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COMMITTEE PRINT

PASSAMAQUODDY—ST. JOHN

APPENDIX MATERIAL

COMPILED IN CONJUNCTION WITH THE

HEARING ON

S. 2573

A BILL TO AUTHORIZE THE INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT, INCLUDING HYDROELECTRIC POWER DEVELOPMENT OF THE UPPER ST. JOHN RIVER, AND FOR OTHER PURPOSES

FOR THE

COMMITTEE ON PUBLIC WORKS
UNITED STATES SENATE

AUGUST 12, 1964

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LETTER OF TRANSMITTAL

U.S. SENATE,
COMMITTEE ON PUBLIC WORKS,
August 31, 1964.

Hon. PAT MCNAMARA,
Chairman, Committee on Public Works,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is material compiled as an appendix to the Passamaquoddy hearings, held on August 12, 1964.

This material is compiled in this separate volume because it is the reference documents which preceded the report from the Department of the Interior, upon which the hearing on the Passamaquoddy project was held. In presiding over the hearings in your behalf and at your request, I have reviewed the material and believe it is of such value to the committee members that it should be printed in a separate volume.

Sincerely yours,

EDMUND S. MUSKIE, *U.S. Senator.*

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PASSAMAQUODDY—ST. JOHN

SUMMARY OF EXHIBITS

All available reference material relating to the Passamaquoddy project which was published prior to the August 12, 1964, hearing by the Senate Public Works Committee has been made a part of the committee's document files. With the exception of the 12-volume International Joint Commission Report of 1961, all of this reference material issued by Federal agencies is reproduced in this appendix to the Passamaquoddy-St. Johns hearings.

The full International Joint Commission report with its appendixes is too voluminous to reproduce. However, a table of contents of that report is contained in this appendix on p. 177 and the documents are available for review at the committee's office.

This material is assembled and published here because all of it is mentioned during the course of the hearing on the Passamaquoddy project and will continue to be referred to in additional hearings.

In this appendix there is included material other than official reference documents which was referred to during the hearing and which will be of value in the study of the project.

The material herein is:

1. Brief chronological history of Passamaquoddy project.
2. Summary: July 1963 report, Passamaquoddy Study Committee.
3. Report: Secretary of the Interior to President John F. Kennedy, dated July 1963.
4. "Load and Resources Study, December 1961."
5. Report of the International Joint Commission, April 1961.
6. Letters from President Kennedy re Passamaquoddy project.
7. Progress reports on Passamaquoddy project.
8. Biographies of members of the Army-Interior Advisory Board and of Dr. Lorenz G. Straub and Dr. Arthur Casagrande.
9. Reprint of provisions of Senate Resolution 148, 85th Congress, and Senate Document 97, 87th Congress, re use and development of water resources.

BRIEF HISTORY OF THE PASSAMAQUODDY PROJECT

The ocean tides have long been envisioned as a source of power. "Tide mills" were constructed in Europe as early as the 11th century and in America as early as 1617. Such small tidal hydromechanical power developments were practical for grinding corn or spices as the work could be adjusted to the periodic and varying power from the tides. Electrification and the rapid industrial and economic growth of the 20th century, however, have established a heavy growth in demand for electric power, and today the economic utilization of power requires its availability on a controlled schedule. Utilization of the tides to generate a substantial quantity of power requires provision for the storage of large quantities of water so that discharges may be made from a higher to a lower elevation through hydraulic turbines. Passamaquoddy Bay located near the mouth of the Bay of Fundy experiences smaller tidal ranges than those occurring in the head of that bay in Canada. The large area of Passamaquoddy Bay with the substantial additional area of Cobscook Bay is favorable for a tidal power project.

From 1924 to 1934, Dexter P. Cooper, Inc., prepared plans originally for an international tidal power project at Passamaquoddy and Cobscook Bays, but later for a project located wholly in the United States. The project would have had an initial installation of 235,000 kilowatts with provision for an additional 100,000 kilowatts.

In 1927 Murray & Flood, engineers, of New York City, reported on the international project proposed by Cooper. They estimated that an installed capacity of 400,000 kilowatts with a firm capacity of 122,000 kilowatts could deliver 1,594 million kilowatt-hours annually to Woburn, Mass., at an average cost of 8.09 mills per kilowatt-hour. The total estimated cost of the project at 1926–27 price levels was $125 million.

In 1935, the Passamaquoddy Bay Tidal Project Commission of the U.S. Federal Emergency Administration of Public Works recommended construction of an initial Cobscook Bay project, all within the State of Maine, at an estimated cost of $30 million. The recommended initial project was approved by the U.S. Government and $10 million (later reduced to $7 million) was allotted to the U.S. Army Corps of Engineers to start construction. Work progressed until August 1936 with an expenditure of about $7 million, and was discontinued due to lack of further appropriations by the Congress.

In 1941, the Federal Power Commission concluded that Passamaquoddy tidal power (development of U.S. waters only) could not compete successfully at that time with river hydroelectric power potentially available in the State of Maine. The Commission stated, however, that this conclusion should not preclude thorough exploration of the possibilities of a large international tidal power project at Passamaquoddy by the Governments of the United States and Canada.

The International Joint Commission conducted investigations of the Passamaquoddy international tidal power project from 1948 to 1961.

In May 1961, Senator Edmund S. Muskie, of Maine, recommended to the President that the administration explore all unanswered questions in the report of the International Joint Commission and that serious attention be given to those suggestions made by the Commission which would affect a final determination on the feasibility of the project.

As a result, in May 1961, President Kennedy asked the Department of the Interior to review the International Joint Commission's report on the international Passamaquoddy tidal project and the upper St. John River hydroelectric power development, with the request that he be advised on changes in fuel, engineering, and financial costs which might result in making the project economically feasible.

On July 1, 1963, the Secretary of the Interior submitted his report to the President recommending early authorization of the project.

A supplementary report to the July 1, 1963, report was prepared by the Passamaquoddy-St. John River Study Committee and submitted to the Secretary of the Interior on August 3, 1964. That report has been published in the August 12, 1964, hearings on S. 2573.

SUMMARY REPORT TO PRESIDENT JOHN F. KENNEDY OF THE PASSAMAQUODDY STUDY COMMITTEE OF THE DEPARTMENT OF THE INTERIOR ON THE INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT AND UPPER ST. JOHN RIVER HYDROELECTRIC POWER DEVELOPMENT

LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., July 1, 1963.

THE PRESIDENT,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT: This in my reply to your letter of May 20, 1961, asking this Department to review the International Joint Commission's report on the international Passamaquoddy tidal project and the upper St. John River hydroelectric power development.

You requested that I advise you concerning the changes in fuel, engineering, and financial costs which might result in making the project economically feasible. After exhaustive review and study made in close collaboration with the U.S. Army Corps of Engineers, utilizing information on load and resource data furnished by the Federal Power Commission, and the technical know-how available from the bureaus within this Department, I am transmitting to you the report of our findings. I am also transmitting the report of the Secretary of the Army and the accompanying review by the Chief of Engineers commenting on the International Joint Commission report which have been full coordinated with this Department.

I have determined that the development of the Passamaquoddy tidal project and the upper St. John River is both desirable and economically feasible. The plan envisions a tidal power development at Passamaquoddy Bay and a hydroelectric powerplant on the upper St. John River which would provide 1,250,000 kilowatts of dependable capacity, of which 1 million kilowatts would be peaking capacity and 250,000 kilowatts of capacity which would meet the local area loads. You will be pleased to note that this proposed plan will preserve in its entirety the free-flowing nature of the Allagash River and its superb recreational values.

The Department's proposal is feasible from an engineering and economic viewpoint. The benefit-cost ratio is 1.27 to 1 based on current U.S. project feasibility standards and using an interest rate of 2⅞ percent with power repayment within 50 years after each unit becomes revenue producing.

We recognize that suitable arrangements will have to be made with the Canadian Government for the United States to construct the Passamaquoddy tidal project and to work out an equitable sharing of the downstream benefits from power development of the St. John River in Canada.

In view of the extensive previous studies made on this project dating back to 1922 and the opportunity which still exists for additional engineering work in advance of construction, I recommend that this report be used as the basis for early authorization of the

international Passamaquoddy tidal power project and the storage and hydroelectric development on the upper St. John River by the U.S. Army Corps of Engineers and the marketing of the power by the Department of the Interior.

I also recommend that you request the Secretary of State to immediately initiate negotiations with the Government of Canada, looking toward a satisfactory arrangement for the sharing of the power and flood control benefits of the St. John River in Canada and the development of the Passamaquoddy tidal power project by the United States.

Respectfully yours,

STEWART L. UDALL,
Secretary of the Interior.

LETTER OF SUBMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., July 1, 1963.

MEMORANDUM

To: Secretary of the Interior.
From: Passamaquoddy-St. John River Study Committee.
Subject: The international Passamaquoddy tidal power project and the upper St. John River hydroelectric power development.

We herewith submit our final report on the international Passamaquoddy tidal power project and upper St. John River hydroelectric power development in accordance with your direction.

This report has been prepared under the general supervision of Assistant Secretary Kenneth Holum, Water and Power Development, and under the personal supervision of Under Secretary James K. Carr. This work has been done in response to the President's request of May 20, 1961, in which the Department of the Interior was asked to review the International Joint Commission report and to advise the President as to what changes in fuel, engineering, and financing costs might result in making the project economically feasible. It was also requested that the President be advised as to the hydroelectric power development on the upper St. John River and other matters relating to the International Joint Commission report:

MORGAN D. DUBROW,
Chairman:
KNOLAND J. PLUCKNETT,
CHARLES W. LEAVY,
MARK ABELSON,
J. KARL LEE,
JOSEPH E. GUIDRY,
Project Engineer.

SUMMARY REPORT

The time is at hand for America to fulfill man's centuries-old dream of harnessing the energy of the tides.

The place is Passamaquoddy Bay on the United States-Canadian border between Maine and New Brunswick.

The primary result will be 1 million kilowatts of dependable and needed peaking capacity for the region and, combined with hydroelectric development of the upper St. John River, 250,000 kilowatts of dependable load factor firm energy for use primarily in Maine, both at a cost substantially below the cost of alternative sources of power. The construction activity and resultant low-cost power will breatly benefit the economy of Maine, other New England States, and the Maritime Provinces of Canada. The international Passamaquoddy tidal project will be a unique engineering undertaking and will certainly become a tourist magnet, contributing further to the economy of the area.

By direction of the President, we have made an exhaustive review and study of the report by the International Joint Commission on the international Passamaquoddy tidal power project and the upper St. John River. Our conclusion is that the tidal power project is economically and engineeringly feasible alone or in conjunction with development of the Dickey site on the upper St. John River for storage and power, and a reregulating dam at the Lincoln School site. The Dickey site would preserve for all time the recreational value and wilderness character of the Allagash River.

The Secretary of the Interior has recommended to the President that this report be used for the basis of early authorization of the tidal power project and the storage and hydroelectric development of the upper St. John River. The Secretary has recommended this as a U.S. project for construction by the U.S. Army Corps of Engineers and the marketing of the power by the Department of the Interior.

Because the tidal power project would involve construction on both sides of the boundary, satisfactory arrangements will have to be worked out with Canada, including a sharing of the power and flood control benefits. The Secretary of the Interior has recommended to the President that the Secretary of State immediately initiate negotiations with the Government of Canada.

Study highlights

Our study was made in close collaboration with the Army Corps of Engineers and utilized load and resource data provided by the Federal Power Commission and the New Brunswick Electric Power Commission. It shows that—

The tidal power project should be constructed to provide 1 million kilowatts of capacity.

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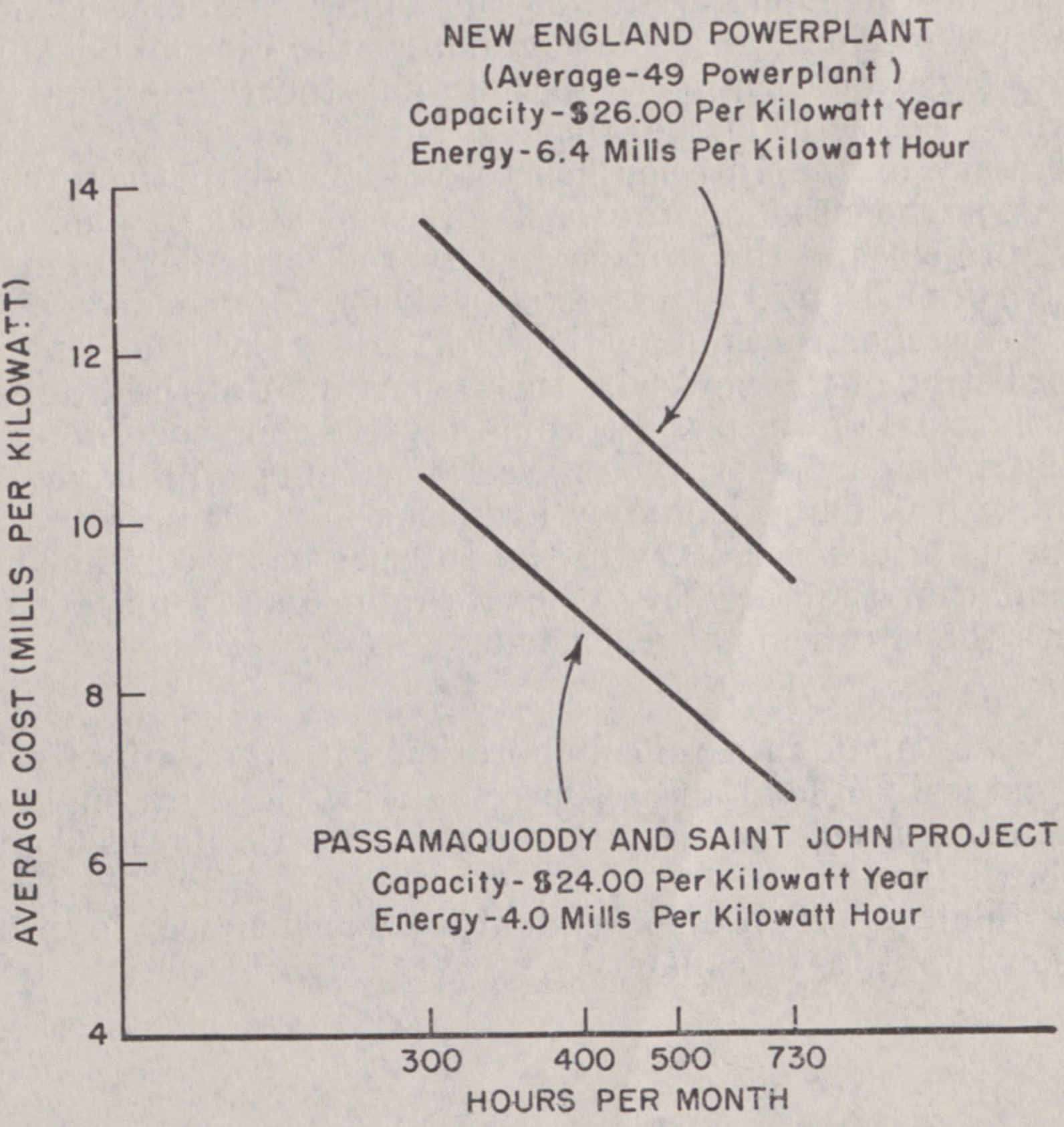
It is economically feasible to operate this project primarily to provide 1 million kilowatts of peaking power for only 1 hour per day, to meet the spiraling heavy 5 to 6 p.m. peakloads of the New England States and of the Maritime Provinces if they so desire.

