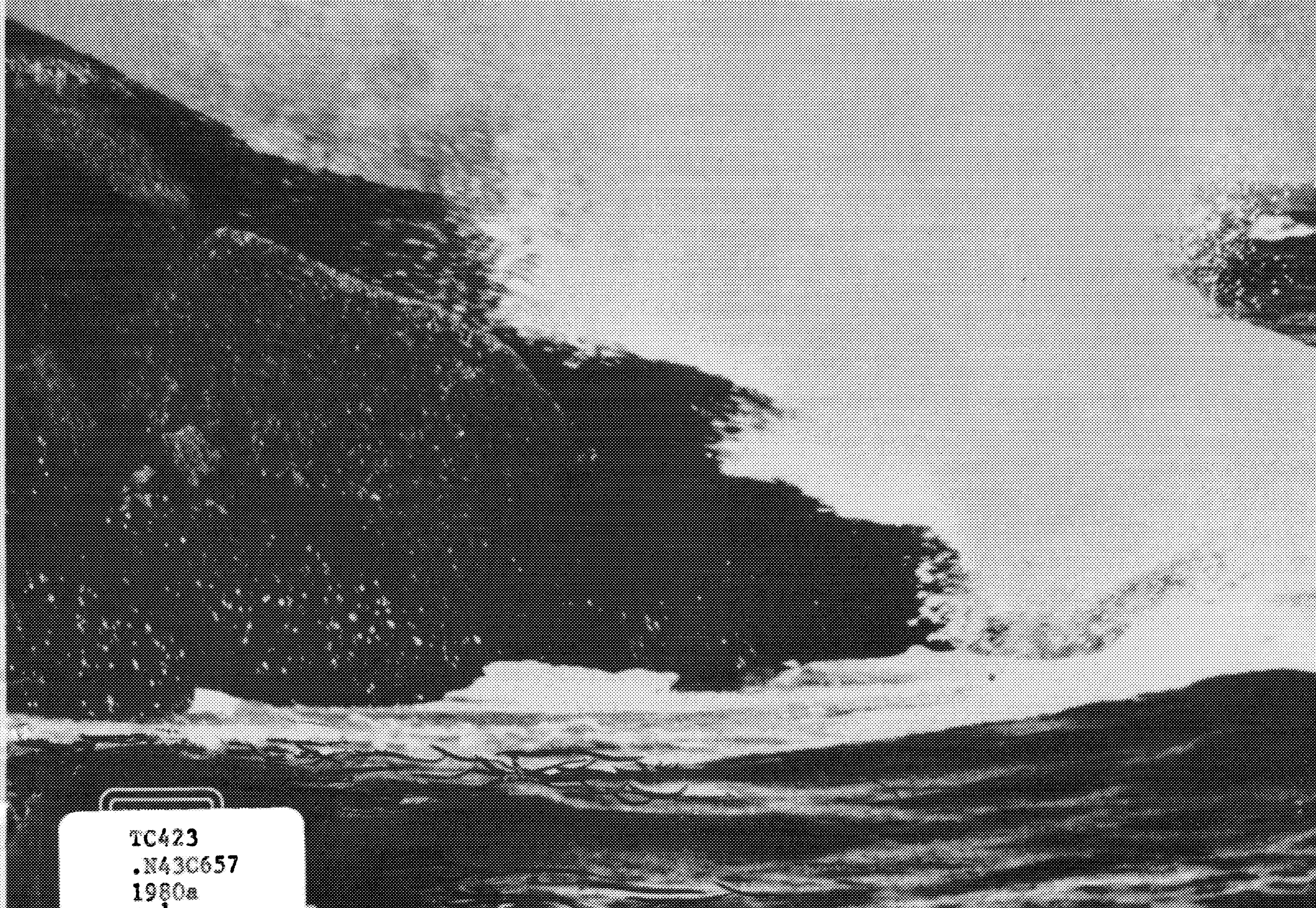
INVESTIGATION OF TIDAL POWER

Cobscook Bay Maine



New England Division

AUGUST 1980

Investigation of Tidal Power
Cobscook Bay, Maine

August 1980

U.S. Army Engineer Division, New England
424 Trapelo Road
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INVESTIGATION OF TIDAL POWER
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EXECUTIVE SUMMARY

This report presents the results of an expanded reconnaissance study of the feasibility of developing large scale tidal hydroelectric power facilities at Cobscook Bay, Maine. Since studies were first authorized by Senate Resolution in 1975, a series of investigations have been conducted dealing with the economic feasiblity of developing such a project. This report differs from earlier reports in that environmental baseline conditions are presented, potential social and environmental impacts are identified, and consideration has been given to the marketing and integration of intermittent, single pool tidal power into the existing New England electrical system.

A major change has occurred in the methodology used by Government agencies to determine the economic efficiency (benefit-to-cost ratio) of public power projects. Recent Water Resources Council (WRC) rulings recognize that "In many cases, benefits may vary over the life of a project. This may be due to such factors as staged development of the hydropower project, changes in operation of the hydropower project resulting from changes in the resource mix in the total generating system, and real escalation in fuel costs (if the most likely alternative is a thermal plant)." In past reports New England Division performed economic analyses taking into account real escalation of fuel costs. This report, which is based on such an analysis, verifies earlier findings that certain tidal power projects within Cobscook Bay are economically efficient, that is, have benefit-to-cost ratios greater than unity when analyzed within the relative price shift (real fuel cost escalation) framework.

In this report four single pool alternatives are considered. Earlier studies indicated that single pool, single effect projects are capable of producing energy at lower costs than other configurations. The alternatives considered are located at Dudley Island, Goose Island, Birch Point and Wilson Ledges and ranged in size from 18 to 970 megawatts. After preliminary cost estimates were made, two alternatives were selected for further analysis, Birch Point and Goose Island. The Federal Energy Regulatory Commission (FERC) has developed power values utilizing relative price shift analysis. In accordance with recent WRC guidance, relative price shift analysis takes into account the differential price changes among commodities without including the effect of general inflation; in the case of energy values, fuel price escalation is considered. Based on analysis utilizing Department of Energy fuel price projections, FERC provided an energy value of 108 mills per kilowatt-hour.

No capacity credit has been taken at this time. Detailed studies may be undertaken at a future time to determine whether value should be associated with tidal project capacity. A summary of costs and benefits for the two projects is presented in the following table:

Location	Birch Point	Goose Island
Installed Capacity	165 MW	195 MW
Dependable Capacity	0	0
Annual Generation	560,000,000 KWH	660,000,000 KWH
First Cost of Tidal Power Project (August 1980)	$675,800,000	$734,300,000
Annual Cost Including Transmission (7-1/8%, 100 years)	$53,213,000	$57,685,000
Annual Benefit Including Energy at 108 mills/Kwh and Employment Benefits	$63,110,000	$74,083,000
Benefit-to-Cost Ratio	1.2 to 1.0	1.3 to 1.0

Despite the intermittent nature of single pool tidal power, New England's power planning group (NEPOOL) has stated that tidal power could be integrated and utilized within the New England system. According to current estimates by FERC, it appears that the tidal project will displace oil-fired generation.

The question of finanical feasibility has been addressed, but it is unresolved. For a project to be financially feasible, the power produced must be sold at a rate that will allow the Federal Government to recover its investment within 50 years, assuming an 8% rate of interest. The Corps of Engineers does not market power it produces. The Department of Energy (DOE) is responsible for marketing. Currently, the Southeastern Power Administration (SEPA) is the DOE agency most likely to market any power generated at Cobscook Bay. SEPA has determined that Cobscook Bay energy would have to be sold for 94 mills/Kwh using recent cost estimates in order for the Federal Government to recover its investment within 50 years. Based on existing market conditions (energy costing about 45-50 mills/Kwh), SEPA determined that there would be no market for tidal energy. However, no attempt has been made to ascertain what market conditions will exist in 1995. Using relative price shift analysis and DOE fuel price projections, FERC has estimated that the real cost of energy (excluding general inflation) will be 108 mills/Kwh in 1995. If this estimate proves to be correct, a rate of 94 mills (excluding general inflation) would be relatively attractive. However, at this time, a relative price shift analysis has not been undertaken for financial analysis.

Environmental evaluations presented in this report provide information for the Cobscook Bay area as a whole. Impact analysis is generic in nature. This approach was taken as the operational modes of the various dam alignments have not been finalized. Should further studies be authorized, an intensive analysis of the impacts due to the development of tidal power in Cobscook Bay would be carried out.

A tidal power project would result in major impacts on the marine, estuarine, and riverine systems in the project area. Any alterations to these systems would affect circulation, salinity, sedimentation, temperature, shoreline erosion, flushing, ice formation, and nutrient levels. Nutrient and sediment supply would be reduced in intertidal areas and beaches, which, in turn, would result in significant alterations in the estuarine biota.

Commercially important invertebrates that are found in the Cobscook Bay area include: soft-shell clams, blue mussels, sea scallops, American lobsters, rock and Jonah crabs, northern shrimp, bloodworms and sand worms. Impacts on benthos due to construction activities would occur during dredging and filling operations. The presence of large tidal dams would cause an increase in sedimentation due to the reduction in the tidal regime, as well as loss of mixing within the water column would affect the existing organisms.

Nine species of marine mammals are common to the Gulf of Maine and the Cobscook Bay area, and include the fin, minke, humpback and right whales, the harbor porpoise, the harbor seal, and gray seal. Impacts on these mammals during construction would most likely be minor; however, the larger mammals would be very much restricted in their movement into and out of the bay once the facilities are in operation.

Those species observed in the Cobscook Bay area which are on the Endangered Species List of the Endangered Species Act of 1973, and which would require consultation under Section 7 of the Act are: the fin, humpback, right, sei, blue, and sperm whales, the shortnose sturgeon, the bald eagle, and the Arctic peregrine falcon. Cobscook Bay is the most important nesting area of the bald eagle in Maine, with approximately 20 to 25% of the total production of eagles in the northeastern United States occurring around the bay.

There are no Federally listed endangered plant species in the Cobscook Bay area.

All fish species found in the bay area are important biologically in the overall trophic ecology of the region. A major concern would be the effects of tidal power on the feeding and reproduction of the various species. Some depend on the intertidal benthic organisms as their main food source. The food source would be adversely affected as a result of the reduction of the intertidal zone due to project implementation. Should anadromous fish species be involved with project implementation, proper mitigation measures would have to be applied to avoid impacts upon them.

Impacts on the terrestrial environment would be those associated with transmission line construction and maintenance, and dam and access road construction. The general area studied by the Department of Energy (Bonneville Power Administration) is between Cobscook Bay and the Bangor area and is approximately 100 miles long and 50 miles wide.

Impacts associated with bird and wildlife populations would depend upon their relationships and associations with the marine habitat they depend on for food. Populations could be displaced to other areas in search of food and shelter which would put pressure on the existing populations.

Construction of a tidal power project at Cobscook Bay would probably result in increased visitation for the first few years after completion, but, assuming current trends continue, level off, and stablize after several years. Based upon experienced visitation at other Corps projects, Maine State Parks and other recreational facilities that offer a useful comparison, the projected visitation at the proposed Cobscook Bay Tidal Power Project at completion of construction is estimated at 200,000 people annually. It is reasonable to expect that visitation will gradually increase and level off at about 300,000 people annually.

Nearly all of the alternative dam locations under consideration tie-in to rural areas of coastline where historic resources appear unlikely to exist, with the single exception of the Lubec end of the Dudley alternative. Historic structures or historic archaeological resources may exist in this area. Numerous wrecks, some of which may be of historic significance, may be located within the proposed dam construction areas.

Species that may be profitable for mariculture in Cobscook Bay are the Atlantic salmon, trout, lobster, oysters, mussels, and snails. All of these species have been used in mariculture experiments except for the snail. At present, there are some pilot experiments and Federally sponsored programs to investigate the marketability of these species.

The most significant socioeconomic impacts associated with the project are expected to occur during project construction. The influx of up to 2,000 construction workers would be the source of the most significant impacts on the social and economic characteristics of the area. The demand for housing and municipal services would increase with the influx of workers. The size of this demand would be a function of the number of outside workers employed in the project, the length of their stay, the proportion bringing dependents, and the pattern of their location. In addition, increased traffic, noise, and activity associated with actual construction could disrupt local life styles over the 5-year construction period. Over the long term, impacts on the local communities would be less severe. It is anticipated that most of all the construction workers would leave the area once construction was completed. Anticipated long term effects include: increased tourism within the project area, the possibility of a highway over the dams directly connecting Lubec and Eastport, and the addition of 500,000,000 to 700,000,000 kilowatt hours of electric energy to New England's electric system from a native, renewable resource.

Assuming that the study continues with minimal delays, a tidal power project could be in operation by 1995. Subsequent to this report two to three years of environmental and planning studies would be undertaken to determine which, if any, alternative should be developed and to prepare an environmental impact statement. If at the end of those studies the project still appears feasible, a request for project authorization would be made to the Congress. If authorized, three to five years of engineering design and preparation for construction would follow. Around 1990, construction could begin and the project would be operational around 1995. Cost for the project would be borne either entirely by the Federal Govenment as in the past, or by the State and Federal Government in some arrangement similar to President Carter's proposed 10 percent State, 90 percent Federal cost sharing plan.

The tidal power project has been found to be economically feasible using current Water Resource Council criteria. Environmental impacts would include significant alterations to the existing marine, esturaine, and riverine ecosystems. Relatively favorable long-term socioeconomic impacts have been identified. It appears that a tidal power project would reduce New England's (and the Nation's) dependence on oil while increasing energy independence.

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I. INTRODUCTION

Small tide mills have existed in Europe since the 12th century. Slades Spice Mill, located in Chelsea, Massachusetts, built in 1734, was the first self serve tidal mill built in the United States. While tidal power has been studied for the purpose of generating electricity throughout the world since the 19th century, only two tidal hydroelectric power plants are in existence today; a 240 megawatt project on the Rance River in France and a 400 kilowatt station on the Kislaya Guba Gulf in the Soviet Union. Recently, studies have taken place in Canada, England, Korea, France, and China. The United States has two locations where tide ranges are great enough to support large conventional tidal hydroelectric power projects, the Cook Inlet region in Alaska with a mean tide range of 25.1 feet and the Cobscook-Passamaquoddy Bay region in Maine with its mean tide range of 18.2 feet. This report presents the Corps' current findings on tidal power development at Cobscook Bay in Maine.

Purpose and Authority

This is a report on the feasibility of constructing a large tidal hydroelectric facility in the vicinity of Passamaquoddy Bay at Cobscook Bay near Eastport, Maine. Basic authority for this study is derived from a Resolution adopted on 21 March 1975 by the Committee on Public Works of the United States Senate and from subsequent directives from the Office of the Chief of Engineers. The Resolution is shown below.

> RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under the provisions of Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the report on Passamaquoddy-St. John River Basin Power Project, Maine, transmitted to Congress by the President of the United States on July 12, 1965 published as House Document No. 236, 89th Congress, and other pertinent reports, with a view to determining the current feasibility taking full advantage of the latest technological advances, of the Passamaquoody Tidal Power Project in the interest of providing tidal power, recreation, economic development and related land and water resources purposes.

Scope of Study

The principal thrust of this study is to determine whether it is economicallly feasible to develop a large Tidal Power facility at Cobscook Bay in Maine. This study, however, is not limited to economic issues as past studies have been. Environmental, marketing and other aspects of tidal power projects have also been addressed. Also since this study is intended to look at a specific type of project, namely a tidal hydroelectric project, efforts to study solar, wind, hydropower and other alternatives have not been made. The study is essentially a reconnaissance effort, although in some areas the study has gone into more detail. This document should be regarded as an "expanded reconnaissance report."

Study Participation and Coordination

Study participants and brief summaries of their activities are presented below:

- U.S. Army Engineer Division, New England - provided study management, coordination, hydropower estimates, design and cost estimates for civil works, environmental, economic, social and marketing discussions, and prepared the report.

- U.S. Department of Energy, Federal Energy Regulatory Commission - provided preliminary conventional and final real fuel cost escalation power values.

- U.S. Department of Energy, Bonneville Power Administration - provided preliminary designs and estimated costs for transmission lines and substations.

- U.S. Department of Energy, Southeast Power Administration - provided a financial analysis and comments on marketability of tidal power.

- U.S. Department of Interior, Fish and Wildlife Service - furnished data from its Coastal Characterization Study and Generic Environmental Assessment for a tidal power project.

- U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Region - provided an environmental assessment and evaluation.

- University of Maine, Orono, School of Forest Resources - prepared a report entitled "Habitat Utilization by Southward Migrating Shorebirds in Cobscook Bay, Maine, during 1979."

- University of Maine, Orono, Project for Balanced Growth for Maine - conducted initial public meetings and a Symposium of Relative Price Shift Analysis.

- Passamaquoddy Indian Tribe, Pleasant Point Reservation, Half Moon Cove Tidal Power Project - provided comments on the study and participated by coordinating their study.

- Stone & Webster Engineering Corporation - provided recommendations as to size and type of turbines for the project and provided preliminary cost estimates for a typical powerhouse and generating equipment.

- New England Power Planning (NEPOOL) - provided basic system data, comments on integration of tidal power, and comments on transmission requirements. However, NEPOOL did not perform any of the analyses contained in this report.

- State of Maine - State agencies provided input and comments on various aspects of the study.

Early in the summer of 1978, a series of five workshops on the tidal power study were held. These were followed by three public meetings held later that summer. In August of 1979 the results of a preliminary economic analysis were furnished by letter to local government officials and a news release was made. In November 1979 a symposium on "Relative Price Shift Analysis as Applied to Public Power Projects" was held in Portland, Maine. Subsequently, a report of the symposium was complied and distributed. Since then public involvement activities have been limited to correspondence and responding to requests for speakers. It appears as though the concept of tidal power at Cobscook Bay is viewed favorably by the public, and Governor Brennan of Maine has expressed his support as have several Congressional representatives.

The Report and Study Process

This report is divided into three parts; the main report, the environmental appendix, and a combined correspondence and public involvement appendix. The main report discusses all aspects of the study in sufficent detail to allow the reader to formulate opinions.

The multi-objective planning framework utilized by the Corps in its studies is designed to insure that a complete and systematic evaluation is accomplished. Problems, needs, concerns and opportunities are identified and addressed. Plans are formulated and evaluated and impacts are assessed. Public input is sought throughout the study and efforts are made to keep the public informed of the study progress and significant findings. The approaches used for this study are consistent with the President's Water Resources Council's "Principles and Standards" and the National Environmental Policy Act of 1969.

As the study progresses in depth data will be developed to allow increasingly detailed evaluation and assessment of alternatives, until it is possible to identify the best alternatives from both environmental and economic development viewpoints. Ultimately, using the study findings and public involvement, a plan judged to be in the best public interest will be identified.

Other Studies

Since 1920, when Mr. Dexter P. Cooper first analyzed the potential for tidal power, the Passamaquoddy-Cobscook area has been studied extensively. In 1935, the Corps of Engineers actually started construction of a tidal power project in Cobscook Bay during President Roosevelt's tenure. From

1948 to 1961, engineering and economic feasibility of a tidal power project in the Passamaquoddy Bay area was studied and reviewed by an International Engineering Board. From 1963-1965, the U.S. Department of the Interior, in conjunction with the Corps of the Engineers, reviewed and refined prior studies. Also, since 1973 the New England Division, Corps of Engineers, has intermittently reviewed the economic and engineering feasibility of various tidal power projects in the region.

If the Cobscook Bay Tidal Power Project had been built in 1936, the estimated annual cost over its 100-year life would have been 2.4 million dollars. The cost of energy from that project (which would have produced 308,000,000 kwh annually) would have been 7.8 mils/kwh. This is quite low when compared to today's production costs.

In 1976 (Reference 30) the Corps, using the traditional benefit to cost ratio form of economic analysis, reported that the cost of building and operating a large, tidal installation in this region would exceed the benefits. The same conclusion was reached in a separate report (Reference 39) compiled by the Department of Energy (formerly the Energy Research and Development Administration - ERDA) in early 1977. These reports were based on the benefit/cost ratio which results from comparing a project's estimated annual power benefits; i.e., the cost of producing needed power by an alternative means, with total annual project costs: i.e., operation, maintenance, major equipment replacements and initial investment amortized. For a project to be justified economically, the annual benefits would have to be either equal to or greater than the annual costs. Since the purpose of the tidal project is to produce power, its justification should be based on power benefits.

After the 1976 study, due to the energy situation and rising cost of fossil fuel generating alternatives, former Governor Longley of Maine suggested the feasibility of tidal power be re-evaluated based on "life cycle" costing. "Life Cycle" analysis takes into account the charges in the cost of generating electricity from an alternative source over its life. This includes inflation, fuel cost increases, etc. In response to the governor's request, the Corps performed a preliminary life cycle cost analysis of the International Passamaquoddy Tidal Power Project (Reference 30). Separately and concurrently, a preliminary life cycle cost analysis was also prepared by ERDA (Reference 39) for one of the Cobscook Bay alternative projects. The two independent studies arrived at similar conclusions, which indicate that the projects were economically feasible when viewed from this method of analysis.

To the extent that these inital life cycle cost analyses included general inflation in the escalation rates utilized, they were not in accordance with the Water Resources Council's Principles and Standards. Therefore, the Office of the Chief of Engineers directed New England Division to conduct a similar analysis excluding general inflation.

Following the completion of the inital life cycle analysis, the Canadian Government was contacted. On 10 May 1978, the Canadian Government formally indicated by letter that it did not wish to participate in further joint studies in the Passamaquoddy region. Therefore, in subsequent studies, international plans have not been considered.

In 1979, a preliminary economic study using an inflation free relative price shift analysis was accomplished for several possible tidal power alternatives located entirely within Cobscook Bay (Reference 33).

Projects considered ranged from 4 megawatts to 450 megawatts of installed capacity. Single pool and multipool projects were analyzed. The projects were evaluated based solely on economic criteria. The study concluded that none of the alternatives considered were economically efficient using conventional, static, benefit to cost analysis. However, several large single pool projects were found to be economically justifiable assuming various fuel price escalation rates and utilizing relative price shift analysis.

Since the 1979 study did not address power integration or environmental concerns the Office of the Chief of Engineers directed that a more complete study be accomplished. The results of this study are presented in this report.

Currently two other significant studies are being conducted in the vicinity of Cobscook Bay. One is a smaller tidal power project at Half Moon Cove in Cobscook Bay and the other is a large oil refinery at Shackford Head in Cobscook Bay.

The smaller tidal power project is being studied by the Passamaquoddy Indians with funding from the Department of Energy. Currently a 12 MW facility with annual generation of 38 GWH is planned. If this facility and certain large tidal power alternatives at Cobscook Bay were both built modifications to the smaller project would be necessary to make them compatable.

The other project is a 250,000 barrel per day refinery currently being planned by the Pittston Company of New York. If this project were built along with certain large tidal power alternatives, large locks would have to be included as part of the tidal power project to accommodate tankers.

It should be noted that final decisions to build either the refinery or the Half Moon Cove tidal power project have not been made and that the future of these projects is uncertain.

II. PROBLEM IDENTIFICATION

National and Regional Objectives

The primary objective of the tidal power projects under consideration is to reduce the region's (and Nation's) dependence on foreign oil for energy generation. Currently in New England about 60 percent of the region's annual energy requirements are met using oil fired generating facilities. A tidal power project would displace oil generated energy, reduce dependence on foreign oil and keep U.S. dollars in the United States. Any tidal power plan developed would have to be technically, environmentally, economically and socially acceptable.

Existing Conditions in the Study Area

Physical Setting

The study area is located about 300 miles northeast of Boston and about 50 miles east of Bangor, in Washington County, Maine. Washington County is the most easterly county in the United States. Eastport and Lubec are the two largest shoreline communities. Other smaller shoreline communities include Perry, Pembrook, Edmunds, Dennyville, Whiting and Trescott (See Figure 1).

Located entirely in the United States at the mouth of the Bay of Fundy, Cobscook Bay drains an area of approximately 400 square miles and has a surface area of about 39 square miles at high tide (See Figure 2). Depths in the bay range to 150 feet below National Geodetic Vertical Datum (formerly known as "mean sea level"). The bay's many peninsulas, coves and internal bays create the opportunity to consider various tidal power configurations. These irregularities give the bay a shoreline that is about 230 miles long. This long shoreline in conjunction with the large tide range results in about 7 square miles of intertidal mudflats (see Figure 3). The three most significant streams flowing into Cobscook Bay are the Dennys, Pennamaquan, and Orange Rivers. These drain 130, 45 and 35 square miles, respectively. The Dennys River is the only gaged stream within Cobscook Bay's drainage. It has an average annual discharge of about 190 cfs.

Cobscook Bay experiences tides of usually large magnitude. The tides are classified as semi-diurnal with two high and low tides occurring each lunar day. The time of occurrance of high and low tides varies daily since the 24 hour solar day is the basis for our calendar day and lunar day has a duration of approximately 24 hours and 50 minutes. Throughout the lunar month (about 27-1/2 days) the tide range varies with the phases (position) of the moon. The highest or "spring" tides occur at the "new" or "full" moons and the lowest or "neap" tides occur at the first and last quarters (see Figure 31 for more information). The range of tides in Cobscook Bay have varied from a minimum neap tide of 11.3 feet to a maximum spring tide of 25.7 feet. The average tide range in the bay is 18.2 feet with

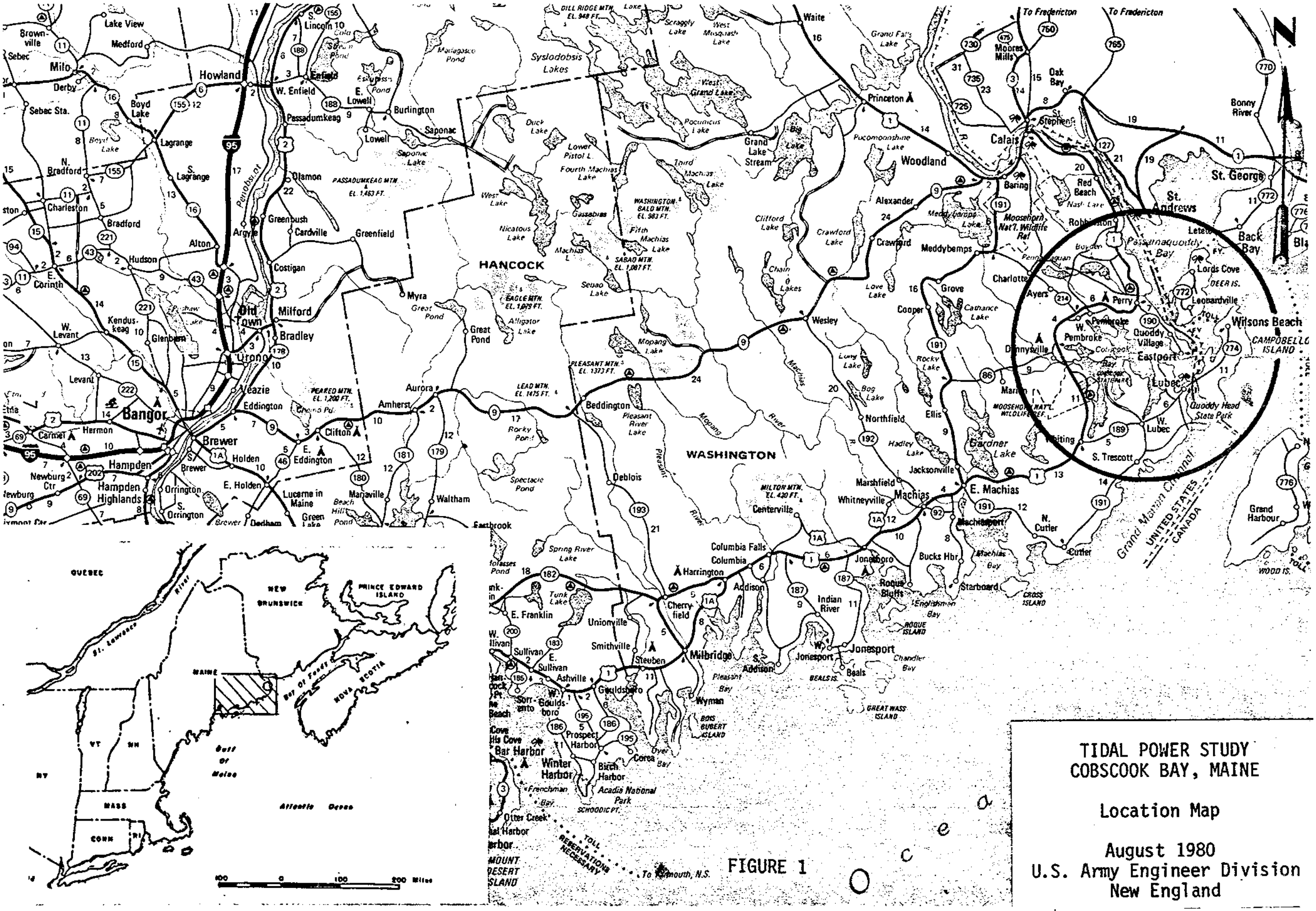
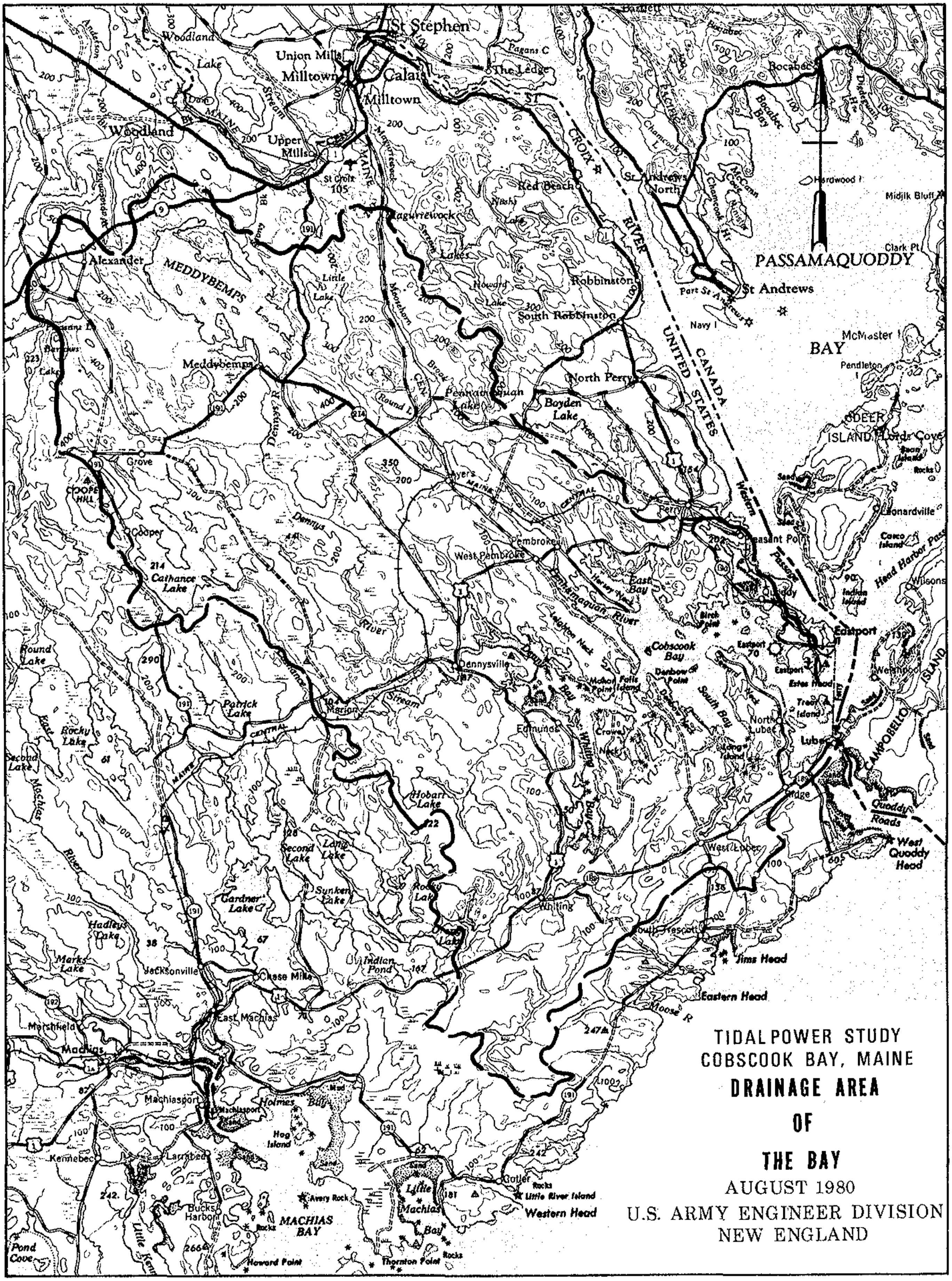


FIGURE 1

TIDAL POWER STUDY
COBSCOOK BAY, MAINE

Location Map

August 1980
U.S. Army Engineer Division
New England



TIDAL POWER STUDY
COBSCOOK BAY, MAINE
DRAINAGE AREA OF THE BAY
AUGUST 1980
U.S. ARMY ENGINEER DIVISION
NEW ENGLAND

FIGURE 2

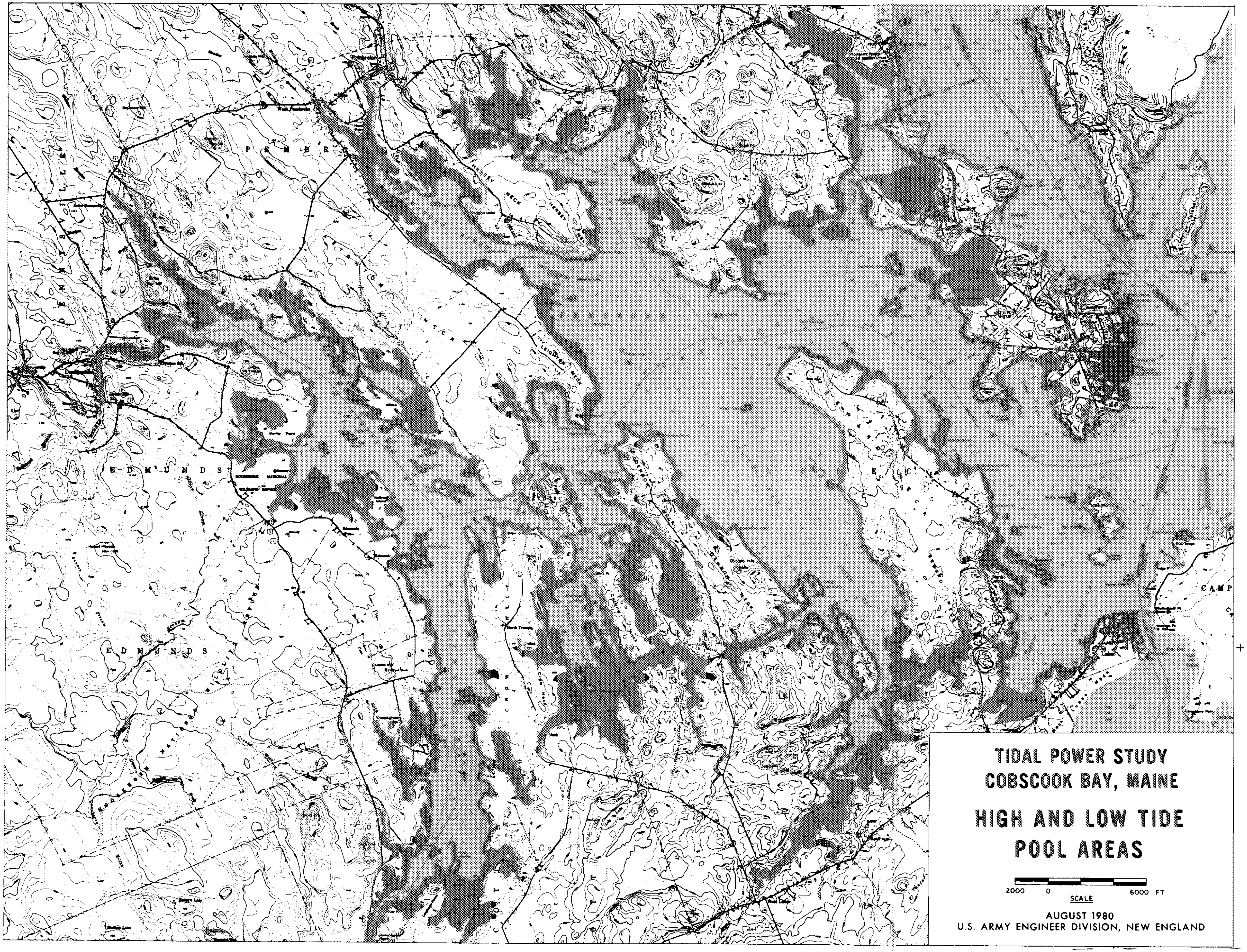

TIDAL POWER STUDY
COBSCOOK BAY, MAINE
HIGH AND LOW TIDE
POOL AREAS
2000 0 SCALE 6000 FT
AUGUST 1980
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

FIGURE 3

average neaps of about 15.7 feet and average springs of about 20.7 feet. During each tidal cycle an average volume of approximately 17 billion cubic feet of water enters and leaves the bay. These extreme hydrodynamic conditions, resulting from the large tide range maintain the bay waters in a well mixed state with oxygen supersaturation commonly occurring.

Onshore breezes blow several miles inland along the coast, bringing cooling trends in the summer and warming trends in the winter. The Labrador current flowing southward along the Nova Scotian coast brings cold water into the Gulf of Maine. Average temperatures range from 60°F in the summer to 15°F in the winter. Severe fog is often encountered especially during dark hours of summer months. The average annual precipitation is 43 inches and the average snowfall is 70 inches. This results in an annual runoff of about 28 inches per year from the bay's 400 square mile drainage area.

Cobscook Bay can be considered to be divided into two bays at the Falls Island constriction (Reversing Falls), an outer bay which responds to tide changes similar to the ocean and an inner bay which behaves somewhat differently. Generally, tidal changes in the inner bay lag the outer bay by one and one-half hours. Maximum differences between inner and outer pool elevations of as much as eight feet have been observed. Flow rates exceeding 200,000 cfs typically occur at the restriction and currents exceeding 9.5 ft/sec have been observed. In the outer bay around Shackford Head tidal currents of about 5.0 ft/sec have been observed with mean current velocities being about 3.0 ft/sec.

Based solely upon literature review, water quality in Cobscook Bay and its freshwater tributaries appears to be good. Water temperatures in the bay range seasonally from about 1°C to 11°C, with slightly higher temperatures occurring in the vicinity of major freshwater inflows. Salinity throughout the bay varies from about 31 to 32 ppt. The freshwater inflows are small compared to the tidal exchnage of water in the bay and, therefore, have little effect on the bay as a whole. The bay remains relatively ice-free during winter.

The Cobscook Bay area is located in the extreme northeasterly corner of the United States and is part of the Appalachian province which includes a region of mountainous and coastal lands and waters extending from Alabama to Newfoundland. The region, in general, is characterized by low, bedrock hills and wide, flat plains with long, marine estuaries occupying the lower parts of the coastal valleys. The unique distribution of land and water which makes up Cobscook Bay is the surface expression of a thick succession of Silurian volcanic and sedimentary rocks that have been folded into a broad northeastwardly plunging anticline bordered by a northeast trending faults. The barriers across this bay consist of the folded resistant rock of the Silurain succession. At the International Boundary a major fault which strikes north, northwest along the St. Croix River Channel is assumed to extend continuously for 30 miles from Campobello Island to Oak Bay.

The overburden in the region consists primarily of glacial till and marine sediments. Glacial till is generally found directly overlying the bedrock, and is exposed on the tops and slopes of some of the higher bedrock hills. In many places the till was subjected to wave action while the region was submerged and was either removed from the rock or reworked to form poorly developed beach deposits, which now mark former elevations of sea level. Overlying the till in the valleys are deposits of sand and gravel outwashed from the retreating glacier when its front stood close to the present shore line. After the glacier had melted back some distance from the coast, silt and clay were laid down over the previous sediments in all the lowlands to an elevation of approximately 100 feet above sea level. Uplifting since glacial times has caused the emergence of much of the pre-glacial land masses but the drowned river valleys and islands of the Cobscook Bay Region show that much of the old land is still submerged. Wave and current action in the existing rivers and bays had built up recent deposits of sand and silt which blanket the older deposits of marine clay.

The Cobscook Bay area is located in Zone 1 of the Seismic Probability Chart for the United States. The seismic map indicated that damage in this zone would be minor. However, a cursory review of available historical data reveals that approximately 30 earthquake epicenters have been recorded within a 75 mile radius of the project area. In 1978, two solar powered seismic array stations were established by the Corps of Engineers about 20 miles west of the project site to monitor seismic activity in the Cobscook Bay region. Since the installation there has been no significant activity recorded at the stations which have been continually monitored at the Weston Observatory in Weston, Massachusetts.

Recent published reports on crustal subsidence in eastern Maine and measured by the comparison of vertical leveling between Bangor and Calais, Maine, coupled with the geological and historical data indicates that the coastal zone is warping downward towards the east. Between 1942 and 1966 the relative subsidence was up to 175 mm (6.94 inches). This is considered a minimum figure. Recent studies in 1979 have reportedly reconfirmed these values.

The mineral resources of the project area are composed of lead, zinc, and copper, none of which are commercially developed at the present. The Bureau of Mines Minerals Yearbook of Maine for 1977 lists the mineral produced for Washington County as sand, gravel, peat and stone in that order of value.

Environmental Setting

Terrestrial Ecosystem

Vegetation. The land surrounding Cobscook Bay is rocky and hilly, with many streams, lakes and bogs. Agricultural lands, including blueberry barrens are present, with most of the area being made up of softwood or mixed hardwood-softwood forests.

Softwoods found in the area include spruce, fir, pine, hemlock, cedar and tamarack, with hardwoods consisting of birch, aspen, maple and beech. Alders can be found near the water bodies. The forest cover is second growth timber as a result of the virgin forest having been logged or destroyed by fire in years past. Timber harvesting does occur in the Cobscook Bay area, however, notto the extent as in other areas of Maine further inland.

Wildlife. As a result of low human activity, combined with the presence of almost all types of wildlife habitat, the Cobscook Bay area has a rich and diverse wildlife fauna. Upland big game species include whitetail deer, moose, and black bear. Small mammals commonly found include bobcat, snowshoe hare, red fox, red squirrel, porcupine, muskrat, beaver, raccoon and meadow vole.

The upland areas contain habitat for woodcock, grouse, a variety of songbirds, predatory hawks and owls. Waterfowl that utilize both inland and coastal waters include black duck, ring-necked duck, teal, wood duck, goldeneye, bufflehead, scoters, mergansers and Canada geese.

Bald eagles and osprey are present and depend heavily upon the marine resources found in the bay.

Based on the USFWS Coastal Characterization Study, Region 6 (Reference 42), the average annual legal harvest of whitetail deer from 1959 to 1977 was 7,870, with 1.4 deer killed per square mile. For black bear, from 1969 to 1977, average harvest consisted of eight bear, with 1.3 bear killed per 100 square miles.

Although repiles and amphibians are not abundant in Maine, the marshes, bogs and rivers may support a high number of certain species. Coastal Maine is inhabited by sixteen amphibian species and fourteen reptile species. There are no native lizards in Maine (Reference 42). Table 5 in the Appendix lists those herptiles found in coastal Maine. The mink frog and the northern water snake are found only in Region 6, which includes Cobscook Bay; all other species are found in areas of coastal Maine.

Factors that may affect the abundance nad distribution of reptiles and amphibians include agriculture, pollution, small impoundments and any other disturbances to the land, water and forest. Little information is available concerning reptiles and amphibians that inhabit the Maine coast. More research is needed in the following areas: population studies, impacts of pesticides, and impacts from peat mining on the habitat of the four-toed salamander.

Rare and Endangered Species. Cobscook Bay is the most important nesting area of the bald eagle (Haliaeetus leucocephalus), with approximately 20 to 25 percent of the total production of eagles in the northeastern U.S. occurring around the bay. During 1978, 17 intact nests were found, with eight being occupied, and four producing young (Reference 43). Important nesting and spring/summer feeding areas for bald eagles includes all of Cobscook Bay except for outside Seward Neck/Birch Point (Figure 4), with the entire bay being significant in the winter (Figure 5). Eagles that nest in the area occasionally remain during the winter as the ice-free water attracts waterfowl which serve as an important part of the eagle's winter diet.

The Arctic peregrine falcon (Falco peregrinus tundrius) is a transient during spring and fall migrations. There are, however, no defined migration corridors or concentrations of peregrines in the area (Reference 43).

There are no Federally listed endangered plant species in the Cobscook Bay area. The monkey-flower (Mimulus ringens var. colpophilus) is on the list of Smithsonian Institution's Endangered and Threatened Plants of the U.S. Three species that are considered critical in Maine include the bird's eye primrose (Primula laurentiana), beachhead iris (Iris hookeri), and roseroot (Sedum rosea). These are arctic species whose southernmost range is the northeast coast of Maine. Intensive surveys may reveal the presence of these species in the project area.

The following vascular plant species have been reported to be present at stations in Washington County. They are considered rare by the New England Botanical Club (NEBC) as reported in the 1978 publication entitled "Rare and Endangered Vascular Plant Species in Maine." However, the presence of these plants is questionable as some stations date back to the 1800's.

As previously stated, it should be noted that, at present, none of these are on the Federal list of endangered plants for this area or are they being proposed for inclusion on this list.

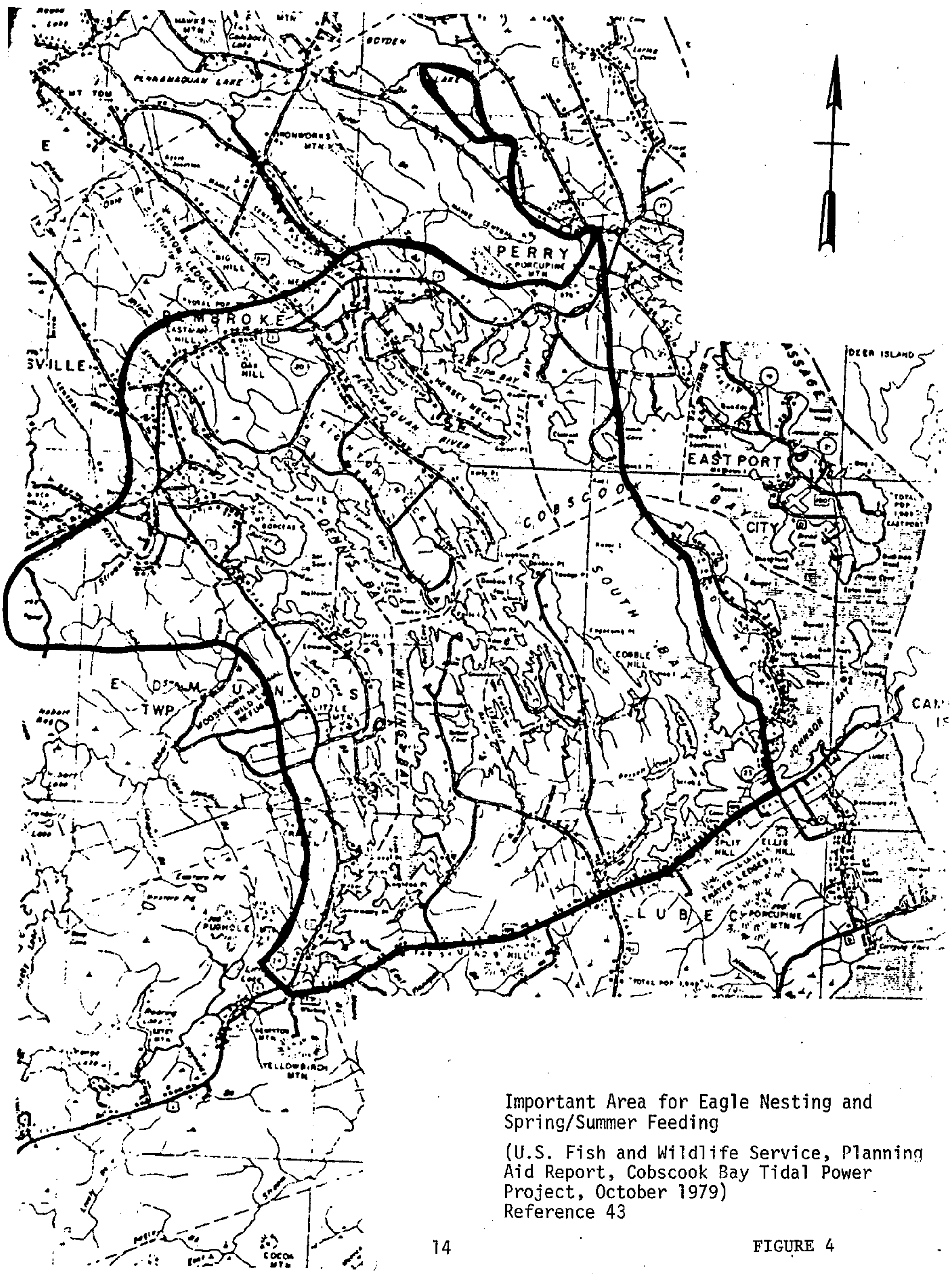
Iris hookeri Penny - Coastal ledges and beaches, Washington County

Arethusa bulbosa L. - Bogs - More common along the coastal zone

Betula caervlea - grandis Blauch - Mixed woods - Washington County

Geocaulon lividum (Richards) Fern. - Alpine barrens and coastal bogs Washington County

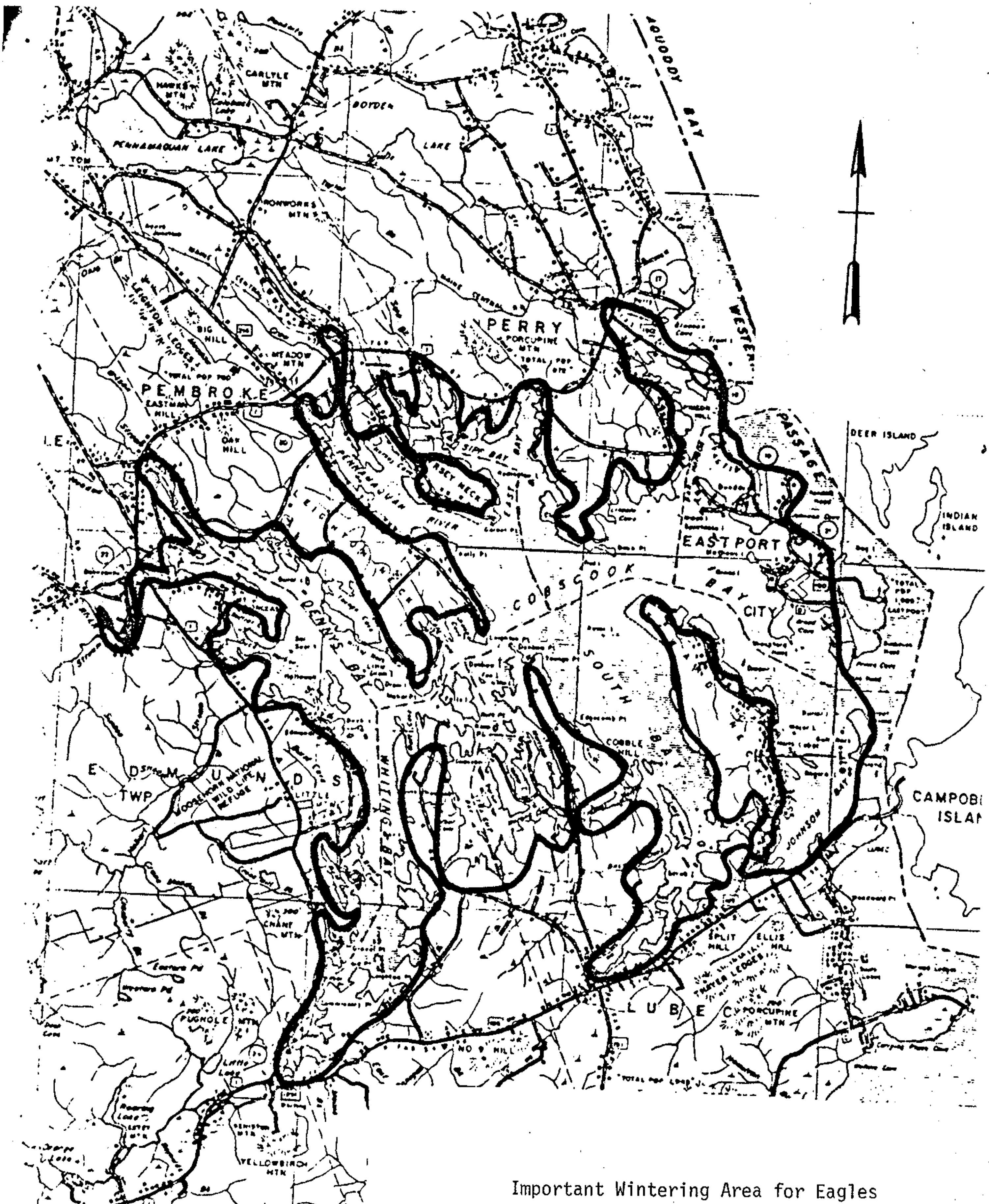
Nuphar microphyllum (Pers) Fern - Shallow water (fresh), occurring in northern half of the State.



