaline crab is known to be an important predator of Mya populations (Ropes, Reference 34) but it appears to have decreased all along the New England coast in recent years, and at the present time, at least, does not seem to be an important threat to Mya arenaria in the Hampton-Seabrook estuary. It is of some importance in the estuary as a scavenger and as a food for the larger fish.

Breeding: Females with eggs attached occur throughout the year, but larvae are most abundant in the spring and summer.

Geographic Ranges: Bay of Fundy to Long Island.

Temperature Tolerance: (DeVarigny, Reference 11) -- upper lethal limit, 38°C.

Crangon septemspinosa (Say) "Sand shrimp"

Habits: While the sand shrimp appeared in only a few grab samples, it was collected in very large numbers while seining the inshore shallows for fish. This abundant species is a very important link in the estuary food web. It uses the strong pincers of its first pair of legs to prey on Nereis and other marine worms, and is itself preyed upon by waterfowl such as the mallard duck (Green, Reference 19) and fish. While like most sand-dwelling animals they cannot stand more than brief exposure to the air, they are otherwise quite hardy with respect to temperature and salinity.

Breeding: Sand shrimp spawn in winter or summer. Developing eggs are carried by the female for a period of several weeks (Yonge, Reference 46).

Geographic Ranges: Labrador to North Carolina.

Temperature Tolerance: (Huntsman and Sparks, Reference 22) -- 1°C per 5 min. rise from an acclimation temperature of 20°C resulted in an LD50 at 30.0°-32.5°C; acclimated to 15°C -- LD50 of 27.5°C (Mihursky and Kennedy, Reference 28).

Homarus americanus (Milne-Edwards) "American lobster"

Habits: This scavenger is found throughout the estuary and offshore waters on both soft and rocky bottoms. It supports a local lobster fishing industry and is one of the most commercially valuable species in the area.

Breeding: Eggs carried by the female for ten to eleven months; hatch in zoeal or mysis stage and go through a planktonic development period before becoming benthic.

Geographic Ranges: Canada to North Carolina (offshore in southern areas).

Temperature Tolerance: Acclimated to 5°C, upper thermal tolerance is 22.1°C; Acclimated to 15°C, upper thermal tolerance is 28.2°C; Acclimated to 25°C, upper thermal tolerance is 29.5°C; (McLeese, Reference 27).

Typhosella sp.

Habits: This is the most abundant amphipod in the offshore area. It is found in fine sand which it burrows through, probably feeding on interstitial detritus. It is an important food organism for some of the migrating sea ducks which feed in that area in the autumn (Stott, Reference 42).

Breeding: No information available.

Geographic Ranges: Unknown.

Temperature Tolerance: No information available.

Echinarachnius parma (Lamarck) "Sand dollar"

Habits: The sand dollar, Echinarachnius parma, occurs in subtidal areas of the harbor region of the estuary, but is most common just offshore in water from 10-30 feet in depth, where it may be found in densities of 20 to $30/m^2$.

These animals lie buried just below the surface of the sand so that their round outlines may be seen. They feed on small organic particles by passing the sand and detritus through which they burrow over the aboral surface by means of club-shaped spines, the fine particles dropping down between the spines to be carried by cilia to the food tracts of the oral surface. Flounders, cod, and haddock are known to feed on sand dollars (Miner, Reference 29).

Breeding: Spawning takes place in spring and early summer and results in the production of a planktonic larvae.

Geographic Ranges: Bay of Fundy to Cape Hatteras.

Temperature Tolerance: No information available.

2.7.2.5 Biology of Important Fishes

Ammodytes americanus (DeKay) "Sand eel or Sand launce"

Habits: Sand eels travel in large schools, usually staying close to the bottom where they can quickly bury themselves in sand if danger threatens. Though diving observations showed this species occurring only at Station H-1, it probably extends up the river channels as far as suitable sandy substratum exists. They feed on small Crustacea (especially copepods), fish fry, and worms. They are fed upon in turn by larger fishes; cod, haddock, hake, striped bass, etc. They are commercially important in some areas as a bait fish, but there is no fishery for them in the Hampton-Seabrook estuary.

Breeding: Probably January to March; the spawning and larval life has not been described (Bigelow and Schroeder, Reference 3).

Geographic Ranges: Labrador to Cape Hatteras.

Temperature Tolerance: No information available, but they are known to move into deeper water in winter to escape the low temperatures and may also leave shallow bays in summer if the temperature gets too high (Bigelow and Schroeder, Reference 3).

Liopsetta putnami (Gill) "Smooth flounder"

Habits: Liopsetta putnami was the second most encountered species of flounder in the Hampton-Seabrook estuary. It is very similar to the winter flounder, but smaller, rarely attaining a length of 12 inches. It is generally confined to estuaries, river mouths, shallow bays, and harbors where it feeds on small crabs, shrimp, and polychaetes (Bigelow and Schroeder, Reference 3). Although the smooth flounder is usually found over muddier bottoms than the winter flounder, no direct correlation of species to bottom type was apparent in the Hampton-Seabrook estuary. Though an excellent food fish, they are of less commerical value than the winter flounder because they are smaller and less numerous.

Breeding: December to March; in estuaries and harbors; eggs and larvae unknown (Bigelow and Schroeder, Reference 3).

Geographic Ranges: Arctic to Boreal (Ungava Bay - Massachusetts Bay).

Temperature Tolerance: Upper limit 31.6° to 32.8°C (1°/5 min. until death), (Huntsman and Sparks, Reference 22).

Menidia menidia (Linnaeus) "Silversides"

Habits: Silversides are pelagic inshore fish which normally travel in large schools. They were caught with the shoreline seine at virtually all stations throughout the estuary. They are omnivorous feeders, ingesting copepods, mysids, shrimp, amphipods, cladocerans, annelids, mollusks, larvae, insects, algae, and diatoms, all mixed with sand and mud. They provide food for almost every predaceous fish that enters the estuary, including striped bass and pollock.

Breeding: In May, June, and early July they gather in schools to deposit their eggs on sandy bottoms, often in among the Spartina grass. The eggs stick to the substrate in ropy clusters and sheets until the larvae hatch (Bigelow and Schroeder, Reference 3).

Geographic Ranges: (Northern race) Gulf of St. Lawrence to Chesapeake Bay.

Temperature Tolerance: May need summer temperatures as high as 20°C for spawning (Bigelow and Schroeder, Reference 3).

Morone saxatilis (Walbaum) "Striped bass or Rock fish"

Habits: The habitat of the striped bass ranged from surf-swept beaches to shallow bays, inlets and estuaries. Migrating striped bass usually reach the Hampton Harbor area by mid-June and remain until late September or early October. As they move into the estuary they feed on a wide variety of fish and invertebrates, including crabs, shrimp, worms, and the soft parts of clams and mussels. Personal communication with fishermen incidates that fishing for stripers was best on the flooding tide in the Blackwater and Hampton Rivers and in Tidemill Creek.

Breeding: Most striped bass are produced in southern waters (e.g., Long Island Sound and Chesapeake Bay) and migrate up the coast during the third year. Though spawning of striped bass has been reported in the Parker River (Massachusetts), there is no evidence that they spawn in the Hampton-Seabrook estuary which is only a few miles north.

Geographic Ranges: Gulf of St. Lawrence to North Florida, Alabama, and Louisiana; running up into freshwater to spawn.

Temperature Tolerance: Adults tolerant of abrupt changes between 8° and 27°C at salinities between 0 and 35 o/oo; juveniles survived the same transfers only at temperatures between 13° and 21°C (Tagatz, Reference 43).

Osmerus mordax (Mitchell) "Rainbow smelt"

Habits: Adults travel in schools, in shallow water, but off the bottom. They move slightly offshore in summer to cool water and gather in harbors and estuaries in early autumn where they remain until the water warms to the required temperature in spring, and they can make their spawning runs up into freshwater streams. The adults then return to shallow water; the eggs sink to the bottom and stick in clusters to pebbles, water weeds, and each other. They hatch in about 15 days and the young return to the sea sometime during their first summer (Bigelow and Schroeder, Reference 3).

Breeding: May spawn in the upper reaches of the Hampton-Seabrook estuary, but no verifying evidence has been gathered.

Geographic Ranges: Labrador to New Jersey; also landlocked in various lakes in New Hampshire, Maine and Canada.

Temperature Tolerance: Upper lethal limit (1°C/5 min. rise until death) - 21.5° to 28.5°C (Huntsman and Sparks, Reference 22).

Pseudopleuronectes americanus (Walbaum) "Winter flounder"

Habits: The winter flounder is probably the most sought after sport fish in the estuary. Flounders comprised the bulk of the catch made by fishermen from the Hampton Harbor Bridge and from boats within the harbor. Pseudopleuronectes is the most common shallow-water flounder in the Gulf of Maine (Bigelow and Schroeder, Reference 3). It inhabits open coastal waters and fishing banks, as well as harbors, bays, and estuaries. During the summer months those found in shoal waters may move out to the cooler channels or into offshore waters. The food of the winter flounder consists of larvae, diatoms, copepods, amphipods, crabs, shrimp, worms, and mollusks; they are limited in the size of their prey by their small mouth size (Bigelow and Schroeder, Reference 3).

Breeding: January to May on sandy bottoms in shallow water or estuaries; eggs and larvae have been found in the Hampton-Seabrook estuary, and it probably is a spawning ground for them.

Geographic Ranges: Grand Banks and Labrador to North Carolina and Georgia.

Temperature Tolerance: Upper lethal limit 27.9° to 30.6°C (Huntsman and Sparks, 1924). Lower lethal limit -1.8°C (Umminger, Reference 47).

Fundulus heteroclitus (Linnaeus) "Mummichog or Killifish"

Habits: Fundulus heteroclitus is by far the most abundant fish species in the Hampton-Seabrook estuary and probably constitutes a very important link in the estuarine food webs. Though scarce in the main harbor, it was numerous in the smaller, more protected tributaries of the estuary. On extremely high tides Fundulus was observed swimming along the flooded grass of the high salt marsh. These omnivorous fish feed on diatoms, eelgrass, and other vegetation, foraminiferans, shrimp, and other small crustaceans, and occasionally larval or juvenile fish. Fundulus is, in turn, an important food source for the sport fish and acquatic birds of the estuary (Bigelow and Schroeder, Reference 3).

Breeding: In June, July, and August, Fundulus spawns within the estuary in extremely shallow water.

Geographic Ranges: Gulf of St. Lawrence to Texas.

Temperature Tolerance: Acclimation temperature 28°C - Upper limit (48 hrs.) = 37°C; acclimation temperature 20°C - Upper limit (48 hrs.) = 34°C; acclimation temperature 20°C - Lower limit (48 hrs.) = 2°C; acclimation temperature 14°C - Upper limit (48 hrs.) = 32°C; acclimation temperature 14°C - Lower limit (48 hrs.) = 1°C -- (Doudoroff, Reference 15).

Pungitius pungitius (Linnaeus) "Nine-spined stickleback"

Habits: The stickleback is a shore fish; most live their whole lives in estuarine locations, but are at home in water of full ocean salinity or freshwater, also. Pungitius is usually a permanent year-round resident of estuaries, where it feeds omnivorously and voraciously on small invertebrates, fish eggs, and fish fry (Bigelow and Schroeder, Reference 3).

Breeding: Spawns in summer in brackish and freshwater where the males often build nests in sheltered spots. The females lay the eggs in the nests, and the males fertilize and guard the eggs until they hatch.

Geographic Ranges: Arctic to New York and west to Alaska, and from Iceland and European coast to the Mediterranean and the Black Sea.

Temperature Tolerance: No information available.

Pollachius virens (Linnaeus) "American pollock"

Habits: Pollock are caught by fishermen from the Hampton Harbor Bridge and from the Seabrook shoreline of the harbor. This pelagic species enters the estuary in the summer months to feed on silversides, sand eels, and mummichogs. Fishermen report them to be most abundant on the flooding tide. They are also found in the rocky portion of the offshore area.

Breeding: In the Gulf of Maine pollock spawn in open water during late autumn and early winter, when temperatures are falling (Bigelow and Schroeder, Reference 3). It does not spawn in the estuary.

Geographic Ranges: On both sides of the North Atlantic in boreal and cool temperate waters, south on the North American coast to North Carolina.

Temperature Tolerance: Upper limit - 28°C (0.1 hr.), (Britton Reference 6).
Lower limit - -2°C (0.1 hr.), (Britton Reference 6).

Tautogolabrus adspersus (Walbaum) "Cunner"

Habits: The cunner lives along the New England coast from just below the low tide mark to about 10-15 fathoms. They are found among the eelgrass, around wharf piles, rocks, and seaweeds, and in the deeper salt creeks, though not appreciably brackish water. They are omnivorous, scavenging in harbors, and browsing among seaweeds, stones, and pilings, devouring mussels, barnacles, small snails, amphipods, shrimp, lobsters, sea urchins, bryozoans, ascidians and occasionally small fish or fry (Bigelow and Schroeder, Reference 3). In the Hampton-Seabrook estuary area they are a dominant form around the rocks in the offshore region.

Breeding: Spawns from late spring to early summer; eggs are buoyant and young fish hatch in about 3 days.

Geographic Ranges: Atlantic coast of North America from the offshore banks of Newfoundland to New Jersey, and occasionally to Chesapeake Bay.

Temperature Tolerance: Upper limit - 29°C in summer (survived by all fish);
Lower limit - 5°C in summer (survived by all fish);
Upper limit - 25°C in winter (survived by all fish);
Lower limit - 1°C in winter (survived by all fish);
(Haugaard and Irving, Reference 20).

2.7.2.6 Pre-Existing Environmental Stresses

Very few sources of pollution occur at the present time in the Hampton-Seabrook harbor estuary. Some dredging and filling of the marsh has taken place to permit building by private landowners, but this has been minor. In 1965 the U. S. Army Corps of Engineers dredged 300,000 cubic yards of sand from Hampton Harbor and the channel extending to the ocean. The dredged material was placed on the northern end of Hampton Beach. Maintenance dredging off the channel has taken place in subsequent years, 1968 and 1971. Although no extensive study was conducted at any of these times, it appears that this dredging has had little effect on the estuary.

Small boats in the estuary and at the Hampton Beach marinas are probably causing a minor amount of oil pollution, untreated wastes, and garbage disposal during the summer months, but this has had no noticeable effect on the biota.

The town of Hampton dumps sewage (which has received primary treatment) into one of the tributaries of the estuary. A scarcity of life -- probably due to the presence of chlorine -- has been noted in the immediate vicinity of the outflow pipe, but the influence of the sewage outfall seems to be rapidly abated, and no effect attributable to it has been observed in the estuary as a whole.

The eelgrass, Zostera marina, was almost completely wiped-out throughout New England by the wasting disease epidemic in the early 1930's. Although this species is not particularly common in the Hampton-Seabrook estuary, it cannot be definitely shown that the scarcity is a result of the original epidemic, as eelgrass populations have again become plentiful in other localities in New Hampshire, and it is not known if this species was ever abundant in the estuary.

One disease known to be present in the area is gaffkemia, a disease of lobsters. Although it isn't a problem in the natural habitat, impounded lobsters in the area have been known to be affected by this infection. It is known that in an impoundment an increase in temperature increases the prevalence of the disease.

The encroachment of blue mussels, Mytilus edulis, in some intertidal areas of the marsh, particularly clam Flat #4 (same as Station C-10, as shown in Figure 2.7-4) has certainly limited the productivity of the soft-shelled clam, Mya arenaria, in the immediate area of the mussel beds, i.e., the mussel has taken up intertidal substrate that might have otherwise been used by the soft-shelled clam. Attempts at controlling the encroachment of mussels on Flat #4 by the New Hampshire Fish & Game Department in 1965-67 were fairly successful and the soft-shelled clam population was able to re-populate the clam flat (Ayer, Reference 1). At present there is evidence to suggest the mussel population is again increasing on this clam flat. If substrate conditions changed, either naturally or were induced by man, to the advantage of the mussel, there is certainly an adequate number of mussel larvae in the water to take advantage of the change and colonize new areas.

In early September, 1972, a bloom of the dinoflagellate, Gonyaulax tamarensis, was sufficient to cause a "red tide" situation. Many intertidal or benthic filter feeders, e.g., the soft-shelled clam, Mya arenaria; the ribbed pod shell, Siliqua costata; and the blue mussel, Mytilus edulis, accumulated enough of these dinoflagellates to reach toxic levels. Although there was little evidence of mass mortalities, some individual clams probably died and clam flats were closed to prevent paralytic shellfish poisoning. At the time of this writing (December 1972), the amount of G. tamarensis has decreased and clam flats will probably be opened soon. This was one of the few recorded times that a bloom of Gonyaulax tamarensis has caused "red tide" conditions in the Hampton-Seabrook estuary, although it is known that the organisms are often found in lesser numbers along the New Hampshire shore. The ultimate cause of the bloom is not well-understood but investigation by various state and federal agencies is continuing.

References

1. Ayer, William C. 1968. Soft-shelled Clam population study in Hampton-Seabrook Harbor. N.H. Fish and Game Department. 39 pp.

2. Bass, N. R. and Brafield, A.E. 1972. The life cycle of the polychaete, *Nereis virens*. Jr. Mar. Biol. A.U.K. 52: 701-726.

3. Bigelow, H. B. and Schroeder, W.C. 1953. Fishes of the Gulf of Maine. U. S. Fish. & Wildl. Ser., Fish. Bull. 53(74): 577 pp.

4. Bradley, W. H. and Cooke, P. 1959. Living and ancient populations of the clam, *Gemma gemma*, in a Maine coastal tidal flat. U. S. Fish. & Wildl. Ser., Fish. Bull. 58(137): 304-334.

5. Brafield, A. E. and Newell, G. E. 1961. The behavior of *Macoma balthica*. Jr. Mar. Biol. Assoc. U. K. 41: 81-87.

6. Britton, S. W. 1924. The effects of extreme temperature of fishes. Amr. Jr. Physiol. 67: 411-421.

7. Clark, R. B. 1962. Observations on the food of *Nephthys*. Limnol. & Oceanog. 7(3): 380-385.

8. Clements, F. E. and Shelford, V. E. 1939. *Bio-ecology*. New York, John Wiley & Sons, Inc. 425 pp.

9. Costello, D. P. *et al*. 1957. Methods for obtaining and handling marine eggs and embryos. Woods Hole, Mass., Mar. Biol. Lab. 247 pp.

10. Crisp, D. J. and Ritz. 1967. Changes in temperature tolerance of *Balanus balanoides* during its life cycle. Helgo. wisc. Meeres. 15: 98-115.

11. DeVarigny, H. 1887. Ueber die Wirkung der Temperature hohungen auf einige Crustaceen. Centralbl. F. Physiol. 1(8): 173.

12. DeWolf, R. A. and Loosanoff, V. L. 1945. Biology of the ocean quahog. IN: The ocean quahog fishery of Rhode Island. U. S. Fish. & Wildl. Ser., Dept. Int. and Rh. Is. Div. Fish & Game, Dept. Ag. and Conser.

13. Dexter, R. W. 1944. The bottom community of Ipswich Bay, Mass. Ecology. 25(3): 352-359.

14. Dexter, R. W. 1947. The marine communities of a tidal inlet at Cape Ann, Mass.: a study in bio-ecology. Ecol. Mongr. 17: 261-294.

15. Doudoroff, P. 1945. The resistance and acclimation of marine fishes to temperature changes. II. Experiments with *Fundulus* and *Atherinops*. Biol. Bull. 88: 194-206.

16. Drew, G. A. 1907. The habits and movements of the razor shell clam, *Ensis directus*. Biol. Bull. 12: 127-40.

17. Fraenkel, G. 1960. Letha high temperatures for three marine invertebrates: Limulus polyphemus, Littorina littorea, and Pagurus longicarpus. Oikos 11(2): 171-182.

18. Graham, J. J. 1956. Observations on the alewife, Pomobolus pseudoharengus (Wilson) in freshwater. Univ. Toronto Biol. Ser. 62: 1-43.

19. Green, J. 1968. The biology of estuarine animals. Seattle, Univ. of Wash. Press. 401 pp.

20. Haugaard, N. and Irving, L. 1943. The influence of temperature upon the oxygen consumption of the cunner, Tautogolabrus adspersus (Walbaum), in summer and in winter. Jr. Cell. Comp. Physiol. 21(1): 19-26.

21. Henderson, J. T. 1929. Lethal temperatures of Lamellibranchiata. Contr. Canadian Biol., N. S. 4: 399-411.

22. Huntsman, A. G. and Sparks, M. I. 1924. Limiting factors for marine animals. III. Relative resistance to high temperatures. Contrib. Canadian Biol., N. S. 2: 95-114.

23. Kennedy, V. S. and Mihursky, J. A. 1971. Upper temperature tolerances of some estuarine bivalves. Ches. Sci. 12(4): 193-204.

24. Kenny, R. 1969. Temperature tolerance of the polychaete worms Diapatra cuprea and Clymenella torquata. Mar. Biol. 4: 219-223.

25. Kushins, L. J. and Mangum, C. P. 1971. Responses to low oxygen in two species of the mud snail Nassarius. Comp. Biochem. Physiol. 39A: 421-435.

26. Levinton, J. 1972. Stability and trophic structure in deposit-feeding and suspension-feeding communities. Am. Nat. 106(950): 472-486.

27. McLeese, D. W. 1956. Effects of temperature, salinity, and oxygen on the survival of the American lobster. Jr. Fish. Res. Bd. Can. 13(2): 247-272.

28. Mihursky, J. A. and Kennedy, V. S. 1967. Water temperature criteria to protect aquatic life. Amr. Fish. Soc., Special Publication No. 4: 20-32.

29. Miner, R. W. 1950. Field book of seashore life. New York, G. P. Putnam's Sons. 888 pp.

30. Odum, E. P. 1959. Fundamentals of Ecology. Phil., Pa., W. S. Saunders Co. 546 pp.

31. Read, K. R. H. and Cumming, K. B. 1967. Thermal tolerance of bivalve molluscs, Modiolus modiolus (L), Mytilus edulis (L) and Brachidontes demissus (Dillwyn). Comp. Biochem. Physiol. 22(1): 149-155.

32. Remane, A. and Schlieper, C. 1971. Biology of brackish water. New York, John Wiley & Sons, Inc. 372 pp.

33. Rhoads, D. 1967. Biogenic reworking of intertidal and subtidal sediments in Barnstable Harbor and Buzzards Bay, Massachusetts. J. Geol. 75: 461-466.

34. Ropes, J. W. 1968. The feeding habits of the green crab, *Carcinus maenas* (L). Fish. Bull. 67: 183-203.

35. Ropes, J. W. and Stickney, A. P. 1965. Reproduction cycle of *Mya arenaria* in New England. Biol. Bull. 128(2): 315-327.

36. Russell-Hunter, W. D. 1970. Aquatic productivity. New York, The MacMillan Co. 306 pp.

37. Sanders. H. L., Goudsmit, E. M., and Hampson, G. E. 1962. A study of the intertidal fauna of Barnstable Harbor, Massachusetts. Limnol. Oceanogr. 7: 63-79.

38. Smith, R. I., ed. 1964. Keys to marine invertebrates of the Woods Hole region. Woods Hole, Mass. Contri. No. 11, Systematics-Ecology Program, Mar. Biol. Lab. 208 pp.

39. Southward, A. J. 1958. Note on some temperature tolerances of some intertidal animals in relation to environmental temperatures and geographic distribution. Jr. Mar. Biol. Assoc. U. K. 37: 49-66.

40. Stauffer, R. C. 1937. Changes in the invertebrate community of a lagoon after disappearance of the eelgrass. Ecology 18(3): 427-431.

41. Stickney, A. B. 1964. Salinity temperature and food requirements of soft-shell clam larvae in laboratory culture. Ecology 45: 283-291.

42. Stott, R. 1971. (Sea Ducks of New Hampshire). Unpublished M. S. Thesis. University of New Hampshire.

43. Tagatz, M. E. 1961. Tolerance of striped bass and American shad to changes of temperature and salinity. U. S. Fish. & Wildl. Ser., Special Sci. Rpt. Fish. No. 338. 8 pp.

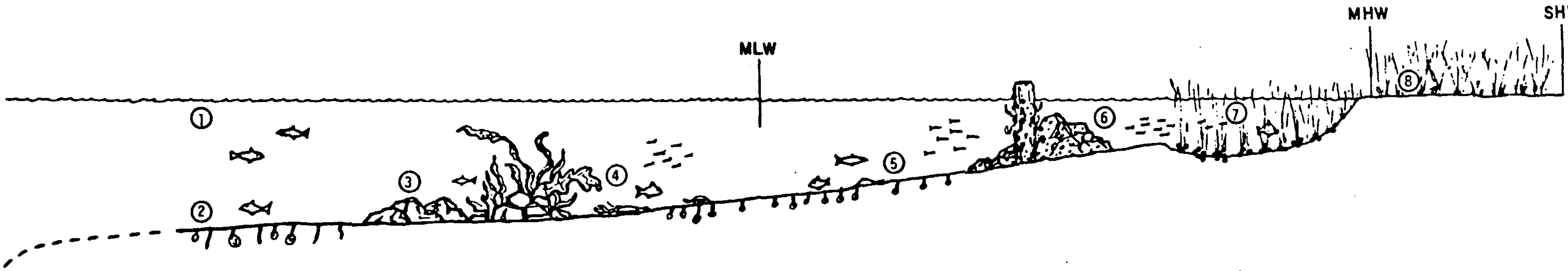
44. Thorson, G. 1946. Reproduction and larval development of Danish marine bottom vertebrates, with special reference to the planktonic larvae in the Sound (Oresund). Medd. Komm. Har. Plankt. 4(1): 1-523.

45. Turner, H. J., Jr. 1953. A review of the biology of some commercial molluscs of the east coast of North America. Div. Mar. Fish. Mass. Dept. Conserv., Rept. Invest. Shellfish. 6: 39-74.

46. Yonge, C. M. 1963. The Seashore. New York, Athenaeum. 350 pp.

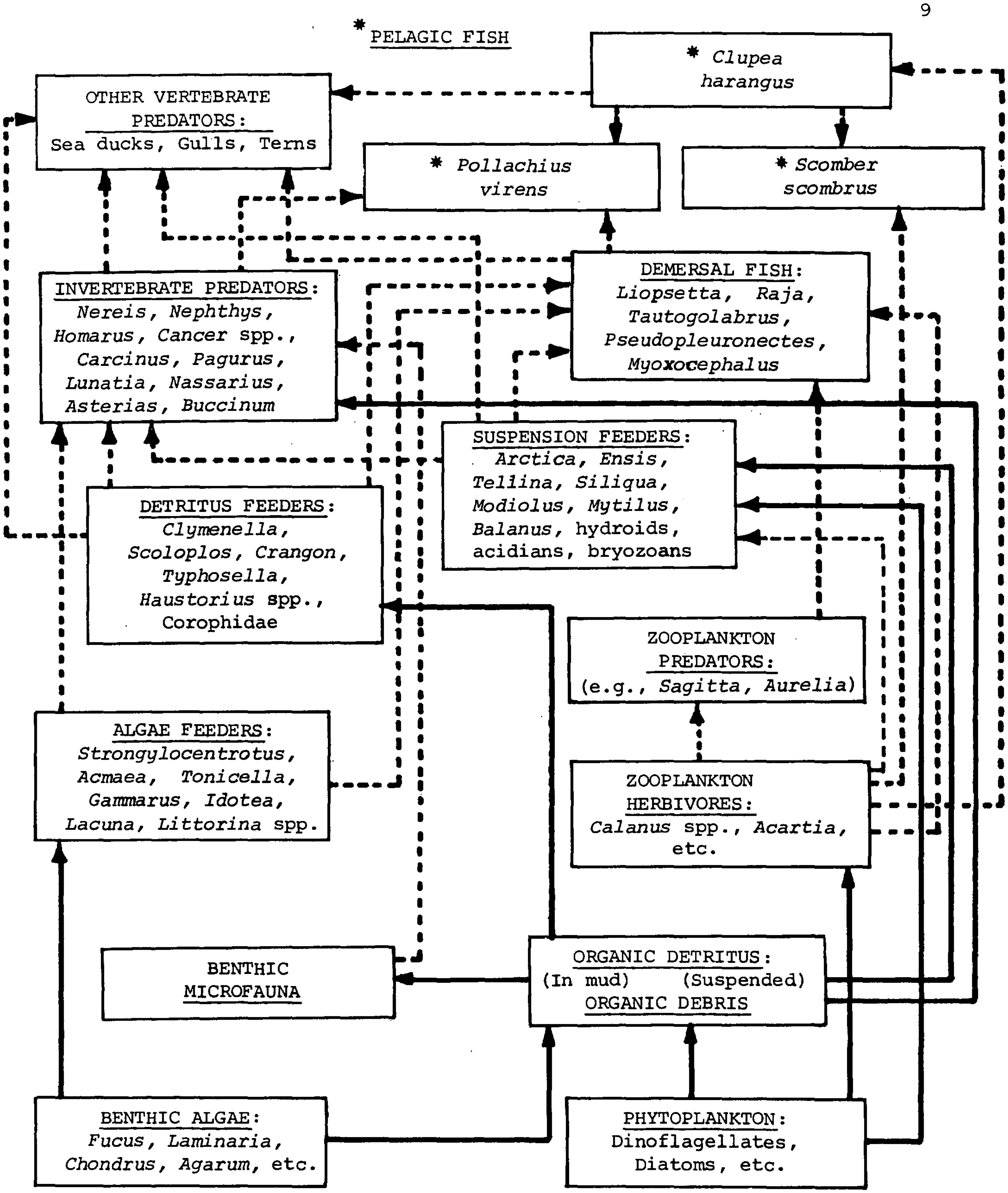
47. Umminger, B. L. 1970. Effects of sub-zero temperatures and trawling stress on serum osmolality in the winter flounder, *Pseudopleuronectes americanus*. Biol. Bull. 139(3): 574-579.

48. Third Annual Report of the Maine Yankee Atomic Power Company, 1971.



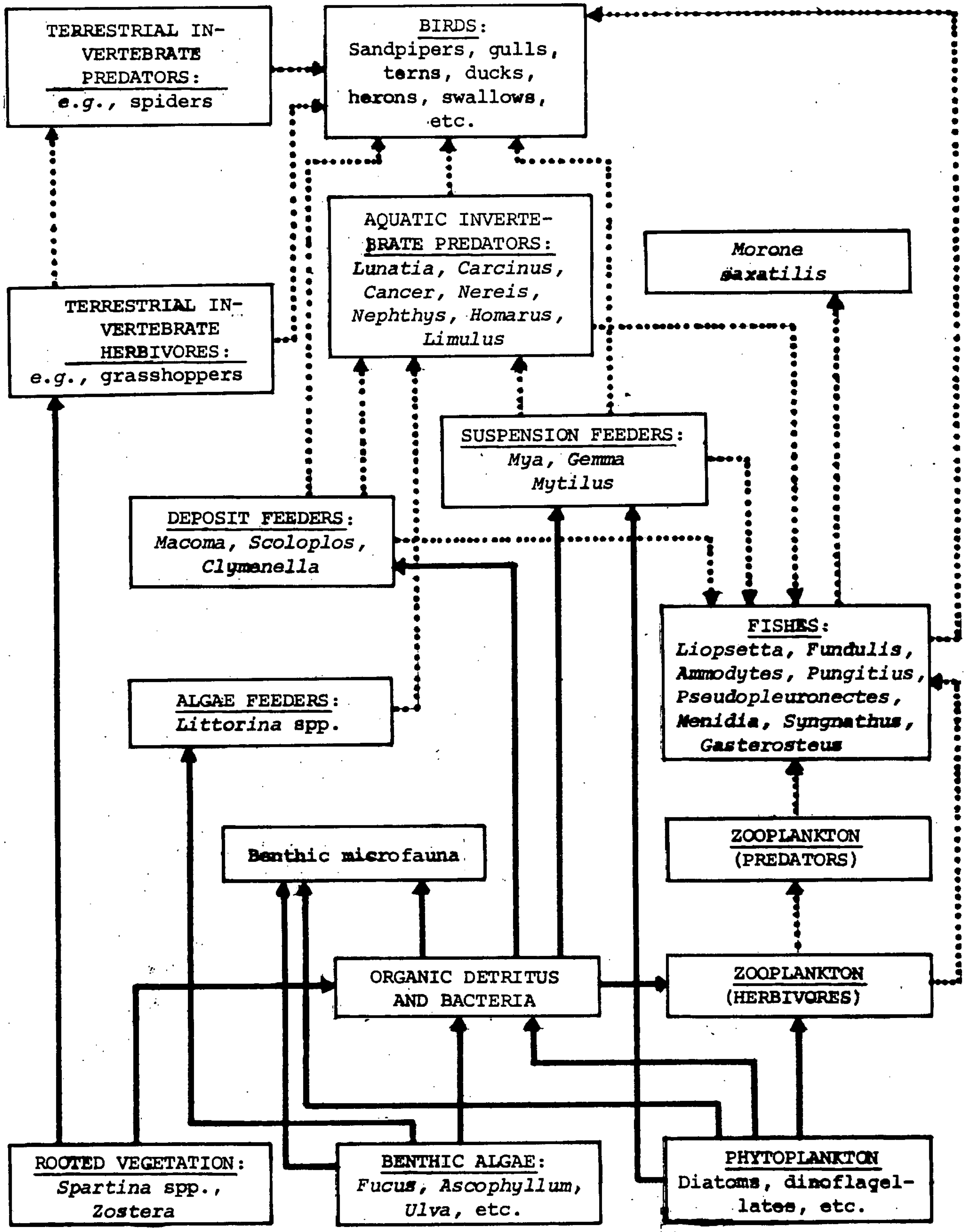
① OFFSHORE Pelagic	② OFFSHORE Soft Bottom	③ OFFSHORE Hard Substrate	④ ESTUARY Subtidal Flats and Channels	⑤ ESTUARY Intertidal Flats	⑥ ESTUARY Intertidal Rocks and Pilings	⑦ LOW MARSH	⑧ HIGH MARSH
DOMINANT SPP. *Squalus acanthias* *Scomber scombrus* *Pollachius virens* *Aurelia aurita* *Cyanea capillata* *Calanus finmarchicus* Other planktonic organisms: *e.g.*, copepods cladocerans ostracods, larvae of sessile benthic invertebrates	*Cancer* spp. *Pagurus* spp. *Crangon septemspinosa* *Homarus americanus* *Lunatia heros* *Nassarius trivittatus* *Haustorius* sp. *Spisula solidissima* *Arctica islandica* *Ensis directus* *Tellina agilis* *Siliqua costata* *Echinarachnius parma* *Nereis* spp. *Nephthys* spp. *Clymenella toquata* *Scoloplos fragilis* *Liopsetta putnami* *Pseudopleuronectes americanus* *Myoxocephalus octodecimspinosus* *Prionotus carolinus* *Morone saxatilus*	*Laminaria digitata* *Laminaria saccharina* *Chondrus crispus* *Agarum cribrosum* *Homarus americanus* *Cancer* spp. *Asterias vulgaris* *Strongylocentrotus drobachiensis* *Tonicella ruber* *Lacuna vincta* *Acmaea testudinalis* *Littorina littorea* *Thais lapillus* *Modiolus modiolus* *Mytilus edulis*. *Balanus balanoides* *Mogula* sp. *Pagurus longicarpus* *Tautogolabrus adspersus* *Morone saxatilus*	*Littorina littorea* *Mytilus edulis* *Lunatia heros* *Carcinus maenas* *Limulus polyphemus* *Crangon septemspinosa* *Pagurus* spp. *Cancer* spp. *Homarus americanus* *Haustorius* sp. *Mya arenaria* *Macoma balthica* *Nereis* spp. *Nephthys* spp. *Scoloplos fragilis* *Clymenella torquata* *Liopsetta putnami* *Pseudopleuronectes americanus* *Ammodytes americanus* *Fundulus heteroclitus* *Pungitius pungitius* *Menidia menidia* *Syngnathus fuscus* *Gasterosteus aculeatus* *Morone saxatilus*	*Littorina littorea* *Mytilus edulis* *Lunatia heros* *Carcinus maenas* *Limulus polyphemus* *Crangon septemspinosa* *Pagurus* spp. *Cancer* spp. *Homarus americanus* *Haustorius* sp. *Mya arenaria* *Macoma balthica* *Nereis* spp. *Nephthys* spp. *Scoloplos fragilis* *Clymenella torquata* *Liopsetta putnami* *Pseudopleuronectes americanus* *Ammodytes americanus* *Fundulus heteroclitus* *Pungitius pungitius* *Menidia menidia* *Syngnathus fuscus* *Gasterosteus aculeatus* *Morone saxatilus*	*Thais lapillus* *Littorina littorea* *Littorina obtusata* *Littorina saxatilis* *Balanus balanoides* *Mytilus edulis* *Ascophyllum nodosum* *Fucus vesiculosus* *Lacuna vincta* *Carcinus maenas* *Fundulus heteroclitus* *Pungitius pungitius* *Menidia menidia* *Syngnathus fuscus* *Gasterosteus acyleatus*	*Spartina alterniflora* *Littorina saxatilus* *Littorina littorea* *Littorina obtusata* *Modiolus demissus* *Ascophyllum nodosum f. scorpioides* *Fucus vesiculosus var. spiralis* *Balanus balanoides* *Anurida maritima* *Carcinus maenas* Shore birds *Fundulus heteroclitus* *Pungitius pungitius* *Menidia menidia* *Syngnathus fuscus* *Gasterosteus aculeatus*	*Spartina patens* *Melampus bidentatus* *Littorina saxatilis* Marsh insects Spiders, mites, etc. Shore birds Terrestrial animals (Ecotone between aquatic and terrestrial communities) In high marsh pools: *Fundulus heteroclitus* *Pungitius pungitius* Marsh pool corixids