A storage and hydroelectric project at the Dickey site on the upper St. John River, with a reregulating reservoir at the Lincoln School site, should be constructed and integrated with offpeak power from the tidal power project to provide 250,000 kilowatts of dependable load factor energy.

Two 345,000-volt transmission circuits should be built from Passamaquoddy to Boston, with a switching point at Bangor, Maine, for interconnecting with three 230,000-volt circuits from the Dickey powerplant to Bangor.

Construction could be accomplished in three stages for the sake of orderly development. The first would be construction of Dickey Dam and Reservoir with an initial installation of 150,000 kilowatts of capacity. The second, to be completed 5 years after completion of stage I, would be construction of Passamaquoddy tidal basin facilities and installation of 500,000 kilowatts of capacity, and an additional 300,000 kilowatts of capacity at Dickey. The third, to be accomplished 10 years

POWER COST AT PLANT
(No transmission)



after completion of stage II facilities, would complete 1 million kilowatts of installed capacity at Passamaquoddy and 750,000 kilowatts of installed capacity at Dickey. On this schedule because of the long construction period and leadtime, both Passamaquoddy and Dickey would have to be started at about the same time.

Total cost of full development is estimated at $1,025,446,000, including $76,040,000 interest during construction.

At 2⅞ percent interest, the total cost can be repaid from power revenues in 50 years after each power unit goes on the line.

The benefit-to-cost ratio for stage I is 2.55 to 1 and for full development, 1.27 to 1. Total annual costs for full development are $36,872,000 as against total project benefits of $46,849,000, of which $42,129,000 are power benefits, $2,065,000 recreation, and $2,655,000 area redevelopment.

Although we propose that the tidal power project and upper St. John River development be fully integrated, our economic analysis clearly indicates that either project is financially feasible and could stand on its own feet as a separate project.

Full development will require 14,116 man-years of employment for local labor and provide $80,360,000 in wages and salaries.

Both peaking power and load factor firm power can be produced for $24 per kilowatt of capacity and 4 mills per kilowatt-hour at site. This compares very favorably with the 1961 average of $26 and 6.36 mills for all powerplants, hydro and thermal, in New England.

A ready market awaits this new source of supply. Existing thermal and hydro capacity in the New England States, upper New York State, New Brunswick, and Nova Scotia totaled 13.3 million kilowatts in 1960. The FPC and New Brunswick Electric Power Commission estimate that the area's power requirements in 1980 will be 36 million kilowatts. To meet this load, 23 million kilowatts of new capacity will be required.

Further, because of the flexibility of hydro operations for peaking purposes, Passamaquoddy-Dickey power will fit in ideally with the relatively inflexible large thermal generating units (possibly in excess of 500,000 kilowatts) which will be installed to meet future baseload requirements in New England.

The Fish and Wildlife Service of this Department has reported that there will be no adverse effects on fish and wildlife from the Passamaquoddy tidal power project.

As a matter of fact, the development of an alternate source of low-cost power creates an opportunity to enhance the fisheries of New England by removal of existing small, inefficient hydro projects which now block the migration of anadromous fish.

While no dollar value was attributed to flood control and storage, the upper St. John will provide almost complete regulation of the river above Dickey and will provide flood control protection for the lower St. John River.

Storage on the upper St. John River will greatly increase the kilowatt output of downstream power dams on the St. John River on the Canadian side of the border.

The tides as an energy source

In contemplating the potential of Passamaquoddy, it is important to recognize that the tide is a perpetual energy source, fully predictable and dependable, and never in danger of drying up.

The level of the sea alternately rises and falls under the force of astronomic conditions dependent on the relative positions of the sun, earth, and moon. The height of the tide varies with these forces and the physical makeup of the coastline. The greatest rise and fall of the tides in the world occur in the head of the Bay of Fundy, on the Nova Scotia coast, where tides as high as 40 to 50 feet occur. Passamaquoddy Bay is a bay of about 110 square miles off the Bay of Fundy. Here tidal range varies from a maximum of 26 feet to a minimum of 12.7 feet, with an average tidal range of 18.1 feet. There are generally two complete tidal cycles, that is, two high tides and two low tides each day. This is the case in the Passamaquoddy Bay area.

For centuries, man has envisioned putting the rise and fall of the tides to work for him. As early as the 11th century, man developed tide mills in Europe, and such installations were built in America as early as 1617. They were used mainly for grinding corn or spices—work that could be adjusted to the periodic flow of the tides.

To produce electric energy from water requires water falling from a higher elevation to a lower elevation, and passing through turbines which spin generators. To utilize the tides for production of electric power and to assure having power when it is needed require storage to hold back large quantites of water at high tide for release through turbines at low tide. The job can be done with a single large pool regulated by floodgates, but in such event power can be produced only at those times in the tidal cycle when the difference between the elevation of the pool and the ocean is sufficient for operation of turbines. A combination of two storage pools, however, one to store incoming tidewaters at a high level and the other at low level with gates to keep the high tides out, can make possible some generation around the clock.

The Passamaquoddy tidal power project is a two-pool plan, with Passamaquoddy Bay trapping the incoming tidewaters and providing the high storage pool for water to be dropped through turbines into the low pool to be formed by the adjacent Cobscook Bay.

The only tidal development for electric power under full-scale construction today is the LaRance tidal project in France. The Russians are known to have plans for utilizing the tides to produce electric power also. Passamaquoddy represents the first and best chance for the United States to make a practical beginning in this new field of energy production.

History of Passamaquoddy

U.S. interest in developing the Passamaquoddy tidal power project dates back to 1919 when Dexter P. Cooper, an eminent American engineer, backed by private investment capital, first proposed a plan for harnessing the tides there.

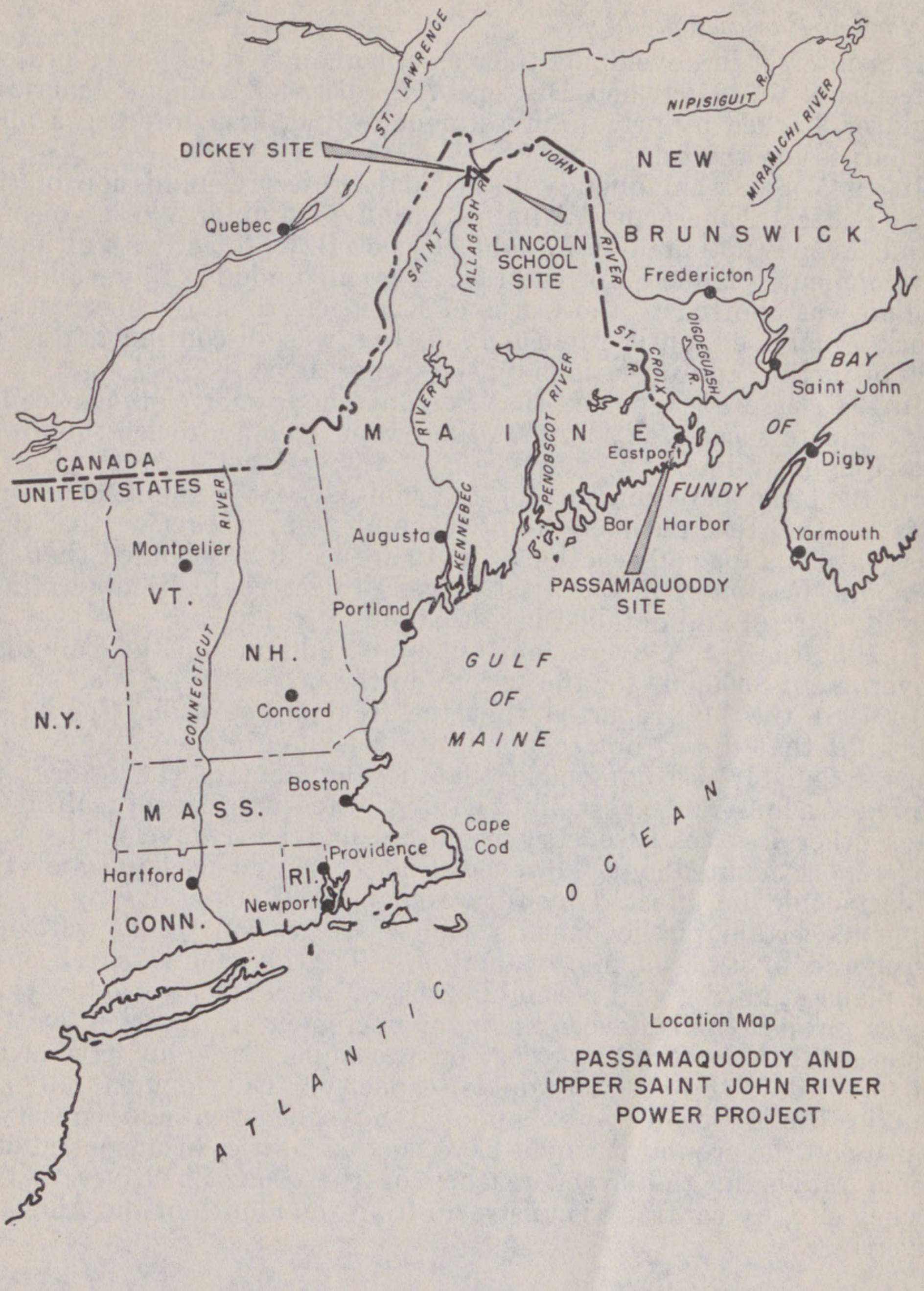
In 1935 a Passamaquoddy Bay Tidal Project Commission of the U.S. Federal Emergency Administration of Public Works recommended construction of an initial Cobscook Bay project with ultimate development planned to embrace Passamaquoddy Bay, and $7 million was allotted to the Corps of Engineers to start construction. Work progressed until August 1936, but was discontinued due to lack of further appropriations by the Congress.

In 1941 the FPC reported that Passamaquoddy development could not compete successfully at that time with river hydroelectric power available in Maine.

In 1948 the Governments of the United States and Canada requested the International Joint Commission to review the then existing plans for construction. In 1950 the IJC concluded that the economic feasibility of the tital power project could be determined only by careful and detailed investigations.

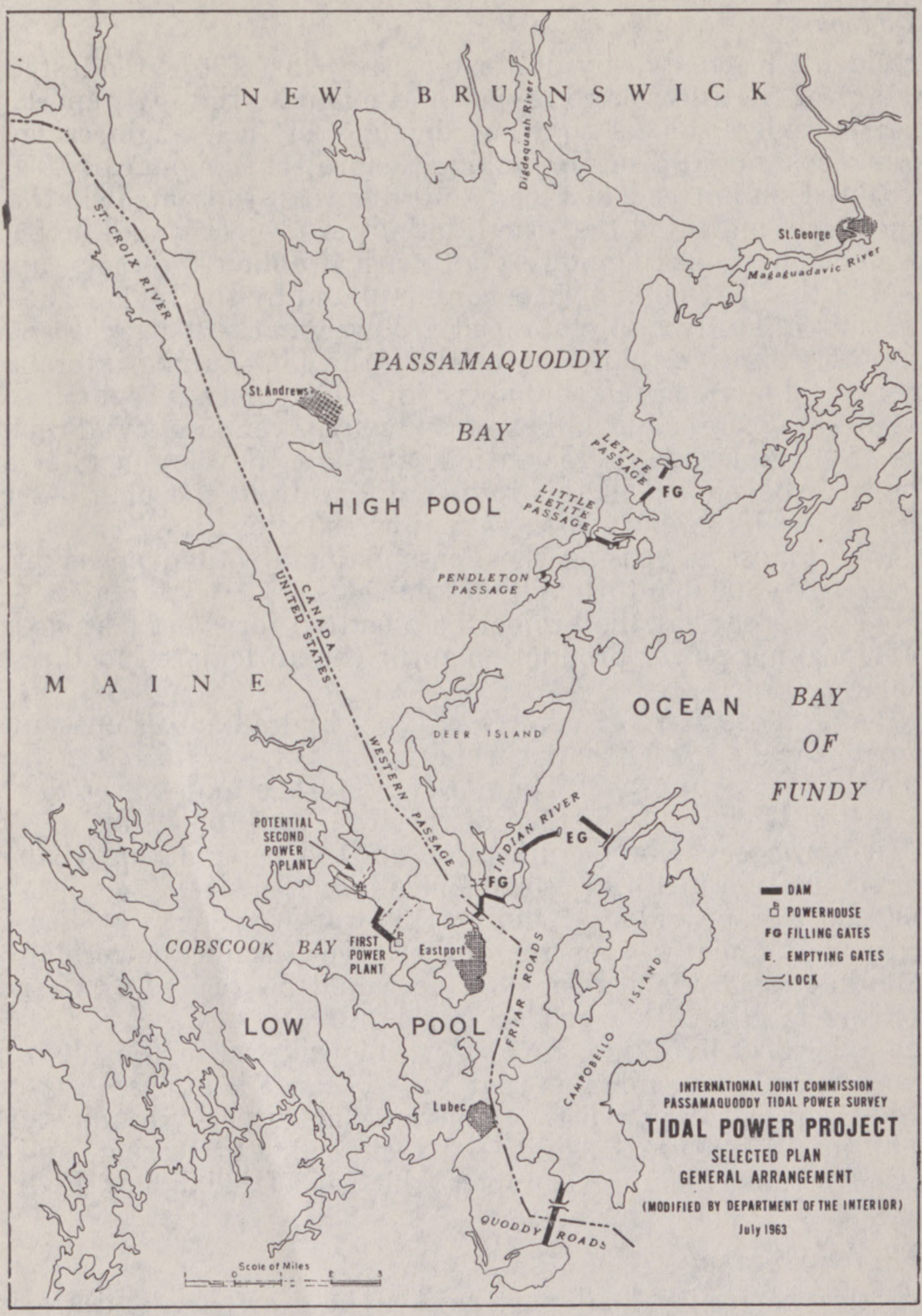
In 1956 the U.S. Government put up $3 million and the Canadian Government $300,000 for the IJC to do the necessary detailed study.