Important Area for Eagle Nesting and Spring/Summer Feeding

(U.S. Fish and Wildlife Service, Planning Aid Report, Cobscook Bay Tidal Power Project, October 1979)
Reference 43

FIGURE 4



Important Wintering Area for Eagles

(U.S. Fish and Wildlife Service, Planning Aid Report, Cobscook Bay Tidal Power Project, October 1979)
Reference 43

FIGURE 5

Nymphyaea tetragona Georgi - Shallow water (fresh), occurring in northern half of the State

Sedum rosea (L) Scop - Coastal ledges and beaches, Washington County

Rubus chamaemorus L. - Alpine barrens and coastal bogs, Washington County

Empetrum atropurpureum Fern & Wieg - Alpine barren and coastal bogs, Washington County

Kalmia latifolia L - Rocky woods, occurring from Washington County south

Primula laurentiana Fern - Ledges, Washington County

Mimulus ringens var *colpophilus* Fern - Fresh water estuaries - Washington County - on Smithsonian list

Wetlands (Palustrine System). Those wetland types identified by the U.S. Fish and Wildlife Service's National Wetlands Inventory in the Cobscook Bay area include the following: marine subtidal/open water, marine subtidal/ unconsolidated bottom, marine intertidal/beach/bar, marine intertidal/flat, marine intertidal/rocky shore, marine intertidal/ aquatic bed, estuarine subtidal/unconsolidated bottom, estuarine intertidal/beach/ bar, estuarine intertidal/flat, estuarine intertidal/rocky shore, estuarine intertidal/ aquatic bed, estuarine intertidal/emergent, estuarine subtidal/ rock bottom, and estuarine subtidal/open water. (See Table 2 in Appendix for legend of the NWI classification.)

Table 1 summarizes the habitat distribution as collected for the USFWS Coastal Characterization Study for Region 6 (Reference 42), which includes Cobscook Bay.

TABLE 1

SUMMARY OF HABITAT DISTRIBUTION (APPROX. ACREAGE)
FOR USFWS COASTAL CHARACTERIZATION REGION 6

No. Towns Included	Tide Flats	Salt Marsh[1]	Other Wetlands[2]	Uplands	Total
24	16,428	2,366	23,750	391,046	417,162

[1] Includes Salt Marsh and Salt Meadow types

[2] Includes all other wetland types (fresh water)

Salt marshes are the most common vegetation along the edges of Cobscook Bay, being inundated with salt water at each high tide, and are made up of tidal creeks and emergent vegetation. The channels are dominated by saltmarsh cordgrass (Spartina alterniflora).

Aquatic Ecosystem

Marine Fisheries. Over 100 fish species have been recorded from the Quoddy Region (Linkletter et al., 1977). Most commercial fishing takes place outside Cobscook Bay, on the Perry Shore of Western Passage, specifically for herring. Herring processing actively takes place in the town of Eastport, with one packing and three processing plants in operation. Other small fisheries include alewives and eels. No groundfish are commercially fished for inside Cobscook Bay.

The amount of recreational fishing that takes place is not known. Those species that are known to be taken include winter flounder, mackerel, redfish, cod, pollock, tomcod and striped bass (Reference 43).

Redfish (ocean perch) have commonly been observed feeding on the surface at Eastport. According to the National Marine Fisheries Service, this type of surface feeding is unique within its range, and has proposed that this area be designated a sanctuary under the Marine Sanctuaries Act (16 U.S.C. 1431-1434).

It has not been determined to what extent Cobscook Bay serves as a spawning and nursery area for fish. Larvae of the following species were found in plankton surveys done in 1960 by Legaré and Maclellan: rock eel, sand dab, lumpfish, wrymouth, sea snail, cod, haddock, whiting, smelt, pollock, butterfish, winter flounder, hake and herring.

As the catch statistics pertain only to fish landings and not where the fish were actually taken, a definitive value of the fisheries resources can not be determined. However, neither Cobscook Bay nor Passamaquoddy Bay have significant commercial finfish resources (Reference 27).

Benthic Organisms. The species diversity of benthic invertebrates is higher here than anywhere else along the Maine coast due to the diversity of habitat, nutrient supply, and the over-all trophic ecology of the region. Other factors may include the large tidal range, the counterclockwise circulation produced by local weather patterns and substrate types (Reference 43).

Some of the invertebrates found in the bay occur only in the deeper waters of the Gulf of Maine, or are arctic species. Consequently, the Maine State Planning Office has designated three critical areas in Cobscook Bay. They are Birch Islands, Crow Neck and Wilburs Neck.

Commercially important invertebrates are: the soft shell clam (Mya arenaria), blue mussel (Mytilus edulis), sea scallop (Placopecten magellanicus), American lobster (Homarus americanus), rock crab (Cancer irroratus), Jonah crab (Cancer borealis), Northern shrimp (Pandalus borealis), bloodworm (Glycera dibranchiata), and sandworm (Nereis virens).

Soft-shell clams and sea scallops are the most important commercially harvested invertebrates in Cobscook Bay. Though the intertidal flats support large populations of clams, factors such as tidal scouring and flocculent sediments, smothering by epibenthic algae, and limited access to clamming areas (Reference 43) limit production in certain areas of the bay. Scallop beds that are significant are found in Whiting Bay, South Bay/Cobscook Bay, and Johnson Bay/Friar Roads.

Sandworms and bloodworms are harvested on the intertidal mudflats, primarily outside the Quoddy Region because of the softer sediments in that area. Some are harvested within the bay itself, although to a much lesser extent.

Lobsters are not harvested in sufficient quantities to support a significant commercial fishery (Reference 43). This low production may be a result of tidal scour, turbulence, siltation, poor food supply, predation and extreme tidal range.

Other invertebrates that are harvested commercially include blue mussels, periwinkles and rock crabs. A limited year round fishery currently exists within the bay for periwinkles. However, these species do have potential for commercial utilization depending upon market conditions.

According to a survey conducted for the Pittston Oil Refinery Impact Statement, 1978, (Reference 41), worms were most numerous in the silt-clay subtidal areas, followed by chitons, clams, amphipods, the brittlestar (Ophiura robusta) and sea urchins. Snails were found in the rocky intertidal areas, and intertidal areas contained periwinkles, limpets, clams and worms.

Plankton. What little is known about planktonic organisms within Cobscook Bay comes from the International Passamaquoddy Fisheries Board Report to the International Joint Commission prepared by Legare´ and Maclellan in 1959.

The predominant phytoplanktons in Cobscook Bay are diatoms. Species include Thalassiosira, Chaetoceros, and Biddulphia, with their concentrations varying greatly from month to month.

Zooplankton are comprised mainly of copepods, with the most dominant species being Calanus finmarchicus, Pseudocalanus minutus and Centropages typicus; most probably immigrating from the Gulf of Maine. Three species considered to be local in the region are Tortanus discaudatus, Acartia clausi and Eurytemora herdmani (Reference 27). Other zooplankton consist of eggs, larvae, and juveniles of fish, crabs, euphausids, mussels, barnacles, chaetognaths and annelids. Legare and Maclellan identified 22 species of fish larvae in their survey.

Marine Mammals. Nine species of marine mammals are common to the Gulf of Maine and the Cobscook Bay area, and an additional 12 species occur rarely. Table 2 lists those mammals that can be found in the project area.

The harbor porpoise and harbor seal are the most common marine mammals in the area. The porpoise population found in the Passamaquoddy-Cobscook Bay Region may be the last healthy one in the Atlantic.

The fin, minke, humpback, and right whales can be seen frequently in the area, the minke being the most common witha population of nearly 80,000 in the North Atlantic. Fin whales can be seen in nearshore waters from late spring to late summer, and humpbacks are farther offshore during the summer.

The fin, minke, humpback and right whales are baleen whales (those without teeth), and are the largest in the whale family. They feed somewhat on small fish, but their diet consists mainly of krill (planktonic crustaceans and larvae) and copepods that can be found throughout the water column. The feeding habits of the various species of cetaceans differ, e.g., right whales feed near the surface, humpbacks and minkes below the surface, and the fin whales will feed near the middle of the water column.

The harbor seal and the gray seal occur in the area, with the harbor seal being more common. These seals, in addition to the harbor porpoises, utilize the Quoddy region for reproduction and as a nursery area. In summer and early fall, the harbor porpoise population may be centered in this region (Reference 27). Harbor seals maintain a breeding population of several hundred in the bay, with local populations of both harbor seals and porpoises depending upon the area for food and shelter throughout the year. In Region 6 of the Coastal Characterization Study, (Reference 42), 30 harbor seal, and 2 gray seal haulout sites were identified in the period of 1965-1976. Most of the marine mammals can be found in the area during the spring and summer, migrating to southerly waters in the fall.

TABLE 2
MARINE MAMMALS IN THE STUDY AREA

Common Name	Scientific Name
Common	
Harbor porpoise	Phocoena phocoena
Pilot whale	Globicephala melaena
White side dolphin	Lagenorhynhcus acutus
Fin whale	Balaenoptera physalus
Minke whale	Balaenoptera acutorostrata
Humpback whale	Megaptera novaeangliae
Right whale	Balaena glacialis
Harbor seal	Phoca vitulina
Gray seal	Halichoerus grypus
Rare	
White beaked dolphin	Lagenorhynchus albirostris
Common dolphin	Delphinus delphis
Killer whale	Orcinus orca
Bottlenosed dolphin	Tursiops truncatus
Gray grampus	Grampus griseus
Striped dolphin	Stenella coeruleoalba
Beluga	Delphinapterus leucas
Sei whale	Balaenoptera borealis
Blue whale	Balaenoptera musculus
Sperm whale	Physeter macrocephalis
Pygmy sperm whale	Kogia breviceps
Northern bottlenosed whale	Hyperoodon ampullatus

Vegetation. Macroalgae, or seaweeds, are the most abundant form of marine vegetation found in the area. Brown, red and green algae are common along the shore and in the intertidal and subtidal areas of the bay. Brown algae are dominant in the rocky intertidal and subtidal plant communities. The rockweeds *Ascophyllum* and *Fucus* are dominant intertidal species, and the kelps *Laminaria* and *Agarum* dominate the subtidal areas. These communities provide habitat for a large number of marine and estuarine animals. Cobscook Bay has a high density of sea urchins who, like fish, graze heavily on the macroalgae. Other marine vegetation consists of eelgrass beds which are found throughout the bay. Production of seaweeds and eelgrass is extremely high in Cobscook Bay, and is significant in the trophic ecology of the region (Reference 43).

Rare and Endangered Species. The fin, humpback, right, sei, blue, and sperm whales are all listed as endangered species under the Endangered Species Act of 1973.

Freshwater Fisheries. Freshwater fisheries in the Cobscook Bay area consist of diadromous fisheries in the coastal streams that flow into the bay. Anadromous fisheries include Atlantic salmon, alewife, rainbow smelt, striped bass and sea-run brook trout. American eels, which are catadromous, can also be found in these streams. After growing to maturity here, they migrate to the ocean to spawn.

The Dennys River is considered the most important Atlantic salmon river in the Cobscook drainage basin, supporting an annual run of up to 700 fish (Reference 43). A factor influencing the migration of salmon is the annual water flow in the Dennys River itself. Should the runoff be low in dry years, salmon remain in Dennys Bay until the fall, instead of running during the late spring and early summer.

In the spring, alewives ascend the Dennys and Pennamaquan rivers for spawning. Those runs in the Dennys rivers are fished commercially by the towns of Dennysville and Meddybemps, while those in the Pennamaquan are fished by the town of Pembroke (Reference 43). The Dennys and Pennamaquan rivers are also fished commercially for adult eels in their migration downstream to the ocean in late summer and fall.

Rainbow smelt are fished for sport also in the Dennys River during late April and early May. Striped bass are caught occasionally in the Dennys River, and sea-run brook trout are found primarily in the Orange and Pennamaquan rivers. A nonanadromous brook trout population exists in the Dennys River upstream from the estuary (Reference 43).

Rare and Endangered Species. The shortnose sturgeon (*Acipenser brevirostrum*) is anadromous in some of the tributaries in the Gulf of Maine and Passamaquoddy region and is listed as endangered on the Federal list of endangered species. It is doubtful that it is established in Cobscook Bay rivers due to their small size. The shortnose sturgeon is generally associated with large river systems.

Avifauna

The intertidal areas of Cobscook Bay attract an extremely high density of shore and wading birds, including resident, breeding, wintering and migrant species. The area is utilized especially for shorebirds for feeding and accumulating energy reserves for their migration to wintering areas in South America. Species commonly found are semipalmated sandpiper, Bonaparte's gull, herring gull, great black-backed gull, ring-billed gull, sanderling, black-bellied plover, semipalmated plover, least sandpiper, dowitcher and great blue heron. Many of these birds can be found in the estuaries during their autumn migration.

Cobscook Bay also provides an important wintering area for waterfowl because of the lack of ice cover. Common species include black ducks, bufflehead, old squaw, white-winged, black and surf scoters, red-breasted mergansers, and common eiders.

Region 6 of the USFWS Coastal Characterization Study (Reference 42), that includes Cobscook Bay, has seven major seabird islands. The five most important islands are Old Man Island (east), Libby Island, Browney Island, The Brothers and Flat Island. Old Man Island (east) has one of the only two U.S. razorbill colonies in the coastal zone. Machias Seal Island is an important area for arctic terns, common puffins and also razorbills.

Two important seabird nesting sites in Cobscook Bay are Goose Island and Spectacle Island. Cormorants, eiders, herring gulls and great black-backed gulls are commonly found here.

Glaucous and iceland gulls, which are winter residents, are found in the greatest numbers near Lubec and Eastport. The migratory Bonaparte's gull have high concentrations in the tens of thousands in Passamaquoddy Bay near Eastport. Thirty major feeding areas and thirty-four roosting sites for migratory shorebirds have been identified in Region 6 of the USFWS Coastal Characterization Study (Reference 42).

Region 6 also has a large wintering population of purple sandpipers, remaining along the coast until April or early May. Four wintering areas have been identified within this region.

The waters in the mouth of Passamaquoddy Bay near Eastport support approximately one-half to two million northern phalaropes annually.

Concentrations of semipalmated sandpipers are known to exist at Half-Moon and Carrying Place Coves, Lubec Narrows and Machias Bay. Blue-winged and green-winged teal have small breeding populations in these areas.

The black duck is the most numerous waterfowl species that overwinters in the region. The large tidal range results in extensive exposed flats that provide excellent feeding grounds for the black ducks. Occurring in moderate number during the winter are Common Goldeneye, Oldsquaw, Common Eider, and Red-breasted merganser. The occurrence of sea ducks is similar to that of the black ducks, however, their distribution varies by species.

Region 6 of the USFWS Coastal Characterization Study (Reference 42) is also an important area for ring-necked ducks. Eider nesting colonies are present in large numbers, and migrating brant utilize this region as a stopover in their spring migration.

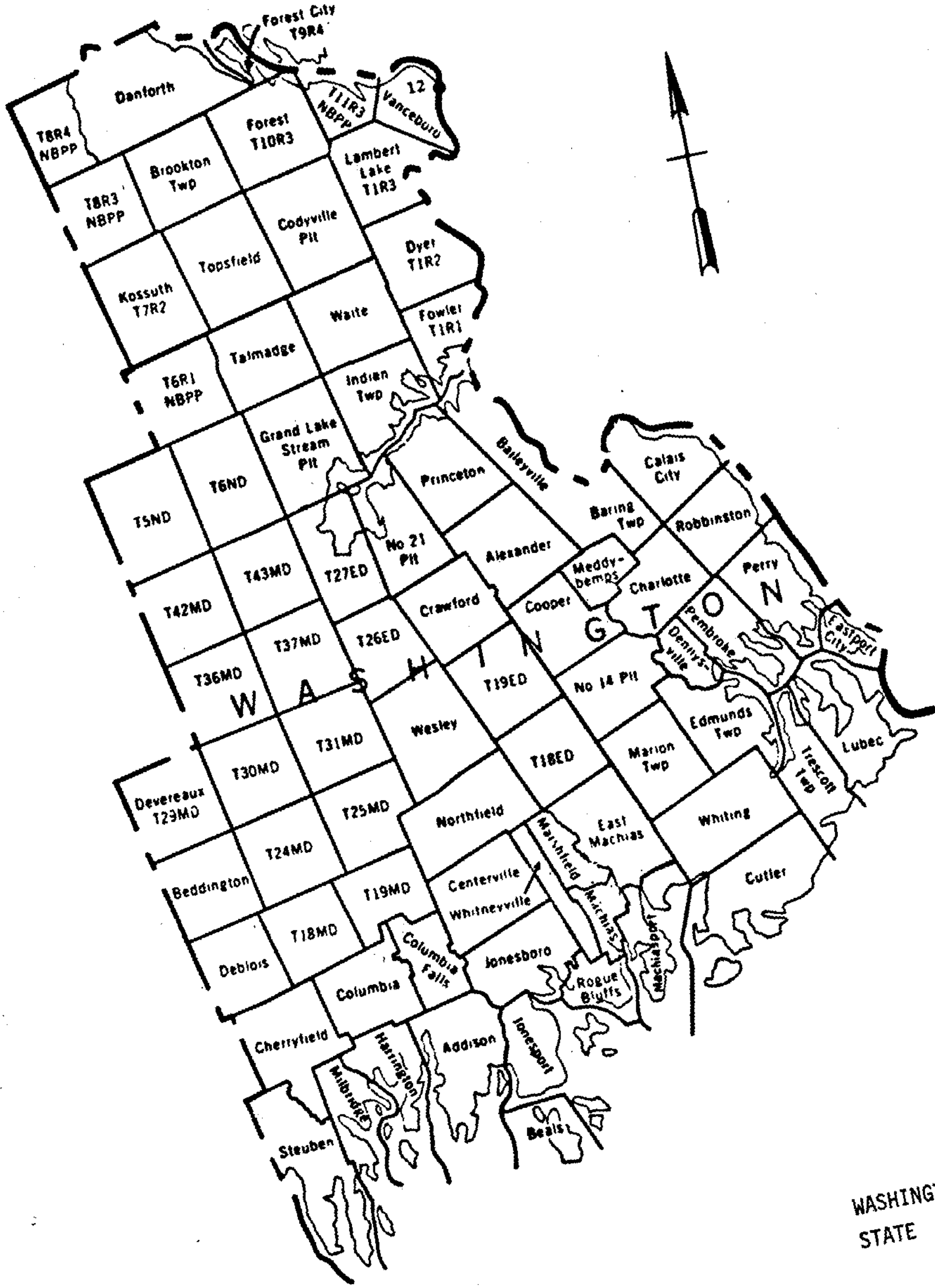
The habitat selection and specific food habitats of wintering waterfowl in the marine, estuarine and riverine systems of the area are not well known (Reference 42). Data gaps in the knowledge of waterfowl biology and ecology for the region include the population status of the black duck and the common goldeneye, effects of pesticides and contaminants, coastal ice formation and the ecological role of mergansers (Reference 42).

Cultural, Social and Economic Setting

Demographic Trends

Washington County data has been utilized to describe the social and economic characteristics of the study area. Washington County (Figure 6) occupies 2,554 square miles, 85 percent of which is forested land. Its 1975 population was 32,854 with a population density of 13 persons per square mile. This represents about 3 percent of the population of the State of Maine. The county's population increased 10 percent from it 1970 population of 29,859. This exceeds the 6.6 percent growth experienced by the state for the same period. Most of the county's residents live in the coastal areas. The five largest communities in Washington County lie within one hour's drive of the project area.

Census figures from 1930 to 1970 show the population of Washington County decreasing each decade from 37,826 in 1930 to 29,859 in 1970, a total loss of 21 percent. Meanwhile the State population for each decade between 1930 and 1970 registered an increase resulting in a total increase of 194,625 or 24 percent from 797,423. The decline in population in Washington County is due to its remote location, a reduction in full time employment opportunities, and a decline in industries, especially fisheries. A comparison of county and State population figures is presented in Table 3. The turnaround in population experienced between 1970 and 1975 (an increase of 10%) is attributed mainly to an influx of urban dwellers seeking new lifestyles.



WASHINGTON COUNTY
STATE OF MAINE

FIGURE 6

Table 3
Population Trends 1930-1975
Washington County and State of Maine

	Washington County	Percent Change From Preceding Decade	Washington County as Percent of State	State of Maine	Percent Change From Preceding Decade
1930	37,826		4.7	797,423	
1940	37,767	-0.2	4.5	847,226	6.2
1950	35,187	-6.8	3.9	913,774	7.9
1960	32,908	-6.5	3.4	969,265	6.1
1970	29,859	-9.3	3.0	992,048	2.4
1975	32,854	10.0	3.1	1,057,955	6.6

Source: U.S. Census

The majority of in-migrants are young and middle-aged men and women, many married and some with children, according to a report by Louis A. Ploch of the University of Maine, called "Maine's New Pattern of In-Migration." "Quality of life" seems to be a major motivation for the move to Maine (and Washington County) according to Ploch's survey (Reference 44). It appears that these in-migrants are willing to give up the higher paying jobs to find a more relaxed lifestyle. The new comers "value Maine's Natural resources, its lack of population crowding, and the positive personal attributes of its citizens," (Reference 44). High land prices and taxes in the more rapidly growing areas elsewhere have been an incentive to move to Maine as well. Other in-migrants to Maine are older persons, returning to their State or retiring after years of visiting.

Housing

The Census reported that in 1970 there was a total of 14,021 housing units in Washington County. Of this total, 9,468 housing units were occupied, 8,010 (84.6%) were occupied by their owner, and 1,458 (15.4%) were rented. Two thousand two hundred eighty-four dwelling units (14.7%) were vacant, and 2,269 were seasonal units. Only 386 of the 2,284 vacant units were actually available with 208 for sale and 178 for rent. The rest (1,898) were classified as "other vacant" by the Census, and according to Census definition were units held for settlement of an estate, units held for occupancy by a caretaker, units held for personal reasons by the owner, or year-round units used seasonally.

In 1970, there was a total of 28,989 people living in housing units in Washington County. The average household size, therefore, was 3.1 persons per household (28,989 people divided by 9,468 occupied housing units).

Most of the structures in the county were one family units. Of them, 752 year-round housing units in Washington County, 10,285 (87.5%) were one unit structures, 639 (5.4%) were structures with two, three, or four units, 123 (1.0%) were structures with 5 to 19 units, and 705 (6.0%) were mobile homes or trailers. The 1970 Census data also showed that housing in Washington County was old with 72.8 percent (8,550) of the year-round houses being built before 1940.

In 1970, the Census relied on two indicators to describe the condition of a housing unit and determine whether or not it was substandard. These two indicators were plumbing facilities and numbers of individuals per room per housing unit. When a unit was described as having more than one person per room or lacking complete plumbing it was considered substandard. Complete plumbing was defined as including three items; piped water, a flush toilet, and a bathtub or shower.

Using these two indicators, the 1970 Census reported that Washington County had a total of 3,583 (30.5% of year-round units) housing units which lacked complete plumbing facilities, and 625 units (6.6% of occupied units) which were over-crowded. Although, the data were not adjusted for double counting, they suggest that perhaps as many as one-third of the housing units in Washington County were substandard.

Windshield surveys, interviews with municipal officials, and analyses of tax records were performed in order to update the Census information and present some picture of the housing situation in Washington County in 1975 (Reference 45). Compilation of the data showed that Washington County gained 1,617 new housing units and lost 266 over the five year period between 1970 and 1975. This resulted in a net increase of 1,351 housing units or a growth rate of approximately 12.8 percent for the county. The major components of the housing change in the county were new single family dwellings and new mobile homes, together accounting for close to 84 pecent of the additions. Of the total of new units, 695 were single family units, 659 mobile homes, 131 multi-family units, and 132 units were converted from other type structures.

The vacancy rate is an indicator of the health of the housing situation. A healthy vacancy rate, usually around 6 percent allows for a certain mobility in the population and provides a choice in housing types and locations. The vacancy rate for Washington County in 1970 as defined by the Census falls short of this at 4.1 percent. Vacancy rates in 1975 for each community as well as the county on the whole were generated by the Washington County Regional Planning Commission (WCRPC) (Reference 46) through sales and rental market surveys. Their surveys revealed that of the total number of year-round housing units counted in the windshield survey (11,874), 68 were vacant and for sale, 23 vacant and for rent. This total of 91, expressed as a percent of the total occupied units plus the 91 vacant for sale or rent, indicates a vacancy rate of under one percent. Even with the possibility of having undercounted the vacancy rate is extremely low and indicates a limited housing flexibility of the population.

Economic Activity

Most economic activity in the county is related to natural resource-based industries. Few of the resources have been developed beyond their primary state. Generally, the raw resources are exported, bringing more money to the "outsiders" who make them into final products than to county residents. Washington County has an abundance of natural resources, principally, forestry and marine. Over 80 percent of the county's land has commercial value, with 70 percent of it currently being utilized.

Forestry has always been the major industry in Washington County with forests covering 92 percent of the county's land area. Pulp, paper, and lumber products are the major industrial use of the woodlands. Eleven forest industry companies own approximately 66 percent of the total forest land in the county and provide many jobs. The two largest employers, the St. Regis Company and the Georgia-Pacific, together employ more than 900 county residents; the other companies employ considerably less.

In the fishing industry, shellfish bring in the greatest landed value. Many species of finfish are either ignored or underutilized due to lack of capital to finance harvesting and processing. Although the county has approximately 700 miles of coastline, the potential for a major fishing industry is limited since federal support of this industry has traditionally been weak and commercial fish are decreasing in number. The county provided nearly 40 percent of the State's softshell clams. Development along the coast, however, has caused some serious pollution problems resulting in the closing of nearly 10 percent of the county's clamflats.

Lowbush blueberries are the backbone of agriculture in Washington County. Growing on the barrens and on former cropland, blueberries from Washington County make up 80 percent of the total blueberry crop for the State. This industry, although seasonal and low skilled, provides jobs and brings millions of dollars into the county each year.

Washington County has a great deal to offer in beauty and history that has attracted people for decades, making tourism an important industry. Tourism, however has not been developed fully because of the county's remote location.

Washington County has experienced little industrial growth. What growth has occurred has been on the small commercial scale, including new stores, motels, shops, and offices. Some Government jobs have opened up along with some other jobs in the non-manufacturing field. The county has been experiencing a gradual conversion from a blue-collar worker county with jobs primarily in the manufacturing field to a more non-manufacturing county.

Employment

Manufacturing, services, and wholesale and retail trade are the three major employment sectors in Washington County. The U.S. Census indicated that 9,490 persons were employed in the county in 1970 with 31 percent in manufacturing, 19 percent in services, 17 percent in wholesale and retail trade, 11 percent in agriculture/forestry/fisheries, 8 percent in construction and mining, 7 percent in public administration, 5 percent in transportation/communications/utilities and 3 percent in finance, insurance, and real estate sectors. Table 4 shows a total workforce decrease of 6 percent and the shift in employment distribution since 1950.

Although employment in manufacturing decreased between 1950 and 1970 the manufacturing sector employed the largest proportion of the labor force throughout that period. The decreased employment in this sector was due largely to the decline of the sardine canning industry. The agriculture/forestry/fisheries sector went from second place in 1950, employing 19.3 percent of the labor force, to fourth place in 1970, employing 10.7 percent. The decline in this sector reflects the overall decline in fish resources off the Northeast Atlantic coast and the decrease in the number of acres farmed. Employment in the services sector increased between 1950 and 1960, and 1960 and 1970 to employ the second largest proportion of the labor force, 19.3 percent in 1970. Employment in the wholesale and retail trade sectors has increased each decade between 1950 and 1970 (with 16.7 percent employed) and follows the services sector.

In 1970, half of those employed in the county were blue collar workers, an unusually large proportion of whom were nonfarm laborers, almost 13 percent versus 6 percent for the State. Seventeen percent were classified as craftsmen, foremen and kindred workers versus 15 percent for the State and fewer than 9 percent were considered professional versus 12 percent for the State (Table 5).

TABLE 4

Employment by Industry
Washington County, Maine

Industry	1950	Percent of Employed	1960	Percent of Employed	1970	Percent of Employed	Percent change 1950-1970
Agriculture, Forestry Fisheries	1959	19.3	898	9.4	1,016	10.7	-48.1
Construction and Mining	638	6.3	1,256	13.2	749	7.9	16.9
Manufacturing	3,265	32.2	3,047	31.9	2,960	31.2	-9.3
Transportation, Communication, Utilities	694	6.8	513	5.4	445	4.7	-35.9
Wholesale and Retail Trade	1,348	13.3	1,488	15.6	1,587	16.7	17.7
Finance, Insurance, and Real Estate	92	0.9	110	1.2	235	2.5	155.4
Services	1,523	15.0	1,474	15.4	1,827	19.3	20.0
Public Administration	446	4.4	511	5.4	661	7.0	48.2
Other	169	1.7	247	2.6	—	—	—
Total	10,134		9,542		9,490		-6.4

Notes: 1970 figures do not include 14 and 15 year olds. Total employment including those would equal 146; 46 in agriculture, 100 nonagriculture.

Source: U.S. Census, 1950, 1960, 1970

TABLE 5

OCCUPATIONAL CATEGORIES: WASHINGTON COUNTY AND MAINE

Occupation	Washington County Number	Washington County Percent	Maine Number	Maine Percent
Professional, technical & kindred	803	8.5	44,924	12.3
Managers/Administrators, Exfarm	794	8.4	32,234	8.8
Sales Workers	478	5.0	21,005	5.7
Clerical & Kindred Workers	1,072	11.3	50,611	13.8
Craftsmen, and Kindred Workers	1,600	16.8	55,148	15.1
Operatives, except transport	1,567	16.5	68,978	18.9
Transport Equipment Operatives	471	5.0	15,085	4.1
Laborers, except farm	1,203	12.7	22,195	6.1
Farmers and farm managers	172	1.8	4,806	1.3
Farm laborers & farm foremen	244	2.6	5,340	1.5
Services, ex private household	920	9.7	39,875	10.9
Private household workers	166	1.7	5,649	1.5
Total All Workers	9,490	100.0	365.850	100.0

Source: U.S. Bureau of the Census, 1970 Census of Population, "General Social and Economic Characteristics."

Historically, the shortage of year-round jobs has made for high unemployment in Washington County and has been a significant factor in making this county close to the poorest in Maine. Unemployment rates ranged from 8.6 to 9.6 percent in the 1970 to 1974 period, averaging 13 percent in 1975.

The seasonal nature of available employment puts personal income at a very low level. 1970 Census figures show that the income of Washington County show residents were among the lowest in the State. The median income recorded by the Census for 1969 was $6,137 for Washington County, the lowest in the State whose median income level was $8,205. The State Planning Office reported a 44.7 percent increase over the 1969 figures for 1977, although the annual figures for interim years have been fluctuating reaching a low of $4,911.00 in 1971. Fourty-one percent of all families in Washington County had incomes under $8,000 with about seven percent earning more than $25,000 in 1977. This compares to the State figures of 15.7 percent earning less than $8,000 and 11.2 percent earning more than $25,000.

Land Use

Washington County's surface area totals 1,865,600 acres or 2,915 square miles. The total land area for the county equals 2,554 square miles. The major land use categories as identified by the WCRPC Land Use Element of the Regional Comprehensive Plan for Washington County are forest industry land, privately-owned forest land, agriculture, Federal and State lands, Indian reservations, and other. Table 6 provides a breakdown of these categories by acreage and percentage of total land area.

Table 6
Land Use, Washington County, 1975

Category	Acres	Percent of Total
Forest Industry Land	1,055,824	64.6
Privately-Owned Forest Land	336,576	20.6
Agriculture	69,500	4.2
Federal and State Lands	59,600	3.6
Indian Reservation	18,100	1.1
Other	94,900	5.9
Total Land Area	1,634,500	100.0

Lands commercially forested in Washington County total approximately 1,439,000 acres. This includes forest industry land, privately-owned forest land, and some public lands. This acreage totals 89 percent of the total land area in the county.

Approximately 66 percent of the total land area of Washington County is being managed for pulpwood and lumber production by 11 companies with a minimum of 1,900 acres per owner. Historically, this land has been kept off the private real estate market, and if sold, it usually goes to another forestry concern.

Most urban development in Washington County has occurred within the coastal communities which contain approximately 75 percent of the county's total population. The county has over 700 miles of coastline with very little development when compared to other coastal counties in Maine.

The "other" category includes urban, residential, transportation, institutional, industrial and commercial uses, making up 5.9 percent of Washington County's land area. For the most part, coastal development in the county reflects the maritime and fishing economies of the last century. About a dozen small communities are scattered along the shoreline at the mouths of rivers where inlets offer protection for sailing vessels. Most of these towns are smaller today than they were in 1900.

During the first half of this century, coastal development was minor. A few towns installed sewer systems; wharves and breakwaters were built on a small scale and some dredging and filling operations were conducted. In general, however, industry and urbanization had a minor impact during this period.

Since about 1960, the county's coastal resources, including open land, have experienced increasing pressure for development. Specifically, residences and seasonal homes have been built in unprecedented number along the shore. Parcels of land which were formerly of minimal value for want of access are in great demand for vacation retreats. Rising family income levels and more leisure time have brought about a noticeable increase in home development in the county.

Agriculture in Washington Country developed in a subsistence level when early settlers first went up the Machias Rvier in search of hay in 1762. Small family farms flourished from 1800 to 1880 and have since declined. Today, only a small portion (4.2%) of Washington County's total land area is used for agricultural production. Lowbrush blueberries are the backbone of agriculture in Washington County as discussed earlier. As new techniques for propagation, fertilization, and increased production are developed and applied, the blueberry crop will become increasingly valuable to Washington County's economy. In addition, there are smaller amounts of land devoted to poultry, vegetable, dairy and beef cattle farming.

A number of factors contribute to the limited extent of agricultural activites within the county. Some soils are unsuitable and the growing season is short. Transportation time, distances, processing facilities, and costs are also factors that limit expansion of agricultural activities in Washington County.

The county ranks second in the State in the amount of inland surface water, being exceeded only by Piscataquis County. Within the confines of the county are 277 lakes and ponds totalling 134,053 acres. There are more than 1,000 miles of rivers and streams, covering a total 5,522 acres, in the county with the majoirity being among the cleanest in the State because of lack of intensive industrial, agricultural, or residential development within the watersheds. Wetlands are an important and fragile resource in the county, serving to limit flood damage, augment water flows during dry periods, and preserve wildlife habitats. The Department of Inland Fisheries and Wildlife estimates that 91,525 acres of Washington County fall within some category of wetlands. These inland water resources total 231,100 acres taking up 12.4 percent of the county's total area.

Many lakes in the county are relatively unchanged by man, and accessible only by foot. The rapid development of permanent logging roads have increased accessibility of some lakes and ponds by automobile, extending their recreational use.

As indicated in the land use table, close to 60,000 acres or 4 percent of Washington County's land area is classified as Federal and State lands. A recent exchange of public lands, held in the form of public lots, to the Georgia-Pacific Paper Company has reduced the total acreage of public lands in Washington County by close to 10,000 acres. The exchange resulted in an increase of public lands in a county in the eastern part of the State bordering the Bigelow preserve.

Approximately 25,000 acres are under Federal jurisdiction. The Bureau of Sports Fisheries and Wildlife manages the majority of this land within the Moosehorn National Wildlife Refuge which covers an area of 22,666 acres. Moosehorn provides a visitor center, a nature auto tour, and hiking trails, as well as other facilities. Two thousand eight hundred acres of this refuge are designated as a Federal wilderness area. The remaining Federal lands include the St. Croix Island National Monument, property on Petit Manan Point and Island, and some military holdings.

The Bureau of Parks and Recreation and the Department of Inland Fisheries and Wildlife manage much of the land under State jurisdiction.

The Pleasant Point Indian Reservation is located in Perry and accounts for the 18,100 acres or 1.1 percent of Washington County's land area.

Recreation

The most popular outdoor recreation activities in the State of Maine, according to the 1977 Maine Statewide Comprehensive Outdoor Recreation Plan (SCORP), are picnicking, swimming, bicycling, snowmobiling and nature walking. Only summer and winter activities were surveyed, however, hunting, which is basically a fall activity, was not listed. Driving for pleasure (sightseeing in general) was not studied, but if it were, it would probably be the most popular summer activity. Other popular activities include motorboating, camping, fishing, canoeing, ice skating, jogging, basketball, ice fishing, tennis, and downhill and cross country skiing.

Recreation facilities in the county are also relatively few and are used to a great degree by tourists passing through the area on their way to Canada. The following are the major recreation areas in the Washington County/Cobscook region:

Cobscook Bay State Park, Edmunds (868 acres) offers overnight camping, nature trails, picnicking, fishing, boat launching, and snowmobiling;

Quoddy Head State Park, Lubec (531 acres) is the eastern most point in the U.S. as well as having the greatest tidal range, and offers picnicking, a nature trail and sightseeing;

Roque Bluffs State Park, Roque Bluffs (274 acres) is being developed as an overnight camping area and offers picnicking, swimming and fishing;

Gleason Point, Perry (100+ acres) is undeveloped but has high potential either as a day-use or overnight camping area;

Eastern Head, Trescott (263 acres) is undeveloped but includes nearly 16,000 feet of ocean frontage and a 500-foot beach within a protected harbor;

Fort O'Brien, Machiasport (2 acres) is an historic site maintained as a day-use facility;

St. Croix Island National Monument, Calais (14 acres) is an undeveloped historical landmark with future plans providing for the development of historical interpretation facilities;

Moosehorn National Wildlife Refuge, Edmunds and Baring (22,666 acres) provides a visitor center, nature auto tour, hiking trails and other facilities;

Great Works Wildlife Management Area, Edmunds (641 acres) is managed primarily as a waterfowl nesting area, but is well suited for hunting, fishing, canoeing, hiking, wildlife photography and camping;

National Geographic Society Boulder, Perry, marks the 45th parallel, half way between the North Pole and the equator;

Roosevelt Memorial Park, Campobello Island, New Brunswick, Canada is a nearby tourist attraction which includes President Franklin D. Roosevelt's summer home, a museum and related facilities.

In addition to these recreation areas, there are several boat access facilities in Washington County located in Robbinston, Jonesport, Lubec, Millbridge, Vanceboro and Danforth. There are also a number of buildings and sites on the National Register of Historic Places including five in Eastport and two in Lubec. Other public outdoor recreation facilities in the county include six public parks, tennis courts in Eastport, Machias and Calais, a golf course and swimming pool in Calais, and several private camping areas along with local docks and beaches.

There are relatively few public recreation and support facilities available in the Cobscook Bay area compared to other regions in the State of Maine. There are no major commercial centers, mostly seasonal motels (with none in Eastport), and only one seasonal diner and no indoor recreation facilities in Eastport. The current most popular resident recreation activities in this area are hunting and fishing.

Historic and Archaeological Resources

The earliest known prehistoric sites in the Passamaquoddy Bay area date from about 1000 B.C. to the time of European contact. Other sites dating from as early as 9000 B.C. may have existed within the region, but rising sea levels and attendant erosion may have destroyed or obscured their remains. Also, it should be noted that most recorded sites were identified by the presence of large shell heaps, which may not have been a feature of earlier sites.

Recorded prehistoric sites in Cobscook Bay reflect intensive use of marine food sources, primarily soft shell clams. Some hunting also appears to have been done. Most tools recovered consist of projectile points of stone, and scraping and cutting implements of stone or made from beaver incisors. Pottery appears in the area at the beginning of this period (c. 1000 B.C.), but seems later to have decreased in use.

Evidence of semisubterranean oval or round dwellings about 12 feet in diameter are present at the sites dating between 200 and 800 years ago. Finds of animals killed in winter demonstrates that the occupants of these houses lived on the coast during that season.

Toward the end of the prehistoric period there are indications of a worsening climate, and deer population appears to have dropped considerably. Rising sea levels in the region also changed the locations of productive clam beds. A shift to seasonal migration of people from the coast to inland areas may have been partly conditioned by these environmental changes.

At the time of European contact, the native inhabitants appear to have spent their summers on the coast and wintered inland. The reverse of the prehistoric pattern, this probably reflects adaptation to the European fur trade system, with trapping in the interior during winter and trade with the ships which arrive in summer.

Recorded prehistoric sites within Cobscook Bay occur primarily on relatively sheltered portions of the shoreline, often near estuaries. Since archaeological surveys of the region are still incomplete, an archaeological reconnaissance of these area may become necessary as project planning proceeds.

Historic period land use of the Cobscook Bay coastline has been largely maritime, though there have been repeated attempts since the early 19th century to mine various metallic ores at exposed cliff faces.

Nearly all of the alternative dam locations under consideration tie in to rural areas of coastline where historic resources appear unlikely to exist. The single exception is the Lubec end of the Dudley alternative, which occupies a commercial waterfront area. Historic structures or historic archaeological resources may exist in this area.

The numerous coves and inlets of Cobscook Bay provided secluded rendezvous for smugglers between the French and New England colonies during the 17th and 18th centuries, and British Canada and New England during the Revolutionary War and the War of 1812 periods. Fishermen also used the bay from an early date and their activity became a mainstay of the area's economy during the 19th century. The considerable tidal fluctuation and narrow channels of Cobscook Bay probably resulted in numerous wreck though none are currently recorded within the alternative dam alignments.

Electric Energy Situation

System

The availability of a dependable, economical supply of electricity is of vital importance to the people of New England and to the economy of the region. An important instrument in providing this electric service is the New England Power Pool (NEPOOL), a regional organization established in 1971 by the area's utilities to further enhance the reliability and improve the economics of bulk power supply. The electric systems making up NEPOOL own or control 99.6% of all New England generation.

NEPOOL has two main functions: one planning and operations. The primary function of New England Power Planning (NEPLAN) is to provide a central planning staff which has the responsibility of preparing electric load forecasts, evaluating alternate generation and transmission plants, recommending reliability standards, and facilitating the joint ownership of power plants through optimization of size and location.

The operating arm of NEPOOL is the New England Power Exchange (NEPEX). Utilizing advanced computers and a complex communications network, NEPEX, through its four satellites located in Connecticut, Massachusetts, New Hampshire and Maine, controls all the major generating units in New England, insuring that at all times power is produced from the most efficient units available and at the lowest possible cost, consistent with maximum reliability of service.

Greater reliability is a fundamental objective and benefit of power pooling. This benefit is most readily explained in terms of an emergency. Assume, for example, that one of the interconnected companies suddenly loses the output of a major generating unit. Instantly, other companies make up the temporary deficit. Energy is constantly interchanged among member companies with no awareness by the customer of its source.

Further reliability benefits of NEPOOL arise from the coordinated scheduling of shutdowns for maintenance and repair of generating units and transmission activities. Operation of the pool allows coordination of this "downtime" so that service reliability to customers of all companies is not threatened by the coincidental unavailability of bulk power facilities.

Consumers do not demand electric energy in the same quantity throughout the year or even through the day. The amount of electricity being demanded by customers in one peak use hour of the day could be two times the lowest hourly use during that day. Electric suppliers must have enough power production capacity to meet that one peak hour demand.

At the same time, generating units cannot operate all year long. They require regular maintenance. Because many of them operate under extreme conditions of temperature and steam pressures, they are subject to unexpected outages. So the utility must not only have enough capacity for that peak hour use, but it must have "reserve capacity" as well. If each company operated by itself, its "reserve capacity" might have to be a larger portion of its forecasted peak demand depending on the number and size of generating units it had. With the diversity afforded by NEPOOL, all utilities in the pool can assure reliable service, with an adequate reserve, at a substaintial savings to customers.

Because of the pool's operations, a lesser number of generating units need be built than if each company was building plants for only its own customers and this economy of scale provides further savings to consumers.

Another economic benefit comes in the operation of power plants. The actual operating costs of producing electricity vary widely from one power plant to another depending on its age, design, type and delivered cost of its fuel. Through its computer capabilities, NEPOOL optimizes the operation of the combination of generating units which results in lower costs consistent with maximum reliability of service, without regard to which company actually owns the unit.

It is evident that the existance of NEPOOL results in lower energy costs and increased energy security and reliability for New England. NEPOOL also makes it possible for intermittent energy sources such as run of river hydropower or tidal power to be intergrated into a system so as to allow maximum use of the resources.

NEPOOL's members include investor owned companies, municipalities and cooperatives. The total supply of electric energy in New England is broken down by ownership in Table 7.

Table 7
Source of New England
Electric Energy Supply (1978)

Source	Percent of Total
Investor Owned Utilities	91
Municipal and Cooperative	1
Non-Utilities	5
Imports	3

(From Reference 6)

In New England, there are 38 class A and class B investor owned utilities (that is, having annual operating revenues in excess of one million dollars). Table 8 lists these utilities and figure 7 shows the location of New England's largest electric utility groups.

Demand

The demand for electricity fluctuates during the course of the day. The peak demand is about twice the demand required by customers during the early morning hours.

TABLE 8

Investor-Owned Class A and B Electric Utilities in New England

December 31, 1978
(System ownership shown in parenthesis)

Maine
Bangor Hydro-Electric Company
Central Maine Power Company
Maine Electric Power Company, Inc.†
Maine Public Service Company
Maine Yankee Atomic Power Company*

New Hampshire
Concord Electric Company
Connecticut Valley Electric Company, Inc. (CVPS)
Exeter and Hampton Electric Company
Granite State Electric Company (NEES)
Public Service Company of New Hampshire

Vermont
Central Vermont Public Service Corporation
Citizens Utilities Company—Newport Division
Green Mountain Power Corporation
Vermont Electric Power Company, Inc.†
Vermont Yankee Nuclear Power Corporation*

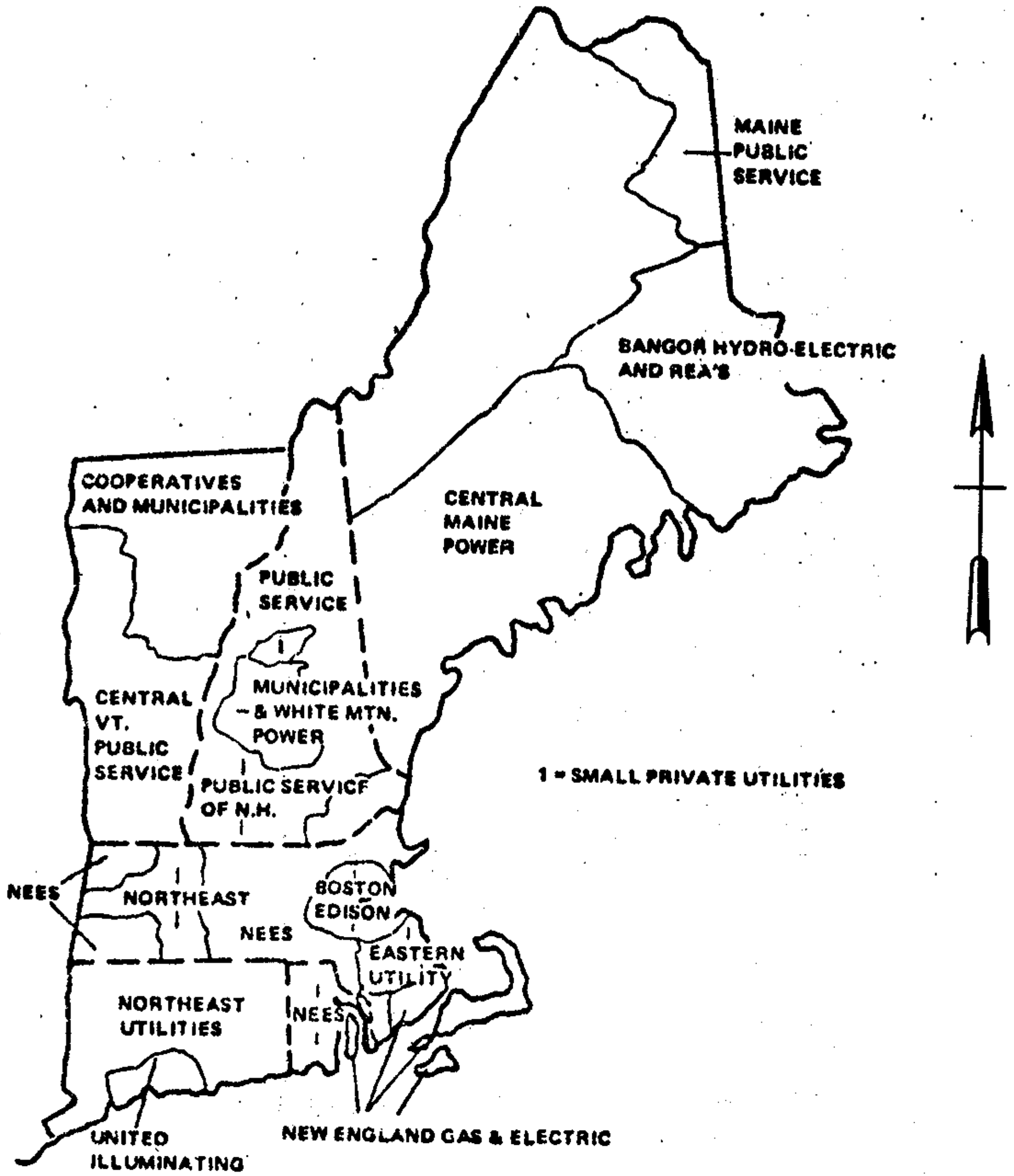
Massachusetts
Boston Edison Company
Brockton Edison Company (EUA)
Cambridge Electric Light Company (NEGEA)
Canal Electric Company (NEGEA)
Fall River Electric Light Company (EUA)
Fitchburg Gas and Electric Light Company
Holyoke Power and Electric Company (NU)
Holyoke Water Power Company (NU)
Massachusetts Electric Company (NEES)
Montaup Electric Company (EUA)
Nantucket Electric Company
New Bedford Gas and Edison Light Company (NEGEA)
New England Power Company (NEES)
Western Massachusetts Electric Company (NU)
Yankee Atomic Electric Company*

Rhode Island
Blackstone Valley Electric Company (EUA)
Narragansett Electric Company, The (NEES)
Newport Electric Corporation

Connecticut
Connecticut Light and Power Company, The (NU)
Connecticut Yankee Atomic Power Company*
Hartford Electric Light Company, The (NU)
Northeast Nuclear Energy Company (NU)
United Illuminating Company, The

System Abbreviations:
CVPS — Central Vermont Public Service Corporation
EUA — Eastern Utilities Associates
NEES — New England Electric System
NEGEA — New England Gas and Electric Association
NU — Northeast Utilities
† — Jointly-owned transmission company
* — Jointly-owned nuclear generating company

SOURCE: ECNE (Reference 6)



Source: A study of the Electric Power Situation in New England 1970-1990, New England Regional Commission.

FIGURE 7

Figure 8 depicts hourly demand patterns for peak winter and summer days and for typical spring and autumn days. Currently and historically New England experiences winter peaks. In 1979, a peak demand of about 15,000 megawatts was experienced on 19 December. Average daily peaks are around 12,000 MW and typically during early morning hours demand is around 7,000 MW.

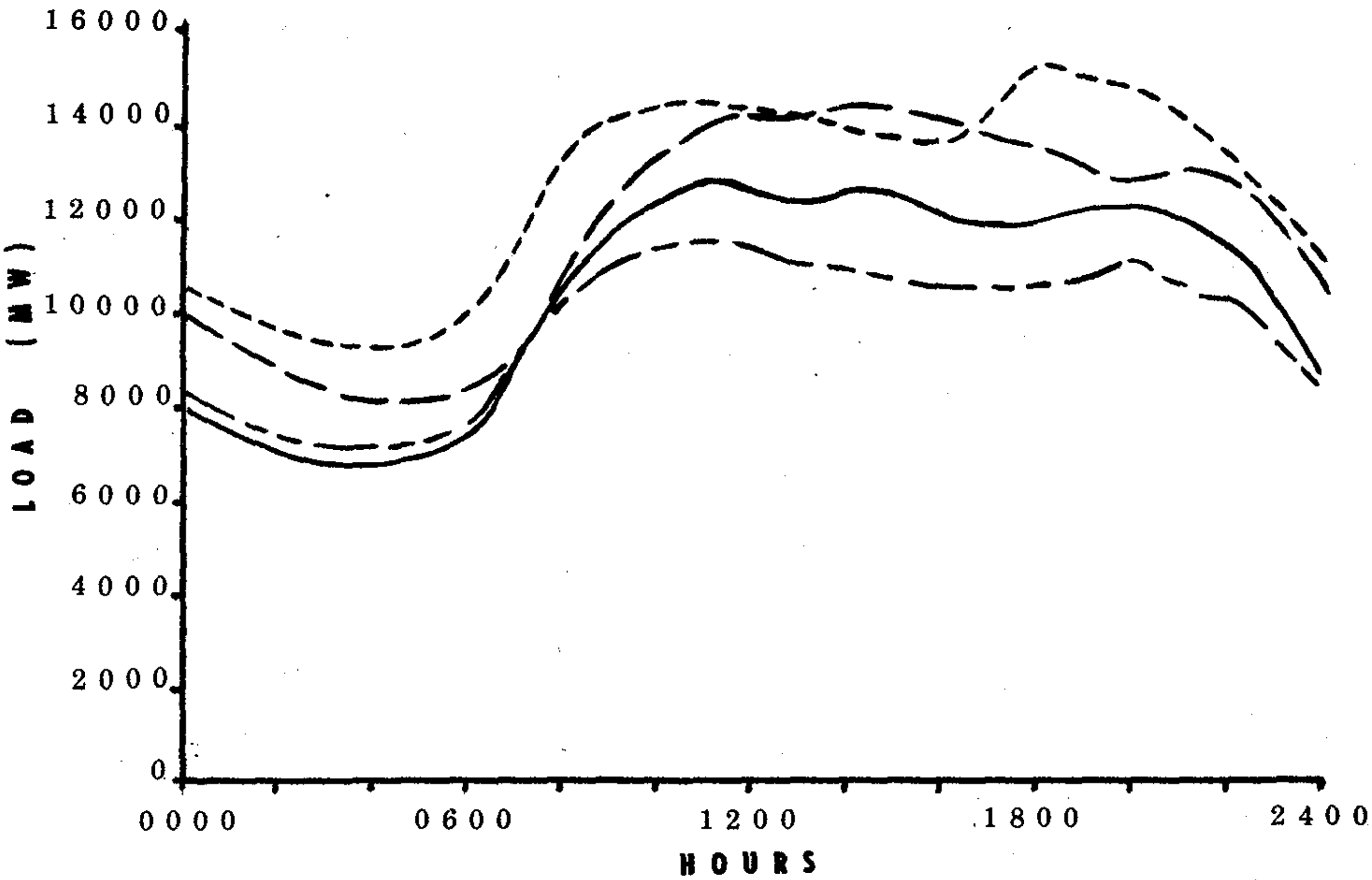
Because people's habits tend to be similar, the rise and fall in demand is predictable. The selection of the type of plant to meet customer demand is based on the type of load a plant will serve and the availability, cost and special characteristics of each fuel. Some plants must operate almost constantly to handle the continuous day and night demand (base load). A second type of plant handles the heavy and fluctuating daytime demand of homes, schools, offices, and industry (intermediate load). These plants are called "cyclers" and can be operated in a manner that allows them to shutdown and startup each day. A third type of plant, called peaking plants, handle the rapid upsurges of peak demand such as those between 5 and 6 pm in the winter and mid-afternoon in the summer. It is uneconomical, on any basis, for one kind of plant to handle the entire electric energy demand. A mixture of types is necessary.