PSNH SEABROOK STATION	COMMUNITIES OF THE HAMPTON-SEABROOK ESTUARY AND ADJACENT OFFSHORE AREAS	FIGURE 2.7-1



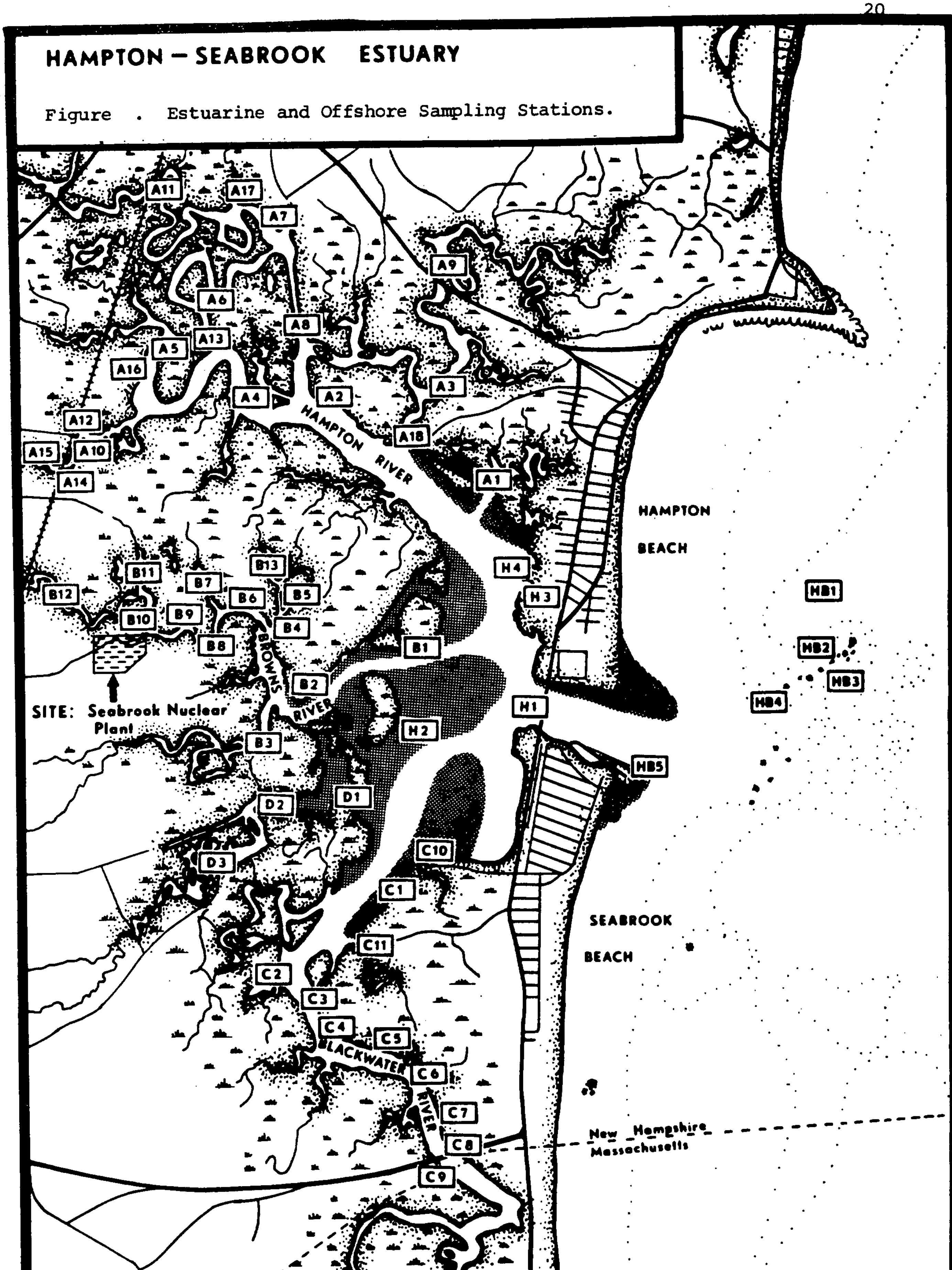
Solid line represents transfer from first to second trophic levels; dashed line represents transfer between higher trophic levels.

PSNH SEABROOK STATION	FOOD RELATIONSHIPS OF MAIN GROUPS OF ANIMALS IN THE OFFSHORE AREA	FIGURE 2.7-2

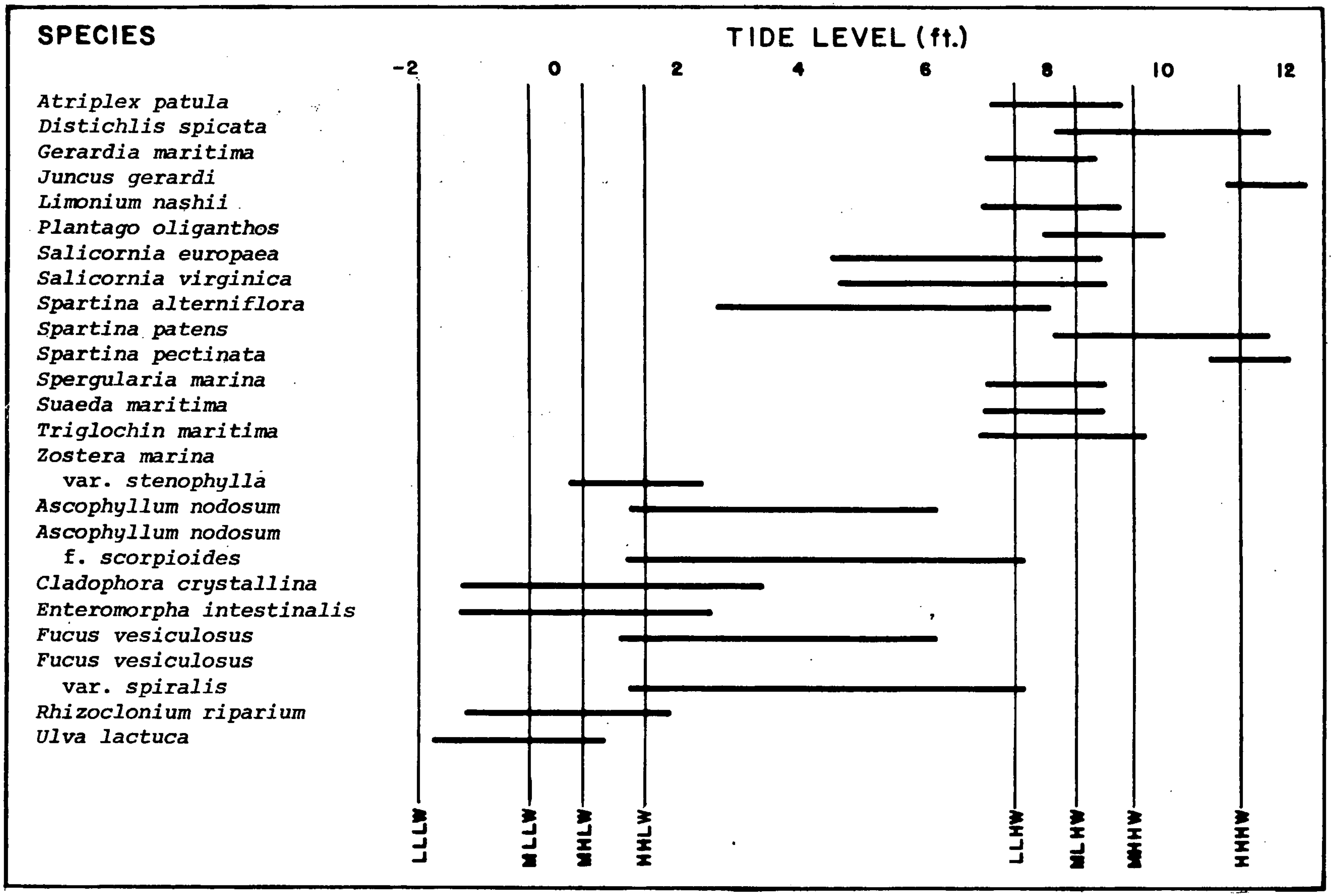


Solid line represents transfer from first to second trophic levels; dashed line represents transfer between higher trophic levels.

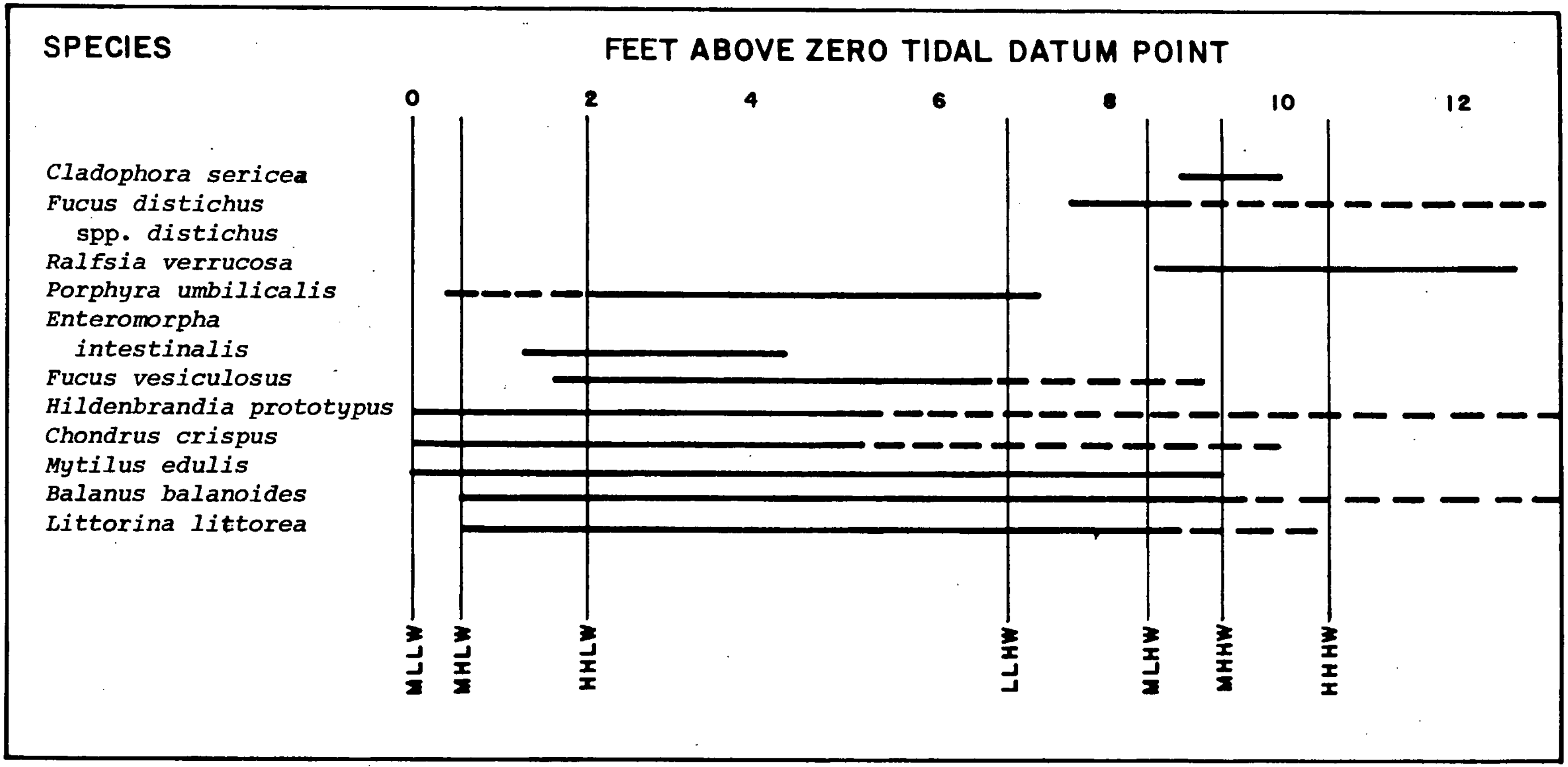
PSNH SEABROOK STATION	FOOD RELATIONSHIPS OF MAIN GROUPS OF ANIMALS IN THE ESTUARINE AREA	FIGURE 2.7-3



PSNH SEABROOK STATION	ESTUARINE AND OFFSHORE SAMPLING STATIONS	FIGURE 2.7-4



PSNH SEABROOK STATION	ZONATION PROFILE OF CONSPICUOUS PLANTS AT THE ESTUARINE LOCATION NEAR STATION A-10	FIGURE 2.7-5



PSNH SEABROOK STATION	ZONATION PROFILE OF THE CONSPICUOUS ORGANISMS AT BECKMAN'S POINT, SEABROOK, NEW HAMPSHIRE	FIGURE 2.7-6

2.8 Background Radiological Characteristics

A field and laboratory survey of the region around Seabrook Station was conducted in order to supply information about background radiological characteristics.

The survey included a number of different analyses. First, in situ external environmental gamma field measurements were made utilizing Yankee's Reuter Stokes RSG-42 pressurized ionization chamber. Based on these readings, a followup study was conducted by the consulting firm of Environmental Analysts, Inc. Background environmental gamma radiation levels were measured by Environmental Analysts at 21 field points using a pressurized ion chamber and a sodium iodide gamma ray spectrometer. Measurements were made within a 15 mile radius of the site with primary emphasis on the area within a 5 mile radius. In addition to the field survey, 63 samples of environmental media including surface water, well water, bottom sediments, soils, marsh grass, soft shell clams, flounder, shrimp, lobster, plankton, algae, mussels, clam worms, and milk were collected for radiological analysis by Teledyne Isotopes, Inc. The field survey instrumentation and results are described below.

The field spectra were taken using a gamma ray spectrometer with a 4-by-4 inch cylindrical sodium iodide detector and a multichannel analyzer. The spectrometer was calibrated to span a gamma energy range of zero to 3.2 MeV, which encompasses the gamma emissions of essentially all environmental radionuclides of both natural and fallout origin. The measured exposure rates were separated into components attributed to cosmic radiation and to fallout activity, potassium-40, and the natural decay series of uranium-238 and thorium-232 using a "spectrum stripping" computer program, developed by Environmental Analysts, based on the energy band method of Beck et al, Reference (1).

Points where field spectra were taken are listed in Table 2.8-1. The location of field spectra sites are shown by number in Figure 2.8-1. In addition to field spectra, Environmental Analysts took readings at each site using a Reuter Stokes RSS-111 high pressure ionization chamber which measures the ionizing radiation exposure rate in microroentgens (μR) per hour (1 μR per hour = 8.76 mR/year). It is sensitive to variations equivalent to 5 milliroentgens per year within the natural background level. The chamber consists of a 0.120-inch-thick stainless steel walled sphere filled with argon to a pressure of 25 atmospheres. A sensitive MOSFET electrometer measures the ionization current produced in the detector gas by the gamma radiation.

The pressurized ionization chamber was calibrated before and after the survey, using a standard radium-226 source certified by the National Bureau of Standards (NBS Gamma-Ray Standard 3815-72). Appropriate corrections were made for background radiation and for radium gamma ray scatter. A separate calibration constant was used for cosmic radiation, as the pressurized ionization detector response is slightly less for high-energy cosmic radiation than for terrestrial gamma rays. The cosmic ray exposure rate increases with altitude as shown in Table 2.8-2. This table was used to determine the cosmic ray exposure rate at each of the measurement locations. In the vicinity of the Seabrook site, elevations ranged from sea level to approximately 200 feet, with a corresponding cosmic exposure rate of about 32 milliroentgens per year. After subtracting the cosmic component from the total exposure rate, the contributions due to potassium-40, the two natural decay series, and fallout can be determined.

The results of this field survey are found in Table 2.8-3 by station number as shown in Table 2.8-1. The environmental gamma radiation exposure rate varied from 54 to 98 milliroentgens (mR) per year, with the cosmic component accounting for approximately 32 mR per year at all locations. The natural emitters (potassium-40, the uranium-238 series, and the thorium-232 series) contributed from 17 to 66 milliroentgens per year to the total exposure rate.

The smallest component of the total gamma radiation field was fallout from nuclear weapons tests which was detectable in 19 spectra and generally contributed less than 5 milliroentgens per year. The predominant fallout nuclide was cesium-137; however, zirconium-95 and niobium-95 were also detected in the spectra where fallout was evident.

Considerable variability in field fallout activity at similar locations was noted. For example, spectrum 2 (see Table 2.8-3) taken directly over the marsh at the end of Rocks Road in Seabrook showed a 4-8 mR/yr exposure rate from fallout activity. Spectrum 7, taken over the marsh at the Hampton Beach Yacht Club in Hampton showed only a trace of fallout activity. A third spectrum, number 11, taken on the marsh at Farm Dock (Depot Road, Seabrook) showed 1-4 mR/year fallout activity. The exposure rate for fallout activity is expressed as a range due to the manner in which it is computed. However, the data does indicate differences between what appear to be similar sites.

The average total exposure rate at three marsh sites was 61 mR/year. This compares to an average exposure rate at sixteen terrestrial points of 77 mR/year. Site number 8 on the beach at Hampton Beach State Park showed an exposure rate of 67 mR/year. The annual exposure rates reported are extrapolations from measurements made over a short time interval with environmental conditions specific to that interval. Previous studies, (References 1 and 2) have documented variations in normal background with time. These variations are caused by variations in soil moisture, by changes in radon emanation, snow cover, and the washout of radon daughters by percipitation. Variations in instantaneous exposure rates at a point over a period of years has been measured by the AEC's Health and Safety Laboratories and have been found to vary by $\pm$20 percent. Monthly or quarterly fluctuations in natural background of this order may be expected (Reference 6).

Natural field environmental gamma radiation levels have been measured previously at several towns in New Hampshire during 1966 by the National Center for Radiological Health (Reference 5) using a portable gamma scintillation counter. Measurements were made using a 2-inch NaI(Tl) crystal which was calibrated with a highly sensitive muscle equivalent chamber.

Average values of background gamma dose rate at eleven towns in New Hampshire are shown in Table 2.8-9. The average background gamma dose rate for the eleven towns was 89.3 mrad/year. Twelve readings made in Seabrook, Hampton, and Hampton Falls averaged 85.6 mr/year. The above readings were generally made in the vicinity of a highway but away from areas of disturbed soil or other man-made surfaces.

In addition to the field survey, sixty-three samples of various environmental media were collected for laboratory analysis by Teledyne as described earlier. The majority of samples were analyzed by high resolution gamma spectroscopy using a lithium drifted germanium detector with analytical sensitivities as shown in Table 2.8-4. Milk samples (samples #61-63) were analyzed for Strontium-90 activity. Ground water samples were collected from municipal and private sources in Seabrook, Hampton Falls, Kensington, Hampton and Salisbury. Ground water samples #41, 43, and 45 were gamma scanned, while samples #42, 44, and 46-60 were analyzed specifically for Ra-226 by a technique involving degassing, collection of Radon-222 gas as it evolved over a two week period, and counting of the evolved radon gas in an internal proportional counter. From the Radon-222 activity, it is possible to calculate the Radium-226 activity in the water sample. Tritium was measured in ground water samples #42, 44 and 46-60 using a gas counting technique sensitive to environmental levels.

Table 2.8-5 summarizes the environmental media which were sampled, the sampling locations, and lists the sample number by which analytical results are reported in Table 2.8-6. Each sampling location in Table 2.8-5 is assigned a number which may be used to locate that point in Figures 2.8-2 and 2.8-3. The results of the analyses of environmental media are described below.

Radiological analysis of bottom sediments from inside the harbor (pt. 2 in Figure 2.8-2) and the area where the discharge pipe will terminate (point 1) indicates the presence of only natural activity. The average activities noted at each point are summarized below:

	Sediment Analysis-picocuries per gram of Sediment		
	Potassium-40	Radium-226	Thorium-228
Discharge Area	11.1	.43	.68
Clam Flat #2	14.3	.34	.51

Any fallout activity which may be present is below the detection sensitivities shown in Table 2.8-4.

The eight surface water samples showed no gamma activity in excess of analytical sensitivities as shown in Table 2.8-4. Two attached algae samples, Fucus vesiculosus, from two points (#6 and #18 in Figure 2.8-2) showed considerable variability in background acitivity. Both samples were taken off similar granite outcroppings. The harbor sample (#6) had Thorium-228 activity of 70 pCi/kg, Potassium-40 activity of 6100 pCi/kg, and Cesium-137 and Radium-226 activity of less than 21, and 12 pCi/kg respectively. The offshore sample taken at the mouth of Hampton Harbor inlet had Thorium-228 activity of less than 21 pCi/kg, Potassium-40 activity of 10700 pCi/kg, and Cesium-137 and Radium-226 levels of 50 and 70 pCi/kg respectively. It is clear that although these two algae collection points are separated by less than 0.6 miles, significant differences exist in the background activity levels.

Soil samples from four points all showed the same nuclides. Cesium-137, Potassium-40, Radium-226, and Thorium-228 were detected in all six samples. Of interest are the differences noted in duplicate samples taken from the same general area. Two soil samples taken at Normandeau Labs (point #12 on Figure 2.8-2) showed sharp differences in the activity from each nuclide. Results indicate that variation in activity at several very close sampling points from a given nuclide may be as great as variations between widely separated points.

Softshell clam analysis showed only Potassium-40 and Radium-226 activity. Of interest was the level of Radium-226 noted. Four of five clam samples showed radium levels ranging from 60-330 pCi/kg with an average of 140 pCi/kg. These radium levels are elevated over normal environmental levels and will be studied in greater detail during the preoperational radiological monitoring program. The only other marine medium showing detectable levels of activity besides Potassium-40 was blue mussels which also showed elevated Radium-226 levels averaging 195 pCi/kg for the two of three mussel samples above the detection sensitivity of 12 pCi/kg for this isotope.

Plankton, clam worms, and lobster all showed no activity above the minimum detectable levels shown on Table 2.8-4. Sand shrimp and flounder showed only K-40 activity.

Two varieties of marsh grass collected showed the ability to concentrate Beryllium-7. Both varieties of grass, Spartina patens, and Spartina alterniflora showed similar levels of Be-7, averaging 2300 pCi per kilogram.

Milk analysis from three dairies showed Cesium-137 levels averaging 15 pCi per liter. Strontium-90 levels averaged 5.9 pCi/l. These levels are entirely consistent with reports from Manchester, N. H. which is a station for the EPA, Pasteurized Milk Network. Manchester, N. H. reported a 12 month average for Sr-90 and Cs-137 of 8 and 18 pCi/l respectively (Reference 3).

The potable groundwater supplies sampled showed an average Radium-226 activity of 1.74 ± 2.60 pCi/l. The public water supplies sampled showed an average Radium-226 level of 0.81 ± .82 pCi/l with a minimum of .15 pCi/l and a maximum of 2.5 pCi/l. Private groundwater supplies showed average Radium-226 levels of 2.72 ± 3.26 pCi/l with a minimum of 0.15 and a maximum of 8.2 pCi/l.

These same samples of potable ground water showed tritium levels averaging 194 ± 71 pCi/l with a minimum of 90 pCi/l and a maximum of 330 pCi/l. Public water supplies averaged 230 ± 70 pCi/l while private supplies averaged 162 ± 58 pCi/l. Tritium has been measured previously in the drinking water for Concord, New Hampshire as part of the Environmental Protection Agency's Tritium Surveillance System. A sample collected on January 11, 1972 was found to have 500 pCi/l tritium (Reference 4).

Environmental air concentrations of gross beta activity was determined through 1967 in Concord, New Hampshire (40 miles from Seabrook), and Lawrence, Massachusetts (20 miles from Seabrook) by the Air Surveillance Network of the National Air Surveillance Networks Sections, Division of Air Quality and Emission Data, Bureau of Criteria and Standards, National Air Pollution Control Administration. Results from this Network through 1965 are shown in Table 2.8-7.

Airborne gross beta activity in Concord, N. H. for 1966-1969 is shown in Table 2.8-8. Data indicates a decline in activity from the 1950's and early 1960's during the most recent years for which information is available.

References

1. H. L. Beck, W. M. Lowder, B. G. Bennett, and W. J. Condon, "Further Studies of External Environmental Radiation," HASL-170, USAEC Health and Safety Laboratory, New York, NY (1966)

2. H. L. Beck, W. J. Condon, and W. M. Lowder, "Spectrometric Techniques for Measuring Environmental Gamma Radiation," HASL-150, USAEC Health and Safety Laboratory, New York, NY (1964)

3. Radiological Health Data and Reports, Sept. 1972, p. 484

4. Radiological Health Data and Reports, August 1972, p. 440

5. National Center for Radiological Health, "Summary of Natural Environmental Gamma Radiation Using a Calibrated Portable Scintillation Counter", Radiological Health Data and Reports, Nov. 1968, p. 679-695

6. H. L. Beck, et. al., "New Perspectives on Low Level Environmental Radiation Monitoring Around Nuclear Facilities," <u>Nuclear Technology</u>, Vol. 14, pp. 232-239, (1972)

TABLE 2.8-1

BACKGROUND RADIOLOGICAL STUDY FIELD SPECTRA LOCATIONS

Location	Description
1	Seabrook, end of Rocks Rd. - northern point
2	Seabrook, end of Rocks Rd. - southern point
3	Seabrook, Rocks Rd. - west of locations 1 and 2
4	Seabrook, Rocks Rd. - power line turn
5	Hampton Falls, Brimers Lane
6	Hampton Falls, end of Depot Avenue
7	Hampton, Hampton Beach Yacht Club
8	Hampton Beach State Park
9	Hampton Beach, on road behind Police and Fire Depts.
10	Portsmouth, at Portsmouth Public Service Office - Route 1
11	Seabrook, Depot Rd. - Farm Dock
12	Seabrook, Meterological Tower
13	Seabrook, New Zealand Rd. (Route 107) - pole #607
14	East Kingston, Route 107 substation
15	Amesbury, Mill St. - Mass. Electric substation
16	Haverhill, Kenoza Ave. Park
17	Salisbury, County Rd. - pole #11
18	Seabrook Beach, Route 1A - church at intersection of Lowell Street
19	Seabrook, Dows Lane - off Depot Rd.
20	Hampton Falls, Route 88 - Burwell Farm
21	Hampton Falls, Route 84 - pole #398

TABLE 2.8-2

ABSOLUTE COSMIC RAY INTENSITIES
(LATITUDE NORTH 50°)*

Pressure (g/cm^2)	Altitude (ft)	Exposure Rate (uR/hr)
1033	0	3.59
1000	910	3.82
950	2320	4.30
900	3800	4.96
850	5300	5.95
800	6930	7.34
750	8620	9.36
700	10400	12.3
650	12300	16
600	14300	21

*Wayne M. Lowder and Harold L. Beck, "Cosmic Ray Ionization in the Lower Atmosphere," J. Geophys. Res., 72 (19), p. 4661, 1966.

TABLE 2.8-3

BACKGROUND RADIOLOGICAL STUDY
FIELD SPECTRA RESULTS

Station Number from Table 2.8-1	Exposure Rates (mR/yr)				Total Exposure Rates (mR/yr)**
	K-40	U-238	Th-232	Fallout	
1	13	8	12	1-4	66
2	5	6	6	4-8	54
3	13	9	18	1-4	76
4	8	8	12	1-4	64
5	15	12	14	1-4	77
6	19	10	14	ND*	75
7	15	10	14	Trace	71
8	16	9	10	Trace	67
9	17	12	15	1-4	78
10	14	14	14	1-4	77
11	6	7	11	1-4	57
12	15	12	17	Trace	76
13	14	23	15	Trace	84
14	12	13	15	1-4	76
15	22	21	23	ND	98
16	16	15	14	1-4	79
17	13	13	17	1-4	78
18	18	13	13	1-4	77
19	14	11	12	1-4	70
20	15	15	16	1-4	79
21	16	15	18	1-4	83

* ND - not detected.
** Measured using Reuter Stokes RSS - 111 pressurized ionization chamber

TABLE 2.8-4

ENVIRONMENTAL SAMPLE DETECTION SENSITIVITY BY HIGH RESOLUTION GE(Li) GAMMA SPECTROSCOPY

All gamma spectrum analysis are made using a lithium drifted germanium detector. Based on calibrations performed by contractor's analytical laboratories, representative minimum detectable activities (three times the standard deviation of background) are given below by isotope for 1 liter of water or milk and 1 kilogram of any other environmental media when counted for 480 minutes. This is the minimum counting time for environmental samples collected during the background study.

Isotope	Water or Milk (1 Liter) pCi/1	Other Environmental Media (Soil, Vegetation, Fish, etc.-1 kg) pCi/kg
Be-7	60	100
Cr-51	60	100
Mn-54	6	10
Co-58	6	10
Se-75	52	90
Fe-59	11	18
Zr-95	11	19
Ru-103	7	11
Ru-106	60	100
I-131	8	13
Cs-134	7	11
Cs-137	7	12
Ba-140	25	42
La-140	6	10
Ce-141	12	20
Ce-144	52	90
K-40	52	90
Th-228	12	21
Ra-226	12	21
Co-60	6	10

TABLE 2.8-5

BACKGROUND RADIOLOGICAL STUDY ENVIRONMENTAL MEDIA SAMPLE LOCATION SUMMARY

Media	Location (Collection Point Desig. 1-19 found in Figure 2.8-2)		No. of Samples From that Location	Sample Numbers Used Table 2.8-6 (Tabulation of results)
Bottom Sediments	Offshore Discharge Area	(1)	3	1,2,3
	Clam flat	(2)	3	4,5,6
Surface Water	Browns River-Ebb Tide	(3)	1	7
	Browns River-Flood Tide	(3)	1	8
	Harbor	(4)	2	9,10
	Offshore Discharge Area	(5)	4	11,12,13,14
Attached Algae	Offshore	(6)	1	16
	Harbor	(18)	1	15
Marsh Grass	Marsh near site	(7)	2	28,29
	Marsh near site	(8)	2	30,31
Soil Samples	On site-high ground	(9)	1	22
	On site-shore	(7)	1	21
	State Park	(11)	2	17,18
	Normandeau Associates Laboratory	(12)	2	19,20
Soft Shell Clams	Clam flat #1	(2)	5	23,24,25,26,27
Blue Mussels	Harbor	(14)	3	32,33,34
Plankton	Harbor	(15)	1	35
	Offshore	(1)	1	36
Sand Shrimp	Offshore	(17)	1	37
Clam worm	Harbor	(18)	1	38
Lobster	Offshore	(19)	1	39
Flounder	Harbor	(18)	1	40

TABLE 2.8-5 (continued)

Media	Location (Collection Point Desig. 21-38 found in Figure 2.8-3)	No. of Samples From that Location	Sample Numbers Used Table 2.8-6 (Tabulation of results)
Ground Water	Sullivan Property Well (21)	2	41, 42
	Bondi's Restaurant Well (22)	2	43, 44
	Brimers Lane Well (23)	2	45, 46
	Seabrook Town Well #1 (24)	1	47
	Seabrook Town Well #3 (25)	1	48
	Seabrook Town Well #4 and 5 (26, 27)	1	49
	Salisbury Water Supply Company Well #5 (28)	1	50
	Salisbury Water Supply Company Well #6 (29)	1	51
	Salisbury Water Supply Company Well #7 (30)	1	52
	C. Randall Well (31)	1	53
	T. L. Boyd Well (32)	1	54
	Hampton Water Co. Well #9 (33)	1	55
	Kensington Elementary School (34)	1	56
	Robert F. Walker Well (35)	1	57
	R. P. Merril Well (36)	1	58
	Donald Janvrin (Spring) (37)	1	59
	Spruce Cabin Well (38)	1	60
Milk	W. W. Marston Dairy, Hampton Falls *	1	61
	L. G. Hurd Dairy, Hampton *	1	62
	C. W. Burwell Dairy, Hampton *	1	63

(* Not shown on map)

TABLE 2.8-6

BACKGROUND RADIOLOGICAL STUDY-ENVIRONMENTAL MEDIA TABULATION OF RESULTS

Bottom Sediments

Sample Number (*2)	Nuclide	(pCi/gm) wet
1	K-40	10.8 ± 1.5
	Ra-226	0.42 ± 0.10
	Th-228	0.63 ± 0.12
2	K-40	11.3 ± 1.5
	Ra-226	0.46 ± 0.10
	Th-228	0.77 ± 0.14
3	K-40	11.2 ± 1.5
	Ra-226	0.42 ± 0.10
	Th-228	0.65 ± 0.12
4	K-40	13.8 ± 2.0
	Ra-226	0.34 ± 0.08
	Th-228	0.56 ± 0.10
5	K-40	14.9 ± 2.0
	Ra-226	0.34 ± 0.08
	Th-228	0.52 ± 0.10
6	K-40	14.2 ± 2.0
	Ra-226	0.35 ± 0.08
	Th-228	0.45 ± 0.10

Surface Water Samples

	Nuclide (pCi/ml)
7	(*1)
8	*
9	*
10	*
11	*
12	*
13	*
14	*

Attached Algae

(*F. vesiculosus*)

	Nuclide	(pCi/gm) wet
15	K-40	6.1 ± 0.8
	Th-228	.07 ± 0.03
16	Cs-137	0.05 ± 0.02
	K-40	10.7 ± 1.5
	Ra-226	0.07 ± 0.02

(*1) All Gamma Emitting Nuclides were equal to or less than Detection Sensitivities in Table 2.8-4.

(*2) Sample Numbers are those listed in Table 2.8-5.