In 1961 the IJC reported that the tidal power project could be built but that it was not economically feasible under existing conditions. The IJC recommended that development of the project be viewed as a long-range possibility having better prospects of realization after other less costly energy resources had been developed. The IJC report pointed out, however, that economic feasibility of the project could be affected by future changes in costs and by giving value to certain public benefits such as recreation which were not considered in its economic evaluation. The IJC found the best of the plans studied to be a combination of the Passamaquoddy tidal power project and development of incremental capacity at the proposed Rankin Rapids project on the upper St. John River with 300,000 kilowatts of dependable capacity. Development of the Rankin Rapids project was opposed by sportsmen and conservationists on the ground it would have flooded a series of unspoiled and scenic rapids in the lower reaches of the Allagash River. (The Dickey site, by contrast, is upstream from the mouth of the Allagash River.)



Location Map

PASSAMAQUODDY AND
UPPER SAINT JOHN RIVER
POWER PROJECT


NEW BRUNSWICK
Diggequash River
St.George
Magaguadavic River
ST. CROIX RIVER
St. Andrews
PASSAMAQUODDY
BAY
HIGH POOL
LETITE PASSAGE
FG
LITTLE LETITE PASSAGE
PENDLETON PASSAGE
CANADA
UNITED STATES
MAINE
OCEAN
BAY OF FUNDY
DEER ISLAND
WESTERN PASSAGE
POTENTIAL SECOND POWER PLANT
INDIAN RIVER
EG
FG
COBSCOOK BAY
FIRST POWER PLANT
Eastport
FRIAR ROADS
CAMPOBELLO ISLAND
LOW POOL
Lubec
QUODDY ROADS
Scale of Miles
DAM
POWERHOUSE
FG FILLING GATES
E. EMPTYING GATES
LOCK
INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY
TIDAL POWER PROJECT
SELECTED PLAN
GENERAL ARRANGEMENT
(MODIFIED BY DEPARTMENT OF THE INTERIOR)
July 1963

A new look

President Kennedy, by letter of May 20, 1961, requested the Secretary of the Interior to review and evaluate the IJC report, with special consideration as to what changes in fuel, engineering, and financing cost might result in making the project economically feasible. Our Study Committee had a load and resources study made in the area which clearly indicated that the tidal power project would be feasible if developed as a peaking powerplant with 1 million kilowatts capacity instead of the 300,000 kilowatts contemplated by the IJC. The loads and resources study also embraced a power marketing area considerably more extensive than that used by the IJC, taking into account technological advances in the power industry since its report. Additional studies were made and the results are given in our full report in terms of tangible power, recreation, and area development benefits.

The plan developed in this review differs from the plan described as best in the IJC report in these major respects:

1. We propose increasing the Passamaquoddy tidal power project capacity from 300,000 to 1 million kilowatts.
2. We propose that the project be operated for short periods every day for peaking power production to fit the anticipated load pattern of the area.
3. We propose use of axial flow-type hydraulic turbines in lieu of conventional vertical shaft turbines.
4. We propose upper St. John River storage and power development at the Dickey site instead of the Rankin Rapids site.
5. We propose some modification of the reregulating dam and power production facilities at the Lincoln School site.

Our plan for providing 1 million kilowatts capacity at Passamaquoddy contemplates construction of two 50-unit powerplants of 500,000-kilowatt capacity each. One would be located at Carrying-place Cove and the other at Carlow Island.

The axial flow hydraulic turbine was considered in the IJC report but was not recommended at that time because it appeared that the cost differential compared to a conventional-type hydraulic turbine did not justify its use. Additional technical, engineering, and cost information now definitely support the use of axial flow hydraulic turbines.

Quoddy for peaking

The electric utility load pattern for the New England-Maritime Provinces area has only one sharp peak each day. It occurs approximately between 5 and 6 p.m. and on load curves is so pronounced that it can be described more properly as a "spike" rather than a "peak."

The basic operating plan for Passamaquoddy as a "peaking" powerplant is this: During the high tide prior to a peaking period, the high pool is filled to the highest possible elevation. Similarly, during the low tide prior to a peaking period, the low pool is emptied to the lowest

possible elevation. These pool elevations are then maintained until the start of the peaking period when water from the high pool is dropped through the powerplants to the lower pool. Water accumulated in the lower pool then is released to the ocean through emptying gates whenever the ocean tide is below the level in this pool.

Following the peaking period, offpeak or secondary energy then can be produced until the time and tides are such that the pools must be refilled or emptied in preparation for the next peaking period. We estimate that about 1 billion kilowatt-hours of offpeak energy could be generated by Passamaquoddy and, as a result of the upper St. John development, about 600 million kilowatt-hours of energy at downstream hydroelectric plants of the New Brunswick Electric Power Commission.

By itself, the hydro project at the Dickey site could produce only about 150,000 kilowatts of dependable 60-percent load factor power. Integrated with offpeak Passamaquoddy power, it can produce 250,000 kilowatts of dependable load factor power. Further, Dickey capacity can be used for peaking during neap tides when not enough water would flow into the high pool for Passamaquoddy to generate its entire 1 million kilowatts of capacity for a full hour.

The Dickey powerplant would not, by itself, be able to use all of the offpeak power available from Passamaquoddy for integration into a firm energy pattern. This means offpeak Passamaquoddy power would be available for integration with potential other hydro projects in the area.

Reregulation and downstream benefits

A hydroplant operating to serve a load with sharp peak characteristics requires a reservoir downstream to catch the water released through the turbines during peaking hours and reregulate the flow of the river. The reregulating reservoir for the Dickey site is proposed for the Lincoln School site. Further studies are required as to the precise location of the Dickey powerplant site and the contemplated discharge from this plant. No cost estimates were included in the present study to cover the cost of the reregulating reservoir. However, we anticipate that power revenues from reregulating reservoir will support the cost thereof; therefore cost of this facility is not a factor in the overall plan of development.

Considerable benefits would accrue to existing and potential downstream hydro developments by virtue of storage on the upper St. John River. An estimate of these benefits was obtained from studies made of the St. John River by the St. John River Board of the New Brunswick Electric Power Commission. For the Dickey development, they range from 225 million kilowatt-hours per year to 739 million kilowatt-hours per year between 1970 and 1980, and in most of these years would be greater than 500 million kilowatt-hours. After 1980 they level out at 650 million kilowatt-hours.

Recreation benefits

Passamaquoddy and Cobscook Bays offer a panorama of water and scenic views complemented by the Fundy Isles of Campobello, Deer Island, and Grand Manan, all located in Canada.

The principal attraction to tourists would be the tidal power project itself, featuring ocean dams 7½ miles in total length. An engineering marvel, its operations would feature the rise and fall of the tides, the impounding of water in two natural pools, navigation locks for unrestricted movement of boats, emptying and filling gates, and power transmission.

Many hundreds of thousands of persons who now visit other parks and attractions in the general area doubtless would make a stopover at Passamaquoddy which will attract additional hundreds of thousands of visitors. This would greatly benefit the area, particularly Washington County, headquarters of the proposed project. This county now has the lowest median income of any county in Maine.

The Bureau of Outdoor Recreation estimates that present visitations to the Passamaquoddy area total about 216,000 visitor-days and would be 500,000 visitor-days by 1975, increasing to more than 4½ million visitor-days by the year 2025. We have applied the conservative recreational value of only 80 cents per visitor-day in arriving at average annual recreational benefits of $2,065,000.

Because of the unique nature of the Passamaquoddy tidal project and its potential attraction for travelers, we have recommended that the project development include a visitor center with adequate parking facilities, picnic areas, boat-launching sites at convenient locations, frequent roadside overlooks, and interpretive signs at appropriate points.

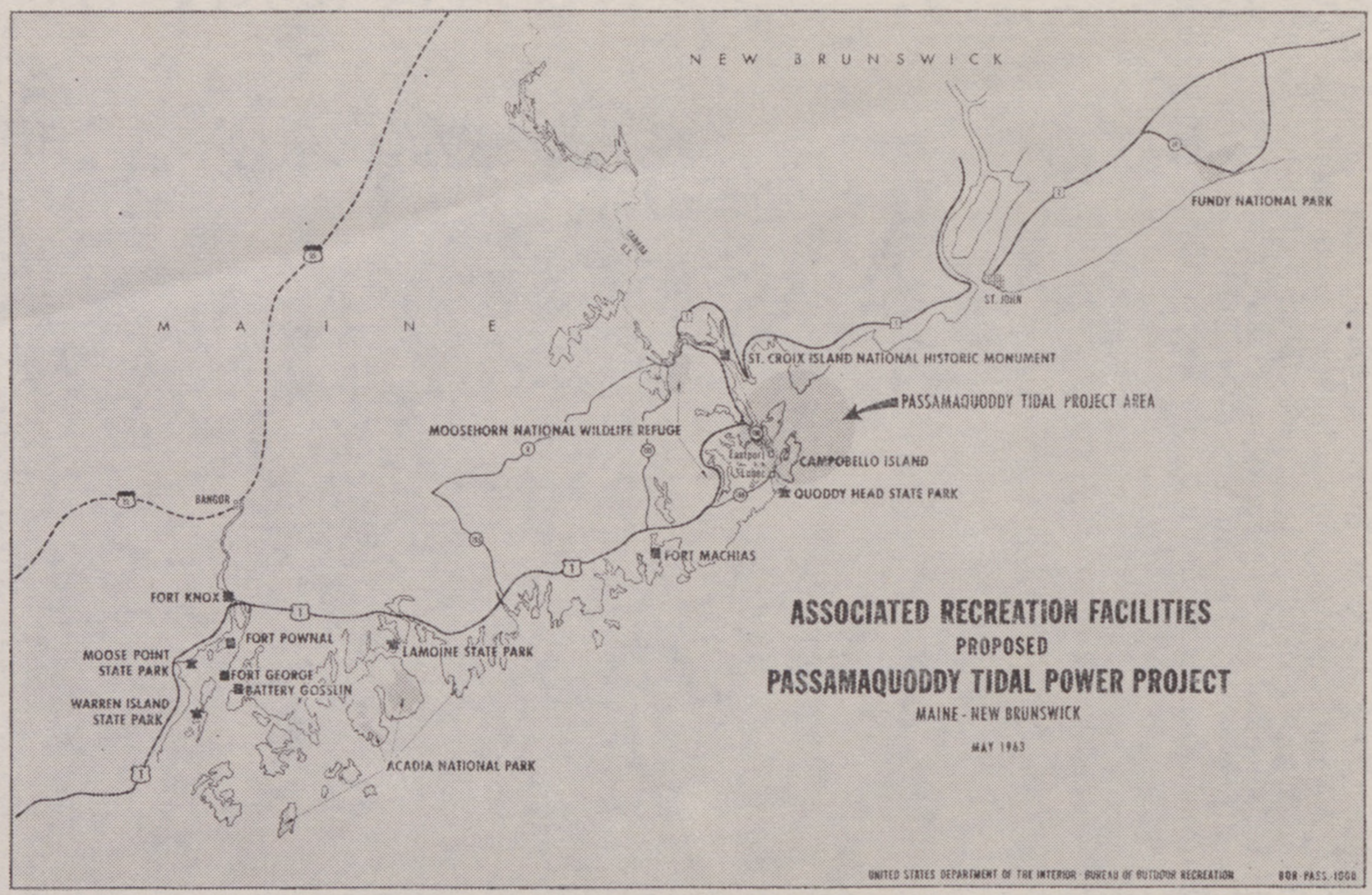
Area redevelopment benefits

Both the Passamaquoddy and Dickey power developments are located within counties which are designated as "redevelopment areas" based on criteria set forth in the Area Redevelopment Act of 1961 (75 Stat. 47). Construction of these projects would significantly reduce unemployment in those two areas. An estimated 14,116 man-years of local labor would be utilized during construction of the full development, with annual wages and salaries amounting to an estimated $2,729,000 and total wages and salaries adding up to $80,360,000.

Summary

The Passamaquoddy tidal power project and upper St. John River development are feasible and desirable from both an engineering and economic point of view. Their development will bring a significant block of low-cost power on the line at a time when it is needed. The tidal power project with its 7½ miles of dams would be a tourist magnet contributing further to the economy of the region.

France is already constructing a tidal power project and Russia is planning one. It will enhance the stature of the United States in the electric power field to proceed at once with the Passamaquoddy project. This project also will add to our store of electrical knowledge and possibly lead to economies of construction which will make feasible other tidal power projects in this country.