A nuclear plant is more expensive to build, but less expensive to operate, making it an ideal choice as a base load plant. Today the total cost of a kilowatt-hour from an existing nuclear plant in New England is less than just the fuel cost component of fossil-fueled power plants. Its round-the-clock operation supplies continuous power for the constant portion of consumer requirements. It is also a natural partner for pumped-storage generation because of its low fuel cost. A pumped-storage plant uses low-cost, off-peak electric power to pump water into an upper reservoir during periods of low consumer use. The water is then released during periods of high demand to generate electricity. This form of operation provides peak serving energy at a lower cost than peak energy production by oil-fired alternatives.

In 1978, nuclear plants provided 35 percent of New England's generation. Dispite increasing reliance on nuclear generation, fossil-fueled (oil in particular) steam plants continue to supply the largest part of New England's energy requirements.

Table 9 shows sources of New England's generating capacity in January 1979.

DEMAND CURVES FOR NEW ENGLAND



WINTER PEAK LOAD 12/19/79 - - - -
SUMMER PEAK LOAD 8/2/79 — —
TYPICAL SPRING WEEKDAY 4/18/79 — - -
TYPICAL AUTUMN WEEKDAY 10/10/79 ——

TIDAL POWER STUDY
COBSCOOK BAY, MAINE

TYPICAL DEMAND CURVES
FOR NEW ENGLAND

August 1980

U.S. Army Engineer Division
New England
FIGURE 8

Table 9
Generation Sources in New England

Source	Summer Rating (MW)	Winter Rating (MW)
Conventional Hydropower	1,272	1,284
Pumped Storage	1,633	1,633
Nuclear	4,134	4,250
Fossil	12,073	12,324
Gas Turbine	1,154	1,477
Internal Combustion	256	260
Combined Cycle	183	206
TOTAL	20,705	21,434

Table 10 shows types of fuel (by percent) for New England's generation in recent years compared to U.S. average.

Table 10

Fuel Sources for Electric Power
United States and New England
(Percent of Total)

	1972		1974		1976	
Fuel Type	U.S.	N.E.	U.S.	N.E.	U.S.	N.E.
Gas	21.5	1.0	17.2	1.2	14.7	0.4
Coal	44.2	4.7	44.5	7.4	46.3	2.6
Hydro	15.6	7.5	16.1	6.9	13.9	6.9
Nuclear	3.1	14.0	6.1	24.4	9.4	33.2
Oil	15.6	72.8	16.1	60.1	15.7	56.9

(From Reference 6)

Inspection of Table 10 reveals that fuel consumption for electric energy production in New England is radically different than it is elsewhere in the United States. While coal dominates most of U.S. production, oil is the primary fuel used in New England, followed by nuclear. This unusual fuel mix results primarily from the fact that New England has to date discovered no significant conventional energy resources of its own (other than wood and water) which can be utilized in central generating stations. It must rely on other regions and other countries for its coal, oil, gas and uranium. For fossil fuels, this requires transportation of large quantities into the region. A one million kilowatt electric plant would require the daily delivery of 10,000 tons of coal (a one-mile long train), 1.7 million gallons of oil per day or 250,000 mcf of gas per day. By comparison, the equivalent amount of fuel for a nuclear plant can be delivered by six tractor trailer trucks - just once per year.

The cost of fuel represents 55 percent of electric operating expenses and it is the largest single expense item for the industry in the region. The fuel consumed in 1978 by the total electric utility industry in New England was equivalent to about 5.3 billion gallons of oil.

At present, it appears that continued development of nuclear power offers the greatest promise for controlling New England's fuel cost as well as providing protection against dwindling suppliers, market uncertainties and environmental restrictions associated with fossil fuels.

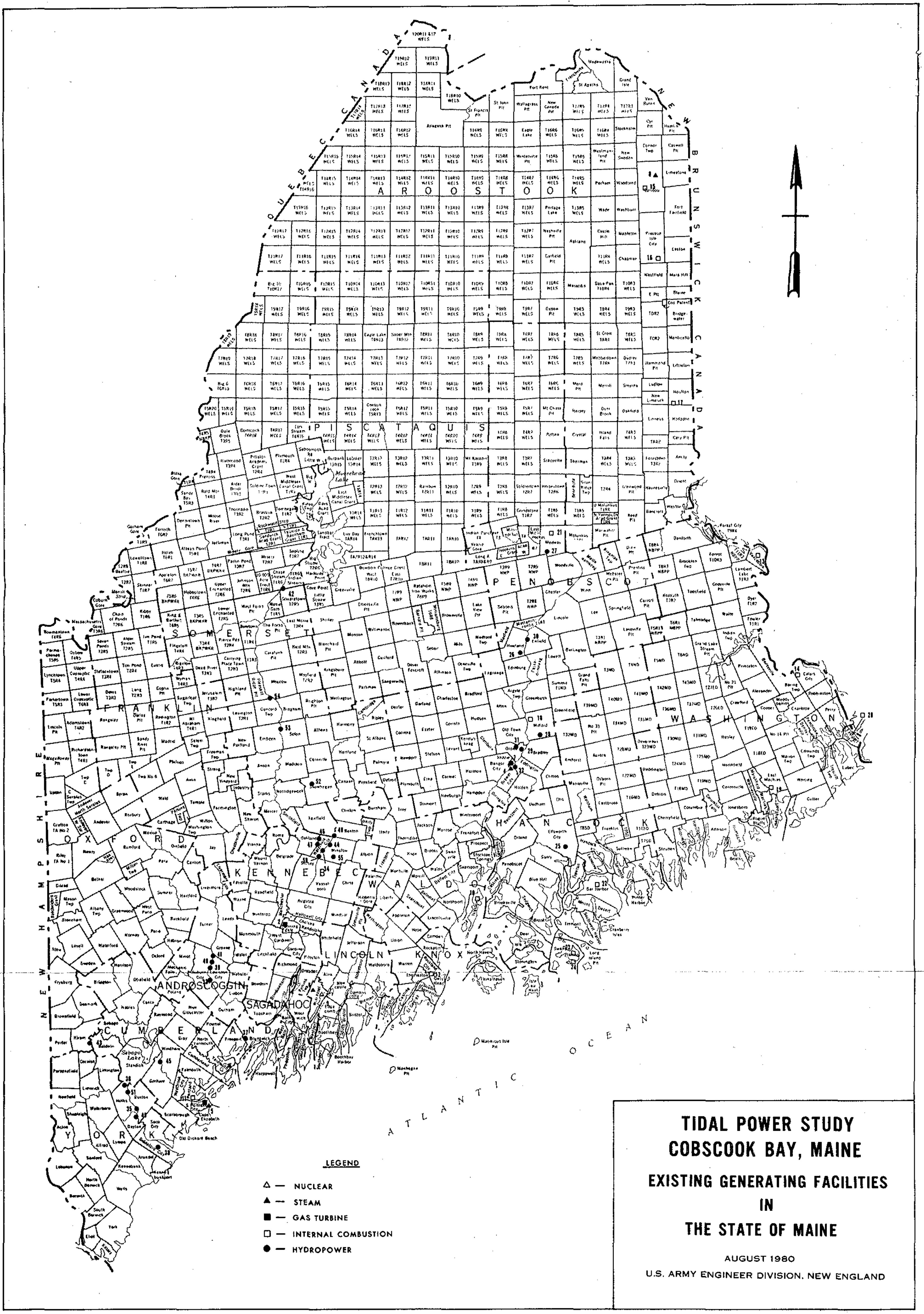
Maine would be the primary area impacted by a potential tidal power project. While it is not known how much energy a tidal power project would supply for Maine it is reasonable to assume that a large percentage of such a project's energy would be used in Maine.

In 1978 Maine consumed 7,699 gigawatt hours (GWH) of energy (a gigawatt hour is equivalent to one million kilowatt hours). Maine generated 8,208 GWH, therefore, Maine was a net exporter of energy. In fact in the same time frame New England was an exporter of energy generating 79,737 GWH and using only 75,289 GWH. However, of the total generation, over 40,000 GWH (950 GWH in Maine) was generated using oil and over 28,000 GWH (5,000 in Maine) using nuclear power. Table 11 lists Maine's electric utility generating facilties and the map shown as figure 9 shows the location of these facilties. In addition, there are 39 industrially-owned hydroelectric generating facilities in Maine with a total nameplate capacity of about 235,300 kilowatts.

Electricity is carried from generating plants to load centers by means of high-voltage transmission lines, and then is carried to individual customers through low-voltage distribution lines. Throughout New England, additions and improvements to the transmission and distribution systems are constantly being made to interconnect sources of energy supply, to strengthen ties with neighboring utilities and to supply customers' increased requirements for power.

The region's major generating plants are interconnected by 345,000 volt transmission lines which now extend from New York State through Connecticut and Massachusettts to New Brunswick, Canada. Underlying the 345 kv "backbone" transmission system are lower voltage (69,000, 115,000 and 230,000 volts) transmission lines which generally serve local as opposed to regional power requirements by transmitting power from the "backbone" system to local load centers.

These lines, which are shown on Figure 10 are part of the transmission grid which extends over the entire northeast region of the country. This grid improves the reliability and economy of the New England power supply by making it possible to transfer power from one area to another to meet constantly changing needs while always using the most efficient generating units available.



TIDAL POWER STUDY
COBSCOOK BAY, MAINE

EXISTING GENERATING FACILITIES IN THE STATE OF MAINE

AUGUST 1980

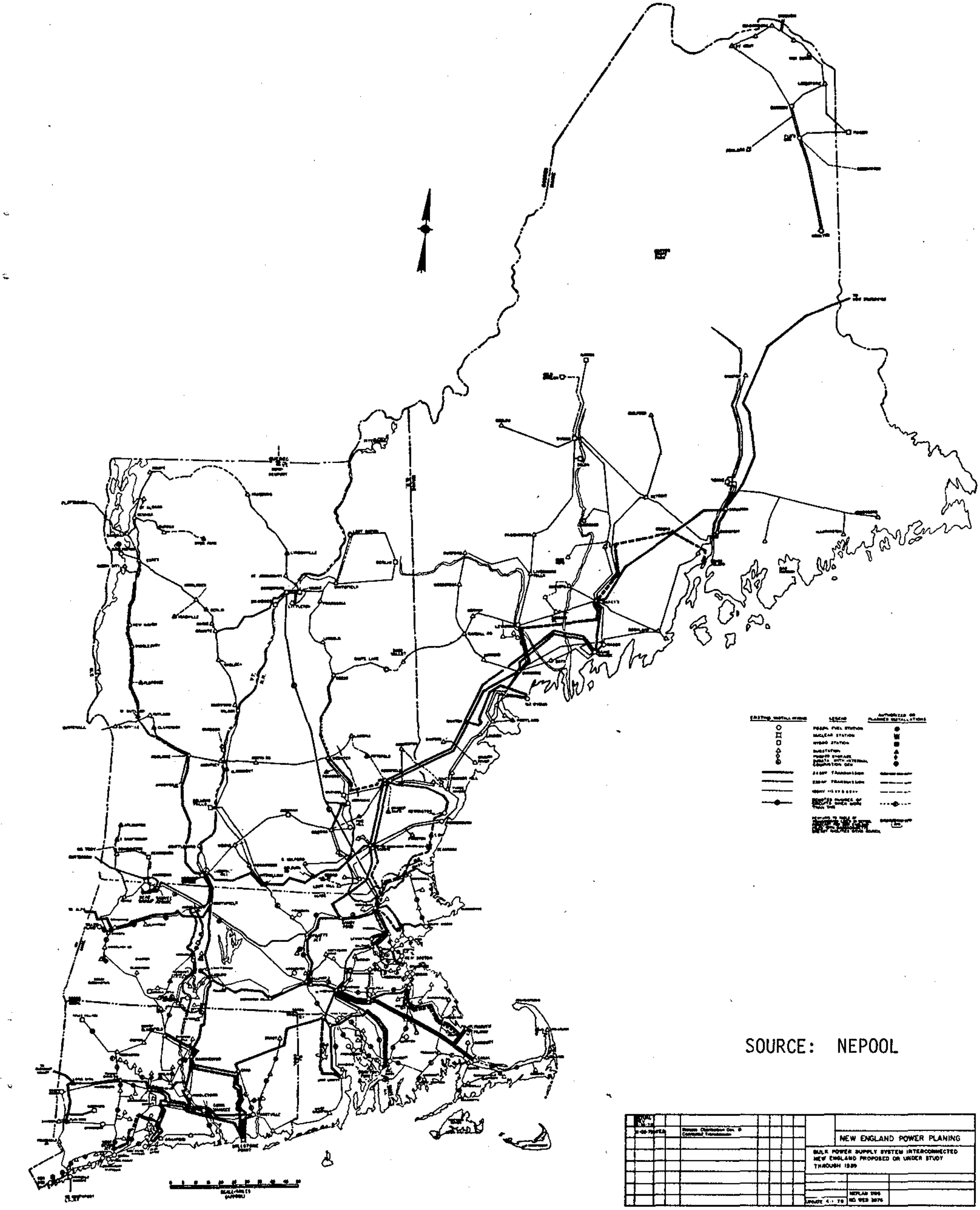
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

TABLE 11

EXISTING ELECTRIC UTILITY GENERATING FACILITIES IN MAINE

Project Number	Project Name	Community	Utility	Capacity (KW) FPC 1979	Type of Unit
1	Cape	S. Portland	Central Maine Power Co.	35,105	Gas Turbine
2	Farmingdale	Farmingdale	Central Maine Power Co.	4,000	Gas Turbine
3	Graham	Veazie	Bangor Hydro-Electric Co.	6,000	Gas Turbine
4	Graham Station	Veazie	Bangor Hydro-Electric Co.	57,450	Steam
5	Cape	S. Portland		Retired 1979	Steam
6	Mason	Wiscasset	Central Maine Power Co.	146,500	Steam
7	W.F. Wyman	Yarmouth	Central Maine Power Co.	846,036	Steam
8	Caribou Steam	Caribou	Maine Public Service Co.	19,000	Steam
9	Maine Yankee	Wiscasset	Maine Yankee Atomic Power	864,000	Steam (Nuclear)
10	Islesboro	Islesboro	Central Maine Power Co.	254	Internal Comb.
11	Peaks Island	Portland	Central Maine Power Co.	1,756	Internal Comb.
12	Rockland	Rockland	Central Maine Power Co.	2,000	Internal Comb.
13	Portable Plant	Vanceboro	Eastern Maine Elec. Coop.	300	Internal Comb.
14	River St. Plant	Calais	Eastern Maine Elec. Coop.	2,200	Internal Comb.
15	Caribou	Caribou	Maine Public Service Co.	7,100	Internal Comb.
16	Flos Inn Diesel	Presque Isle	Maine Public Service Co.	6,000	Internal Comb.
17	Houlton	Houlton	Maine Public Service Co.	1,000	Internal Comb.
18	Milford	Milford	Bangor Hydro Electric Co.	2,000	Internal Comb.
19	E. Machias	E. Machias	Bangor Hydro Electric Co.	1,000	Internal Comb.
20	Eastport	Eastport	Bangor Hydro Electric Co.	4,000	Internal Comb.
21	Medway	Medway	Bangor Hydro Electric Co.	8,000	Internal Comb.
22	Bar Harbor	Bar Harbor	Bangor Hydro Electric Co.	8,000	Internal Comb.
23	Swan Falls	Swans Island	Public Service Co. of NH	3,000	Internal Comb.
24	Minturn	Minturn	Swans Island Elec. Coop.	350	Internal Comb.
25	Ellsworth Falls	Ellsworth	Bangor Hydro Electric Co.	8.900	Hydro
26	Howland	Howland	Bangor Hydro Electric Co.	1,875	Hydro
27	Medway	Medway	Bangor Hydro Electric Co.	3,440	Hydro
28	Milford	Milford	Bangor Hydro Electric Co.	6,400	Hydro
29	Orono	Orono	Bangor Hydro Electric Co.	2,332	Hydro
30	Stanford	West Enfield	Bangor Hydro Electric Co.	3,800	Hydro
31	Stillwater	Stillwater	Bangor Hydro Electric Co.	1,950	Hydro
32	Veazie	Veazie	Bangor Hydro Electric Co.	8,400	Hydro
33	Androscoggin 3	Lewiston	Central Maine Power Co.	3,600	Hydro
34	Messalonskee 4	Waterville	Central Maine Power Co.	800	Hydro
35	Bar Mills	Hollis	Central Maine Power Co.	4,000	Hydro
36	Bonny Eagle	Standish	Central Maine Power Co.	7,200	Hydro
37	Brunswick	Brunswick	Central Maine Power Co.	Being Redevel.	Hydro
38	Cataract	Saco	Central Maine Power Co.	6,650	Hydro
39	Continental Mills	Lewiston	Central Maine Power Co.	1,776	Hydro
40	Deer Rips	Auburn	Central Maine Power Co.	6,540	Hydro
41	Gulf Island	Lewiston	Central Maine Power Co.	19,200	Hydro
42	Harris	Indian Stream	Central Maine Power Co.	75,000	Hydro
43	Hiram Falls	Baldwin	Central Maine Power Co.	2,400	Hydro
44	Milstar	Waterville	Central Maine Power Co.	4,800	Hydro
45	North Gorham	Gorham/Windham	Central Maine Power Co.	2,250	Hydro
46	Oakland	Oakland	Central Maine Power Co.	2,800	Hydro
47	Rice Fips	Oakland	Central Maine Power Co.	1,600	Hydro
48	Shawmut	Fairfield	Central Maine Power Co.	4,650	Hydro
49	Skelton	Dayton	Central Maine Power Co.	16,800	Hydro
50	Union Gas	Winterville	Central Maine Power Co.	1,500	Hydro
51	West Buxton (Upper)	Buxton	Central Maine Power Co.	6,625	Hydro
52	Weston	Skowhegan	Central Maine Power Co.	12,000	Hydro
53	Williams (Solon)	Embden	Central Maine Power Co.	13,000	Hydro
54	Wyman Hydro	Moscow	Central Maine Power Co.	72,000	Hydro
55	Fort Halifax	Winslow	Central Maine Power Co.	1,500	Hydro
56	Kennebunk	Kennebunk	Kennebunk Municipal	150	Hydro
57	Sandy River	Norridgchols	Madison Municipal	408	Hydro
58	Caribou	Caribou	Maine Public Service Co.	800	Hydro
59	Squa Pan	Squa Pan	Maine Public Service Co.	1,500	Hydro

SOURCE: Federal Power Commissions's Form - 12, Utility operating reports - 1979



SOURCE: NEPOOL

FIGURE 10

Future Conditions Without the Project

Physical Setting

The physical setting of Cobscook Bay would remain essentially unchanged. Water quality should remain stable unless other possible projects are undertaken. With or without a Federal tidal power project some changes will occur in the area if either the Pittston Oil Refinery or the Half Moon Cove Tidal Power project is developed.

Environmental Setting

The state of the aquatic ecosystem within the project area can be assumed to follow the same pattern as it has in the past and now exists. Also, conditions would be, in part, dependent upon the socioeconomic conditions in the area.

Mariculture would most likely continue to be developed in the Cobscook Bay area, with the success of these developments depending on market conditions, sophistication of culturing techniques and availability of sites.

Commercial fisheries are expected to slowly decline. According to the USFWS Coastal Characterization Study (Reference 42): "...the landed weight of many species have declined over a 20-year period, while the landed value has continued to increase, especially in such fisheries as lobster and clams." The lack of growth can be attributed to such factors as the distance from market, a lack of convenient processing plants, and competitively lower prices in other areas of New England. However, the success of mariculture development would have some influence on the value of fisheries in the future.

Harbor porpoises and seals would continue to depend upon the area for food, shelter and reproduction. Whales would still be common in the bay providing their numbers in the open ocean remain constant.

Anadromous and catadromous species would not be impeded in their migration between the ocean and freshwater. Rivers would support self-sustaining populations provided that the fish passage facilities already present are kept in operation. Unless stocking programs are curtailed, those rivers that maintain populations by this method would continue to do so.

One factor that would effect all aspects of the aquatic ecosystem would be the construction of the Pittston Oil Refinery. The most important aspect here would be the possibility of oil spills in the bay which would have adverse effects on marine and freshwater resources. Reference is made to the Pittston Oil Refinery Final Environmental Impact Statement prepared by the Environmental Protection Agency, 1978, for a thorough discussion of these impacts (Reference 41).

Those lands surrounding Cobscook Bay would remain in their present state. Wildlife populations would probably maintain their present carrying capacity, providing there are no alterations in habitat. The structure, composition and diversity of the vegetative communities would not differ from the present. As timber harvesting occurs on a small scale, there would probably not be an intensification of forest management practices in the project area.

Cobscook Bay and its surrounding lands would continue to support many species of upland birds, shorebirds and waterfowl. However, should the Pittston Oil Refinery be built, the avifaunal resources within the bay would be affected. The possibility of oil spills would determine the effects on the present populations.

Cultural, Social and Economic Setting

Population growth will depend on the development of the county's resources. The long-term benefits and costs of major industrial development from outside the indigenous resource pool are unknown. In any case, it would probably cause major fluctuations in the population growth rate. Native resources, however, if developed, would provide a stable base for steady growth in the future as shown on Table 12 below.

Table 12
POPULATION PROJECTIONS
Washington County

Age Group	1975 Population	1980 Population	1985 Population	1990 Population
0-4	2,266	3,394	2,724	3,393
5-9	3,319	3,201	3,244	2,649
10-14	3,228	3,092	3,194	3,237
15-19	2,846	2,330	3,086	3,188
20-24	1,969	1,573	2,318	3,070
25-29	932	1,805	1,563	2,302
30-34	1,354	2,100	1,793	1,553
35-39	1,974	2,049	2,082	1,779
40-44	1,866	2,013	2,025	2,061
45-49	1,917	1,899	1,978	1,991
50-54	1,793	1,811	1,846	1,925
55-59	1,665	1,678	1,728	1,761
60-64	1,560	1,664	1,569	1,618
65-69	1,485	1,458	1,500	1,417
70-74	1,305	1,190	1,237	1,267
75+	1,432	1,651	1,469	1,302
Total	30,918	32,808	33,368	34,518

Source: Stone and Webster

Close to 70 percent of the county's land area is essentially unavailable to accommodate growth. As indicated earlier, 11 forest companies own 66 percent of Washington County's land area. The Tree Growth Tax Law which is applied to this acreage discourages conversion to other land uses. Furthermore, because of increasing demands of wood products, these companies have been acquiring more forest land in order to meet demands. In general, then, corporate-owned forest land would not be used to accommodate population growth. An additional 59,600 acres which is held in Federal and State game refuges, parks, and public lots, is off limits to growth. Indian reservations, accounting for just over one percent, also would not be available for development.

Therefore, approximately 500,000 acres, less than one third, of the county is left to absorb development pressures. This area is generally the coastal belt of towns along U.S. Route 1. The coastal section, for reasons such as land availability, ownership patterns, essential services, etc., will bear the burden of any population growth in the future.

Within the coastal area, no single municipality can be predicted to grow at a rate faster or slower than the county as a whole. The factor which would influence settlement patterns including jobs, taxes, and land use regulations, are not expected to differ greatly from one town to another in Washington County. However, any large development, employing a few hundred people, could unbalance the population distribution. Predicting the occurrence and magnitude of such a development could not be done with any certainty.

It is predictable that various kinds of development will be proposed. In addition to a tidal power project like this one, fisheries (inside and offshore), deep water ports and oil refineries could be located here. The Pittston Oil Company has been studying the possibility of establishing a refinery and deepwater port at Shackford Head in Eastport. This area, although sparsely populated, offers some development incentives that to a large extent are unavailable along much of the New England coast. However, no coastal plan has actually been developed which identifies the best areas for industrial growth.

All Maine communities possess certain tools with which to evaluate and regulate the use of at least some natural resources. These tools include shoreland zoning, the plumbing code, subdivision controls, and clam ordinances.

Although population in Washington County has been growing snce 1970, it is difficult to judge whether it is a short range trend or one that would continue indefinitely because of the employment situation. Nevertheless, unanticipated growth places additional burdens upon a municipality's services and complicates land use priorities. Therefore, the need for land use controls is paramount in regulating desired development.

Historically such land use controls have been lax or non-existent in Washington County. The WCRPC in the development of their Land Use Element for the Regional Comprehensive Plan identified several resources that could be threatened by uncontrolled land use development, including forest lands farmlands, clamflats, and the shoreline. In general, Washington County towns have been slow about implementing zoning or permit systems. Regulations imposed by State legislation have only been half-heartedly enforced. Land use regulation is fragmented into a number of different laws, ordinances, and regulations; administration rests several different authorities.

It is expected that the present trends in recreational use and visitation to existing facilities in the region will continue. Most of the recreational attractions in the area are not terminal in nature and depend to a great extent on sightseers for the bulk of present visitation. Considering the continuing increases in gasoline prices as well as the cost of participating in many recreational activities, it is not expected that any dramatic increases in visitation to the region's present recreation areas will take place.

Most of the recreational needs and desires in Maine are for local urban facilities such as tennis courts, swimming pools and areas, playing fields, and recreation areas for children. None of these needs can be met by construction of a tidal power project at Cobscook Bay. Recreational use in the area probably won't change appreciably without construction of the project, whereas with the project existing facilities probably would receive more use and additional recreational facilities may be provided. However, any additional development would probably be limited due to the prevailing economic climate of the area and increasing travel costs. Without the project it is not likely that any new significant recreational development would take place in the Eastern Maine/Cobscook Bay area.

Electrical Energy Situation

If the project is not built it is likely that the energy which would have been produced by the tides will continue to be produced using oil. Total oil displacement by coal is unlikely. Major technological breakthrough regarding renewable resources are not predictable, however, it is reasonable to assume that such breakthroughs will not be developed to the extent that they can be intergrated on a large enough scale to displace all of New England's oil generation for several decades.

Electric load growth forecasting is difficult at best. In New England, NEPOOL is the primary source of such estimates. The most recent estimate, (April 1980), anticipates winter and summer peaks of 24,170 MW and 19,280 MW, respectively, for the year 1995. Planned system capability for that period, taking into account retirements, purchases and additions are in excess of 27,000 MW. It is expected that energy demand will increase at a rate of 2.6 percent per year. It is also projected based, on planned additions purchases and retirements, that the fuel mix prevailing in 1995 will be approximately as shown in Table 13.

Table 13
Projected 1995 Generation Mix
(Percent of Total Generation)

Fuel	Percent of Total Generated
Hydro	11.7
Coal	17.3
Nuclear	33.2
Oil	37.8

Source: NEPOOL

Table 14 below shows NEPOOL's planned generation additions through 1995 (Reference 20). Figure 11 is a graphic representation of NEPOOL's anticipated peak winter day in 1994-95

Problems, Needs and Opportunities

The Cobscook Bay Tidal Power study was undertaken to determine whether it is feasible to develop electric energy using the large tide range that exists in the vicinity of Eastport, Maine. The concept is not new. It has been repeatedly studied since 1920 when Dexter P. Cooper first conceived the idea. The problem is apparently not technical, as every group that has studied the concept since 1935 has found it to be technically feasible. In fact, similar projects have been built in the Soviet Union and France. What are the problems? Essentially there are three concerns:

- Is the project economically feasible?
- Are potential environmental impacts which could result from the project acceptable?
- Can the project's power be utilized effectively?

If a feasibility study is undertaken following this report these questions along with several technical questions will be the focus of that study.

If the project is built it will displace, almost exclusively, energy that would otherwise have to be generated using oil. Clearly, based on the previous section, New England's energy independence situation would be enhanced by reducing oil dependency. The need for such a project, or for that matter any project, that uses renewable resources, is apparent.

New England is fortunate in a few ways with respect to energy sources. It has wood and water in abundance. It also has the unusually large tide range found at Cobscook Bay. Wood, though renewable, is not as attractive as hydropower or any of the other solar technologies (direct, wind, passive). The reason for this is simple, it takes several years to renew the wood resources while solar resources, tides, runoff, wind, sunlight are continuously renewed. A review of either the Corps of

TABLE 14

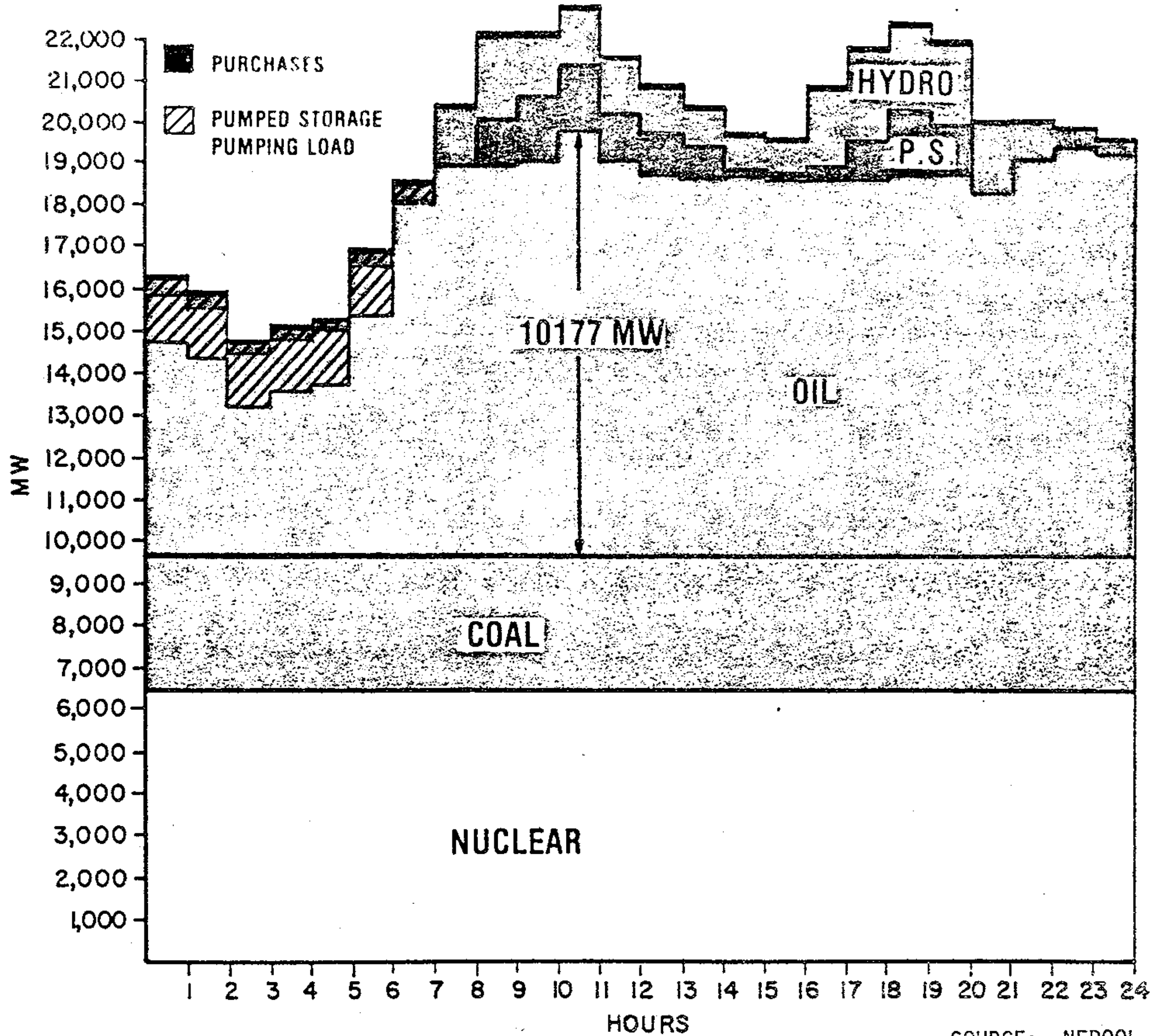
COMMITTED AND PLANNED CHANGES IN GENERATING EQUIPMENT THROUGH 1995

SYSTEM	STATION & UNIT	UNIT TYPE#	FUEL TYPE ##	NEPOOL STATUS[X] AUTHORIZED (A) (A*) PLANNED (P) UNDER STUDY (S)	MFG.	CAPABILITY NOM. CAP. MW SUMMER	WINTER	EFFECTIVE DATE MONTH	YEAR
Northeast Utilities	Dwight #2-4	Hy	--	A	--	1.50	1.50	Jan. 1,	1980
Central Maine Power Company	Barkers Mill	Hy	--	A	--	1.50	1.50	Feb. 1,	1980
Northeast Utilities	Bantam	Hy	--	A	--	0.32	0.32	June 1,	1980
Chicopee Municipal Light Plant	-- #1,2,3	IC	FO2	A	GM	8.25	8.25	Nov. 1,	1980
New England Electric System	Lawrence #1 & 2	Hy	--	A	--	17.00	17.00	July 1,	1981
Mass. Municipal Wholesale Electric	Stony Brook	CC	FO2	A*	GE	279.00	341.00	Nov. 1,	1981
Public Service Co. of New Hampshire	Garvins #1&2	Hy	--	A	--	6.00	6.00	Nov. 1,	1981
Central Maine Power Company	Brunswick/Topsham	Hy	--	A	--	12.00	12.00	Mar. 1,	1982
Vermont Group	Bolton Falls	Hy	--	P	--	4.20	5.60	May 1,	1982
Hudson Electric Light Dept.	Cherry St. #13, 14, 15	IC	FO2	S	--	18.00	18.00	Nov. 1,	1982
Mass. Municipal Wholesale Electric	Stony Brook	GT	FO2	A*	GE	130.00	170.00	Nov. 1,	1982
Mass. Municipal Wholesale Electric	-- #1	ST	REF	S	--	75.00	75.00	Nov. 1,	1982
Public Service Co. of New Hampshire	Murphy Dam	Hy	--	P	--	2.00	2.00	Nov. 1,	1982
Vermont Group	Chase Mills	Hy	--	S	--	6.00	8.00	Nov. 1,	1982
Public Service Co. of New Hampshire	Seabrook #1	NP	UR	A*	W/GE	1150.00	1150.00	Apr. 1,	1983
Northeast Utilities	Hadley Falls #2	Hy	--	A	--	15.00	15.00	June 1,	1983
Mass. Municipal Wholesale Electric	-- #2	ST	REF	S	--	75.00	75.00	Nov. 1,	1983
Vermont Group	E. Georgia	Hy	--	S	--	6.50	8.60	Nov. 1,	1983
Vermont Group	J.C. McNeil #1	ST	WOD	P	--	46.00	46.00	Nov. 1,	1983
Public Service Co. of New Hampshire	Seabrook #2	NP	UR	A*	W/GE	1150.00	1150.00	Feb. 1,	1985
Boston Edison Company	(Fuel Cell)	FC	FO1	P	UT	10.00	10.00	Aug. 1,	1985
Vermont Group	Mississquoi	Hy	--	S	--	17.20	22.80	Nov. 1,	1985
Boston Edison Company	Pilgrim	NP	UR	A*	CE/GE	1150.00	1150.00	Dec. 1,	1985
Northeast Utilities	Millstone Pt.#3	NP	UR	A*	W/GE	1150.00	1150.00	May 1,	1986
Vermont Group	N. Hartland	HY	--	S	--	1.90	2.60	Nov. 1,	1986
Central Maine Power Company	Sears Island	ST	Col	A*	--	568.00	568.00	Nov. 1,	1989
Boston Edison Company	Edgar #7	ST	Col	S	--	800.00	800.00		1992
NEGEA / EUA	Canal #3	ST	Col	S	--	600.00	600.00	Nov. 1,	1992

EXHIBIT 12

NEW ENGLAND PEAK DAY DISPATCH - WINTER 1994/95

24 Units Converted to Coal & NEPOOL Planned Units



SOURCE: NEPOOL

FIGURE 11

Engineers National Hydropower Study or the Regional Hydropower expansion study managed by the New England River Basins Commission reveals the limited nature of our hydropower resource. Figure 12 shows existing dams in Washington County which have been subjected to a preliminary screening by Corps of Engineers for the New England River Basins Commission. Based on preliminary analyses, assuming run of river operation, all of the sites listed could produce energy for less than 100 mils/kwh. As detailed studies are made, it is expected that costs will increase.

Nuclear power expansion has essentially stopped during the last few years. No one knows what the future of nuclear power is in New England now. In the short term nuclear power appears to be the cleanest, most technically proven method of displacing large amounts of oil generation.

Coal and the environmental problems associated with it are under study. Presently only two coal plants operate in New England, one in Massachusetts and one in New Hampshire. They handle only a small part of New England's demand.

As we approach the year 2000 in New England it is likely that a great deal of emphasis will be placed on solar resources; sun, winds, tides and water as we attempt to displace oil-fired electric generation. The tidal project is one such resource and, like hydropower, it is proven, works at relatively high efficiencies and the technology is available now.

Planning Constraints

General planning constraints and guidance for this investigation are contained in Public Law 91-190, National Environmental Policy Act; Public Law 91-611, River and Harbor and Flood Control Act of 1970; Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972; Public Law 93-251, Water Resources Development Act of 1974; and the Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources."

Specific guidance is found in the following Department of the Army regulations; ER 1105-2-14, ER 1105-2-50, ER 1105-2-210, ER 1105-2-220, ER 1105-2-230, ER 1105-2-240, ER 1105-2-250, ER 1105-2-507, ER 1105-2-800 and ER 1105-2-921.

In the design of any tidal dam, meausres must be taken to insure maintenance of navigation and to accommodate fish and mammal passage as required. Endangered species which are known to exist or are presumed to exist within the project area include the bald eagle, Arctic peregrine falcon, several species of whales, and the shortnose sturgeon, and would require consultation under Section 7 of the Endangered Species Act of 1973.

Planning Objectives

Planning Objectives of this study reflect national and regional needs as applicable to the tidal power investigation. It should be noted that

HYDROPOWER POTENTIAL AT EXISTING DAMS
IN WASHINGTON COUNTY

	Project Name	Community	River/Stream	Capacity Kw	Energy Mwh	Mills/Kwh
1.	Columbia Falls	Columbia Falls	Pleasant River	505	1,775	96.5
2.	Upper Dam	Pembroke	Penamaquan River	471	1,479	91.3
3.	Danforth Dam	Danforth	Crooked Brook Falls	517	1,808	83.9
4.	Cherryfield	Cherryfield	Naraguagus	698	2,422	75.1
5.	Whitneyville Upper	Whitneyville	Machias River	2,376	8,352	74.0
6.	Machias River Dam 3	Machias	Machias River	743	2,610	73.3
7.	E. Machias River Dam	E. Machias	E. Machias River	1,133	3,981	72.7
8.	Whitneyville Lake	Whitneyville	Machias River	1,485	5,220	72.5
9.	W. Grand Lake Outlet	Grand Lake Stream Plantn.	Big Lake Lower	941	3,293	67.7
10.	Orange River Dam	Whiting	Orange River	416	1,462	57.6
11.	Meddybemps Lake	Meddybemps	Meddybemps Lake	417	1,467	57.4
12.	Vanceboro Dam	Vanceboro	St. Croix River	1,583	5,542	53.7
13.	Machias River Lower Dam	Machias	Machias River	3,003	10,556	52.1
14.	Machias River Dam 2	Machias	Machias River	2,970	10,440	44.6
15.	Murchie Dam	Calais	St. Croix River	4,004	14,014	44.0
16.	Saco Falls Dam	Columbia	Pleasant River	1,271	2,381	42.1
17.	Mill Town Dam	Calais	St. Croix River	4,939	17,287	39.6
18.	Calais Union Dam	Calais	St. Croix River	4,528	15,847	37.7
19.	Machias River Dam 4	Machias	Machias River	4,158	14,616	23.1
			Total	36,108	124,552	

FIGURE 12

the order of the objectives is not intended as an indication of their relative importance. As the study progresses, the planning objectives will be refined and modified with the possibility that some could be dropped. It is also possible that as the study progresses additional objectives may be identifed and added. The planning objectives recognized at this time include:

- increase New England's electric energy supply
- development of a native renewable energy resource to it's maximum potential
- increase national and regional energy independence

III. FORMULATION OF PLANS

Management Measures

There are a number of management measures which may be employed to reduce New England's dependence on oil for the production of electrical energy and to satisfy other planning objectives as well. Structural measures include conversion of oil fired facilities to coal, building additional coal and nuclear facilities, construction of hydroelectric and tidal power projects, and development of alternative energy sources including, but not limited to wind, passive solar, coal liquification photovoltaics, wave action, geothermal, wood, and other biomass, and purchases of imported power. Non-structural measures would consist mainly of conservation and load management. A brief discussion of the primary function of each measure, including inherent advantages and disadvantages, is presented below.

Conversion of oil facilities to use coal as a fuel directly reduces the amount of oil needed for electric energy production. The concept is technically sound and economically implementable at many facilities. The conversion, however, is not without problems. Key factors that must be considered are the availability of water or rail transportation facilities and protection of ambient environmental quality.

The construction of new coal and nuclear facilities also directly reduces oil use. New coal facilities have problems similar to converted facilities and the current social-political climate in New England makes development of nuclear projects difficult if not impossible.

Hydroelectric facilities including run-of-river, pumped storage, conventional and tidal power, also directly reduce the amount of oil used for generation. While these projects do not degrade air quality, or create dangerous waste materials they tend to permanently alter existing physical conditions at the project site. Sometimes they displace inhabitants and adversely effect resident wildlife. The fuel, water, is a renewable resource.

Wind power is one of the oldest forms of energy. Wind power is clean and many sites are available. Energy from such projects is intermittent, as is energy from single pool tidal power projects and run-of-river hydropower projects. Energy from such projects is dependent on natural phenomena, wind, tides and runoff. Man cannot control when fuel will be available. In the case of tidal power or run-of-river power energy availabilty can be predicted with a reasonable accuracy. Wave action offers promise on a small scale. Passive solar is basically an at-site technology. It is useful for space and hot water heating. It is not particularly adaptable to large centralized facilities. Liquified coal, photovoltaics, nuclear fusion and biomass will, perhaps, be the predominant energy sources of the 2000's. Once fully developed, these technologies could lead to energy independence for the Nation.

Purchases of imported power would reduce our direct dependence on oil but do little to enhance our energy independence.

Conservation is perhaps the best short-term answer to oil use reduction. Lower thermostats, insulation and other conservation methods directly reduce oil use and have limited impacts on changes in life style.

Load management is primarily aimed at rearranging the timing of electic demand. This involves the changing of people's habits. Once established, load management would allow more use of base load and intermediate power sources (lower cost, coal, nuclear and hydroelectric) and require less peaking power (expensive pumped storage and oil dependent combustion turbines). Of course, load management assumes that nuclear and coal energy sources will continue to be developed and ultimately displace existing oil generating facilities.

Plan Formulation Rationale

The purpose of this investigation is to determine the feasibility of developing tidal power by taking advantage of the large tide range experienced in the Cobscook-Passamaquoddy Bay area. Therefore, alternative studies do not include all the management measures indicated in the previous section. Any of the measures mentioned would help to reduce oil consumption and be compatible with any possible tidal power project.

In 1979, a number of tidal power alternatives located entirely within Cobscook Bay were subjected to a preliminary economic analysis. Single pool and multipool projects ranging from 4 to 450 megawatts were considered. None of the alternatives analyzed were found to be economically feasible using conventional, static benefit to cost analysis. However, some of the larger single pool projects were found to be economically acceptable using certain fuel price escalations and a dynamic benefit to cost ratio analysis known as relative price shift analysis. Single pool alternatives with large areas of the bay impounded and relatively small installed capacities were found to produce energy at the lower costs per kilowatt hour than did small linked basins or paired basins. Such single pool projects generate energy twice daily at different times each day with the time of occurrence being dependent on the tide cycle. The single pool projects have no dependable capacity and no monetary value associated with the capacity. While multipool plans provide for some dependable capacity an amount of installed capacity 3 to 4 times greater than the dependable capacity must be provided. In other words, a great deal of money must be spent on turbines and generators whose total potential is never realized. Generally, then, that study seemed to indicate that large single pool projects allow maximum utilization of the tidal resources. It was found that lowest cost energy could be produced when single pool project turbines and generators were sized to operate for 5 to 6 hours per tide cycle on the average. The unique relationship between installed capacity and energy produced from a project for a period of time is referred to as a "capacity factor." The work done for the 1979 report strongly suggested that for single pool tidal power alternatives projects sized and operated to have a capacity factor around 0.4 might produce energy at a lower cost per kilowatt hour than other configurations.

Based on these preliminary economic findings four single pool plans were selected for more detailed analysis in this study. One small single pool plan and three large single pool plans were considered in this study. If future studies are found to be warranted a two pool plan and a scheme involving multiple small single pool plans will be addressed in sufficient detail to determine if such schemes are indeed economically inferior to large single pool plans as indicated by the 1979 study and to ascertain the environmental impacts assoicated with their development.

The Plans of Others

Currently a study of a small single pool 12 megawatt tidal power project within Cobscook Bay is being conducted by the Passamaquoddy Indians. The project, located at and known as Half Moon Cove, has been under study for the past several years. On 19 June 1980, the Federal Energy Regulatory Commission granted a prelimiary permit to the Passamaquoddy Tribal Council. This permit allows the tribe to study Half Moon Cove for tidal power feasibility for up to three years. At this time, New England Division is not aware of current cost estimates for the proposed project.

Owing to the Half Moon Cove project and the long history of the tidal power study in the region, local residents of the area have formed a Tidal Power Committee. While New England Division has never been formally made aware of the existence of this group it appears from news clippings that the committee is interested in the development of several small, electrically interconnected, tidal power projects including Half Moon Cove.

The Pittston Oil Company of New York has proposed a 250,000 barrel per day refinery and deep water port at Eastport on Shackford Head. Information regarding this proposal can be found in the project's Final Environmental Impact Statement, (Reference 51). Figure 13 shows the locations of the Half Moon Cove Tidal Power project and the proposed refinery.

Description of Plans

As previously mentioned all the plans under consideration are single pool projects. A single high pool system is one in which a barrier cuts off a single tidal basin from the ocean. The basin pool is filled when the ocean tide level is higher than the pool level and the barrier is closed when the ocean tide falls. Power is generated during the period when the ocean level is lower than the pool level by discharging water through turbines from the pool to the ocean. The pool is filled by the operation of filling gates, and no power is generated during filling nor is generation started until sometime after filling has been accomplished. Although such a system produces "reliable" energy, it is neither continuous nor available on demand. Some operating flexibility might be possible within a given low tide cycle based on short-term load demand forecasts. Theoretically, the systems process could be reversed and generation takes place by discharging into a low single pool; however, the high pool system is usually preferred since change in pool level per unit discharge is less in the upper levels of the basin.

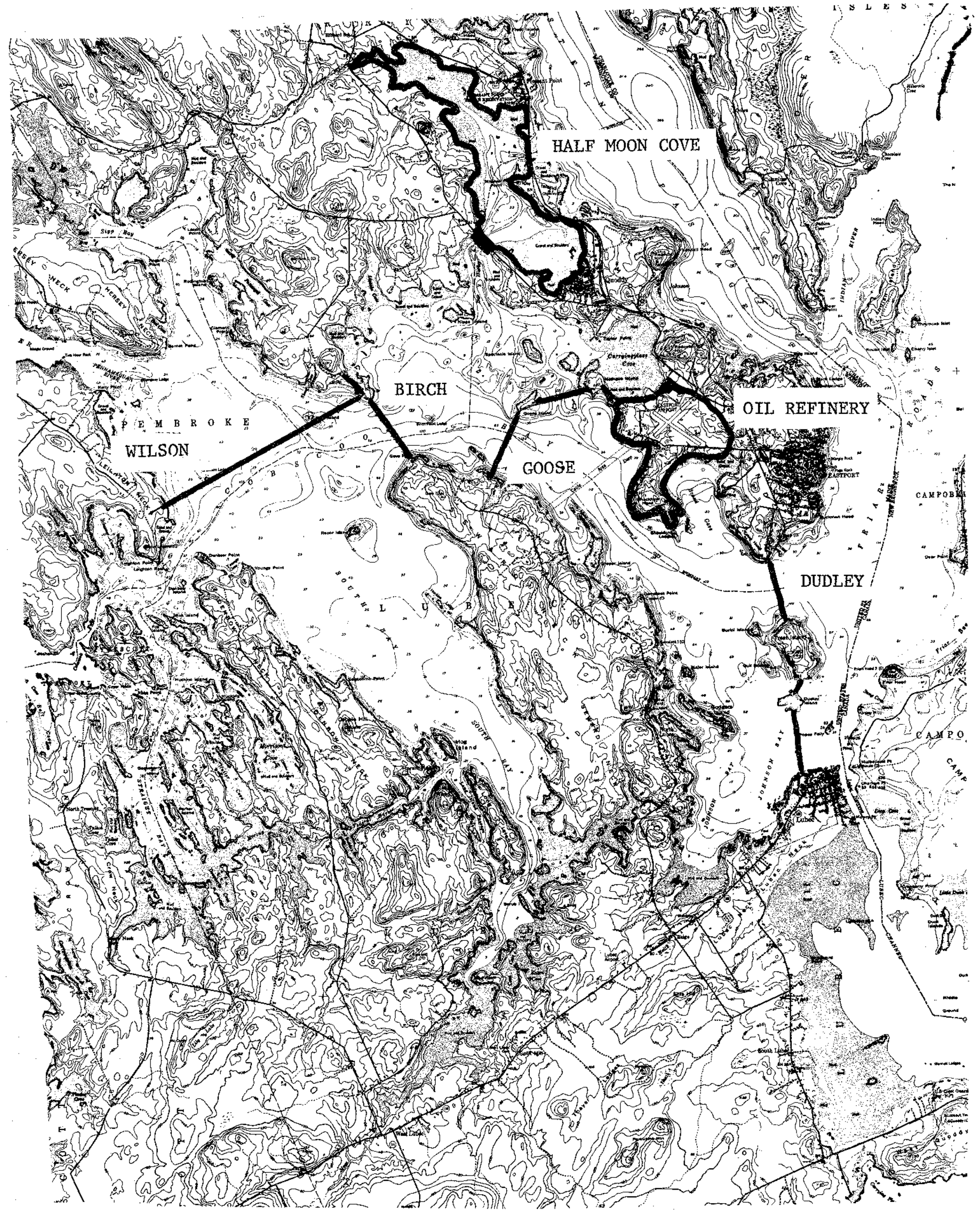
The major structural elements of a tidal power project as planned are a powerhouse, gates, a lock, a fishway and large earth and rockfill dams.