TABLE 2.8-6 (Continued)

Soil Samples

Sample Number	Nuclide	pCi/gm
17 - State Park	Cs-137	0.08 ± 0.02
	K-40	12.3 ± 1.7
	Ra-226	0.37 ± 0.10
	Th-228	0.55 ± 0.10
18 - State Park	Cs-137	0.11 ± 0.02
	K-40	13.8 ± 2.0
	Ra-226	0.45 ± 0.10
	Th-228	0.49 ± 0.10
19 - Normandeau Lab	Cs-137	0.09 ± 0.02
	K-40	14.8 ± 2.0
	Ra-226	0.21 ± 0.05
	Th-228	0.29 ± 0.06
20 - Normandeau Lab	Cs-137	0.05 ± 0.02
	K-40	2.2.8 ± 0.5
	Ra-226	0.06 ± 0.03
	Th-228	0.07 ± 0.03
21 - Onsite, shore	Cs-137	0.33 ± 0.06
	K-40	5.0 ± 0.8
	Ra-226	0.08 ± 0.02
	Th-228	0.24 ± 0.04
22 - On Site, High Ground	Cs-137	0.05 ± 0.02
	K-40	8.7 ± 1.3
	Ra-226	0.54 ± 0.10
	Th-228	0.81 ± 0.13

Soft Shell Clams

Sample Number	Nuclide	(pCi/gm) wet
23 - Clam flat #1	K-40	2.9 ± 0.5
	Ra-226	0.09 ± 0.03
24 - Clam flat #1	K-40	1.2 ± 0.02
	Ra-226	0.33 ± 0.06
25 - Clam flat #1	K-40	2.1 ± 0.3
	Ra-226	0.06 ± 0.03
26 - Clam flat #1	K-40	2.6 ± 0.4
27 - Clam flat #1	K-40	1.7 ± 0.3
	Ra-226	0.08 ± 0.03

TABLE 2.8-6 (Continued)

Marsh Grass

Sample Number	Nuclide	(pCi/gm) wet
28 - Spartina patens	Be-7 K-40	2.6 ± 0.4 4.0 ± 0.6
29 - Spartina patens	Be-7 K-40	2.8 ± 0.4 3.0 ± 0.5
30 - Spartina alterniflora	Be-7 K-40	1.7 ± 0.4 0.50 ± 0.25
31 - Spartina alterniflora	Be-7 K-40	2.1 ± 0.4 0.50 ± 0.25

Blue Mussels

Sample Number	Nuclide	(pCi/gm) wet
32 - Harbor	K-40	1.5 ± 0.3
33 - Harbor	K-40 Ra-226	1.7 ± 0.3 0.16 ± 0.04
34 - Harbor	K-40 Ra-226	1.5 ± 0.3 0.23 ± 0.05

Plankton

Sample Number	Nuclide
35 - Harbor	(*1)
36 - Offshore	*

Sand Shrimp

	Nuclide	(pCi/gm)
37 - Offshore	K-40	1.6 ± 0.3

Clam Worm

	Nuclide
38 - Harbor	*

Lobster

Location	Nuclide
39 - Offshore	*

(*1) All Gamma Emitting Nuclides were equal to or less than Detection Sensitivities in Table 2.8-4.

TABLE 2.8-6 (Continued)

Flounder

Sample Number	Nuclide	(pCi/gm) wet
40 - Harbor	K-40	2.2 ± 0.3

Well Water

Sample Number	Nuclide	(pCi/1)
41 - Sullivan Property	*1	
42 - Sullivan Property (gas counting for H-3, Ra-226)	Ra-226 H-3	0.25 ± .07 100 ± 30
43 - Bondi's Restaurant	*1	
44 - Bondi's Restaurant - Resample (gas counting for H-3, Ra-226)	Ra-226 H-3	1.9 ± 0.4 190 ± 30
45 - Brimer's Lane	*1	
46 - Brimer's Lane - Resample (gas counting for H-3, Ra-226)	Ra-226 H-3	8.2 ± 1.5 110 ± 30
(Note: Sample 47-60 gas counted for Tritium and Ra-226)		
47 - Seabrook Town Well #1	Ra-226 H-3	2.5 ± 0.5 310 ± 40
48 - Seabrook Town Well #3	Ra-226 H-3	0.15 ± 0.04 200 ± 40
49 - Seabrook Town Well #4 & #5 (Common Line)	Ra-226 H-3	0.40 ± 0.09 100 ± 40
50 - Salisbury Water Supply Well #5	Ra-226 H-3	0.25 ± 0.07 220 ± 40
51 - Salisbury Water Supply Well #6	Ra-226 H-3	0.40 ± 0.09 270 ± 40
52 - Salisbury Water Supply Well #7	Ra-226 H-3	0.25 ± 0.07 190 ± 40
53 - C. Randall Well	Ra-226 H-3	1.8 ± 0.4 130 ± 30
54 - T. L. Boyd Well	Ra-226 H-3	8.1 ± 1.5 90 ± 30

(*1) All Gamma Emitting Nuclides were equal to or less than Detection Sensitivities in Table 2.8-4.

TABLE 2.8-6 (Continued)

Well Water

Sample Number	Nuclide	(pCi/l)
55 - Hampton Water Co. Scammon Well #9	Ra-226 H-3	1.0 ± 0.2 310 ± 40
56 - Kensington Elementary School Well	Ra-226 H-3	0.15 ± 0.04 240 ± 40
57 - Robert F. Walker Well	Ra-226 H-3	0.15 ± 0.04 240 ± 40
58 - R. P. Merril Well	Ra-226 H-3	0.46 ± .10 190 ± 40
59 - Donald Janvrin (Spring Sample)	Ra-226 H-3	0.20 ± 0.05 240 ± 40
60 - Spruce Manor Cabin Well	Ra-226 H-3	3.4 ± 0.50 170 ± 40

Milk

Sample Number	Nuclide	(pCi/l)
61 - W. W. Marston Dairy Browns Road Hampton Falls, N. H.	Cs-137 K-40 Sr-90	21 ± 4 1200 ± 200 5.3 ± 0.8
62 - L. G. Hurd Dairy Old Stage Road Hampton, N. H.	Cs-137 K-40 Sr-90	8.4 ± 1.6 1200 ± 200 6.1 ± 1.0
63 - C. W. Burwell Dairy Hampton, N. H.	Cs-137 K-40 Sr-90	16 ± 3 1100 ± 200 6.2 ± 1.0

TABLE 2.8-7

Airborne Gross Beta Radioactivity ($\rho Ci/m^3$)
Concord, N.H., Lawrence, Mass. 1953-1965

Location	1953-1957 Max	1953-1957 Avg	1958 Max	1958 Avg	1959 Max	1959 Avg	1960 Max	1960 Avg	1961 Max	1961 Avg	1962 Max	1962 Avg	1963 Max	1963 Avg	1964 Max	1964 Avg	1965 Max	1965 Avg
New Hampshire	14.0	4.1	20.4	4.1	14.2	3.3	0.3	0.1	22.1	3.6	10.0	5.7	10.0	5.9	3.4	1.2	1.0	0.3
Massachusetts	58.8	3.3	33.0	4.5	71.0	3.8	0.5	0.1	53.0	2.2	22.4	6.1	22.4	6.2	4.4	1.2	2.0	0.4

Source: Data reported in Appendix B, Table 23 of "Preliminary Air Pollution Survey of Radioactive Substance - A Literature Review. U.S. Department H.E.W., National Air Pollution Control Administration Publication (No. APTD 69-46)

TABLE 2.8-8

AIRBORNE GROSS BETA ACTIVITY - CONCORD, NH
1966-1969

Airborne Gross Beta (pCi/m^3)

	1966	1967	1968	1969
Min.	0.1	0.1	0.1	---
Max.	0.3	1.2	1.1	---
Avg.	0.15	0.5	0.8	0.5

Note: Values recorded above were taken from a graphical summary so values may differ slightly from numerical values reported by the Radiation Alert Network.

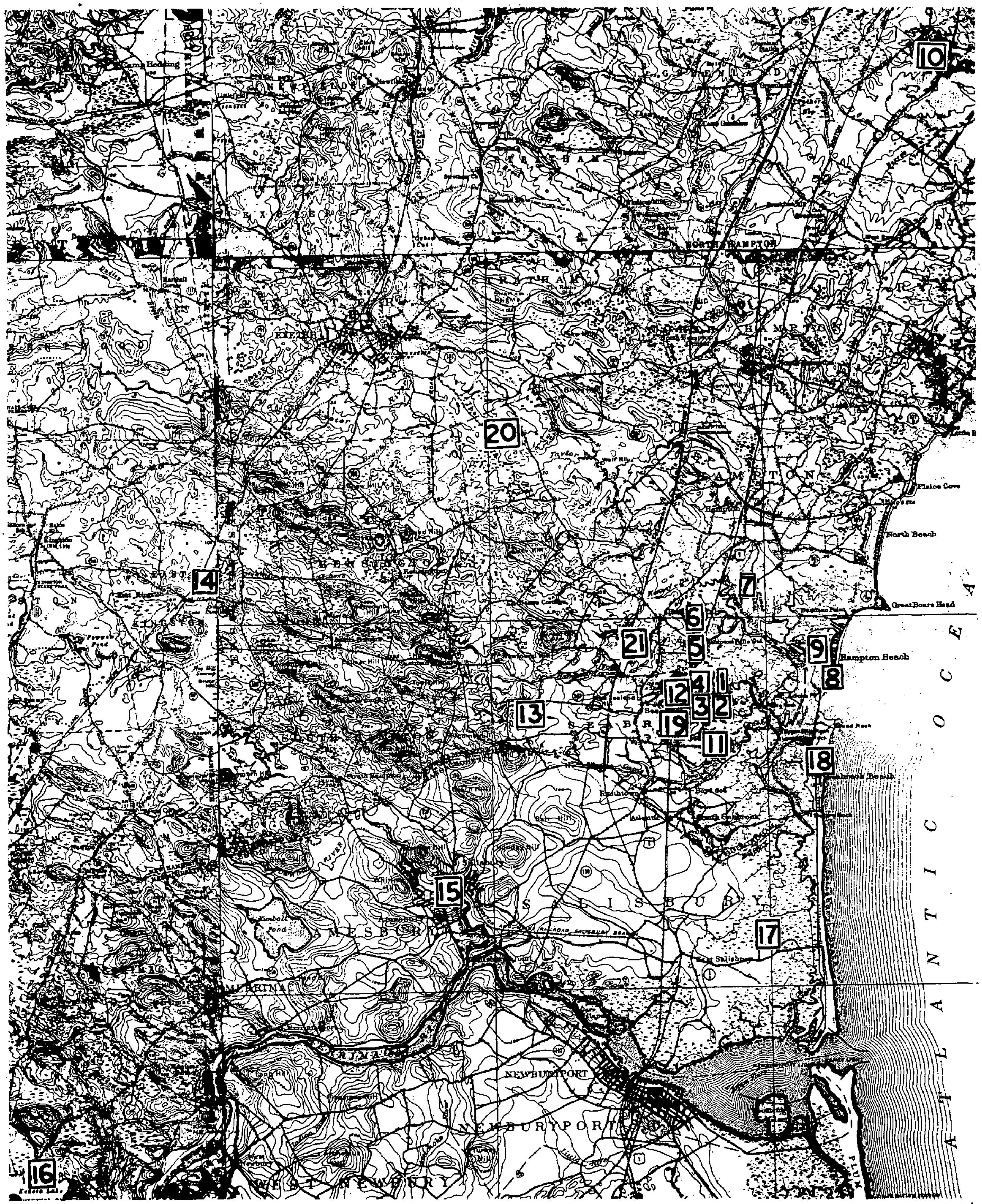
(Source: Radiological Health Data and Reports, p. 698 Dec. 1970)

TABLE 2.8-9

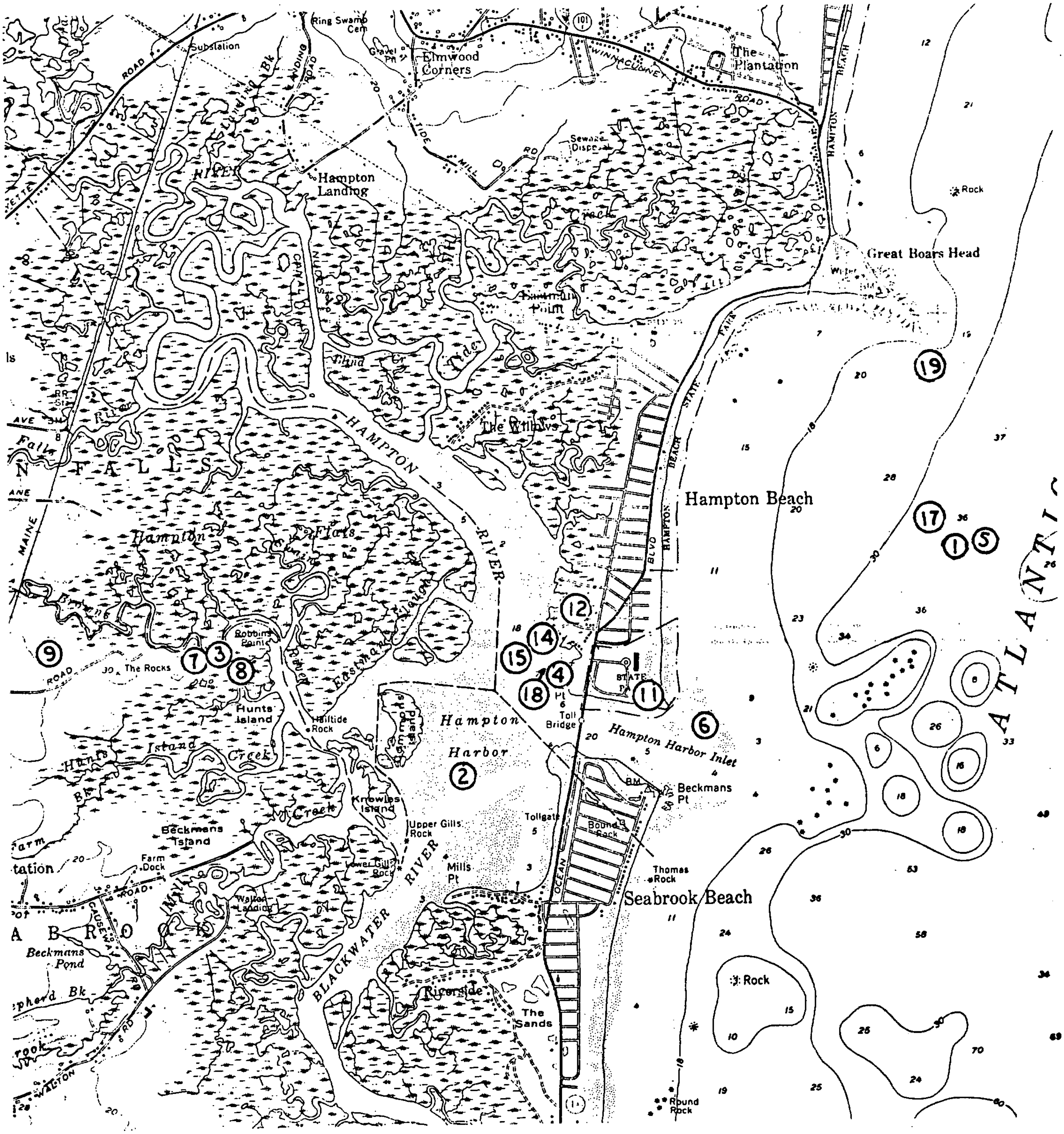
Average Values of Background Gamma Dose Rate Measurements in New Hampshire as Determined by the National Center for Radiological Health

City	Average (mrad/year)	Number of Observations
Concord	97.2	8
Hampton Falls	84.1	4
Hampton	87.6	4
Henniker	88.5	4
Keene	82.3	6
North Branch	92.0	2
Northwood	94.6	3
Portsmouth	91.1	21
Rochester	92.0	3
Seabrook	85.0	4
Smithtown	87.6	4

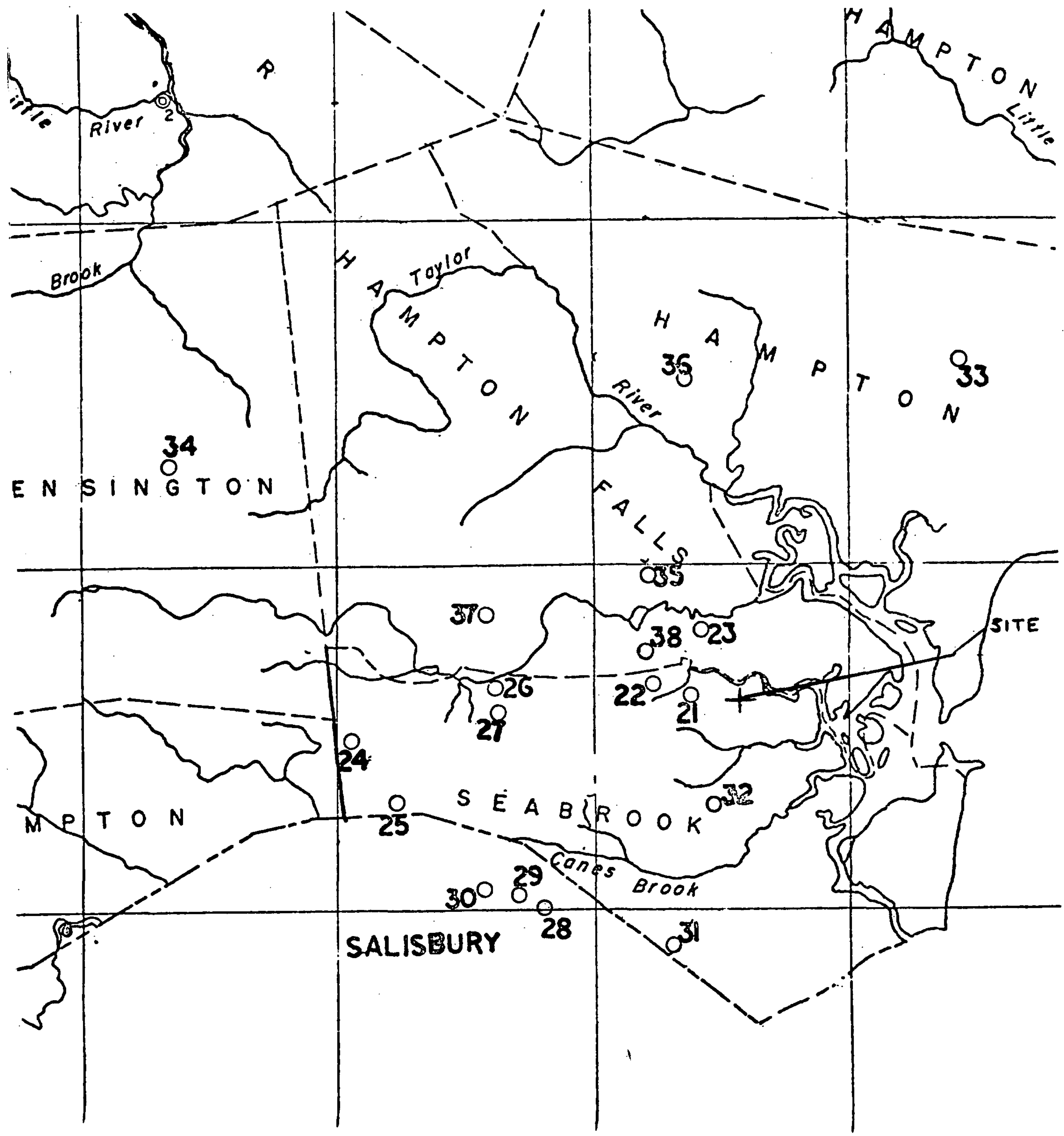
Source: Adapted from Reference 5, p. 692.



PSNH SEABROOK STATION	BACKGROUND RADIOLOGICAL STUDY FIELD SPECTRA LOCATIONS	FIGURE 2.8-1



PSNH SEABROOK STATION	BACKGROUND RADIOLOGICAL STUDY ENVIRONMENTAL MEDIA SAMPLING LOCATIONS	FIGURE 2.8-2



PSNH SEABROOK STATION	BACKGROUND RADIOLOGICAL STUDY GROUND WATER SAMPLING LOCATIONS	FIGURE 2.8-3

2.9

2.9 Other Environmental Features

The features of the terrestrial and aquatic environment surrounding the Seabrook Site have been described in the preceding sections. In many ways the quality ascribed to a sector of the environment depends upon the attitudes of the observer. It is difficult to compile the feelings of nearby residents about the salt marsh without creating a collage of values. At one side of the picture are those who wouldn't see a blade of grass disturbed while at the other are those who advocate filling and developing the marsh to make it "really productive". The most prominent evidence of the environmental regard held for the site by the local residents is their use of a sizable portion of it for the municipal dump. This creates a scene which is offensive. The unburned litter is not confined to the dump alone, but lines either side of the road through the site and is swept by prevailing winds into the adjacent woodland. During dump burning operations, the smoke has been observed to extend over wide areas of the site and beyond. Certainly there are visitors who regret such conditions; yet they persist.

On a more positive side, there are local residents who use the site as a point of access to the adjacent salt marsh. Bird watchers have been seen surveying salt marsh pools and river channels. Sportsmen such as duck hunters and clam diggers utilize the Rocks Road for salt marsh visits. As mentioned elsewhere, the site itself is stocked with ring-necked pheasant which are hunted by a few local residents.

We know that whether or not a nuclear plant is built or whether or not a shopping center is built or a new road constructed, the site will change. We know, too, of the aesthetic quality some ascribe to the adjacent marsh and from our scientific studies of its ecological importance. After observing the area one thing which appears to be missing and which undoubtedly has a bearing on the range of popular attitudes is any planned program or facility by which a resident or a visitor may learn about the salt marsh. On Cape Cod, the National Seashore and Wellfleet Bay Sanctuary have self-guiding facilities through which the visitor may learn of the marsh and the sea. Nothing of this sort is known to exist along the coast of New Hampshire.

Public Service Company of New Hampshire is willing to cooperate with other parties in developing an education center which can show the variety of life forms dependent upon and contributing to the ecology of the marsh and its perimeter. This center would also be equipped to tell the story of Seabrook Station and energy conversion. It remains to be seen whether sufficient local interest can be developed to bring the environmental training aspects of the center to fruition.

The Applicant is interested in setting aside the marsh areas of the site after construction is complete as a wildlife refuge in perpetuity. Although this intent has been announced publicly, the details of the plan will not be formulated for some time.

3. THE PLANT

3 THE PLANT

3.1 External Appearance

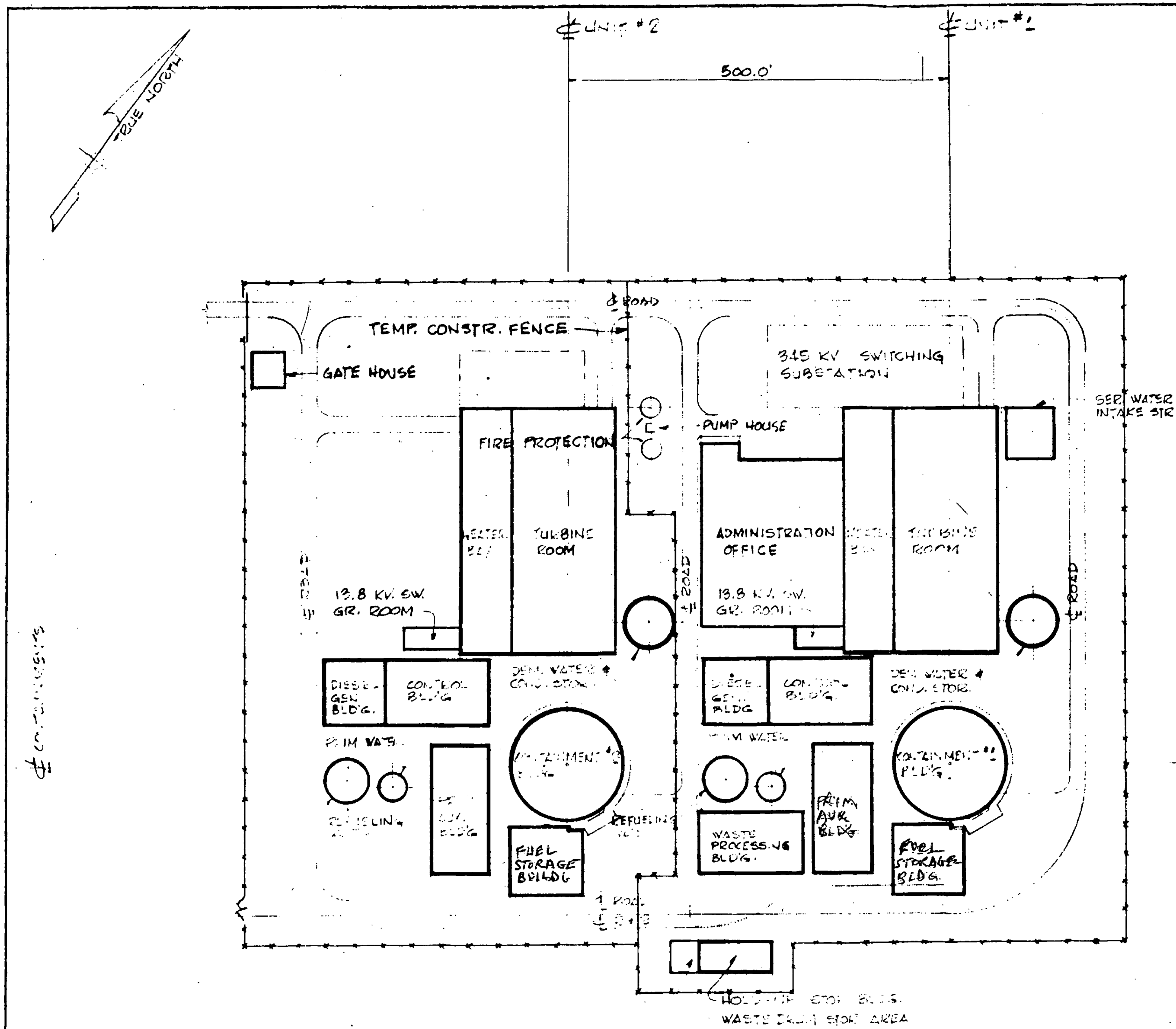
The general arrangement of the proposed site is shown in Figure 3.1-1. In this figure, the 3000-foot radius exclusion boundary and the location of significant structures are apparent. The property line will closely follow the exclusion boundary. The plant will generally be obscure except to site visitors and people along parts of the coastal highway approximately 1.5 miles away.

Even though the plant will only be viewed from a distance, the applicant early in the design process retained Kling/Planning, Division of the Kling Partnership, to advise on land planning and site design. Kling made many valuable suggestions on usages of the site area and protection of its natural attributes. These were embodied in scale models of the plant structures set into detailed representations of the site and its environs. From photographs of the models, Figures 3.1-2 and 3.1-3, one may sense the profile of the plant and the degree to which it will be visible. The Kling/Planning report appears in its entirety in Appendix I.

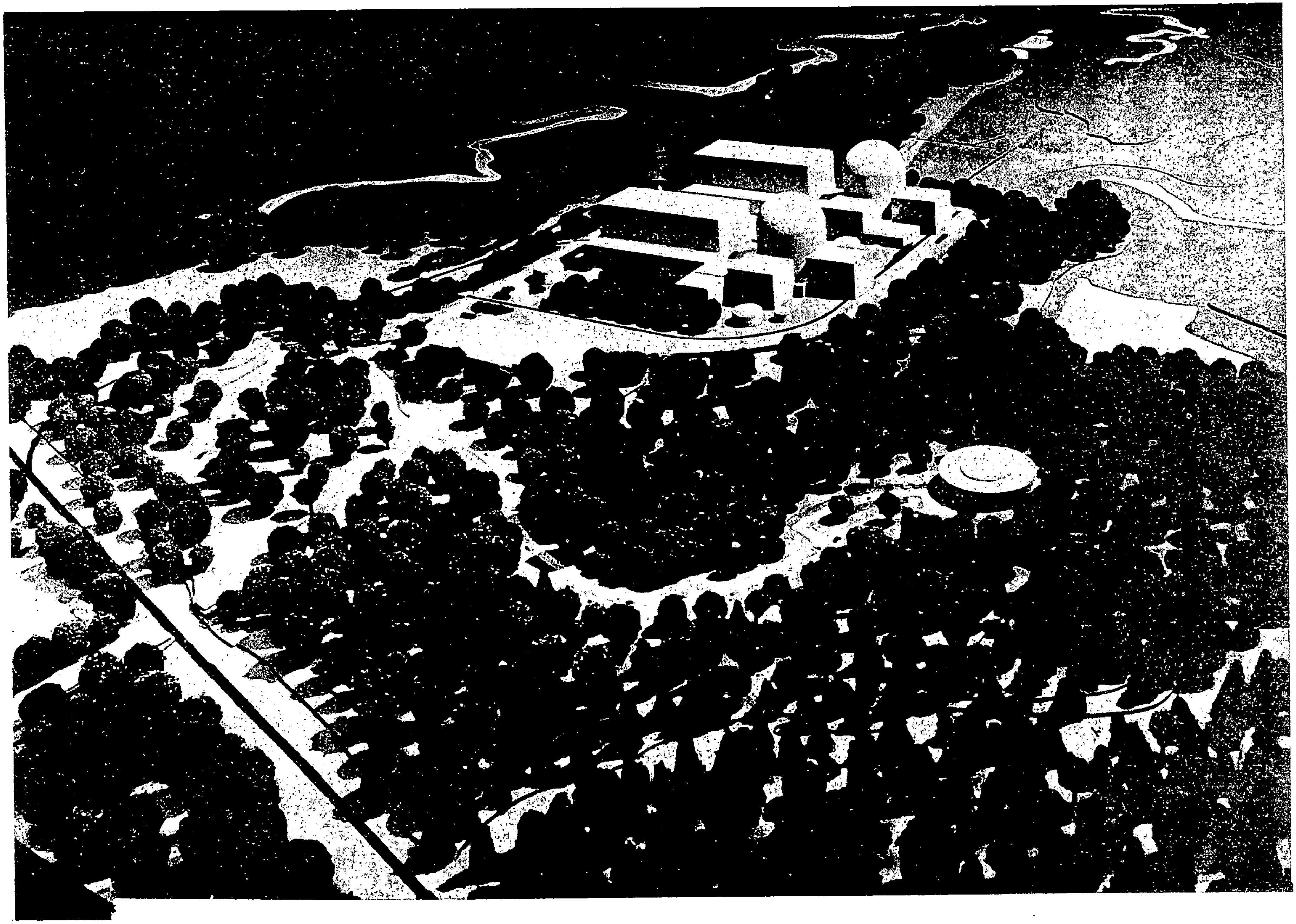
The details of architectural treatment for the plant structures have not been developed at the time of writing. However several features of the ultimate treatment can be described here. The containment structures will be natural concrete with no greater height then functional requirements dictate. The turbine buildings will be enclosed with metal siding conservatively colored to blend the structures with their natural surroundings. A border of trees and shrubs will be maintained around the plant proper to screen the lower structures and break up the features of the larger ones.

As construction concludes, the grounds and disturbed areas will be landscaped or restored to natural conditions. This treatment will be commensurate with the arrangement and usage of the education center and any other provisions for recreation on the site. Materials will be used in the plantings which are compatible with the salt environment and complement the indigenous species.

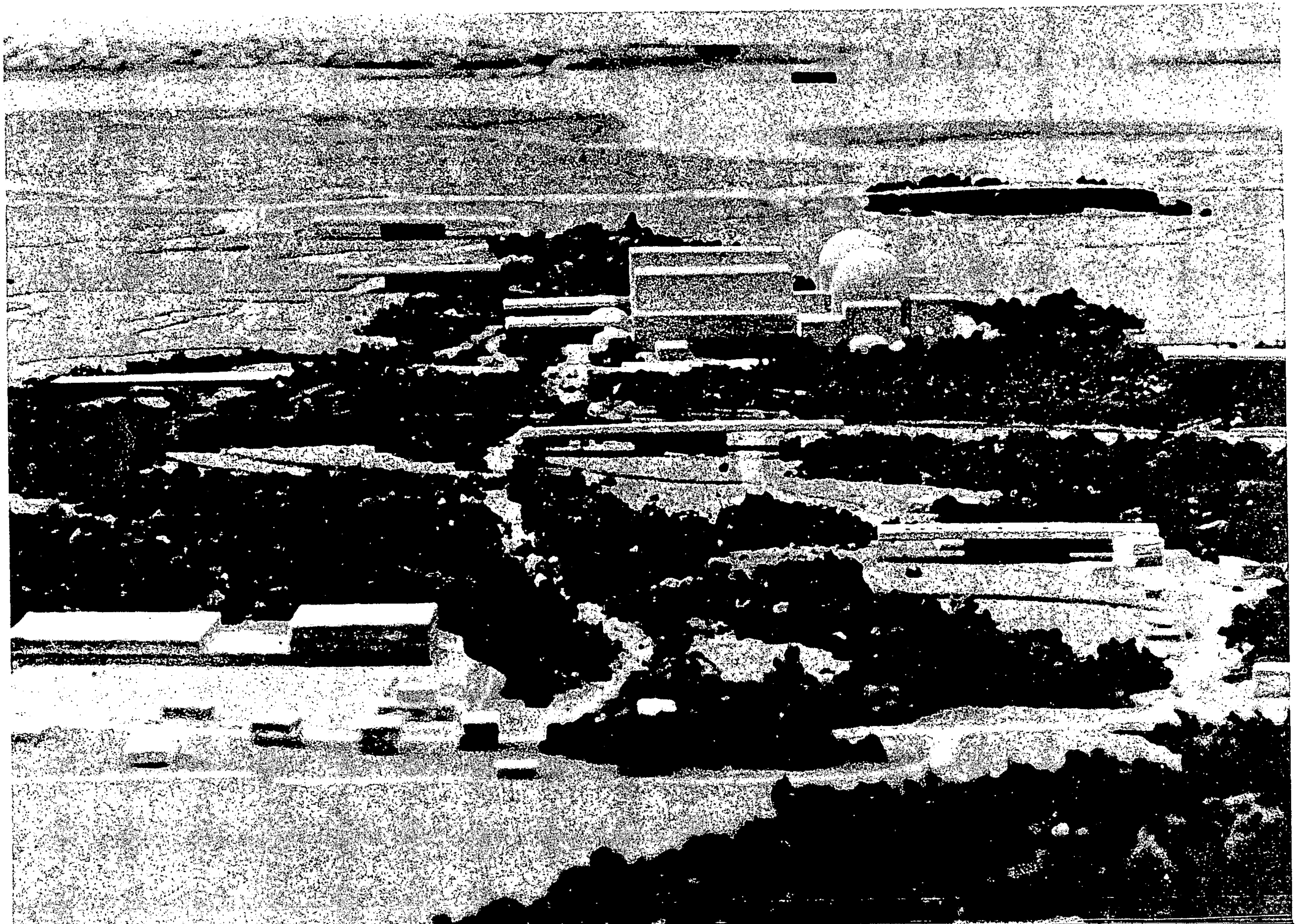
The plant will not require a tall stack for gaseous releases. These will be discharged from a duct attached to the exterior of the containment building. The release point will be at approximately the same elevation as the top of the containment. Liquid releases from the plant will be discharged with the circulating water offshore in the ocean.



PSNH SEABROOK STATION	PLOT PLAN	FIGURE 3.1-1



PSNH SEABROOK STATION	PHOTOGRAPH OF SITE MODEL	FIGURE 3.1-3



PSNH SEABROOK STATION	PHOTOGRAPH OF SITE MODEL	FIGURE 3.1-2

3.2

3.2 Reactor and Steam-Electric System

Two similar nuclear generating plants will be erected on the site. They are identified as Unit No. 1 and Unit No. 2 in accordance with their sequence of construction. In each unit power emanates from a pressurized water reactor, designed and furnished by Westinghouse Electric Corporation. The preparation of the site and the erection of both units is to be performed by United Engineers and Constructors, Inc., the architect-engineer. Each unit will have one 1800 rpm turbine generator rated at 1200 MW and manufactured by General Electric Company. Each turbine consists of one high pressure element and three low pressure elements. The generator is liquid cooled.

The reactor core contains 193 fuel assemblies. Each assembly contains 204 fuel rods. The rods contain slightly enriched uranium dioxide pellets enclosed in Zircaloy-4 tubes. The initial enrichment varies according to the core region as follows:

Region 1 (inner) contains 65 fuel assemblies enriched to approximately 2.25 w/o U-235.
Region 2 contains 64 fuel assemblies enriched to approximately 2.80 w/o U-235.
Region 3 contains 64 fuel assemblies enriched to approximately 3.30 w/o U-235.

Refueling is accomplished by discharging approximately one-third of the exposed fuel and inserting fresh fuel in a predetermined loading pattern.

The reactor core is cooled by pressurized water circulating through the core and through four parallel coolant loops. Each loop contains one reactor coolant pump for forced flow, one steam generator for the generation of secondary steam and the transfer of heat from the coolant and the necessary piping and instrumentation. Film boiling in the core, which would interfere with core cooling is prevented by maintaining the coolant pressure at a sufficient margin above the saturation pressure. This function is accomplished by the pressurizer which consists of a pressure vessel piped to one of the coolant loops. Pressure is controlled by either adding heat to or cooling a steam bubble within the pressurizer. Heat is added by electric emersion heaters in the liquid space and removed by spraying liquid coolant in the steam space. System overpressure is prevented by instrumentation, the release of steam through a relief valve and ultimately by code safety valves attached to the steam space of the pressurizer.