NEW BRUNSWICK
MAINE
FUNDY NATIONAL PARK
ST. JOHN
ST. CROIX ISLAND NATIONAL HISTORIC MONUMENT
PASSAMAQUODDY TIDAL PROJECT AREA
MOOSEHORN NATIONAL WILDLIFE REFUGE
Eastport
CAMPOBELLO ISLAND
QUODDY HEAD STATE PARK
BANGOR
FORT MACHIAS
FORT KNOX
FORT POWNAL
LAMOINE STATE PARK
MOOSE POINT STATE PARK
FORT GEORGE
BATTERY GOSSLIN
WARREN ISLAND STATE PARK
ACADIA NATIONAL PARK
ASSOCIATED RECREATION FACILITIES
PROPOSED
PASSAMAQUODDY TIDAL POWER PROJECT
MAINE - NEW BRUNSWICK
MAY 1963
UNITED STATES DEPARTMENT OF THE INTERIOR · BUREAU OF OUTDOOR RECREATION
BOR-PASS.-1008

Harnessing the energy of the tides is a big idea and a big undertaking. We must think big and act big if we are to take full advantage of the opportunities modern technology holds out to us. Generally, the development of the Passamaquoddy tidal project and the upper St. John River could do as much for New England and the Nation as Grand Coulee Dam has done for the Pacific Northwest and the Nation.

REPORT OF THE PASSAMAQUODDY-ST. JOHN STUDY COMMITTEE

THE INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT

AND

UPPER ST. JOHN RIVER HYDROELECTRIC POWER DEVELOPMENT

Report to President John F. Kennedy
In Response to Letter
of May 20, 1961

STEWART L. UDALL
SECRETARY OF THE INTERIOR

JULY 1963

LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., July 1, 1963.

THE PRESIDENT,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT: This is my reply to your letter of May 20, 1961, asking this Department to review the International Joint Commission's report on the international Passamaquoddy tidal project and the upper St. John River hydroelectric power development.

You requested that I advise you concerning the changes in fuel, engineering and financial costs which might result in making the project economically feasible. After exhaustive review and study made in close collaboration with the U.S. Army Corps of Engineers, utilizing information on load and resource data furnished by the Federal Power Commission, and the technical know-how available from the bureaus within this Department, I am transmitting to you the report of our findings. I am also transmitting the report of the Secretary of the Army and the accompanying review by the Chief of Engineers commenting on the International Joint Commission's report which have been fully coordinated with this Department.

I have determined that the development of the Passamaquoddy tidal project and the upper St. John River is both desirable and economically feasible. The plan envisions a tidal power development at Passamaquoddy Bay and a hydroelectric powerplant on the Upper St. John River which would provide 1,250,000 kilowatts of dependable capacity, of which 1 million kilowatts would be peaking capacity and 250,000 kilowatts of capacity which would meet the local area loads. You will be pleased to note that this proposed plan will preserve in its entirety the free-flowing nature of the Allagash River and its superb recreational values.

The Department's proposal is feasible from an engineering and economic viewpoint. The benefit-cost ratio is 1.27 to 1 based on current United States project feasibility standards and using an interest rate of 2⅞ percent with power repayment within 50 years after each unit becomes revenue producing.

We recognize that suitable arrangements will have to be made with the Canadian Government for the United States to construct the Passamaquoddy tidal project and to work out an equitable sharing of the downstream benefits from power developments of the St. John River in Canada.

In view of the extensive previous studies made on this project dating back to 1922 and the opportunity which still exists for additional engineering work in advance of construction, I recommend

that this report be used as the basis for early authorization of the international Passamaquoddy tidal power project and the storage and hydroelectric development on the upper St. John River by the U.S. Army Corps of Engineers and the marketing of the power by the Department of the Interior.

I also recommend that you request the Secretary of State to immediately initiate negotiations with the Government of Canada, looking toward a satisfactory arrangement for the sharing of the power and flood control benefits of the St. John River in Canada and the development of the Passamaquoddy tidal power project by the United States.

Respectfully yours,

STEWART L. UDALL,
Secretary of the Interior.

LETTER OF SUBMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., July 1, 1963.

MEMORANDUM

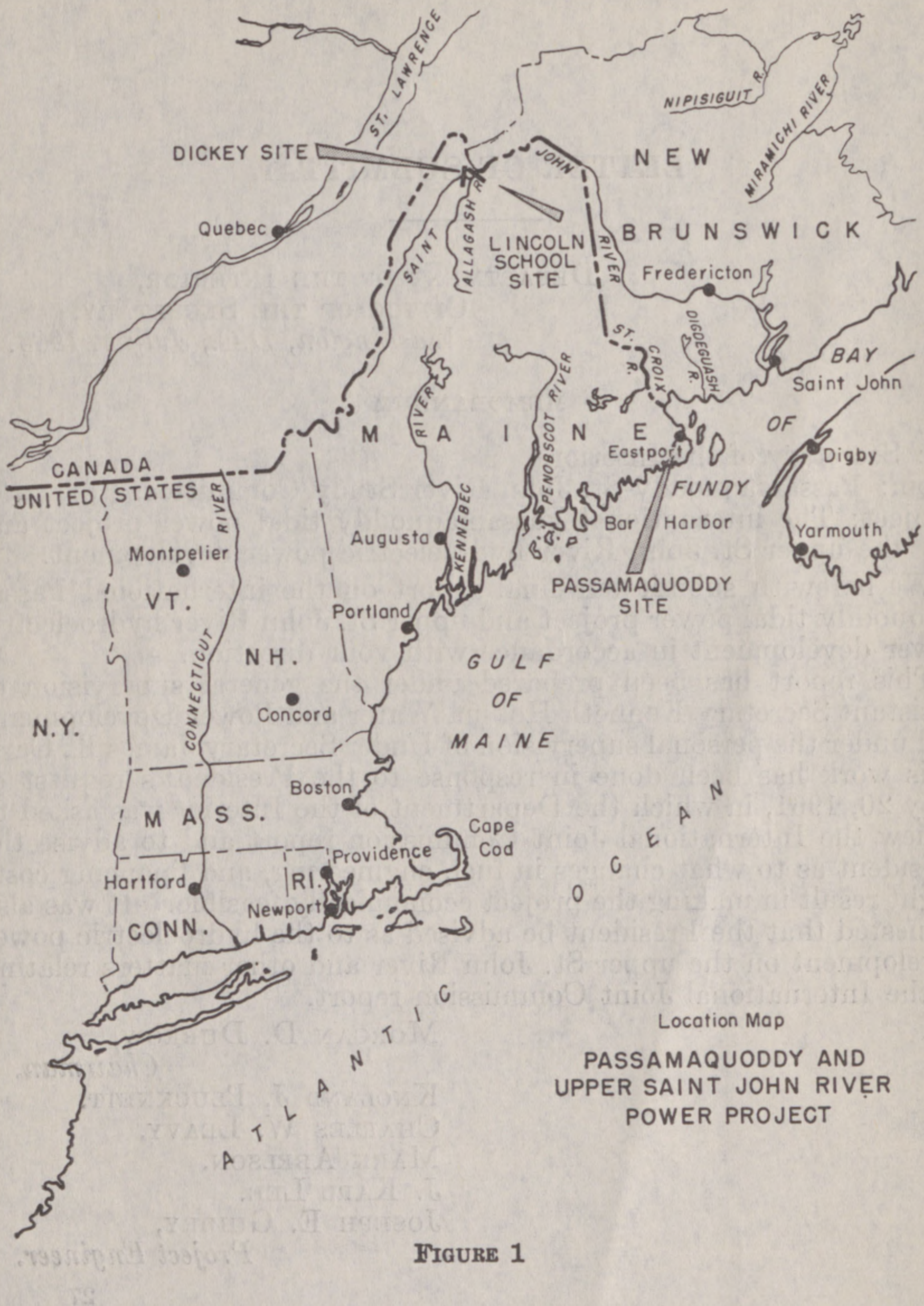
To: Secretary of the Interior.
From: Passamaquoddy-St. John River Study Committee.
Subject: The international Passamaquoddy tidal power project and the upper St. John River hydroelectric power development.

We herewith submit our final report on the international Passamaquoddy tidal power project and upper St. John River hydroelectric power development in accordance with your direction.

This report has been prepared under the general supervision of Assistant Secretary Kenneth Holum, Water and Power Development, and under the personal supervision of Under Secretary James K. Carr. This work has been done in response to the President's request of May 20, 1961, in which the Department of the Interior was asked to review the International Joint Commission report and to advise the President as to what changes in fuel, engineering, and financing costs might result in making the project economically feasible. It was also requested that the President be advised as to the hydroelectric power development on the upper St. John River and other matters relating to the International Joint Commission report.

MORGAN D. DUBROW,
Chairman.
KNOLAND J. PLUCKNETT.
CHARLES W. LEAVY.
MARK ABELSON.
J. KARL LEE.
JOSEPH E. GUIDRY,
Project Engineer.

36-986—64——3



Location Map

PASSAMAQUODDY AND
UPPER SAINT JOHN RIVER
POWER PROJECT

FIGURE 1

PREFACE

For centuries man has observed the tides and envisioned their utilization as a source of useful energy. An eminent American engineer, Dexter P. Cooper, as far back as 1919, put forward a plan for harnessing the high tides in the Passamaquoddy area to develop electric power by building dams and sluiceways in the openings into the Bay of Fundy and a powerhouse between Passamaquoddy Bay and Cobscook Bay.

The International Passamaquoddy Engineering Board was appointed by joint agreement between Canada and the United States by authority of a reference on August 2, 1956, made in accordance with the Boundry Waters Treaty of 1909 and with U.S. Public Law 401, 84th Congress, 2d session, approved January 31, 1956. This Board determined that a tidal power project could be built and operated in the Passamaquoddy area and that a two-pool arrangement is best suited for the site conditions using the waters of Passamaquoddy and Cobscook Bays. On April 4, 1961, the International Joint Commission found that the Passamaquoddy tidal power project was not economically feasible under present conditions. The IJC (International Joint Commission) recommended that development of the project be viewed as a long-range possibility having better prospects of realization when other less costly energy resources available to the area are exhausted. The Commission in this recommendation by the IJC pointed out that economic feasibility of the project may be affected by future changes in the costs and benefits considered in the evaluation of the project. Further, the IJC observed that the two Governments may wish to give consideration to the desirability of crediting the tidal project with certain public benefits that have not been included in the economic feasibility determinations presented in this report.

The IJC found that the combination of the Passamaquoddy tidal power project and incremental capacity at Rankin Rapids on the upper St. John River was most feasible. It further observed that changes in economic considerations, markets for power and technological changes and advances in construction and equipment could result in greater economic feasibility.

President Kennedy, by letter of May 20, 1961, requested the Secretary of the Interior, Stewart L. Udall, to review and evaluate the IJC's report. Upon completion of this review, the President requested the Secretary to advise of his judgment as to what changes in fuel, engineering, and financing cost might result in making the project economically feasible. The President also requested advice on the advisability of hydroelectric power development on the upper St. John River and other relative matters regarding the IJC report.

In December 1961, the Passamaquoddy-Upper St. John Study Committee had a load and resources study made in the New Bruns-

wick, Canada-New England areas. In this study, the knowledge, experience and expertise garnered in the Department of the Interior was utilized, and it clearly indicated that the Passamaquoddy tidal power project would be feasible if developed as a peaking powerplant in the magnitude of 1 million kilowatts instead of 300,000 kilowatts as studied in the IJC report. This is consistent with current practices in the electric utility industry which are trending now to using large thermal electric generating units to meet the baseload and hydro (conventional and pumped storage) for peaking. This development fits into the predicted future load requirements of the areas.

This preliminary investigation and study also made observations concerning the need for further study on low head axial flow turbines, operation of the tidal power project as a peaking plant, integration with other thermal and hydroelectric generation, and interconnection with electric utilities systems in Canada and the United States.

In the public works bill for fiscal year 1963, Congress appropriated $200,000 for the Secretary to perform the basic studies required to determine the validity of the peaking power concept for the Passamaquoddy tidal power project. These studies have been completed and are described herein. They clearly support the engineering and financial feasibility of the Passamaquoddy tidal power development for peaking purposes. The studies also clearly demonstrate the economic and financial feasibility of hydroelectric power development on the upper St. John River.

COOPERATING AGENCIES AND ACKNOWLEDGMENTS

The basic IJC report contained fundamental engineering studies and technical data prepared by the Corps of Engineers, the Federal Power Commission, and the New Brunswick Electric Power Commission. These agencies were contacted to a considerable extent throughout the course of the review and study and each agency was most cooperative in making all information available. The Corps of Engineers was particularly helpful in supplying all available information on the programing of the computer studies from the basic report, including basic designs and operating procedures and those contemplated for future operations. The Federal Power Commission furnished data on utility loads, generating facilities, and expected load growths and patterns for the future.

Complete cooperation was received within this Department. The Bureau of Reclamation made the horizontal axial flow turbine studies, the computer studies, the powerhouse and the transmission line designs, the review of the structural designs and construction cost, including the maintenance and replacement cost estimates. The Bureau of Outdoor Recreation, the Fish and Wildlife Service, and the National Park Service were most helpful.

The International Passamaquoddy Tidal Power Project
and
Upper St. John River Hydroelectric Power Development

PURPOSE AND SCOPE OF REPORT

The purpose of this report is to present the result of studies made to review the IJC's report on the international Passamaquoddy tidal power project, April 1961. It includes the potentialities of hydroelectric power development on the upper St. John River integrated and interconnected electrically with the Passamaquoddy tidal power project and with the power systems of New England and New Brunswick.

The report examines further the findings of the preliminary load and resources study which was released by the Department on March 6, 1962. This study was made for a power marketing area considerably more extensive than was used in the IJC's report but within economical transmission distance from the proposed Passamaquoddy tidal power project and upper St. John River hydroelectric powerplants.