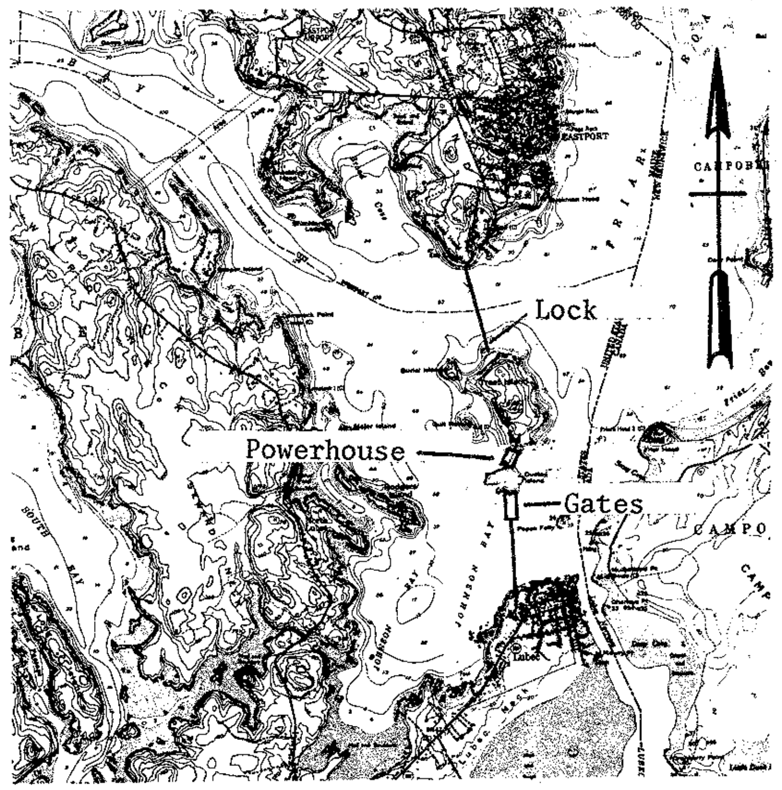
Figure 13 shows the location of each of the four alternatives and briefly describes the pertinent features of each alternative. The "Wilson alignment" impounds East Bay and the Pennamaquan River with a dam that originates at Leighton Neck, passes through Wilson Ledges and Red Island, terminating at Birch Point. The "Birch alignment" impounds the Inner Bay, South Bay and East Bay and originates at Birch Point and terminates at Seward Neck. The "Goose alignment" impounds the same areas as the Birch alignment with the addition of Half Moon Cove and originates at Seaward Neck, passes through Goose Island and Mathews Island to Moose Island. The "Dudley alignment" follows the 1935 dam alignment and impounds all of Cobscook Bay. It originates at Eastport, passes through Treat and Dudley Islands and terminates at Lubec. The Dudley alignment is signficantly different than the 1935 alignment, however, in that the powerhouse is located between Treat and Dudley Islands instead of on Moose Island between Johnson Cove and Carrying Place Cove. Figure 14 shows the pertinent features of the 1935 alignment. The primary reasons for the Moose Island powerhouse location in 1935 was that it would allow further development on an international plan that involved both Passamaquoddy Bay and Cobscook Bay. Given Canada's current position of non-interest in the pursuit of an international plan and the economies to be realized by locating the powerhouse between Dudley and Treat Island this change in plan seems reasonable.

Design Considerations

Foundations

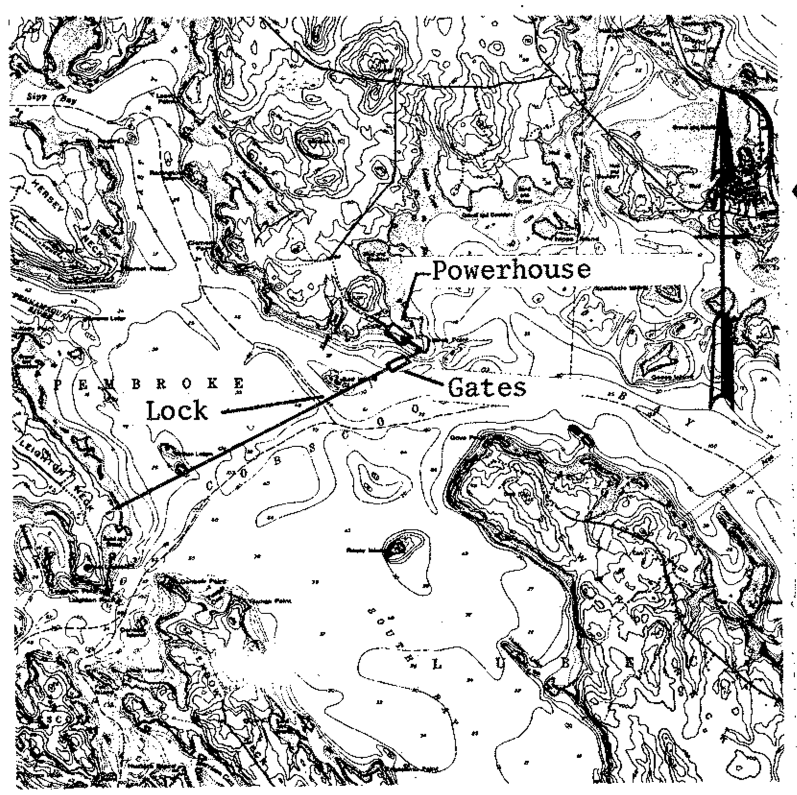
Explorations for the proposed alignments consisted of borings made at the Dudley site in 1936 and a seismic reflection survey of the four alignments under study as shown on Figure 15a. The seismic reflection reconnaissance surveys were conducted in May 1979 and consisted of multiple lines at each of the sites. No direct velocity data was made during the survey. The estimate of the average velocity of the sediments was achieved by correlation of data along seismic lines on the North Dudley site with geologic profiles prepared on the basis of explorations made in 1936. By calibrating the survey with the known geologic conditions at the North Dudley site a maximum degree of reliability was obtained for the site surveys. No explorations have been made on the alignments to verify assumed foundation conditions shown on Figures 15b through 15e.





Dudley Alignment - Would consist of an earth and rockfilled dam approximately 1.5 miles in length with a maximum height of 140 feet. At high tide the dam would impound an area of 39.5 square miles. Installed capacities ranging from 120 MW to 970 MW with average annual energies ranging from 470 GWH to 1420 GWH were investigated.

Goose Alignment - Would consist of an earth and rockfilled dam approximately 2.0 miles in length with a maximum depth of 125 feet. At high tide the dam would impound an area of 33.5 square miles. Installed capacities ranging from 100 MW to 815 MW with average annual energies ranging from 400 GWH to 1215 GWH were investigated.



Wilson Alignment - Would consist of an earth and rockfilled dam approximately 2.5 miles in length with a maximum depth of 90 feet. At high tide the dam would impound an area of 6.0 square miles. Installed capacities ranging from 18 MW to 150 MW with average annual energies ranging from 70 GWH to 220 GWH were investigated.

Birch Alignment - Would consist of an earth and rockfilled dam approximately 1.0 miles in length with a maximum depth of 115 feet. At high tide the dam would impound an area of 28.5 square miles. Installed capacities ranging from 80 MW to 700 MW with average annual energies ranging from 340 GWH to 1040 GWH were investigated.

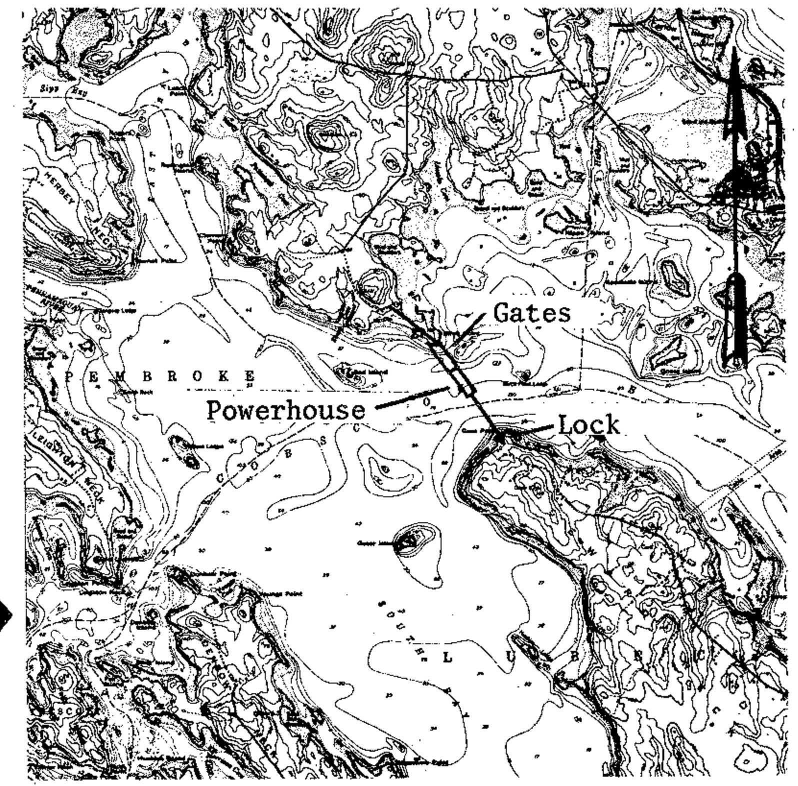
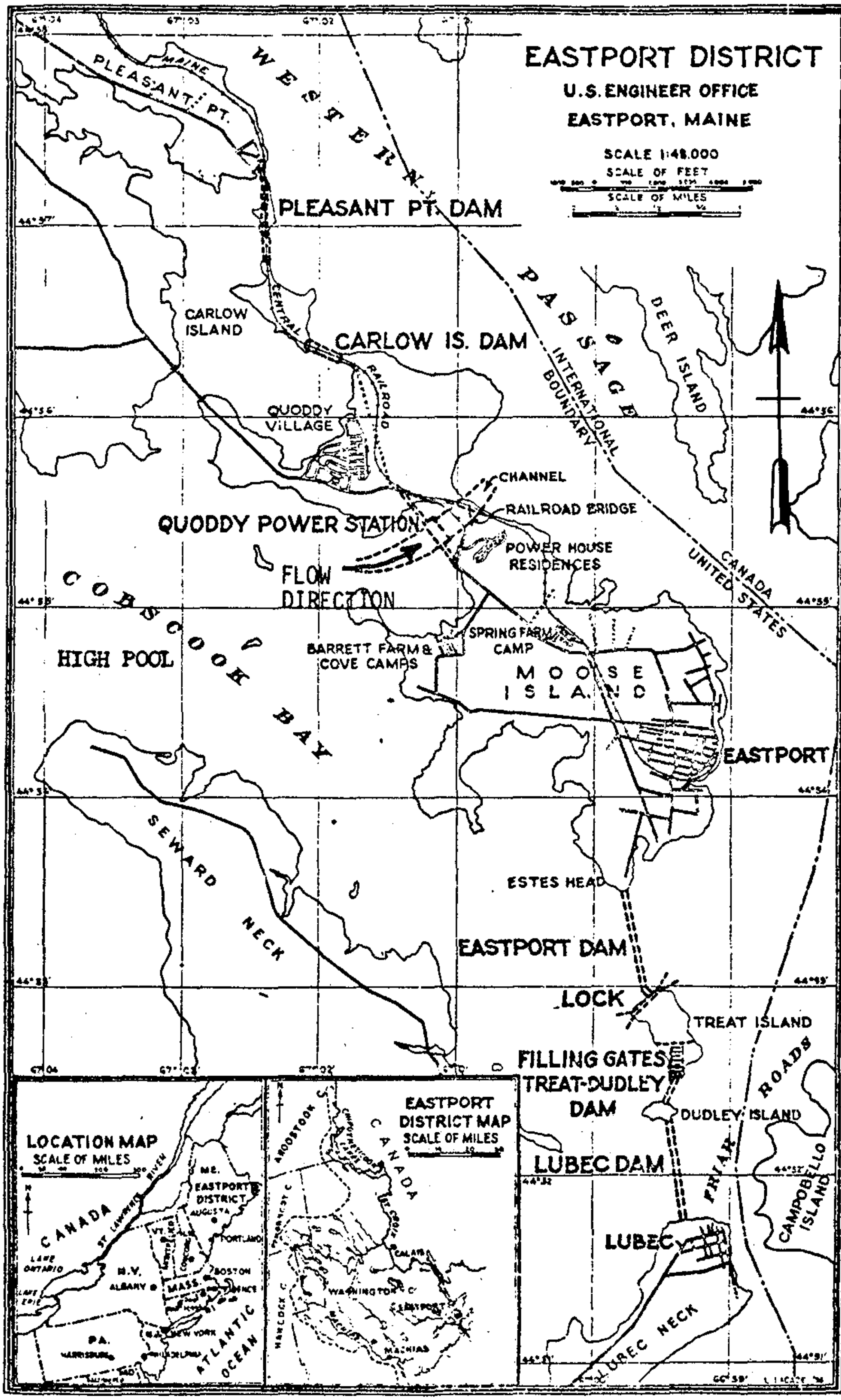


FIGURE 13



COBSCOOK BAY - 1935
FIGURE 14

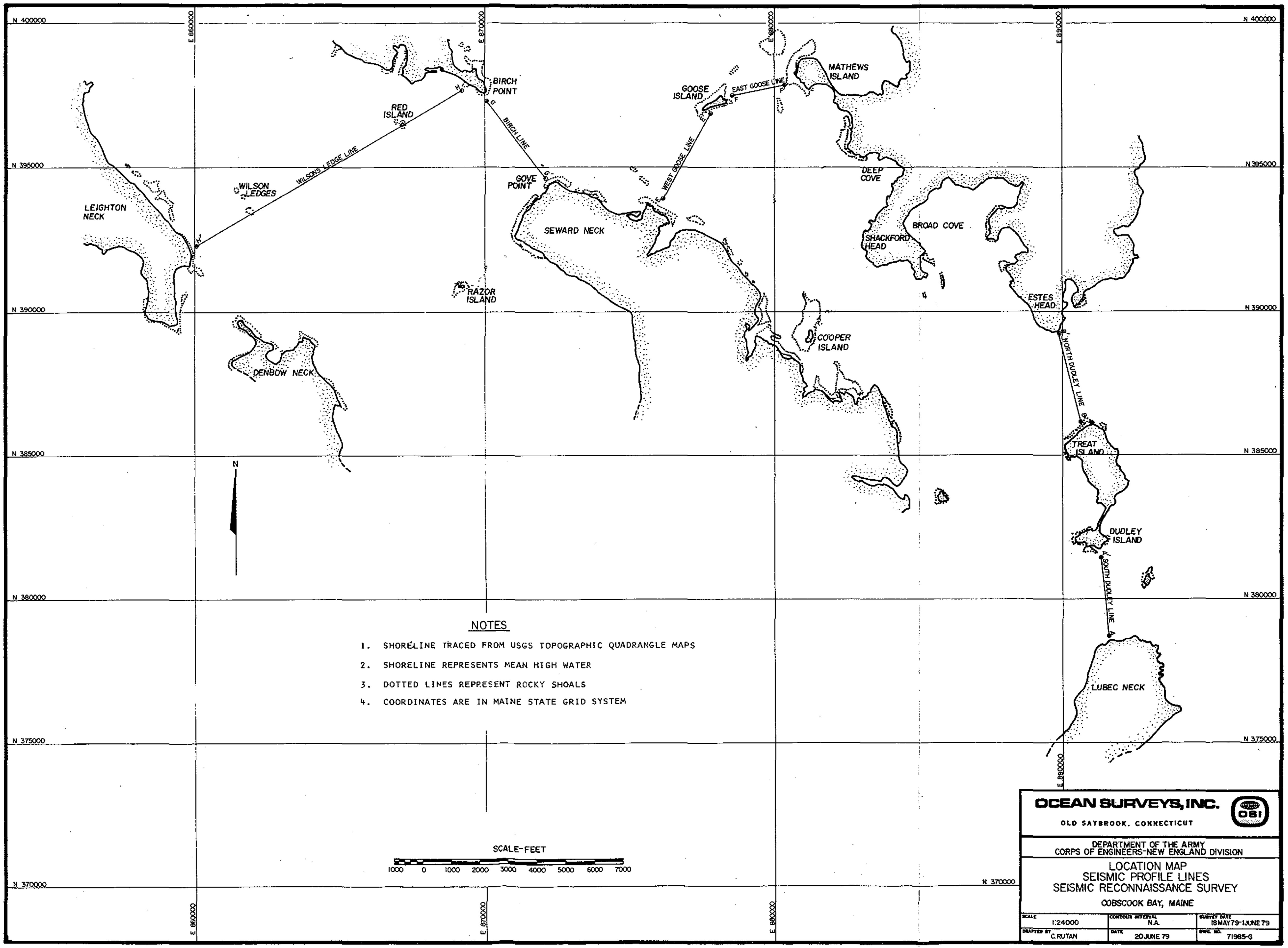

MATHEWS ISLAND
GOOSE ISLAND
EAST GOOSE LINE
BIRCH POINT
RED ISLAND
BIRCH LINE
WEST GOOSE LINE
WILSONS LEDGE LINE
WILSON LEDGES
GOVE POINT
DEEP COVE
LEIGHTON NECK
SEWARD NECK
BROAD COVE
SHACKFORD HEAD
RAZOR ISLAND
ESTES HEAD
COOPER ISLAND
DENBOW NECK
NORTH DUDLEY LINE
TREAT ISLAND
DUDLEY ISLAND
SOUTH DUDLEY LINE
LUBEC NECK
NOTES
1. SHORELINE TRACED FROM USGS TOPOGRAPHIC QUADRANGLE MAPS
2. SHORELINE REPRESENTS MEAN HIGH WATER
3. DOTTED LINES REPRESENT ROCKY SHOALS
4. COORDINATES ARE IN MAINE STATE GRID SYSTEM
SCALE-FEET
1000 0 1000 2000 3000 4000 5000 6000 7000
OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-NEW ENGLAND DIVISION
LOCATION MAP
SEISMIC PROFILE LINES
SEISMIC RECONNAISSANCE SURVEY
COBSCOOK BAY, MAINE
SCALE 1:24000
CONTOUR INTERVAL N.A.
SURVEY DATE 18MAY79-1JUNE79
DRAFTED BY C.RUTAN
DATE 20JUNE79
DWG. NO. 71965-G

FIGURE 15a

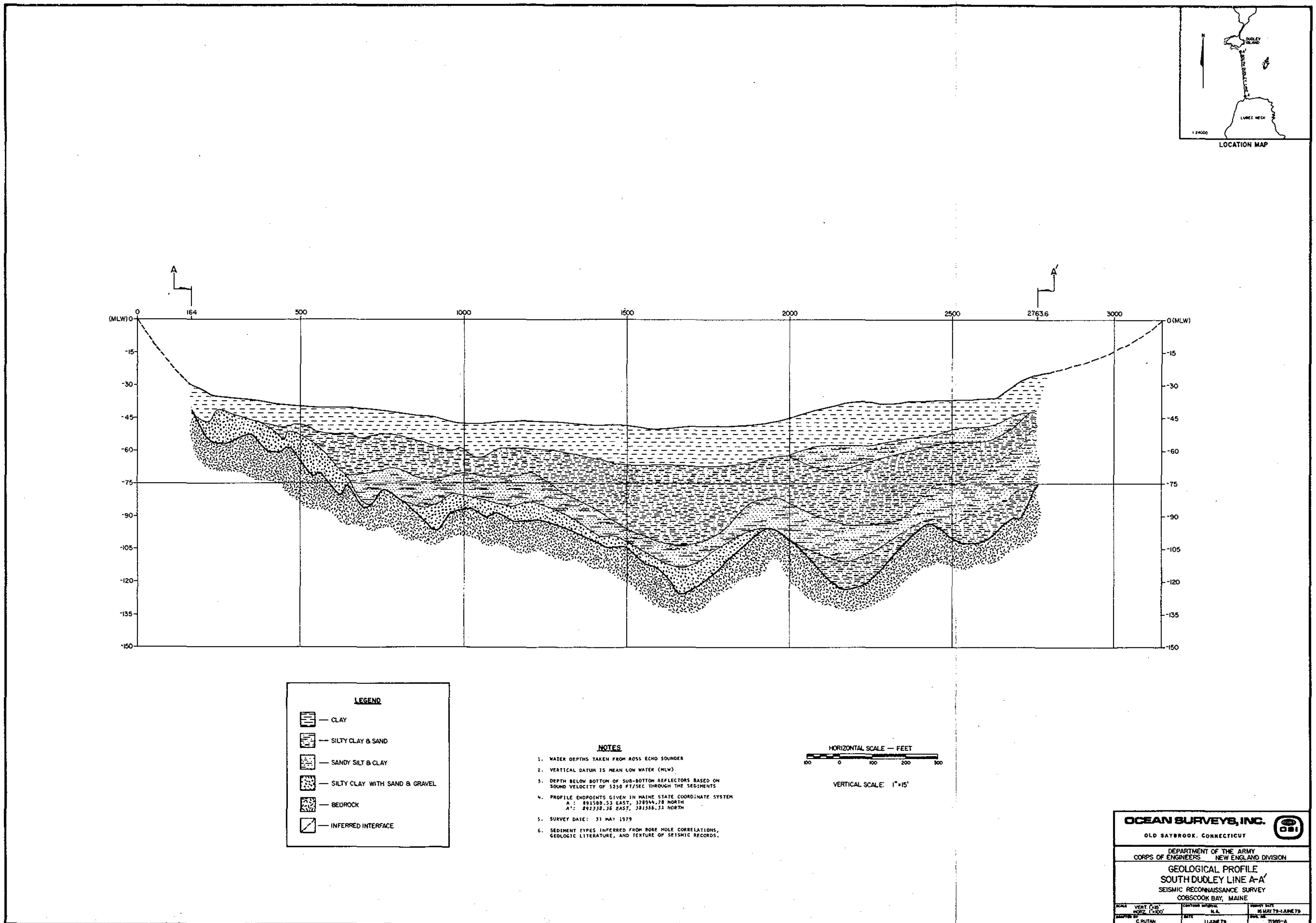
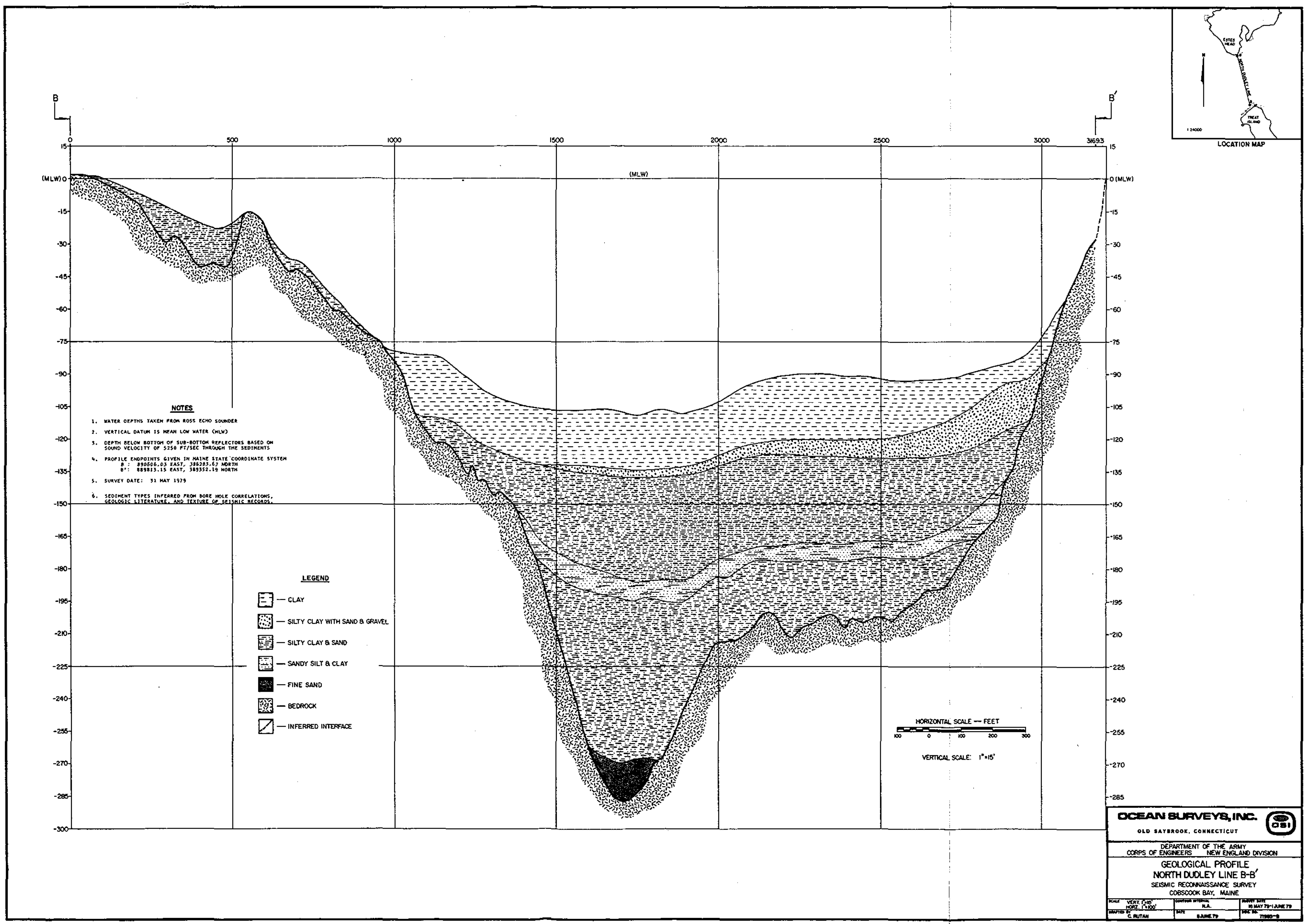

LOCATION MAP
DUDLEY ISLAND
LUBEC NECK
A
A′
(MLW) 0
0
164
500
1000
1500
2000
2500
2763.6
3000
0 (MLW)
-15
-30
-45
-60
-75
-90
-105
-120
-135
-150
LEGEND
CLAY
SILTY CLAY & SAND
SANDY SILT & CLAY
SILTY CLAY WITH SAND & GRAVEL
BEDROCK
INFERRED INTERFACE
NOTES
1. WATER DEPTHS TAKEN FROM ROSS ECHO SOUNDER
2. VERTICAL DATUM IS MEAN LOW WATER (MLW)
3. DEPTH BELOW BOTTOM OF SUB-BOTTOM REFLECTORS BASED ON SOUND VELOCITY OF 5250 FT/SEC THROUGH THE SEDIMENTS
4. PROFILE ENDPOINTS GIVEN IN MAINE STATE COORDINATE SYSTEM
A : 891500.53 EAST, 378944.78 NORTH
A′: 892338.36 EAST, 381566.31 NORTH
5. SURVEY DATE: 31 MAY 1979
6. SEDIMENT TYPES INFERRED FROM BORE HOLE CORRELATIONS, GEOLOGIC LITERATURE, AND TEXTURE OF SEISMIC RECORDS.
HORIZONTAL SCALE — FEET
100
0
100
200
300
VERTICAL SCALE: 1"=15'
OCEAN SURVEYS, INC.
OSI
OLD SAYBROOK, CONNECTICUT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS NEW ENGLAND DIVISION
GEOLOGICAL PROFILE
SOUTH DUDLEY LINE A-A′
SEISMIC RECONNAISSANCE SURVEY
COBSCOOK BAY, MAINE
VERT. 1"=15'
HORZ. 1"=100'
N.A.
C. RUTAN
11 JUNE 79
71905-A

FIGURE 15b



B
B'
(MLW)
NOTES
1. WATER DEPTHS TAKEN FROM ROSS ECHO SOUNDER
2. VERTICAL DATUM IS MEAN LOW WATER (MLW)
3. DEPTH BELOW BOTTOM OF SUB-BOTTOM REFLECTORS BASED ON SOUND VELOCITY OF 5250 FT/SEC THROUGH THE SEDIMENTS
4. PROFILE ENDPOINTS GIVEN IN MAINE STATE COORDINATE SYSTEM
B : 890606.03 EAST, 386283.67 NORTH
B': 889813.15 EAST, 389352.19 NORTH
5. SURVEY DATE: 31 MAY 1979
6. SEDIMENT TYPES INFERRED FROM BORE HOLE CORRELATIONS, GEOLOGIC LITERATURE, AND TEXTURE OF SEISMIC RECORDS.
LEGEND
— CLAY
— SILTY CLAY WITH SAND & GRAVEL
— SILTY CLAY & SAND
— SANDY SILT & CLAY
— FINE SAND
— BEDROCK
— INFERRED INTERFACE
HORIZONTAL SCALE — FEET
VERTICAL SCALE: 1"=15'
LOCATION MAP
OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS NEW ENGLAND DIVISION
GEOLOGICAL PROFILE
NORTH DUDLEY LINE B-B'
SEISMIC RECONNAISSANCE SURVEY
COBSCOOK BAY, MAINE
VERT. 1"=15'
HORZ. 1"=100'
N.A.
C. RUTAN

FIGURE 15c

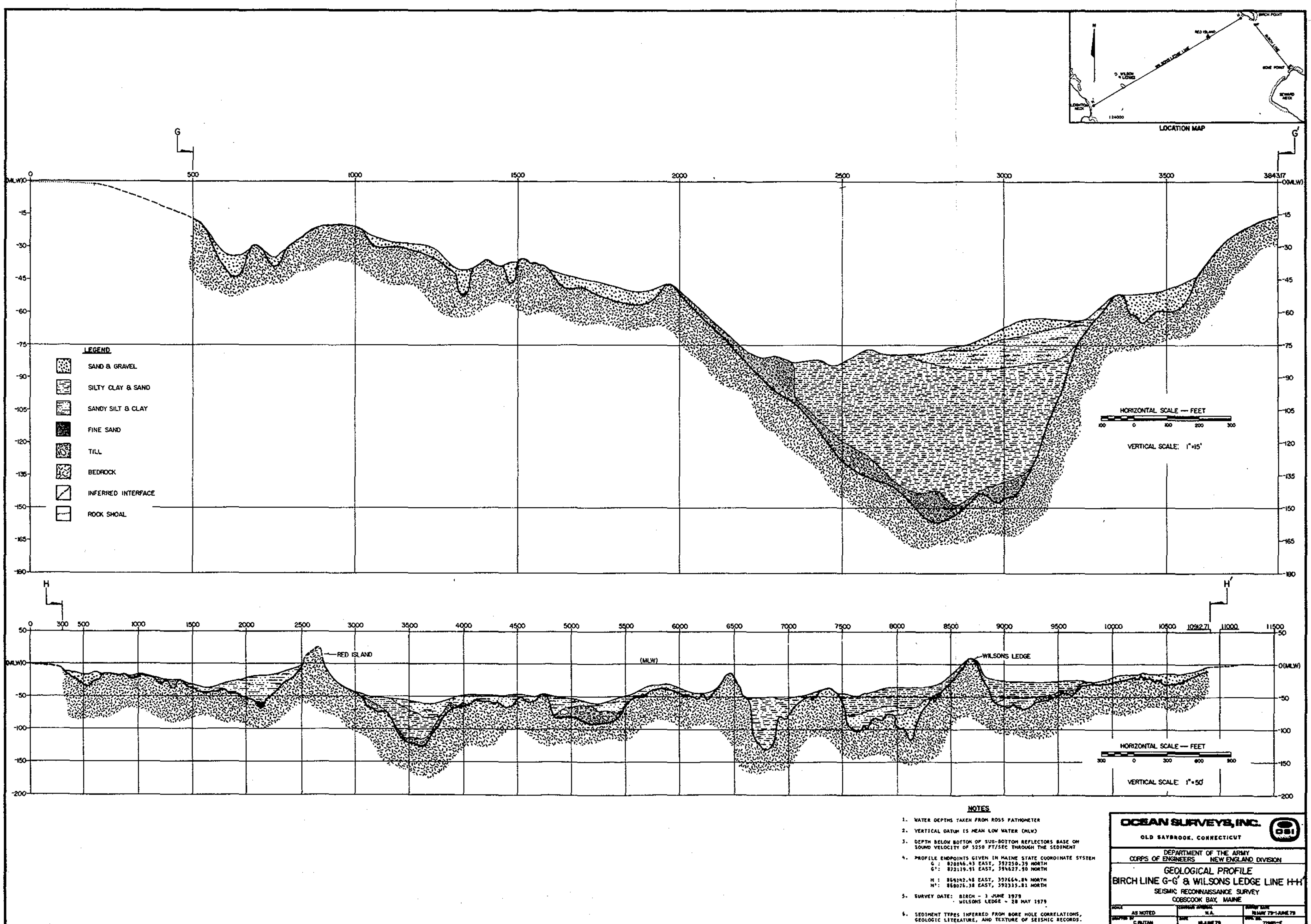

LOCATION MAP
LEGEND
SAND & GRAVEL
SILTY CLAY & SAND
SANDY SILT & CLAY
FINE SAND
TILL
BEDROCK
INFERRED INTERFACE
ROCK SHOAL
RED ISLAND
WILSONS LEDGE
(MLW)
HORIZONTAL SCALE — FEET
VERTICAL SCALE: 1"=15'
VERTICAL SCALE: 1"=50'
NOTES
1. WATER DEPTHS TAKEN FROM ROSS FATHOMETER
2. VERTICAL DATUM IS MEAN LOW WATER (MLW)
3. DEPTH BELOW BOTTOM OF SUB-BOTTOM REFLECTORS BASE ON SOUND VELOCITY OF 5250 FT/SEC THROUGH THE SEDIMENT
4. PROFILE ENDPOINTS GIVEN IN MAINE STATE COORDINATE SYSTEM
5. SURVEY DATE: BIRCH - 1 JUNE 1979 · WILSONS LEDGE - 28 MAY 1979
6. SEDIMENT TYPES INFERRED FROM BORE HOLE CORRELATIONS, GEOLOGIC LITERATURE, AND TEXTURE OF SEISMIC RECORDS.
OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS NEW ENGLAND DIVISION
GEOLOGICAL PROFILE
BIRCH LINE G-G' & WILSONS LEDGE LINE H-H'
SEISMIC RECONNAISSANCE SURVEY
COBSCOOK BAY, MAINE
AS NOTED
N.A.
C.RUTAN

FIGURE 15d

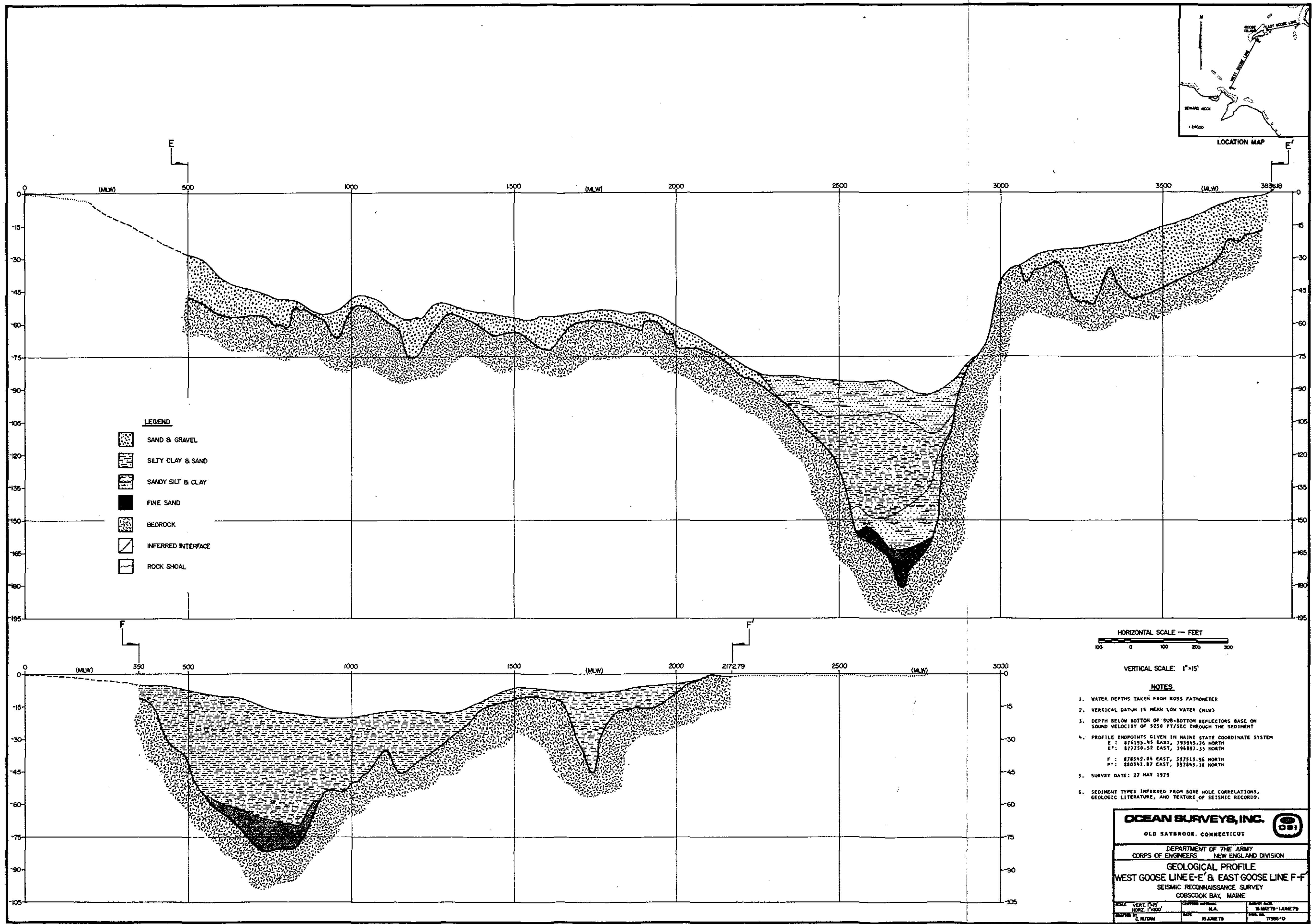

LOCATION MAP
E
E'
F
F'
(MLW)
LEGEND
SAND & GRAVEL
SILTY CLAY & SAND
SANDY SILT & CLAY
FINE SAND
BEDROCK
INFERRED INTERFACE
ROCK SHOAL
HORIZONTAL SCALE — FEET
VERTICAL SCALE: 1"=15'
NOTES
1. WATER DEPTHS TAKEN FROM ROSS FATHOMETER
2. VERTICAL DATUM IS MEAN LOW WATER (MLW)
3. DEPTH BELOW BOTTOM OF SUB-BOTTOM REFLECTORS BASE ON SOUND VELOCITY OF 5250 FT/SEC THROUGH THE SEDIMENT
4. PROFILE ENDPOINTS GIVEN IN MAINE STATE COORDINATE SYSTEM
E : 876195.45 EAST, 393945.76 NORTH
E': 877750.52 EAST, 396897.35 NORTH
F : 878549.04 EAST, 397513.96 NORTH
F': 880341.87 EAST, 397843.10 NORTH
5. SURVEY DATE: 27 MAY 1979
6. SEDIMENT TYPES INFERRED FROM BORE HOLE CORRELATIONS, GEOLOGIC LITERATURE, AND TEXTURE OF SEISMIC RECORDS.
OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS NEW ENGLAND DIVISION
GEOLOGICAL PROFILE
WEST GOOSE LINE E-E' & EAST GOOSE LINE F-F'
SEISMIC RECONNAISSANCE SURVEY
COBSCOOK BAY, MAINE
N.A.
C. RUTAN
15 JUNE 79
71985-D

FIGURE 15e

The sediment types have been inferred based upon consideration of exploration data on the Dudley sites, and a literature search dealing with the geology and geologic history of the area and the texture of the seismic reflections as they appear on the graphic records. No attempt has been made to delineate rock types on the geologic profile. In general, previous foundation studies on earlier structures have indicated that the rock is sufficiently competent for most concrete structures. Design of individual structures would be based on the rock structures at the particular location.

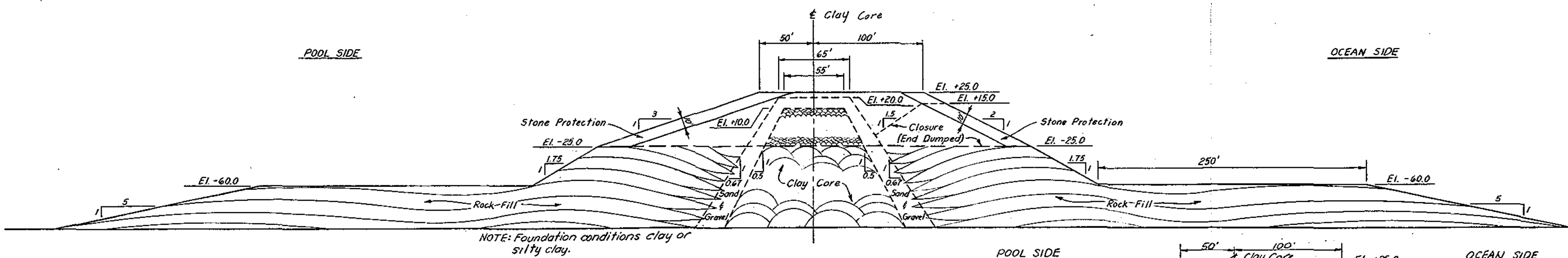
The project is located in Zone 1 on the Seismic Probability Chart for the United States. The Seismic Zone Map indicates that damage in this zone would be minor with a seismic coefficient for design of .025. A cursory review of available historical data reveals, however, that approximately 30 earthquake epicenters have been recorded within 75 miles radius of the project area in the United States and Canada. Of this number the majority of the earthquakes were in the intensity ranges of III to IV with a maximum earthquake of an intensity VIII occurring in the Bay of Fundy approximately 35 miles west of the site. Closer to the site an earthquake of intensity VII occurred on 21 March 1904 at 6:00 a.m. This earthquake which was documented in records by the National Earthquake Information Service (NEIS) and the Earthquake History of the United States (EHUS) was felt over an area of 150,000 square miles. The proximity to the project site of these reported epicenters will require further documentation as their presence may influence the design of structures.

Two solar powered seismic array stations PQ-0 and PQ-1 were established by the Corps of Engineers in 1978 at Cooper Hill and East Ridge School approximately 20 miles west of the project site to monitor seismic activity in the Cobscook Bay region. Since installation there has been no significant activity recorded at the stations which are continuously monitored at the Weston Observatory in Weston, Massachusetts.

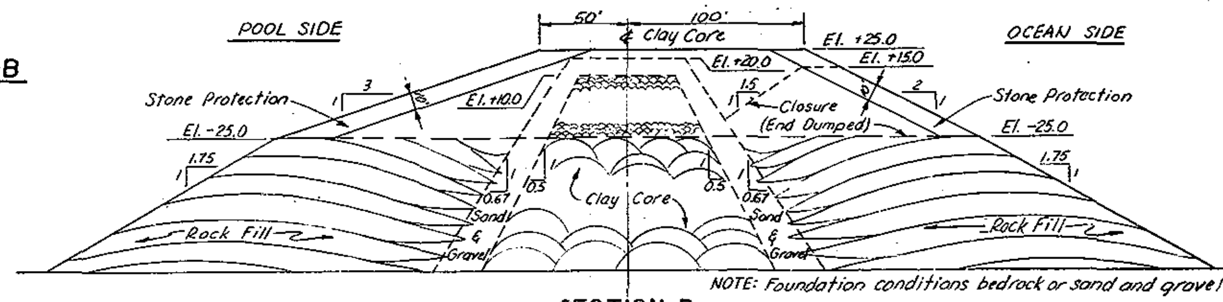
Embankment Sections

For the purpose of this report, the embankment sections developed for the 1959 International Passamaquoddy Tidal Power Project Report, have been adapted to the conditions for the present Cobscook Bay alignments. These sections (Figure 16), were selected on the basis of practicablility of construction and their pool retention capability. A detailed summary of prior studies and investigations pertaining to the design of tidal dam embankments in the Passamaquoddy region can be found in Appendix 9 of the report on the Internatioinal Passamaquoddy Tidal Power Project (Reference 15). During later design stages refinements will be made to the above embankment sections to improve constructibility and economy of materials.

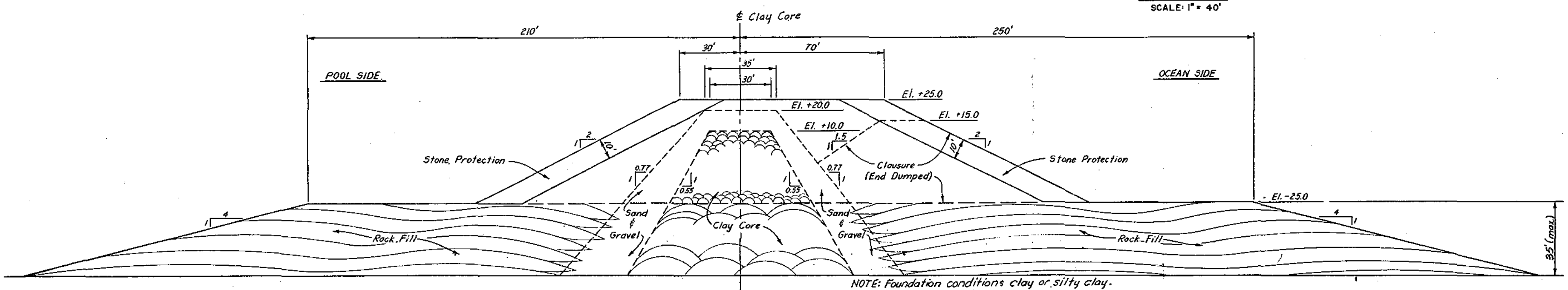
Major considerations associated with embankment design are; selection and availability of appropriate construction materials; determination of suitable constructable cross-section geometry and feasible methods of material placement. These basic considerations have both independent and inter-related effects on design and cost of the tidal dams.



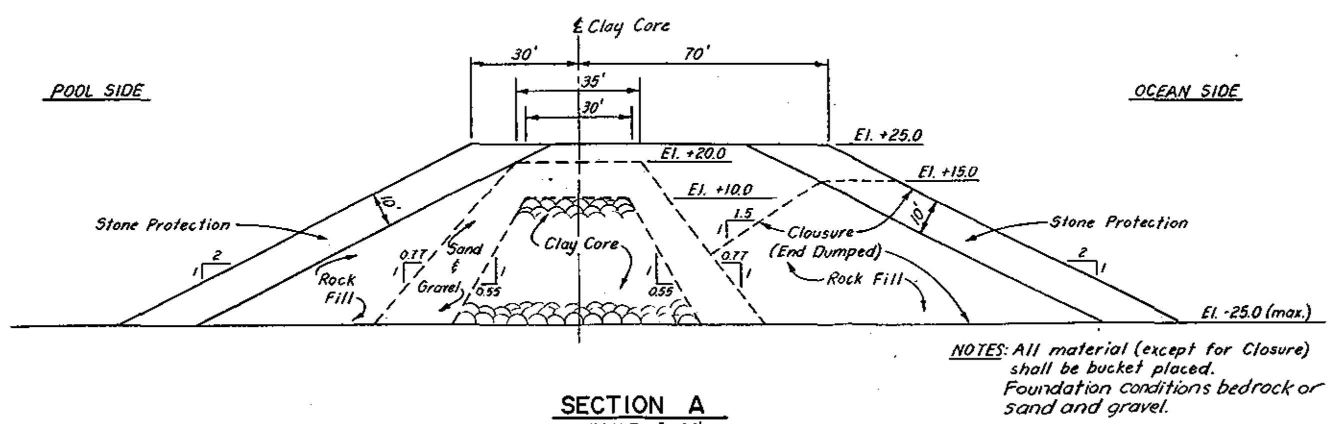
SECTION B-B
SCALE: 1" = 40'



SECTION B
SCALE: 1" = 40'



SECTION A-A
SCALE: 1" = 20'



SECTION A
SCALE: 1" = 20'

GENERAL NOTES:
1. All material below El. -25.0 shall be scow dumped.
2. All material above El. -25.0 (except Closure) shall be bucket-placed.
3. Closure materials shall be end-dumped.
4. Refer elevations to National Geodetic Vertical Datum.
5. The sections were adopted from the 1959 Passamaquoddy Report, Plate 9-17.

TIDAL POWER STUDY
COBSCOOK BAY, MAINE

BIRCH AND GOOSE ALIGNMENTS
TYPICAL SECTIONS

SCALE IN FEET
20' 0 20' 40'
40' 0 40' 80'

U.S. ARMY ENGINEERS DIVISION, NEW ENGLAND
AUGUST 1980

FIGURE 16

After review of previous studies and investigations pertaining to the design of tidal dam embankments in the Passamaquoddy region, the central clay core embankment cross-section (figure 16) is considered the best alternative for the region's tide and foundation conditions. The central clay core type of construction has the advantages of protecting the impervious material more completely against erosion, having greater seepage resistance and making economically effective use of readily available materials. During later design stages other "state of the art" tidal embankments should be investigated for their possible application to the Cobscook Bay region.

The central clay core embankment section consists of a central scow dumped clay core flanked on both sides of a sand and gravel transition zone with rock fill on the outer slopes of the embankment. The basic embankment section is further stabilized by a rock fill apron on both sides of the embankment in the case of clay or silty clay foundation.

Construction Materials

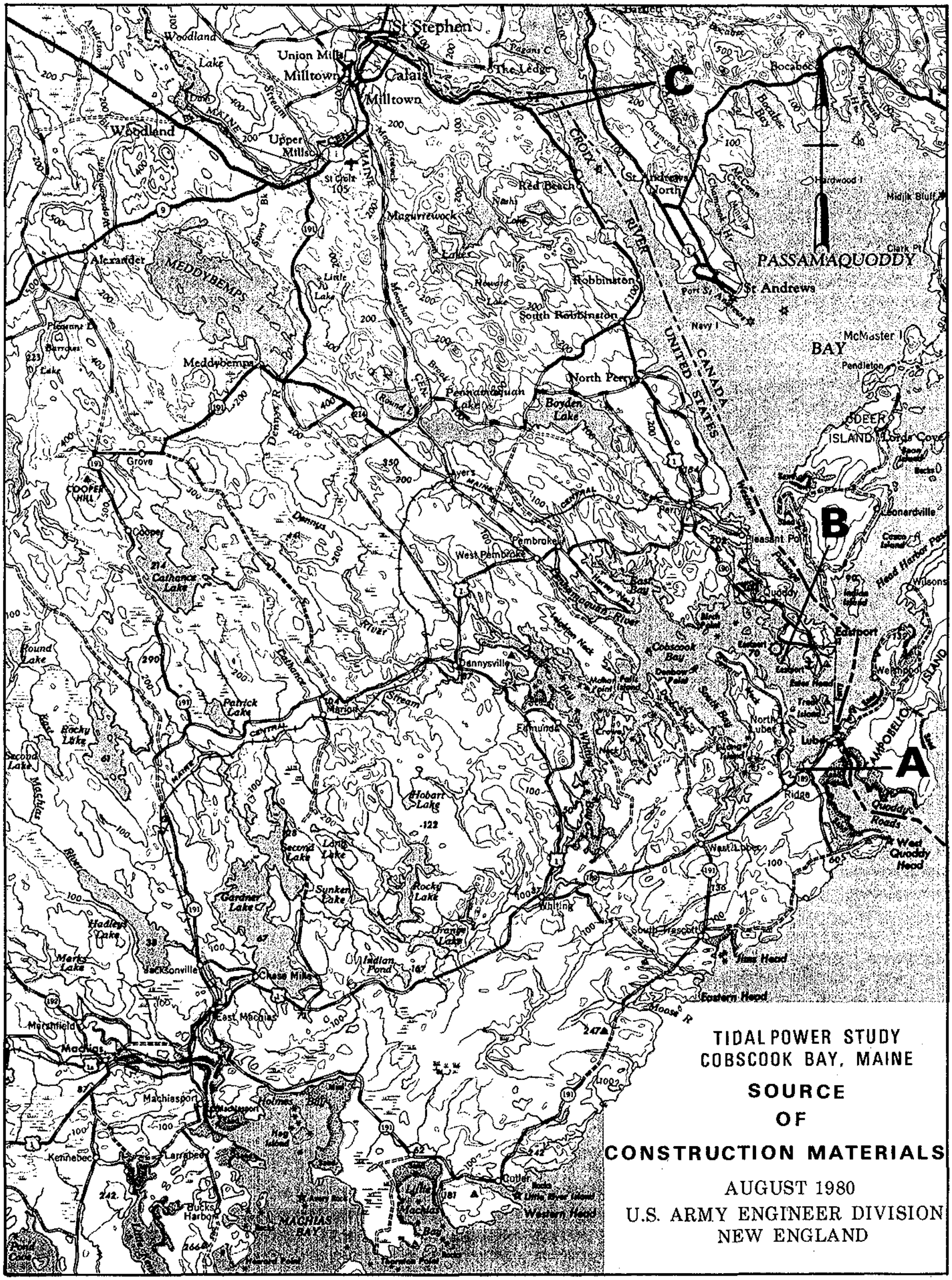
Sources of off-site earth and rock construction materials are available within 25 miles of the project work (Figure 17). Primary sources of earth borrow material investigated for the 1936 construction were from the south and west shores of Johnson Bay. These sources were selected as the only areas adaptable to low-cost excavation by floating equipment and within a short distance of the dam sites (Figure 17, Location A).

Numerous locations were considered as potential quarry sites for stone protection materials and concrete aggregates. Shackford Head on Moose Island was considered the most probable source for concrete aggregate. Utilization of this source will require selective quarrying to separate the desired diabasic rock types from the shale and rhyolitic trap rocks present in the area (Figure 17, Location B).

Two potential sources of rock for sources of protection stone were located by earlier studies in granite formations adjacent to the St. Croix River approximately 25 miles from the project in the vicinity of Devils Head and Elliot Mountain. These areas were selected based on the assumed quality of the granite and their access to water transportation (Figure 17, Location C).

Turbogenerating Equipment and Powerhouse

Tidal power plants require low head-high discharge-type turbines capable of operating efficiently under a range of relatively low heads. To accomplish this, costly large size turbines are necessary and the propeller-type unit with variable pitch blades (Kaplan), is normally considered most appropriate. Propeller turbines may be vertical, horizontal or slant mounted and of the tube, bulb or straflo design. Currently, the bulb design, with a horizontal shaft and generator installed in a bulb surrounded by the water passages appears most economical.



TIDAL POWER STUDY
COBSCOOK BAY, MAINE

SOURCE OF CONSTRUCTION MATERIALS

AUGUST 1980
U.S. ARMY ENGINEER DIVISION
NEW ENGLAND

FIGURE 17

The bulb unit assumed for the cost estimates would be rated 15 MW at 13.2-foot net head and a speed of 56.25 rpm. The diameter of the turbine runner would be approximately 25 feet. Current information indicates there would be no economic advantage in going to larger size machines. Layout and cost estimates are based on units with adjustable runner blades, adjustable wicket gates and flow in one direction only.