Reactor control is provided by the moderator (coolant) and temperature coefficients of reactivity, by neutron absorbing control rod clusters, and by a neutron absorber (boron as boric acid) dissolved in the reactor coolant.

Each nuclear steam supply system will be initially operated with a thermal output of 3425 MWt; the core is rated for 3411 MWt and the approximate net electrical rating is 1200 MWe. The core design output is 3579 MWt. In-plant electrical consumption is expected to be between 50 MW and 60 MW.

3.3

ENV

PUBLIC SERVICE Company of New Hampshire

SEABROOK STATION
Engineering Office:
20 Turnpike Road
Westborough, MA 01581

October 8, 1975

United States Nuclear Regulatory Commission
Directorate of Licensing
Washington, D.C. 20555

RECEIVED OCT 9 1975

Supplement to Environmental Report
Seabrook Station Units 1 & 2
Docket Numbers 50-443 and 50-444

Gentlemen:

Pursuant to the Atomic Energy Act of 1954, the Commission's rules and regulations thereunder, Public Service Company of New Hampshire hereby supplements its Environmental Report filed on March 30, 1973, as heretofore supplemented, by supplying information on Appendix I requested in a letter dated September 12, 1975 from Mr. Daniel R. Muller to Mr. W. C. Tallman. The information is in accordance with enclosure 1 of the letter.

Please let us know if you have any questions on the material.

Very truly yours,

John D. Haseltine

John D. Haseltine
Project Manager

JDH:jeb

cc: Parties of Record

FOR INFORMATION ONLY

10774

I

CERTIFICATE OF SERVICE

I, John D. Haseltine, hereby certify that on Oct 7, 1975, I made service of the within document by mailing copies thereof, postage prepaid, first class or airmail, to:

Daniel M. Head, Esquire
Atomic Safety and Licensing Board Panel
U.S. Atomic Energy Commission
Room 1211D, Landow Building
7910 Woodmont Avenue
Bethesda, Maryland 20014

Joseph F. Tubridy, Esquire
4100 Cathedral Avenue, N.W.
Washington, D.C. 20016

Dr. Marvin M. Mann
Atomic Safety and Licensing Board Panel
U.S. Atomic Energy Commission
Landow Building
7910 Woodmont Avenue
Bethesda, Maryland 20014

Frederic S. Gray, Esquire
Office of the General Counsel
Office of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Donald W. Stever, Jr., Esquire
Assistant Attorney General
Office of the Attorney General
State House Annex, Room 208
Concord, New Hampshire 03301

Anthony Z. Roisman, Esquire
Berlin, Roisman & Kessler
1712 N. Street, N.W.
Washington, D.C. 20036

Atomic Safety and Licensing Appeal Board Panel
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dr. Ernest O. Salo
Professor of Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

Dr. Kenneth A. McCollum
1107 West Knapp Street
Stillwater, Oklahoma 74074

Atomic Safety and Licensing Board Panel
U.S. Atomic Energy Commission
Landow Building
7910 Woodmont Avenue
Bethesda, Maryland 20014

Ms. Elizabeth H. Weinhold
Bradstreet Road
Hampton, New Hampshire 03842

Robert A. Backus, Esquire
Devine, Millimet, Stahl & Branch
1838 Elm Street
Manchester, New Hampshire 03105

Norman C. Ross, Esquire
30 Francis Street
Brookline, Massachusetts 02146

Ellyn R. Weiss, Esquire
Deputy Assistant Attorney General
Commonwealth of Massachusetts
Office of the Attorney General
7th Floor, 131 Tremont Street
Boston, Massachusetts 02111

John D Haseltine

Supplement
October, 1975

INSTRUCTION SHEET FOR UPDATING
SEABROOK STATION
ENVIRONMENTAL REPORT

Changes and Corrections

The following tabulated pages and figures are to be inserted either as replacement for existing Environmental Report pages and figures, or as new material.

Delete		Insert
	Chapter 5	
none		Entire Appendix 5.A at end of Chapter 5.

SEABROOK STATION

Environmental Report
Construction Permit Stage

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

SEABROOK, NEW HAMPSHIRE

June 1973

ENVIRONMENTAL REPORT

TABLE OF CONTENTS

ENVIRONMENTAL REPORT
(Continued)

ENVIRONMENTAL REPORT
(Continued)

ENVIRONMENTAL REPORT
(Continued)

ENVIRONMENTAL REPORT
(Continued)

SEABROOK STATION

Tables

Tables

Tables (continued)

Tables (continued)

Tables (continued)

Tables (continued)

SEABROOK STATION

List of Figures

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

3.3 Plant Water Use

A quantitative water-use diagram for the Seabrook Station, showing water flows to and from various plant water systems, is shown in Figure 3.3-1 and Table 3.3-1.

The station uses water from two sources in the course of its operation:

1. Circulating water for the condenser heat dissipation and service water systems is taken from the Gulf of Maine through an offshore-ocean-intake. This forms the largest usage of water in the station. The circulating water is discharged back into the Gulf of Maine through an offshore diffuser system. A description of this system is provided in Section 3.4.

2. The municipal water supply provides the station with the water required for the potable and sanitary systems, the station demineralized water makeup system and fire system makeup. Secondary plant leakage and sanitary system wastes are treated in the sewage plant. Sewage plant effluent, regenerant from the demineralized water system, non-recycleable radioactive wastes and blowdown from the steam generators are diluted with circulating water and discharged into the Gulf of Maine through the offshore diffuser system. Descriptions of these systems are provided in Sections 3.5, 3.6 and 3.7.

No evaporative cooling is proposed for dissipating heat from the Seabrook Station condensers. Service water is used only for cooling in the primary and secondary component cooling heat exchangers. Therefore, the consumptive use of water taken in from the Gulf of Maine is expected to be negligible. Leakage of water in either the circulating water system (which operates under a vacuum) or the service water system would be returned to the Gulf of Maine via system overflows and would not add to the consumptive use.

The consumptive use of municipal water during plant operation averages 90,000 gallons per day. This includes water required for sanitary and potable services, plant demineralizer makeup requirements and fire system testing. It does not include any allowance for consumptive use during a fire. During pre-operational testing, consumptive use of municipal water is expected to be 20 million gallons per unit, used over a nine month period.

The characteristics of the influent waters are provided in Section 2.5. The quality of plant effluents are provided in Sections 3.5, 3.6 and 3.7.

Roof and uncontaminated floor drains are collected and discharged directly into the Brown River.

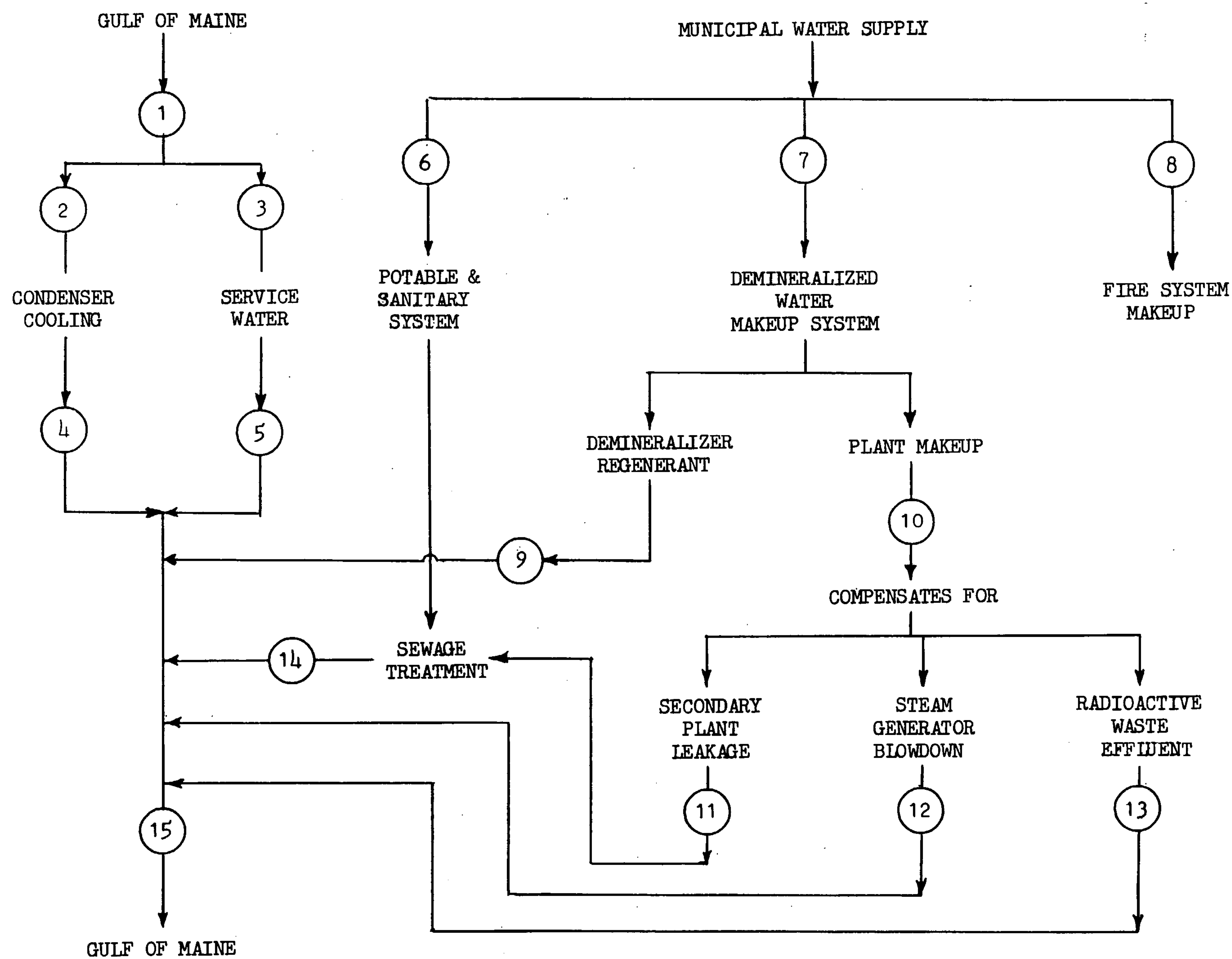
TABLE 3.3-1

PLANT WATER USE

POINT	CONDITION A FLOWS	CONDITION B FLOWS	NOTES
1	748,000 gpm	386,000 gpm	Continuous flow
2	728,000 gpm	364,000 gpm	Continuous flow
3	20,000 gpm	22,000 gpm	Continuous flow
4	728,000 gpm	364,000 gpm	Continuous flow
5	20,000 gpm	22,000 gpm	Continuous flow
6	9,000 gpd	9,000 gpd	Intermittent flow
7	0-200 gpm	0-200 gpm	Maximum flow, with two demin. operating, is 400 gpm
8	As Req'd	As Req'd	Required for fire or evaporative losses
9	30,000 gal/ 3.5 days	30,000 gal/ 3.5 days	Discharge flow rate 50-100 gpm
10	0-200 gpm	0-200 gpm	Maximum flow, with two demin. operating, is 400 gpm
11	20 gpm	10 gpm	Continuous
12	70 gpm	35 gpm	Continuous or intermittently, as required
13	1,500 gpd	1,500 gpd	Intermittent
14	37,800 gpd	23,400 gpd	Maximum capability of 50,000 gpd
15	748,000 gpm	386,000 gpm	Continuous flow

CONDITION	LOAD UNIT 1	LOAD UNIT 2
A	Full	Full
B	Full	Cooldown

PSNH
SEABROOK STATION



PLANT WATER USE DIAGRAM

FIGURE 3.3-1

3.4

3.4 Heat Dissipation System

3.4.1 System Concept and Reasons for Selection

The heat dissipation facility for the Seabrook Station is a once-through, offshore-ocean-intake and offshore-ocean-discharge system. All heat dissipation functions for the plant are performed by this system; it provides heat removal from the main condensers and service water heat exchangers.

Cooling water is taken from and returned to the waters of the Atlantic Ocean at inlet and discharge structures located east of Hampton Beach, New Hampshire. The physical, chemical and hydrological description of this body of water including its natural temperature pattern is presented in Section 2.5.

This heat dissipation concept has been selected for the Seabrook Station on the basis of environmental, engineering and economic considerations. It is designed to provide an acceptable environmental impact with less detrimental effects than any of the alternate concepts which were evaluated. Although not estimated to be the least cost cooling scheme, it makes use of a proven design at a significant cost saving over some other systems which were considered.

One of the objectives in the selection of this heat rejection system was minimizing the expected environmental impact. Of prime concern was the protection of the marsh lands from any permanent damage as well as the protection and enhancement of the existing clam flats and water front facilities. Special consideration was also given to the protection of terrestrial, aquatic and bird life that now inhabits the area. Finally, it was specified that the selected system of heat dissipation would not provide hazards or impediments to highway, railroad, ship or air traffic in the region.

Another objective included in the selection of the heat dissipation system is that it incorporate a maximum amount of proven and reliable technology. The overall safety requirements of the plant and the very important environmental concerns do not allow the use of any significant amount of unproven and uncertain design. It was recognized, however, that consideration must be given to new ideas, theories, laboratory research and prototype field tests. To the fullest extent practicable and consistent with orderly design, this work has been taken into account in the selection of the heat dissipation scheme.

The final consideration that was evaluated is the relative cost and commitment of resources to the heat dissipation system. The energy resources of the earth are finite and in general, are non-replaceable; therefore, a factor in selection of the system was that it have a minimum commitment to the use of non-replaceable resources. In this regard, a system requiring the least amount of power for operation is more desirable than one requiring larger amounts.

3.4.2 Description of Heat Dissipation System

3.4.2.1 General Specifications

The heat dissipation system for the Seabrook Station uses once-through ocean cooling and is designed to provide all heat removal requirements for a two unit plant. The quantity of heat dissipated by each unit is approximately 8×10^9 BTU/hour for condenser cooling during full load normal operation. For this purpose the quantity of ocean water provided is 364,000 gpm per unit for condenser cooling plus an additional flow of 10,000 gpm per unit for the service water heat exchanger. Consequently, the total flow is 374,000 gpm per unit and 748,000 gpm for both units. There is no consumptive use of cooling water thus the amount returned to the ocean at the point of discharge is 374,000 gpm per unit (748,000 gpm for both units). This flow amount is maintained during normal operation throughout the year. All cooling water is drawn from the ocean at a location about 3,000 feet offshore of Hampton Beach. It flows through an 18 foot inside diameter tunnel of about 13,000 feet in length to the pumphouse located at the plant site. The time of travel through the tunnel at full flow capacity of 748,000 gpm is about 33 minutes at a velocity of approximately 6.5 feet/second. Upon entering the pumphouse the velocity decreases to allow for debris screening before entering the pumps.

One main condenser is provided for each unit. The circulating water temperature is raised 44°F as it passes through the condenser. Time of travel through the condenser is about 16 seconds at the specified flow of 364,000 gpm per unit. Having passed through the condensers, the cooling water flows approximately 15,000 feet through another 18 foot I.D. tunnel to the offshore submerged discharge structure. Travel time through the discharge lines for 748,000 gpm flow is 38 minutes at approximately 6.5 feet/second.

Figures 3.4-1 and 3.4-2 show the route of the circulating water tunnels and some typical details. Figure 3.4-3 is a flow diagram of the heat dissipation system for the Seabrook Station.

3.4.2.2 Intake System

The intake system includes one offshore submerged inlet, one 18 foot inside diameter tunnel and a pumphouse located at the site.

Final design and exact location of the offshore inlet structure is being determined by hydrographic, environmental and hydraulic model studies. The inlet structure is located about 3,000 feet east of Hampton Beach where the water depth is approximately 30 feet MLW. The structure is firmly attached to the tunnel riser shaft to provide stability from wave induced forces. Cooling water enters near the top of the inlet which is just below mid-depth in the water column.

This submerged structure has low profiles and is not placed in a navigation channel. Therefore it does not interfere with normal boat traffic in the area. However, if required by the U. S. Coast Guard, appropriate navigation markers will be provided.

The velocity of inflow at the point where water enters the inlet is no greater than 1.4 feet/second. This velocity is rapidly attenuated with distance from the inlet opening and reduces to about 0.5 fps at a 5-foot distance and about 0.25 fps at a 10-foot distance. This low approach velocity allows normal movement of fish in the area and reduces the possibility of fish entrapment and bottom scouring.

Experience with offshore inlet structures along the coast of California indicates that a horizontal inflow current has much less potential for fish entrapment than a vertical current. A horizontal inflow direction is maintained about an inlet structure by means of a "velocity cap". This is a flat plate positioned just above the opening to the vertical inlet shaft. The "velocity cap" allows inflow to enter the gap between it and the inlet shaft from only a horizontal direction and has been demonstrated to reduce fish entrapment by as much as 95 percent at the offshore inlets of some power plants (Reference 1). The features of the "velocity cap" are being further investigated before a final design for the Seabrook Station inlet is determined.

Figure 3.4-4 shows the preliminary design concept for the offshore inlet structure with a velocity cap. Construction of the inlet structure is simplified by the use of six identical sections which can be fabricated onshore, brought offshore to the already fabricated hub and individually lowered into position. The center hub is fabricated in the dry, inside the cofferdam used to construct the riser shaft of the intake tunnel. As shown in Figure 3.4-4 the top of the hub is fitted with a circular hatch which can be removed to provide access to the structure for inspection and maintenance, both during and after construction.

The 18 foot internal diameter intake tunnel is at a depth of about 200 feet below MSL. Its slope is slightly downward toward the plant site to allow proper drainage during construction and, if necessary, during dewatering of the tunnel. Figure 3.4-1 shows the route of the intake tunnel. The pumphouse located at the site contains six circulating water pumps. Each pump is rated for 130,000 gpm flow at a 80 foot pumping head. Also contained in the intake structure are vertical traveling screens, a large forebay and appropriate hydraulic equipment such as valves and stoplogs. In plan view, the intake structure is 188 feet by 105 feet and the bottom elevation of the forebay is -43 feet MSL. Figures 3.4-5 and 3.4-6 show the preliminary arrangement of the intake structure.

From the pumphouse, the circulating water flows to the condensers through two buried conduits of about eleven feet inside diameter. The circulating water passes through the condensers and then is returned to the ocean via a similar bedrock tunnel of 18 feet inside diameter along the route shown in Figure 3.4-1.

3.4.2.3 Discharge System

The heat dissipation system discharges into the waters of the Atlantic Ocean at an offshore location east of Hampton Beach, New Hampshire. Heated discharge water reaches this point through an 18 foot inside diameter tunnel and a riser shaft of the same diameter. The elevation of the discharge tunnel is about - 200 feet MSL and is slightly sloping downward toward the plant to allow proper drainage. Hydro-thermal model studies are in progress to determine the design and exact location of the outlet structure. Discharge concepts under investigation in these studies include single port outfalls and multi-port diffusers.

The first concept to be tested in the hydro-thermal model studies was that of a single port or "submerged buoyant jet" which discharges the heated circulating water for each unit through a single opening located some distance above the ocean bottom. The second concept for which testing is now in progress is that of a submerged multi-port diffuser in which the circulating water from each unit is discharged through a number of ports spaced along a diffuser pipe. Many variations of port spacing, number of ports and orientation of diffuser pipe are possible for any given offshore discharge location. The purpose of the model studies is to determine these design parameters as well as to compare the heat dissipation characteristics of the different concepts.

Each scheme is subjected to detailed testing in a physical hydraulic model for the purpose of predicting temperatures and velocities induced in the vicinity of the heated discharge. When model testing is completed, these schemes will be evaluated from the viewpoint of their probable effect on the marine ecology as a basis for selecting the particular scheme with the least impact on the water environment. A description of each concept is presented below.

Single Port Discharge

Hydro-thermal model studies for this discharge concept are now completed. A description of these studies and the results is presented in Appendix J "Buoyant Jet Discharge Report" by Alden Research Labs, 1969.

The single port discharges, one for each unit, are in a water depth of 35 feet or more at a location about 5,000 feet east of Hampton Beach. The discharge port is above the sea bed and the flow is directed horizontally or at a small upward angle in order to minimize scour and bottom effects. The two ports are spaced sufficiently far apart to ensure that the heated plumes do not interfere with each other.

A buoyant jet discharge model study of the single-port discharge concept was performed for the Public Service Company of New Hampshire in 1969 by Alden Research Laboratories. This model study was undertaken to determine the thermal dilution pattern and hydrodynamic effects of the single-port ocean discharge. Operational parameters were assumed to be those of the earlier Seabrook Nuclear Station design which is close, but not identical, to the present design. Through analytical methods the results of the 1969 study can be used to provide a preliminary prediction for the present design as shown on Figure 3.4-7 which indicates approximate surface temperature rises (for one unit) resulting from the submerged single-port discharge.

The first model study also investigated velocities along the sea bed due to the single-port horizontal discharge. Results of the tests showed for a flow of 980 cubic feet/second, yielding an initial velocity of 14 feet/second that at 25 feet from the conduit exit the velocity was 10 feet/second, but reduced to 6 feet/second at 140 feet. At 200 feet the center line velocity was 4 fps and at 260 feet less than 2 fps.

Other tests to determine bottom velocities showed that for a flow of 600 cubic feet/second yielding an initial velocity of 8.5 fps the maximum bottom velocity was 6 fps at 85 feet from the point of discharge with a reduction to about 3.5 fps at 140 feet. At 200 feet, the velocity was 2.5 fps and at 260 feet less than 2 fps. The present design for the Seabrook Station specifies about 834 cfs discharge per unit yielding an exit velocity of 11.8 fps from a 9.5 foot diameter port. This suggests that the expected bottom velocities for the present design would lie between the respective values for the two tests described above.

The results of the single port model studies are presented in more detail in Appendix J.

Multi-Port Diffuser Discharge

A number of alternatives are possible within the multi-port diffuser concept. An important consideration in optimizing the performance of a multi-port diffuser is the orientation of the diffuser with respect to the shore line. The orientation of the diffuser and nozzles is determined by the magnitude and direction of the ambient ocean currents in the vicinity of the diffuser site.

A plan of the preliminary diffuser location is shown in Figure 3.4-1. The diffuser consists of a buried 11.0 foot inside diameter conduit with many smaller diameter ports through which the heated discharge is injected into the receiving body of water. Although the same quantity of heat (BTU's) is released, the multi-port diffuser is capable of achieving a greater dilution and temperature reduction than is the single port outfall at the same location because more ambient ocean water is entrained with the multiple jets. The more rapid mixing process induced by the action of the many diffuser jets can achieve a lower temperature rise at any given depth adjacent to the point of discharge as well as in the flow away zone (surface layer) emanating from the near-field mixing area.

The details of the diffuser design and location are being determined through the use of field surveys, analytical methods and hydro-thermal model studies being conducted at Alden Research Laboratories. Much of this work is now in progress, but the design details have not yet been firmly established. Enough is known about diffuser design and performance to be certain that a design can be developed to satisy environmental protection criteria. At present, it is anticipated that the diffuser will be located approximately 2,000 feet northeast of the Outer Sunk Rocks. The main barrel is a partially or fully buried conduit of 11.0 feet inside diameter. Discharge water flows out through a series of nozzles or holes provided along the main barrel. The exact spacing, orientation and diameter of these discharge holes will be determined from hydro-thermal model studies anf from analytical techniques. The injection angle of the individual jets is slightly above horizontal to avoid bottom scour effects. Jet velocities are 12 - 15 feet/second at the points of discharge beyond which they rapidly decelerate. The ports are oriented to achieve optimum dilution and mixing, with the ambient water entrained by the jets' momentum. This orientation is to be determined from field survey data on local ocean currents and on the prevailing circulation pattern of the waters in the vicinity of the diffuser. Field surveys to determine these natural currents are in progress and are discussed in Section 5.1. The precise location and design of the diffuser will be determined when more field data is available and when more model studies have been completed.

3.4.2.4 Minimization of Thermal Shock to Marine Life

Thermal shock to aquatic biota during shutdown or refueling is reduced by virtue of two aspects of the design of the Seabrook Station. First, two reactor units are provided which allows refueling or scheduled shutdowns to be planned such that only one unit is inoperative at a given time. The other unit is kept operating and thus the supply of heated discharge water can be kept at the same temperature rise and the flow reduced by a factor of one-half or the flow kept at the same amount with the temperature rise reduced by one-half.

The other aspect of the Seabrook Station discharge which reduces the potential for thermal shock to aquatic biota is the rapid dilution of the discharge plume. As indicated in Appendix J, the single port discharge produces a maximum surface temperature of 13°F above ambient which occurs within a zone of only about 300 square feet and the 4°F isotherm is contained within a zone of less than 500 feet radius from the point of discharge.

For the multi-port diffuser concept the maximum surface temperature rise within the near-field region of the discharge is even less than for the single port. Throughout most of the near-field region of the multi-port discharge the temperature rise is only about 4-6°F above ambient. The only exception to this is in the subsurface portions of the rising buoyant jets. Beyond the near-field region the temperature influence decays until it reaches ambient conditions.

Due to the relatively low temperature rise throughout almost all of the near-field region, it is unlikely that shutdown of both units could result in significant thermal shock to aquatic biota residing in the heated water. The maximum thermal shock to which marine life could be subjected is only 4-6°F since that is the temperature of the surface layer in the near-field mixing zone. It is unlikely that marine life could reside in the rising buoyant jets for more than a few seconds due to the dynamics and momentum of the plumes. Therefore it is not possible for any aquatic species to become acclimated to temperatures higher than 4-6°F above ambient for the multi-port discharge. Thermal shock of this magnitude is considered sub-lethal for almost all marine species.

3.4.2.5 Control of Marine Fouling and Debris Removal

Marine fouling is controlled in the circulating water system by three methods: chlorination, mechanical cleaning and heat treatment. The fouling control scheme varies in different portions of the system as described below.

Based upon operating experience at other power stations, it is expected that marine fouling will not occur in the discharge portion of the system from the condenser to the offshore outlet. The presence of heated discharge water in this portion of the system provides continuous control over the growth of marine fouling organisms.

The intake portion of the circulating water system is subject to the settlement and growth of fouling organisms and thus special fouling control measures are required. This portion of the system extends from the offshore inlet structure to the condensers and includes the tunnel between those points as well as the circulating and service water pumphouses and offshore inlet structures.

Fouling Control is accomplished in the intake tunnel and offshore inlet with heat treatment. By adjustment of appropriate valves at the pumphouse, the flow in the tunnels is reversed and heated discharge water flows out through the intake tunnel. The method of flow reversal requires that the plant reduce load so that the temperature rise through the condenser is lowered. This is necessary because the hot water in the discharge tunnel will be drawn back into the plant when the flow is reversed. The amount of load reduction is based on not exceeding 5 inches Hg backpressure on the steam side of the condensers while flow reversal is being performed. To maintain this backpressure, the outlet temperature of the condenser must not exceed about 120°F.

The temperature of the heat treatment water must be adequate to eliminate most fouling organisms in a reasonable amount of time. It is known that the higher the temperature, the less time is required to accomplish fouling control. At 110°F the required duration of heat treatment is 1 - 2 hours. Lower temperatures would require longer time to complete the procedure.

It is known that the settlement of marine fouling organisms in New Hampshire coastal waters is most prolific during the summer and early fall, and that it is considerably less during the winter and early spring. Consequently, the required frequency of heat treatment varies according to the seasonal settlement rate of the fouling organisms. Based upon operating experience at other power plants in New England, it is expected that de-fouling should be performed once or twice each month during the period from June through October and as infrequently as about once every two months for the remaining portion of the year.

Control of marine fouling in the circulating water pumphouse is accomplished by means of mechanical cleaning and application of protective coatings. As shown in Figure 3.4-6 the pumphouse is divided by a concrete partition into two sections, one for each unit. Each half contains three circulating water pumps, traveling screens, screenwells and one forebay. During a scheduled shutdown of one of the units, its half of the pumphouse is isolated from the system by closing the appropriate valves shown in Figure 3.4-3. This permits dewatering of one side of the pumphouse to allow mechanical cleaning of the fouled surfaces. After the pumphouse surfaces have been scraped they are prepared and covered with a protective coating such as a commercially available anti-fouling marine paint.

Fouling Control is accomplished in condensers and in the conduit joining the pumphouse to the condensers by means of chlorination. By periodic introduction of chlorine into the flow at the pumphouse, these portions of the system are kept free of fouling organisms. Heat treatment is not practical for fouling control in the condenser tubes because control of slime or bacterial growth which occurs there requires temperatures in excess of 130°F. It is not possible to achieve temperatures above about 120°F with this system so heat treatment of the condensers for fouling control is not possible. If slime and bacterial growth are allowed to accumulate in the condensers, the heat transfer process occurring therein will become inadequate.

3.4.2.6 Disposal of Debris Collected in the Circulating Water System

During normal operation a small amount of debris is collected on the traveling screens. It is anticipated that this amount will be much less than from conventional intakes because the Seabrook Station has an offshore subsurface inlet and consequently does not entrain floating debris. Many conventional intakes have surface inlets which tend to entrain considerable amounts of floating debris.

In addition, heat treatment is performed often enough to control fouling organisms in their larval stage, thus preventing any significant accumulation of fouling debris. All debris collected by the traveling screens is taken away by truck and used for landfill. None of the debris is returned to the ocean.

3.4.2.7 Service Water System

The service water system consists of two completely independent and redundant flow loops, each of which supplies cooling water to a primary component cooling water heat exchanger and various non-essential heat loads in the conventional steam plant. Flow is supplied by four vertical, centrifugal service water pumps per loop taking suction from either of the two tunnels near the plant site. The service water system is connected to the circulating water structure by two independent and redundant lines. Each service water flow loop discharges into the discharge tunnel, thus completing the flow train concept during normal operation and flow reversal.

During normal operation, the service water flow is 10,100 gpm per unit at a temperature rise of about 30°F. The service water system draws water from the main circulating water intake structure before the condensers and discharges into the circulating water discharge tunnel after the condenser. Since the condenser cooling water has a temperature rise of 44°F the service water discharge does not raise the temperature of the plant's effluent at the offshore outlet structure.

3.4.3 Hydrographic Survey and Hydro-Thermal Model Studies

A long term hydrographic survey and a hydro-thermal model study are in progress. The purpose of these investigations is to determine the design and location of the offshore discharge and inlet structures.

Hydrographic data is being collected throughout the near-field and far-field region of the proposed discharge zone. These surveys include monitoring of current velocity and direction at numerous locations and depths using ducted rotor current meters, surface drift cards, surface drogues, dye releases, seabed drifters and moored steamers. Other hydrographic data being collected includes temperature, salinity and density profiles throughout the study area. Continuous monitoring of water level variations is accomplished by a tide gage located inside Hampton Harbor. Wind speed and direction is recorded continuously at a location adjacent to the study area on Hampton Beach and seabed sediment transport is monitored along the beach and in the vicinity of the intake and discharge structures.

Hydrographic studies of the circulation patterns and physical and chemical parameters of the near-shore waters in the vicinity of the proposed intake and discharge ports for the Seabrook Station have been in progress since September 1972 by Normandeau Associates, Inc. The engineering aspects of these studies are designed primarily to assess the near-field dynamics and impact of the circulating water system, to provide field data especially on currents for use by Alden Research Laboratory in running their hydraulic model tests of various intake and diffuser schemes, to delimit source waters to this section of the coastal zone, and to evaluate possible far-field effects of the thermal discharge. These studies are outlined below:

Near Field Studies to Date

1. Current speed and direction:

   a. Continuous monitoring from moored subsurface buoys using Bendix Q-15 current meters and Model 270 recorders (see location map, Figure 3.4-8); mid-water at moorings #1, 2 and 3 since January 1973, mid-water at moorings #4 and 6 since February 1973, mid-water at mooring #7 since May 1973, near-bottom at mooring #5 since May 1973 and near-surface at mooring #8 beginning in June 1973.

   b. Streamer studies: Diver observations of the behavior of neutrally buoyant plastic tapes tied at 5 foot intervals from near-surface to bottom; periodically since February 1973.

   c. Anchor stations: 13 hour continuous observations of currents at various depths; periodically since October 1972.

2. Circulation patterns:

   a. Drifter releases: drift bottles and sea-bed drifters deployed from various locations since September 1972.

   b. Drogue releases: tracking of drogues rigged at near-surface and 25 foot depth during daylight hours; November 1972.

3. Water temperature:

   a. Continuous monitoring from moored buoys using Rustrak recorders (see location map, Figure 3.4-8); mid-water at mooring #1 since January 1973; near-surface at mooring #4 since March 1973; mid-water at mooring #4 since March 1973 and near-bottom at mooring #5 since May 1973.

   b. Profiles during all anchor stations (see above) and plankton cruises using Martek Monitoring Systems and Beckman Salinometers.

   c. Profiles during slack water runs at high water and low water approximately every two weeks since April 1973 at moorings #1, 3, 4, 5 and 7 and in the Hampton estuary.

4. Water salinity, density, and dissolved oxygen:

   a. Profiles during all anchor stations (see above) and plankton cruises using Martek Monitoring Systems and Beckman Salinometers.

   b. Profiles during slack water runs (see above).

5. Tidal level: continuous monitoring at Hampton Harbor marina since November 1972.

6. Wind speed and direction: continuous monitoring at Hampton Beach State Park since December 1972.

7. Sediment transport: monthly measurements of sediment accumulation or erosion by observation of stakes at 10 locations since April 1973.

Far Field Studies to Date

1. Current speed and direction:

    a. Continuous monitoring scheduled at a deep water mooring 5 miles offshore starting in early June 1973.

    b. Streamer studies: periodic starting in June 1973.

    c. Periodic monitoring at deployable moorings starting in June 1973.

    d. Anchor stations: periodic as necessary during the summer and fall of 1973.

2. Circulation patterns: drifter releases from various locations since September 1972.

3. Water temperature, salinity, density, and dissolved oxygen: profiles during all plankton cruises out to 25 miles offshore; September 1972; January 1973; and monthly since May 1973.

The hydrographic data is used to assist in the design and location of the offshore inlet and discharge structures. In the hydro-thermal model studies being conducted at Alden Research Laboratories, hydrographic data is used to determine current patterns and water temperatures which must be simulated. By evaluating the hydraulic behavior of the offshore inlet and discharge structures in the model basin, their location and optimum design are being selected.

For the hydro-thermal model studies now in progress at Alden Research Laboratories, a submerged multiport diffuser discharge concept is being investigated. With this concept, heated water is discharged through an array of high velocity jets located about 5,000 feet offshore of Hampton Beach, N. H. All jets are located near bottom in about 40 feet of water. The overall performance and dilution capability of such a discharge scheme depends upon the interaction of near-field and far-field effects.

Near-field effects are those which are directly governed by the diffuser discharge. Rapid dilution and cooling of the effluent is achieved by the turbulent entrainment of cooler ambient seawater into the diffusers jets. Important variables influencing the temperature distribution in the near-field zone are the general diffuser orientation, magnitude and direction of currents in the receiving body of water, submergence of the diffuser nozzles, jet velocity, nozzle size and nozzle spacing. Data on temperature distribution and currents in the receiving body of water is provided by the hydrographic survey described above.

Far-field effects are those which are determined by the hydraulic, topographical and meteorological conditions of the ambient water body. The temperature distribution in the far-field is affected by ambient turbulence, surface heat loss, tidal and ocean current flushing, and possible re-entrainment into the near-field zone through the action of currents. Hydrographic data on water circulation and current patterns, density profiles and temperature variation as well as meteorologic data are factored into the evaluation of far-field effects.

In the hydro-thermal model basin the characteristics of the near-field region of discharge as well as the behavior of the offshore inlet structure are evaluated. To the fullest extent practical, physical hydrographic conditions are simulated or modeled directly. These conditions include water movement, average water temperature, bathymetry, diffuser configuration and discharge characteristics. Hydrographic conditions such as salinity and temperature variations which cannot be simulated in the model basin are factored into the near-field performance evaluation by analytical techniques.

As constructed, the hydro-thermal model basin represents a prototype area of approximately 1800 acres. It is an undistorted model (horizontal and vertical scale are the same) with a scale ratio of 115:1. The boundaries of the 9,000 foot x 9,000 foot prototype model basin area are shown on Figure 3.4-8. In the model basin this area is represented in a 79 foot x 79 foot concrete basin in which the seabed topography has been carefully modeled. Currents similar to those observed in the ocean study area can be duplicated in the model basin and air temperature can be controlled inside the model building to simulate heat transfer to the atmosphere.