The load and resources study emphasized the potential market for peaking power and developed the approach in which Passamaquoddy tidal power project would be in the magnitude of 1 million kilowatts instead of 300,000 kilowatts as proposed in the IJC's report. The load and resources study predicated the development of a low-cost horizontal flow hydraulic turbine and conducting extensive digital computer studies to demonstrate their performance and to obtain the capacity and energy output for the peaking operation at Passamaquoddy. Other studies on the cost of the deepwater structures were suggested.

These studies have been completed and the results are given in terms of tangible power, recreation and area redevelopment benefits.

The major changes in the plan developed in this review compared to the plan of the Passamaquoddy Engineering Board in the IJC's report are—

(1) Increasing the Passamaquoddy tidal power project installation from about 300,000 kilowatts to near 1 million kilowatts.

(2) Operating the Passamaquoddy tidal power project for short periods every day for peaking power production, which fits the anticipated load pattern of the area.

(3) Use of axial-flow type hydraulic turbine in lieu of conventional vertical shaft turbine.

(4) On the upper St. John River, constructing a major storage and power project at the Dickey site instead of Rankin Rapids.

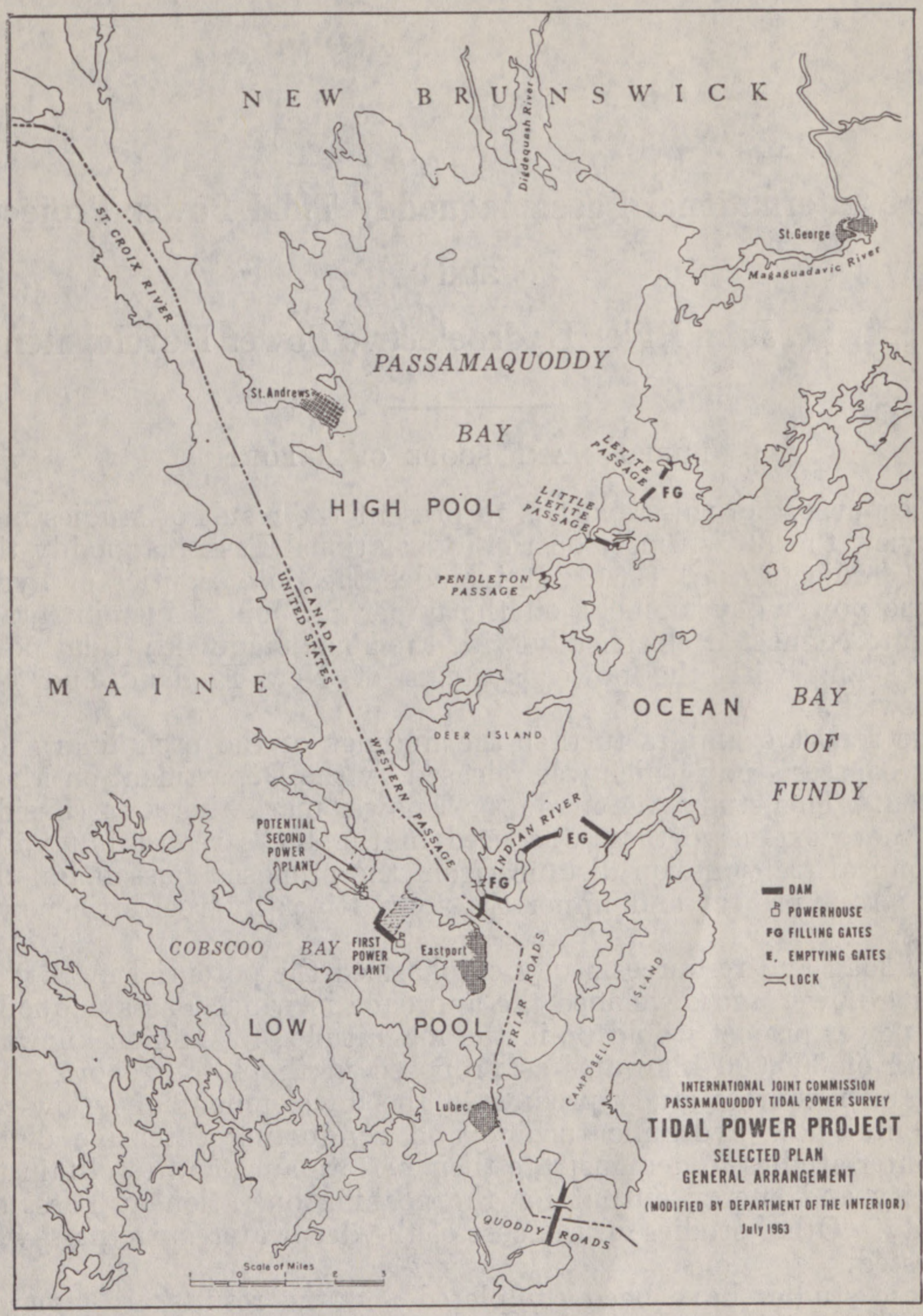


FIGURE 2

(5) Some modification of the reregulating dam and power production facilities at Lincoln School.

These modifications will not result in major problems. The axial flow hydraulic turbine was considered in the IJC's report, but at that time was not recommended because it appeared that the cost differential compared to a conventional-type hydraulic turbine did not justify the use of the newer type hydraulic turbines. Additional technical, engineering, and cost information definitely support the use of axial-flow hydraulic turbines.

SUMMARY—FINDINGS

In response to the President's question in his letter of May 20, 1961, to Secretary Udall as to what changes in fuel, engineering, and financing cost might result in making the Passamaquoddy tidal power project economically feasible, the following has been determined:

(1) The Passamaquoddy tidal power project is feasible on current fuel prices which are essentially the same as those used in the IJC report.

(2) The Passamaquoddy tidal power project is feasible with the change in the engineering plan to provide peaking power in the order of 1 million kilowatts' capacity. The IJC report recommended developing the Passamaquoddy tidal power project for production of continuous baseload power with about 300,000 kilowatts' capacity.

(3) The project is feasible for development by the U.S. Government based on an interest rate of 2⅞ percent as prescribed on July 26, 1962, by the Bureau of the Budget for project formulation. Power costs are repayable within 50 years after each power unit becomes revenue producing.

The Passamaquoddy tidal project powerplant would have an ultimate installed capacity of 1 million kilowatts and the Dickey project would have an ultimate installed capacity of 750,000 kilowatts. The coordinated and integrated operation of these two plants would produce 1 million kilowatts of dependable peaking capacity and 250,000 kilowatts of dependable capacity at 60-percent load factor delivered to the load centers. In addition, about 1 billion kilowatt-hours of offpeak energy could be generated by Passamaquoddy and about 600 million kilowatt-hours of energy at downstream hydroelectric plants of the New Brunswick Electric Power Commission. A reservoir and powerplant would be provided at the Lincoln School site for reregulation of releases from Dickey and generation power from the Allagash River flows. A transmission system would be available for the delivery of this power to load centers and its offpeak capacity could be utilized for delivery of power generated by others.

The proposal is feasible from an engineering and economic viewpoint. The benefit-cost ratio is 1.27 to 1 based on current project formulation principles and using an interest rate of 2⅞ percent. Project repayment was envisioned at an interest rate of 2⅞ percent.

Even though the Canadian Government has common interests in this proposal, the analysis has been based upon the standards and criteria applicable to such developments in the United States. The Canadian interests will be tully recognized and made the subject of negotiations with the Canadian Government as early as practicable.

Although core drillings and additional studies are needed to firm up the cost of the Dickey project, there is good evidence that the Dickey site is satisfactory to construct a storage and hydroelectric project as studied in this review report. The first 500,000-kilowatt powerplant of the Passamaquoddy tidal power project will utilize every facility which was envisioned in the IJC report for the development of the 300,000-kilowatt powerplant. The location of a second powerhouse at Passamaquoddy tidal power project for an additional 500,000 kilowatts is believed to be satisfactory. As usual, additional

studies and design will be necessary for the orderly development of the Dickey project and the Passamaquoddy tidal power project.

The development of the Dickey site on the upper St. John with a suitable reregulatory dam near Lincoln School affords an immediate opportunity for production of low cost load factor power for Maine and New England.

The early development of Passamaquoddy tidal power project coordinated with the upper St. John River provides an opportunity for the development of a considerable additional load factor power at Dickey site and assures the generation of greater dependable peaking capacity at Passamaquoddy. Substantial benefits will accrue throughout the area by coordination and integration with existing power systems.

This development of an alternate source of low-cost power creates an opportunity to enhance the fisheries of New England by removal of existing, small, inefficient hydroprojects which now block the migration of anadromous fish. It also protects for all time the great recreational values of the Allagash River.

Power developed from these projects can be beneficially marketed in the New England-New Brunswick areas at cost of at least 25 percent lower than the average power cost in 1961, thereby strengthening the economy of the area and the Nation.

RECOMMENDATIONS

We recommend that—

(1) This report be sent to the Congress as a basis to seek early authorization of the international Passamaquoddy tidal power project, and the storage and hydroelectric development on the upper St. John River, by the U.S. Army Corps of Engineers, and the marketing of the power by the Department of the Interior; and

(2) That the President instruct the Secretary of State to immediately initiate negotiations with the Government of Canada to work out a satisfactory arrangement for the sharing of the power benefits of the St. John River in Canada from storage on the upper St. John River in the United States, and the development of the Passamaquoddy tidal power project by the United States.

THE TIDE—AN ENERGY RESOURCE

In contemplating the potential of Passamaquoddy, it is essential to recognize that the tide is a perpetual energy resource, fully predictable and dependable.

The level of the sea alternately rises and falls, even in the most sheltered locations and in the calmest weather, completely independent of surface disturbances from wind and waves. This rhythmic motion of the tides has been observed by man for centuries.

The alternate rise and fall of the sea is due to forces which are astronomic in origin and dependent on the relative positions of the earth, sun, and moon. The height of the tide varies with these forces and the physical configuration of the coastline. When the attractive forces of the sum and moon are in conjunction, or opposition, as at a

new moon and full moon, their combined action produces a tide greater than usual, called the spring tide. When the moon is at first or third quarter, the tide is unusually low and is called the neap tide. There are generally two complete tidal cycles, that is, two high tides and two low waters each day. This is the case in the Passamaquoddy Bay area.

The greatest rise and fall of the tides in the world occurs in the head of the Bay of Fundy on the Nova Scotia coast where tides as high as 40 to 50 feet are observed.

At Eastport, Maine, also on the Bay of Fundy, similar tides are experienced, but of lesser magnitude. The maximum observed tidal range at this location is 26 feet with a minimum of 12.7 feet and an average tidal range of 18.1 feet. These are the tides which make possible the development of the Passamaquoddy tidal power project.

INTERNATIONAL JOINT COMMISSION PLAN

The report of the International Passamaquoddy Engineering Board sets forth the results of a comprehensive survey to determine the engineering and economic feasibility of developing the international tidal power potential of Passamaquoddy Bay in Maine and New Brunswick. It includes investigations of the engineering and economic aspects of the tidal project by itself; the engineering and economic aspects of the tidal project combined with an auxiliary source of power supply to supplement the varying output of the tidal powerplant; the market for and value of the power from the tidal power project with and without an auxiliary; and the possible effects that construction of the tidal project may have on the regional and national economies.

The Board conducted a series of field investigations and studies of site conditions in the Passamaquoddy-Cobscook Bay area. These investigations included aerial mapping, deep and shallow water drilling, land drilling, underwater mapping, analysis of soils, and tidal gaging. Core drilling in great water depths and high tidal velocities and underwater mapping with sonic equipment constituted two of the most costly and difficult undertakings of the survey.

The project arrangement selected for design included the 101 square miles of Passamaquoddy Bay as the high pool and the 41 square miles of Cobscook Bay as the low pool, with a powerhouse located at Carryingplace Cove.

The selected IJC plan would have provided an installed generating capacity of 300,000 kilowatts, a dependable capacity of 95,000 kilowatts, and an average annual generation of about 1,843 million kilowatt-hours.

This plan called for 90 filling gates, 40 in Letite Passage and 50 between Western Passage and Indian River. In the reach between Pope and Green Islets 70 emptying gates, similar to the filling gates set at a lower elevation, would empty the lower pool. Four navigation locks were planned for this tidal project. The outdoor-type powerhouse would have 30 generating units of 10,000 kilowatts rated capacity, each with an overload of 15 percent. The turbines selected were fixed-blade propeller type.

A comparison of the performance of fixed-blade and Kaplan turbines indicated that the greater efficiency of the Kaplan turbine was

offset by its greater cost. The horizontal-axis, bulb-type turbine-generator recently developed in Europe and adopted for use in the single-pool tidal project in LaRance estuary on the northwest coast of France was also studied by the Engineering Board for possible use in the Passamaquoddy project. This unit can be used as a turbine, pump, or sluiceway, with flow in either direction.

Studies by the Board showed that the bulb-type turbine generator develops approximately as much power as the Kaplan, and structural studies indicated that the powerhouse structure would cost about $300,000 less per unit than with conventional units. This saving, however, was offset by the greater cost of the bulb-type turbine generator set and the need to compensate for electrical stability due to low rotative inertia. The Board adopted the conventional fixed-blade type in its plan for the Passamaquoddy project.

In order to supplement the varying output from the tidal power project, the Board considered several different auxiliary power sources to determine the best type for meeting the power loads of the region. These studies included river hydroelectric plants, pumped-storage plants, and steam-electric auxiliaries.

A number of river hydroelectric sites were examined and Rankin Rapids on the upper St. John River in Maine was selected by the Board as the best source of auxiliary power. The Rankin Rapids project would provide 2.8 million acre-feet of usable storage capacity. Operated in conjunction with the Passamaquoddy tidal plant, the combined project would provide 555,000 kilowatts of dependable capacity and 3,063 million kilowatt-hours of average annual generation.

Four project combinations were selected by the Board for evaluation of costs and benefits. These were (1) the Passamaquoddy tidal project alone; (2) the tidal project operated in combination with all the Rankin Rapids project; (3) the tidal project supplemented by incremental capacity only at Rankin Rapids; and (4) the tidal project supplemented by the Digdequash pumped-storage auxiliary.