Figure 18 shows a cross-section of a typical powerhouse unit bay. An indoor powerhouse is planned for this bulb unit configuration due to the rigorous climate in Maine.

The deck on the intake side of the powerhouse would be at elevation 27′ NGVD, which provides 13.5 ft. of freeboard above the elevation of the maximum operating pool. This is the same freeboard shown in the cross-section of the vertical shaft propeller units proposed in the 1959 Passamaquoddy Study (Reference 15), but more than was proposed for the slant axis units in the 1976 study (Reference 30).

On the draft tube side of the powerhouse, the roof deck over the indicated electrical and mechanical galleries is shown at elevation 34, on the assumption that three galleries would be required. However, it may be found, as the powerhouse design is developed in more detail, that only two galleries would be needed. In this case, the deck could be lowered to elevation 27 to match the intake side of the powerhouse.

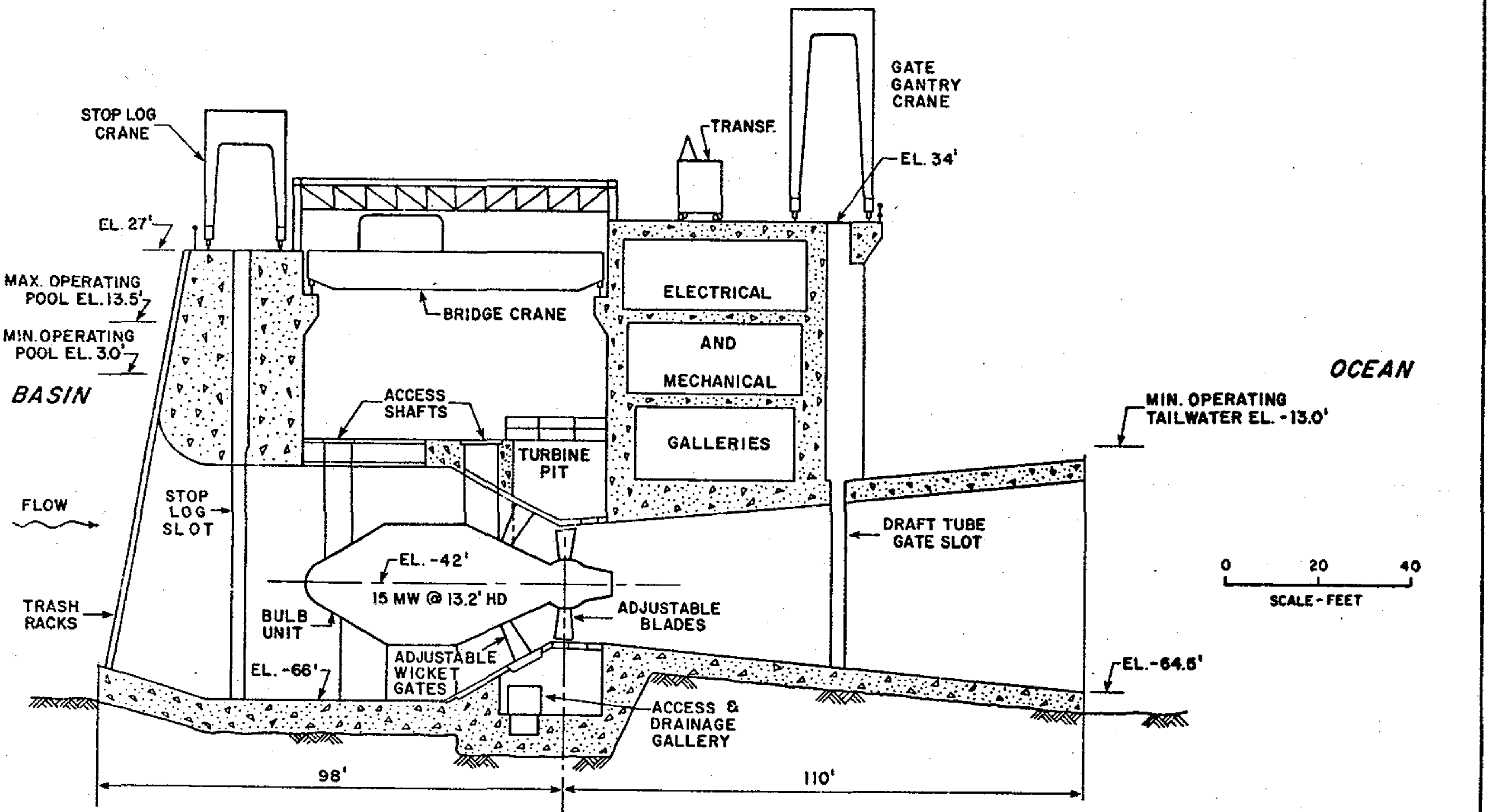
For estimating purposes, it was assumed that each powerhouse unit bay would be 60 feet wide and constructed as a separate module. When design is developed further, it may appear preferable to construct two-unit modules.

A single service and assembly bay is proposed for each tidal powerhouse. For estimating purposes it has been assumed that it would be 83 feet wide. The service bay length would match that of the powerhouse unit bay superstructure. The roof would be of reinforced concrete, designed to support trucks and large items of equipment. A stiff leg derrick would be provided for lowering heavy equipment through a large hatch in the roof to the main floor below, where it could be picked up by the powerhouse bridge cranes.

The service bay would include the station sump pumps and unwatering pumps, oil room, air compressors, stair and elevator tower, and space for equipment assembly and maintenance. Also included would be a machine shop, electric shop, locker room, and other service facilities.

Running the full length of the powerhouse and service bay would be two bridge cranes with a combined capacity of 300 tons, which is assumed sufficient to lift the heaviest generator assembly.

Normally, a unit would be shut down by closing the wicket gates, just as on a vertical shaft turbine. However, if the wicket gates should fail to close for any reason, a wheeled gate would be lowered into the draft



NOTE: All elevations are based on the National Geodetic Vertical Datum (NGVD), formerly Mean Sea Level Datum.

POWER HOUSE CROSS SECTION
PROPOSED TIDAL PROJECT
COBSCOOK BAY, MAINE

STONE & WEBSTER ENGINEERING CORPORATION
JANUARY 1979

U.S. Army Engineer Division, New England

FIGURE 18

tube gate slot to stop the flow. A single gate measuring approximately 35 feet x 35 feet would be sufficiently large to close off one turbine water passage. A 120 ton capacity draft tube gate gantry crane, as shown on the powerhouse cross-section, would be used to transport each draft tube gate along the powerhouse and to lower it into any one of the unit draft tubes. There would be one draft tube wheeled gate provided for the smaller sized power stations and two for the larger.

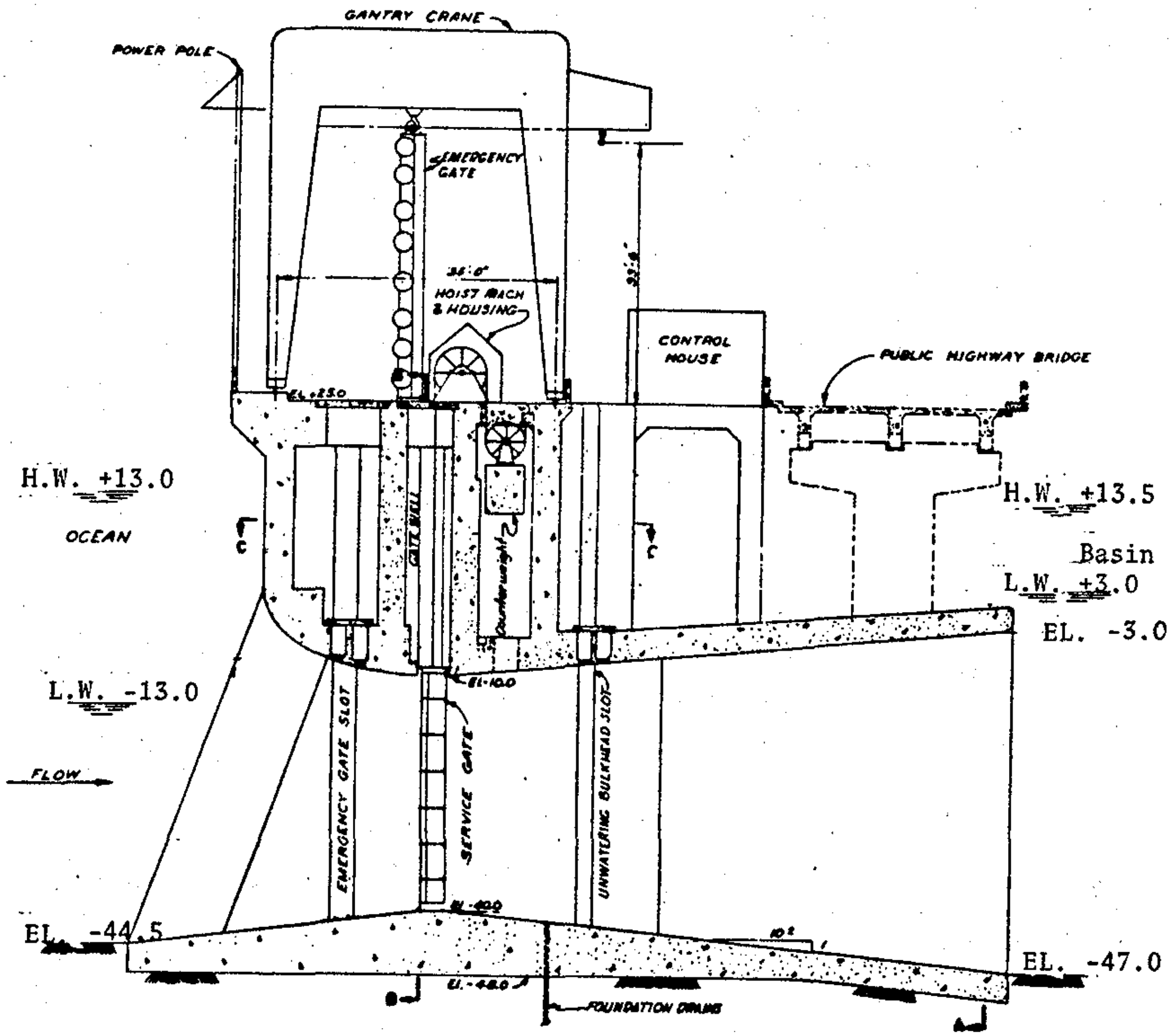
In addition to the wheeled gates, a number of draft tube slide gates could be provided. These would be used only for routine unwatering of the units, when installation would be under balanced head conditions with no flow through the unit. Slide gates are considerably less costly than wheeled gates.

For use in unwatering the units, a number of sets of steel intake stop logs would be provided. A set of six identical stop logs would be required to close off the intakes of one turbine unit. Three stop logs would be stacked in each gate slot on either side of the central pier which divides the intake into two sections. For handling the intake stop logs, there would be a 25 ton capacity gantry crane, as indicated on the drawings of the powerhouse cross-section.

Gates

For the "single high pool one-way generation" mode of operation in Cobscook Bay, filling gates would be incorporated into the barrier of the tidal power plant to permit filling the pool on the incoming tide. Since the gates must be opened and closed in accordance with the diurnal tide cycle (705 times annually), they must be capable of rapid, frequent operation and be free as possible of the maintenance and operating problems to assure the reliability of the tidal plant. Earlier detailed studies by Dexter P. Cooper, the International Passamaquoddy Engineering Board, as well as others, have resulted in the selection of the vertical-lift gate, in a submerged venturi setting, as appropriate for tidal power operation. The venturi characteristic of the gate is basically a uniformly expanding discharge section. Model studies of this gate design have demonstrated it to be highly efficient hydraulically. Discharge coefficients (C_d) in the orifice equation, of 1.7 were found possible as a result of the venturi section providing "velocity head" recovery. More recently the use of louvered-type flap gated structure has been suggested by others but a hydraulic analysis of this type gate was not made a part of the current studies, and all filling gate studies were based on the hydraulics and costs of standard 30′ x 30′ verticle lift venturi gate, shown in Figure 19.

The total required filling gate area at any site is a function of the hydraulic capacity of the tidal plant. The volume of water discharged through the turbines during the generating tide must be filled through the gates during the rising tide.



NOTE: All elevations are based on the National Geodetic Vertical Datum (NGVD), formerly Mean Sea Level Datum.

TIDAL POWER STUDY
COBSCOOK BAY, MAINE

Cross-Section
Typical Filling Gate
Structure

U.S. Army Engineer Division
New England

FIGURE 19

Siting of the gate structures was accomplished to minimize the amount of excavation (partially rock excavation) while insuring that the foundation of the structure would be rock. This included minimizing the excavation for channels leading to and from the gate structures. Structures will be reinforced concrete. Equipment, including all gates, cranes, and hoisting mechanisms, is as recommended by previous reports (Reference 15).

Because tidal power development involves low head-high discharge installation it becomes hydraulically vital that headrace and tailrace losses be kept to a minimum. It is also economically vital that required rock excavation for the headrace and tailrace channels be kept to a minimum in the siting of a tidal power project. Quite detailed studies, performed as part of the original Passamaquoddy work (Reference 15), found it economical to maintain average headrace and tailrace velocities at just under 3 feet per second, limiting average hydraulic head losses to about 0.04 foot per thousand feet of channel.

For purpose of establishing minimum excavation requirements in the current studies, maximum headrace and tailrace velocities were set at about 4 feet per second, resulting in a maximum hydraulic loss in the order of 0.07 foot per thousand. The maximum velocities and required excavation were established assuming a minimum operating headrace water level of +3.0 feet NGVD and a minimum tailrace level at -13.0 feet NGVD.

Locks

For the purpose of this study a standard lock was adopted for the three alternatives which sealed off large bay areas. The inside dimensions of the lock are 95 feet long, 25 feet wide and 12 feet deep at mean low water (mlw). (See Figure 20).

It was assumed that the "floor" of the lock itself would be in excavated rock, i.e., it would not be concrete, and the lock walls would be designed for free draining rock backfill.

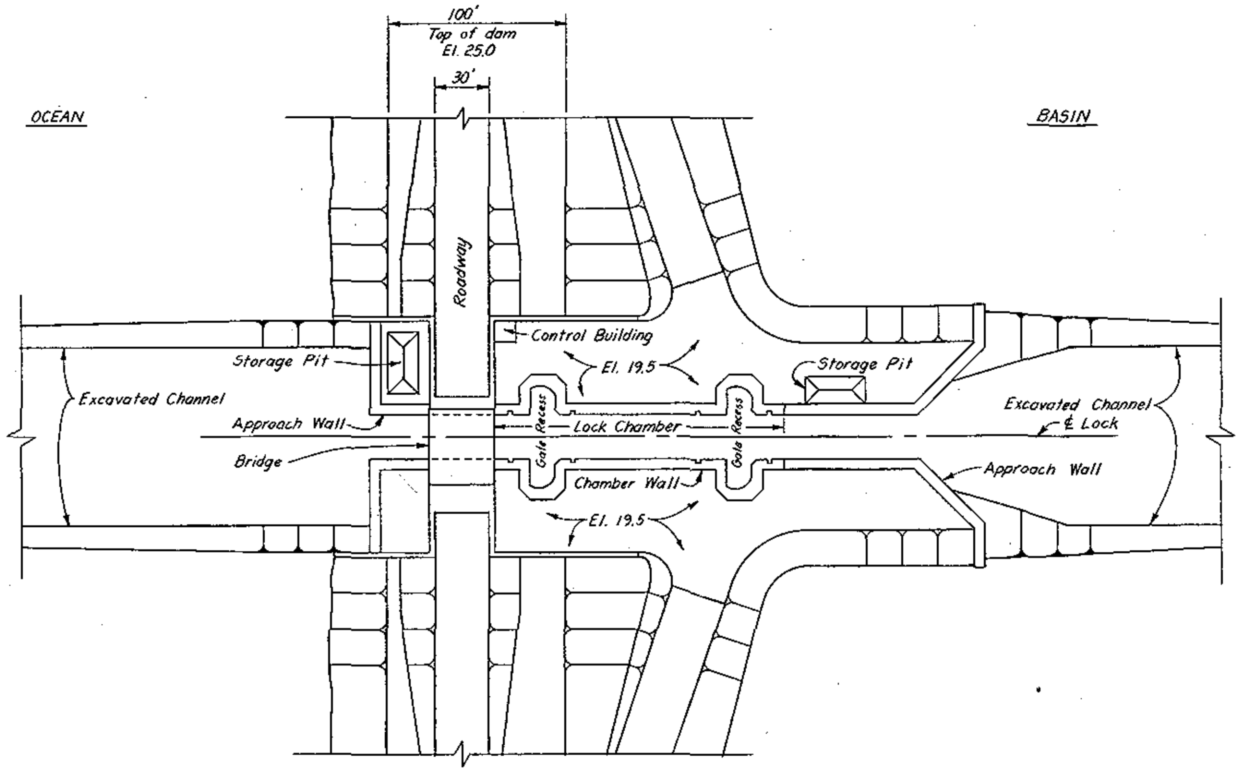
For purpose of this study, it was assumed that, for all alignments and installed capacities, the locks could be located in a rock excavation on or near the shore. Channels 100 feet wide and 12 feet below MLW were then excavated through rock and earth from the lock structure to deep water.

Other Structures

Information on cofferdams can be found in the technical appendix. Fish passages which are a significant feature have not been designed yet, however, for cost estimating purposes a lump sum amount has been assumed.

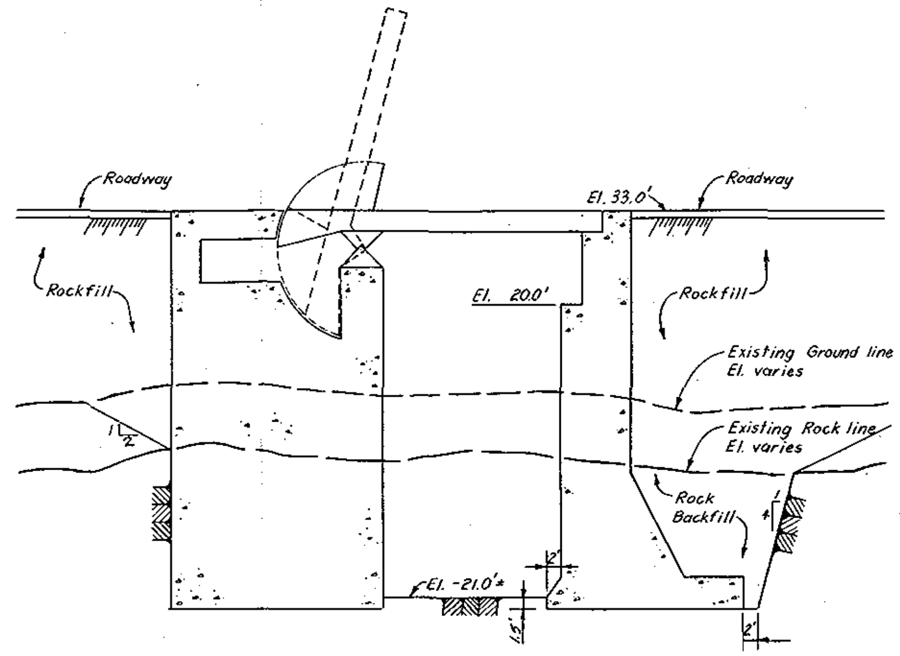
Transmission

Studies performed by Bonneville Power Administration for the preliminary economic report (Reference 33), served as the basis for transmission



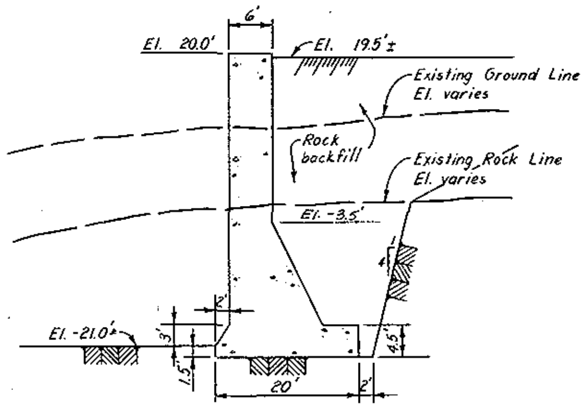
PLAN

SCALE: 1" = 40'



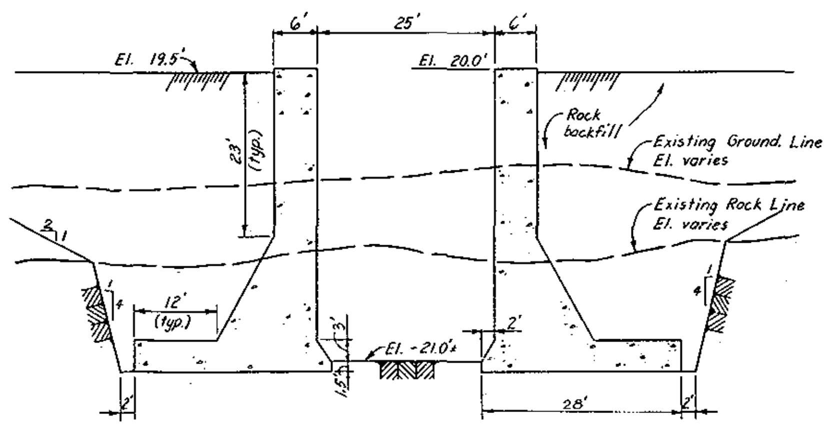
SECTION ON ℄ OF BRIDGE

SCALE: 1" = 10'



SECTION THRU APPROACH WALL

SCALE: 1" = 10'



SECTION THRU LOCK CHAMBER

SCALE: 1" = 10'

Note: All elevations are based on the National Geodetic Vertical Datum (NGVD), formerly Mean Sea Level Datum.

TIDAL POWER STUDY
COBSCOOK BAY, MAINE
ALL ALIGNMENTS
LOCK
PLAN AND SECTIONS

SCALE IN FEET

U.S. ARMY ENGINEERS DIVISION, NEW ENGLAND
AUGUST 1980

FIGURE 20

data. At that time preliminary design cost estimates for seven alternative tranmission plans were derived. Selected designs have been updated for this study.

Power Estimates

Performance characteristics are normally defined by curves indicating the relation between hydraulic head, discharge, efficiency and power output for the specific turbine speed. For purposes of this study, typical curves, relating head, discharge and generating capacity as a percentage of the rated values were taken from Reference 29. Rated generating capacity (nameplate) was computed using a rated head of 10 feet, discharge and adopted 80 percent efficiency in the basic power equation:

$$K = \frac{QHE}{11.8}$$

It was further assumed that the system would operate satisfactorily at 15 percent overload.

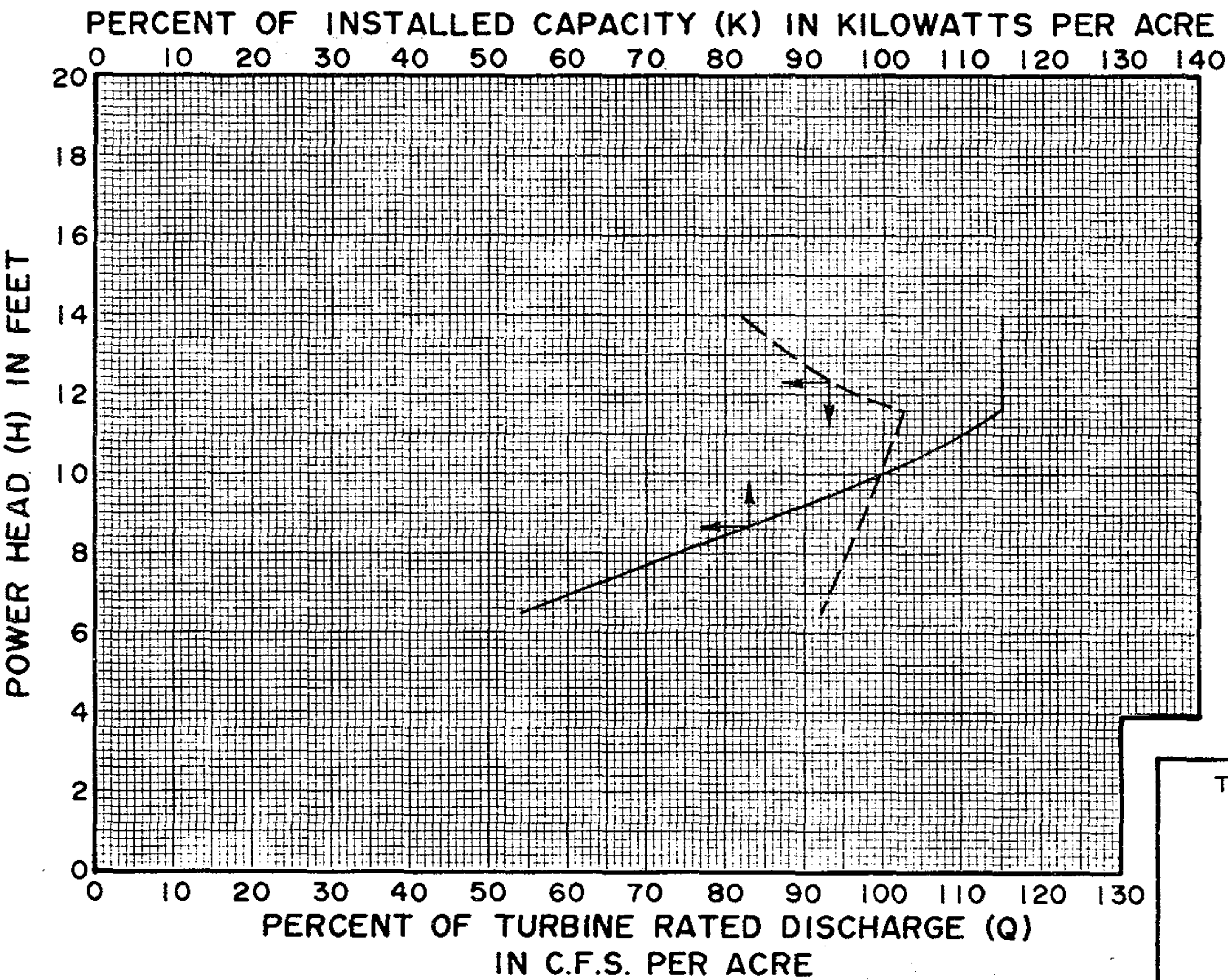
The variable pitch blade propeller unit will function efficiently with heads ranging from about 65 to 140 percent of rated head. A rated head of 10 feet was selected permitting generation for heads ranging from 6.5 to 14 feet. The optimum rated head would probably vary with the site and installed capacity, but for relative screening purposes, it was assumed constant for all comparisons.

With the selected rated head, the required discharge capacities were determined for a range of installed capacities in kilowatts per acre of tidal pool area, using the basic power equation. Once the turbine capacities were determined, the adopted performance curves were used to determine the turbine characteristics at heads relative to the rated head. The typical unit characteristic demonstrates the operation flexibility of the unit plus the restraints of the 15 percent overload limitation. It is known that when maximum output is being developed (15 percent overload) and head is sufficient, then flow is cut back to prevent excessive overload and possible damage to the generator. When heads are below the minimum of 6.5 feet, it was assumed that no power would be generated and when heads are greater than 11.5 feet, flow will decrease with power output holding constant at 15 percent overload. Studies to determine the feasibility of using oversized generators should be made a part of any final design effort. Table 15 lists quantitative values used in the development of the performance curve shown on Figure 21.

TABLE 15

TURBINE PERFORMANCE CHARACTERISTICS

Installed Capacity	7 KW/AC		14 KW/AC		28 KW/AC		42 KW/AC	
Head (feet)	Flow cfs/ac	Power kw/ac	Flow cfs/ac	Power kw/ac	FLow cfs/ac	Power kw/ac	Flow cfs/ac	Power kw/ac
14	8.4	1.8	16.8	16.1	33.6	32.2	50.4	48.6
13	9.1	8.1	18.2	16.1	36.4	32.2	54.6	48.6
12	9.8	8.1	19.6	16.1	39.2	32.2	58.8	48.6
11	10.5	7.7	21.0	15.4	42.0	30.8	63.0	46.2
Rated 10	10.3	7.0	20.6	14.0	41.2	28.0	61.8	42.0
9	10.0	5.8	20.0	11.6	40.0	23.2	60.0	34.8
8	9.8	5.1	19.6	10.2	39.2	20.4	58.8	30.6
6.5	9.4	3.9	18.8	7.8	37.6	15.6	56.4	23.4



UNIT CHARACTERISTIC CURVES BASED ON A RATED HEAD OF 10 FEET.

$$K = \frac{QHE}{11.8}$$

TIDAL POWER DEVELOPMENT

COBSCOOK BAY

TYPICAL UNIT CHARACTERISTICS

APRIL 1980 MAINE

FIGURE 21

The economic benefits of any tidal power project are a function of the average annual energy that can be produced. For the Cobscook Bay sites the annual energy per unit pool area was estimated by performing manual step routings for various selected installed capacites in order to simulate the power operation. These routings were cursory in nature and were applied through the average tidal range of 18.2 feet for the selected rated capacities of 7, 14, 28 and 42 kilowatts per acre of tidal pool area. It should be noted that these routings do not present the refinement or optimization that could only be accomplished through detailed computer simulation studies, however, they are considered appropriate for purposes of site screening.

For single high pool plans, power is generated during the period when the ocean level is lower than the pool level by discharging water through turbines from the pool to the ocean. In an effort to maximize energy, the times at which generation begins for each of the selected rated capacities were derived by trial in order to determine best relationships between head, discharge and generation time resulting in the maximum production of energy.

The minimum head at which power could be satisfactorily generated was 6.5 feet. This minimum head requirement was a governing factor in establishing generation time for many of the installations. As shown on Figure 22, all operating schemes end generation at this minimum head of 6.5 feet. The heads at which operation begins is, however, flexible, and is dependent on the interrelationships between head and discharge capacity throughout the routing period resulting in the production of maximum energy. This is evidenced on Figure 22 by observing the relative delayed starting times with the larger installed capacity. Since the hydraulic capacities of the 28 and 42 kw/acre installed capacities, are relatively large (increased pool drawdown), the starting times of generation were delayed such that maximum heads would be available. The rated capacities of 7, 14, 28 and 42 kw/acre, permitted approximately 345, 300, 180 and 135 minutes of generation per mean tide cycle, respectively.

As shown on Figure 22 that there is about a one foot differential between initial pool level and high tide level because of the inability to completely fill the pool to high tide by gravity.

With the relationship of head, discharge and generating times developed from the routines, the relationships of rated capacity, energy per tide cycle and plant factor (capacity factor), were developed as shown on Figure 23. As the curves on this plate demonstrate, energy increases with increasing installed capacity but at the decreasing rate. It can be seen that the energy produced is intermittent regardless of the installed capacity and that the smaller installed capacities, while producing less energy, have the benefit of longer generating times relative to the larger installed capacities which have the advantage of producing more energy but with shorter generating times.

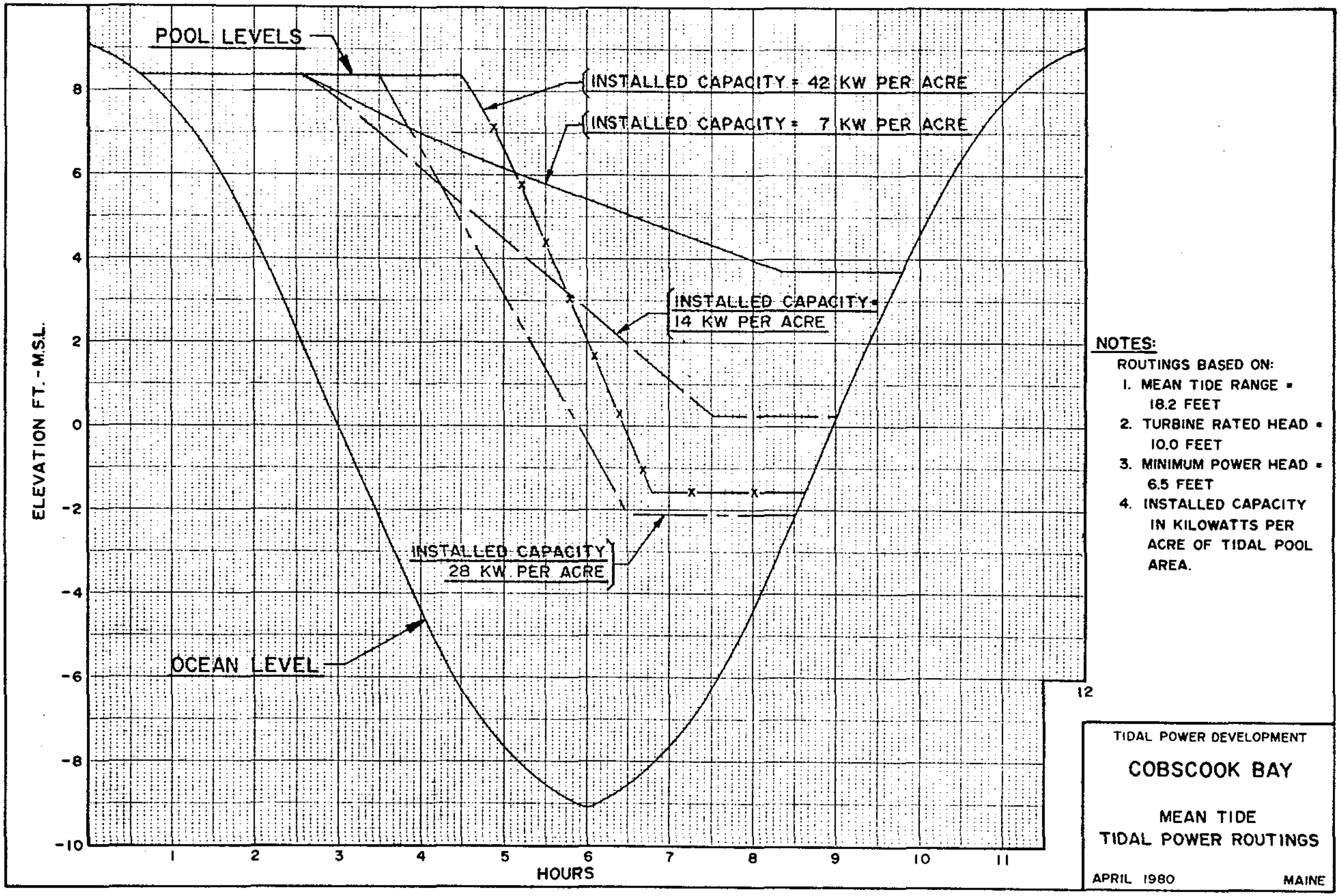
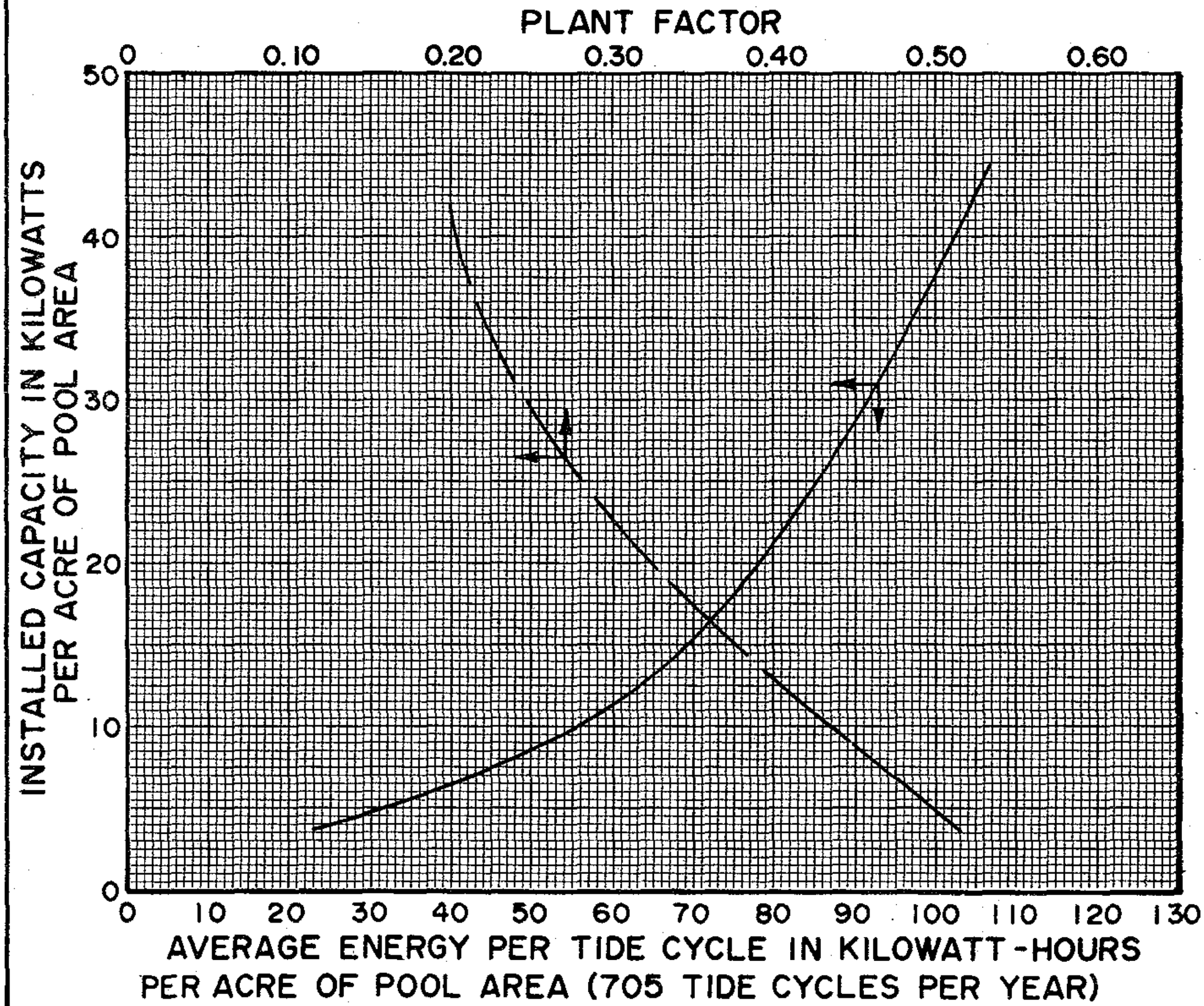

POOL LEVELS
INSTALLED CAPACITY = 42 KW PER ACRE
INSTALLED CAPACITY = 7 KW PER ACRE
INSTALLED CAPACITY = 14 KW PER ACRE
INSTALLED CAPACITY 28 KW PER ACRE
OCEAN LEVEL
ELEVATION FT.-M.S.L.
8
6
4
2
0
-2
-4
-6
-8
-10
1
2
3
4
5
6
7
8
9
10
11
12
HOURS
NOTES:
ROUTINGS BASED ON:
1. MEAN TIDE RANGE = 18.2 FEET
2. TURBINE RATED HEAD = 10.0 FEET
3. MINIMUM POWER HEAD = 6.5 FEET
4. INSTALLED CAPACITY IN KILOWATTS PER ACRE OF TIDAL POOL AREA.
TIDAL POWER DEVELOPMENT
COBSCOOK BAY
MEAN TIDE
TIDAL POWER ROUTINGS
APRIL 1980
MAINE

FIGURE 22



CURVES BASED ON:

1. MEAN TIDE RANGE = 18.2 FEET
2. TURBINE RATED HEAD = 10.0 FEET
3. MINIMUM POWER HEAD = 6.5 FEET

TIDAL POWER DEVELOPMENT

COBSCOOK BAY

CAPACITY VS ENERGY AND PLANT FACTOR

APRIL 1980 MAINE

FIGURE 23

The routings and energy developed are considered representative for mean tide cycle, however, more flexible operating procedures could result during an outgoing tide by varying the start of generation thereby varying the resulting capacity and energy output depending on the anticipated power demand.

From the graphical routings on Figure 22, the generation and filling times can be determined. It is seen that the required rate of flow through the gates is proportional to the rate of flow through the turbines, by the ratio of their respective generating times. For example: for an installed capacity of 14 kw/acre, from Figure 22 it is observed that three-fifths as much time is available for filling as for generating, and therefore, the gate capacity must be one and two-thirds times greater than the turbine capacity. With the hydraulic capacity (Q) of the gate known, the gate area (A) required to pass this flow is determined from the "orifice" equation.

$$Q = C_d A \sqrt{2gh}$$

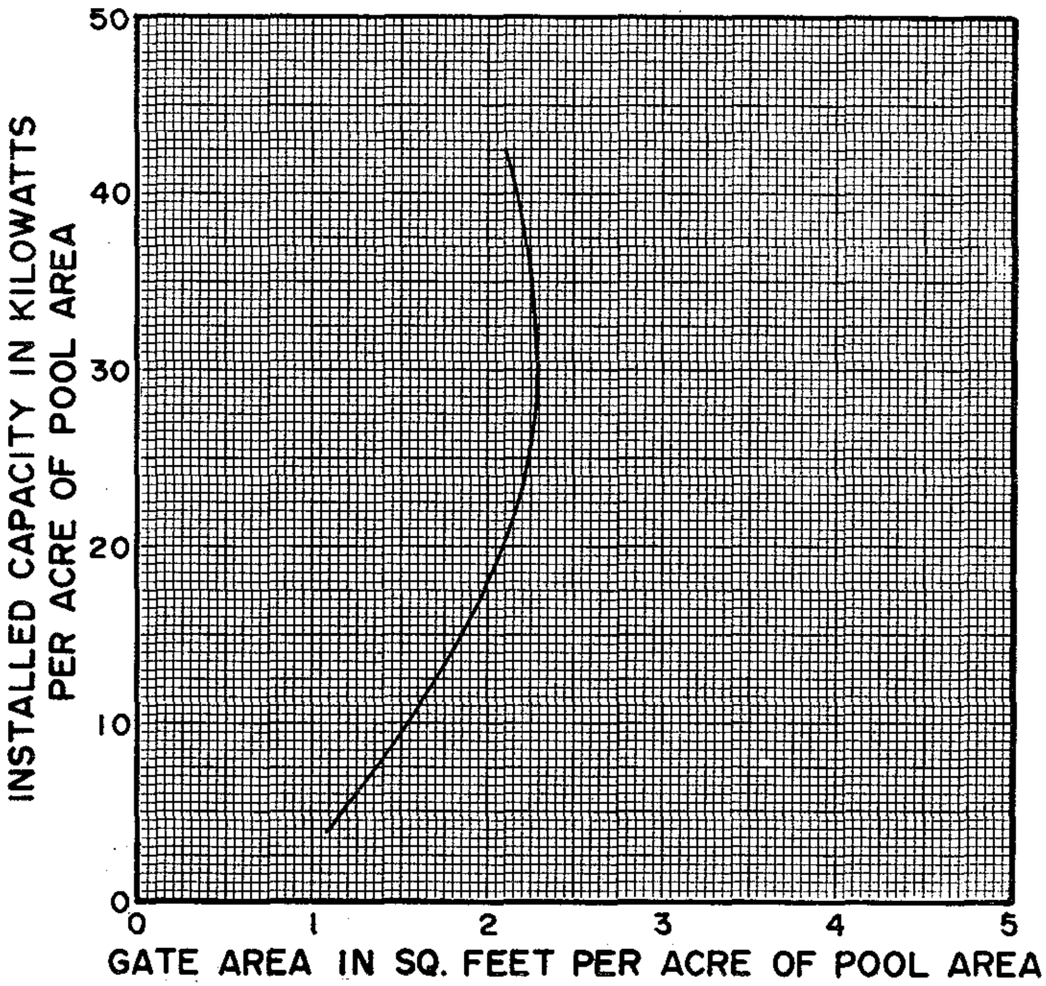
where C_d = coefficient of discharge of the gate. From previous model studies by the Corps, the average coefficient of discharge for the venturi gate under normal operating conditions was determined to be approximately 1.7. This relatively high coefficient is attributable to the submerged "venturi" expansion of the gate and its effectiveness in regaining the velocity head of the discharge.

h = average head differential between the ocean and the pool during filling operations. The head differential varies during the fill period but it was assumed that the average for the period would not exceed 2 feet. With a 2-foot head differential, velocities through the gate opening would be in the order of 20 ft/sec. The relationship between required gate area and installed capacity per acre of pool area is graphically presented as Figure 24.

Cost Estimates

Estimates of costs for the tidal project are presented in this section. Initially cursory conservative cost estimates of powerhouse, gates, dams, cofferdams, excavation and locks were prepared for each of the four alternatives under study, assuming four different installed capacities for each alterative - 16 estimates.

Pertinent data for that brief analysis is presented in Table 16 below.



CURVE BASED ON:
1. MEAN TIDE RANGE = 18.2 FEET
2. TURBINE RATED HEAD = 10.0 FEET

TIDAL POWER DEVELOPMENT

COBSCOOK BAY

INSTALLED CAPACITY VS. FILLING GATE AREA

APRIL 1980 MAINE

FIGURE 24

Table 16
Initial Cost Estimate Results

Alternative	Capacities MW	Energies GWH	Capacity Factors	Costs $/KW (Dec. 1979)
Dudley	120-970	470-1,420	15-50	1600-3,300
Goose	100-815	400-1,215	15-50	2100-3,500
Birch	80-700	340-1,040	15-50	1900-3,500
Wilson	18-150	70-222	15-50	3600-10,000

The data derived tended to reinforce the earlier findings (Reference 33), that projects designed to operate at annual capacity factor around 40% (0.4) provided lowest cost energy. Based on the results shown in Table 16 above it was decided to refine estimates for selected alternatives designed to operate at annual capacity factors of about 40%. Owing to the high costs associated with the Wilson alternative (2-3 times greater than other alternatives) and also to its limited hydroelectric potential compared to other alternatives it was decided to delete this alternative from further economic analaysis.

It was also decided that the Dudley alternative would not be analyzed further for this study. The Dudley alternative was deleted because at this time it appears to have more possible potential problems in terms of construction than do the Birch and Goose alternatives.

If studies of Cobscook Bay continue more rigorous analysis may be undertaken for the Dudley and Wilson alternatives. A discussion of environmental impacts which can be identified at this time for these alternatives can be found in Section IV, EVALUATION OF PLANS.

Refined cost estimates were prepared for both the Goose and Birch alternatives. Elements included were gates, powerhouses, turbogenerators, dams, locks, cofferdams and excavation. No other costs were considered. Table 17 presents data from these estimates.

Table 17
Refined Cost Estimates
(July 1979 price level)

Alternative	Capacity MW	Energy GWH	Capacity Factor	$/KW	Mills/kwh
Birch	105	401	45	2874	54
Birch	165	560	40	2487	52
Birch	225	650	35	2403	59
Goose	135	500	45	2561	49
Goose	195	660	40	2291	48
Goose	225	760	35	2044	49

Based on the results present in Table 17 above, complete estimates were prepared for the following alternatives:

Goose Alternative - 195 MW (Installed Capacity)
Birch Alternative - 165 MW (Installed Capacity)

Pertinent data describing these alternatives are shown on Table 18 and Preliminary project layouts and profiles are shown as Figures 25 through 28. Project Estimates are presented in Table 19.

Table 18
Pertinent Data Goose and Birch Alignments

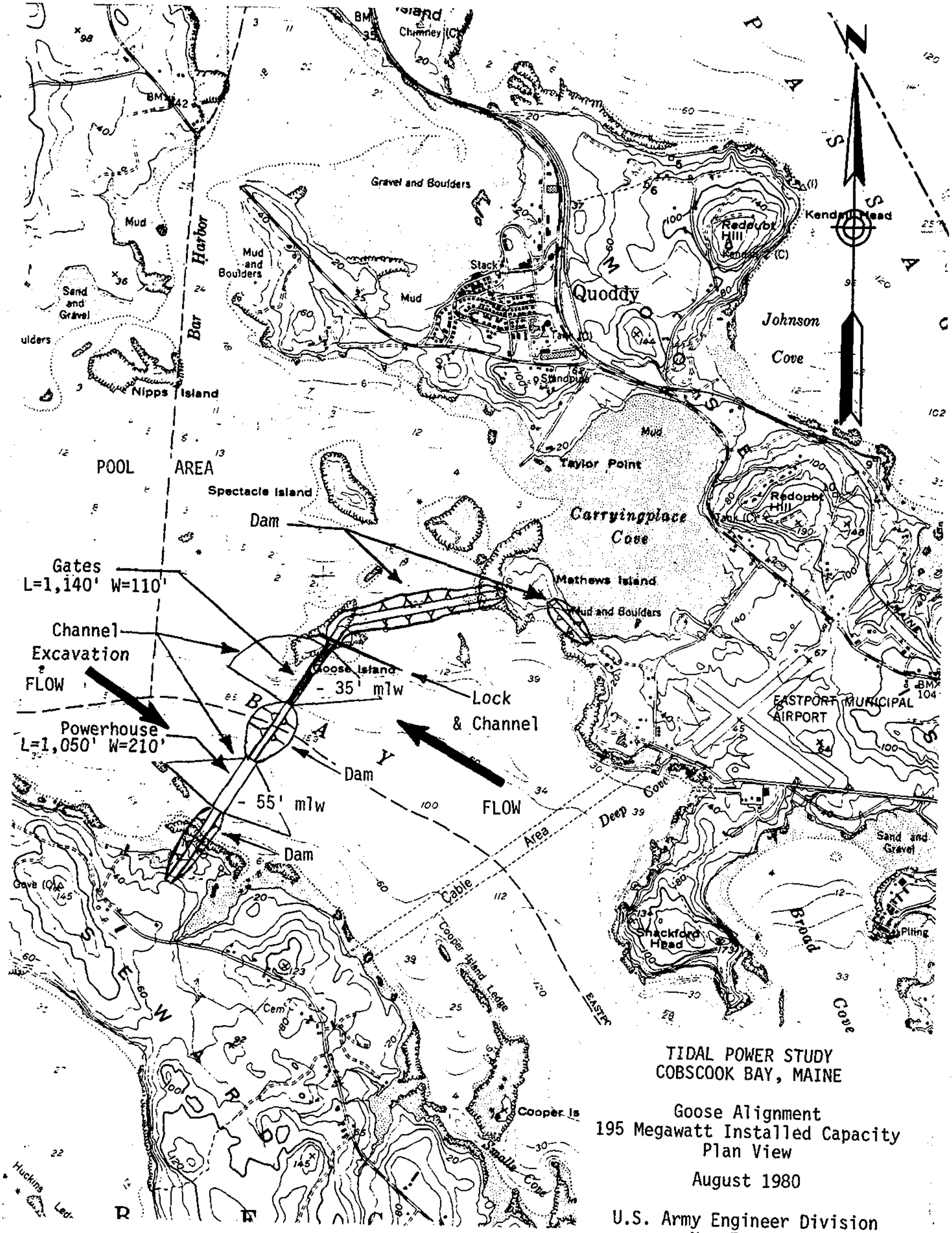
TOTAL PROJECT:	GOOSE - 195	BIRCH - 165
Length	8,100′±	5,100′±
Top Elevation	+25.0′	+25.0′
Datum	NGVD	NGVD
Excavation	990,000 cy	375,000 cy
Fill	5,700,000 cy	3,450,000 cy
POWERHOUSE:		
Length (total*)	1,050′	890′
Installed Capacity	195 MW	165 MW
No. of Units	13	11
length of units	780′	660′
width/unit	210′	210′
Turbine (units)		
type	Horizontal Bulb	Horizontal Bulb
capacity	15 MW	15 MW
rated head	13.2	13.2
center line of unit	El. -42.0′	El. -42.0′
Max. Operating Pool	El. +13.5′	El. +13.5′
Min. Operating Pool	El. +3.0′	El. +3.0′
Min. Tailwater	El. -13.0′	El. -13.0′
Structural Excavation	65,000 cy	25,000 cy
Channel Excavation	300,000 cy	255,000 cy
GATES:		
Length (total)	1,140′	990′
No. required	30	26
Type	Vertical Lift (submerged venturi)	Vertical Lift (submerged venturi)
Invert	El. -40.0′	El. - 40.0′
Structural Excavation	50,000 cy	10,000 cy
Channel Excavation	570,000 cy	90,000 cy

Table 18

Pertinent Data Goose and Birch Alignments (Cont.)

	GOOSE - 195	BIRCH - 165
DAM:		
Length (overall)	5,800′±	4,000′±
Top Elevation	+25.0′	+25.0′
Top Width	Varies (100′ min. to 150′ max.)	Varies (100′ min. to 150′ max.)
Maximum Height	130′±	120′±
Fill		
stone protection	480,000 cy	190,000 cy
rockfill	3,750,000 cy	2,500,000 cy
sand and gravel	600,000 cy	260,000 cy
clay core	900,000 cy	550,000 cy
LOCK:		
Length (inside)	95′	95′
Width (inside)	25′	25′
Min. Depth (@ Mean Low Water)	12′	12′
Top	El. +20.0′	El. +20.0′
Invert	El. -21.0′	El. -21.0′
COFFERDAMS:		
Length	7,200′±	5,300′±
Max. Height	85′±	100′±
Top Elevation		
earthen embankment	+20.0′	+20.0′
timber or steel sheeting	+18.0′	+18.0′

*Includes mass concrete separating the units.