During testing of discharge and inlet concepts temperature distribution and water movement are monitored in the model basin. About 300 computer monitored temperature sensors are arranged throughout the model. Current meters, dye and small surface drifters are used to observe water movement.

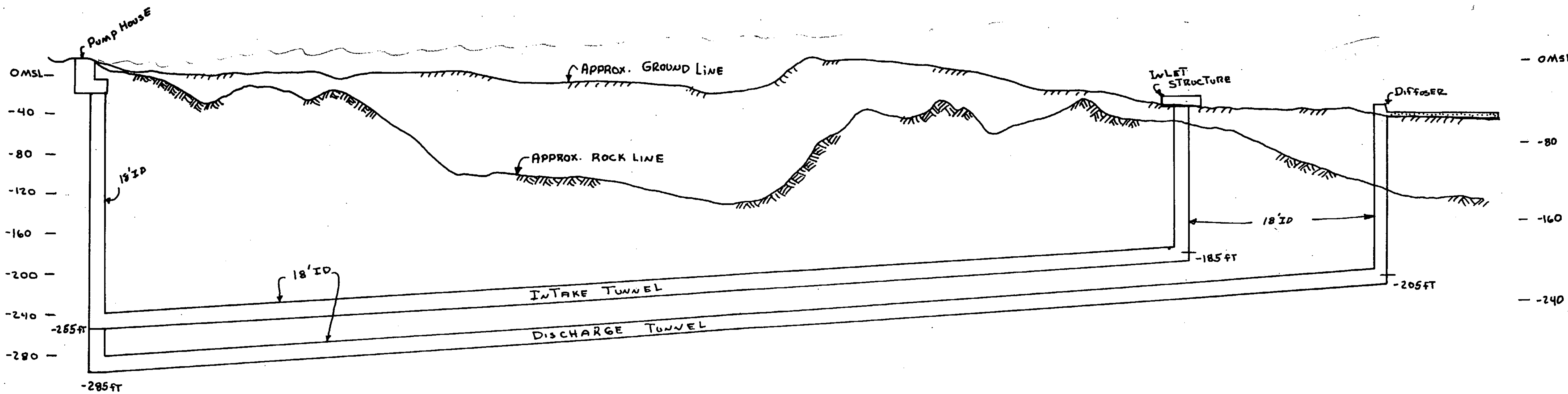
Far-field effects are not represented in the model basin. These effects are too subtle and would require an unreasonably large model basin to be evaluated in a physical model study. Consequently, far-field studies are to be performed analytically after the near-field model tests are complete. Included in this evaluation will be an investigation of the potential for recirculation or re-entrainment of effluent back into the discharge zone. Far-field hydrographic data concerning water circulation, physical and chemical characteristics of the source waters for the area will be factored into this analysis.

When completed, these model studies will provide a thorough evaluation of the performance of the Seabrook Station's offshore discharge and intake structures.

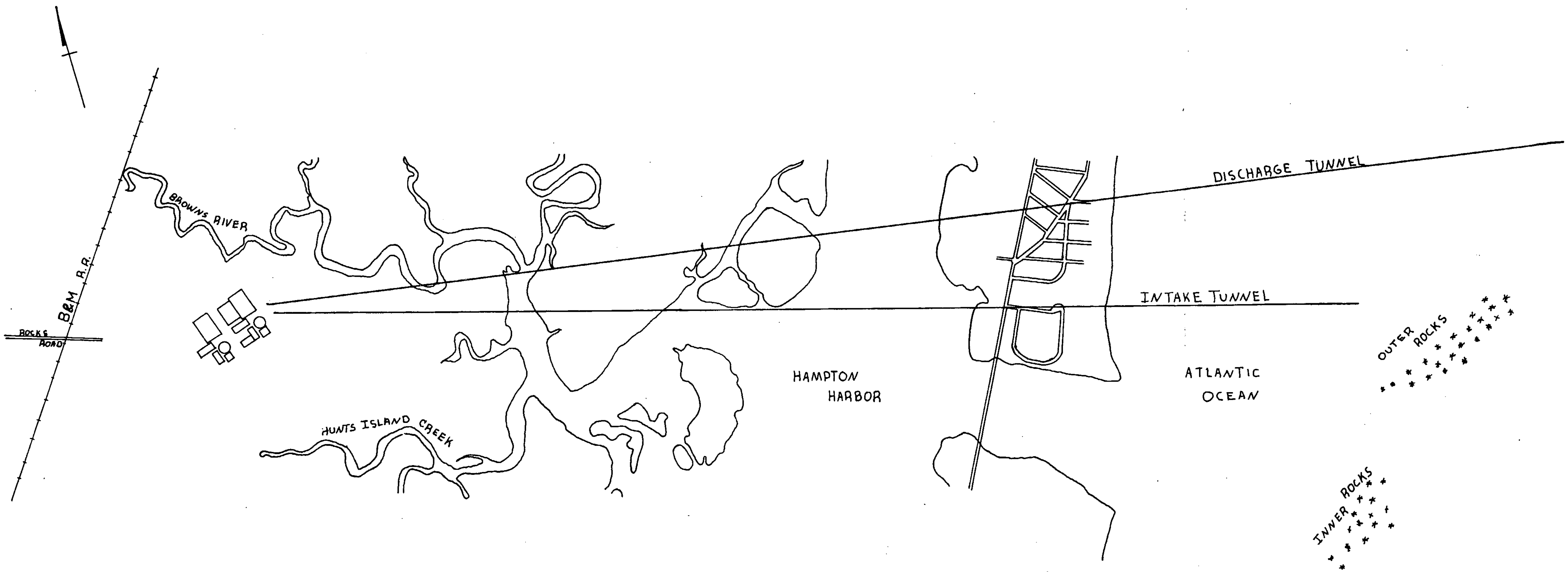
These studies have been in progress since 1972 and will continue through 1973 or longer until an acceptable design has been determined.

References

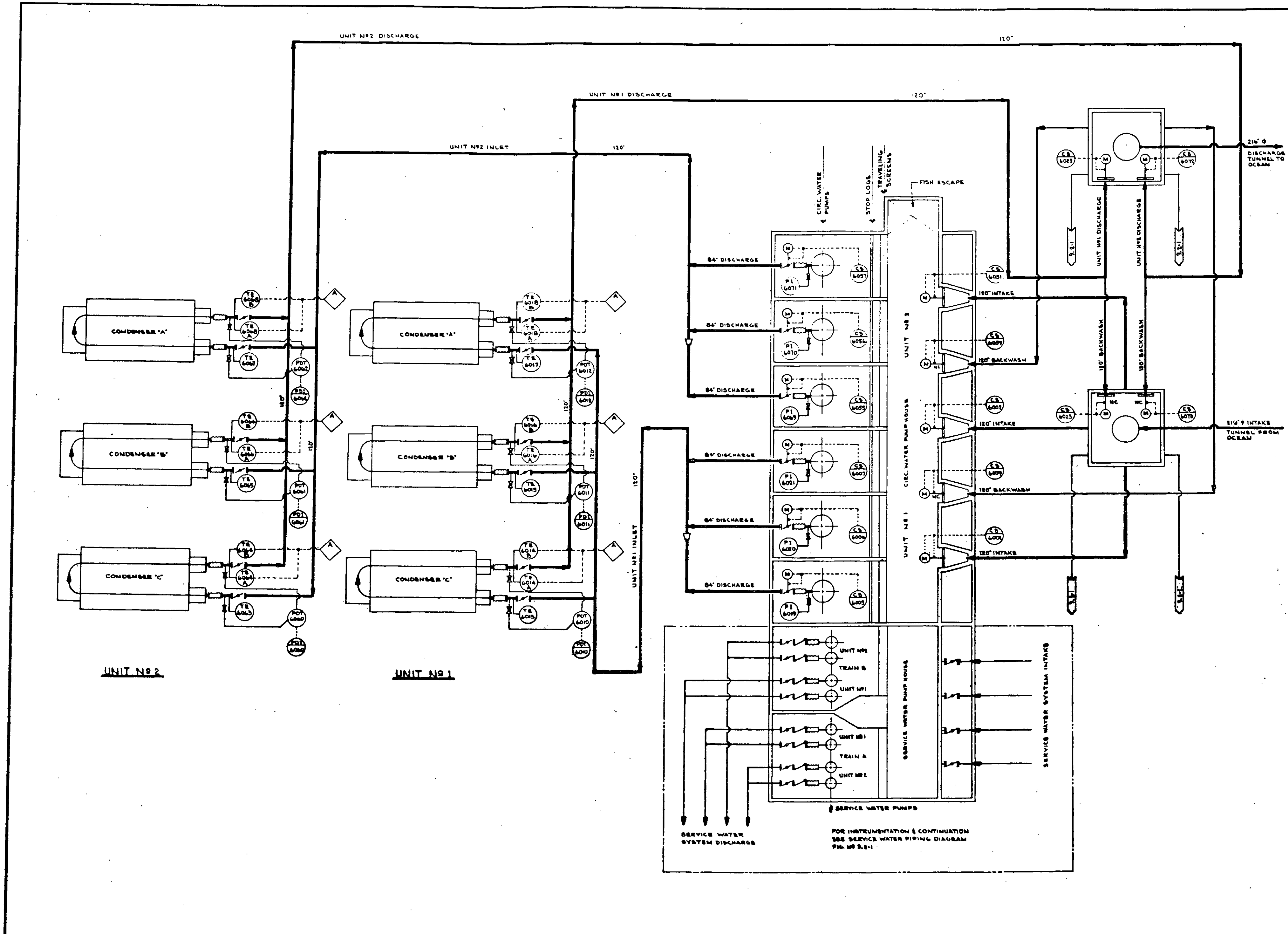
1. Weight, Robert H., "Ocean Cooling Water System for 800 MW Power Station", Journal of the Power Division, Proceedings of the American Society of Civil Engineers - Proceedings Paper No. 1888, December 1958.



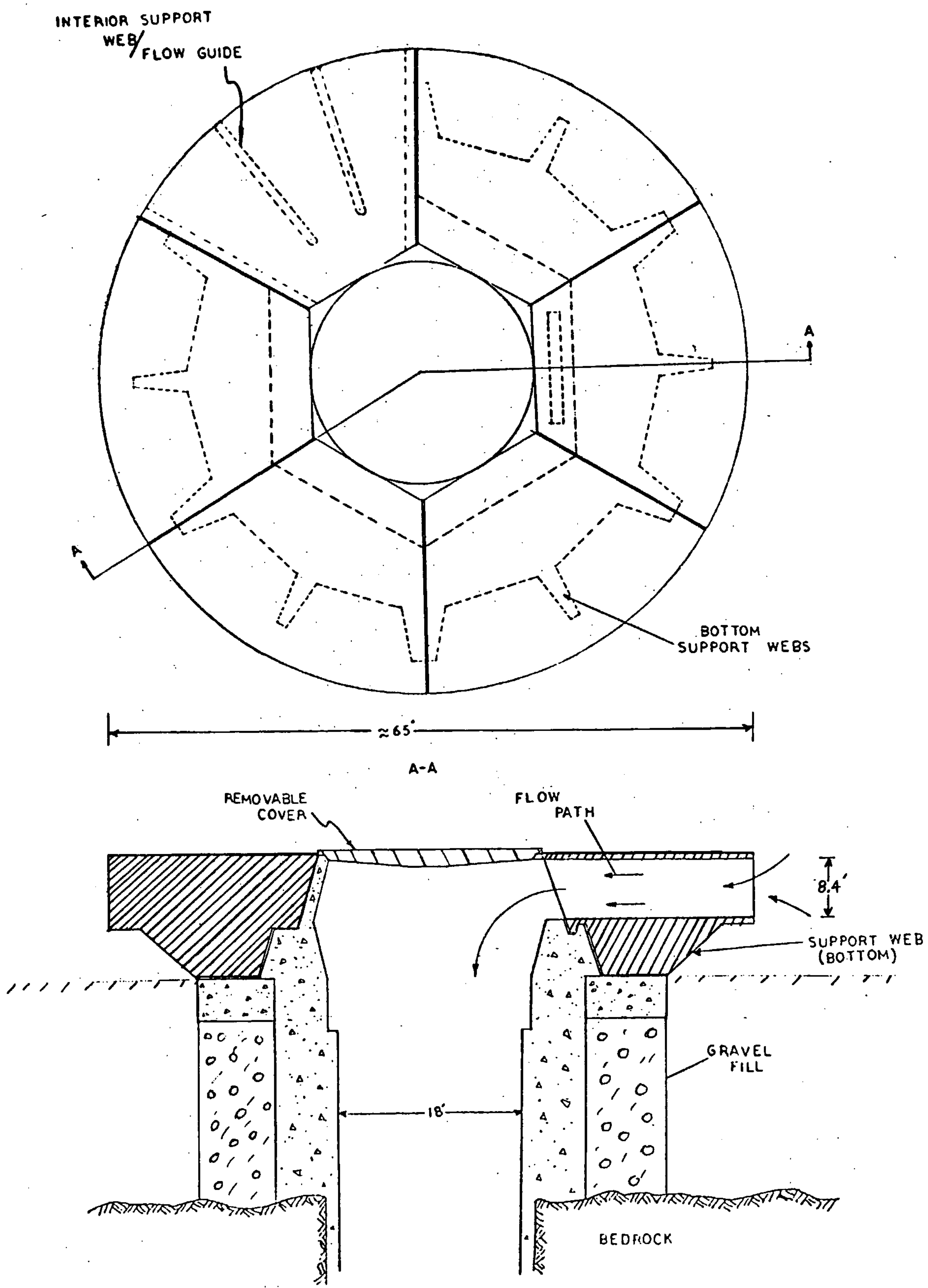
PSNH SEABROOK STATION	PROFILE OF CIRCULATING WATER SYSTEM	FIGURE 3.4-1

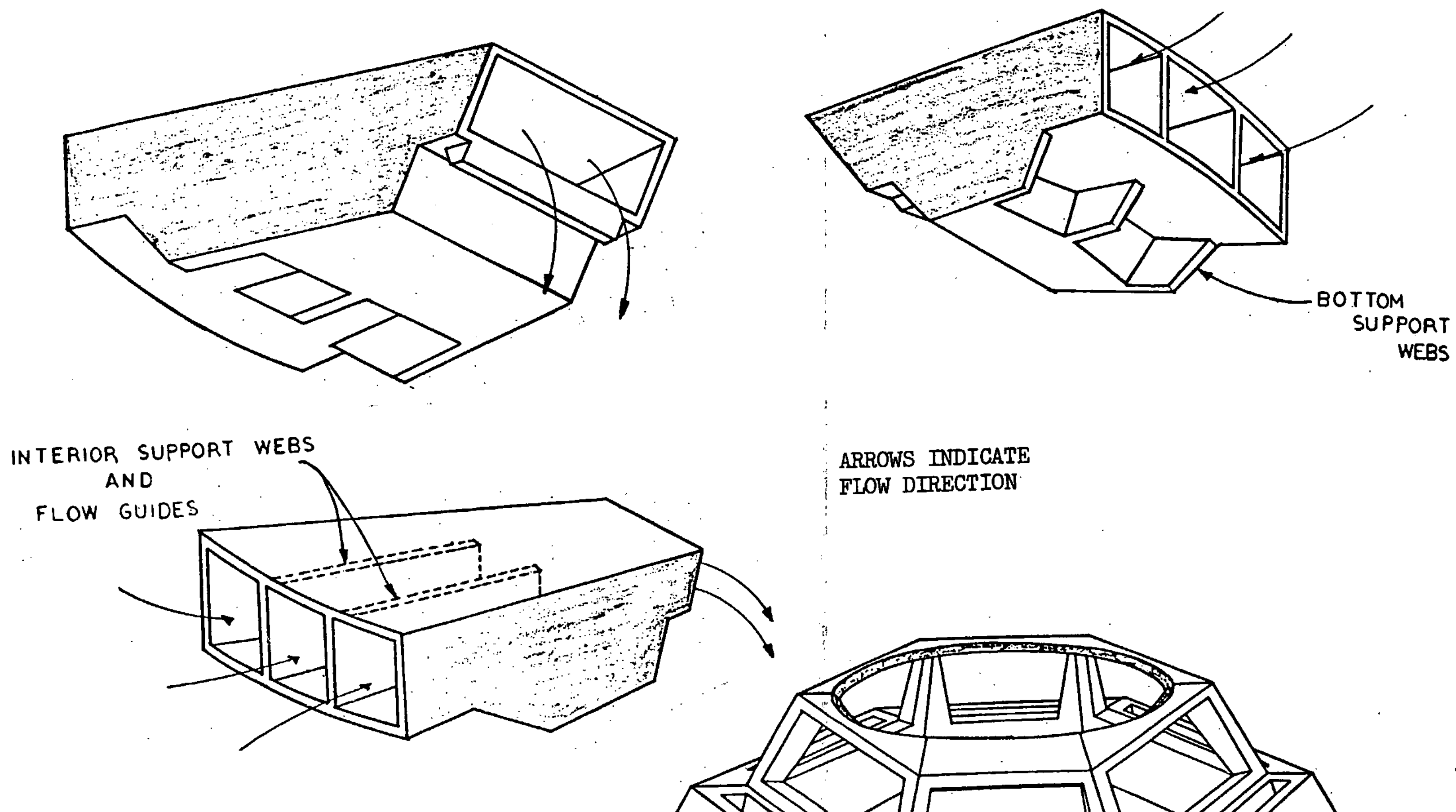


PSNH SEABROOK STATION	LAYOUT OF CIRCULATING WATER SYSTEM	FIGURE 3.4-2

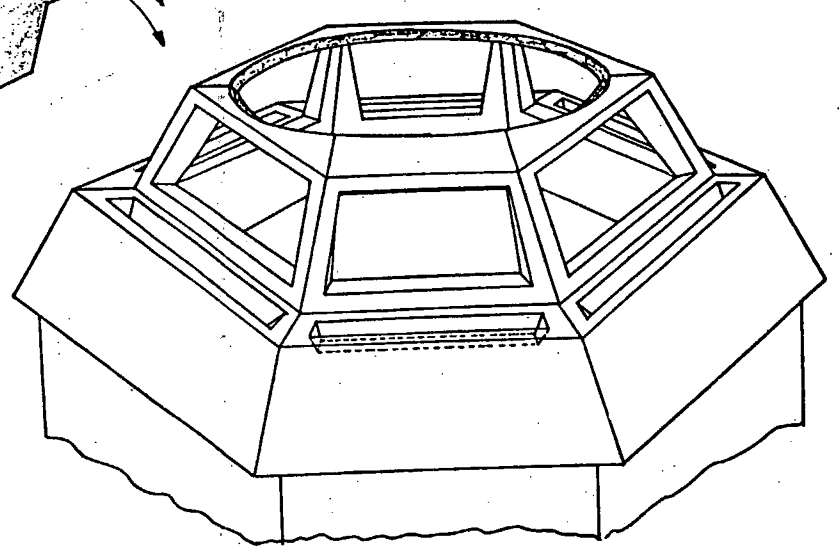


PSNH SEABROOK STATION	FLOW DIAGRAM	FIGURE 3.4-3



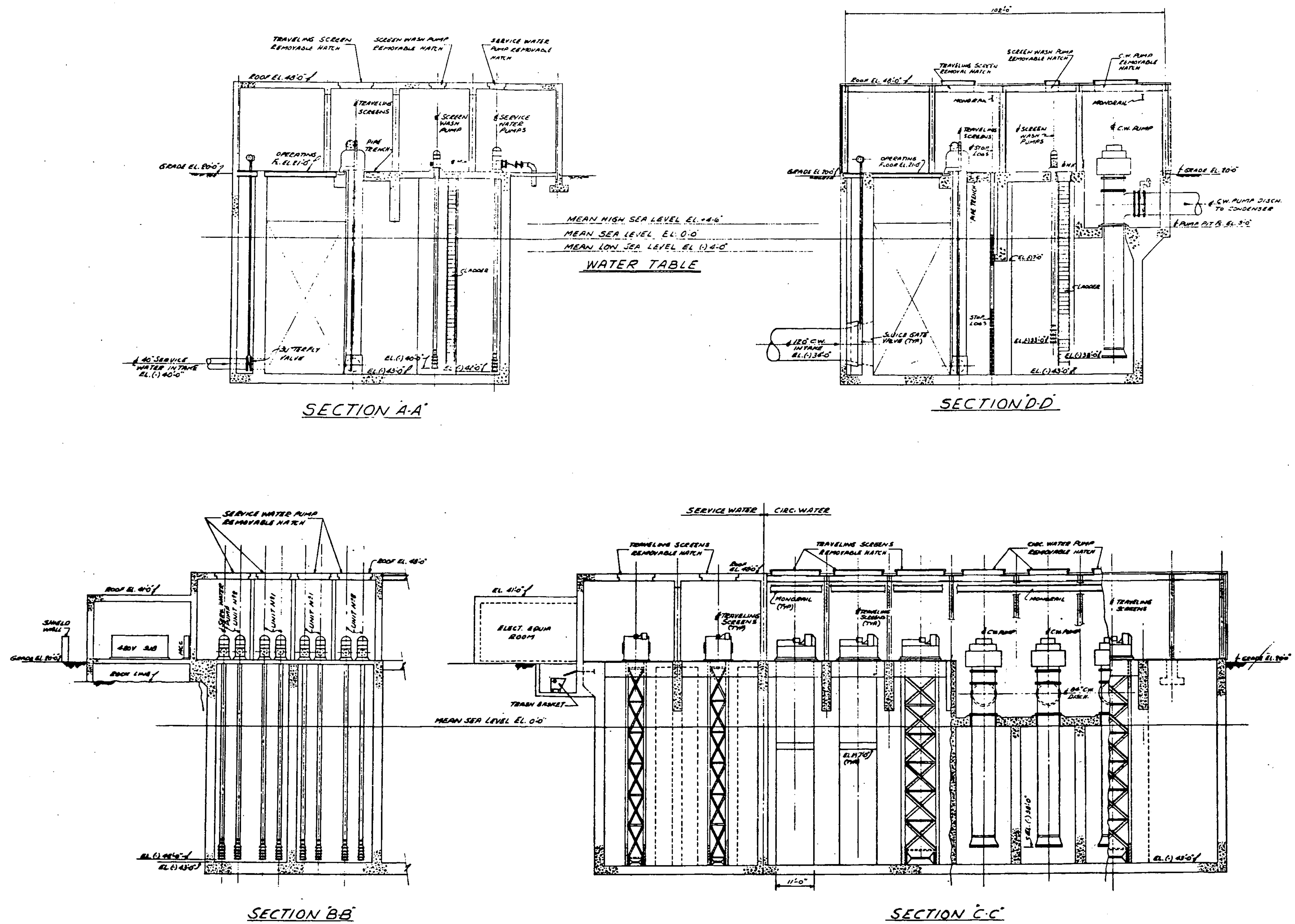


VELOCITY CAP SECTION
6 TOTAL

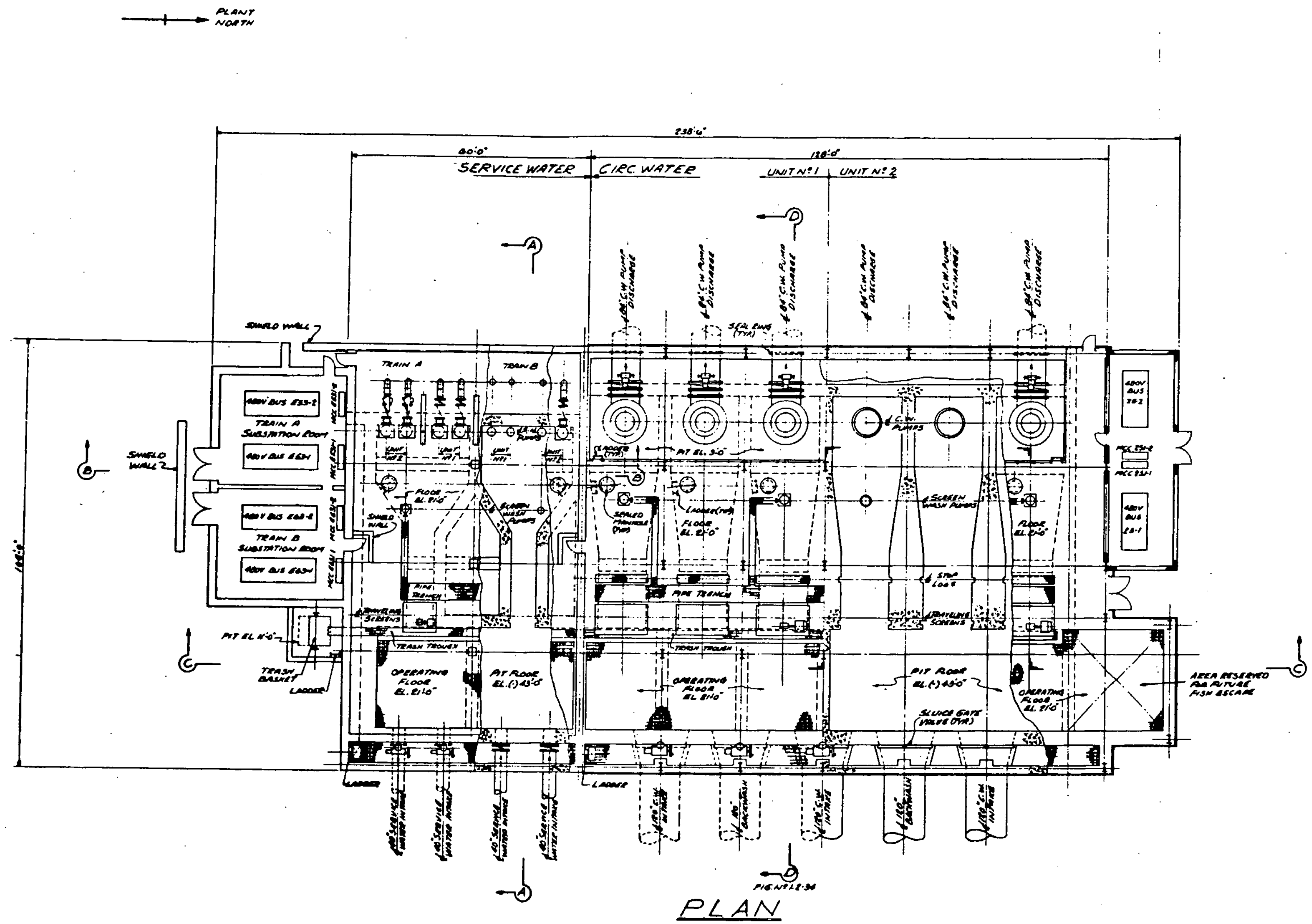


INLET STRUCTURE SUPPORT HUB
(cover removed)

PSNH SEABROOK STATION	INLET STRUCTURE	FIGURE 3.4-4



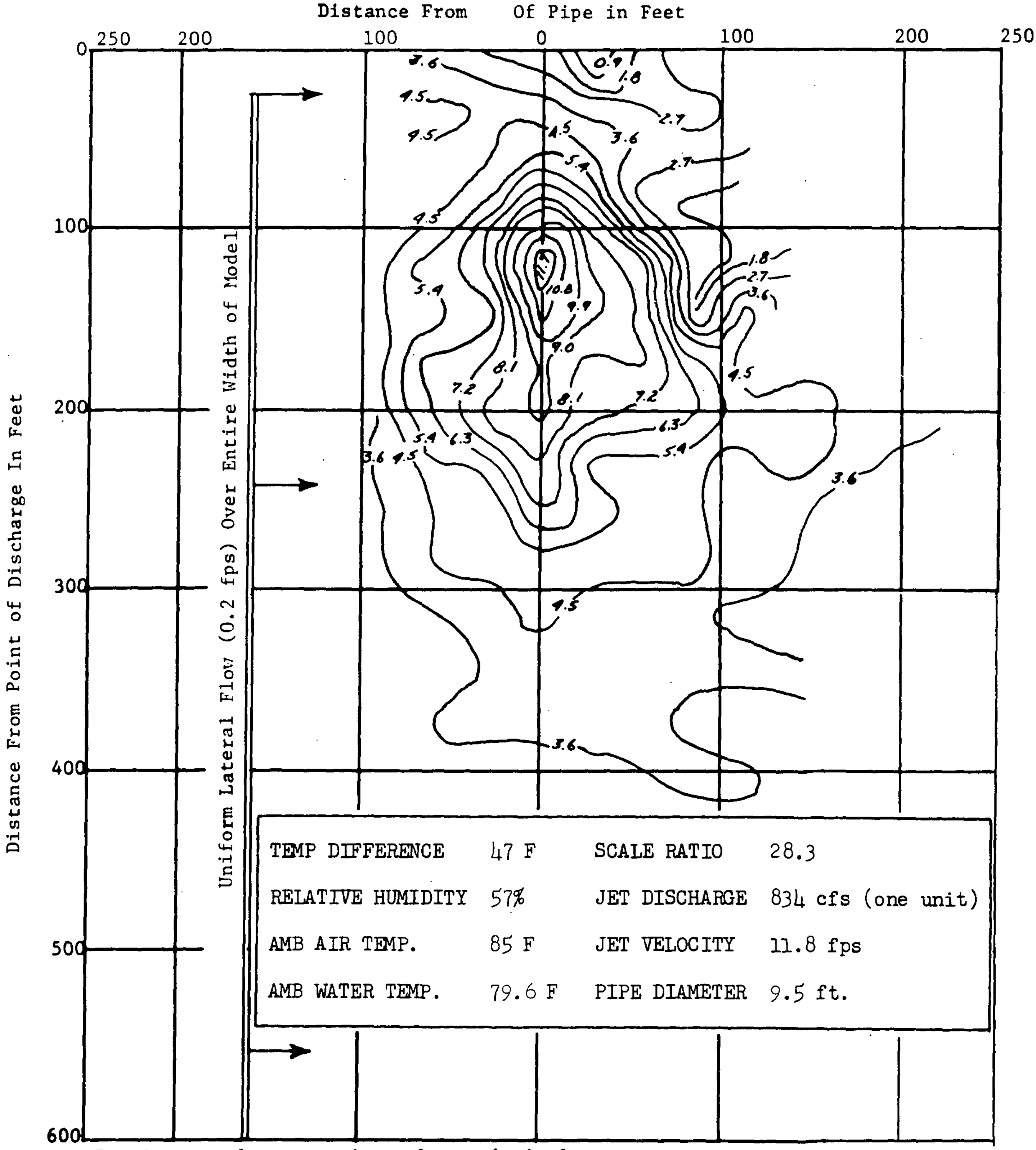
PSNH SEABROOK STATION	PUMP HOUSE SECTIONS GENERAL ARRANGEMENT	FIGURE 3.4-5



PSNH SEABROOK STATION	PUMP HOUSE PLAN-VIEW GENERAL ARRANGEMENT	FIGURE 3.4-6

SEABROOK MODEL STUDY

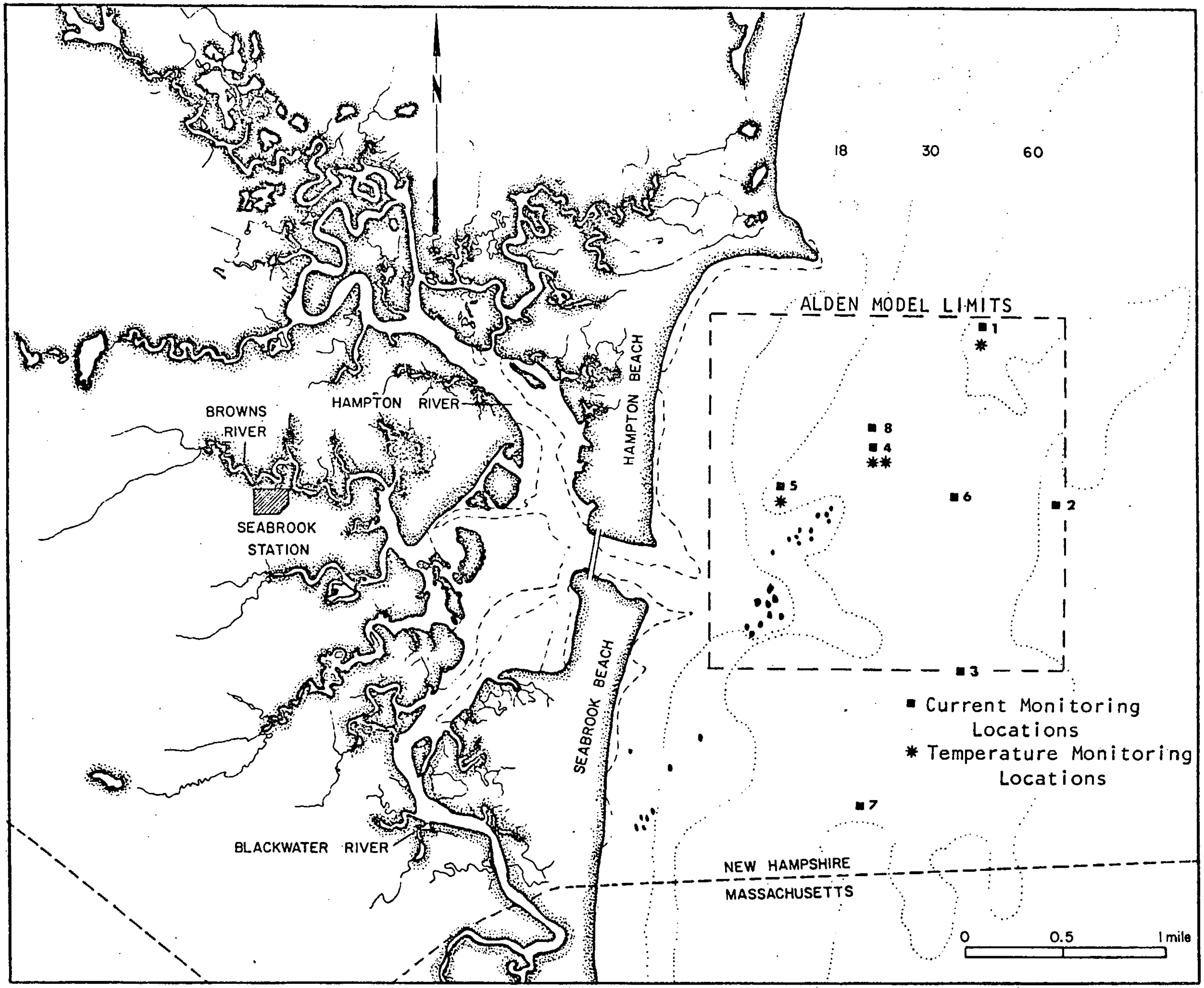
Single Port Discharge
Plan Isotherms at Surface
(ΔT's in Degrees F)



TEMP DIFFERENCE	47 F	SCALE RATIO	28.3
RELATIVE HUMIDITY	57%	JET DISCHARGE	834 cfs (one unit)
AMB AIR TEMP.	85 F	JET VELOCITY	11.8 fps
AMB WATER TEMP.	79.6 F	PIPE DIAMETER	9.5 ft.

Results are for one unit, submerged single port.

PSNH SEABROOK STATION	SINGLE PORT DISCHARGE PLAN ISOTHERMS AT SURFACE	FIGURE 3.4-7



PSNH SEABROOK STATION	HYDRO-THERMAL MODEL BOUNDARIES AND LOCATION OF CURRENT METERS AND TEMPERATURE MONITORS	FIGURE 3.4-8

3.5

3.5 Radwaste Systems

The generation of power within each of the Seabrook units results in the presence of radioactive materials in various forms and quantities within the reactor core, reactor coolant system, and associated systems and components. The vast majority of the radioactivity produced (fission products) is completely contained within the cladded fuel rods and is therefore not available for release to fluid systems nor to the environment. However, with imperfections in the cladding (pinholes, fine cracks), a small fraction of these fission products escape from the affected fuel rods to the reactor coolant. The other main source of radioactivity to the reactor coolant is the corrosion of primary system surfaces and irradiation of the corrosion products within the reactor core.

Fission and corrosion product radionuclides within the reactor coolant system constitute the source of radioactivity to associated systems and components. This radioactivity appears in letdown and leakage from these systems and components which in turn forms the source of radioactivity in liquid and gaseous discharges from the Seabrook site and in solid waste materials generated at the site. System effluents are collected, processed, monitored, and directed for either reuse or release to the environment by the radioactive waste treatment systems. Solid radioactive wastes are collected and packaged for shipment and off-site disposal.