Four conclusions of the International Passamaquoddy Engineering Board which are particularly pertinent to the Department of the Interior's review are quoted as follows:

> (1) A tidal power project using the waters of Passamaquoddy and Cobscook Bays can be built and operated. The two-pool type of project is best suited for the site conditions in the area and the power markets it would serve. The tidal project arrangement selected makes best use of the site conditions.
>
> (2) The first cost (construction cost) of the tidal power project by itself would be $484 million. With interest during construction, the investment would be $532.1 million. The tidal power power project would have an installed capacity of 300,000 kilowatts and a dependable capacity of 95,000 kilowatts. Average annual energy would be 1,843 million kilowatt-hours. However, for maximum power benefits, the tidal power project would have to be combined with an auxiliary power source.
>
> (3) The most favorable project combination is the tidal power project operated in conjunction with a river hydro-

electric auxiliary built at the Rankin Rapids site on the upper St. John River in Maine. The combined cost of the tidal project and the Rankin Rapids auxiliary is $630 million. With interest during construction, the investment would be $687.7 million. The dependable capacity of this combination would be 555,000 kilowatts, and average annual generation would be 3,063 million kilowatt-hours.

(4) Construction of the tidal project-Rankin Rapids combination would increase low flows in the lower St. John River by a considerable amount, thus increasing substantially the usefulness of the river for downstream generation of power. Downstream benefits accruing to existing powerplants were included in the economic evaluation.

DEPARTMENT OF THE INTERIOR PLAN

The basic plan envisioned by the Department of the Interior proposes Passamaquoddy developed as a peaking powerplant supplying a substantial portion of all the peaking power requirements of an extensive marketing area embracing the New England States and the New Brunswick area. This need stems from the anticipated load pattern forecast for the area which would have a substantial peak and the ever-increasing use of large capacity, more or less fixed output, thermal generating plants to supply the base load. Tidal power which is essentially hydroelectric power with the added features of dependability and predictability is particularly suitable for supplying peaking power. The plan envisions use of the basic two-pool concept developed in the IJC's report with the significant modification that horizontal-flow turbines would be utilized in the powerplant instead of the conventional vertical-shaft turbine generator units. In subsequent sections of this report, the computer studies, which demonstrated the feasibility of the peaking power operation, are discussed, as well as development of the horizontal axial flow turbines, the study of deep water structures, and the general impact of peaking power operation in the tidal development.

OTHER TIDAL DEVELOPMENTS

The only tidal development for electric power under full-scale construction today is the LaRance tidal project in France. This site was visited by Assistant Secretary Holum and his Assistant and Chief Engineering Research Adviser, Morgan Dubrow, on their return from a 4-day symposium on peakload coverage in Venice, Italy, May 20–23, 1963. A portion of their report is quoted as follows:

> This project is presently the largest tidal project under construction in the world. It will have an initial power installation of 240 megawatts in 24 turbine sets and could have an ultimate installation of 320 megawatts. It is being built at an approximate cost of about $80 million and represents the continued effort of French engineers over a 20-year period to harness the energy of the tides at San Malo. The site is ideal for the construction of such a tidal project because it is a narrow estuary with a tidal range of 13½ meters (that is roughly 44 feet). The LaRance tidal project is operated for

peaking capacity or energy. Since the units are reversible, it is designed to take whatever advantage of the tides for generation to fit into the powerloads of the French electric system.

The LaRance tidal project which is under construction certainly inspires the officials and engineers of the Department of the Interior who have been concerned with the review of the Passamaquoddy tidal power project and the St. John River. Every effort will be made to quickly obtain authorization and make plans for construction of the Passamaquoddy project coordinated with the St. John River.

HORIZONTAL AXIAL FLOW TURBINES

One of the first steps in the current study was to contact all known turbine manufacturers to determine the availability of horizontal axial flow turbines to obtain their operating characteristics and cost. Personal visits were made with engineering personnel of the Allis-Chalmers Manufacturing Co., York, Pa.; Neyrpic, New York, N.Y.; Westinghouse Electric Manufacturing Co., Philadelphia, Pa.; and the English Electric Co. Correspondence was conducted and replies received from the James Leffel & Co., Springfield, Ohio; Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.; Newport News Shipbuilding & Dry Dock Co., Newport News, Va.; Dominion Engineering Co., Ltd., Montreal, Quebec, Canada; Nichimen Co., Inc., New York, N.Y.; Mitachi New York, Ltd., New York, N.Y.; and Vevey Engineering Works, Ltd., New York, N.Y.

The basic designs advanced by the Allis-Chalmers Co. utilizing an "inclined-shaft" and the Neyrpic Co.'s French "bulb-type" were the only two types currently available, as was found by the International Joint Engineering Board.

The Office of the Chief Engineer, Bureau of Reclamation, concentrated on improving and developing a suitable type of horizontal flow turbine, illustrated in the report. This turbine would be of the adjustable blade propeller type with the shaft inclined at about 30° from the horizontal, the waterways as straight as possible, and with the conventional air-cooled-type generator located above the waterline. Each unit would be rated at 14,000 horsepower, 10,000 kilowatts at 13.2 feet of head, 43.4 revolutions per minute. There would be fixed stay vanes but no wicket gates. The propeller blades would close when a unit is shut down. All parts exposed to sea water would be either stainless steel or stainless steel clad to protect against corrosion. The shaft would be hollow to provide maximum rigidity with least weight. Guide bearings would be water lubricated. The two-way thrust bearing would be between the turbine and generator and would be oil lubricated. Expected performance of this unit is shown in figure 3.

During the course of the investigations, the French bulb-type horizontal flow turbine generator was inspected by the Assistant Secretary for Water and Power and by the Chairman of the Passamaquoddy Study Committee. These units are being further investigated by the Office of the Chief Engineer of the Bureau of Reclamation. We have shown a turbine based on a proposal of the Allis-Chalmers

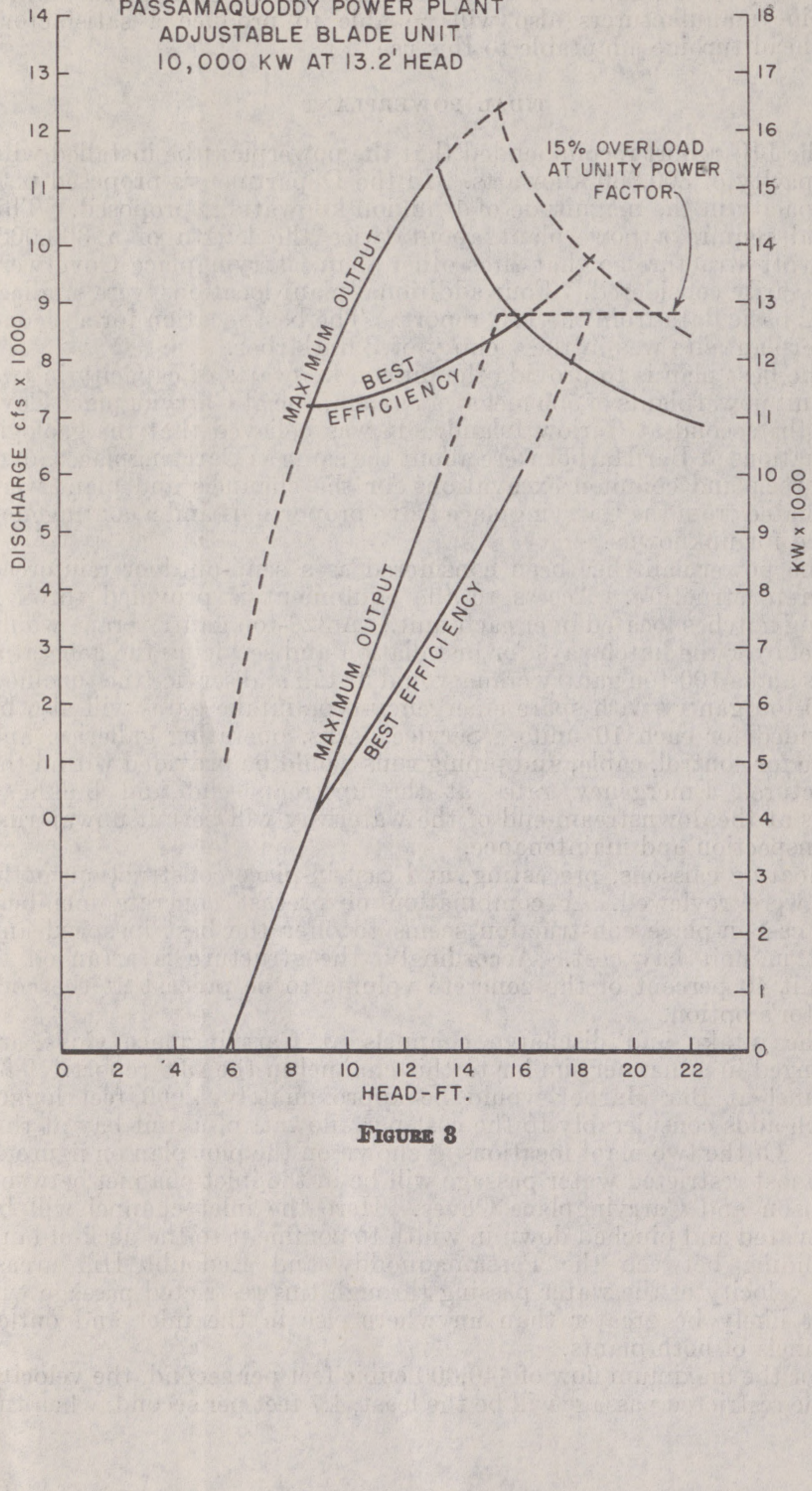

PERFORMANCE CURVES
PASSAMAQUODDY POWER PLANT
ADJUSTABLE BLADE UNIT
10,000 KW AT 13.2' HEAD
15% OVERLOAD AT UNITY POWER FACTOR
MAXIMUM OUTPUT
BEST EFFICIENCY
MAXIMUM OUTPUT
BEST EFFICIENCY
DISCHARGE cfs x 1000
KW x 1000
HEAD-FT.
0 2 4 6 8 10 12 14 16 18 20 22
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

FIGURE 3

Manufacturing Co. because it offers complete electrical reliability, simplicity of design, and low construction cost. Undoubtedly other turbine manufacturers also will be able to produce a satisfactory low-head turbine adaptable to this use.

TIDAL POWERPLANT

The IJC report recommended that the powerplant be installed with a capacity of 300,000 kilowatts. In the Department's proposed plan a capacity in the magnitude of 1 million kilowatts is proposed. This would require a powerplant about twice the length of a 300,000-kilowatt structure so that sites other than Carryingplace Cove were necessarily considered. Four additional plant locations were studied, using basic data from the IJC report. The best location for a second powerplant site was in the vicinity of Bar Harbor.

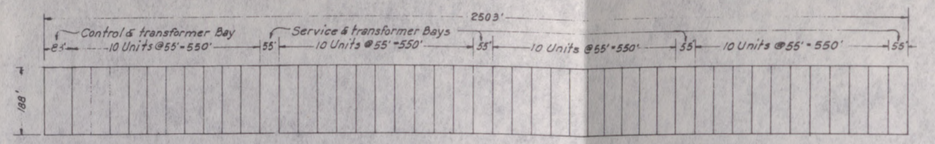
The best plan is to provide the million kilowatts of capacity in two 50-unit powerplants of 500 megawatts each, one at Carryingplace Cove and the second at Carlow Island. It was believed that the geologic formations at Bar Harbor were about the same as Carryingplace Cove. The rock and common excavations for the channels and plant were estimated from the Carryingplace Cove proportions and a contingency added for unknowns.

The powerplant has been considered as a semi-outdoor reinforced concrete structure. Access to the equipment is provided through rolling hatches located over each unit. A 320-ton gantry crane would travel over the hatchways for installation and servicing the generator units and a 100-ton gantry crane would install and service the turbines. A 90-ton gantry with spare emergency-type intake gates will also be provided for each 10 units. Service decks, operating galleries, and space for control, cable, and piping runs would be provided within the structure. Emergency gates at the upstream end and bulkhead gates at the downstream end of the waterway will permit unwatering for inspection and maintenance.

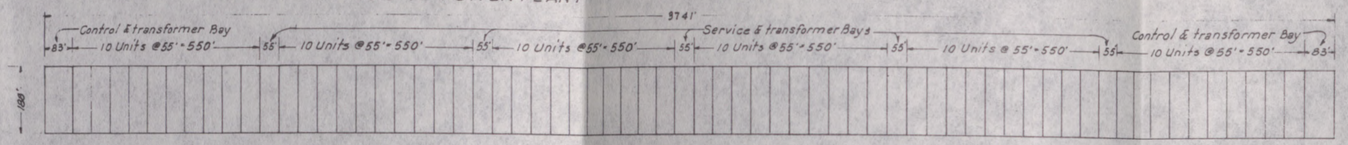
Floating caissons, precasting, and cast-in-place construction methods were reviewed. A combination of precast concrete members and cast-in-place construction seems to offer the best in speed and least in unit bay cost. Accordingly, the structure is arranged to permit 40 percent of the concrete volume to be precast at the contractor's option.

The intake and discharge channels at Carryingplace Cove are arranged in a manner similar to this channel in the IJC report. The channel at Bar Harbor would be approximately 4,000 feet longer which adds considerably to the cost per kilowatt of a unit bay at this site. Of the two plant locations as shown on the plot plan on figure 4, the most restricted water passage will be in the inlet channel between Johnson and Carryingplace Coves. Here the inlet channel will be excavated and pinched down in width to confine it to the neck of land extending between the Passamaquoddy and Redoubt Hill areas. The velocity of the water passing through this restricted passage will most likely be greater than anywhere else in the inlet and outlet channels of both plants.