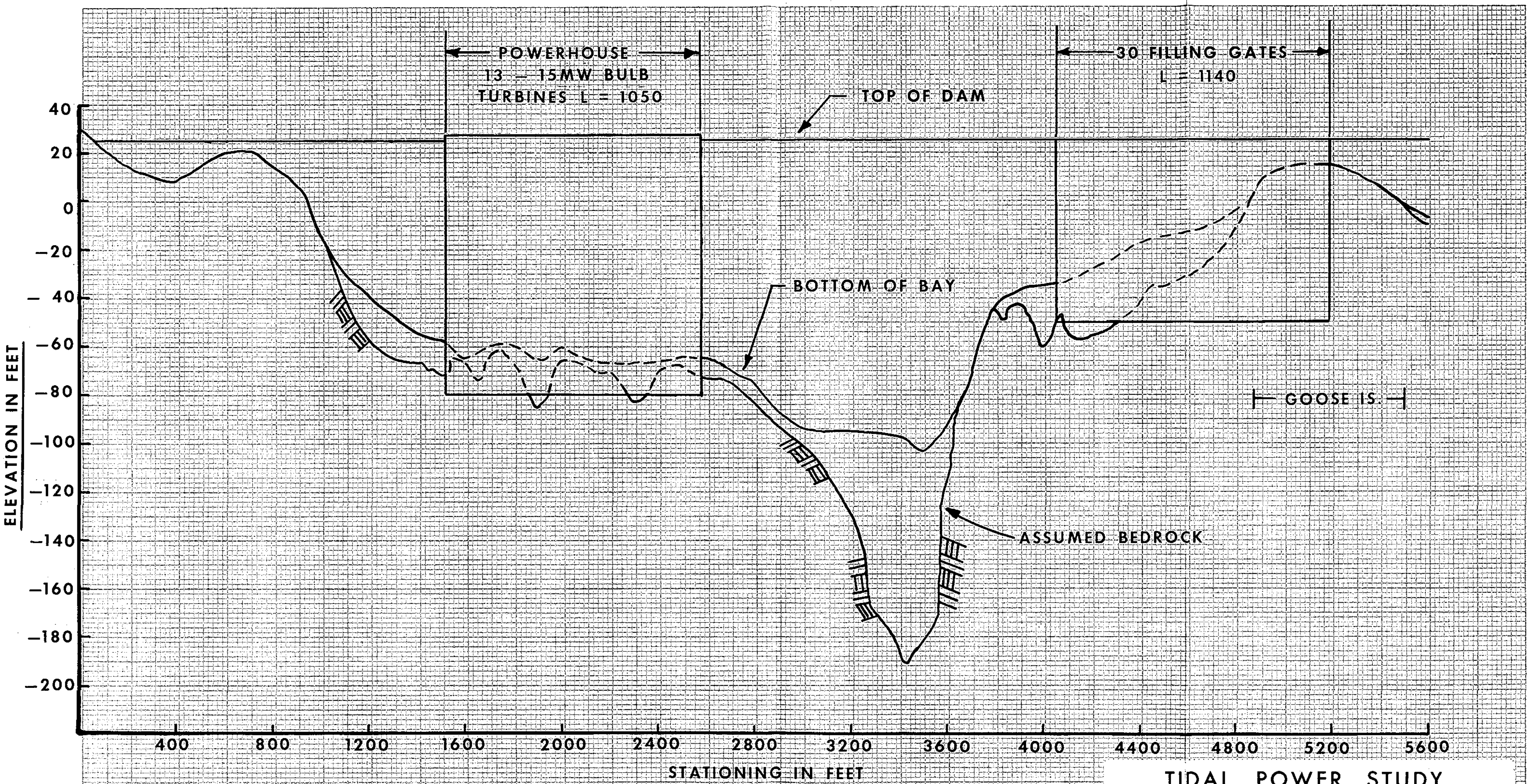
TIDAL POWER STUDY
COBSCOOK BAY, MAINE

Goose Alignment
195 Megawatt Installed Capacity
Plan View

August 1980

U.S. Army Engineer Division
New England

FIGURE 25



NOTES:

"BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY PERFORMED IN JUNE 1979

TOP OF GATES AND DAM AT EL. +25
TOP OF POWERHOUSE DECK AT EL. +27

DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

SCALE

VERT. 1 in. = 400 ft.

HORIZ. 1 in. = 40 ft.

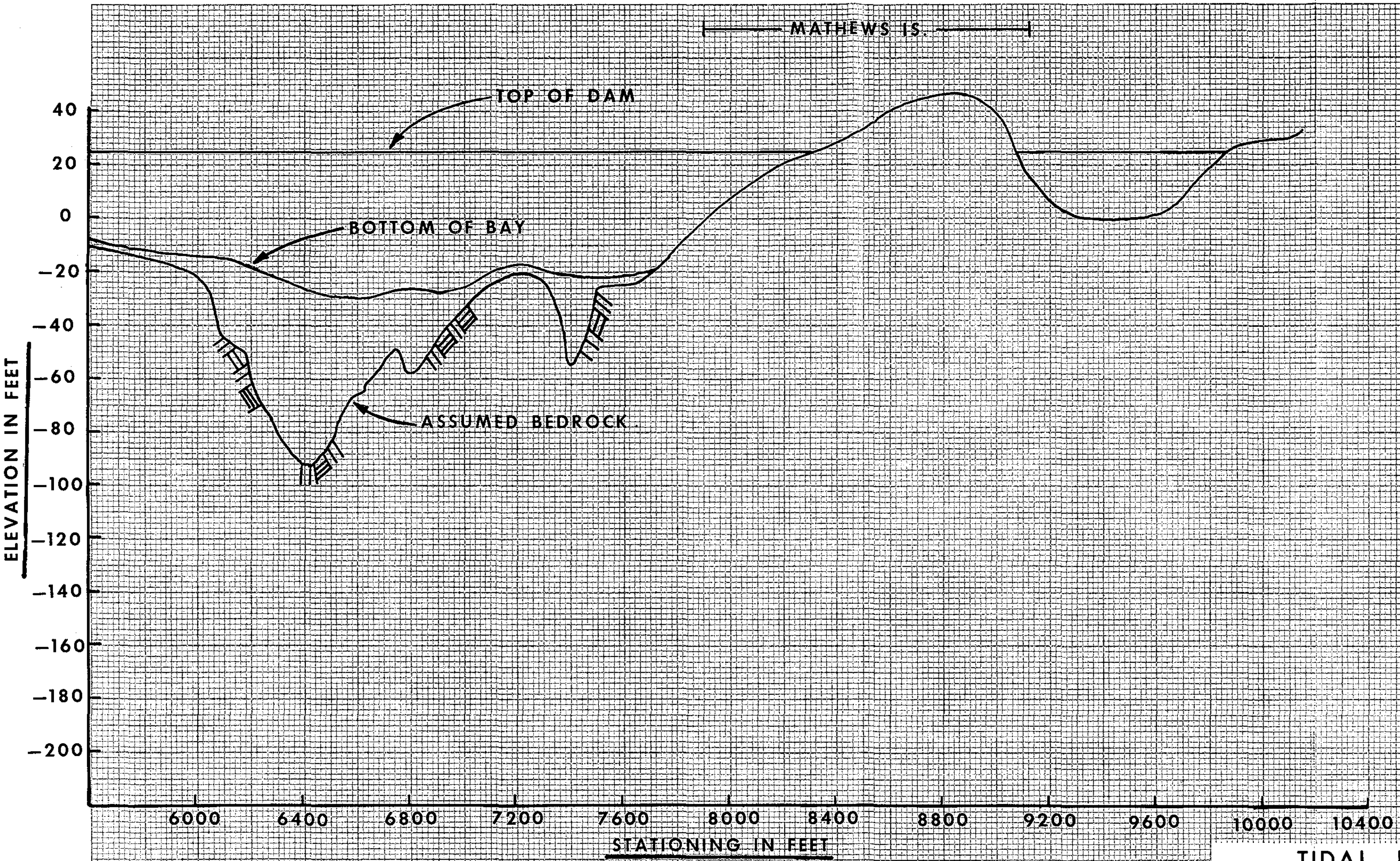
TIDAL POWER STUDY
COBSCOOK BAY, MAINE

GOOSE ALIGNMENT PROFILE

AUGUST 1980

ARMY ENGINEER DIVISION, NEW ENGLAND

FIGURE 26



NOTES:

"BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY PERFORMED IN JUNE 1979

TOP OF GATES AND DAM AT EL. +25
TOP OF POWERHOUSE DECK AT EL. +27

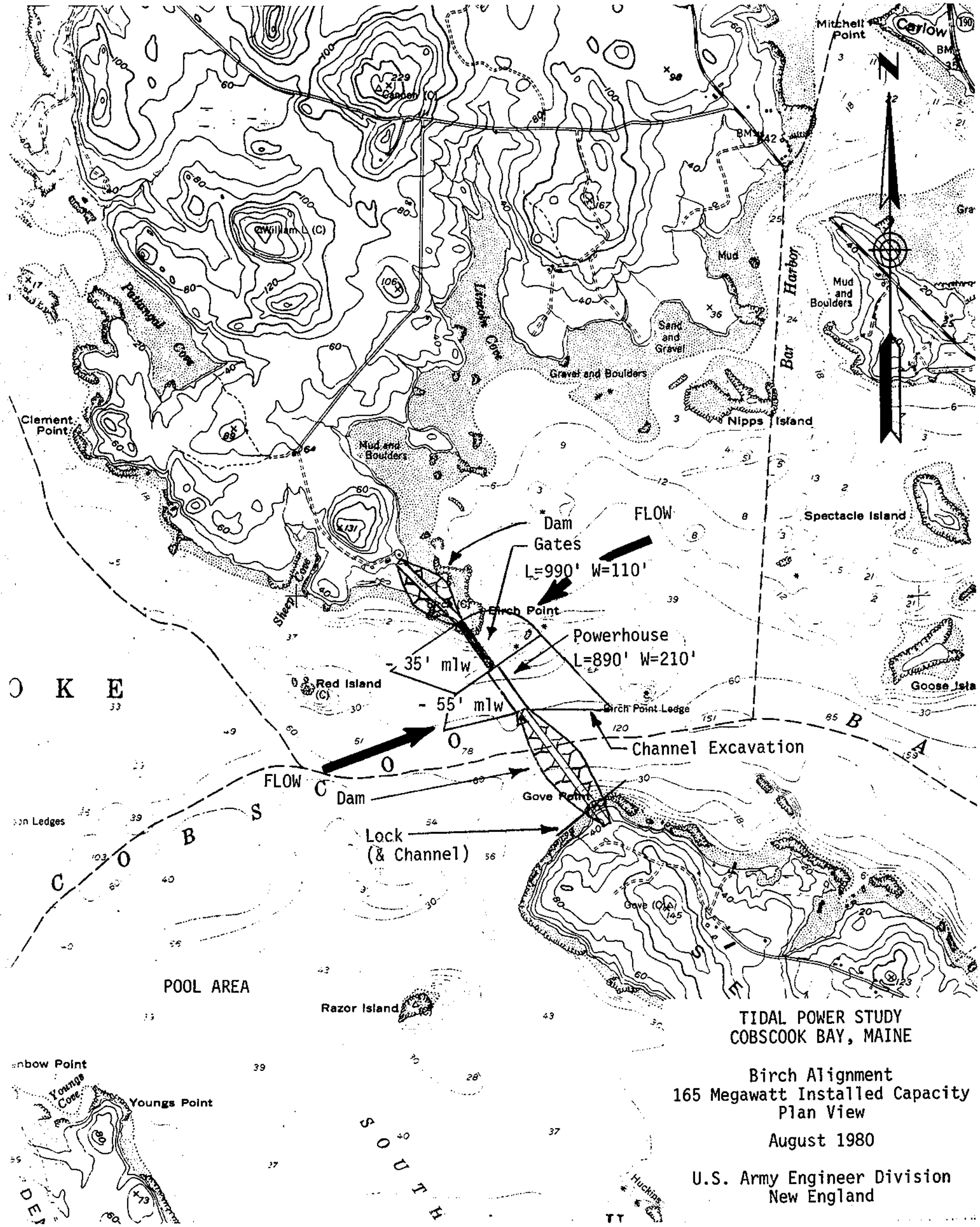
DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

SCALE

VERT. 1 in. = 400 ft.
HORIZ. 1 in. = 40 ft.

TIDAL POWER STUDY
COBSCOOK BAY, MAINE
GOOSE ALIGNMENT
PROFILE
AUGUST 1980
ARMY ENGINEER DIVISION, NEW ENGLAND

FIGURE 26



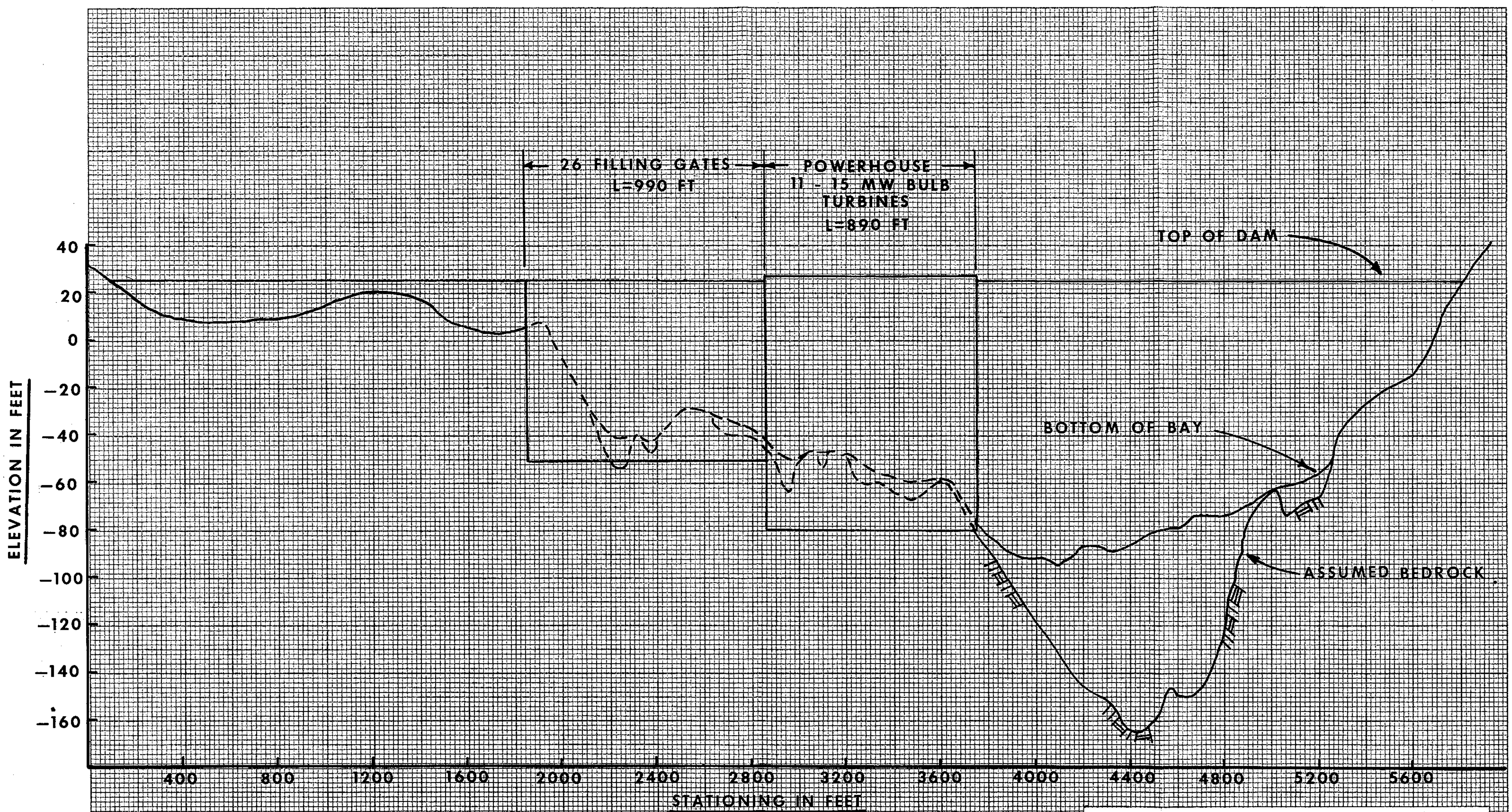
TIDAL POWER STUDY
COBSCOOK BAY, MAINE

Birch Alignment
165 Megawatt Installed Capacity
Plan View

August 1980

U.S. Army Engineer Division
New England

FIGURE 27



NOTES:

"BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY PERFORMED IN JUNE 1979

TOP OF GATES AND DAM AT EL. +25
TOP OF POWERHOUSE DECK AT EL. +27

DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

SCALE

VERT. 1 in. = 400 ft.
HORIZ. 1 in. = 40 ft.

TIDAL POWER STUDY
COBSCOOK BAY, MAINE
BIRCH ALIGNMENT
PROFILE
AUGUST 1980
ARMY ENGINEER DIVISION, NEW ENGLAND

FIGURE 28

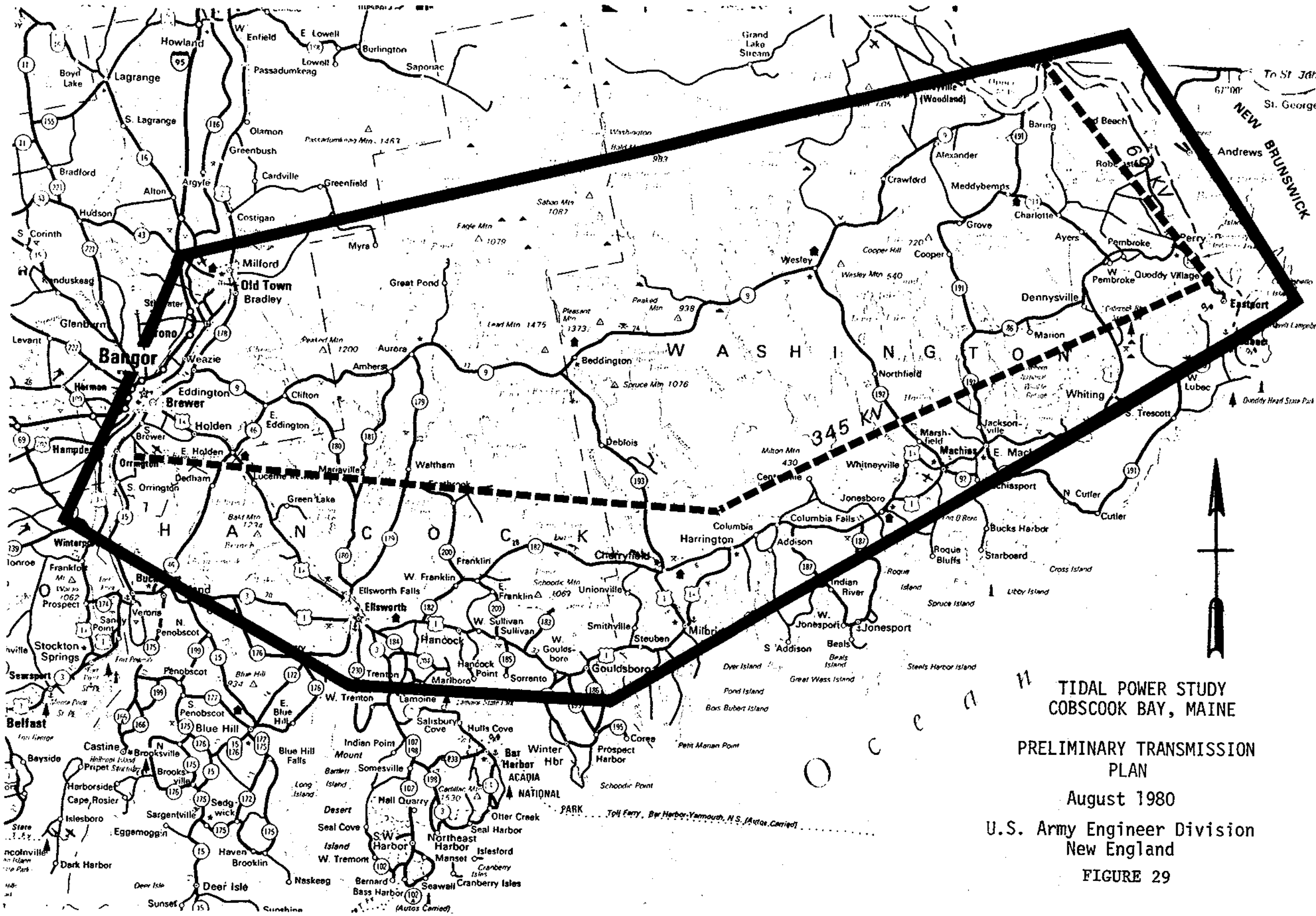
Table 19
Cobscook Bay Project Cost Estimate

Alternative Installed Capacity Average Annual Energy	Goose Alignment 195 MW 660 GWH	Birch Alignment 165 MW 560 GWH
Dams	60,100,000	36,200,000
Navigation locks	14,500,000	13,700,000
Sluice Gates	82,200,000	70,300,000
Powerhouse	274,000,000	286,400,000
Cofferdams	56,300,000	41,400,000
Service Facilities	1,400,000	1,200,000
Relocations	1,000,000	1,000,000
Fishways	2,000,000	2,000,000
Subtotal	491,500,000	452,200,000
Contingency - 15%	73,700,000	67,800,000
Subtotal	565,200,000	520,000,000
E & D and S & A - 10%	56,500,000	52,000,000
Subtotal	621,700,000	572,000,000
Real Estate Inc. 20% ctg.	1,000,000	1,000,000
Service Equipment	600,000	600,000
Project Cost	623,300,000	573,600,000
Construction Time (years)	5	5
Interest During Construction	111,000,000	102,200,000
Project Life (years)	100	100
Interest and Amortization	52,400,000	48,200,000
Operations & Maintenance	1,400,000	1,200,000
Major Replacement	600,000	500,000
Annual Cost	54,400,000	49,900,000
Cost of Energy mills/kwh	88	96
Cost Per Kilowatt $/kw	3,800	4,100

Computation based on 7-1/8% interest rate, August 1980 price levels.

For this report Bonneville Power Administration prepared a preliminary transmission design and estimate for a hypothetical 200 MW tidal power project. Figure 29 shows the preliminary transmission plan. The heavy dashed lines in Figure 29 do not represent actual transmission line routes or corridors which, of course, have not been determined.

For generating capacity of 200 MW, the integrating transmission will most likely be either 230-kV or 345-kV. The investment cost of a 345-kV system is comparable to that of a 230-kV system. The 230-kV alternative has lower line costs but greater substation costs. Since transmission losses would be lower for 345-kV, a 345-kV system has been assumed in developing the cost estimates. Peak losses are in the order of 1.5% for a 345-kV system and 4.0% for a 230-kV systems. For the 345-kV system energy losses resulting from transmission are less than 1.0%.



TIDAL POWER STUDY
COBSCOOK BAY, MAINE

PRELIMINARY TRANSMISSION PLAN

August 1980

U.S. Army Engineer Division
New England

FIGURE 29

A 345-kV system will also have the advantage of not introducing a new voltage level into the area (115-kV and 345-kV being the existing voltage levels). A sketch of the integrating transmission system is shown as Figure 30. The system includes a 69-kV line from the project to Calais.

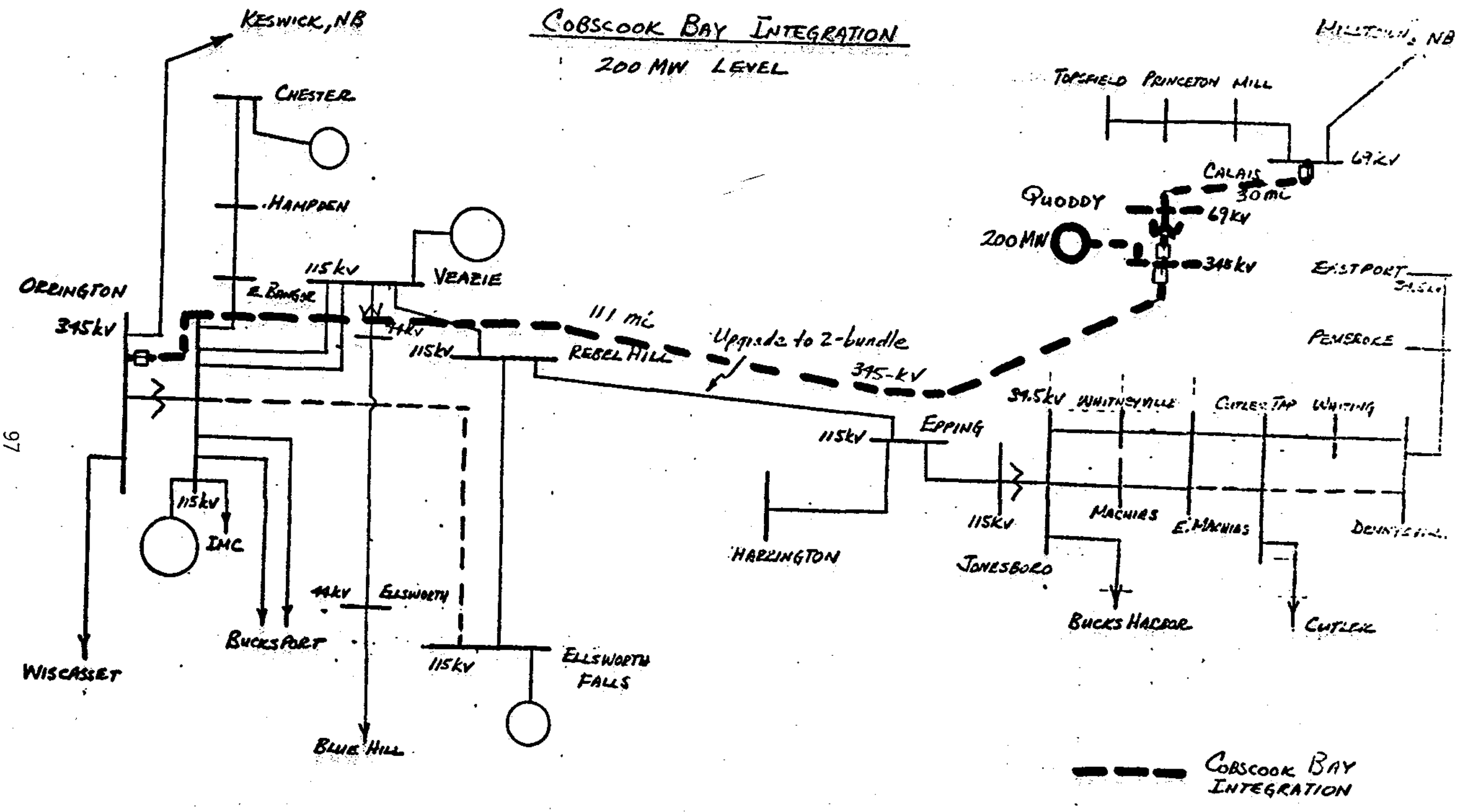
Facilities for transformation at Epping have not been included because the need for such facilities have not been thoroughly investigated. However, the addition of a 345/115-kV transformer bank at Epping would improve the reliability of service to that area. A cost estimate of the preliminary plan is shown in Table 20.

Table 20
Cobscook Bay Tidal Power Project
Cost Estimates - Transmission Facilities
(7-1/8% Interest Rate)

	Investment ($000)			Annual Cost ($000)		
	Construction	IDC	Total	I&A	O&M	Total
Lines						
Quoddy - Orrington						
345-kV WHF (111 miles)	20,000	3,340	23,340	1,790	200	1,990
Quoddy - Calais						
69-kV WHF (30 miles)	4,000	670	4,670	360	40	400
Subtotal	24,000	4,010	28,010	2,150	240	2,390
Substation Facilities						
Quoddy - 345/69 kV Transformer	3,100	502	3,620	300	40	340
2-345-kV PCB's	1,500	250	1,750	150	50	200
Calais - 69-kV PCB	150	30	180	20	10	30
Orrington - 2-345-kV PCB's	1,500	250	1,750	150	50	200
Subtotal	6,250	1,050	7,300	6,120	150	770
Power System Control	1,000	170	1,170	110	50	160
TOTAL	31,250	5,230	36,480	2,880	440	3,320

Note: Service Life: Lines (WHF) 38 years (WHF: Woodpole H-frame Line)
Substation 28 years
PSC 20 years (PSC: Power System Control)
Replacements have been included in the calculation of annual costs.
IDC @ 7-1/8% interest: 16.7% of construction cost

A generating plant at Sears Island, Maine, of 568 MW is planned to be in service (Table 14, page 52) and connected to the New England 345 kV network approximately 15 miles south of Orrington. The addition of the 200 MW Cobscook Bay generation connected to the network at Orrington results in a possible total flow into the New England 345 kV system of 1368 MW (600 MW from New Brunswick, 568 MW Sears Island and 200 MW from Cobscook Bay). The loading and stability effects of the level of power flow on the New England system has not been studied. Such a study could indicate the need for



BANGOR HYDRO-ELECTRIC SYSTEM TO EASTPORT

FIGURE 30
RBP
3-5-80

additional transmisssion reinforcements to the NEPOOL 345 kV grid. These possible reinforcements are not included in estimates shown on Table 20 and, therefore, are not included in the total cost of the project. Such studies are beyond the scope of this reconnaissace report but would be undertaken if the study continues.

Table 21 shown below present the approximate total investment and annual costs associated with a 165 MW tidal power project at Birch Point and also for a 195 MW tidal power project at Goose Island assumming a 100-year project life, 7-1/8 percent interest and August 1980 price levels. Costs for the 200 MW transmission plan have been used for both alternatives.

Table 21
Cost of Two Possible Tidal
Power Projects Including Transmission ($000)
(August 1980 Price Level; 7-1/8% Interest Rate; 100-Year Project Life)

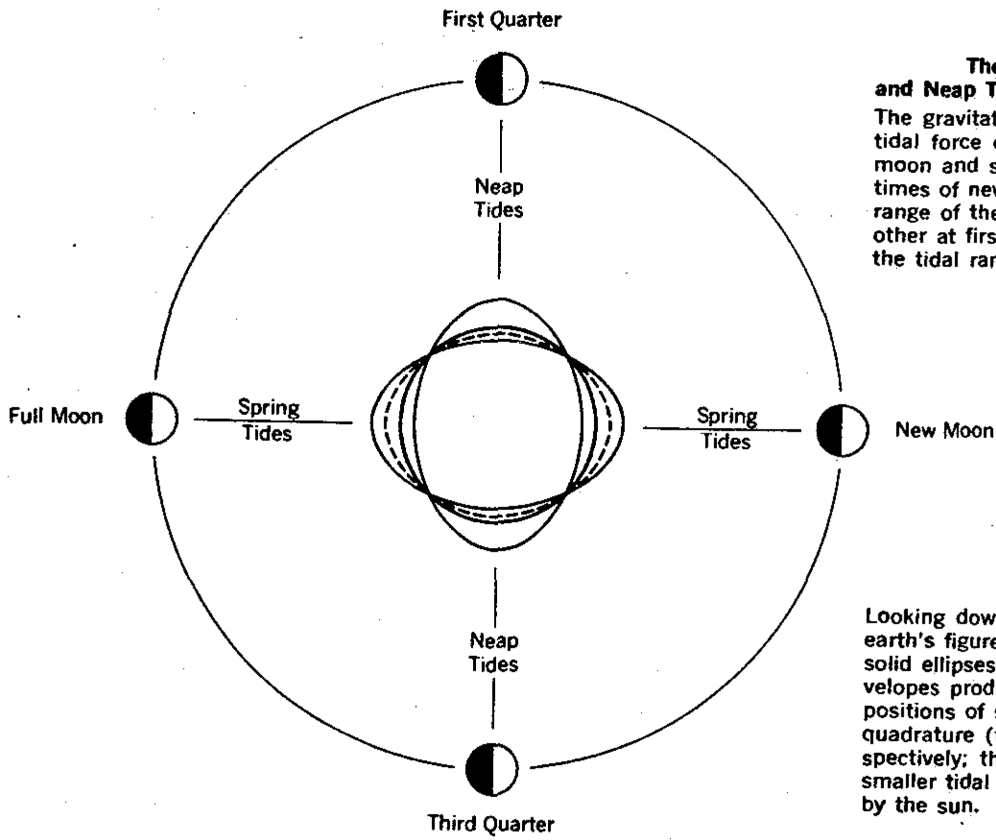
Alternative	Installed Capacity MW	Average Annual Energy GWH	Total Investment	Annual Cost	mills/kwr (including 1% Trans. Loss)	$/KW
Birch	165	560 (554*)	716,112	53,213	96	4,300
Goose	195	660 (654)	774,612	57,685	88	4,000

*(554) reflects 1% transmission loss

Integration of Tidal Power

Tidal power output from a single pool system is dependent on the relative position of tides. Therefore, unless elaborate, expensive, pumped storage or other energy storing devices are built single pool tidal power project energy cannot be retimed. Single pool tidal power projects produce power intermittently following the lunar tidal cycle which is out of phase with the solar cycle by 50 minutes each day. This phenomena causes the tides and tidal generation to occur later each day. It occurs as often at 3 a.m. as it does at 6 p.m. Not only does the cycle of tidal power advance daily, it varies in magnitude during each generating cycle from 0 at the start to full potential and back to 0 at the end of cycle. This is due to the fact that the level between the pool and ocean (head) varies throughout the generation cycle. Finally, the total available head for any generation cycle during a given month varies with the position of the moon and sun with respect to the earth. Figure 31 illustrates the relative forces exerted by the moon and sun and the resulting spring (large tide range) and neap (smaller tide range) tides.

Information on the timing and variability of tidal power generation has been developed by determining hourly generation for a typical one month period. The arbitrarily selected tidal month was that of July 1978.



The Phase Inequality; Spring and Neap Tides

The gravitational attractions (and resultant tidal force envelopes) produced by the moon and sun reinforce each other at times of new and full moon to increase the range of the tides, and counteract each other at first and third quarters to reduce the tidal range.

Looking down on the north pole of the earth's figure (central solid circle). The two solid ellipses represent the tidal force envelopes produced by the moon in the positions of syzygy (new or full moon) and quadrature (first or third quarter), respectively; the dashed ellipse shows the smaller tidal force envelope produced by the sun.

FIGURE 31

The hourly generations were determined by first manually performing step routings for a spring and neap tide and establishing the timing and magnitude of the generation with respect to timing of high tide. Hourly generation for the month was then determined by extrapolation between the two routings, and the already available mean tide routing, with respect to timing from high tide and tide height as published in "Tide Tables" of the U.S. Department of Commerce. Figure 32 graphically shows the output from a hypothetical tidal power project. Table 22 shows percent of installed capacity available at a given hour.

The variability and timing peculiarities associated with energy output from single pool tidal power projects has always militated against such developments. During the course of this study, NEPOOL, New England's primary power planning and dispatching organization was consulted regarding the absorbability and intergratability of 200 MW of intermittent power. NEPOOL indicated that it anticipted no problems in integrating the energy although studies would be necessary to determine specific electrical interties and operational impacts on the local system. If this study continues, system modeling will be undertaken to determine exactly what units tidal power would displace when operating. Based on Federal Energy Regulatory Commission findings the tidal power project will displace oil in the 1995 time frame. Figure 33 below is a representation of what fuels might be used to meet New England's peak load in 1994 - 1995. Two hundred megawatts of tidal power has been superimposed to illustrate potential oil displacement. While it is impossible to determine exactly what units would not operate it is clear that oil fired units will likely be shutdown during tidal power production.

The question of integration from an operational and electrical sense is a technical question. A companion economical question which is associated with integration is what is the value of non-dependable capacity and intermittent predictable energy.

It is generally agreed that a single pool tidal power project has no dependable capacity. It can be demonstrated that like wind power the presence of a tidal power project in a system enhances system reliability and allows lowering reserve requirements without adversely affecting loss of load probability (Reference 2). Therefore, it may be possible after detailed study to attribute some "capacity credit" to single pool tidal power projects. Currently, however, capacity is assumed to have no value.

The value of single pool tidal power project energy has been the subject of much analysis as it is the basis on which current Cobscook Bay Tidal Power Alternatives are judged for economic efficiency. This subject is discussed in the following section.

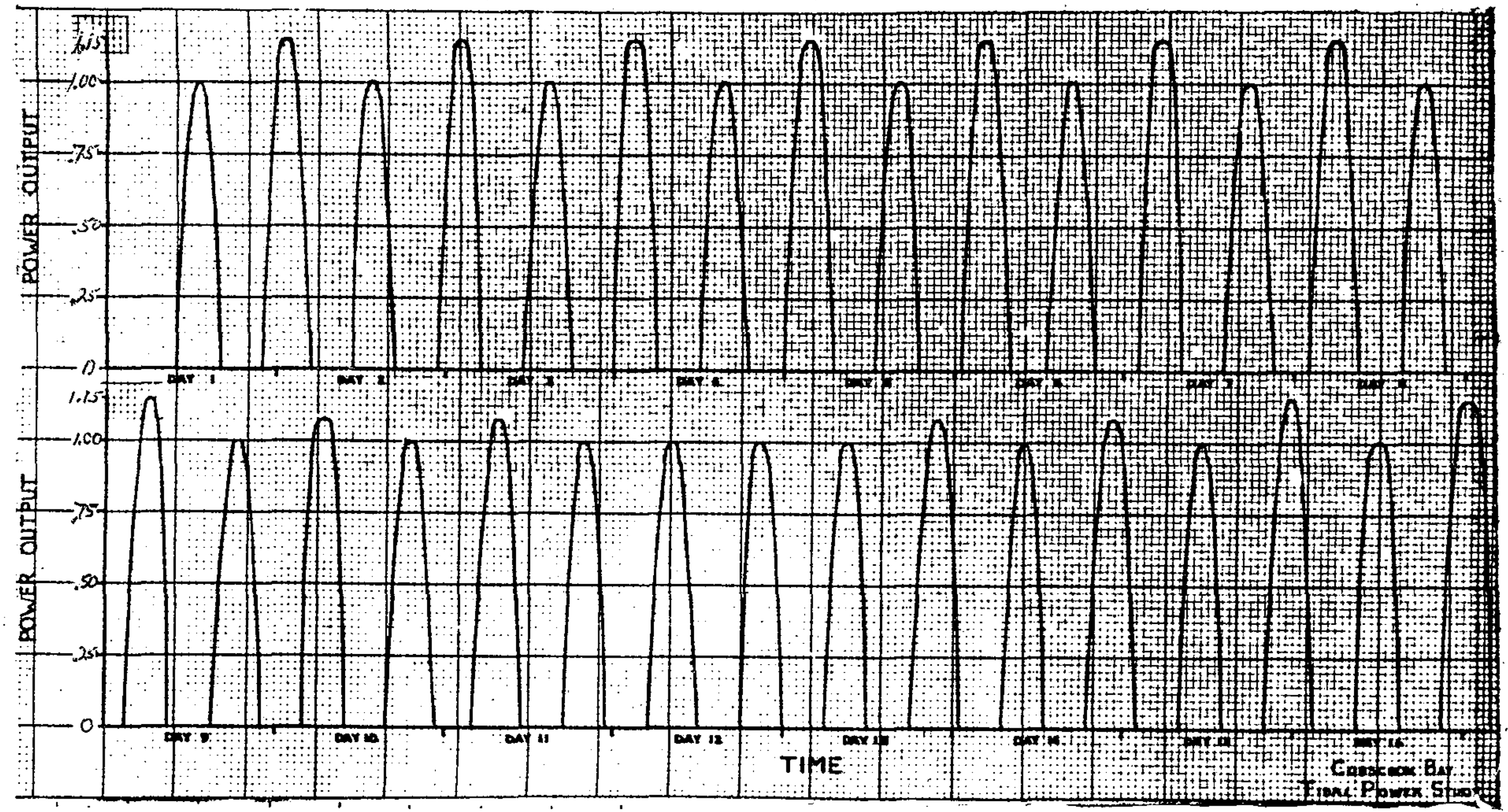

POWER OUTPUT
1.15
1.00
.75
.50
.25
0
POWER OUTPUT
1.15
1.00
.75
.50
.25
0
TIME

FIGURE 32

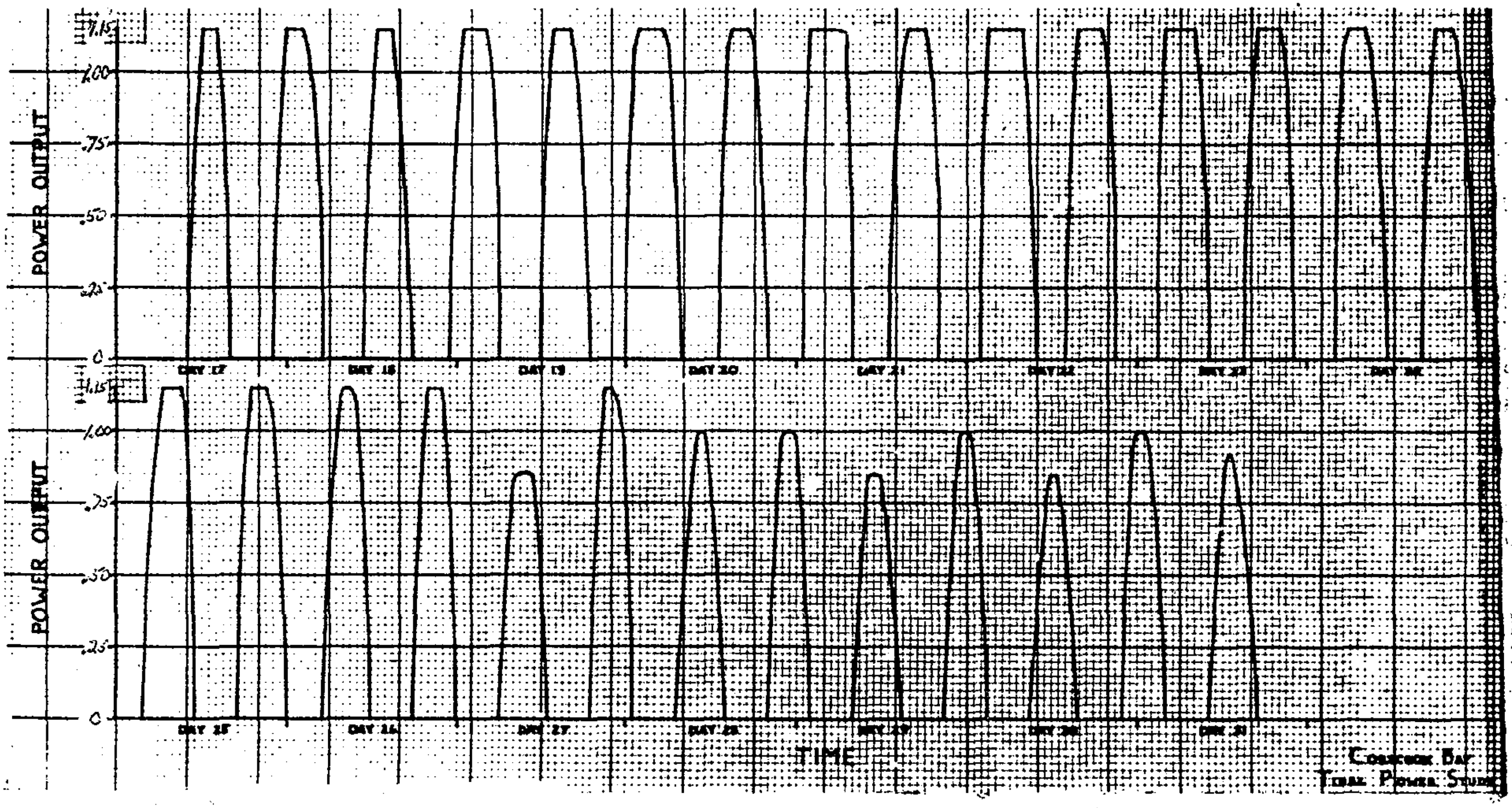

POWER OUTPUT
1.00
.75
.50
0
DAY 17
DAY 18
DAY 19
DAY 20
DAY 22
DAY 23
POWER OUTPUT
1.15
1.00
.75
.50
.25
0
DAY 25
DAY 26
DAY 27
DAY 28
DAY 30
TIME

FIGURE 32

TABLE 22

TYPICAL TIDAL POWER OUTPUT
- SINGLE POOL PROJECT -

Date \ Time	M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
July 1	0	0	0	0	(0746-16.8)			0	0	0	0	.62	.92	1.00	.92	1.15	0	0	(2007-18.0)		0	0	0	.62
2	1.08	1.15	1.15	.92	.38	0	(0838-16.8)				0	0	.85	1.00	1.00	.92	.46	0	(2007-18.1)			0	0	0
3	.23	1.08	1.15	1.15	.85	0	0	(0923-16.9)			0	0	.38	.77	1.00	1,00	.85	.38	0	0	(2139-18.2)		0	0
4	0	.85	1.15	1.15	1.15	.69	0	0	(1007-17.0)		0	0	0	.54	.92	1.00	1.00	.77	.31	0	0	(2221-18.3)		0
5	0	.54	1.00	1.15	1.15	1.08	.54	0	0	(1048-17.1)		0	0	0	.69	.92	1.00	1.00	.62	0	0	(2301-18.3)		
6	0	0	.69	1.08	1.15	1.15	.92	.31	0	0	(1126-17.2)		0	0	.46	.77	1.00	1.00	.85	.46	0	(2339-18.3)		
7	0	0	0	.85	1.15	1.15	1.15	.77	0	0	(1204-17.3)		0	0	0	.62	.92	1.00	1.00	.77	.23	0	0	0
8	(0017-18.2)		0	.62	1.00	1.15	1.15	1.00	.46	0	0	(1243-17.3)		0	0	0	.69	1.00	1.00	.92	.54	0	0	0
9	(0057-18.0)			0	.69	1.08	1.15	1.15	.85	0	0	(1323-17.3)			0	0	.46	.85	1:00	1.00	.85	.46	0	0
10	(0137-17.8)			0	0	.92	1.08	1.08	1.08	.69	0	0	(1403-17.3)			0	0	.62	.92	1.00	1.00	.77	.23	0
11	0	(0219-17.5)			0	.54	.92	1.08	1.08	.92	.46	0	0	(1447-17,3)			0	0	.69	1.00	1,00	.92	.62	0
12	0	(0306-17.2)			0	0	.54	.92	1.00	1.00	.69	.23	0	0	(1535-17.4)			0	0	.77	1.00	1.00	.92	.54
13	0	0	(0357-17.0)			0	0	.62	.92	1.00	1.00	.62	0	0	0	(1626-17.5)		0	0	.46	.85	1.08	1.08	1.00
14	.54	0	0	(0451-16.9)			0	0	.62	.92	1.00	.92	.62	0	0	(1719-17.8)			0	0	.54	.92	1.08	1.08
15	1.00	.46	0	0	(0550-17.0)			0	0	.69	.92	1.00	.92	.62	0	0	(1817-18.3)			0	0	.54	1.00	1.15
16	1.15	1.00	.46	0	0	(0650-174)			0	0	.85	1.00	1.00	1.00	.62	0	0	(1914-19.0)			0	0	.77	1.08

Notes:

1. Output is expressed as a percent of installed capacity.
2. Output is determined assuming a 40% plant factor and a rated head of 10 feet.
3. Time and elevation (mlw) of peak tide is inserted appropriately during hours of zero power generation.

Cobscook Bay Tidal Power Study
U.S. Army Engineer Division, New England
January 1980

TABLE 22

TYPICAL TIDAL POWER OUTPUT
- SINGLE POOL PROJECT
(Continued)

Date \ Time	M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
July 17	1.15	1.15	1.08	.77	0.	0	(0748-18.0)		0	0	0	.77	1.15	1.15	1.15	.77	0	0	(2012-19.8)		0	0	0	.85
18	1.15	1.15	1.15	1.08	.85	0	0	(0844-18.8)		0	0	0	.92	1.15	1.15	1.15	.85	.46	0	0	(2108-20.7)	0	0	0
19	.92	1.15	1.15	1.15	1.15	1.00	0	0	(0939-19.6)		0	0	0	1.00	1.15	1.15	1.15	1.00	.54	0	0	(2201-21.4)	0	0
20	0	1.08	1.15	1.15	1.15	1.15	1.08	.31	0	(1033-20.2)		0	0	0	1.08	1.15	1.15	1.15	1.08	.62	0	0	(2255-21.8)	0
21	0	0	1.15	1.15	1.15	1.15	1.15	1.15	0	0	(1125-20.6)		0	0	.77	1.08	1.15	1.15	1.15	1.00	0	0	(2347-21.8)	
22	0	0	0	1.15	1.15	1.15	1.15	1.15	1.15	.31	0	(1217-20.7)		0	0	.85	1.15	1.15	1.15	1.15	1.00	0	0	0
23	(0039-21.4)		0	0	1.15	1.15	1.15	1.15	1.15	92	0	0	(1309-20.5)		0	0	.92	1.15	1.15	1.15	1.15	1.00	0	0
24	.0	(0131-20.7)		0	0	1.08	1.15	1.15	1.15	1.00	.62	0	0	(1401-20.0)		0	0	.92	1.15	1.15	1.15	1.08	.77	.38
25	0	(0226-19.7)		0	0	.69	1.08	1.15	1.15	1.15	.92	0	0	(1455-19.3)		0	0	0	.92	1.15	1.15	1.15	1.00	.69
26	0	0	(0320-18.6)		0	0	.62	1.00	1.15	1.15	1.08	.62	0	0	(1549-18.6)		0	0	0	.85	1.15	1.15	1.15	.85
27	0	0	(0418-17.5)		0	0	0	.46	.85	.85	.85	.85	.38	0	0	(1646-17.9)		0	0	0	.77	1.15	1.15	1.08
28	.92	0	0	(0518-16.7)		0	0	0	.46	.77	1.00	1.00	.77	.31	0	0	(1746-17.4)		0	0	0	.69	1.00	1.00
29	1.00	.62	0	0	(0618-16.2)		0	0	0	.31	.85	.85	.85	.62	.23	0	0	(1842-17.2)		0	0	0	.69	1.00
30	1.00	.92	.54	0	0	(0716-16.1)		0	0	0	.38	.69	.85	.85	.62	.15	0	0	(1937-17.3)		0	0	0	.77
31	1.00	1.00	.92	.54	0	0	(0809-16.2)		0	0	0	.38	.77	.92	.85	.54	.15	0	0	(2028-17.5)		0	0	.38

Notes:
1. Output is expressed as a percent of installed capacity.
2. Output is determined assuming a 40% plant factor and a rated head of 10 feet.
3. Time and elevation (mlw) of peak tide is inserted appropriately during hours of zero power generation.

Cobscook Bay Tidal Power Study
U.S. Army Engineer Division, New England
January 1980

EXHIBIT 12

NEW ENGLAND PEAK DAY DISPATCH - WINTER 1994/95

24 Units Converted to Coal & NEPOOL Planned Units

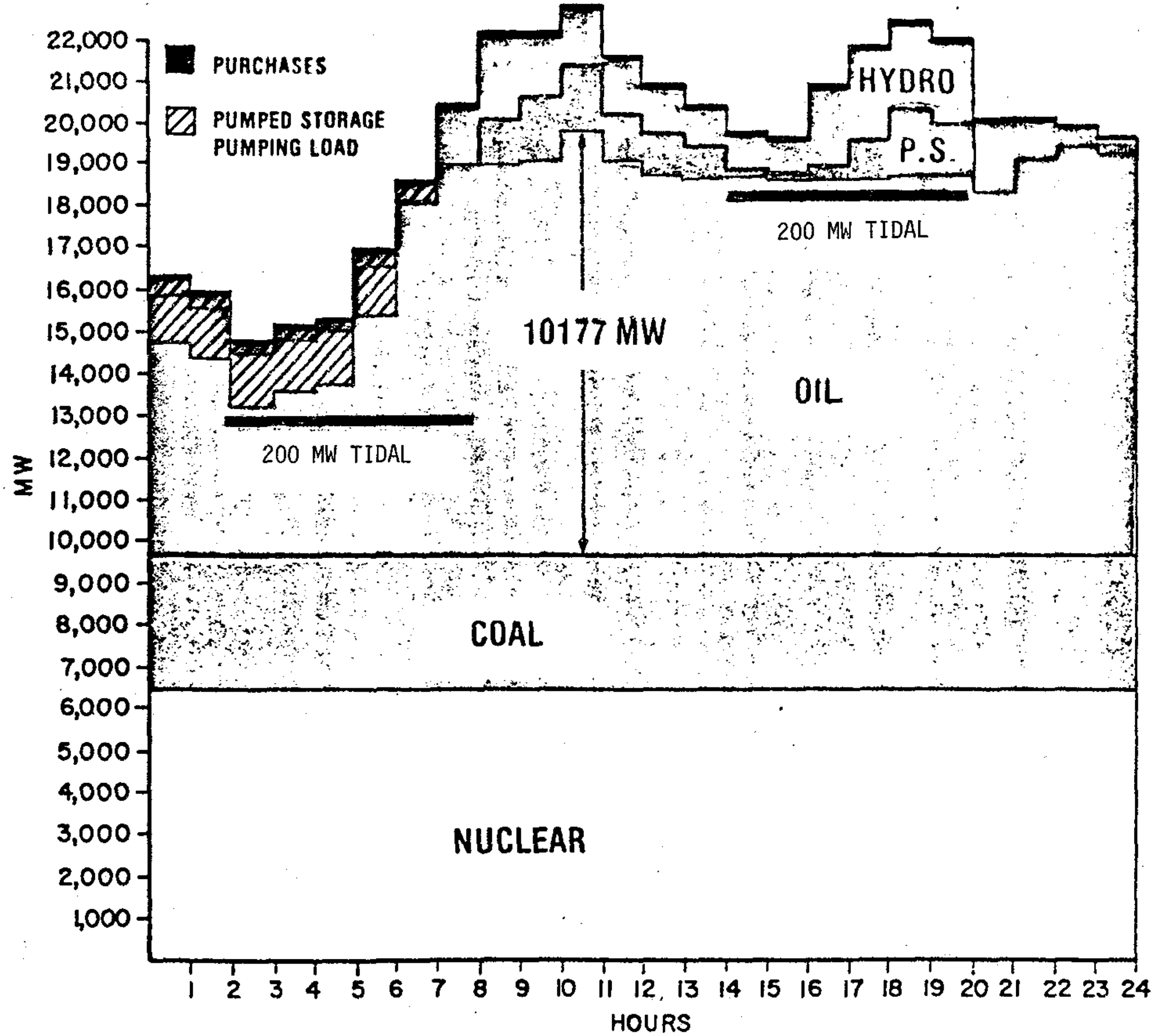


FIGURE 33

IV. EVALUATION OF PLANS

At this early stage of study detailed assessments and evaluations of plans are neither desirable or appropriate. Studies to determine the impacts of specific alternatives have not been undertaken. If the investigation continues such studies will be undertaken and specific impacts can be identified and addressed. In this report possible potential areas for impacts are identified and generalized comments regarding these impacts are presented. Economic evaluations of two plans are presented in detail since it is the result of these evaluations which play the largest role in the decision as to whether to continue this study.