The design and operational objectives of the Seabrook radioactive waste treatment systems are to maintain during normal operation the radioactivity content of liquid and gaseous effluents from the site such that the dose guidelines expressed in the proposed Appendix I to 10 CFR Part 50 are met. The following descriptions of the design and operation of the radioactive waste treatment systems and presentations of the estimated radioactivity content of Seabrook effluents serve to quantify the magnitudes and characteristics of the releases. These releases are then used as the sources for the radiological environmental impact analyses, which are presented in Section 5.3 of this report.

3.5.1 Radioactive Liquid Treatment Systems

The principle objective in designing the Seabrook radioactive liquid treatment systems is to provide collection and processing capability that will allow recycling of as much of the liquid extracted from the reactor coolant system as possible. Reuse criteria for reactor coolant include limits on chemical purity and dissolved gas content. The primary treatment systems at Seabrook are designed to maintain as much of the reactor coolant letdown and leakage within these reuse limits as possible. This is accomplished through segregating the collection and processing of recycleable liquids from non-recycleable liquids. Primary treatment systems designed to recycle liquids are the boron recycle system and drain channel A of the liquid waste processing system. Drain channel B of the liquid waste processing system collects and processes non-recycleable primary system and miscellaneous wastes that are discharged from the site.

Normal plant operation is anticipated to result in a certain degree of radioactivity within the secondary coolant systems of the Seabrook units through primary-to-secondary steam generator tube leakage. Blowdown and leakage of secondary coolant then, constitute radioactive liquid effluents, the radioactivity contents of which are reduced and/or accounted for by the steam generator blowdown processing system and the condensate leakage collection system.

Thus, radioactive liquid wastes are generated within both the primary and secondary coolant systems at each of the Seabrook units and the wastes extracted from the primary systems are either recycleable or non-recycleable. The collection and treatment systems are provided accordingly.

Figure 3.5-1 depicts in simplified flow-diagram form the sources of the various types of radioactive liquids, where they are directed for treatment among the above-mentioned systems, the interrelationships between the systems for the two Seabrook units, and the discharge pathway for those radioactive liquids that are released to the environment. The discussions that follow describe the design and operation of each of these systems in more detail with estimates of radioactivity releases for those systems discharging to the environment.

Boron Recycle System

One boron recycle system serves both Seabrook units. This system collects and processes deaerated, recycleable liquid that is extracted by diversion or leakage from systems and equipment containing reactor coolant. Reactor coolant system volume and chemistry adjustments result in diversion flow from the chemical and volume control systems (downstream of the reactor coolant filter) to the boron recycle holdup tanks. Equipment drainage and leakoff of deaerated, recycleable reactor coolant within the containments enter the respective reactor coolant drain tank. The liquid collected in these tanks is pumped through a recycle evaporator feed demineralizer and filter to a recycle holdup tank. Deaerated, recycleable equipment drainage and leakoff from outside the containments are transported by drain lines directly to a recycle holdup tank. When the recycle holdup tank level warrants processing, the liquid is pumped to the recycle evaporator unit with the resulting distillate directed through the recycle evaporator condensate demineralizer and filter to a reactor makeup water storage tank for reuse within the reactor coolant system. Dissolved and entrained gases removed by the evaporator unit are directed to the gaseous waste processing system for holdup as described in Section 3.5.2. Evaporator bottoms are reclaimed for use as boric acid within the chemical and volume control system.

The major sources of liquid directed to the boron recycle system are indicated on Figure 3.5-1 and amount to an estimated 1.48×10^6 gallons per year (both units) that is reclaimed for use within the reactor coolant systems instead of released from the site.

Another feature that reduces liquid discharge from the chemical and volume control system is the load following capability afforded by the boron thermal regeneration system (one for each unit). These systems are operated as an on-demand side stream of each chemical and volume control system whereby reactor coolant boron concentration adjustments for load follow are performed without liquid diversion from the chemical and volume control system.

Considerations for the control of tritium levels within the Seabrook units result in the use of the boron recycle system for processing an estimated 200,000 gallons per year per unit of reactor coolant from feed and bleed operations. This processed liquid is discharged to the environment instead of recycled in order to maintain reactor coolant tritium levels such that containment access during both power operation and refueling shutdowns is not unduly limited. The release route this liquid takes from the boron recycle system to the environment is as shown on Figure 3.5-1. The anticipated annual radioactivity release by radionuclide from this source is shown in Table 3.5-1 and is based upon the information supplied in response to Question 31 of the source term questionnaire, located in Appendix G of this report.

Drain Channel A of the Liquid Waste Processing System

One liquid waste processing system serves both units. Drain channel A is the portion of this system that collects and processes recycleable, aerated liquid leakage from reactor coolant equipment and components. This liquid is collected in the waste holdup tank and when a sufficient volume is accumulated, the liquid is pumped through the waste evaporator feed filter to the waste evaporator unit. Distillate from the evaporator is directed to the waste condensate tank through the waste evaporator condensate filter. Additionally, the distillate can be directed through the waste evaporator condensate demineralizer if sampling and analysis shows ion exchange is required in order for the liquid to be reused. The contents of the waste condensate tank are pumped to a reactor makeup water storage tank for use as reactor coolant system makeup water.

All of the liquid collected and processed by drain channel A is expected to be recycled. This reduces the amount of liquid discharge from the site by an estimated 120,000 gallons per year (both units).

Drain Channel B of the Liquid Waste Processing System

This equipment train processes non-recycleable and miscellaneous liquids that are discharged from the site. The sources of these type liquids range from non-recycleable aerated reactor coolant leakage to radiochemistry laboratory rinse water with corresponding wide variability in radioactivity content. The reactor coolant that enters drain channel B constitutes the vast majority of the radioactivity input. This liquid is collected by the equipment and floor drainage system which directs it to the floor drain tank. When the floor drain tank level warrants processing, the contents are pumped through the waste processing evaporator and waste evaporator condensate demineralizer and filter to a waste monitor tank. The contents of a waste monitor tank are sampled and analyzed for radioactivity and then released through a discharge valve interlocked with a process radiation monitor to the service water system and on to the Atlantic Ocean via the circulating water system.

Collection of miscellaneous, potentially radioactive liquids such as laboratory sample rinses and sink drains, decontamination water, etc. is not expected to require evaporation or demineralization by drain channel B before discharge from the site. This liquid is filtered into a waste monitor tank and released from the site as described above for processed, non-recycleable reactor coolant leakage. The anticipated annual release of radioactivity by radionuclide from the aggregate of liquid discharged from drain channel B of the liquid waste processing system is shown in Table 3.5-2 and is based upon the information supplied in response to Question 31 of the source term questionnaire, located in Appendix G of this report.

Steam Generator Blowdown Processing System

Control of the steam generator secondary side liquid chemistry is achieved by blowdown and demineralized water makeup. The radioactivity content of this blowdown is dependent on reactor coolant radioactivity levels and the primary-to-secondary leakage rate. The anticipated annual average levels for these parameters are such that processing is required before discharing blowdown from the site. The detailed design for the steam generator blowdown processing system has not been completed at this time so that the processing description is limited to the fact that evaporation and/or demineralization or their equivalent will be provided.

The anticipated annual release of radioactivity by radionuclide from steam generator blowdown from both units is shown in Table 3.5-3 and is based upon the information supplied in response to Questions 25, 26, and 31 of the source term questionnaire, located in Appendix G of this report.

Secondary System Condensate Leakage Collection

With radioactivity present in the secondary sides of the steam generators, moisture carryover brings some radioactivity to the remainder of the secondary coolant system. Consequently, leakage of secondary system condensate forms a potential radioactive liquid release source. The amount of radioactivity reaching condensate leakage points is minimized by the high quality of the steam exiting the steam generators so that no processing of condensate leakage before discharge is required. A central collection point within each unit's turbine building is provided to allow sampling and analysis for radioactivity content. The liquid is released from the site via the circulating water system.

The anticipated annual radioactivity release by radionuclide from condensate leakage from both units is shown in Table 3.5-4 and is based upon the information supplied in response to Question 31 of the source term questionnaire, located in Appendix G of this report.

Summary of Seabrook Radioactive Liquid Releases

The above described individual sources of radioactive liquid effluents are combined in Table 3.5-5. This listing includes the total amount of each radionuclide estimated to be released from the site from operating both Seabrook units in terms of both release quantity and release concentration. The discharge concentration is obtained by diluting the released radionuclides with the combined flows of the service and circulating water systems, 748,000 gpm. Table 3.5-5 also gives the half-lives, 10 CFR 20 Table II MPCw's, and discharge fractions of these MPCw's for the radionuclides involved.

The total shown for tritium, 827 curies per year from each unit, reflects the tritium control measure of reactor coolant system feed and bleed and release at the rate of 200,000 gallons per year at each unit. This operation produces 677 curies of tritium release with the remaining 150 curies released with non-recycleable reactor coolant leakage (112 curies), steam generator blowdown (32 curies), and secondary system condensate leakage (6 curies).

The release routes of the above radioactive liquids are indicated on the flow diagram, Figure 3.5-1. Liquid processed for discharge by the boron recycle system accumulates in the waste monitor tanks. Alter sampling for radioactivity analysis, the liquid is discharged from the waste monitor tank through a process radiation monitor to the service water system. Non-recycleable reactor coolant leakage accumulates in the floor drain tank from where it is processed and directed to the waste monitor tanks. This liquid is then sampled and released as described above for boron recycle system releases. Miscellaneous liquid wastes follow the same release route to the service water system as for the above liquids.

Steam generator blowdown from each of the Seabrook units is directed from the blowdown tanks to the steam generator blowdown processing system. After processing the liquid is released to the service water system. Secondary system condensate leakage is collected in the turbine building sumps. From here the liquid is directed to the sanitary waste treatment plant and then to the circulating water system.

All these waste liquids, once released to the service water system, experience the same release path to the Atlantic Ocean. The service water system discharges to the circulating water system which carries the radioactivity to the Atlantic Ocean.

3.5.2 Radioactive Gaseous Treatment Systems

The radioactive gaseous waste treatment systems at Seabrook consist of (1) a gaseous waste processing system for removal and treatment of radioactive gases from the reactor coolant system (2) a filter system for processing the potentially radioactive condenser air ejector discharge and (3) ventilation filter systems for those areas that contain radioactive systems. Of these systems, only the gaseous waste processing system is shared by the 2 units. Figure 3.5-2 is a flow diagram showing the gaseous release paths from the site.

A. Gaseous Waste Processing System

The gaseous waste processing system (GWPS) is designed to remove fission product gases from the reactor coolant and to have the capacity to hold up these gases for extended periods of time. The system is also designed to collect and store fission gases from the boron recycle evaporators and the reactor coolant drain tank. Since the system reduces gaseous radioactivity levels during unit operation, it significantly reduces the escape of these gases arising from any possible reactor coolant leakage.

The GWPS consists mainly of a closed loop comprised of two waste gas compressors, two catalytic hydrogen recombiners and ten gas decay tanks to accumulate the fission product gases. The system is shown schematically in Figure 3.5-3. One gas compressor and one recombiner are normally used, with the second units on a standby basis.

The major input to the system is from the volume control tanks of Units 1 & 2. Approximately 0.7 scfm of hydrogen, containing fission product gases, is vented from the vapor space in each volume control tank to the GWPS. (See Appendix G, Answer No. 20 for stripping fractions in volume control tank.) The activity input to the GWPS is shown in Table 3.5-6.

The hydrogen gas is mixed with the nitrogen stream in the GWPS. The N_2-H_2 mixture is pumped by the compressor to the hydrogen recombiner. Oxygen is added to the recombiner and the hydrogen is oxidized to water vapor on the catalytic surface. The water vapor is removed and the resulting nitrogen stream containing the fission product gases is circulated to the gas decay tank and back to the compressor suction to complete the loop.

Each of the gas decay tanks is capable of being isolated from the loop and of being vented to the stack through a HEPA and charcoal filter system. By alternating use of the tanks, the inventory in any one tank can be minimized.

The environmental releases from the GWPS are shown in Table 3.5-7. The release from leakage is based on an estimated 100 ft^3 per year minimum detectable leak rate from the system. The planned release from the gas decay tanks is based on sufficient holdup time to effectively decay all isotopes except Kr-85.

B. Condenser Air Ejector Filter System

Radioactive gases will be released with the condenser air ejector discharge when the combination of failed fuel and primary-to-secondary steam generator leakage exists. A filter system consisting of a humidity control device, a high efficiency particulate filter and a charcoal adsorber will be installed to process this release path. The system will be utilized in accordance with the Technical Specifications (see Appendix G, Answer No. 28). The charcoal adsorber will have a minimum gas residence time of 0.25 sec and will be impregnated with an agent for the removal of organic iodines.

The estimated releases from the condenser air ejector are shown in Table 3.5-7. These are based on primary-to-secondary leakage of 20 gal/day, primary and secondary coolant concentrations as shown in Appendix G (Tables G-1 & G-2), an effective iodine carryover fraction of 0.01 from the steam generators, an iodine DF of 2000 in the condenser, and a charcoal adsorber efficiency of 99 percent for iodine.

C. Ventilation Filter Systems

Those areas in the station that have the potential for leaking hot reactor coolant have filter systems on the ventilation exhaust. These filter systems contain high efficiency particulate filters and charcoal adsorbers. The charcoal adsorber will have a minimum gas residence time of 0.25 sec and will be impregnated with an agent for the removal of organic iodines. The containment and the primary auxiliary building contain filter systems of this type.

The containment purge filter system is rated at 6000 cfm and is utilized when required in accordance with the Technical Specifications (see Appendix G - Answer No. 18). The estimated radioactivity releases from containment purging are shown in Table 3.5-7. These are based on 40 gal/day reactor coolant leakage to the containment, 10 percent iodine release from the flashing fraction (0.44), 100 percent noble gas release, 4 containment purges per year and a charcoal adsorber efficiency of 99 percent.

The primary auxiliary building ventilation exhaust from those areas containing hot reactor coolant (chemical and volume control system) is routinely filtered. The total flow from these areas is 7500 cfm and is directed to the unit vent stack. The estimated releases from these areas are shown in Table 3.5-7. These releases are based on the assumptions discussed in Appendix G - Answer No. 30, 10 percent iodine release from the flashing fraction of the leakage and a charcoal adsorber efficiency of 99 percent.

The waste disposal building, which served both units, has high efficiency particulate filters on the ventilation exhaust. The exhaust flow rate is 35,000 cpm and is directed to the unit 1 vent stack. Releases from this building are described above under the GWPS.

3.5.3 Solid Radioactive Waste System

Operation of the Seabrook units results in the generation of radioactive wastes that are processed in solid form. These wastes vary in physical and radioactivity characteristics and are handled accordingly by the solid radioactive waste system. One such system handles the solid radioactive wastes generated by both Seabrook units. The system encapsulates all solid radwastes for shipment from the site to an AEC licensed disposal facility. No solid radwastes are permanently stored at the site. Shipping containers and methods are in compliance with AEC and Department of Transportation regulations.

The solid radwaste materials that are encapsulated stem from the following sources:

a) Evaporator concentrates
b) Spent resin
c) Chemical drains
d) Filter cartridges
e) Compressible waste materials

Evaporation of radioactive liquids by the waste processing evaporator produces radioactive bottom concentrates that are periodically sent to the waste evaporator concentrates tank. From here, the concentrates are transferred to a shipping container and fixed with a solidifying agent (cement or a proven chemical). Concentrates from the boron recycle evaporator are recycled for reuse so that bottoms production is from the waste processing evaporator only. The estimated annual volumetric production and radioactivity content of these bottoms are approximately 2200 ft^3 and 0.6 Curies/ft^3, respectively (for both units after solidification).

The spent resins are flushed from their respective demineralizers (spent fuel, CVCS, waste processing, boron recycle) to the spent resin storage tank. As with evaporator bottoms, the spent resins are then transferred to a shipping container and fixed with a solidifying agent. An estimated 1270 ft^3 of spent resin with approximately 38 Curies/ft^3 are produced and shipped annually by the operation of both units.

The chemical drains collect in the chemical drain tank and are encapsulated and solidified for shipment in the same manner as evaporator bottoms and spent resins. The estimated annual amount of this source of solid waste is 490 ft^3 (by both units after solidification) with minimal radioactivity content (on the order of 0.1 μCi/ft^3).

Filter cartridges are removed from service usually when the pressure drop across the filter becomes excessive. Large, high activity filter cartridges are raised into a filter removal shield and transferred to a shipping container. Small, low activity filter cartridges are encapsulated in 55 gallon steel shipping drums. The estimated annual production of spent cartridges from both units is 30 per year.

Compressible, radioactivity contaminated solid waste materials such as paper, rags, disposable protective clothing, plastics, etc., are encapsulated directly in 55 gallon steel shipping drums. These items are compacted within the drums by a hydraulic press. When filled, the drums are covered and sealed. An estimated 240 drums of such waste material are expected annually from both units.

The shipping container used for evaporator concentrates, spent resins, chemical drains, and large, high activity filter cartridges is a steel vessel surrounded by a reinforced concrete shipping cask. Design and transporation of the container are in compliance with 10 CFR 71 of the AEC regulations and DOT Requirements. The 55 gallon steel shipping drums used for low activity level solid wastes comply with the standard DOT 17-H requirements.

TABLE 3.5-1

RADIOACTIVE LIQUID RELEASES FROM BORON RECYCLE SYSTEM
(total for both Seabrook units)

Radionuclide	Annual Release (Curies/year)	Radionuclide	Annual Release (Curies/year)
I-131	7.9-2*	Cs-134	7.9-2
I-132	2.7-2	Cs-136	4.2-2
I-133	1.2-1	Cs-137	3.9-1
I-134	1.7-2	Te-132	8.2-3
I-135	6.7-2	Ba-140	1.3-4
		La-140	4.2-5
Sr-89	1.2-4	Ce-144	1.0-5
Sr-90	3.9-6		
Sr-91	5.8-5	Mn-54	1.2-4
Y-90	4.5-5	Mn-56	4.4-3
Y-91	1.8-3	Co-58	3.8-3
Y-92	2.1-4	Co-60	1.1-4
Zr-95	2.1-5	Fe-59	1.5-4
Nb-95	2.1-5	Cr-51	1.4-4
Mo-99	1.7+0		
		TOTAL	2.5

*7.9-2 = 7.9×10^{-2}

TABLE 3.5-2

RADIOACTIVE LIQUID RELEASES FROM DRAIN CHANNEL B OF THE LIQUID WASTE PROCESSING SYSTEM
(total for both Seabrook units)

Radionuclide	Annual Release (Curies/year)	Radionuclide	Annual Release (Curies/year)
I-131	2.8-2*	Cs-134	9.8-3
I-132	9.5-3	Cs-136	5.3-3
I-133	4.2-2	Cs-137	4.9-2
I-134	5.9-3	Te-132	2.8-3
I-135	2.4-2	Ba-140	4.5-5
		La-140	1.5-5
Sr-89	4.0-5	Ce-144	3.5-6
Sr-90	1.4-6		
Sr-91	2.0-5	Mn-54	4.1-5
Y-90	5.6-6	Mn-56	1.5-3
Y-91	2.3-4	Co-58	1.3-3
Y-92	2.6-5	Co-60	3.9-5
Zr-95	7.4-6	Fe-59	5.3-5
Nb-95	7.4-6	Cr-51	4.9-5
Mo-99	2.1-1		
		TOTAL	0.39

*2.8-2 = 2.8×10^{-2}

TABLE 3.5-3

RADIOACTIVE LIQUID RELEASES FROM STEAM GENERATOR BLOWDOWN
(total for both Seabrook units)

Radionuclide	Annual Release (Curies/year)	Radionuclide	Annual Release (Curies/year)
I-131	2.5-1*	Cs-134	2.7-2
I-132	1.6-2	Cs-136	1.4-2
I-133	2.5-1	Cs-137	1.5-1
I-134	4.1-3	Te-132	2.3-2
I-135	8.5-2	Ba-140	4.1-4
		La-140	1.1-4
Sr-89	3.8-4	Ce-144	3.2-5
Sr-90	1.4-5		
Sr-91	9.0-5		
Y-90	1.3-5	Mn-54	3.8-4
Y-91	5.9-4	Mn-56	2.9-3
Y-92	1.8-5	Co-58	1.3-2
Zr-95	7.0-5	Co-60	3.8-4
Nb-95	7.0-5	Fe-59	5.0-5
Mo-99	4.7-1	Cr-51	4.7-4
		TOTAL	1.5

*2.5-1 = 2.5×10^{-1}

TABLE 3.5-4

RADIOACTIVE LIQUID RELEASES FROM SECONDARY SYSTEM CONDENSATE LEAKAGE
(total for both Seabrook units)

Radionuclide	Annual Release (Curies/year)	Radionuclide	Annual Release (Curies/year)
I-131	5.0-2	Cs-134	1.4-3
I-132	3.2-3	Cs-136	6.8-4
I-133	5.0-2	Cs-137	6.4-3
I-134	8.2-4	Te-132	1.2-3
I-135	1.7-2	Ba-140	2.1-5
		La-140	5.7-6
Sr-89	1.9-5	Ce-144	1.6-6
Sr-90	6.4-7		
Sr-91	4.7-6		
Y-90	6.4-7	Mn-54	1.9-5
Y-91	3.0-5	Mn-56	1.4-4
Y-92	9.0-7	Co-58	6.4-4
Zr-95	3.5-6	Co-60	1.9-5
Nb-95	3.5-6	Fe-59	2.5-6
Mo-99	2.3-2	Cr-51	2.3-5
		TOTAL	0.15

*2.0-2 = 2.0×10^{-2}

TABLE 3.5-5

SUMMARY OF SEABROOK RADIOACTIVE LIQUID RELEASES
(total from all sources from both units)

Radionuclide	Half-Life	10CFR20 MPCw (μCi/ml)	Annual Release Rate (Curies/year)	Discharge Concentration (μCi/ml)	Discharge Fraction of MPCw
I-131	8.06 da.	3-7*	4.1-1	3.1-10	1.0-3
I-132	2.28 hr.	8-6	6.0-2	4.5-11	5.6-6
I-133	20.8 hr.	1-6	4.6-1	3.4-10	3.4-4
I-134	52.3 min.	2-5	2.8-2	2.1-11	1.1-6
I-135	6.7 hr.	4-6	2.0-1	1.6-10	4.0-5
Sr-89	50.8 da.	3-6	5.6-4	4.2-13	1.4-7
Sr-90	28.9 yr.	3-7	2.0-5	1.5-14	5.0-8
Sr-91	9.67 hr.	5-7	1.7-4	1.2-13	2.4-7
Y-90	64 hr.	2-5	6.4-5	4.7-14	2.4-9
Y-91	58.8 da.	3-5	2.7-3	2.1-12	7.0-8
Y-92	3.53 hr.	6-5	2.6-4	2.0-13	3.5-9
Zr-95	65.5 da.	6-5	1.0-4	7.5-14	1.3-9
Nb-95	35.1 da.	1-4	1.0-4	7.5-14	7.5-10
Mo-99	66.6 hr.	4-5	2.4+0	1.7-9	4.3-5
Cs-134	2.06 yr.	3-6	1.2-1	8.7-11	2.9-5
Cs-136	13 da.	6-5	6.2-2	4.6-11	7.7-7
Cs-137	30.2 yr.	2-5	6.0-1	4.7-10	2.4-5
Te-132	78 hr.	3-6	3.5-2	2.6-11	8.7-6
Ba-140	12.8 da.	2-5	6.1-4	4.5-13	2.3-8
La-140	40.2 hr.	2-5	1.7-4	1.2-13	6.0-9
Ce-144	284 da.	1-5	4.7-5	3.5-14	3.5-9
Mn-54	313 da.	1-4	5.6-4	4.2-13	4.2-9
Mn-56	2.58 hr.	1-4	9.0-3	6.1-12	6.1-8
Co-58	71 da.	9-5	1.9-2	1.4-11	1.6-7
Co-60	5.28 yr.	3-5	5.5-4	4.1-13	1.4-8
Fe-59	45 da.	5-5	2.6-4	2.0-13	4.0-9
Cr-51	27.8 da.	3-6	6.8-4	5.0-13	1.7-7
		TOTAL	4.5	TOTAL 3.3-9	TOTAL 1.5-3
H-3	12.3 yr.	3-3	1654	1.2-6	4-4

*3-7 = 3×10^{-7}

TABLE 3.5-6

Activity Input to the Gaseous Waste Processing System During Normal Operation (Per Unit)

Isotope	Input, Ci/Year
Kr-85m	6.6 + 3*
85	8.5 + 2
87	3.1 + 3
88	1.2 + 4
Xe133m	1.1 + 4
133	7.8 + 5
135	2.6 + 4

* 6.6 + 3 = 6.6×10^3

This table based on 3654 MWt and 0.2% failed fuel.

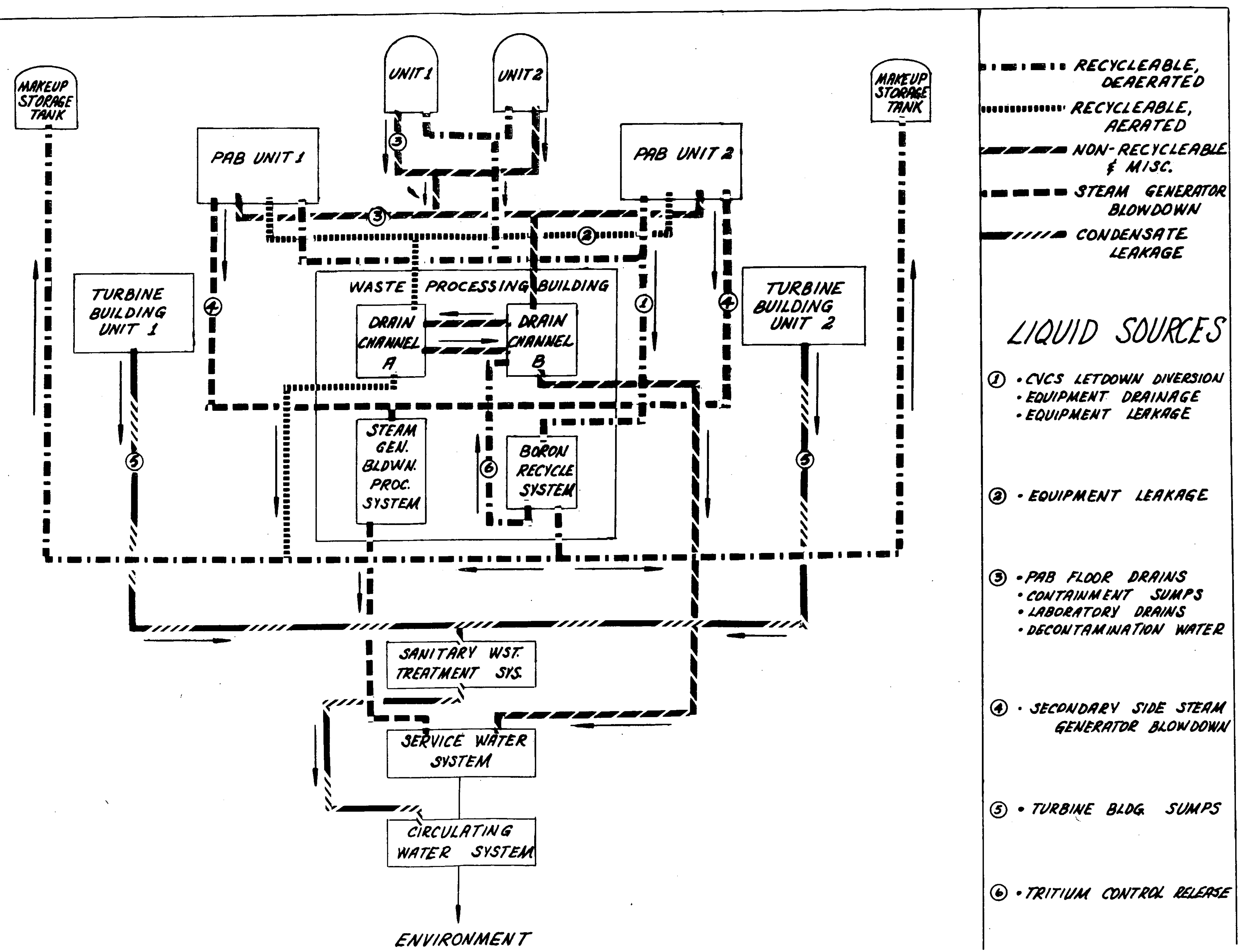
TABLE 3.5-7

Estimated Gaseous Releases from Normal Operation

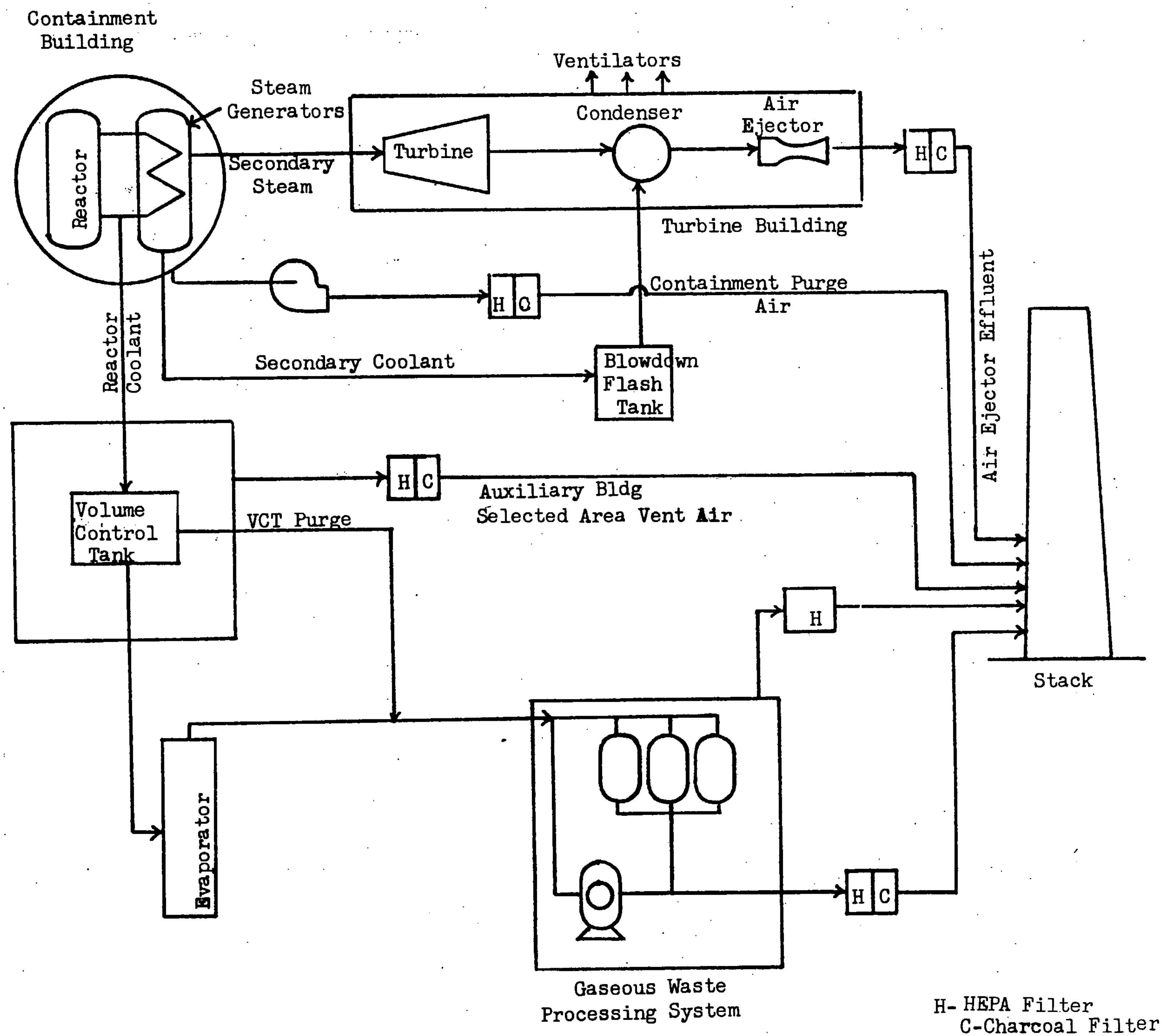
Isotope	Containment Venting(1)	Average Release Rate, Ci/Year Auxiliary Building Leakage(1)	Condenser Air Ejector(1)	Waste Gas System Leakage(1)	Turbine Building Leakage(1)	Gas System Release(1)	Total (1 Unit)	Total (2 Unit)
Kr-85	1.4+0*	3.5-2	6.9-1	1.6+2	-	3.5+3	3.7+3	7.4+3
85m	6.0-2	5.4-1	1.1+1	2.2+0	-	-	1.4+1	2.8+1
87	1.0-2	2.8-1	6.0+0	1.8-1		-	6.5+0	1.3+1
88	6.9-2	9.1-1	1.9+1	2.2+0	-	-	2.2+1	4.4+1
Xe131m	5.7+0	7.9-1	1.6+1	-	-	-	2.2+1	4.4+1
133	6.9+1	2.1+1	4.4+2	6.9+2	-	-	1.2+3	2.4+3
133m	6.0-1	4.4-1	8.8+0	8.2+0	-	-	1.8+1	3.6+1
135	3.5-1	1.5+0	2.9+1	1.9+1	-	-	5.0+1	1.0+2
135m	-	4.7-2	9.1-1	-	-	-	9.6-1	1.9+0
138	-	1.7-1	3.5+0	-	-	-	3.7+0	7.4+0
I-131	1.4-3	5.4-5	3.8-4	-	2.5-5	-	1.8-3	3.6-3
132	5.7-6	1.8-5	2.4-5	-	1.7-6	-	5.0-5	1.0-4
133	2.3-4	7.6-5	3.8-4	-	2.5-5	-	6.9-4	1.4-3
134	1.4-6	1.1-5	6.3-6	-	4.1-7	-	1.8-5	3.6-5
135	4.1-5	4.1-5	1.3-4	-	8.5-6	-	2.2-4	4.4-4

* $1.4+0=1.4x10^{0}$

(1) Based on 1 unit



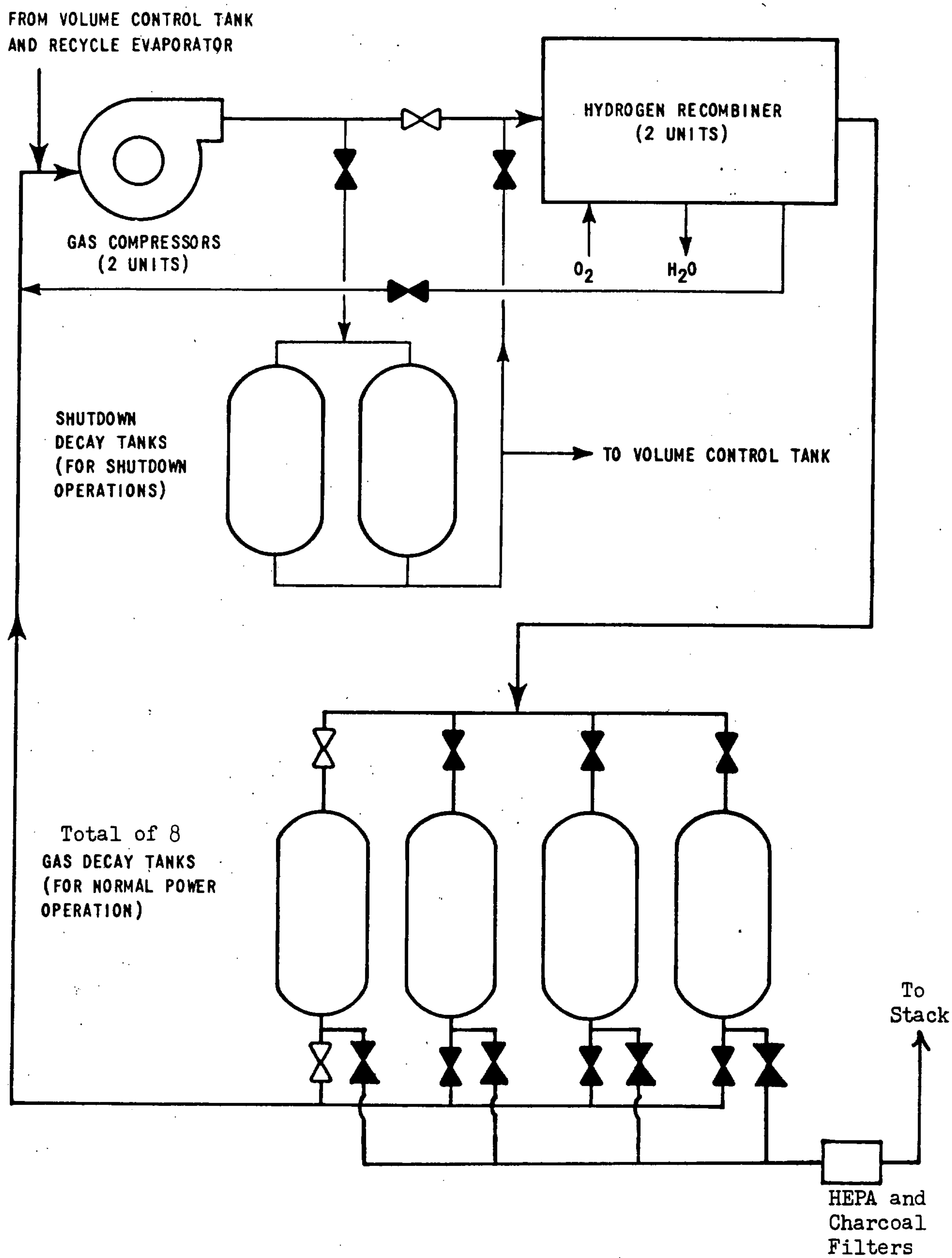
PSNH	RADIOACTIVE LIQUID	FIGURE
SEABROOK STATION	TREATMENT & RELEASE	3.5-1



PSNH
SEABROOK STATION

SOURCES OF
GASEOUS WASTE

FIGURE
3.5-2



PSNH Seabrook Station	GASEOUS WASTE PROCESSING SYSTEM	FIGURE 3.5-3

3.6

3.6 Chemical and Biocide Systems

3.6.1 Circulating Water System

The intake portion of the circulating water system from the ocean inlets to the condensers is subject to the settlement of marine fouling organisms, particularly during their growth seasons. These organisms must be dislodged and removed from the circulating water system to allow proper cooling water flow. This is accomplished by periodically, as required, routing hot circulating water from the condenser discharge through the circulating water intake conduit by means of a valving arrangement located in the intake structure.