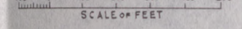
For the maximum flow of 440,000 cubic feet per second, the velocity in the restricted passage will be the least, 4.7 feet per second, when the

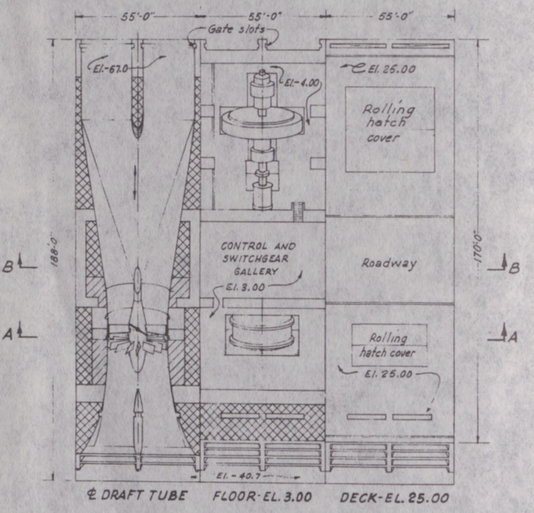


DECK-EL. 25.00
40 UNIT POWER PLANT

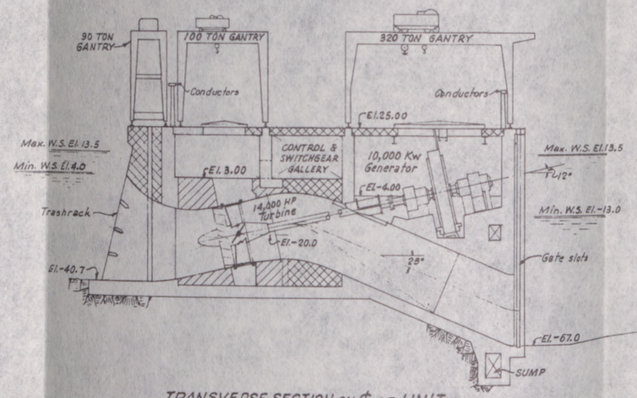


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60 UNIT POWER PLANT

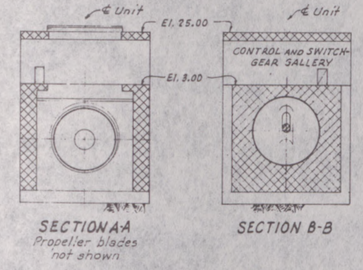


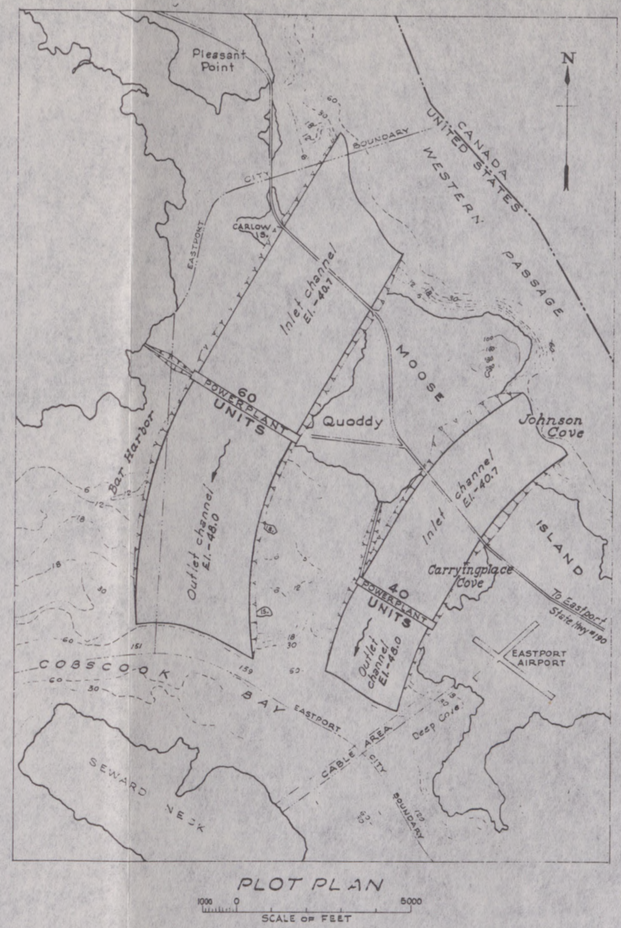


TYPICAL PLANS



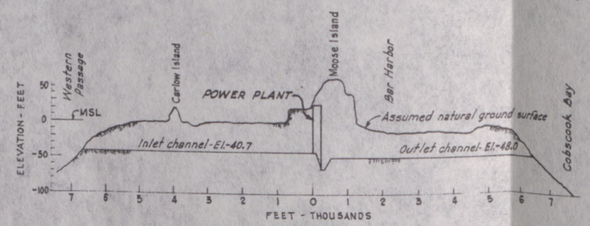
TRANSVERSE SECTION ON ℄ OF UNIT



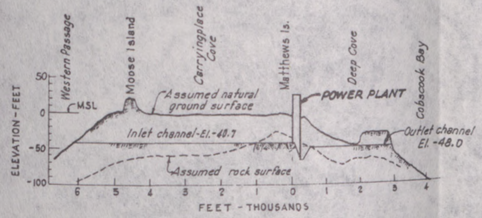


PLOT PLAN

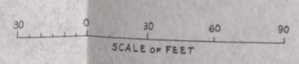
1000 0 5000
SCALE OF FEET



PROFILE THRU 60-UNIT POWER SITE



PROFILE THRU 40-UNIT POWER SITE



CONCRETE SYMBOLS

- Cast in place
- Cast in place or precast option
- Second stage.

UNIT DATA

GENERATOR ..... 10,000 Kw
TURBINE; ADJUSTABLE PITCH PROPELLER TYPE,
- HORSEPOWER 14,000
- SPEED ..... 43.4 rpm
- HEAD ..... 13.2 Ft
- Q ..... 11,000 cfs

CRANES,
ONE 320 TON SANTRY EACH POWERPLANT
ONE 100 TON SANTRY EACH POWERPLANT
ONE INTAKE GATE SANTRY CRANE WITH ONE PAIR OF EMERGENCY-TYPE INTAKE GATES FOR EACH TEN UNITS.

NOTE: THE ARRANGEMENT SELECTED IN THE REPORT UTILIZES 50 UNITS IN EACH POWERPLANT INSTEAD OF 60 AND 40 UNITS AS SHOWN.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

PASSAMAQUODDY TIDAL POWER PROJECT
REVIEW OF IJC REPORT
RECONNAISSANCE ESTIMATE
40 AND 60 UNIT POWER PLANTS
GENERAL PLANS, SECTIONS AND PROFILES

DRAWN MCF ..... SUBMITTED .....
TRACED ..... RECOMMENDED .....
CHECKED KCA ..... APPROVED .....
CHIEF ENGINEER

DENVER, COLORADO APRIL 5, 1963 | X-Dr-D-893

36-986 O - 64 (Face p. 40)

FIGURE 4

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MANHATTAN, KANSAS

upper and lower pool elevations are 13.50 and 0.3, respectively, and the greatest, 5.7 feet per second, when the upper and lower pool elevations are 4 and 9.2, respectively.

DEEP-WATER STRUCTURES AND GATES

The IJC's report indicates that a large portion of the project cost is involved in the deep-water structures in Western Passage, Indian River, and Head Harbour Passage. In view of its experience in deep-water construction cost, the Bureau of Yards and Docks of the Navy was requested to review the IJC's report and to advise whether there were any breakthroughs in construction techniques or design which occurred since the preparation of the IJC's report which might hold promise for reducing the cost of the deep-water structures and coffer dams required during the construction phases. The Bureau of Yards and Docks concluded from their review that due to the thoroughness and modernity of the investigations, no major construction breakthroughs can be offered. However, several suggestions for reducing costs were offered, as shown in the following quoted portion of the report.

The Chief Engineer's Office of the Bureau of Reclamation concurred that there might be an opportunity for saving money in the actual construction phases, but that it may be necessary to add some additional embankment material.

In order to determine the impact of peaking power operation on the gates, a review was likewise made of the IJC recommendations. This review indicated general concurrence with the IJC design, but additional studies for prevention of icing with consideration of an alternate type of gate design using a horizontal shaft, square leaf, butterfly valve are desirable.

The following is quoted from the report of the Bureau of Yards and Docks which was transmitted to the Department of the Interior on January 22, 1963:

> Review of the project studies indicates that a high degree of thoroughness has been applied to the investigations. Because of this thoroughness and modernity, no new major construction breakthroughs can be offered. However, some observations and suggestions are submitted for consideration.
>
> a. The Board's investigation so far has logically not been done with the intention of producing definitive designs for the various installations of dams and cofferdams, but with the idea of producing simple schematic outlines to be used as bases for computing cost conservative estimates. These estimates are then applied in relation to the benefits to be derived in determining the relative cost-benefit ratios for the project. There is no doubt that, in succeeding stages of preliminary and finalized design, refinements would be made which would result in some savings for certain features of the work and thus would tend to reduce the preliminary estimates. However, due to the complex nature of the project, it is equally probable that conditions unforeseen in the preliminary investigation analyses will result in added costs

probably offsetting possible savings. Without going through the complete steps of detailed design, it would be highly inadvisable to introduce additional cost saving concepts as a basis for justifying reduced estimates and thus risk the hazards that these could not be realized in the overall project cost.

b. The evaluation studies performed by the International Passamaquoddy Engineering Board have been carried sufficiently far to include consideration of—

(1) Various types of core material and several arrangements and combinations of materials in the cross sections of the structures.

(2) Armoring methods based on generally standarized procedures.

(3) Cofferdam structures employing standard tried and true examples in both shallow and deep water. The schemes are based on sound and conservative engineering principles and are probably the only safe bases for evaluating a project of this type.

(4) Depositing of the fills based primarily on the use of standard barges which are of about 1,400-ton maximum capacity. These are probably the cheapest methods so far devised for placing rock in large quantity.

c. If the project generates sufficient interest to justify employment of further study effort in the next planning stage, the following list contains items which are typical of those which might be investigated:

(1) Greater accuracy of control for the deposit of the materials for the cores of the dams. The three methods of placement described in the Board report are bottom-dump scows, end-dumping trucks working out from shore, and special bottom-dump buckets which would be lowered through the water by crane. The utilization of hinged trunks or tremies on the bottom-dump barges may be more effective in preventing scatter and lateral transport by swift currents. It would be well also to consider the possibility of using flat-decked barges equipped with articulated tremies into which bulldozers on the decks could push the materials. Another alternative would be the employment of vertical towers with elevator-operated skips for placement of materials. The use of underwater television cameras for determination of surface contours of the partially completed mounds would be a refinement in overall control methods. Imprisonment of the sand before dumping by packaging it in plastic bags and dumping the bags, instead of the raw materials, would result in greater accuracy and less segregation than by surface dropping, but the relative economy of this method would have to be proven.

(2) Alternative methods of transport for the core materials like cableways and belt conveyors. The quantities involved are so tremendous that there must be an enormous transport system. A fleet of only two or three barges would probably match any cableway. This project would probably use 20 or 30 barges.

(3) Further refinement in the widths and design slopes of the mound, with an eye toward reduction in the total quantities required. These refinements would have to keep in mind the various design criteria to satisfy environmental conditions of wave action, currents, percolation rates, and foundation conditions. For example, if wave action were the only criteria, the side slopes of the dams could probably be made steeper, with ample stability, based on experience with a recently constructed breakwater at the Naval Station, Newport, R.I.

(4) Use of nuclear energy explosions for building the dams. There is a possibility that in the future methods may be developed so that by the use of nuclear explosives it would be possible to reduce the cost of some features of this project. This is not within present engineering talent capability.

(5) Placement of the smaller size core materials by means of a hydraulic dredge with submerged pipeline and discharge.

(*d*) The order of magnitude of any possible economies may not prove to be large enough to be really significant in changing the present overall picture. It should be remembered that a significant reduction in the total cost of the dam and coffer dam structures, below that reflected in the present cost estimates will be difficult of accomplishment unless unusual breakthroughs can be applied to all phases of the design and construction features. It would be really unusual for such a set of conditions to prevail. A breakthrough on some one important feature may significantly reduce its cost but the impact of this reduction on the total cost of structures would be felt to much lesser extent.

(*e*) In the implementation of a construction project of this magnitude, the advisability of using a system of program evaluation and report techniques similar to the PERT system should be considered. Weather conditions prevailing at this site would certainly dictate the use of carefully planned methods for the scheduling of construction. A system like PERT with machine control and guidance would be an almost indispensable aid to successful accomplishment of the entire construction program.

(*f*) It would not be basically sound to predict a large reduction in the presently estimated total cost of the dam and coffer dam structures. The possible methods of reducing costs outlined above are all subject to confirmation as to feasibility and relative economy. No doubt savings can be made and opportunities will be found in the later design stages for certain features. However, it is very doubtful that these savings will offset costs now unforeseen which will inevitably arise during a detailed design. The estimates are probably properly conservative for an evaluation of a project of this degree of complexity. It is believed that the cost estimates have properly been based on concepts which are reasonable, feasible, sound, and conservative, but which are subject to refinement in later, more detailed studies.

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TRANSMISSION SYSTEM

The project plan envisions a basic transmission system interconnecting the Passamaquoddy tidal powerplant with the Dickey plant on the upper St. John River serving Maine, other areas in New England, and New Brunswick, and terminating in the Boston, Mass., area A diagram of the ultimate transmission plan developed by the chief engineer, Bureau of Reclamation, is included in figure 5 of the report.

Two 345-kilovolt transmission circuits are visualized for delivery of power to Boston with a switching point at Bangor, Maine, for interconnecting with three 230-kilovolt transmission circuits from the Dickey powerplant to Bangor, Maine. These lines are primarily designed for the project purposes, but their offpeak capacity could be utilized by other power systems in the area. The power transmission system was designed for stable operation following double line to ground faults near the powerplants.