Economic Evaluation

Economic Efficiency

The purpose of this section is to evaluate the economic benefits which will accrue to certain tidal power alternatives.

The economic analysis contained in this section is unique in that it represents the first time that future real escalation in fuel costs has been factored into the estimate of benefits. This is based on directives contained in WATER RESOURCES COUNCIL; Procedures for Evaluation of National Economic Development (NED) Benefits and Cost in Water Resources Planning (Level C); Final Rule. (Federal Register, Vol. 44, No. 242, Dec. 14, 1979, p. 72940.)

> "In many cases, benefits may vary over the life of a project. This may be due to such factors as staged development of the hydropower project, changes in operation of the hydropower project resulting from changes in the resource mix in the total generating system, and real escalation in fuel costs if the most likely alternative is a thermal plant."

Other methodological changes contained in the WRC Procedural Manual which will be employed in the analysis are:

> "(A) All interest and amortization costs changes to the alternative shall be calculated on the basis of the Federal discount rate; (B) no costs for taxes or insurance shall be charged to the alternative."

In recognizing the fuel escalation issue, a report entitled "Preliminary Report on the Economic Analysis of the Project," Tidal Power Study, Cobscook Bay Maine, was prepared by the New England Division in March 1979 and updated in July 1979 (ref. 33). The report evaluated hydropower benefits by the "static" conventional method, the "life-cycle" costing method and the "relative price shift (real fuel cost escalation method)." Subsequently the method used was the subject of a Symposium held at the University of Maine at Portland, Maine (Reference 36).

The conceptual basis for evaluating the benefit from energy produced by hydropower plants is society's willingness to pay for these outputs. In the absence of direct measures of willingness to pay, such as marginal cost pricing, the benefit from energy produced by hydroelectric powerplants is measured by the resource cost of the most likely alternative to be implemented in the absence of the hydroelectric plant. The Federal Energy Regulatory Commission (FERC) formerly Federal Power Commission (FPC) has selected the alternative of an oil-fired combined cycle generating station to be most likely in the absence of hydroelectric facilities in Cobscook Bay as described in Section IV. The costs of the oil-fired alternative were estimated by FERC. The costs of the hydroelectric alternatives were estimated by the New England Division and include project first costs, operation and maintenance costs and transmission line costs.

When FERC estimates the costs of the thermal alternative, two costs are addressed, the capacity cost and the energy cost. The measure of the value of the hydropower project's generating capacity is the total of the thermal plant's amortized investment cost, transmission costs, interim replacement costs, and fixed operating and maintenance costs. The measure of the values of the hydropower project's energy production is the total of the thermal plant's variable operation and maintenance costs and fuel costs. Since there is no dependable generating capacity associated with these single pool tidal power projects, only the energy value is taken as an economic benefit. Using conventional power value calculation methods in January 1980 FERC indicated that for an oil-fired combined cycle alternative the corresponding hydroelectric energy value for the Tidal Power would be 49 mills/kwh.

The task of incorporating real fuel escalation into the computation of the energy value resulted in two separate sub-tasks to be addressed, namely (i) the appropriate framework of analysis and (ii) the approximate real fuel price escalation rates.

The framework of analysis chosen was relative price shift analysis. The method goes beyond a static benefit-to-cost comparison by considering changes in underlying price relationships that might occur over the life of the project. Real price changes, net of general inflation, are used. The use of relative price shifts is discussed in the Water Resources Council's "Establishment of Principles and Standards for Planning."

> "When prices are used in evalution they should reflect the real exchange values expected to prevail over the period of analysis. For this purpose, relative price relationships and the general level of prices prevailing during the planning study will be assumed to hold generally for the future, except where specific studies and considerations indicate otherwise."

The focus on real price relationships is important. The basic rationale for this approach is as follows: The monetary values of any good is ultimately valued in Reference to other goods (goods refer to all things of value - i.e., labor, material goods) available in the market place. If all goods inflated at the same rate, then in effect their value would not be altered. By concentrating on relative price changes, we are considering fundamental changes in the valuation of a single good, which in this case is oil. Relative price shift analysis is used in order to fully quantify the benefit resulting from power generation with a renewable resource. The price for any good can change relative to the general level of prices, therefore, in an era of continued inflation the need to focus price shifts among commodities gains in importance. The utilization of relative price shift methodology elicits the potential economic energy benefit associated with tidal power much more clearly.

Relative price shift analysis can be performed either by a series of hand calculations or through the utilization of a computer model. A model was created by FERC and is detailed in Chapter 5 of their August 1979 publication Hydroelectric Power Evaluation (ref. 40). Based on the capacity and energy costs of the most likely alternatives, the model is used to develop at-market power values for both tidal and other hydroelectric power.

For purposes of the Cobscook Bay Study, the relative price shift analysis was performed for the New England Division by the New York Regional office of FERC. The power values were calculated by hand. No value for capacity has been taken for the project based on the following FERC rationale:

> "...the electrical output of the two single pool projects is controlled by the tide and electrical power is available at approximately 13-hour intervals, for relative short periods, and at varying peak outputs. The availability of power from the project would occur with periods of peak utility demand only once every several days. For this reason, the capacity value (dollars per kilowatt-year) has been taken to be zero."

The energy value represents the total value of Cobscook Bay and reflects the displacement value of energy from oil-fired generating units from 1995 through 2095. Power values were calculated for the 38.6 percent capacity factor Goose Island configuration. The 100-year period of analysis begins with the expected project on-line date of 1995.

The cost of fuel oil displaced by the Cobscook Bay Project was escalated in accordance with the Department of Energy Office of Conservation and Solar Energy Tables which were published in the Federal Register on January 23, 1980 (Reference 7). The oil prices contained in the tables are escalated from 1980 through 2010, at a rate not including inflation (real increases) based upon constant dollars. From 2010 to the 100th year of projcet life (2095), fuel prices were assumed to increase along with the general rate of inflation, i.e., no real increase using constant dollars. All displaced energy costs were discounted to the year 1995, using the Federal interest rate of 7-1/8%. These discounted costs were asummed and then multiplied by the 100-year capital recovery factor. The power values are shown in Table 23 below:

TABLE 23

Cobscook Bay Project - Power Values

Capacity Value	Energy Values
($KW-Yr.)	(Mills/KW Hr.)
0	108

A separate and concurrent relative price shift analysis was accomplished by the New England Division using a computer model (Reference 33 and 40). Relative price shift energy values ranging from 105 to 115 mills/kwh were derived. This independent analysis used the same fuel price escalations (Reference 7) as did the FERC analysis and appears to verify FERC's findings.

The relative price shift energy value supplied by FERC for the Goose Island alternative is 108 mills/kwh. The value of the 660 gigawatt hours of energy after a one percent reduction for tranmission line losses is $70,567,000 annually.

The employment benefit is based on the utilization of otherwise unemployed or underemployed local labor in the construction of the project. Based on the Direct Construction Cost of the Goose Island alternative, the amount allocated to labor has been estimated at $150,343,200. The distribution among the labor force diversion is as follows:

TOTAL	$150,343,200
Skilled	115,914,600
Unskilled	20,597,000
Other	13,831,600

The application of the appropriate percentage to ascertain the local labor bill based on Water Resources Council guidelines is found below.

Skilled:	$115,914,600 x 30% =	$34,774,400
Unskilled:	20,597,000 x 47% =	9,680,600
Other:	13,831,600 x 35% =	4,841,100
Total Local Labor Bill		$49,296,100

Application of the 100-year capital recovery factor at an interest rate of 7-1/8 percent results in an annual employment benefit of $3,515,800 over the first 100-year project life.

The measure of economic justification, the benefit/cost ratio, for the Goose Island alternative is above unity and is displayed in the summary below (Table 24).

Table 24
SUMMARY OF ECONOMIC ANALYSIS
Goose Island Alternative

Annual Benefits:	
Power	$70,567,000
Employment	3,516,000
TOTAL	74,083,000
Annual Cost (7-1/8% 100-year)	$57,685,000
Benfit/Cost Ratio	1.3 to 1

Similarly, the energy value supplied by FERC for the Birch Point alternative is 108 mills per kwh. The value of the 560 gigawatt hours of annual energy after one percent reduction for transmission line losses is $59,875,000.

Based on the Direct Construction Cost of the Birch Point alternative, the amount allocated to labor has been estimated at $138,320,000. The distribution among labor force divisions is as follows:

TOTAL	$138,320,000
Skilled	106,644,700
Unskilled	18,949,800
Other	12,725,400

The application of the appropriate percentage to ascertain the local labor bill is found below.

Skilled	$106,644,700 x 30% =	$31,993,400
Unskilled	18,949,800 x 47% =	8,906,400
Other	12,725,400 x 35% =	4,453,900
Total Local Labor Bill		$45,353,700

Application of the 100-year capital recovery factor at an interest rate of 7-1/8 percent results in an annual employment benefit of 3,234,000 over the 100-year project life.

The benefit/cost ratio, which is a measure of economic justification, is above unity for the Birch Point alternative and is displayed in the summary below (Table 25).

Table 25
SUMMARY OF ECONOMIC ANALYSIS
Birch Point Alternative

Annual Benefits:	
Power	$59,875,000
Employment	3,235,000
TOTAL	$63,110,000
Annual Cost 7-1/8 % (100-years)	53,213,000
Benfit/Cost Ratio	1.2 to 1

In addition to the benefit/cost ratio, the internal rate of return (IRR) has, in some cases, been employed to access economic feasibiliy. The internal rate of return is the discount rate at which annual costs and benefits are equal. The decision criterion is to reject a project whose IRR is less than the expected cost of financing used to implement the project. At present, the interest rate applicable to Federal project is 7-1/8 percent.

Table 26 below displays the fact that the percentage rate of return for each alternative is greater than the cost of financing.

Table 26
COBSCOOK BAY - INTERNAL RATES OF RETURN

Alternative	Energy Value (Relative Price Shift)	Annual Benefits	Internal Rate of Return
Goose Island	108 mills/KWH	$74,205,000	9-1/4%
Birch Point	108 mills/KWH	63,222,000	8-1/2%

For the purpose of determining the sensitivity of a tidal project's economic efficiency to the method of analysis used; i.e., conventional or relative price shift a conventional benefit to cost and internal rate of return analysis was performed. Using 49 mills/kwh (conventional energy value) instead of the adopted realtive price shift energy value, the benefit to cost ratio for Goose Island (195 MW) was found to be 0.6 to 1. The internal rate of return using the conventional energy value is about 4%.

The interest rate at which the Federal Government can make money available to itself cannot, by law, increase by more than 1/4 percent per year. Historically it has been increasing at that rate. In anticipation of such an increase as of 1 October 1980, project costs have been refigured at 7-3/8 percent and Table 27 below presents a summary of both the 7-1/8 and 7-3/8 analysis.

Table 27
ECONOMIC SUMMARY TABLE
(August 1980 Price Level, 100-Year Project Life)

Feature	Goose Island 7-1/8%	Goose Island 7-3/8%	Birch Point 7-1/8 %	Birch Point 7-3/8%
Installed Capacity	195 MW	195 MW	165 MW	165 MW
Dependable Capacity	0	0	0	0
Annual Energy	660 GWH	660 GWH	560 GWH	560 GWH
Energy Value	108	108	108	108
Energy Production Costs	88 Mills/KWH	92 Mills/KWH	96 Mills/KWH	100 Mills/KWH
Annual Cost (Total)	$57,685,000	$59,871,000	$53,213,000	$55,232,000
(Project)	54,370,000	56,479,000	49,898,000	51,840,000
(Trans.)	3,315,000	3,392,000	3,315,000	3,392,000
Annual Benefits (Total)	$74,083,000	$74,205,000	$63,110,000	$63,222,000
(Power)	70,567,000	70,567,000	59,875,000	59,875,000
(Emp.)	3,516,000	3,638,000	3,235,000	3,347,000
Benefit/Cost Ratio	1.28 to 1	1.24 to 1	1.20 to 1	1.14 to 1
Internal Rate of Return		9-1/4%		8-1/2%

Marketing

Another measure of a project's viability is it's marketability. Basic power marketing guidelines are set forth in Section 5 of the Flood Control Act of 1944 (16 U.S.C. 1970 ed. sec. 825s) which provides that:

> "Electric power and energy generated at reservoir projects under the control of the Department of the Army and in the opinion of the Secretary of the Army not required in the operation of such projects shall be delivered to the Secretary of the Interior (now the Secretary of Energy), who shall transmit and dispose of such power and energy in such manner as to encourage the most widespread use thereof at the lowest possible rates to consumers consistent with sound business principles, the rate schedules to become effective upon confirmation and approval by the Federal Power Commission (now the Federal Energy Regulatory Commission). Rate schedules shall be drawn having regard to the recovey (upon the basis of the application of such rate schedules to the capacity of the electric facilities of the projects) of the

cost of producing and transmitting such electric energy, including the amortization of the capital investment allocated to power over a reasonable period of years. Preference in the sale of such power and energy shall be given to public bodies and cooperatives. The Secretary of the Interior is authorized, from funds to be appropriated by Congress, to construct or acquire, by purchase or other agreement, only such tranmission lines and related facilities as may be necessary in order to make the wholesale quantities for sale on fair and reasonable terms and conditions to facilities owned by the Federal Government, public bodies, cooperatives, and privately-owned companies. All moneys received from such sales shall be deposited in the Treasury of the United States as miscellaneous receipts." (Dec. 22, 1944, CH 665 s5, 58 Stat. 890.)

Under the guidelines set forth in Section 5 of the Flood Control Act of 1944, the sale of power by energy should:

- Encourage widespread use of power
- Utilize lowest possible rates consistent with sound business principles.
- Make sure that rate schedules provide for cost recovery (financial feasibility).
- Provide preference in sale of power to public bodies and cooperatives.

The entire New England power industry is composed of almost 150 different organizations which are involved in electric generation, sales, or both. In 1971 a regional bulk power supply group was begun through the formation of the New England Power Pool (NEPOOL). The objectives of NEPOOL are: (a) to assure that the bulk power supply of New England conforms to proper standards of reliability and, (b) to attain maximum practicable economy, consistent with such standards of realiabilty, in such bulk power supply and to provide for equitable sharing of the resulting benefits and costs. This is accomplished through joint planning, central dispatching, coordinated construction, operation and maintenance of electric generation and transmission facilities.

Day-to-day scheduling and coordiantion of generating units and operation of transmission facilities are accomplished through NEPEX, a central dispatching agency provided for in the NEPOOL agreement. Pool participants subject all entitlements in generating units to NEPEX dispatch.

All transmission facilities rated 69 KV and above and which are owned by NEPOOL participants and which are required to allow energy from power sources to move freely on the New Englnad transmission network are considered to be pool transmission facilities (PTF). Each participant of NEPOOL is then entitled to use the PTF owned by other participants for a number of specified services including the transfer of entitlements of power purchases with both participants and nonparticipants.

The charges to NEPOOL participants for the utilization of these transmission facilities are under the determination of the owning company, unless the generating facility source is classified by NEPOOL as a "pool planned unit." Such designation dictates the availability of a New England wide "postage stamp" transmission rate for "wheeling" over the intergrated 230 KV and 345 KV pool transmission facilities (EHVPTF) and further avail as another separately computed postage stamp rate for transmission service over any lower voltage pool transmission facilities (LVPTF) required for use in wheeling of the power to the purchaser.

Yearly charges for use of the EHVPTF (230 KV and 345 KV lines) for wheeling the output of a pool planned generating unit to the NEPOOL member amounted to $3.00 per KW per year in 1979. Additional wheeling charges may be made by individual companies for wheeling power over non-PTF transmission facilities and/or subtransmission facilities.

Due to the many diverse entities involved in supplying power in the New England States, it is difficult to get exact figures on total electric loads. It appears, however, that the total peak load of the New England area is 1979 was approximately 15,300 MW. Of this, approximately 1,500 MW represented power demand in the State of Maine.

Municipal electric systems and cooperatives (preference customers) located in the New England Staes had combined load of some 1,450 MW. Of this amount, municipalities and cooperatives in Maine had loads of approximately 51 MW.

Given below are the peak demands of preference customers in 1979 followed by tabulation of generating capability:

PREFERENCE CUSTOMER PEAK DEMANDS

State	Municipalities MW	Cooperatives MW	Total MW
Maine	33	18	51
New Hampshire	20	98	118
Vermont	134	41	175
Massachusetts	881	-	881
Rhode Island	5	-	5
Connecticut	217	-	217
Total	1,290	157	1,447

From Reference 47

PREFERENCE CUSTOMER GENERATING CAPABILITY

State	Generating Capacity MW
Maine	3
Connecticut	58
New Hampshire	4
Vermont	69
Massachusetts	434
Rhode Island	-
Total	568

From Reference 47

Given below are pertinent projections of preference customer loads and total loads for the State of Maine and the entire New England area. Projected loads for preference customers are based on an average load growth of 5 percent for cooperatives, 4 percent for Maine municipalities, and 3.2 percent for other New England municipalities. Total New England load are conincident peak loads based on NEPOOL loads as estimated by NEPOOL Planning Committee, as of April 1, 1980.

	Maine		Total New England	
	Preference Customers	Total Loads	Preference Customers	Total Loads
1979	51	1,563	1,447	15,311
1990	78	2,507	2,074	20,650
2000	124	3,710	2,923	28,707

From Reference 47

Rates presently charged to preference customers vary substantially thoughout the New England area with the lowest overall rates charged in New Hampshire and Maine and higher rates charged in Massachusetts, Connecticut, and Vermont. Existing rates on file at the Federal Energy Regulatory Commission as of January 1980 indicated that new higher rate schedules are now being applied to a great portion of the New England area. These filed rates contain capacity charges which vary from $100 to $125 per KW per year in these latter three states. In New Hampshire and Maine, the present capacity charges are considerably below these levels. Energy charges all reflect fuel adjustment charges and are basically dependent upon the fuel costs which are incurred in each of the various areas. Because of the fuel adjustment charges, overall wholesale power costs for preference customers approached 40 mills per KWH in Maine during the latter part of 1979 (Reference 47).

For a project to be considered financially feasible, the Federal Government must be able to sell (market) power produced from project at a price which will allow the Government to repay itself within 50 years at an interest rate of 8%. The Corps of Engineers does not sell power which it generates. The Department of Energy (DOE) is responsible for marketing Corps generated power. In the northeast, there is no DOE marketing agency, therefore, any power generated by the Government at Cobscook Bay would most likely be marketed by the Southeast Power Administration (SEPA) which is located in Georgia. Based on December 1979 - January 1980 price levels, SEPA estimated that power from the 195 MW Goose alternative would have to be sold at 94 mills/KWH to be financially feasible. Therefore, the Government would have to find a market willing to pay about 97 mills/kwh (includes about 2-3 mills/KWH to cover SEPA's administrative expenses). SEPA concluded that since the current 1980 value of similar oil fired energy is only about 50 mills/kwh that no such market exists. However, the Federal Energy Regulatory Commission using relative price shift analysis calculated that similar oil-fired energy would cost 108 mills/kwh in 1995.

If general inflation impacts oil price and costruction costs equally and if DOE's real fuel price escalation projections (ref. 7) materialize, it appears as though the tidal power alternatives considered will be economically feasible and possibly marketable in 1995. The year 1995 is the mostly likely on-line date projected for the alternatives under consideration. It is expected that the detailed engineering and environmental studies required for such projects would require 8 to 10 more years and that actual construction would require 4 to 6 years.

Social, Economic, Cultural and Recreational Considerations

Socioeconomic

If a tidal power project were built in the Cobscook Bay area the occurrence of its social and economic impacts would be confined to certain geographical areas. Three impact areas have thus far been designated, the construction impact area, the service impact area (SIA), and the regional impact area.

The construction impact area include the four communities of Eastport, Lubec, Perry and Pembroke. Impacts experienced within this area would be attributed to the actual construction activities, including impacts from any land takings or impacts from the use of local roads to gain access to the project sites. During construction, trucks and other construction apparatus will cause an increase in traffic and offer problems typically associated with a large influx of workers.

A service impact area has been designated which includes those communities that might be chosen by construction workers for temporary residence. Communities within this impact area will be described in terms of their municipal services, municipal finance, and housing, and their potential to service the construction workers. For this stage of the study, Calais, Eastport, Lubec, Machias, Perry, and Pembroke make up the service impact area, and are expected to receive the majority of the non-local workforce.

Washington County is considered to be the regional impact area. Regional impacts generally take the form of long term economic changes. In the case of a tidal power project, Washington County will probably see an increase in tourism and possibly a slight stabilizing effect on electric rates. At some future time if such stabilized energy costs do become a reality, industry might be attracted to Washington County.

The most drastic social and economic impacts would be felt during the five year construction period. The influx of construction workers to these rural Maine communities is expected to be the major source of these impacts. The first task in delineating the social and economic impacts of the tidal project upon local communities is determining the number of nonlocal construction workers. Once the number has been estimated, how workers distribute themselves within the local communities should be determined. Scenarios describing possible housing schemes and potential impacts on housing supplies and municipal services would be developed.

Calais, Eastport, Lubec, and Machias, four of the six SIA communities, are among the largest communities in Washington County and would offer the construction worker the most in housing and service. These communities are within approximately an hour's drive of the project site, with Eastport within about a half hour's drive. The majority of the county's communities are within about an hour and a half, but many communities are very small and are not felt to offer any amenities or opportunities that would attract the construction workers over the larger communities identified above. Of the smaller communities, it is possible that Perry and Pembroke could be selected to accommodate a mobile home "city" or some concentrated arrangement of construction workers. Construction worker surveys performed by the Institute of Water Resources (IWR) revealed that construction workers overwhelmingly locate in those communities located closest to the project site.

A 1977 study of twelve water resources projects for the Bureau of Reclamation outlined and analyzed the characteristics of construction workers. These projects were in rural areas in seven western states. More recently the Institute of Water Resources (IWR) has compiled data on construction work forces at projects constructed in the Northeast. Review of the results of both of these study efforts provides a base for projecting construction worker characteristics.

A major distinction between the Bureau of Reclamation and IWR data is the fact that projects surveyed by IWR were in the densely populated northeast whereas the Bureau of Reclamation studies were in rural western states. Although Cobscook Bay is in the northeast, the Bureau of Reclamation data may be more applicable, since this region in Maine is sparsely settled.

The Bureau of Reclamation studies indicated that on the average, 53 percent of the workers moved into the project area from elsewhere, establishing new residences. Approximately 25 percent of the nonlocal workers were single, and 75 percent were married. Those moving into the communities who were married have an average family size of 3.57 persons, with 65 percent of these workers bringing their families with them to the construction site.

Although housing choices of nonlocal workers were obtained through the questionnaires, workers were asked the type of unit at their local place of residence. The results showed that half of the nonlocal people moved into trailers, campers, or mobile homes while the other half chose single family homes or apartments. This differed from the housing units of local workers who indicated that 22 percent lived in mobile homes, trailers or campers, with 71 percent living in single family homes and 7 percent in apartments. In the study being conducted by IWR the workforce was composed of 6 percent local workers and 31 percent nonlocal workers. Approximately 43 percent of the nonlocal work force occupies single family homes and apartments, 29 percent stayed in motels, 20 percent occupied mobile homes and trailers.

Preliminary estimates indicate that the tidal power project in Cobscook Bay would have a construction period of five years. The work force would peak between April and October of the fourth year with 1900 workers. It is expected that construction would start with about 600 workers and end with about the same number five years later.

Imposing Bureau of Reclamation percentages on the peak work force for the Cobscook Bay tidal project, 1,007 construction workers would move into the area during peak. If 65 percent of the 75 percent nonlocal married workers brought families averaging 4 persons per family a total of 4,963 family persons plus the 251 single construction workers would produce a population increase of 2,214 during the construction period.

Housing is of particular concern, not only because of the limited number of housing options open, but also because concentrations of construction workers in particular communities would impact municipal services, including education facilities as well as water supply, sewage and solid waste disposal.

At a workshop held in 1978 (Reference 31) interest was expressed for providing construction worker housing that could be turned over for local use at the end of construction. Workshop participants felt that the housing which, if developed, should be of good quality to be useful in the future for tourism or other economic development schemes.

Two major scenarios for housing construction workers need mention: integrating workers with the local communities, or segregating the work force in some type of trailer or mobile home "city" to be removed after construction is completed. Other scenarios such as the possibility of converting large, old homes from their original function to boarding houses should be considered.

Several tasks would be accomplished during study progress to reveal what the implication of a tidal power project would have on the housing situation. These include an inventory of the existing housing stock within a commuting range, examination of scenarios for distributing the work force, determination of local preferences for housing the incoming workers in the interest of immediate and long range social and economic well-being, determination of the housing the indigenous area is willing to furnish, such as motels, hotels, rooming house rentals, etc.

The provision of services, dependent on the distribution of construction workers, is a major concern. The particular issue raised at the workshop was who would be responsible for the services, such as sewage treatment, water, law enforcement, schools, etc. The magnitude of the impact on local services would be closely tied to the distribution of the construction workers, the existing capacity of municipal services, and the current level of use of each service. Future tasks in determining the impact of a tidal power facility on local services would first include a complete inventory of existing services, current level of use and existing capacity, with a highlight on those services in shortage.

Other studies have already been completed that deal with the service issue. These studies call for comprehensive planning and coordination among local, State and Federal agencies for obtaining grants and funds to relieve the pressure of construction activity in municipal services. In one particular instance (Chief Joseph Dam in Columbia, Washington) the Corps was responsible for obtaining funds to mitigate the project's impact on school facilities. With the addition of funds from the local communities permanent schooling facilities were provided that would accommodate those children brought with a construction work force and the local needs once the work force had left.

It is not expected that construction wokers would stay in the local area, once the construction period phases down. A small number of full time jobs would be available for operation and maintenance of the project.

Long term effects are not anticipated to be major impacts on the existing social and economic characteristics of the local communities. Some increase in tourism may be expected as more travelers may pass through the area to see unique tidal project. The greatest effect on local residents may be the possible creation of a roadway on top of the dams of either the Birch, Goose, or Dudley Alternatives that would provide a direct route between Eastport and Lubec. Also, the presence of the large dams would impact navigation, even though locks would be provided. The project purpose itself, the provisions of hydroelectric power, would certainly have implications for the area, although they are more likely to be regional in nature. By project construction an annual addition of 500 to 700 million kilowatt hours of electrical energy derived from native, renewable resources would be added to New England's energy base. To what extent this may stimulate regional development and establishment of new industries has not been determined at this time.

Cultural

None of the four alternative project locations presently being considered have recorded prehistoric sites at their landward ends. However, as archaeological survey of the region is still incomplete, an archaeological reconnaissance of these areas will become necessary if project planning proceeds to further stages of study. As operation of the completed project would decrease tidal fluctuation, erosion of prehistoric coastal sites around the pool would be diminished.

Nearly all of the alternative dam locations under consideration tie-in to rural areas of coastline where historic resources appear unlikely to exist. The single exception is the Lubec end of the Dudley alternative, which occupies a commerical waterfront area. Historic structures or historic archaeological resources may exist in this area. If the Dudley alternative is pursued in further planning, the presence or absence of such resources will be determined and potential effects of construction activity considered in more detail.

The considerable tidal fluctuation and narrow channels of Cobscook Bay probably resulted in numerous wrecks, some of which may be of historic significance. While wrecks within the alternative pool areas would remain unaffected by project construction and operation, any within the dam construction limits would be destroyed. Further research will be undertaken at the next stage of project planning to determine whether any historically significant wrecks are located within the proposed dam construction areas.

Recreational

It is probable that a public roadway will be planned to cross over the dam(s) at whichever alternative may ultimately be constructed. This will be particulaly significant from a public recreation/ access point of view, especially for the Dudley, Goose and Birch alternatives. Lengthy driving distances to and from various locations around Cobscook Bay would be greatly reduced, thereby making existing recreational facilities more accessible with a better potential for increased visitation. The tidal power project in itself would be an important tourist attraction. If it were located along a major transportation route, which would be the case with three of the proposed alternatives and to a lesser degree with the Wilson alternative, then visitation to this project alone could be expected to be significant.

The only major recreational attractions in the vicinity of Cobscook Bay are Quoddy Head State Park, Cobscook Bay State Park, Moosehorn National Wildlife Refuge and the tourist/resort areas of St. Andrews, New Brunswick and Campobello Island. St. Andrews and Campobello Island, and to a lesser extent Cobscook Bay State Park, are destination recreation areas which offer overnight facilities.

Quoddy Head State Park offers about a dozen picnic sites, parking, rest rooms, drinking water and a short hiking trail. It is not near a heavily traveled main route and offers little in the way of a recreational attraction, thereby receiving relatively light visitation averaging around 60,000 people annually. The Moosehorn National Wildlife Refuge provides a visitor center for passing tourists, and even though U.S. Route 1 crosses the refuge, it still receives relatively light visitation averaging around 25,000 people per year. Cobscook Bay State Park has 150 camp sites, two short hiking trails, a boat launching ramp, rest rooms and drinking water. The park is located off U.S. Route 1, but is primarily a stopover for campers and tourists on their way to Canada and is not an attraction to the area itself. Visitation in recent years has averaged a little over 40,000 people annually, about half of whom are campers.

The principal towns in the immediate vicinity of Passamaquoddy and Cobscook Bays are Eastport and Lubec, Maine, and St. Andrews, New Brunswick. Lubec and Eastport are both depressed areas surviving on a declining fishing economy, while St. Andrews is a much more attractive tourist area with several recreational facilities. In addition to the Roosevelt Memorial, Campobello Island also has several beaches and camping areas. Except for Calais, Maine and St. Stephen, New Brunswick, most of the rest of Washington and Charlotte Counties is rural, poor and depressed, and offers relatively little to tourists and recreationists.

Consequently, considering the nature of the Cobscook Bay area and the fact that most of the visitors to the region are tourists on their way to Canada, the proposed tidal power project cannot be expected to experience particularly high visitation. The project would be an attraction to sightseers, especially if a highway over the dams were provided to improve access through the area, but would not offer much in the way of recreational facilities other than possibly a boat launching ramp, picnic area, and a visitor center.

Most of the recreational boating in the area is by local residents and is very limited due to the local economic climate and the rather dangerous tidal conditions, as well as the often poor weather and short summer season. A tidal power project would enhance recreational boating to a small degree by reducing tidal fluctuations, but the future potential for increased use would still remain low. Picnicking use is also expected to be relatively low since picnicking would mostly be incidental to sightseeing. Therefore, the only significant recreational activity which can be directly associated with any of the four power project alternatives is sightseeing. A project visitor center possibly in association with the powerhouse facilities, would be the primary recreational development.

Visitation to existing recreational areas and attractions in eastern Maine and New Brunswick, including Cobscook Bay State Park, Quoddy Head State Park, Moosehorn National Wildlife Refuge, Arcadia National Park, Franklin D. Roosevelt International Park and Fundy National Park, has been relatively steady in recent years with no significant trends up or down. This has also been generally true at Corps of Engineers flood control and navigation projects in New England where public recreational facility use has increased slightly at some projects while decreasing slightly at others, but with only a small upward trend overall.

Construction of a tidal power project at Cobscook Bay would probably result in increased visitation for the first few years after completion, but, assuming current trends continue, level off and stabilize after several years. Based upon experienced visitation at other Corps projects, Maine State Parks and other recreational facilities that offer a usefull comparison, the projected visitation at the proposed Cobscook Bay Tidal Power Project at completion of construction is estimated at 200,000 people annually. It is reasonable to expect that visitation will gradually increase and level off at about 300,000 people annually.

These projections are based on current trends and experience with the assumption that energy costs, and gasoline in particular, continue to increase. It appears that the increased cost of energy will continue to adversely affect those recreation activities that depend upon gasoline for participation. These activities that require the use of an automobile to reach the place of participation will be the most severely affected. Consequently, this will undoubtedly limit visitation to the Cobscook Bay area, as present trends indicate that use of existing recreation facilities has leveled off since the energy "crises" began in 1973. With increased energy constraints recreationists are almost certain to participate in activities closer to home or take vacations at destination resort areas and limit the amount of driving.

Environmental Considerations

Most of the ecological information available for Cobscook Bay is in the form of lists of species known or thought to occur in the area (Reference 27). Little research has been done defining ecological relationships among the different organisms, abundance, distribution, and life histories of species existing in Cobscook Bay. "The system is obviously very diverse and productive, yet little is known about the specific ecological processes that contribute to the diversity and exceptional productivity of Cobscook Bay" (Reference 27).

Any environmental impacts which may occur depend upon the project's operational characteristics, such as pool size and mode of generating power.

Generally, a tidal power project would result in major impacts on the marine, estuarine and riverine systems in the project area. Any alterations to these systems would affect circulation, salinity, sedimentation, temperature, shoreline erosion, flushing, ice formation, and nutrient levels. Nutrient and sediment supply would be reduced in intertidal areas and beaches, which, in turn, would result in significant alterations in the estuarine biota.

Water Quality and Hydraulic Conditions

Several alternate embankment locations have been proposed for the Cobscook Bay Tidal Power Project. Four single pool plans, (Dudley, Goose, Birch, and Wilson) have been advanced. All of these plans, except Wilson, would employ the inner bay as part of the high pool. Wilson would utilize only East Bay and the Pennamaquan River Estuary as the high pool. Behind any of these embankments, current hydraulic conditions would be significantly altered.

Generally speaking, a single pool tidal power project operates by opening filling gates during the rising tide. In this manner the operating pool is filled to near the high tide level. The filling gates are then closed, and the turbines begin generation during the falling tide when a differential head exists at the embankment. The cycle is then repeated. Exact basin elevations for this project would depend on the results of refined hydropower studies.

The mean tide range in the operating pool of each alternative plan will be between 4.7 feet and 10 feet depending upon which capacity factor is selected. Regardless of which operating curve is adopted, water surface levels and rates of filling and drawdown will be significantly changed, however, the mean maximum tidal level will be within about one foot of the current level.

Filling of the operating pool will be through a series of 30 foot by 30 foot filling gates. Maximum velocities through these gates are estimated to be near 20 feet per second. Bulb type turbines will be provided to generate electricity, and exit velocities will be in the range of 18 feet per second. Table 28 provides information on inflows and outflows for the alternative considered.

Currents within and immediately outside of the power pool will be significantly affected in magnitude and direction. The volume of water passing the embankment site will be considerably less than at present and will be concentrated through the turbine and filling gate openings. Reduced currents in the operating pool will have a tendency to decrease the degree of mixing which currently takes place. Residual currents outside the pool would be minimally affected.

TABLE 28

PERTINENT DATA
ALTERNATE EMBANKMENT SITES
COBSCOOK BAY TIDAL POWER PROJECT

Embankment Alignment	Surface Area (High+Mean)/2 (acres)	Maximum Filling Rate: Largest Installed Capacity Factor (10^5 cfs)	Maximum Filling Rate: Smallest Installed Capacity Factor (10^5 cfs)	Maximum Generating Rate: Largest Installed Capacity Factor (10^5 cfs)	Maximum Generating Rate: Smallest Installed Capacity Factor (10^5 cfs)
Dudley	23,123	9.2	5.1	14.	1.7
Goose	19,379	7.7	4.3	12.	1.4
Birch	16,582	6.4	3.7	10.	1.2
Wilson	3,552	1.4	0.79	2.2	0.26

The unusually large tide range in the greater Bay of Fundy area has been attributed in part to the relationship between physical dimensions and the frequency of tidal oscillation. Construction of a tidal power project at Cobscook Bay would likely have some impact on raising tide levels of the surrounding water. Only through further study could this effect be quantified, however, at this time it is felt that the effect will be minimal.

Reduced currents within the operating pool area will result in decreased vertical mixing which in turn will give rise to increased thermal stratification and greater seasonal variations in water temperature. The greatest temperature change would likely occur at the surface layer with a smaller change observed at the deep layer. There is a strong possibility that some amount of ice cover would develop on the pool during the winter months. Little temperature change would be expected outside of the pool area.

The mean surface salinity of the operating pool would likely be reduced. Bottom salinities would likely be altered only slightly. Since there is relatively little freshwater inflow to Cobscook Bay it is not likely that significant stratification of fresh and saline waters would develop. If any of this type of stratification does develop, Dennys Bay is the most probable location since this has the largest freshwater inflow. Outside of the operating pool little change is expected except for the emptying and filling areas where some decreased salinity would occur.

The vigorous tidal mixing currently taking place in Cobscook Bay promotes dissolved oxygen levels near the super-saturation level. Under the proposed plans mixing in the operating pool will be decreased, and it is likely that dissolved oxygen levels in the deep basins of Cobscook Bay will be reduced.

Suspended sediment concentrations in the water column will increase during construction of the project. The main sources of this increased loading will be the suspension of materials being used to construct the embankment and the resuspension of bottom sediment in the vicinity of construction. This temporary increase in suspended sediment will likely promote a short term degradation of other measures of water quality.

Some permanent change in type and distribution of sediment could be expected. Reduced range of water levels and wind fetch should cause a decrease in shoreline erosion within the operating pool. Lower energy levels in the pool should cause more sediments to deposit, thus impacting the distribution of marine sediments. Some deposition of sediment at the mouths of freshwater inflows could be expected.

Construction of the proposed Cobscook Bay Tidal Power Project will significantly alter the hydrodynamic conditions currently existing in the bay. The tide range behind the barrier will be greatly reduced, the mean pool level will be raised, currents and velocities within the pool will be reduced, and less mixing will take place. The potential exists for some stratification of salinity, temperature, and dissolved oxygen, and some winter icing could occur. Levels of suspended sediment and associated degradation of overall water quality will occur during construction and long-range, sediment circulation and deposition patterns will be changed.

Fairly high velocity flow will occur through the filling gates and turbine outlets. This will impact the area outside and adjacent to the embankment structure. Little overall effect is expected on the open ocean away from the structure, however some small increase in tide level is likely due to the closing off of Cobscook Bay.

All conclusions presented in this section have either been extracted from or based upon existing literature. No water quality oriented studies were conducted for this report. Therefore, only statements of a general nature could be made regarding effects of the proposed tidal power project. More quantitative predictions can only be made through more detailed study. A recommended baseline data collection program has been outlined in the Water Quality Report of the Environmental Appendix.

Future conditions in Cobscook Bay cannot be accurately predicted without the aid of modeling. Because of the extremely dynamic situation existing in the bay, the complex geometry and extreme tide range, no "off the shelf" computer model can be utilized to make definitive predictions.

If this study continues and tidal power is found to be feasible it is recommended that a physical model of Cobscook Bay be developed. This model will be constructed and calibrated using data gathered in the previously mentioned baseline studies and other supplemental data. This model would be capable of simulating the action of tides in the bay. Currents, mixing, and stratification could be predicted.

A mathematical model would then be developed based upon the physical hydrodynamic model. The use of a mathematical model would allow for the variation of operating schemes and project layout. Many different simulations for varying conditions could take place using the mathematical model. This would not be practical using the physical model.

Additionally some separate type of modeling effort, likely mathematical, will have to be conducted to determine the amount of increase in tide levels which could be expected in the Bay of Fundy and the Gulf of Maine as a result of blocking off Cobscook Bay. It is not felt that a substantial increase will occur, however, this question should be addressed.

Alternative Alignments

Wilson Alignment: The dam would extend from Leighton Neck, across Wilson's Ledges and Red Island, to Birch Point. Leighton Neck and Birch Point consist of open fields, agricultural land and rock ledges along the shoreline. Wilson's Ledges and Red Island are mainly rock ledges. Vegetation at the sites at Leighton Neck and Birch Point would be disturbed and removed due to construction activities. This would, in turn, affect wildlife in the area that depend on the vegetation for food and cover. Some species may return to the area after construction has been completed, whereas others would be displaced to different areas in search of food. Some agricultural land may be removed from use to build access roads and at the construction site. Adverse impacts on Wilson's Ledges and Red Island would result as most of the islands would be used to accommodate the dam structures. Rock would most likely have to be blasted and removed at the site. This would adversely affect any marine mammals, and migratory and resident shorebirds that utilize these areas.

Birch Alignment: Birch Point and Gove Point are the points of land where the dam abutments and powerhouses would be built. They are both made up of rock ledges and fields, with some forestland being present on Gove Point. Impacts on these areas would be moderate to severe as the facilities that are built would permanently alter the present state of the area.

Goose Alignment: The Goose alignment would extend from Goose Island to Mathews Island. Both islands consist of forestlands, open land and rock ledges. Impacts on these areas would be similar to those associated with the previous alternative.

Dudley Alignment: The Dudley alignment would include Estes Head, Treat Island, Dudley Island, and Lubec Neck. The town of Lubec is located in the area to which the dam would extend. As this area has most probably been disturbed in recent years, impacts at this site would be moderate. Estes Head, Treat and Dudley Islands are made up primarily of field, forests and rock ledges which would be affected by construction of the dam facilities.

Terrestrial Ecosystem

Because no alternative has been fully developed, the exact location of powerhouses, access roads, etc., are not known. Specific impacts on the terrestrial environment cannot, therefore, be fully assessed at this time.

Impacts on the terrestrial habitat would be those largely associated with transmission line construction and maintenance. These impacts will be dealt with on a generic basis at this time because the Department of Energy (Bonneville Power Administration) has not set forth final powerline routes. The general area studied by BPA is between Cobscook Bay and the Bangor area, and is approximately 100 miles long and 50 miles wide.

According to a working paper on powerline right-of-way and wildlife management prepared by the Maine Department of Inland Fisheries and Wildlife in 1975, four acres must be taken into account when determining transmission line routes. They are:

1. Deer wintering areas;

2. Wetlands;

3. Streams, brooks, rivers and other bodies of water;

4. Habitats supporting unique, threatened or endangered biota.

For a complete discussion of the management and associated impacts on these areas due to transmission line routing refer to USFWS Planning Aid Report, 1979 (Reference 43).

In addition to the impacts on wetlands caused by transmission lines are those caused by construction of tidal power facilities. Table 29 indicates the acreages of those wetland habitats which would be affected by the proposed dam alignments. The Dudley-Treat-Lubec alignment would affect the most acreage of wetlands (8,957 acres), and the Wilson alignment the least (1,373 acres).

TABLE 29

INTERTIDAL HABITAT AFFECTED BY PROPOSED TIDAL POWER DAMS

	Intertidal Habitat[1] (acres)					
Dam Alignment	Mudflat	Rocky Shore	Aquatic Bed	Marsh	Beach or Bar	Total
Wilson	829	150	218	87	89	1,373
Birch	4,144	1,278	961	553	153	7,089
Goose	4,719	1,472	1,249	592	210	8,242
Dudley-Treat-Lubec	4,990	1,610	1,382	605	370	8,957

[1]Source of data: FWS National Wetland Inventory Draft Maps

Salt marsh development could occur as a result of changes in the tidal range. Spartina alterniflora and Spartina patens would be the major species affected. These species would shift down the tidal flats, resulting in increased salt marsh at the seaward edge (see Figure 34). Wetland habitat would be increased in certain areas, providing habitat for waterfowl and aquatic mammals. However, some salt marsh habitat would be replced by freshwater habitat. In effect, there would be a change in the distribution and type of vegetation, with a net loss of marshland probably occurring. This would in turn affect wildlife, waterfowl, birds and marine organisms. Much of the intertidal habitat would be altered, and productivity impaired, with approximately half of the plant communities losing their productivity.

Agricultural land in the bay area may be affected. Marshes have been diked and used for agricultural purposes in the past. Because of an increase in the mean tide level, the drainage on this land would be reduced, thereby negatively affecting its current use. Impacts would include increased disease factors and nitrogen deficiency. Water levels would have to be controlled in drainage ditches relative to what is being grown on the land (Reference 49).

Impacts on terrestrial bird and wildlife populations would be contingent on their relationships and associations with the marine habitat upon which they depend on for food. Should a particular habitat be negatively impacted by construction, this would in turn have negative impacts on their survival. Populations would be displaced to other areas in search of food and shelter, thereby putting pressure on existing populations which are assumed to be operating at maximum carrying capacity. The increases in pressure could eventually reduce productivity.

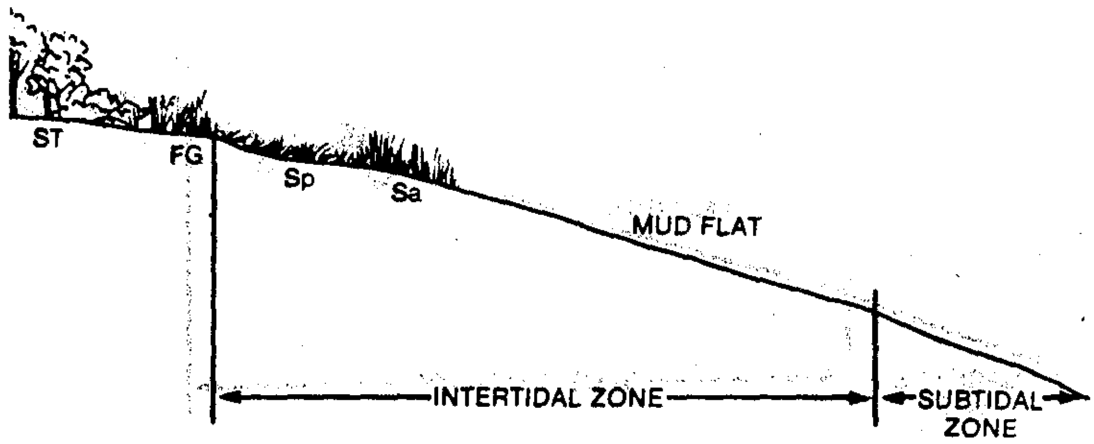
Other impacts on the terrestrial environment would include those associated with dam construction activities such as construction of access roads. Once project details are complete, an inventory of the terrestrial habitat would include inventories of any rare and/or endangered plant species which may or are known to exist, wildlife populations and their respective habitats, foresty accounts and wetland surveys.

Noise from construction activities would result in short term impacts, with most biota returning to the area after completion of the project.

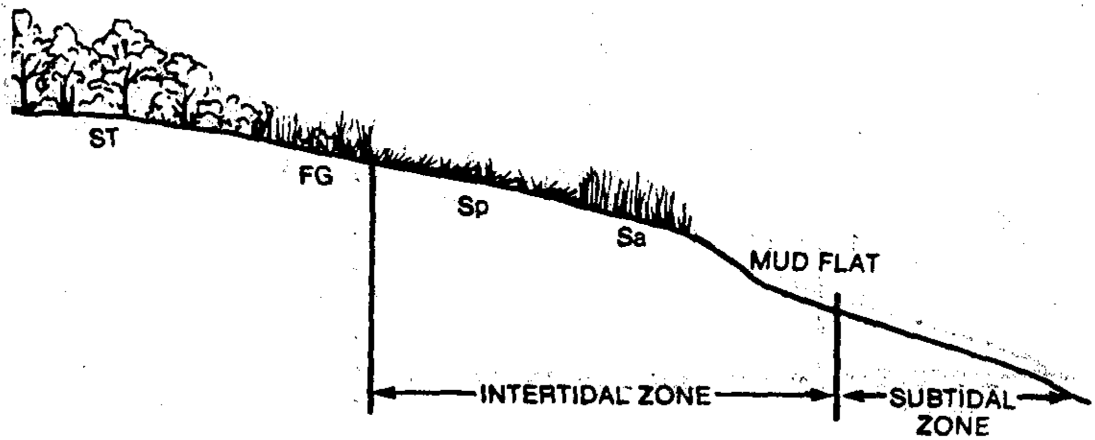
A survey of deer yards located in the areas of access roads and construction activities would be necessary.

Aquatic Ecosystem

Fisheries. All fish species found in the bay area are important biologically to the overall trophic ecology of the region. A major concern would be the effects of tidal power on the feeding and reproduction of the various species. Some depend on the intertidal benthic organisms as their main food source. This food source would be adversely affected by the reduced intertidal zone resulting from project implementation.



EXISTING INTERTIDAL ZONE



POSSIBLE INTERTIDAL ZONE WITH IMPOUNDMENT FOR TIDAL POWER

FG - FRESHWATER GRASSLAND
ST - SHRUBS AND TREES
Sp - SPARTINA PATENS
Sa - SPARTINA ALTERNIFLORA

Conceptual effect of a new tidal regime on a generalized intertidal zone (Hodd 1977).

FIGURE 34

Most species could decrease in abundance if their movement is impeded by the project. "Resident fishes (except for winter flounder) apparently do not spawn to any great extent in Cobscook Bay. These species must maintain their populations by migrant individuals that enter the Bay (Reference 27)."

A critical impact would be associated with the diadromous fisheries of the bay. Their spawning migrations would be impeded by construction activities unless fish passage facilities are provided. Important species affected would be alewife, smelt and Atlantic salmon. In addition to the impediment of movement inland to the rivers for spawning, impacts would also be associated with the movement of juveniles and adults seaward through the powerhouse. There is little information available about the effects of turbines on finfish. Migration could be blocked by conditions existing in the sluiceways such as darkness causing the loss of visual reference needed to allow migratory progress and lack of olfactory clues which are utilized by migrating species (Reference 49). The extent of the mortality will depend on the extent of passage through the turbines.

In addition to the physical barriers presented by construction, the physical and biological aspects of the various habitats these species utilize for spawning and rearing could be affected, such as salt marshes, estuaries and nearby rivers. Also, any changes in the intertidal and subtidal habitats could negatively effect the food resources of any groundfish species which depend heavily on this particular habitat.

Project construction would also cause some changes in circulation patterns and decreases in the current velocity behind the dam structures, resulting in deposition of sediments at the mouths of rivers and streams, and in the overall distribution of surface sediment types. Project construction and implementation could cause delays in the migrations of diadromous species. Those species that swim close to the surface would possibly be delayed only for the amount of time that the filling gates would be open. However, those fish which go through at lower depths would be impeded unless passage facilities were provided.

Each of the dam alignments -- Wilson, Birch, Goose and Dudley -- would adversely affect the movement of migratory species to freshwater for spawning. The fish are able to enter the bay only through the passage between West Quoddy Head and Campobello Island. Fish passage facilities would have to be provided, with different types possibly being built to accommodate the various species.

Although movement up the Pennamaquan River would be equally affected by each of the alternatives, the Wilson alignment would not affect migration up the Dennys River as passage would not be impeded through the channels leading to the river.

According to the report by Iles, 1975, in the proceedings of the workshop on Fundy Tidal Power and the Environment (Reference 49), the complex ecological structures of zooplankton in the bay are related to specific hydrographic features, and that some biological elements found in the system provide food for or are predators on herring populations. As stated, "...any significant change in hydrographic regimes could be followed by a response in the biological system, which could be positive or negative, and could result in differing responses from different species."

Because statistics on distribution, mortality and stock size of the fisheries are inconsistent, it is difficult to specifically assess the impacts on these resources.

Herring will probably enter the bay through the filling gates. Some will pass through the turbines, but the extent of the mortality is not known. Mortality of juvenile and adult herring may also occur from increased water temperatures within the impoundment. Because of this limited access and mortality, a reduction in the herring population within the impoundment is expected

Pollock, haddock, cod and redfish would be reduced greatly or possibly eliminated from behind the impoundment. As some groundfish tend to be less mobile than the more migratory species, they are more likely to be caught up in the powerhouse failities. At present there are no fisheries for winter flounder due to resrictions on otter trawling.

Site-specific impact analyses of tidal power on the commercial fisheries of the region are difficult to accomplish at this time. It can be said that there will be changes in fish populations in general. Additional information and analysis is needed on the distribution, abundance and life history of those species that are found in the bay throughout the year.

Growth and maturation may be affected by changes in temperature and salinity, and the placement of a dam anywhere in the bay may affect migratory routes and change the overall distribution and abundance of food.

In summary, there would most likely be a reduction in commercial herring populations, and a slight increase in the smelt fishery. Alewife and Atlantic salmon fisheries would decline appreciably unless fish passage facilities were provided to allow them to reach their spawning areas.

Benthic Organisms. Knowledge of intertidal populations of benthic organisms in Cobscook Bay is limited because of the lack of an extensive population sampling program. Impacts on benthos due to construction activities would occur from dredge and fill operations. The extent of impacts would depend on the abundance and distribution of the resources in the area of the dredge and fill activities. There could also be a reduction of benthic resources in the surrounding areas of the particular dredge and fill sites, with bottom habitat also being lost at the permanent dam sites. Indirect impacts on the benthic organisms would result from local current patterns being affected, changes in sedimentation, scouring and nutrient transport (Reference 27).