To prevent condenser and service water system fouling, intermittent chlorination is used. In addition, if any organisms remain on the circulating water conduit after heat treatment, it is necessary to utilize intermittent chlorination.

The active chlorine is provided by the addition of sodium hypochlorite. Depending on demand, active chlorine is adjusted at a feed point near the condenser and the service water intake structure and, if necessary at an additional feed point at the circulating water system intake, so that in either place the free available chlorine residual is approximately 0.5 to 1.2 mg/l. (Reference 2) Chlorine is applied for 20 minutes every eight hours, or the equivalent of one hour per day.

Both free and combined residuals are monitored at the condenser inlets and the condenser outlets. Approximately 20 minutes flow or contact time occurs each way between the shoreline and the condensers, and an additional 10 minutes is required for the heated water (44°F temperature rise) to flow from the shoreline to the ocean discharge area.

Free residual chlorine drops fairly rapidly from the condenser inlet to the ocean discharge point due to: (1) continuing consumption of this available chlorine with the extended contact time and (2) increased rate of consumption with the higher reaction temperature available. (Reference 1) With the relationship between free residual and contact time it is possible to regulate the chlorine dosage so that the free residual chlorine at the ocean discharge point is minimal, less than 0.1 mg/l.

At 374,000 gpm maximum cooling water flow per unit and assuming a maximum concentration of free residual chlorine at the 0.1 mg/l, the quantity of discharge is 37 pounds per day (ppd) total chlorine.

The use of chlorination with residuals of less than 1.0 mg/l has been found to have no significant effect upon the corrosion behavior of steel pipe (Reference 3) and copper-nickel tubes. With or without chlorination, the maximum corrosion of the cupro-nickel condenser tubing is estimated at less than 6 and 3 pph of copper and nickel, respectively. Maximum corrosion of steel and cast or ductile iron portions of the circulating water circuits is estimated to be less than 1 pph of iron, also with or without chlorination.

If all the heavy metal corrosion products were to dissolve, the circulating water concentrations would be increased by 0.02 mg/l of copper, .009 mg/l of nickel, and .002 mg/l of iron.

3.6.2 Industrial Waste System

Industrial wastes are generated as a result of the operation of the makeup and blowdown systems described below:

a) Demineralized Water Makeup System

The water for the makeup system is supplied from a city water main extended into the plant from the town of Seabrook, New Hampshire. The water supply from the town is of suitable quality for drinking, and no clarifiers or sand filters are required for turbidity control. The water passes through a vacuum deaerator and two parallel strings of demineralizer trains. Each demineralizer train consists of a strong acid (cation) exchanger, a strong base (anion) exchanger and a mixed bed exchanger. The treated water is then delivered to the condensate and primary water storage tanks.

Each demineralizer train has a capacity of 240,000 gallons per day and the makeup system has a total capacity of 480,000 gallons per day (20 hours in service, 4 hours regenerating). During normal operation, one demineralizer train can supply normal plant makeup requirements.

For regeneration purposes the makeup plant includes in-line acid and caustic systems. The regeneration system includes motor driven pumps, metering equipment, a caustic dilution tank and dilution control. The regeneration systems handle concentrated sulphuric acid and a 50 percent solution of sodium hydroxide. Storage tanks of approximately 5000 gallons capacity are provided for each of the chemicals.

b) Blowdown System

The steam generator blowdown system is designed to operate continuously at a variable flow rate which is dependent upon the concentration of solids in the steam generators. The system is sized to maintain the total solids concentration in the liquid phase of the steam generators at 125 ppm or less for design conditions. The normal blowdown rate is approximately 38,000 lb/hr. In an abnormal operating condition, such as significant seawater leakage into the condenser, the solids concentration is permitted to increase to 600 ppm for short periods of time.

All four steam generators of each unit have their own blowdown and sample lines. With this arrangement, the blowdown from each steam generator can be individually controlled and sampled.

The radiation monitors on the blowdown sample lines are located in the primary auxiliary buildings. There is also a blowdown tank in each primary auxiliary building. All processing of the blowdown is done in the waste disposal building which is common to both units.

The steam generator blowdown liquid from each unit is routed to a blowdown flash tank. The liquid is then flashed into a vapor and a liquid phase at approximately 30 psig. The vapor portion is routed to feedwater heaters, and the remaining liquids and solids are discharged or processed depending upon the radioactivity content.

The liquid effluent drained from the steam generator blowdown tanks may require processing before discharge to the environment. This processing is required when primarily coolant activity levels and steam generator tube leakage release sufficient activity to require treatment before discharge from the site. The blowdown is processed by the steam generator blowdown processing system. One system serves both units.

The specific design of these systems is under evaluation at this time, so that design details and equipment specifications cannot be delineated. The equipment under evaluation for this purpose include evaporators, demineralizers, or their equivalent, and all the associated components.

The following industrial wastes are generated and discharged:

1. Regeneration wastes from the deionizers which provide makeup feed water to the main steam generators.
2. Blowdown (if nonradioactive) from the steam generators.
3. Oily wastes from equipment areas, tank truck unloading areas and storage areas.
4. Blowdown from the auxiliary boiler(s).

In addition, some batches of wastes are generated prior to startup as a result of cleaning the critical piping systems. Also some small quantities of waste may be generated occasionally due to fireside washing of the auxiliary boiler.

The regeneration wastes consist of the ions removed from the process water (high drinking quality well water) plus the excesses of sodium hydroxide and sulfuric acid used in regeneration. Any excess acidity or alkalinity is neutralized to a pH range of 6.5 to 8.0 by adding caustic or acid as required. After the local pH adjustment, the batch of waste is pumped into the circulating water discharge for conveyance to the ocean discharge area.

A regeneration waste batch of about 30,000 gallons occurs approximately every 3.5 days. The dissolved solids content are approximately 5.0 g/l and consist mainly of sodium sulphate with minor amounts of the other constituents normally found in ground and surface waters, such as calcium, magnesium, sodium, bicarbonate, sulfate, chloride and silica. The yearly discharge of these dissolved solids is less than 125,000 pounds per year or an average of 358 ppd.

Nonradioactive blowdown from the steam generators, after flashing, flows through a radiation monitor prior to discharge into the circulating water system. With no primary to secondary steam generator leakage or phosphate treatment of the feedwater, the blowdown would be 35 gpm with a maximum steam generator solids concentration of 125 ppm during normal operation. If there were a steam generator leak, the blowdown would be 53 gpm after flashing. This liquid would be processed by a steam generator blowdown processing unit, having a decontamination factor of approximately 100. The treated effluent would be discharged to the service water discharge pipe and ultimately to the circulating water discharge.

Oily wastes from the equipment areas would be condensate or process water contaminated with a small amount of oil. Wastes from the storage and unloading areas would be mainly rain water contaminated with oil. These streams would flow through an oil separator(s) of the API type to reduce the oil content of the effluent to less than 10 mg/l and grit or suspended solids to less than 100 mg/l. For a maximum of gpm flow with 10 mg/l oil content, 60 ppd of oil would be discharged. The average effluent would have less than 1 ppd of oil from a flow of 20 gpm at 3 mg/l concentration.

Blowdown from the auxiliary boiler(s) would be handled in a manner similar to that from the steam generator blowdown system. Phosphate boiler treatment would be employed but the additional discharge would be only a very small fraction of that occurring from the steam generators.

The coolant, steam and condensate piping systems will be cleaned before startup to remove debris and any oily film. This involves flushing with deionized water before and after flushing with a hot alkaline solution. When the alkaline solution is displaced, it is treated by passage through the holdup tank and pH adjustment tank before discharging. The gross excess alkalinity are removed by massive dosage with acid in the hold tank. Trimming to the acceptable pH range is accomplished in the pH adjustment tank.

References for Section 3.6

1. G. C. White, "Handbook of Chlorination", Van Nostrand Reinhold, New York, 1972.

2. D. B. Anderson and B. R. Richards, "Chlorination of Sea Water - Effects on Fouling and Corrosion", Trans. ASME, J of Enging for Power (Series A), vol. 88, July 1966, pp. 203-208.

3. V. B. Volkening, "Corrosion of Steel Pipe by Chlorinated Sea Water at Various Velocities", Corrosion, vol. 6, April 1950, pp. 123-128.

3.7

3.7 Sanitary and Other Waste Systems

3.7.1 Sanitary Waste System

The sanitary waste system for the station operates initially under a high load to treat the wastes from a construction force. Portable chemical facilities are used to supplement the sanitary waste system. During operation of the plant the load is reduced to treat the wastes from an operating force of approximately 125 and the kitchen facilities.

A biological oxidation unit with the equivalent of tertiary treatment is employed. The system provides grit removal, extended aeration and/or contact stabilization, clarification, excess sludge storage, effluent polishing, and chlorination. Percent expected removals of BOD and suspended solids is 95 to 97 and 98 to 99, respectively.

The effluent should contain approximately 11 mg/l or 5 ppd BOD, 5 mg/l or 2 ppd suspended solids and 8 mg/l or 3 ppd of total phosphates at high load operation and a maximum of 50,000 gpd of wastes. The daily quantities would be 1/10th to 1/5th of the above when operating at low load. The treatment produces an effluent with a pH in the 6.5 to 8.0 range, a dissolved oxygen of more than 5 mg/l,a coliform count of less than 70 on an MPN basis and a free residual chlorine content of 0.5 to 1.0 mg/l at the treatment unit outlet.

The dissolved solids content of the effluent is expected to be nearly the same as the well water supplied to the sanitary and drinking water system. Thus the treated effluent is equivalent in quality to the drinking water standards of the USPHS. The effluent is sampled for periodic analysis to insure quality, before blending with the industrial wastes prior to discharge to the circulating water discharge. The excess sludge produced is removed several times per year to an approved disposal facility.

3.7.2 Origin, Quantity and Nature of Gaseous Waste System

The Seabrook Station, being a nuclear generating plant, does not burn any fossil fuels in the production of electricity during normal operations. There are, however, two pieces of plant equipment which could emit gaseous and particulate wastes to the atmosphere. These are two auxiliary boilers, and four emergency diesel generators, all fired with No. 2, low sulfur (.3 percent), fuel oil.

Steam for heating and process work is normally supplied from the main steam system. During plant outages, the auxiliary boilers furnish this heating and process steam. Should the auxiliary boilers be used to supply the heating and process steam requirements, one unit would operate continuously and the second would operate for a period of 30 days per year. The emergency diesel generators are operated once every month for 2 hours, a total of 24 hours per year per diesel generator, as a normal test procedure. For all four diesel units, this is equivalent to 4 days per year.

The following unit size information is presently available for the fossil fuel fired units:

<u>Auxiliary Boilers</u>
(Based on Continuous Use of Boilers)

Expected operating load:	100,000 lbs. steam/hr.
Capacity:	200,000 lbs. steam/hr.

Expected fuel rate: 900 gallons/hr.

Lower fuel heating value: 143,000 Btu/gallon

Emergency Diesel Generators

Design size: 4500 kW/unit

Expected fuel rate: 310 gallons/hr.

Lower fuel heating value: 143,000 Btu/gallon

Gaseous effluents from the auxiliary boilers and emergency diesel generator contain Nitrogen, Oxygen, Water Vapor, unburned hydrocarbons, Carbon Dioxide, Carbon Monoxide, Sulfur Dioxide, various nitrogen oxides and particulate matter.

The auxiliary boiler units produce an expected 31000 cfm of flue gas at 300°F. The emergency diesel generator units emit 20,000 cfm at 850°F over a 4 day yearly generating period.

The auxiliary boilers and diesel generators are designed to meet the applicable standards for release of gaseous effluents to the environment.

3.8 Radioactive Materials Inventory

The characteristics and amounts of radioactive materials that are shipped to and from the Seabrook site are described below. The radiological environmental impact of such transportation is addressed in subsection 5.3.4.2.

New Fuel

As described in Section 3.2, each Seabrook reactor core requires a total of 99 metric tons of sintered uranium-dioxide, slightly enriched (2.8 w/o average) fuel pellets. These pellets are encapsulated into 39,372 zircaloy-4 cladded fuel rods which are assembled into 193 fuel elements (204 fuel rods per element). The initial loading of a Seabrook unit requires the shipment of 193 elements. They are shipped in AEC-DOT licensed shipping containers designed for Type B fissile Class II material (new fuel). Two fuel elements wrapped in polyethylene are shipped in each container. Truck shipment for the initial core loading of a unit requires 12 or 13 shipments of 16 elements per shipment. New fuel shipping requirements for reload cores are four truck shipments of 16 elements per shipment per year. The shipping distance is approximately 950 miles.

Spent Fuel

With a third of each Seabrook core removed per year, a total of 128 spent fuel assemblies are generated per year and sent to the fuel reprocessing facility. The minimum period of time between removal from the core and shipment from the site is 90 days. The design maximum and average burnups on a fuel element are 50,000 MWD/MTU and 33,000 MWD/MTU, respectively. Shipment by rail permits the use of a cask on the order of 100 tons in weight and 8-10 fuel elements in capacity. Shipping 128 spent fuel elements from the site by rail then, necessitates 13 to 16 shipments annually. Shipment by truck limits the cask weight and capacity to 30 tons and 3 to 4 fuel elements, respectively. Trucking 128 spent fuel elements from the site necessitates 32 to 49 shipments annually. In either case, the cask used is specifically licensed by the AEC and DOT.

Solid Radioactive Wastes

The amounts and types of solid radioactive wastes generated for shipment and off-site burial are described in subsection 3.5.3. The shipping container for evaporator bottoms, spent resins, chemical drains, and large filter cartridges and the 55 gallon steel shipping drums used for the other solid radwastes comply with the AEC-DOT regulations governing the design and specifications for such containers. An estimated 18 container shipments and two or three 100 drum shipments are made each year.

3.9 Transmission Facilities

3.9.1 Line Design

Three transmission lines operating at 345-kv will be required to deliver the power generated by Seabrook Units to the New England 345-kv transmission grid. The lines from Seabrook will connect to the 345-kv system at the Newington Station in Newington, New Hampshire, at the Scobie Pond substation in Londonderry, New Hampshire; and at the Tewksbury substation of the New England Electric system in Tewksbury, Massachusetts. The connection to Tewksbury will be made over a 345-kv line that will be installed and owned by Public Service Company from Seabrook to the Massachusetts state line in South Hampton. The balance of the line from South Hampton to Tewksbury will be owned by the New England Electric System.

These transmission facilities are shown in Figure 3.9-1.

The width of a single H-Frame right-of-way is proposed to be 170 feet as shown in Figure 3.9-2. Where the proposed line parallels another, the distance between centerlines is proposed to be 85 feet. The 85-foot separation will allow proper electrical clearance between adjoining lines with a wind condition which could swing the conductors toward a structure of the adjoining line.

The 85 feet from center to edge of the right-of-way is needed for two reasons. The first is electromagnetic requirements. This distance keeps any building far enough away from the conductors so that there will be no interference from the field developed around the conductor. The second reason is reliability. The phase conductors are installed on 26-foot centers, which leaves the distance from the outside phase to the edge of the right-of-way 59 feet. This allows the growth of the trees on the edge of the right-of-way to attain the height of between 55 and 60 feet before they will endanger the line.

Two types of structures will be used in the line construction. The first one is the conventional wood H-Frame, which is similar to those now in service on 170 miles of 345-kv line in New Hampshire. There will be six to seven structures per mile with a height above ground of between 70 and 95 feet, all depending upon topography. The conductor height will be between 45 and 70 feet above ground at the poles. Figure 3.9-3 shows this type of structure. When the sag between the structures is considered, the conductor will be below the top of trees on each side of the line. In other words, this type of structure offers a very low profile. This type of structure is to be used in the majority of the lines because its construction has high strength; it is relatively easy to transport because of the components used, and is lowest in cost.

The second structure is the single steel pole, shown on Figure 3.9-4. This structure will be used in readily-accessible but restricted rights-of-way, and in an area which has for the most part open country for its background. These structures are heavy and require large concrete foundations and accessibility to the structure locations for heavy equipment. Each of the transmission lines has a continuous rating of 1500 MVA with an emergency capability of 2000 MVA. Each phase of the transmission lines will have two conductors bundled on eighteen inch spacing making a total of three pairs of wires. There will also be two overhead static or ground wires for lightning protection.

Radiated Electrical Noise

Electrical noise can be environmentally significant because it manifests itself as television influence (TVI) and radio influence (RI). The former generally is not a problem because its causes can be avoided easily. TVI usually can be traced to poor contact between ungrounded metal parts. Proper mechanical design of transmission structures insures against this type of noise.

RI, on the other hand, is detectable as audible noise on any amplitude-modulated (AM) radio near the energized line. At the edge of the right-of-way the RI has attenuated to an acceptable level. The design factors having most control over RI levels at a given voltage are size and number of conductors, and physical condition of the conductor surfaces. Environmental factors to be considered include earth conductivity, relative humidity, air density, wind velocity and precipitation rates. All of the latter are variable.

The design of the 345-kv lines in New Hampshire will be the same as that used on 174 miles of line in service since December 4, 1970 except that the conductor will be significantly larger. Because there have been no known reported complaints from radio noise from the present lines it is fully expected the proposed lines will also be capable of operating without having radio noise interfering with the public use of radio equipment. The design of the Massachusetts portion of the transmission system is such that the fair weather radio noise level should be no greater than 30 dB above 1 microvolt per meter at a lateral distance of 100 feet from the outside conductor.

During periods of light summer rainfall, the radio noise level will rise approximately 20 dB above the design level based on empirical studies.

Audible Noise

At the 345 kv transmission voltage level, fair-weather audible noise is nearly undetectable, except by a person standing directly beneath a conductor, or next to a structure. During damp weather, and during periods of light rain, the noise level increases, but still is barely noticeable unless a person is standing or walking within the boundaries of the right-of-way. Heavy rainfall increases the ambient noise level to the extent that the noise produced by the line cannot be detected. The noise level is not high enough to alarm or otherwise displace wildlife.

Induced or Conducted Ground Currents

Standard 345 kv construction includes two aerial ground conductors installed parallel to and above the phase conductors. In addition, a buried ground wire, or counterpoise, is installed on the right-of-way beneath and parallel to the line. At each structure, the aerial ground wires are metallically connected to the structure base ground system, which is in turn connected to the counterpoise. This system provides multiple paths for rapid dispersion of lightning surge currents, and makes these structures no more hazardous to humans or animals than any other tall isolated structure or tree.

In case of a short circuit, where phase conductors are inadvertently connected to or in contact with ground, the line is automatically de-energized within 0.1 second.

At locations where vehicles can be parked beneath the line, special consideration is given to clearance of conductors above ground. This assures that persons will not be subject to hazardous electrostatic voltages when they touch the vehicles. For similar reasons, any long metallic fences parallel to the transmission line are grounded at intervals.

Ozone Production

The 345 kv lines are subject to various levels of corona discharge, depending on weather conditions. Corona discharge is the ionization of air surrounding the conductors and other energized parts. One of the products of corona is ozone. However, ozone is not a stable gas and decays rapidly. Tests made in connection with a research project on ultra high voltage transmission at Pittsfield, Massachusetts, indicate that the lines have no clear influence on the ozone concentration in the nearby air, even during periods of heavy rainfall when corona discharge is at its maximum level.

3.9.2 Use of Adjacent Land

Seabrook-Mass. Line

Land usage adjacent to New Hampshire portion of line:

1. Residential & Rural - 39%, Primarily wooded. Residential at road crossing one house lot deep, remainder wooded.
2. Field - 1%, Farm Land
3. Wooded - 55%, (Except for road crossings Item 1 and 2 result in 95% of line being through wooded area)
4. Business - 4%, Local Business
5. Swamp - 1%, Wet Areas

Land uses adjacent to the right-of-way in Massachusetts are as follows:

1. Residential - 4%, or 1.2 miles - These areas are developing rapidly from nearby population centers.

2.	Industrial	- 1%, or .3 miles - Only private small commercial operations such as gravel pits and sawmills exist.
3.	Recreation	- 1%, or .3 miles - Some tennis courts, swimming pools and a skeet range are the only intensive forms of recreation in the vicinity.
4.	Natural	- 89%, or 18.9 miles - Undeveloped forests consisting of immature second growth stands, swamps, bogs and rivers.
5.	Transportation	- 5%, or 1.6 miles - Roads, Railroads

Seabrook - Scobie Line

1.	Residential & Rural (By Zoning Definition)	- 40%, Primarily wooded. Residential at road crossings - one house lot deep. Remainder woods.
2.	Business	- 2%, Local Business
3.	Wooded	- 50%, (Except for road crossings 90% of line through wooded area)
4.	Swamp	- 8%, Wet Area

Seabrook - Newington Line

1.	Residential & Rural (By Zoning Definition)	- 50%, Primarily wooded. Residential at road - crossings. One house lot deep, 2% crosses field land, remainder wooded.
2.	Wooded	- 20%, With Item 1 total for line actually wooded approximately 70%
3.	Agricultural	- 30%, or 9.7 miles - These lands are largely confined to the better draining soils. Principle agricultural activities are dairying, poultry raising, fruit growing and small scale general farming.

Of the total land area adjacent to the transmission right-of-way, it is estimated that the following applies:

4.	Business	- 12%, Local Business
5.	Industrial	- 7%, Industrial Area by Zoning
6.	Apartment	- 11%, By Zoning Definitions

3.9.3 Right-of-Way Clearing

Clearing along right-of-way for New Hampshire portion of lines will be done under the following guidelines:

The types of clearing to be performed by contractors on various parts of a line, or for the entire line, will be marked on the clearing plan furnished by Public Service Company of New Hampshire. Three types of clearing may be involved. Each has its advantages and disadvantages.

Selective Feathering

Feathered clearing will be specified to obtain minimum clearances between line conductors and vegetation on or adjacent to the rights-of-way. This method of clearing involves the most construction cost and future maintenance costs; however it does provide the most screening for the line.

Where this type of clearing is to be performed, the center hub of each line structure will be staked by the Company in advance of all clearing activity at that location. All existing vegetation within the right-of-way limits, including forest type or ornamental trees, shall be preserved to the greatest extent possible, except where its removal is required for erection of line structures or installation of conductors. In all cases, conductor safety clearances for the type and line voltage involved shall be obtained by trimming or topping. Where the amount of trimming or topping required is such as to endanger the normal life of a tree, or destroy its natural symmetry, at road crossings, along improved roads or other locations where high public visibility is involved the tree shall be removed. All trimming, topping or tree removal shall be done in such a manner as to develop an irregular, softened effect that blends the right-of-way clearing into the surrounding undisturbed vegetation without sharply defined breaks or patterns.

The locations where selective feathering will be used are:

1. At road crossings or other special locations of high visibility right-of-way strips throughout these areas should be cleared with varying alignments to comport with the topography of the terrain.

2. On lines, or portions of lines, along highways and city streets.

3. In general, at any designated location along the route of a line where the Company deems it necessary to keep the removal of vegetation on or adjacent to the rights-of-way to a minimum, consistent with reliable line operation.

Clearing of this type shall be performed under the direction of a Company Inspector who also will determine any additional clearing or trimming required at these locations for access roads, erection of line structures and installation of conductors. He, also, will designate all danger trees that require removal after installation of the conductors.

Selective Clearing

Selective clearing shall be performed at locations noted on the clearing plan of line furnished by Public Service Company of New Hampshire.

Where selective clearing is to be performed, clearing shall include the removal of all trees other than the low-growing varieties.

Existing shrubs, herbs and grasses shall be preserved to the greatest extent practical during the clearing process.

Where the maximum sag of the conductors is well above the vegetation growth in gullies or cuts no removal of forest type trees in these areas will be necessary. Only vegetation to be cut in these areas is necessary for wire stringing.

Clear Cut Areas

Clear cut areas shall be performed at locations noted on the clearing plan.

These areas will be located in remote and unaccessible areas where future maintenance of the vegetation would be expensive and difficult.

Preservation of Existing Ground Cover and Ground Contours

1. Contractor shall take adequate precautions not to remove or damage existing ground cover, brush or other vegetation designated for preservation.

The use of bulldozer blades or grubbing blades to scrape and push cut vegetation or trees will not be permitted. This is to prevent removal of or damage to low growth and desirable ground cover.

2. Where rights-of-way cross streams or other bodies of water selective clearing shall be employed unless area is considered to be highly visible by the public or in a watershed area, then selective feathering shall be employed. The distance from the bank of the stream that this type of clearing is to be employed will be determined by the Company Forester and noted on the clearing plan furnished by Public Service Company of New Hampshire.

3. If stream crossings are required by vehicles used by clearing contractor either a culvert will be installed with selective gravel backfill around it or a bridge of some type will be installed.

Disposal of Cleared Vegetation

1. Windrowing of Brush and Timber
   Timber need not be windrowed separately from the wood, but must be broken by a gap twenty feet spaced to coincide with the twenty-foot breaks in the windrows of brush. In no case shall the twenty-foot gaps in windrows be more than two hundred feet apart measured along the windrow.

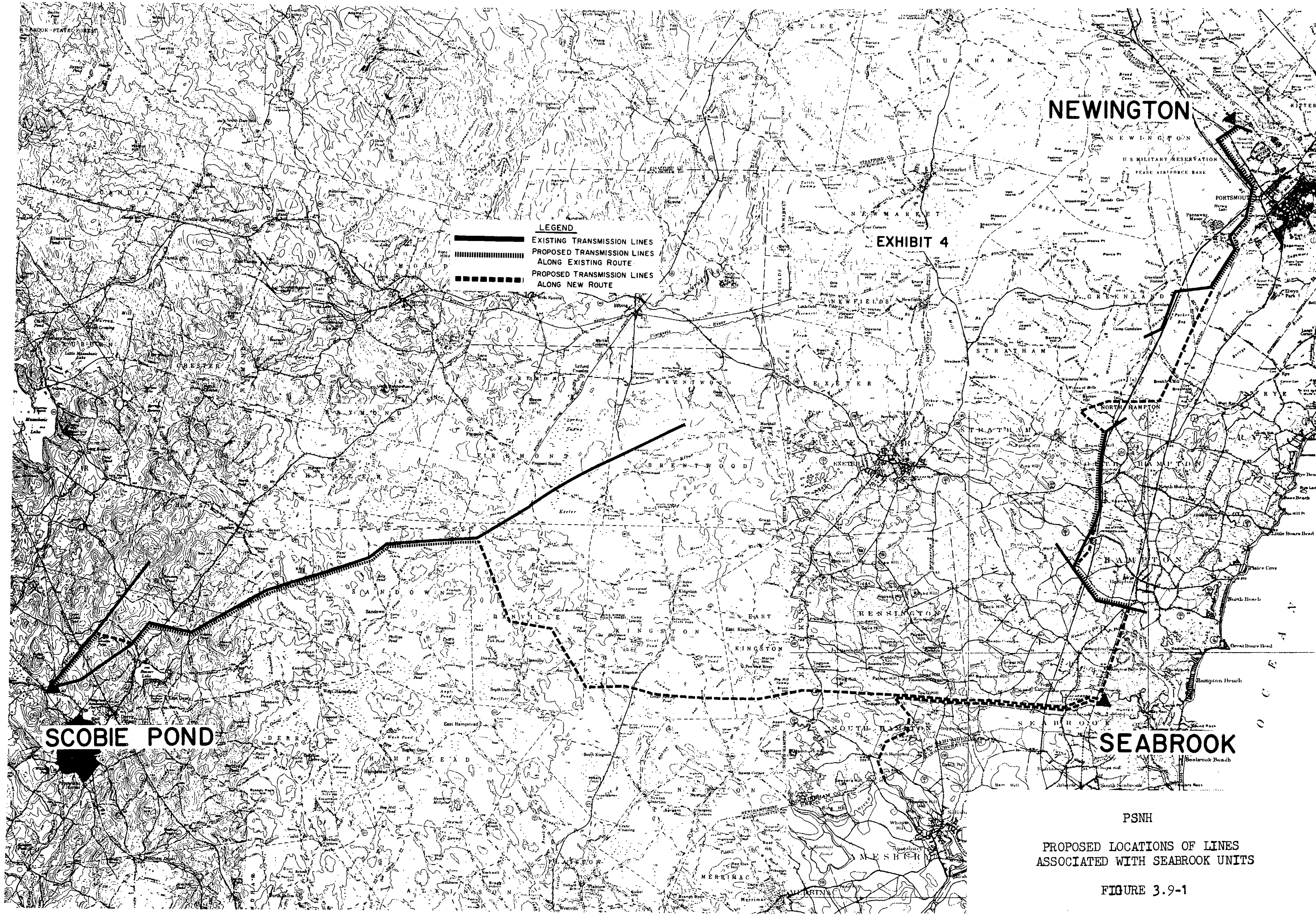
2. Chipping of Vegetation on Rights-of-way
   All growth three inches and under will be chipped and spread throughout the rights-of-way. This chipping will be done in these areas that have been designated as selective feathering and selective cutting.

3. Burning of Cleared Vegetation
   Hand burning may be allowed under special circumstances with permission of local forest fire warden and the Company Inspector. However, before burning is approved notification must be made to the Director of Engineering. Any burning will be done in compliance with all applicable regulations.

Any burning which is allowed shall be done by hand on the rights-of-way in such a manner as not to damage usable logs, wood and vegetation, or other property whether on or off the rights-of-way. No burning shall be done on the survey line, or closer than twenty-five feet to the nearest wire of any power or telephone line.

Clearing of vegetation in Massachusetts will be done during construction of the transmission line and will be done in a manner which will maximize conservation of natural resources and minimize marring and scarring of the landscape. Clearing of natural vegetation will be limited to flora that pose a foreseeable hazard to the transmission line.

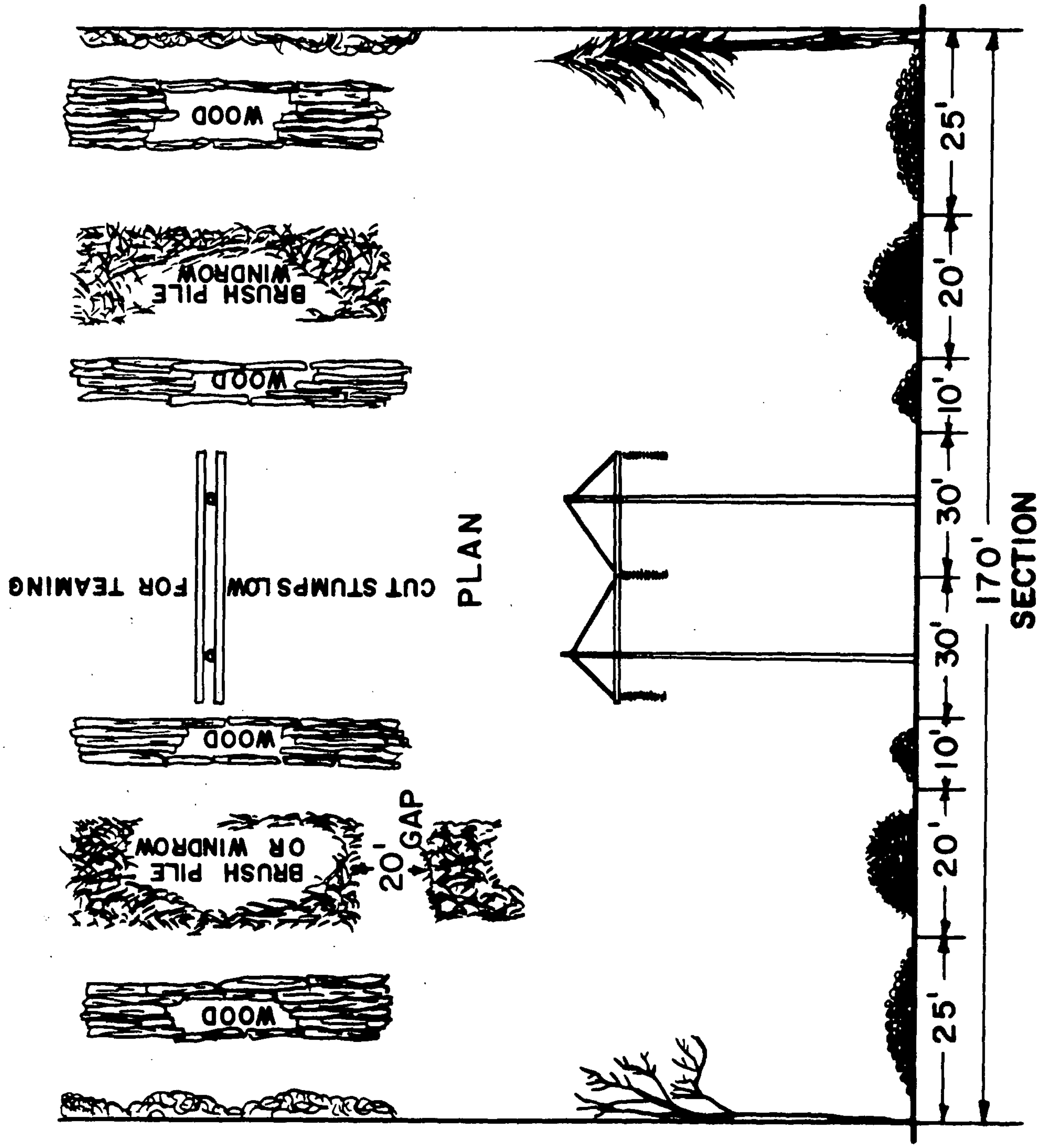
At frequently traveled public roads, maintenance roads will be angled where possible to reduce line of sight up a right-of-way. In high visibility areas, natural vegetative screens will be left to buffer the right-of-way. The proposed line will connect with the New England wide transmission network at an existing substation at Tewksbury, Massachusetts.