Primary productivity would be adversely affected by construction activities because of an increase in turbidity, which would reduce the amount of sunlight penetrating the water column.

Impacts on benthos associated with the operation of the dam and related structures would be an increase in sedimentation due to reduction in tidal energy and a loss of mixing within the water column. Many organisms may not be able to survive substantial depositions of sediments.

An increase in ice formation is also a possibility. This would cover the mud flats and benthos, which may not be able to survive this change. Most ice forms along the upper reaches of the intertidal zone. The production of the intertidal zone would be affected as a result of ice melting and scouring.

A large amount of intertidal habitat would be lost should any part of Cobscook Bay be impounded. This is the result of habitat, normally exposed at low tide, now being covered with water through all tidal cycles. Distribution of benthic invertebrates would be affected by the reduction of the intertidal zone. Redistribution and change in abundance of existing species composition could occur should sediment types change. Changes in sediment type would include increases in loose muddy substrates where populations of deposit feeding marine worm populations would increase. Impacts on the resident and migratory fish and bird populations would also occur as a result of these changes in the benthic populations. Because a new mean tide level would be established, there would be a shift in the height and width of the intertidal clam flats (Reference 49).

Some organisms can survive sediment deposition by burrowing upward. However, such species as Mya cannot as adults (Risk, et al, 1977).

It is estimated that soft-shell clam production would probably decrease by about half. The newly created clam zone would not be productive for about 10 years, but would return to the level of productivity that existed before impoundment (Reference 27).

The permanent flooding of large areas of mudflats would result, therefore, in a large mortality for those species which are adapted to this environment. There may be a reduction in larvae production due to changes in current patterns and distribution of sediments.

The physiological processes of growth and reproduction could be affected by changes in food supply and water temperature.

The Maine State Planning office has identified areas considered critical for certain invertebrates. These areas are Birch Islands, Crow Neck and Wilburs Neck. They are populated with unique populations of invertebrates that consist of arctic species which are rarely found on the coast, or subtidal animals that are rarely found in the intertidal zone.

Except for the Wilson alternative, all of the alignments being considered would impact these critical areas.

The effects of a dam on intertidal benthic animals would result in impacts on other resources present. Benthic animals provide an essential food resource for fish, waterfowl, and shorebirds. The reduction of the zone would decrease the resources in proportion to the amount of area that would be exposed. The effects would vary with location. At some there would a major impact on migratory shorebirds, and in some areas there would still be subtidal populations available for groundfish (Reference 49).

Impacts on commercially important shellfish species within the impoundment would also vary. There may be a slight improvement in the lobster industry, depending upon the baseline productivity of the resource at the time the project is constructed. The quality of the soft-shell clam may improve, but there would be a decline in actual numbers because of the reduced intertidal zone. The impact would be greater with a high pool configuration than with a low pool configuration. The blue mussel and sea scallop production would increase slightly, and production of the periwinkle would decline. There would probably be no change in sea urchin production.

Warmer water temperatures would stimulate the growth of some intertidal plants, which would increase the feed of littorina snails and urchins in intertidal and subtidal areas.

Many benthic populations would not be able to survive the new tidal regime, and organisms would be displaced to habitats at new levels.

Plankton. Phytoplankton production would be affected as a result of impacts on water circulation and temperature, nutrient distribution and light penetration. Along with this, net primary production would be changed. (Reference 43). The extent of these impacts on individual populations cannot be evaluated at this time. An analysis for each alignment would have to be performed to determine the extent of impacts on these populations.

Zooplankton populations within the bay would be affected by resultant impacts on the phytoplankton and distribution of detritus. Any changes in abundance and distribution of zooplankton would impact other portions of the ecological structure in the bay. A study done by Legaré and Maclellan in 1960 proposed that should a tidal power project be built, the impacts on zooplankton would not be significant because copepods in the overall area are tolerant of a wide range of temperature and salinity. However, those organisms that are more sensitive to physical and chemical changes, in addition to those in early stages of development, would be affected to the greatest extent.

Zooplankton would be affected by an increase in suspended particulate matter due to construction activities. Many of the organisms are filter feeders, and this turbidity could interfere with their feeding processes.

Phytoplankton would be least restricted in its passage into and out of the bay due to the operation of gates and locks at the dam.

A change in the flushing pattern could result in a reduction of plankton that are carried into the bay. As a result of an increase in the mean water level after the project is constructed, additional habitat for plankton may be created, thereby allowing a probable increase in primary production.

Marine Mammals. Impacts on marine mammals due to construction activities would most likely be minor in nature. However, when facilities are operating, the larger marine mammals would be greatly restricted in their movement into and out of the bay depending on which alignment is built. When the filling gates are closed, mammals already in the impoundment would be trapped, and those outside would not be able to travel through. The harbor seal has breeding populations in the area, and entrapment in the bay could have a significant impact on them. Feeding habits and also reproduction would be affected, and the Birch, Goose, and Dudley alignments would prevent access to Straight Bay where seal haulout areas are located.

Harbor porpoises found in the bay may spend an inordinate amount of time in the bay and could depend upon the area throughout the year for food and shelter. These species should be studied fully to determine the extent of impact by the project.

Impacts on whales that are known to occur in the area would be similar to those for seals and porpoises. The feeding habits of the whales differ among the various species, and must be taken into account in the placement of dams.

With each of the dam alignments, marine mammals would be impeded in their movement into the bay. In particular, seals would be prevented from migrating in the spring up into the estuaries to their haulout areas, and again in late fall down the estuaries.

Marine Vegetation. A large reduction in tidal flushing could result in the increased growth of blue-green algae. However, with the additional reduction in exposed tidal flats at low tide, primary production from green, red and brown algae would be reduced (Reference 49).

The seaweeds *Ascophyllum* and *Fucus* may increase in the rocky areas as a result of decreased wave exposure along the edges of the impoundment. However, as a result of increased sedimentation, the rocky substrate for macroalgae would most likely decrease, whereas the substrate for marsh grasses would increase.

Other factors that could affect the production of macroalgae would include ice scouring, wave action, and grazing. These increase the rate of turnover of the algae, thereby increasing the net growth (Reference 27.)

Turbidity would limit the light available for subtidal plants which would influence the growth of kelp. In areas at or near the project site, growth would be limited to the shallower depths. Any increases in the temperature regime of the bay would also affect the growth of kelp. These species generally have a low temperature optimum and increases in temperature above the optimum could slow growth.

Productivity of macroalgae in the bay is influenced by the availability of light and suitable substrate, suitable salinities, water temperatures and adequate nutrients. Any changes in these factors due to construction and operation would impact the growth of algae.

Rare and Endangered Species. Consultation on the fin, humpback, right, sei, blue and sperm whales would be required under Section 7 of the Endangered Species Act of 1973.

The shortnose sturgeon, which is also protected is anadromous in some tributaries in the Gulf of Maine. However, as it prefers large rivers, it would probably not occur in the small tributaries found in the Cobscook Bay region, though it has been thought to be an occasional migrant into the Quoddy region. Further studies would have to be carried out to determine its presence in the project area.

Avifauna

Migratory and Shorebirds. Construction of tidal power facilities would adversely impact those birds that feed on intertidal mudflats and in the vicinity of deepwater tidal rips (Reference 42). The degree of impact would depend upon the operational mode of the particular facility that was built.

Those shorebird species most likely to be adversely affected by loss of habitat and food availability are semipalmated sandpipers, semipalmated plovers and black-bellied plovers. Others include Bonaparte's gulls, herring and black-backed gulls, and great blue herons.

Any changes in the draining of the bays would affect the tidal rips that are present. These rips concentrate the food upon which many birds depend. The area off of Eastport where tides converge from Cobscook and Passamaquoddy Bays provides a major feeding area for northern phalaropes, Bonaparte's gulls, herring and black-backed gulls, kittiwakes and dovekies. These species would be affected by any changes in the oceanographic features of this particular area.

The availability and quality of marine invertebrate foods for waterfowl could be adversely affected due to changes in the water regime. Ice formation would also be a factor, but to what extent is not known.

Terrestrial species would be primarily affected by transmission line facilities. Mitigation measures should be taken to route lines away from migration routes, and away from routes between breeding and feeding areas.

Rare and Endangered Species. The bald eagle would be affected by a tidal power project in Cobscook Bay. The magnitude of impacts cannot be evaluated at this time, however, because of the lack of baseline substantive data. Should studies continue, food requirements, effects of development, and mitigation measures would have to be assessed. A formal Section 7 consultation and a detailed biological assessment would have to be completed.

The Maine Department of Inland Fisheries and Wildlife has proposed a bald eagle management program in order to restore a self-sustaining bald eagle population to suitable habitat throughout Maine.

Eagles have been sited at Denbow Neck, Trescott Island, Wilbur Neck, Edmunds, Clement Point, Coggins Head, Mt. Dorcas, Burnt Cove, and Hog Island. All of the dam alignments have the potential to affect the bald eagle's food supplies, which may affect its success in nesting.

Mariculture

Species that may be profitable for mariculture in Cobscook Bay are the Atlantic salmon, trout, lobster, oyster, mussel, and snail. All of these species have been used in mariculture experiments except for the snail. At present, there are some pilot experiments and Federally sponsored programs to investigate the marketability of these species.

Atlantic salmon have good potential provided that strains could be developed which would require less forage area than they presently require. Brook trout and rainbow trout could be reared in holding pens or cages. The source of small fish for rearing and the number of suitable sites within the bay are limiting factors.

The success in rearing lobsters is difficult to assess. The impoundment created by the project has the potential to provide suitable habitat necessary for rearing them, due to a reduction in tidal amplitude and elevated summer water temperatures. Rearing facilities may be developed. Three factors which impact such a venture are: 1.) each lobster must be raised in an individual container because of their aggressiveness, 2.) feeding is expensive, and 3.) they are more susceptible to disease while in culture (Reference 42).

Oysters have already been cultured in pilot plant operations and in small commercial businesses. Future production would depend on rearing sites and market demand. The Passamaquoddy Indian Tribe has had an oyster program operating within the Half-Moon Cove tidal basin for the past two seasons. This program has concentrated on the rearing of European oysters. By the fall of 1980, an estimated total of 300,000 oysters will have been cultured in Half-Moon Cove.

Blue mussels are the easiest species to culture, and investigations are being conducted to determine how raising can be done successfully, but the financial gains from it have not been adequate. Mussel culture has the potential to become very successful once the process is mechanized, and a market developed (Reference 42). The practice of transplanting for a growout operation has presented several problems among which are the spread of disease and habitat disruption.

In 1980, the Passamaquoddy Indian Tribe plans to establish a pilot mussel program.

There is potential for the culturing of snails in Cobscook Bay. At present, the local whelk is prepared for market as canned escargot, and has in trial operation been reported to have a high sales demand and value.

At the biological stations in St. Andrews, New Brunswick, experiments have shown that salmon and trout can be successfully hatched in fresh water, acclimated to saltwater, and then in one season grown to pan-size in cages moored in the ocean. In September 1979, approximately 30,500 salmonids were being held in cages at Deer Island. During the 1980 season, private concerns will be developing their own program on Campobello Island and Grand Manau due to the favorability of the experiments. As the demand for salmon is high and is expected to continue, the potential for cage culture and sea-ranching will also increase.

One or more forms of mariculture are predicted to be a benefit derived from the implementation of a tidal power project. The newly impounded pools would create the habitat necessary to develop mariculture operations. Tidal amplitude would be reduced, and as a result some mudflat areas would be permanently exposed and others would never be exposed. There would be a reduction in wave action. These factors would create conditions in the bay favorable to mariculture development.

Changes in salinity and temperature could negatively affect any mariculture developments presently in operation. Organisms now under culture may not be able to survive any substantial changes in the salinity and temperature regimes of the bay.

Most benefits would accrue in the biological potential that would be created for mariculture development, however economics would dictate how successful these fisheries would be to develop.

Predicted annual gains in 1975 dollars for mariculture within the entire Cobscook Bay are given on the following page. It is reasonable to assume that some portion of these could be applicable to those gains which could be accrued from development in one particular area of the bay.

Salmon	-	1 venture	$ 500,000
Trout	-	4 ventures	2,000,000
Oysters	-	5 ventures	500,000
Lobsters	-	2 ventures	1,000,000
Mussels	-	excellent potential	(2,000,000-3,000,000)
Snails	-	excellent potential	figures not developed
			$4,000,000 (6-7,000,000)

The number of ventures for each fishery is an estimate based on the ease with which such a fishery could be established.

In the future, it can be expected that there will be advances and development of those strains of species which will be able to grow faster under the existing conditions, nutrition and the marketability of products. The value of mariculture development itself will increase because of the growth in demand for products from the ocean.

V. CONCLUSION

Discussion

Unlike earlier recent studies in 1977 and 1979 (References 30 and 33), this study does not exclusively address economic evaluation of the concept of Tidal Power at Cobscook Bay, Maine. Environmental and certain social concerns have been identified. The issues of integration and marketability of tidal power projects have been discussed.

Like the earler studies, using a method of economic analysis which takes into account the changing costs of the fuels utilized for power generation in New England, this study concludes that, at some point after a tidal power project is built net positive benefits will accrue. This is not surprising. New England is highly dependent on oil for electric energy and will be for the foreseeable future. Oil resources of the world are not limitless. Even in the absence of eco-political forces like OPEC, oil would get scarcer and, therefore, more expensive each day. At some point in the future, 20, 50, 100 or 200 years from now oil will not be available at any price. It is safe to assume, that as long as New England has a large amount of oil derived electric energy, electric prices will continue to rise along with fuel costs.

There is no doubt then, if one assumes that the alternative to Cobscook Bay Tidal Power will always be an oil-fired combined cycle facility, that the tidal power project will ultimately prove to be a worth while investment. Had the tidal power project been completed in 1935 it would be producing energy at a cost of less than 10 mills/kwh today.

The question of economic attractiveness at a future time is a two-part question.

- If prices of fuel escalate, will the project be economically feasible and marketable?
- Will technological breakthroughs stop or drastically reduce fuel price escalation?

If fuel prices continue to escalate in accordance with published price projections the project is economically feasible. No studies have been made to assess market conditions for electric energy in the 1995 time frame. It is not known whether consummers will be willing to pay a price which will allow the Government to repay itself for its initial investment. No studies as to the timing of any potential breakthroughs in nuclear fusion or solar technologies have been attempted. These issues, the market conditions in 1995 and the time of occurrence of major technological breakthroughs (leading to substitution and early obsolescence) are difficult to resolve. Even after extensive study any projections would be uncertain..

However, based on current Federal guidelines for evaluation of water resources projects tidal hydropower at Cobscook Bay, Maine, is economically feasible. It has also been established that from an electrical and operational viewpoint the sources of intermittent single pool tidal power project energy could be absorbed and utilized by New England.

Several environmental considerations have been addressed and some possible environmental impacts have been identified. Significantly, Cobscook Bay has one of the largest bald eagle populations in the Northeast. Other rare and endangered species observed in the area include several types of whales, the shortnose sturgeon, and the Artic peregrine falcon. Some unique features of the bay which result directly from the large tidal fluctuations and the accompanying currents might be adversely affected by a project. For example, ice might form on the now essentially ice free bay, dissolved oxygen content in water might decrease, stratification might occur, intertidal habitat would be decreased, the bay's value as a winter feeding ground for birds might be affected. Movements of fish and marine mammals could be hampered. In general, the larger the impounded bay area, the greater the potential for environmental impacts. No environmental impacts have been positively identified as yet.

Social impacts due to the project are felt to be most severe during construction of the project. The influx of construction workers would tax existing service and housing facilities. The noise and associated at-site congestion would also be a factor within the study area. Three potential long term socioeconomic impacts are foreseen at this time; increased tourism due to the presence of the unique project, increased interaction between Lubec and Eastport due to the possibility of shortened overland route (the dams) between them, and most significantly, the annual addition of 500 to 700 million kilowatt hours of electrical energy derived from native, renewable resources.

Summary

The tidal power project has been found to be economically feasible using current Water Resources Council criteria. Environmental impacts would include significant alterations to the existing marine, estuarine and riverine ecosystem. Relatively favorable long term socioeconomic impacts have been identified and the tidal power project would reduce New England's (and the Nation's) dependence on oil while increasing energy independence.

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Cover: Photo and Design by Walter Avallone

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GLOSSARY

Abbreviations

alternating current	ac	head in feet	H
barrel (42 gallons)	bbl	Hertz	Hz
benefit-cost ratio	B/C	horsepower	hp
British thermal units	Btu	kilovolt	kV
cents	¢	kilovolt-ampere	kVA
cubic feet	ft^3	kilowatt	kW
cubic feet per second	cfs	kilowatt-hours	kWh
cubic yard	cu yd	megavolt ampere	MVA
direct current	dc	megawatt	MW
dollars	$	megawatt-hours	MWh
efficiency in percent	E	percent	%
feet	ft	pound	lb
flow in cfs	Q	pounds per square inch	psi
gigawatt	GW	revolutions per minute	r/min
gravitational constant	g	square yards	sq yd

ALTERNATING CURRENT (ac)—an electric current that reverses its direction of flow periodically as contrasted to direct current.

ANADROMOUS FISH—fish, such as salmon, which ascend rivers from the sea at certain seasons to spawn.

AVERAGE LOAD—the hypothetical constant load over a specified time period that would produce the same energy as the actual load would produce for the same period.

BENEFIT-COST RATIO (B/C)—the ratio of the present value of the benefit stream to the present value of the project cost stream computed for comparable price level assumptions.

BENEFITS (ECONOMIC)—the increase in economic value produced by the hydropower addition project, typically represented as a time stream of value produced by the generation of hydroelectric power. In small hydro projects this is often limited for analysis purposes to the stream of costs that would be representative of the least costly alternative source of equivalent power.

BRITISH THERMAL UNIT (Btu)—the quantity of heat energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit, at sea level.

BUS—an electrical conductor which serves as a common connection for two or more electrical circuits. A bus may be in the form of rigid bars, either circular or rectangular in cross section, or in form of stranded-conductor overhead cables held under tension.

BUSBAR—an electrical conductor in the form of rigid bars, located in switchyard or power plants, serving as a common connection for two or more electrical circuits.

CAPACITOR—a dielectric device which momentarily absorbs and stores electrical energy.

CAPACITY—the maximum power output or load for which a turbine-generator, station, or system is rated.

CAPACITY VALUE—that part of the market value of electric power which is assigned to dependable capacity.

CAPITAL RECOVERY FACTOR—a mathematics of finance value used to convert a lump sum amount to an equivalent uniform annual stream of values.

CIRCUIT BREAKER—a switch that automatically opens an electric circuit carrying power when an abnormal condition occurs.

COSTS (ECONOMIC)—the stream of value required to produce the hydro electric power. In small hydro projects this is often limited to the management and construction cost required to develop the power plant, and the administration, operations, maintenance and replacement costs required to continue the power plant in service.

COST OF SERVICE—cost of producing electric energy at the point of ownership transfer.

CRITICAL STREAMFLOW—the amount of streamflow available for hydroelectric power generation during the most adverse streamflow period.

CRITICAL DRAWDOWN PERIOD—the time period between maximum pool drawdown and the previous occurrence of full pool.

DEMAND—see LOAD.

DEBT SERVICE—principle and interest payments on the debt used to finance the project.

DEPENDABLE CAPACITY—the load carrying ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

DIRECT CURRENT (dc)—electricity that flows continuously in one direction as contrasted with alternating current.

ENERGY—the capacity for performing work. The electrical energy term generally used is kilowatt-hours and represents power (kilowatts) operating for some time period (hours).

ENERGY VALUE—that part of the market value of electric power which is assigned to energy generated.

ELECTRIC RATE SCHEDULE—a statement of the terms and conditions governing the sale of electric service to a particular class of customers.

FEASIBILITY STUDY—an investigation performed to formulate a hydropower project and definitively assess its desirability for implementation.

FEDERAL ENERGY REGULATORY COMMISSION (FERC)—an agency in the Department of Energy which licenses non-Federal hydropower projects and regulates interstate transfer of electric energy. Formerly the Federal Power Commission (FPC).

FIRM ENERGY—the energy generation ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

FORCE MAJEURE—an event or effect that cannot be reasonably anticipated or controlled.

FORCED OUTAGE—the shutting down of a generating unit for emergency reasons.

FORCED OUTAGE RATE—the percent of scheduled generating time a unit is unable to generate because of forced outages due to mechanical, electrical or another failure.

FOSSIL FUELS—refers to coal, oil, and natural gas.

GENERATOR—a machine which converts mechanical energy into electric energy.

GIGAWATT (GW)—one million kilowatts.

GRAVITATIONAL CONSTANT (g)—the rate of acceleration of gravity, approximately 32.2 feet per second per second.

HEAD, GROSS (H)—the difference in elevation between the headwater surface above and the tailwater surface below a hydroelectric power plant, under specified conditions.

HERTZ (Hz)—cycles per second.

HYDROELECTRIC PLANT or HYDROPOWER PLANT—an electric power plant in which the turbine-generators are driven by falling water.

INSTALLED CAPACITY—the total of the capacities shown on the nameplates of the generating units in a hydropower plant.

INTERCONNECTION—a transmission line joining two or more power systems through which power produced by one can be used by the other.

KILOVOLT (kV)—one thousand volts.

KILOWATT (kW)—one thousand watts.

KILOWATT-HOUR (kWh)—the amount of electrical energy involved with a one kilowatt demand over a period of one hour. It is equivalent to 3,413 Btu of heat energy.

LOAD—the amount of power needed to be delivered at a given point on an electric system.

LOAD CURVE—a curve showing power (kilowatts) supplied, plotted against time of occurrence, and illustrating the varying magnitude of the load during the period covered.

LOAD FACTOR—the ratio of the average load during a designated period to the peak or maximum load occurring in that period.

LOW HEAD HYDROPOWER—hydropower that operates with a head of 20 meters (66 feet) or less.

(AT) MARKET VALUE—the value of power at the load center as measured by the cost of producing and delivering equivalent alternative power to the market.

MEGAWATT (MW)—one thousand kilowatts.

MEGAWATT-HOURS (MWh)—one thousand kilowatt-hours.

MINIMUM REVENUE REQUIREMENT—funds required to pay all costs incurred by a project.

MULTIPURPOSE RIVER BASIN PROGRAM—programs for the development of rivers with dams and related structures which serve more than one purpose, such as - hydroelectric power, irrigation, water supply, water quality control, and fish and wildlife enhancement.

NUCLEAR ENERGY—energy produced largely in the form of heat during nuclear reactions, which, with conventional generating equipment can be transfered into electric energy.

NUCLEAR POWER—power released from the heat of nuclear reactions, which is converted to electric power by a turbine-generator unit.

OUTAGE—the period in which a generating unit, transmission line, or other facility, is out of service.

(IN) PARALLEL—several units whose AC frequencies are exactly equal, operating in synchronism as part of the same electric system.

PEAKING CAPACITY—that part of a system's capacity which is operated during the hours of highest power demand.

PEAK LOAD—the maximum load in a stated period of time.

PLANT FACTOR—ratio of the average load to the installed capacity of the plant, expressed as an annual percentage.

PONDAGE—the amount of water stored behind a hydroelectric dam of relatively small storage capacity used for daily or weekly regulation of the flow of a river.

POWER (ELECTRIC)—the rate of generation or use of electric energy, usually measured in kilowatts.

POWER FACTOR—the percentage ratio of the amount of power, measured in kilowatts, used by a consuming electric facility to the apparent power measured in kilovolt-amperes.

POWER POOL—two or more electric systems which are interconnected and coordinated to a greater or lesser degree to supply, in the most economical manner, electric power for their combined loads.

PREFERENCE CUSTOMERS—publicly-owned systems and nonprofit cooperatives which by law have preference over investor-owned systems for the purchase of power from Federal projects.

PROJECT SPONSOR—the entity controlling the small hydro site and promoting construction of the facility.

PUMPED STORAGE—an arrangement whereby electric power is generated during peak load periods by using water previously pumped into a storage reservoir during off-peak periods.

RATE OF RETURN ON INVESTMENT—the interest rate at which the present worth of annual benefits equals the present worth of annual costs.

RECONNAISSANCE STUDY—a preliminary feasibility study designed to ascertain whether a feasibility study is warranted.

SECONDARY ENERGY—all hydroelectric energy other than FIRM ENERGY.

SERVICE OUTAGE—the shut-down of a generating unit, transmission line or other facility for inspection, maintenance, or repair.

SMALL HYDROPOWER—hydropower installations that are 15,000 KW (15 MW) or less in capacity.

SPINNING RESERVE—generating units operating at no load or at partial load with excess capacity readily available to support additional load.

STEAM-ELECTRIC PLANT—a plant in which the prime movers (turbines) connected to the generators are driven by steam.

SURPLUS POWER—generating capacity which is not needed on the system at the time it is available.

SYSTEM, ELECTRIC—the physically connected generation, transmission, distribution, and other facilities operated as an integral unit under one control, management or operating supervision.

THERMAL PLANT—a generating plant which uses heat to produce electricity. Such plants may burn coal, gas, oil, or use nuclear energy to produce thermal energy.

THERMAL POLLUTION—rise in temperature of water such as that resulting from heat released by a thermal plant to the cooling water when the effects on other uses of the water are detrimental.

TRANSFORMER—an electromagnetic device for changing the voltage of alternating current electricity.

TRANSMISSION—the act or process of transporting electric energy in bulk.

TURBINE—the part of a generating unit which is spun by the force of water or steam to drive an electric generator. The turbine usually consists of a series of curved vanes or blades on a central spindle.

TURBINE-GENERATOR—a rotary-type unit consisting of a turbine and an electric generator. (See TURBINE & GENERATOR)

VERTICALLY INTEGRATED SYSTEM—refers to power systems which combine generation, transmission, and distribution functions.

VOLTAGE OF A CIRCUIT—the electric potential difference between conductors or conductors to ground, usually expressed in volts or kilovolts.

WATT—the rate of energy transfer equivalent to one ampere under a pressure of one volt at unity power factor.

WHEELING—transportation of electricity by a utility over its lines for another utility; also includes the receipt from and delivery to another system of like amounts but not necessarily the same energy.

A BRIEF CHRONOLOGY - COBSCOOK BAY TIDAL POWER STUDY

March 1975	Senator Muskie's resolution to reevaluate Passamaquoddy with latest technology.
September 1976	Governor Longly requested that we study Passamaquoddy using life cycle analysis.
November 1976	Preliminary economic feasibility study-Passamaquoddy.
April 1977	Revised preliminary economic report on Passamaquoddy including life cycle analysis and a look at some all American Projects.
July 1977	OCE provided guidance on life cycle analysis and directed us to look at relative price shifts, only not taking into account general inflation.
September 1977	OCE authorized us to prepare the POS and proceed with caution, carefully evaluating economics along the way.
May 1978	Canadians decided not to participate in the study.
July 1978	Initial public meetings on Cobscook study.
September 1978	Draft Plan of Study.
December 1978	Preliminary designs; transmission BPA; powerhouse S&W.
March 1979	Final Plan of Study.
March 1979	Preliminary Economic Report (13 alternatives).
June 1979	Directive from OCE to prepare a more complete reconnaissance report addressing marketing, power integration, and environment.
August 1979	Public release of Preliminary Report and announcement of findings after briefing Senator Muskie.
November 1979	Economic Conference on Relative Price Shift Analysis - Utilities and Academics of Maine, concurred with reservations on the method.

November 1979	Water Resources Council's Principles and Standards were revised and now include relative price shift economic analysis for power projects.
August 1980	Reconnaissance Report.

ABRIDGED

CORRESPONDENCE APPENDIX

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDPL-H   20 April 1979

SUBJECT: Memorandum for the Record - Interim Checkpoint Meeting held in OCE on 11 April 1979 on Cobscook Bay Tidal Power - Economic Analysis

TO: HQDA (DAEN-CWP-E)
WASH DC 20314

1. On 11 April 1979 a Checkpoint meeting was held in the Office of the Chief of Engineers for the purpose of examining the status of the Cobscook Bay Tidal Power Project. In attendance were the following:

	NAME	ORGANIZATION
(1)	James E. Callahan	NEDPL-H
(2)	Harmon H. Guptill	NEDPL-H
(3)	Stephen Rubin	NEDPL-E
(4)	Robert C. LeBlanc	NEDPL-H
(5)	Kevin M. McMahon	NEDPL-E
(6)	Joseph L. Ignazio	NEDPL
(7)	Don Barnes	DAEN-CWP-E
(8)	Gene Lawhun (part-time only)	DAEN-CWR-L
(9)	William Knight	DAEN-CWP-P
(10)	Ed Cohn	DAEN-CWP-P
(11)	Russ Rangos	DAEN-CWP-E
(12)	Paul Walker	DAEN-ASH
(13)	George Antle	IWR

2. The attached agenda was generally utilized during the meeting.

3. Mr. Ignazio opened the meeting with a brief background of how we have evolved to the current status on the Cobscook Bay Study, making reference particularly to the OCE endorsement of 28 September 1977 which concurred with NED proceeding with a Plan of Study and investigation of "Life Cycle Costing" for the subject project. Directions were further elaborated on 8 May 1978 from the Chief's Office at which time we were directed to proceed to a "Relative Price Shift Analysis" thereby stripping effects of general inflation from the analysis. Final point of reference concerned the 24 January 1979 letter from the Chief's Office. It was inspired by a "Relative Price Shift" Analysis accomplished for Dickey-Lincoln but included comments regarding the Passamaquoddy Tidal Power Project. Specifically, Mr. Ignazio questioned the intent of Paragraph 4 of the 24 January 1979 letter, which we interpreted as a lack of acceptance of the above "relative price shift" analysis methodology as a means for project economic justification.

In response to this, Mr. Cohn stated that at the time that letter was written Paragraph 4 was motivated by the fact that they had not seen a credible Relative Price Shift Analysis for the tidal project. Inasmuch as copies of our Economic Report of March 1979 were made available prior to and at this meeting, it was Mr. Cohn's opinion that the analysis as submitted removes their concern.

4. Major points of discussion at the meeting which will be important for future decisions on the study were as follows:

(a) Mr. Cohn, OCE: The Economic Analysis Report is credible and acceptable. However, Mr. Cohn believes that the 3% rate of escalation is more realistic and should be selected as a base condition. He suggests further that 1% and 5% cases be carried in the sensitivity analysis section of the report. Mr. Cohn felt the report should be distributed as it provides an excellent procedure and could be useful to IWR or Water Resources Council in reviewing other types of projects using this analysis.

(b) Mr. George Antle, IWR: Mr. Antle felt that the cost of the tidal power project on a per installed kilowatt basis was high, as well as the cost of the electricity produced. Mr. Antle believes we should not look to economics or economic theory to be the savior of this project. Albeit the project is marginal as relates to economic justification. Mr. Antle suggested that we utilize net benefit figures in the sensitivity analysis as this would be less confusing to decision makers than a series of BCR's.

(c) Mr. Antle suggested we evaluate the project with different interest rates. Lower interest rates would likely provide more attractive BCR as would higher plant factor, and the addition of capacity credits. Mr. Antle and Mr. Knight stressed the need to perform marketing analysis to determine how the financial repayment would be made and also whether people in Maine or New England were willing to pay more for tidal power than they are now paying for alternative systems. Mr. Antle referenced the contract now being negotiated by IWR relative to Price Shift Analysis in conjunction with the Section 167 National Hydropower Study. The New England Division could make use of information generated as it would provide us a more in-depth fuel cost projection and improve our analysis. It is our understanding that the contract will be concluded in 6 months.

(d) Mr. Cohn questioned whether the alternative which the Federal Energy Regulatory Commission has supplied are in fact realistic possibilities for the future, or for that matter realistic in view of today's events. In other words, will the President's energy policy, or other forthcoming potential regulations affect a decision makers choice to proceed or not proceed with the Tidal Power Study?

5. As regards the furtherance of this study, work accomplished to date has dealt largely on economic issues with up-dating of engineering costs, adjusted to a so-called "United States Only Plan" within the State of Maine. We have yet to get answers on environmental issues if there are any. Further, marketing studies have not been accomplished. However, Bonneville Power Administration is under contract and dealing with transmission routes and commitments with U. S. Fish and Wildlife Services and National Marine Fisheries Service to develop environmental baseline data are underway.

6. Concensus revealed 3 options available as relates to future study efforts and are as follows:

(1) Submit the present findings as a "negative" Stage I Report. Recommend closing out of the study authorization. Such a course would utilize remaining 1979 funds, and some 1980 monies if necessary.

(2) Submit the findings and recommend study be placed in an inactive, or deferred status. This would leave the study authorization open in the event that it was desired to resume it at a later date. Should the study not get funding over the next 5 year period, it would become a candidate for deauthorization. This scenario would utilize 1979 funds and some 1980 monies.

(3) Continue study, complete a Survey Report and EIS targeted for March 1982. Utilize total study funds of $3,280,000 of which about $1,104,000 have been received through Fiscal 79. This would assure a complete investigation of economic, engineering, environmental, social, and marketing of power and settle the merits of moving forward with the project.

7. Conclusions as reached of the meeting are as follows:

(1) There is need to meet with the Department of Energy officials to ascertain their attitudes concerning plant factors, and capacity credits. Further, if the Corps were to conclude its study efforts as noted in Options 1 and 2, this project may be better in the hands of DOE as their energy program may offer variances to permit project authorization. Certainly they ought to be given the opportunity to pick-up the study if they so desire and with concurrence from Congressional sponsors.

(2) In the event that it is decided to close-out the project, we will need visits to Congressional sponsors to outline status and reasons as well as alternative actions if any.

(3) If the study were to continue, it should perhaps be done for reasons other than economic justification. Therefore, it would be well to get opinions from electrical industry leaders and consultants in energy field. Consultants for DOE have already indicated their support of this tidal type project on a "Life Cycle Analysis" basis.

(4) It is planned to inform Senator Muskie of our current findings and obtain his view prior to a broader distribution of our "relative price shift analysis" report, and seek his views as regards future study actions.

8. Please be advised that the Division Engineer recommends continuation of the study, namely use of Option 3 under paragraph 6. Your comments on the above MFR are requested.

FOR THE DIVISION ENGINEER:

1 Incl
Agenda

Joseph L. Ignazio
JOSEPH L. IGNAZIO
Chief, Planning Division

CF:
DAEN-CWP-E (Mr. Rangos)
DAEN-CWP-P (Mr. Cohn/Mr. Knight)
DAEN-CWP-L (Mr. Lawhun)
Institute for Water Resources (Mr. Antle)

DAEN-CWP-E (20 Apr 79) 1st Ind
SUBJECT: Checkpoint Meeting Held in OCE on 11 April 1979 on Cobscook Bay Tidal Power - Economic Analysis

DA, Office of the Chief of Engineers, Washington, D.C. 20314 14 JUN 1979

TO: Division Engineer, New England

1. After review of the subject MFR, we have concluded that this study should proceed under Option 1.

2. Studies to date indicate that the project will not produce net benefits over costs for the life of the project, even using the relative price shift analysis. We cannot recommend projects for implementation where there are negative net benefits.

3. To date, approximately $800,000 have been expended on this study; it would be difficult to justify expending another $2,500,000 for further investigations for an uneconomic project.

4. We are concerned about the apparent lack of effort in identifying and assessing the environmental impacts of this project. This aspect has received very little attention, and we feel the potential for major adverse impacts is great.

5. More attention should be paid to integrating the power from Cobscook Bay into the power grid. Power can only be generated during relatively short periods of time, and even then the generating time will be out of phase with peak requirements most of the time. Consideration needs to be given to the use of off-peak power being generated from Cobscook Bay.

6. In view of the above, further work on the study is to be directed toward completing and submitting a negative Reconnaissance Report for transmittal to Congress in the shortest practicable time. Effort will concentrate on impact assessment and marketing of power. This effort will be of a reconnaissance level scope of detail.

7. As the FY 1980 appropriations process is still underway, you should determine your anticipated needs for this Fiscal Year and next. In line with this, we are requesting that you submit a schedule for completing the study and a breakdown of funding requirements for the remainder of the work.

FOR THE CHIEF OF ENGINEERS:

wd all incl

HUGH G. ROBINSON
Brigadier General, USA
Deputy Director of Civil Works

STATE OF MAINE
OFFICE OF THE GOVERNOR
AUGUSTA, MAINE
04333

JOSEPH E. BRENNAN
GOVERNOR

November 21, 1979

Col. Max B. Scheider
Division Engineer
Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Scheider:

The purpose of this letter is to comment upon the Army Corps' most recent analysis regarding the Cobscook Bay Tidal Project.

I have asked the Maine Office of Energy Resources and the Maine State Planning Office to review and analyze your "Preliminary Report on the Economic Analysis of the Project", along with previous studies of the Cobscook Bay Tidal project, the "Draft Plan of Study" of September 1978, and other aspects of proposed tidal power development in Passamaquoddy and Cobscook Bays in Maine. In addition, we have reviewed the independent analysis of the project report by Dr. Normand Leberge, Director of the Half-Moon Cove Tidal Power Project for the Pleasant Point Reservation of the Passamaquoddy Tribe. Based upon our analysis I would like to offer the following comments:

First, I believe that more value should be placed on an energy source that is not dependent on non-renewable fuels and that the relative "inflation proofing" that construction of a tidal project would provide should be stressed in any comparative economic analysis. While this "relative price shift" analysis is a step in the right direction and an improvement over conventional static economic analysis, I do not believe that the technique has been carried far enough.

Secondly, I am a little puzzled by the statement in your letter that further economic analysis in July, following the (then) most recent escalation in the cost of oil by OPEC nations, "did not increase the net benefits sufficiently for economic justification." Reference to page iii of the executive summary of the preliminary report indicates a substantial improvement in the benefit cost ratio to nearly 1 at the 3% differential fuel escalation rate, and to about 1.25 at the 5% differential fuel escalation rate for the five alternative proposals listed. It is my understanding that the Army Corps of Engineers has no authority under existing standards and guidelines to evaluate projects, or to recommend continued study, at these differential fuel escalation rates. In this regard, it is interesting to note that many responsible Federal officials, including the U.S. Department of Energy, are forecasting fuel costs to rise at 4-5% above the general rate of inflation through 1990.

I am concerned that your preliminary economic analysis to date has, apparently, merely considered the energy benefits of the project without regard for socio-economic benefits, mariculture opportunities, technology demonstration benefits, and a host of other benefits that would be derived from this project. Such narrow consideration of project benefits seems to run counter to other projects that your division has studies, and to Federal guidelines in this area.

Finally, I am concerned that your analysis limited the "life-cycle" effects to relative price shifts of petroleum fuels, whereas true life-cycle costing would consider such other effects as the cost of replacement structures (35-40 year life for fossil plant equipment vs. 100+year life for tidal or hydro plants).

In summary, I find numerous areas in your analysis in which we are in disagreement, and I would appreciate an opportunity to pursue this further.

I have asked John Joseph of the Maine Office of Energy Resources (OER) to contact your agency to review these points in greater detail.

I understand the Army Corps is working with the OER and the Center for Balanced Growth to arrange a meeting to discuss a number of these concerns. I hope that meeting proves productive in terms of improving the long term energy planning process.

I look forward to working with you on this and various other matters of interest to the State of Maine.

Sincerely,

Joseph E. Brennan

JOSEPH E. BRENNAN
Governor

JEB/sc

CC: Allen Pease, State Planning Office
John Joseph, Office of Energy Resources
Don Larrabee, Maine Office of the Governor - Washington, D.C.
Maine Congressional Delegation

Department of Energy
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

In reply refer to: EOFD

Mr. Robert LeBlanc, Study Manager
Cobscook Bay Tidal Power Study
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Bob:

In response to your request, attached is a table of investment and annual cost estimates for the transmission facilities needed to integrate 200 MW of tidal power generation from Cobscook Bay into the New England transmission grid. The interest rate used in developing the annual costs and IDC is 7-1/8%. O&M costs are based on actual O&M costs for similar facilities on the BPA system.

For a generating capacity of 200 MW, the integrating transmission will most likely be either 230-kV or 345-kV. The investment cost of a 345-kV system is comparable to that of a 230-kV system. The 230-kV alternative has lower line costs but greater substation costs. Since transmission losses will be lower for 345-kV, we have assumed a 345-kV system in developing the cost estimates. Peak losses are in the order of 1.5% for a 345-kV system and 4.0% for a 230-kV system.

A 345-kV system will also have the advantage of not introducing a new voltage level into the area (115-kV and 345-kV being the existing voltage levels). A sketch of the integrating transmission system is attached. The system includes a 69-kV line from the project to Calais.

We have not included any facilities for transformation at Epping because it is not certain that the cost of these facilities should be part of the project cost. Also the need for such facilities has not been thoroughly investigated. However, the addition of a 345/115-kV transformer bank at Epping will improve the reliability of service to that area.

We hope the information we are providing will satisfy your needs. Let us know if you have any questions concerning these cost estimates.

Sincerely,

R. B. Poon

R. B. Poon
Electrical Engineer

Enclosure (2)

Cobscook Bay Tidal Power Project

Cost Estimates - Transmission Facilities
(7 1/8% Interest Rate)

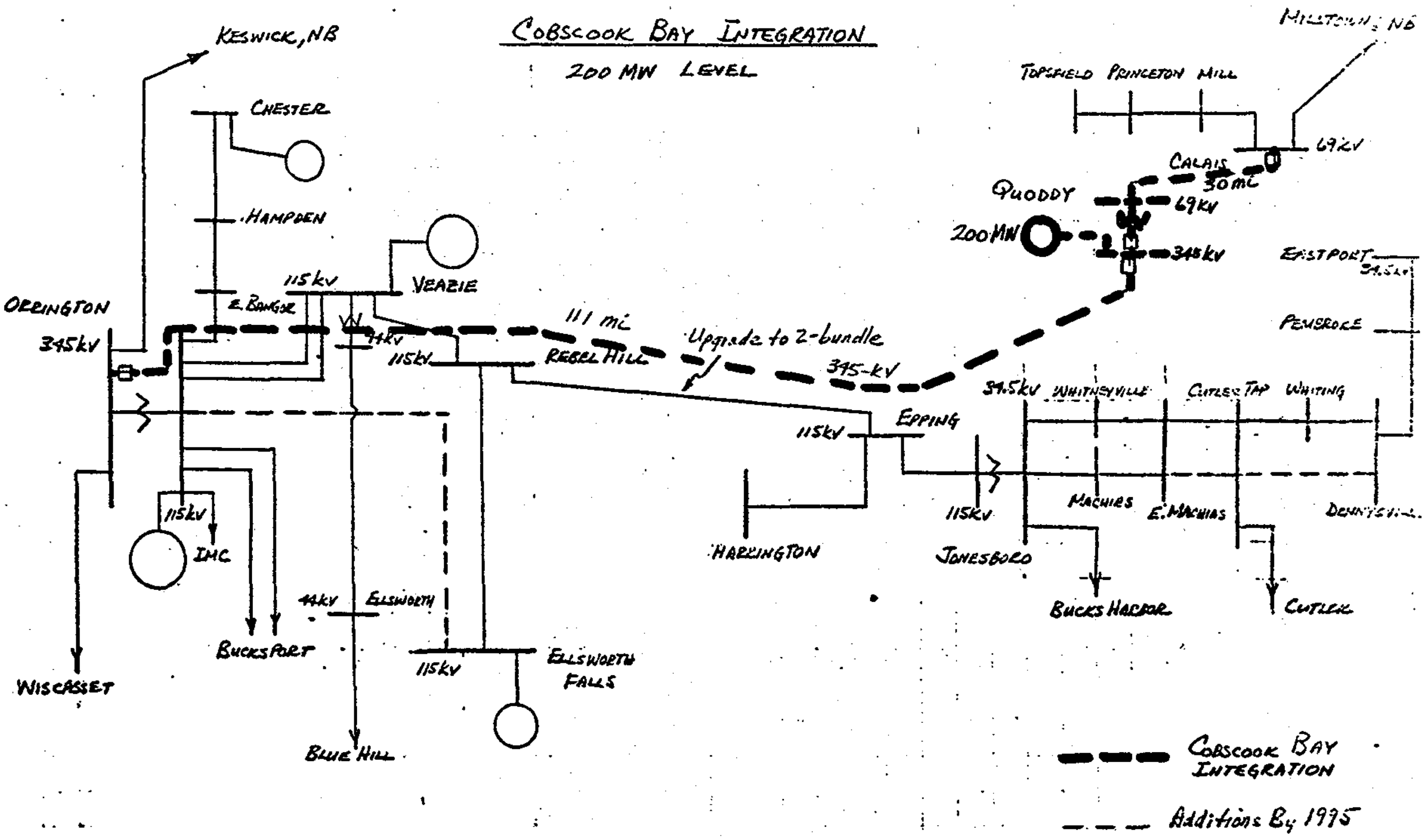
	Investment ($000)			Annual Cost ($000)		
	Construction	IDC	Total	I&A	O&M	Total
Lines						
Quoddy- Orrington 345-kV WHF (111 miles)	20,000	3,340	23,340	1,790	200	1,990
Quoddy-Calais 69-kV WHF (30 miles)	4,000	670	4,670	360	40	400
Subtotal	24,000	4,010	28,010	2,150	240	2,390
Substation Facilities						
Quoddy - 345/69 kV Transformer	3,100	520	3,620	300	40	340
2-345-kV PCB's	1,500	250	1,750	150	50	200
Calais - 69-kV PCB	150	30	180	20	10	30
Orrington - 2-345-kV PCB's	1,500	250	1,750	150	50	200
Subtotal	6,250	1,050	7,300	620	150	770
Power System Control	1,000	170	1,170	110	50	160
Total	31,250	5,230	36,480	2,880	440	3,320

Note:

Service Life: Lines (WHF) 38 yrs
Substation 28 yrs
PSC 20 yrs

IDC @ 7 1/8% interest: 16.7% of construction cost

Bonneville Power Administration
Branch of System Engineering
March 4, 1980



BANGOR HYDRO-ELECTRIC SYSTEM TO EASTPORT

RBP
3-5-80

STATE OF MAINE
OFFICE OF THE GOVERNOR
AUGUSTA, MAINE
04333

JOSEPH E. BRENNAN
GOVERNOR

March 5, 1980

Colonel Max B. Scheider
Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Col. Scheider:

I appreciated the briefing which you and your staff provided me on Monday, 21 January 1980, relating to energy projects for Maine which are currently under study by your Division.

I believe that Maine's future energy needs will be well served by continuation of St. John River Basin Study with emphasis on Masardis and Castle Hill hudro potential on the Aroostook River. In addition, I support a continuation of the tidal power study at Cobscook Bay. I believe that project economics of alternatives under consideration although marginal at this time, will in my view improve with the increasing costs of alternative fossil fuels. Further, the latest economic analysis as now permitted by recently issued Principles and Standards relating to "Relative Price Shifts" could well move the project into economic justification.

Regarding the important and significant Dickey-Lincoln project, I look with much interest upon the Corps completion of the mitigation planning which will finalize environmental evaluation and Environmental Impact Statement so that an objective decision can be made as to proceeding with construction of this important hydro project.

My thanks to you and your staff for your informative briefing, and be assured I will work with you to further these projects.

Sincerely,

Joseph E. Brennan

JOSEPH E. BRENNAN
Governor

JEB/sc

Department of Energy
Southeastern Power Administration
Elberton, Georgia 30635

March 31, 1980

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division
Corps of Engineers
Department of the Army
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

This responds to your letters of January 22, 1980, and February 8, 1980, File NEDPL-H, concerning the possibility of developing a tidal hydroelectric power facility in eastern Maine near Eastport at Cobscook Bay.

Utilizing the data furnished by these letters, the energy from the project would cost an average of approximately 94 mills per kwh excluding any marketing costs. No capacity values can be found for this project.

This estimated cost of 94 mills is almost two and one-half times the FERC estimated energy value of 38 mills per kwh based on August 1979 price levels and is approximately twice the anticipated energy value estimate of 49 mills per kwh based on December 1979 oil price levels.

In light of the above comparisons, it is evident that the project is not financially feasible under existing criteria and the preparation of operating and marketing studies would not be warranted.

If the price of alternative energy continues to increase or evaluation criteria is changed, we will be happy to cooperate with you in future studies.

Sincerely,

Harry F. Wright
Administrator

cc:
Emerson Harper

NEPLAN

New England Power Planning

174 BRUSH HILL AVENUE
WEST SPRINGFIELD, MASSACHUSETTS 01089
TELEPHONE (413) 785-5871

July 3, 1980

Max B. Scheider
Colonel, Corps of Engineers
Division Engineer
NED, Corp of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Colonel Scheider:

As requested in your letter of May 13, 1980 and in accordance with previous discussions held with Messrs. Guptill and LeBlanc of your office we are enclosing the following data for use in evaluating your tidal hydro project at Cobscook Bay.

Exhibit 1. Hourly loads and actual non oil-fired dispatch of pool generation for the winter peak load day of Dec. 19, 1979.

Exhibit 2. Hourly loads and actual non oil-fired dispatch of pool generation for the summer peak load day of Aug. 2, 1979.

Exhibit 3. Hourly loads and actual non oil-fired dispatch of pool generation for typical Spring and Fall days of 1979, viz, April 18th & Oct. 10th.

Exhibit 4. Generation plant data showing unit type, dispatch priority, average full load cost in $/MWH (parameters are: fuel cost, unit heat rate, and transmission penalty factors to the New England Center).

Exhibit 5. Forecasted 1995 hourly loads for the winter, summer, spring, and fall for the peak day and for a typical weekday.

Exhibit 6. Anticipated 1995 winter thermal priority list of Nuclear & Coal fired generation.

With respect to additions to the generating system through January 1996, we suggest you refer to the "New England Load and

Capacity Report, 1980-1995" copies of which were furnished to your personnel at our office recently. Please use only the authorized units as noted on page 55, Appendix B. Exhibit #6 indicates the addition of the 4-1150 nuclear units and the Sears Island coal unit.

With respect to the fuel costs, those shown on the enclosed exhibits are current 1980 costs. Forecasting of costs to 1995 is left to your own methods and trending procedures.

In regards to scheduled maintenance for your 1995 energy replacement study, we suggest you assume the average availability rates indicated on Exhibits 4 & 6 for determining the amount of thermal capacity required to meet the load for all periods of the year. We anticipate, with adequate funding and favorable EPA decisions, that several more existing units will be burning coal by 1995. These units are shown on Exhibit 6 with the appropriate availability rates. Those units still burning oil in 1995 should follow the coal units in the thermal priority list maintaining the same relative priority ranking they have to each other on Exhibit 4.

With respect to the output from the proposed tidal project, we concur that the capacity could not be considered dependable because of the inability to time the output with the daily load demands.

We anticipate no problems in integrating the energy from the proposed tidal project into the total New England load. However, studies would have to be made with respect to details of the specific electrical intertie and the operational impact on the local utility's system.

As discussed with Mr. LeBlanc, by Mr. Ferreira on July 2, our office will be available for clarification and response to questions on the enclosed data and for further detail with respect to your study.

Sincerely,

Art Barstow

Arthur W. Barstow
Manager, Generation Planning

AF/AWB/jel
enc.
c.c. NEPOOL Planning Committee (letter only)
A. Ferreira

FEDERAL ENERGY REGULATORY COMMISSION
NEW YORK REGIONAL OFFICE
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

August 29, 1980

Colonel Max B. Scheider
Division Engineer
Corps of Engineers
Department of the Army
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Coloner Scheider:

In accordance with your letter of December 4, 1979 and your subsequent submittal of May 8, 1980, we have calculated at-market power values for the Cobscook Bay Tidal Power Project. The power values are calculated for the 38.7 percent capacity factor Birch configuration only. The same power values apply to the 38.6 percent capacity factor Goose configuration. This is in accordance with a May 1, 1980 telephone conversation between Mr. F. Craig Zingman of this office and Mr. Robert Le Blanc of your office.

The Cobscook Bay Project has been analyzed on a life cycle cost basis for the one hundred year period beginning with the expected project on line date of 1995. We note that the electrical output of the two single pool projects is controlled by the tide and electrical power is available at approximately 13-hour intervals, for relatively short periods, and at varying peak outputs. The availability of power from the project would concur with periods of peak utility demand only once every several days. For this reason, the capacity value (dollars per kilowatt-year) has been taken to be zero. The energy value represents the total value of Cobscook Bay and reflects the displacement value of energy from oil-fired generating units from 1995 through 2095.

The cost of the oil fuel displaced by the Cobscook Bay Project was escalated in accordance with the Department of Energy-Office of Conservation and Solar Energy tables which were published in the Federal Register on January 23, 1980. This DOE table is based upon constant dollars and the oil prices shown are escalated from 1980 through 2010 at a rate above the general rate of inflation. Ater that, fuel prices were assumed to increase along with the general rate of inflation, i.e., no increase using the constant dollar method (see the attached Figure 1). All displaced energy costs were discounted to the year 1995, using the federal interest rate of 7-1/8 percent and the private interest rate of 11.5 percent. These discounted costs were summed and then multiplied by the one hundred year capital recovery factor appropriate to each interest rate. The power values are shown below:

Cobscook Bay Power Values

	Capacity Value ($/kW-Yr)	Energy Value (Mills/kW hr.)
Federal Cost of Money 7-1/8%	0	108
Private Cost of Money 11-1/2%	0	104

It should be noted that, since these power values were calculated on the constant dollar basis, they are comparable to project construction cost estimates calculated on the same basis for the 1980 through 1995 period.

Should you have any questions concerning these power values or our method of calculations, please call Mr. F. Craig Zingman on FTS - 264-1163.

Sincerely,

Martin Inwald
Acting Regional Engineer

Enclosure
as stated

FIGURE 1

DISCOUNTING METHODOLOGY
REAL FUEL ESCALATION