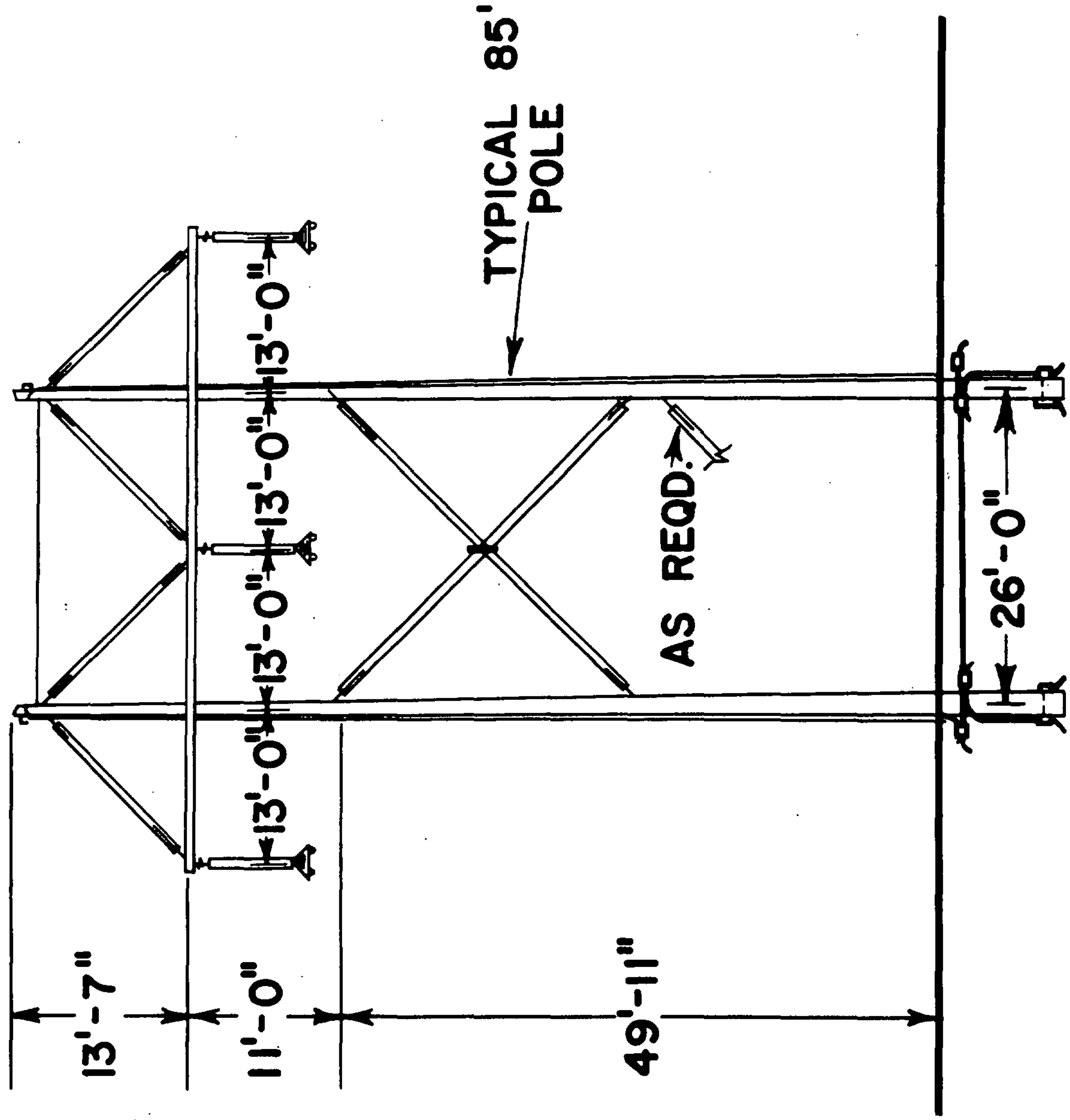
PSNH

PROPOSED LOCATIONS OF LINES
ASSOCIATED WITH SEABROOK UNITS

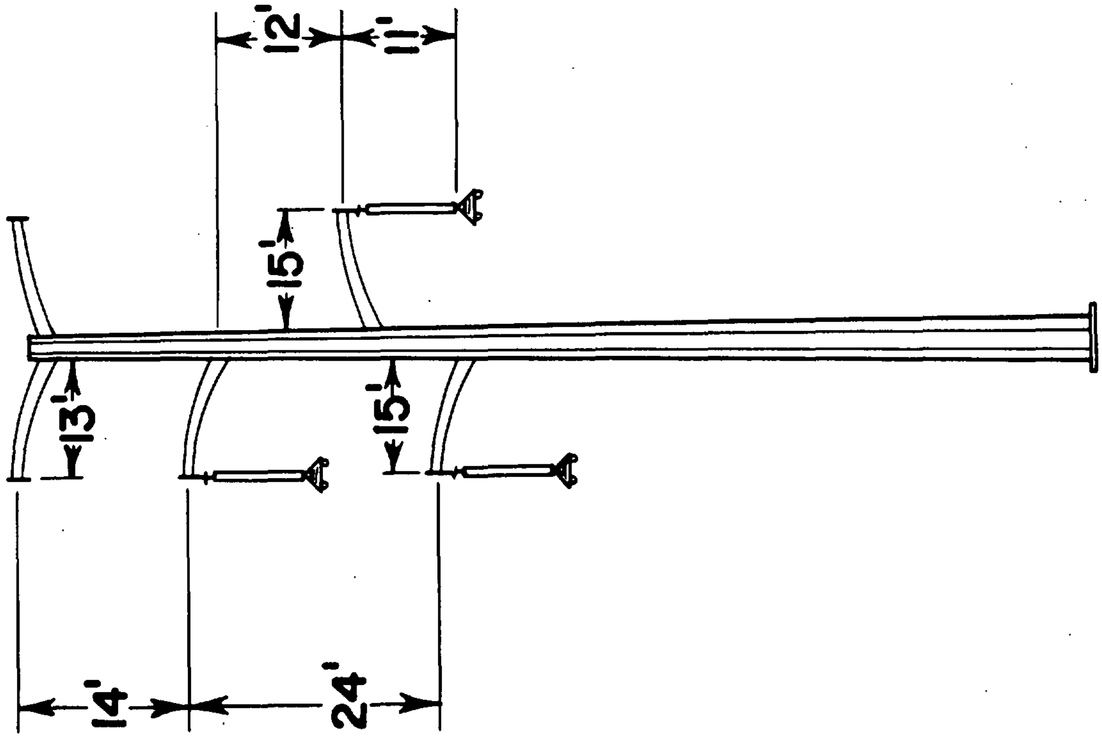
FIGURE 3.9-1



PSNH SEABROOK STATION	345 KV 170' R.O.W. PLAN FOR PILING WOOD AND BRUSH	FIGURE 3.9-2



PSNH SEABROOK STATION	345 KV TRANSMISSION LINE TYPICAL TANGENT STRUCTURE	FIGURE 3.9-3



PSNH SEABROOK STATION	345 KV TRANSMISSION LINE TYPICAL SINGLE STEEL POLE	FIGURE 3.9-4

4. EFFECTS OF CONSTRUCTION

Environmental Report

4.1

4 ENVIRONMENTAL EFFECTS OR SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 Site Preparation and Plant Construction

This section discusses the environmental effects that construction bears on both land and water use. Though there are temporary and permanent changes in each of these areas, the construction program is conducted so as to minimize both the short and long term effects of these changes.

Once started the construction program is expected to continue for a minimum period of six (6) years.

4.1.1 Land Use

Existing Terrain

The tree clearing and site development required for the station creates an unavoidable disturbance to the existing terrain. However, the disturbance is stringently controlled in all areas with tree removal being highly selective and only that portion of vegetation within the confines of the construction area being disturbed.

A tree belt of about 30 feet minimum width will be allowed to remain in place on the periphery of land at the edge of the salt marsh. This serves as a screen to reduce the visual impact the plant may have when viewed from across the marsh. It also serves to help insulate construction noises and prevent their being transmitted unnecessarily beyond the site.

The existing average elevation, above mean sea level, within the proposed layout is about Elev. 18. The proposed yard grade is Elev. 20; so, in general, there is about a 2 feet average increase from the existing ground level. At the east end the average change in the existing ground level decreases by about 2 feet.

The areas which are required for temporary construction activities such as lay down and parking areas, temporary buildings, concrete batch plant etc., are located, where possible, with minor effects on the terrain.

Wildlife Habitat

Surveys and studies of mammals and birds conducted in the area of the plant site indicate there are no rare or unusual species which are located only in this area. Also there is no evidence to indicate the existence of large nesting areas relating to these or any other type of wildlife.

The relatively small number of wildlife now enjoying the habitat will be disturbed and in some cases displaced because of the construction. This displacement is minimal and those contiguous land areas not being affected by the construction effort should be more than adequate to absorb any changes or migrations from the existing habitat.

As a point of interest there are two separate areas within the plant property that are now being used by the Town of Seabrook as an open faced dump. This unacceptable use of the land will cease by the time construction begins. The closing of the dump to any further use is a benefit to the area in general. That portion of wildlife that derived benefits from the dump should be able to sustain themselves in the surrounding land areas not being disturbed.

Building Material Supply Areas

The creation of new building material supply areas cannot be estimated at this time. Construction projects of this magnitude require various types of materials of which many can be purchased locally. It is the policy on this project to purchase from local suppliers whenever possible. The experience on other similar projects in New England has been that these suppliers can usually satisfy the type of demand put on them by the project.

Roads

The existing access road leading into the site from Route 1 is called Rocks Road. It is a public secondary road lined with houses and is paved up to the Boston and Maine Railroad tracks. The roadway then continues easterly through the plant property with a gravel surface and narrow width. The section between the tracks and the plant site, a distance of about 2000 feet, will be relocated and rebuilt. The section east of the plant site may be redesigned as a possible access to a proposed public recreational area. This section is now being used by "parkers" who are littering the area with debris. Access to this area will be restricted when construction begins so this activity should cease.

Another roadway will be installed between the plant area and Route 1 and will serve as the main access to the plant. It will be generally parallel to and north of Rocks Road. The intention is to complete this road early in the construction period. As a result, the traffic load on Rocks Road will be relieved. Also the possibility of traffic congestion on Route 1 will be reduced and a more acceptable traffic pattern and flow during shift changes will be created.

Bridges

A narrow bridge on Rocks Road that spans the railroad tracks is now restricted to a 10 ton load. This is a condition that is unacceptable both during and after the construction period. Loads in excess of this could occur quite often during construction. If it is decided to allow the bridge to remain in use the load carrying capacity will be increased. The bridge is owned by the Boston and Maine Railroad and agreements will have to be reached with them and the responsible civil authority, town or state, to decide what will be necessary to upgrade its structural integrity. Alternately, if the bridge does not remain, a crossing at the grade of the railroad will be installed.

Service Lines

A 6 inch town water line that is now in place on Rocks Road and dead-ended just west of the railroad tracks will be extended into the site. This water is used for drinking and sanitary purposes, plant makeup, and fire protection. The quantities associated with these uses will not put an undue strain on the water supply of the Town of Seabrook.

An existing 345 KV transmission line of single wood pole construction that passes through the plant site will be relocated so as to avoid construction conflicts. This line will also be used to supply construction power requirements.

It is anticipated that no other service lines are required. Sanitary wastes are processed through a packaged treatment plant of proven design that will be approved by the State of New Hampshire and installed on the site. The treatment plant will remain in use following the construction period and is operated by the permanent plant staff. The degree of treatment and type of effluent is controlled under the rules and regulations as set down by the State of New Hampshire. The treated effluent is discharged into the circulating water system and ultimately into the Atlantic Ocean.

Storm drains carrying drainage from building roofs and the plant yard will also be piped to Browns River.

No other liquid wastes are expected to be discharged off the site either in the salt marsh or Browns River.

Disposition of Trash

Material not suitable for reuse or not considered salvageable is disposed of as waste or trash. The trash removal is conducted on a daily basis throughout the construction program. Disposal is off site and in accordance with regulations of the authorities in charge of the disposal area being used.

The open-faced dump located on the plant property and previously mentioned, that is now being used by the Town of Seabrook will not be used. This dump will be closed when construction begins.

Excavation and Land Filling

Excavation or land fill occurs in several areas including: access roads, main plant area, railroad spur tracks and to a lesser extent those areas required for temporary construction activities.

The land within the plant boundary is finish graded to Elevation 20. Excavations reach the deepest in the Reactor Containment and Primary Auxiliary Buildings and are as much as 85 feet below yard grade. The other building excavations range between 10 feet and 40 feet below yard grade. A large amount of this excavation material will be rock and only the latest techniques of rock removal are employed. The existing surface of the rock slopes downward generally in a westerly and southerly direction from Elevation 25± to Elevation 0± within the station layout.

Though they are expected to be measurable predicted quantities of excavated material are not available at this time. Excess material remaining after backfilling has been completed will be deposited on the site. It will be deposited only in those areas that derive a benefit from the added material. The topsoil will be stripped and stockpiled for possible reuse in landscaping after construction is completed.

Quantity of Land Disturbed

The main plant area including the proposed education center will require the clearing and land disturbance of about 40 acres. The rail spurs and other areas used for construction require the additional use of about 55 acres.

Within the main plant area it will require about 3 years time to backfill around the foundation structure after excavation begins. At this stage, there will be some semblance of what the final grades and outline of the plant and plant roads look like. Finish grading and paving will not proceed until construction is complete.

The rail spurs are installed very early in the construction period so construction deliveries can benefit from their use. This activity requires several months to complete.

Those areas disrupted for construction purposes are restored as completion is approached and as their functions diminish in use.

Smoke or Dust Problems

Construction activities are controlled so as to minimize any continuous smoke problem. The burning of rubbish or debris will not be permitted. They will be disposed of off-site in accordance with local regulations. The burning of brush or timber from the land clearing also will not be permitted. It is intended that these items will be processed through wood chippers. The resulting wood chips may be used as mulch for landscaping on the property and any excess will be disposed of off-site.

No open fires will be permitted. Heating boilers, construction equipment exhaust, roofers "pots" etc. are characteristic sources of the insignificant amount of smoke that will be created during the construction period.

A dust problem will be created during construction but the problem will be limited to the site area and will not create an undesirable effect on the area. It will be more pronounced during the earth moving phase of the project and this will occur early in the construction timetable. In an effort to control the problem a water truck will be assigned to the site and will be available on an "as required" basis to spray the dusty areas.

Explosives

Explosives are used on the project, generally in rock excavation. They are used on an intermittent basis for about 2 years. This work is controlled under the terms of regulatory permits for storage and use. Also, they are used in accordance with manufacturer instructions and, in some instances, with their technical assistance. Only personnel experienced in this type of work will be used. Efforts are made to insure that the explosives are used safely and that no damage to outlying properties takes place. Design conditions discourage damage to the rock adjoining that area being removed, thus necessitating extreme care in the blasting techniques used.

Undesirable Impacts On Population

The construction force on site will gradually build up to a peak force of about 2000 men and will remain at that level for about 3 years. Approximately 1500 vehicles will be moving onto and out of the site each day, creating a potentially undesirable impact on the residents of Seabrook. However, with the aid of traffic controls, where necessary, and the use of the additional access road mentioned previously this activity can be controlled and the impact limited.

Truck deliveries are expected to peak at the rate of about 100 per day. This type of traffic will be diverted to the access road and should not be a problem for Rocks Road residents. Some form of traffic control will be instituted at Route 1 in conjunction with local and state authorities. The railroad spur track to be installed will be available for construction deliveries. Rail car deliveries could number in excess of 1000. This will reduce the number of truck deliveries that otherwise will have had to be made. Arrangements will be made with the Town of Seabrook to assure that Rocks Road will be kept in good repair in the event of damage caused by the traffic relating to the project.

Noises associated with the construction effort should not create an undesirable effect. Construction equipment like trucks, cranes, earth movers, pile driving equipment, pumps, compressors, etc. create noise, but in general this noise is limited to the site area. The remoteness from the site boundaries will cause a significant attentuation in noise levels to occur by the time the sounds reach the site boundaries and should have no greater effect than that caused by the traffic on Route 1.

The periodic use of explosives will require the use of blasting mats which will serve to muffle the noise and avoid flying rock.

As the job progresses the noise level should diminish because the work will then be concentrated within the walls of the buildings.

Most of the workers involved on project construction will commute from nearby cities and towns in Massachusetts, Maine, and New Hampshire. A small force of engineering and supervisory personnel will relocate in the area with their families for the duration of the project. There will be no significant impact on school enrollments or unusual demands on other public services caused by the influx of workers to the project. Experience on other large construction projects in the area has shown this to be the case.

Measures To Reverse Undesirable Effects

The measures used in mitigating undesirable effects caused by construction have been discussed. Final plans for areas of erosion control, dust stabilization, landscape restoration, traffic control and the restoration of the affected animal habitat will be developed as the construction program approaches completion.

A qualified landscape architect will be retained to design the landscaping. The areas of erosion control, dust stabilization and animal habitat could become the responsibility of this architect should they be a problem. The policy of disrupting only what is unavoidable for construction will endure for the duration of the project. This will lead to a minimum disturbance of areas immediately adjacent to the station site. An attractively landscaped installation will result from these efforts.

The traffic caused during construction is expected to be significant. Attempts will be made to develop patterns that will minimize congestion and allow for the free and easy flow of traffic. No traffic problems are anticipated following the completion of the project. The vehicular activity associated with the plant during operations will not be significant and truck traffic will be minimal.

There are no known historical or archaeological features associated with the site.

4.1.2 Water Use

Construction will cause only minor environmental effects to the use of water. These effects will occur during the installation of the circulating water system and, more specifically, during the construction of the offshore tunnel shafts and structures. The operation and heat dissipation characteristics of this system are discussed in Section 3.4. Figure 3.4-2 illustrates the route of the tunnels as they leave the plant and extend eastward under the marsh, Hampton Harbor, Hampton Beach and terminating offshore with the tunnel shafts and structures. The discharge tunnel is approximately 13,000 feet long and the intake tunnel is approximately 15,000 feet long.

All dredging and construction operations are conducted in accordance with applicable state and federal regulations. Research will be performed to determine the turbidity tolerance levels of indigenous marine species. The results of this study will be reviewed with appropriate agencies to establish acceptable levels of turbidity. Construction procedures will be selected and monitored to determine if levels can be practically maintained.

Construction methods and procedures are not finalized at this time. The methods discussed in this section reflect the planning as it is presently developed. As more information becomes available, alternate construction methods will be evaluated and those most suitable to the conditions will be used.

Tunnels

The concrete lined tunnel, which has a modified horseshoe shape, is driven using conventional type equipment and methods. A jumbo, containing a gang of rock drills and arranged in a predetermined pattern, is used in the first of an operation cycle that includes drilling, loading, shooting, mucking, scaling, and rock bolting. A typical cycle could advance the excavation about 10 feet.

The drilling, loading and shooting refer to the drilling of the holes, loading them with explosives and finally in a time delay sequence detonating the explosive. The drilling pattern and time delay sequence are predetermined and are dependent on the type and amount of rock to be removed.

The mucking operation refers to the removal of the shot rock which is loaded on a rail type car and transported on rails back through the tunnel to the base of the land shaft. From there it is transferred to a conveyor system that hoists it to the top of the shaft where it is made available for disposal.

During the mucking operation, the jumbo is backed away from the working face. After mucking and while the jumbo is being advanced back to the face, the scaling operation is performed. The surface of the excavation is carefully inspected for loose or jointed rock slabs that may cause a safety hazard by dropping in the tunnel.

Rock bolts or straps are installed in those rock areas that contain fracture zones, joints, sand seams or other conditions that will contribute to unstable rock faces. If these conditions exist for measurable distances then alternate means of reinforcement, similiar to steel rib supports and grouting, will have to be employed.

Normally, the concreting is not started until the tunnel has been driven the entire distance. It will be installed in 40-50 foot sections with the arch and walls being done first and followed by the invert. This sequence allows the rails to remain in use for a longer period of time.

The explosive requirements for this type of work are recognized as a potential contributor to noise levels and vibrations that may prove objectionable. The blasting program will be designed with this in mind and should result in no permanent damage to the environment. Prior to and during the construction period, surveys are made along and in the vicinity of the tunnel routes to record any changes in conditions that may result from the work.

A carefully designed exploration program is being conducted to gain the information necessary to design and construct the tunnel. The program includes rock and soil sampling and testing, collecting geological data, determining rock mechanics etc.

Shafts

The concrete lined land shafts are installed also using conventional methods and equipment. However, the offshore shafts, also concrete lined will require special methods. Figure 3.4-1 shows the profile of the tunnels and makes note of the depth of each shaft.

The land shafts are excavated by installing a caisson down through the overburden to the top of the rock. The earth material is removed by clam shell buckets or conveyor system connected to a head frame at the top of the shaft. A dewatering system will be provided to control the entrance of groundwater into the shaft.

The rock is drilled, blasted and removed in the same manner as the overburden. The wall of the shaft is inspected for loose rock and fracture zones and other features that may require special attention prior to pouring the concrete liner. No special procedures are expected to be required for installing the concrete liner.

The installation of the offshore shafts will require more complex methods. Procedures similar to those used for the installation of bridge piers will be used.

A large prefabricated water tight steel caisson type vessel is floated into position. By adding ballast within its walls, the vessel is lowered to the ocean bottom. The cover is removed and the caisson height is increased by the addition of steel rings. More ballast is added and with the aid of water jetting, the caisson is lowered through the overburden to bedrock. Excavation of the overburden within the caisson is performed in the wet. A concrete mat containing rock anchors to protect against uplift and overturning is installed under water. This seals the bottom and permits dewatering to take place. The work area within the caisson is now ready for the drilling of the shaft under dry conditions.

This shaft will be excavated by drilling, reaming, and slashing. A pilot hole 12-inches in diameter is drilled down through the roof of the already excavated tunnel. A reaming bit containing a number of cutters mounted in a cone configuration is drawn upward by a shaft in the pilot hole. Sufficient pressure is applied to ream the pilot hole to a much larger diameter, about 6 feet. This larger diameter hole with its smooth walls is used during the mucking operation as a disposal chute for the shot rock.

The next operation is drilling and shooting of the remaining rock to be excavated. This is done in lifts of about 10 feet. The drill pattern and delay sequence will provide a funneling effect and allow the shot rock to pass through the reamed hole with more ease. After each lift is mucked, the scaling operation as is done in the tunnel is performed and rock faces are sealed or reinforced as required.

The shot rock that falls to the tunnel is loaded on the same rail type cars used in the tunnel excavation and disposed of in the same manner.

The concrete lining is installed using conventional methods and is performed under dry conditions.

Offshore Structures

Both tunnels will require offshore structures that are located over the riser shafts.

Figure 3.4-4 shows a proposed inlet structure. It is a concrete structure with a hexagonal center hub located over the intake tunnel riser shaft.

Six (6) identical wedge shaped sections are attached to the sides of the hub. The hub is installed in the dry inside the caisson used to construct the shaft. After the caisson is removed the wedge shaped sections, which are prefabricated onshore, are brought offshore and individually lowered into position on the already constructed hub. Provision is made for installing a removable cover to allow access to the structure for inspection and maintenance both during and after the construction period.

Figure 5.4-2 shows the location of a proposed discharge zone in which the circulating water will be discharged through a submerged multi-port diffuser pipe. This diffuser pipe is 11 feet in diameter and contains a number of smaller diameter ports through which the water is discharged. Studies are currently underway to determine the type, length, location, and direction of this diffuser. Design details will not be available until these studies are complete.

However, a concrete structure that will connect the pipe to the riser shaft of the discharge tunnel will be required. This structure will be less complex than the inlet and will be constructed under dry conditions inside the caisson following the installation of the discharge riser shaft.

The diffuser pipe may be partially or fully buried under the overburden. Conventional offshore dredging equipment will be used to install the diffuser subaqueously.

During the installation of the circulating water system, care will be taken to provide safe unobstructed passage for all boat traffic. At no time during the construction process will there be a hazard to navigation.

About 400,000 cubic yards of material will be excavated. No problems are anticipated in disposing of this material either off or on the plant site.

It is anticipated that construction of the circulating water system will require about 3 1/2 years of time starting 1975.

Beneficial Effects To Region

The construction program is designed to respond to environmental concerns. The construction impact will be minimized through the use of existing disturbed areas such as dumps and rights-of-way for transmission lines. Following their use during construction these areas will be restored by replantation or other means so as to compliment the general area.

Areas of recreational and visual significance such as the Rocks at the east end of the property and the coves at the edge of themarsh will be preserved. Access to these areas will be provided if permission is granted by the responsible regulatory body. Public access to the clam flats, salt marsh and the Browns River will be continuously maintained. There will be no filling in the salt marsh.

Recreational facilities for the Town of Seabrook can be established by installing ball fields and playgrounds on land west of the railroad tracks near the Access Road.

A proposed Education Center to be erected on the site will supply educational opportunities to the community. These opportunities could relate to both the environmental and nuclear fields.

The plants will contribute in large measure to the economy of the area. The large construction payroll and the purchase of miscellaneous construction materials and services will be significant and should lead to a beneficial effect on the business climate in the area.

Following construction, the plant will require a force of approximately 125 men to operate the plants. These are permanent personnel, who for the most part are professionally and technically oriented, and who will lend responsible citizenship to the area. These newly created jobs will require an annual payroll in excess of $1,500,000.

During construction the property tax is estimated to amount to $15,000,000. After construction and during the life of the plant the annual property tax is expected to be significant and will be of special importance in broadening the tax base. Very little town services will be required from the Town of Seabrook in reutrn for these tax dollars. The plant except for fire and police protection and some outside water requirements is substantially self-sufficient.

4.2

4.2 Transmission Facilities Construction

During construction, there will be an out migration of wildlife because of the proximity of men and machines. Trees will be cut in the right-of-way to allow construction of the line and improve its future reliability. Brush and wood will be placed in compacted piles in the right-of-way or chipped in highly visible areas. The transmission right-of-way supplies valuable open areas for small game and deer, while the brush piles provide nesting and refuge for birds and small game. The Fish and Game Department of the State of New Hampshire and the Massachusetts Department of Natural Resources have stated that more open spaces are needed. This is being partly provided by these lines.

There will be very little change in hydrology. Stream crossings will be controlled in accordance with New Hampshire Dredge and Fill Permits RSA #149:8-A and with Massachusetts Chapter 784, Acts of 1972, "The Inland Wetlands Act". Soil will be disturbed as little as possible. No machine grubbing will be allowed. No burning will be permitted. Graded areas that will not reseed naturally will be reseeded. Water from rain should be absorbed readily and runoff patterns will not be changed markedly.

Topography along the rights-of-way will be changed only slightly, if at all. At structure locations, the area will have a minimum of grading to allow installation of the structure. At "reel and puller" setups, there will be an area graded for safe and proper operation of the equipment. Upon completion of work around structures and setup locations, the area will be cleaned up and allowed to reseed or if necessary will be reseeded.

4.2.1 Transmission Line Routings

The Seabrook - Newington Line crosses U.S. Route 1 and the Exeter and Hampton Expressway once, I-95 three times and parallels I-95 for approximately two miles. Two crossings of I-95 will be screened on each side of the crossing, but the third crossing is at the junction of I-95 and Eastern New Hampshire Turnpike. This crossing and the remainder of the distance to the Newington Substation will have structures that are of single circuit single steel pole construction similar to the existing structures through the interchange area.

The portion of the line parallel to I-95 will have a 100 foot buffer strip containing mixed hardwoods and some conifers to screen the bulk of the line from the highway. Because of the number of local and major road crossings on this line, much of the right-of-way will be either selectively feathered or selectively cut to reduce the visual impact.

As it leaves the plant, this line crosses a portion of the marsh in Hampton Falls on an existing railroad right-of-way. The construction proposed will be single circuit single steel pole.

The Seabrook - Massachusetts Line (Tewksbury Line) and Seabrook - Scobie line cross the U.S. Routes 1 and I-95. The Seabrook - Scobie Line continues and crosses major New Hampshire Routes 125, 102, and By-Pass 28. Most crossings will be well screened on both sides of the highways. The crossing of Routes 102 and By-Pass 28 will be somewhat open because of existing transmission lines paralleling the proposed line at these locations. Selective feathering will be used where possible to allow a fill-in of growth to reduce visual impact.

The Seabrook - Scobie lines crosses a natural area - Cedar Swamp. Special consideration will be given to this crossing including location of structures, control of that clearing which will be permitted, the time of year for construction and the method of construction.

Because of high urban populations in the Massachusetts portion of the Seabrook - Tewksbury Line the transmission facilities will be visible at certain locations to a great many people; particularly at the major roadway crossings at I-495 and I-93 and that portion paralleling Massachusetts Route 213. Existing transmission facilities are found at all of these high visibility points; thus, an additional circuit will have only an incremental visual impact as opposed to creation of a new visual impact. The three I-495 crossings, the three miles paralleling Massachusetts 213 and the I-93 crossing will receive special aesthetic treatment to minimize their scenic impact.

This will be done by considering the following factors:

1. Structure design.
2. Span distance.
3. Structure location and elevation.
4. Conductor type.
5. Color schemes.
6. Structure material.
7. Insulator types.
8. Natural vegetative screens.
9. Vegetative planting.
10. Access road location.

The Merrimack River will be crossed three times adjacent and parallel to existing transmission facilities. This will not have any effect on the river bank or river flow itself. The structures will be set back from the river to minimize their scenic impact and vegetative screens will be placed where the impact necessitates.

Merchantable logs remain the property of the landowners and will be neatly piled at the right-of-way edge. Slash will be handled in the following manner: Near homes, road crossing and other areas of high visibility it will be reduced to wood chips; in swamps it will be cut into small lengths and left in place to decompose; along the rest of the right-of-way the slash will be placed in compacted piles with a minimum of a 10 foot space at least every 200 feet along the right-of-way. These serve as brush pile shelters providing wildlife habitat.

All construction debris will be properly disposed of. Any areas in which the soil has been disturbed will be graded to soften contours and seeded and mulched where necessary for erosion protection.

4.2.2 Construction Access

In New Hampshire a temporary road will be constructed along the line routes. Where two lines share the same right-of-way only one road will be constructed.

Where new lines parallel an existing line the access will be on the old right-of-way to minimize the damage to the ground in the recently cleared areas. No permanent roads will be constructed. Swamp and bog areas will be reviewed individually before any temporary roads are constructed. As much construction as possible will be performed during the winter months so that a minimum amount of temporary roadways will be constructed through these areas. In Massachusetts of the 32 miles of transmission right-of-way, 29 miles have existing access roads for operation and maintenance. Thus, new access roads will be required on only three miles of right-of-way.

Roads will be constructed along existing topography where possible within the right-of-way, rather than through cut and fill section to minimize erosion. Precautions will be taken to control erosion and silt deposition in water courses. Culverts or bridges will be placed where roadways cross stream or damage swales.

A combination of seeding and encouraging low-growing vegetative cover will be used to stabilize the soils to prevent erosion on slopes.

4.2.3 Protection of Wildlife

The development of a transmission right-of-way helps and does not hinder wildlife production. The natural land area involved in the transmission right-of-way is now 75 percent forested and 25 percent open field in Massachusetts and 90 percent forested and 10 percent open in New Hampshire. Since most of the fields are farmed or intensively used, the forests and swamps are the only wild habitats available. However, because of the lack of open space in these swamps and forests, young vegetation cannot get the sunlight to grow. This suppresses food, protection and nesting cover. As a result, wildlife managers have taken measures to open up forests for better wildlife habitat. Transmission line rights-of-way aid in this objective.

An open right-of-way has a bearing on the ecology of an area. The transition between two or more diverse ecological communities as between a forest and an open right-of-way, is called an ecotone. This forest edge, created by the right-of-way, commonly contains many of the plants and animals of each of these overlapping communities. Thus, both forest species and open-field wildlife find habitat in this edge. There are also certain species that live exclusively in an ecotonal region. As a result, there is found to be a greater variety and density of wildlife in this ecotone. This is commonly called the "edge effect".

The increased and diverse vegetative cover benefits wildlife which receive varieties of habitat, food and shelter.

4.3

4.3 Resources Committed

Numerous resources are involved in construction and operation of a nuclear power station. These resources include the land upon which the facility is located, the materials and chemicals used to construct and maintain the station, the condenser cooling water, fuel used to operate the station, and groundwater used during construction and startup.

The only resource used in significant quantity that is irretrievably committed is the nuclear fuel. The fuel consists of uranium which has been enriched to contain an average of 2.30 weight percent Uranium-235 for the initial core loading; Uranium-238 makes up the remaining 97.7 percent. Reload fuel to replace that discharged at each refueling shutdown will contain about 3.19 weight percent Uranium-235 or an equivalent amount of fissile plutonium. The uranium not consumed during operation and the net plutonium generated are reclaimed and are available for recycle in subsequent operating cycles. This reclaimed material will average 96 percent of the amount charged. With recycle of reclaimed uranium the Uranium-235 consumption for each unit will average about 0.74 metric tons per year or about 30 metric tons for 40 years of unit operation. Recycle of plutonium would reduce these quantities to about 0.60 metric tons per year or 24 metric tons for 40 years of unit operation.

Of the land used for station buildings, it would appear that only a small portion beneath the reactor, control room, radwaste and the turbine-generator buildings would be irreversibly committed. Also, some components of the facility such as large underground concrete foundations and certain equipment are, in essence, irretrievable due to practical aspects of reclamation. The degree of dismantlement of the station, as previously noted, will be determined by the intended future use of the Rocks area, which will involve a balance of health and safety considerations, salvage values, and environmental effects.

For the three lines proposed in New Hampshire there will be 800 acres used as right-of-way. The line in Massachusetts will use 485 acres of right-of-way. The land being proposed for use as right-of-way for these lines is, for the most part, wooded and has a poor grade growth with very little marketable timber. The growth in New Hampshire is about 60 percent hardwood and 40 percent softwood. In Massachusetts the ratios are 75 percent hardwood and 25 percent softwood. All growth in both states is second and third growth.

To our knowledge there are no forest management areas being tranversed by the proposed lines. There is a tree farm in Boxford in close proximity to the Massachusetts line which will not be affected.

The Seabrook - Scobie Line crosses a natural area named Cedar Swamp. Minimum clearing will be involved at the tower locations employing selective feathering.

No clearing will be needed across main body of swamp because it is all swamp grass. No chemical treatment will be applied through this area.

There will be no irreversible or irretrievable commitments made in construction of these 345-KV lines. The only resource that will be removed will be the land area used for the structure foundations. The remainder of the rights-of-way remain in a natural state supporting low growing vegetation and ground cover and will provide food and habitat for birds and small game species. Most of the right-of-way will have potential for multiple use, exclusive of structures, for such things as recreation, agriculture, tree farming and game management. Should the transmission line ever be removed, the land would revert to its natural state and become reforested within 20 years unless it is put to use by man for other purposes.

The plant use of groundwater during construction will be about 35,000 gallons per day (24 gpm). This will be drawn from the Town of Seabrook municipal water supply system which in 1972 had a capacity of about 1100 gpm. The water pumped during the year of 1972 was 256,128,900 gallons (about 488 gpm) which represents about 44 percent of the present capacity of the town's system. The average annual increase of 40 gpm per year until 1990 as predicted in Table 2.5-21 will bring the average amount of water pumped to about 768 gpm in 1979 which represents 70 percent of the

1972 capacity. Adding the 24 gpm for construction will bring the total in 1979 to 792 gpm which represents 72 percent of capacity.

During Unit 1 startup, scheduled for 1979, the plant will use about 20×10^6 gallons of water over a 9 month period. The maximum rate is expected to be about 350 gpm. This additional requirement will be drawn from the Seabrook municipal water system and will be provided by the addition of a well with a capacity equal to at least the required 350 gpm. Thus the additional plant water demand during startup will not constitute an increased utilization of Seabrook's municipal water supply system.

During Unit 2's startup scheduled for 1981, the same water requirement as Unit 1 startup will be imposed upon the municipal water supply system. The well added for Unit 1 will also compensate for Unit 2's startup water demand. The 20×10^6 gallons used during the 9 month startup periods in 1979 and 1981 will represent about 5 percent of that consumed by the Town of Seabrook in 1979 and about 4.5 percent in 1981.

The use of the environment (air, water, land) by the station does not represent significant irreversible or irretrievable resource commitments, but rather a relatively short-term investment. The biota of the region have been studied including the probable impact of the station (Section 5). In essence, only minor damage or loss to the biota of the region has occurred or is anticipated.

Other resources are either left undisturbed, or committed only temporarily during construction or during the life of the station and are not irreversibly or irretrievably lost.