The transmission diagram indicates lines extending to Fredericton, New Brunswick, which could deliver power to Canada providing suitable arrangements are made.

COST ESTIMATES

This study is basically a review of the IJC's plan for the Passamaquoddy tidal power project; hence, the cost estimates used in the IJC's report were utilized to the maximum extent. In those instances where variations exist, cost estimates were prepared by the chief engineer's office of the Bureau of Reclamation, Denver, Colo. The cost estimates used in the report are as follows:

Passamaquoddy construction costs

Item	Installed capacity, 500 megawatts	Installed capacity, 1,000 megawatts
Powerplant	$157,771,400	$351,375,200
Filling gates	64,585,300	64,585,300
Emptying gates	61,108,300	61,108,300
Locks	20,187,500	20,187,500
Dams	80,261,000	80,261,000
Lubec channel	633,500	633,500
Fishways	919,100	919,100
Relocations	3,914,000	4,500,000
Lands and damages	1,859,000	2,500,000
Subtotal	391,239,100	586,069,900
Contingencies	68,369,400	110,924,500
Subtotal	459,608,500	696,994,400
Engineering design, supervision and administration	41,364,800	62,295,000
Total	500,973,300	759,289,400

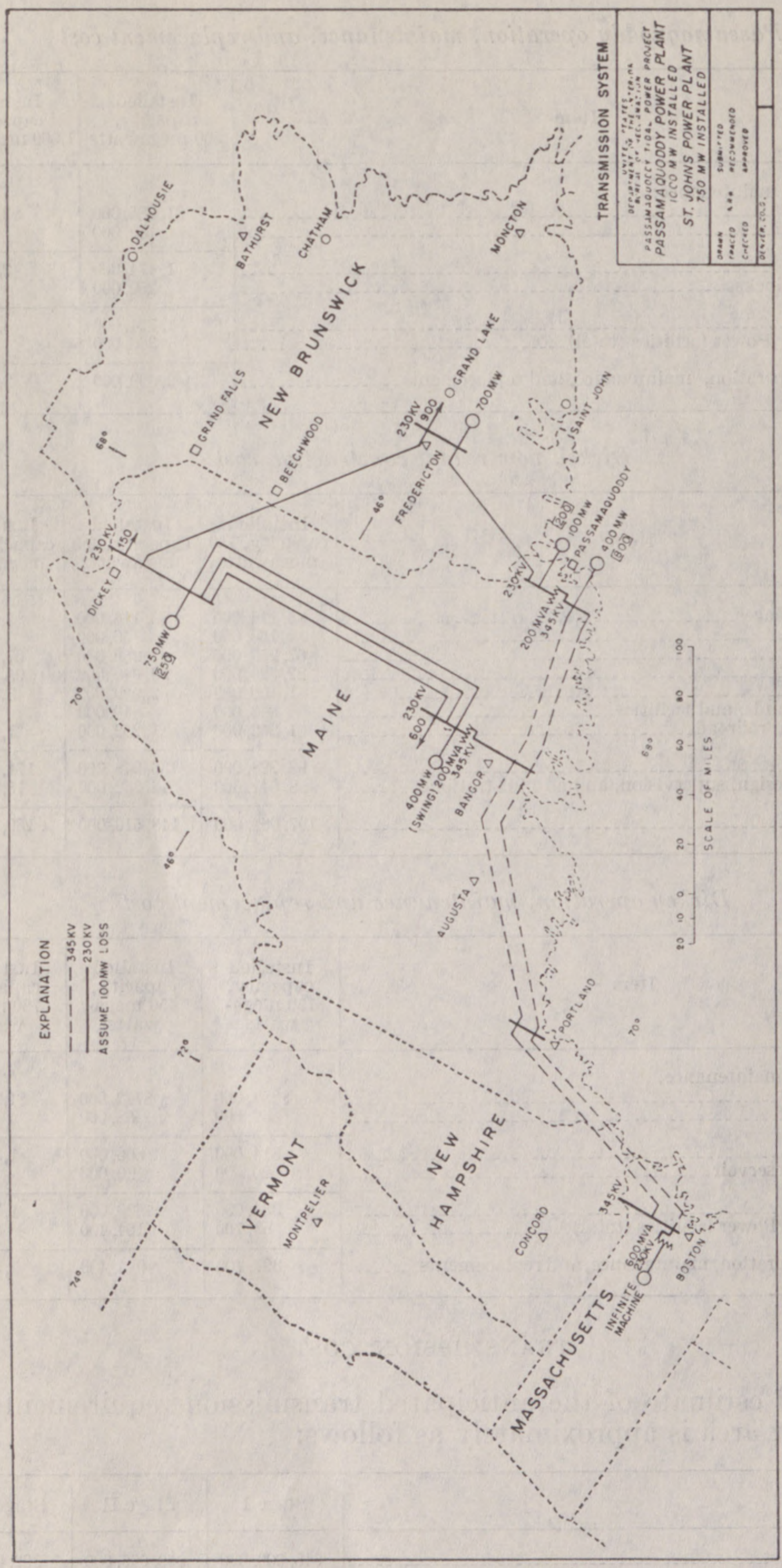

TRANSMISSION SYSTEM
PASSAMAQUODDY TIDAL POWER PROJECT
PASSAMAQUODDY POWER PLANT
1000 MW INSTALLED
ST. JOHNS POWER PLANT
750 MW INSTALLED
DRAWN
TRACED
CHECKED
DENVER, COLO.
SUBMITTED
RECOMMENDED
APPROVED
EXPLANATION
345 KV
230 KV
ASSUME 100MW LOSS
NEW BRUNSWICK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
DALHOUSIE
BATHURST
CHATHAM
MONCTON
SAINT JOHN
GRAND FALLS
BEECHWOOD
DICKEY
FREDERICTON
GRAND LAKE
PASSAMAQUODDY
750 MW
700 MW
100 MW
400 MW
200 MVA W/Y 345 KV
230 KV 900
230 KV 150
230 KV 600
400 MW (SWING) 200 MVA W/Y 345 KV
BANGOR
AUGUSTA
PORTLAND
MONTPELIER
CONCORD
BOSTON
345 KV
600 MVA 230 KV
INFINITE MACHINE
68°
70°
72°
74°
46°
SCALE OF MILES

FIGURE 5

Passamaquoddy operation, maintenance, and replacement cost

Item	Installed capacity, 500 megawatts	Installed capacity, 1,000 megawatts
Operation and maintenance:		
Powerplant	$1,385,000	$2,750,000
Switchyard	89,000	225,000
Subtotal	1,474,000	2,975,000
Gates and locks	250,000	250,000
Total	1,724,000	3,225,000
Replacements: Power facilities (total)	366,000	742,000
Total, operation, maintenance, and replacements	2,090,000	3,967,000

Dickey powerplant construction cost

Item	Installed capacity, 150 megawatts	Installed capacity, 450 megawatts	Installed capacity, 750 megawatts
Lands and damages	$5,116,000	$5,116,000	$5,116,000
Relocations	150,000	150,000	150,000
Dams	67,250,000	67,250,000	67,250,000
Powerplant	22,520,000	59,640,000	95,880,000
Switchyard	1,100,000	2,000,000	3,600,000
Buildings, grounds, and facilities	840,000	840,000	840,000
Access road and railroad	1,252,000	1,252,000	1,252,000
Subtotal	98,228,000	136,248,000	174,088,000
Engineering, design, supervision, and administration	8,841,000	12,262,000	15,668,000
Total	107,069,000	148,510,000	189,756,000

Dickey operation, maintenance and replacement cost

Item	Installed capacity, 150 megawatts	Installed capacity, 450 megawatts	Installed capacity, 750 megawatts
Operation and maintenance:			
Powerplant	$282,000	$742,000	$1,200,000
Switchyard	32,000	58,000	104,000
Subtotal	314,000	800,000	1,304,000
Dam and reservoir	20,000	20,000	20,000
Total	334,000	820,000	1,324,000
Replacements: Power facilities (total)	63,700	164,400	264,500
Total, operation, maintenance, and replacements	397,700	984,400	1,588,500

TRANSMISSION COST

A broad estimate of the anticipated transmission requirements for the project area is approximately as follows:

	Stage I	Stage II	Stage III
Construction cost	$18,000,000	$50,000,000	$92,000,000
Annual operation, maintenance, and replacement cost	150,000	439,000	538,000

ECONOMIC AND FINANCIAL ANALYSIS—PROJECT EVALUATION

The economic justification and financial feasibility of the potential Passamaquoddy-upper St. John project were analyzed using the current evaluation procedures adopted by the U.S. Government. Project benefits and costs were calculated for a 100-year period of analysis using a 2⅞-percent interest rate. Recreation and area redevelopment were included as project purposes. On the basis of these analyses, it was found that the potential Passamaquoddy-Dickey power development is economically justified. Project benefits would exceed project costs in the ratio of 1.27 to 1.

Although we propose that the tidal power project and upper St. John River development be fully integrated, our economic analysis clearly indicates that either project is financially feasible and could stand on its own feet as a separate project.

The project was also found to be financially feasible. Repayment of the cost allocated to power could be accomplished with interest at 2⅞ percent on the unpaid balance within a period of 50 years after each power unit becomes revenue producing. The cost allocated to recreation and area redevelopment would be nonreimbursable.

The project is assumed to be developed on the following schedule:

Stage I—Construction of Dickey Dam and Reservoir and initial installation of 150 megawatts of power-generating facilities.

Stage II—Construction of Passamaquoddy tidal basin facilities and installation of 500 megawatts of power-generating facilities at Passamaquoddy and an additional 300 megawatts of power-generating facilities at Dickey powerplant.

Stage III.—Completion of the 1,000-megawatt installation at Passamaquoddy and 750-megawatt ultimate installation at Dickey.

It was assumed that construction of stage II facilities would be completed 5 years after completion of stage I facilities, and the construction of stage III facilities would be completed 10 years after the completion of stage II facilities.

BENEFITS AND COSTS

Construction of the Passamaquoddy-Dickey power development would create annual equivalent benefits with associated annual equivalent Federal project costs and benefit-cost ratios as follows:

	Benefits	Costs	Benefit-cost ratio
Stage I	9,845,000	3,856,000	2.55 to 1
Stage II	29,235,000	24,427,000	1.20 to 1
Stage III	46,849,000	36,872,000	1.27 to 1

BENEFITS

Benefits creditable to the project were analyzed for three project purposes—power, recreation, and area redevelopment. A discussion of the benefits for each of these purposes follows.

Power benefits.—The annual equivalent power benefits from the potential Passamaquoddy power development are estimated to be $42,129,000. The standard energy-capacity approach was followed in

estimating these power benefits. The energy and capacity values used in this analysis were based on the alternative costs of obtaining equivalent power supplies in the New England-New Brunswick area, utilizing the cost of highly efficient, large size privately financed thermal plants in the Boston area. Allowance was made for transmission costs in converting these power values to at-site conditions. The unit power values used in evaluating power benefits are summarized below; and the estimates of dependable capacity, average annual energy generation, and power benefits for the potential project for initial and full development are summarized in the attached table.

[Value in mills per kilowatt-hours]

Average annual energy:	
Maine	4.1
Boston	3.2
Downstream	3.2

[Per kilowatt]

Capacity:	
Dickey:	
At-market value	None
Less transmission	None
At-site value	$31.20
Passamaquoddy peaking:	
At-market value	29.15
Less transmission	3.00
At-site value	26.15

Power benefits and related data, potential Passamaquoddy-Dickey power development

	Initial stage of development	Full development
Capacity:	*Milliwatts*	*Milliwatts*
Dickey	150	750
Passamaquoddy	----------	1,000
Dependable capacity:		
Dickey	150	250
Passamaquoddy	----------	1,000
Adjusted for 10 percent losses:		
Dickey	136	225
Passamaquoddy	----------	9
Annual energy:		
Total energy:		
At-site production:	*Milliwatt-hours*	*Milliwatt-hours*
Dickey	751,000	1,250,000
Passamaquoddy	----------	1,318,000
Downstream production	656,000	656,000
Adjusted for 8 percent losses:		
At-site production:		
Dickey	695,000	1,150,000
Passamaquoddy	----------	1,213,000
Downstream production	607,000	607,000
Annual power benefits (total):		
Capacity:	*Thousands*	*Thousands*
Dickey	$4,243	$7,020
Passamaquoddy	----------	23,535
Energy:		
Dickey:		
At-site	3,475	5,750
Downstream	1,942	1,942
Passamaquoddy	----------	3,882
Total	9,660	42,129

RECREATION BENEFITS

The recreational aspects of the potential Passamaquoddy tidal development have been studied by the Bureau of Outdoor Recreation. Passamaquoddy Bay and Cobscook Bay, where the Passamaquoddy tidal power project would be located, offer a panorama of water and scenic views which are complemented by the Fundy Isles of Campobello, Deer Island, and Grand Manan—all located in Canada.

The principal attraction to tourists in the area would be the tidal power project itself. An engineering marvel, its operations would feature the rise and fall of the tides, the impounding of water in two natural pools, navigation locks for unrestricted movement of boats, emptying and filling gates, and power transmission.

While the population trend of the Nation and the State of Maine has been generally going up, the number of persons living in Washington County, headquarters of the proposed project, decreased considerably from 1950 to 1960. Of all the counties in the State, Washington County has the lowest median income. Construction of the tidal power project would greatly increase its recreation potential and economic status.

Many thousands of persons who now visit other parks and attractions in the area doubtless would combine their trips to those area with a stopover at Passamaquoddy. Acadia National Park is only 130 miles south of the proposed tidal power project, and West Quoddy Head State Park and Moosehorn National Wildlife Refuge are located nearby.

Because of the uniqueness of the proposed Passamaquoddy tidal power project and its potential attraction for travelers, it is recommended that outdoor recreation provisions be made in project development plans for:

1. A visitor center with adequate parking facilities.
2. Interpretative signs at appropriate points and working models of the tidal power project to be housed in the visitor center.
3. Picnic areas.
4. Boat launching sites at convenient locations.
5. Frequent roadside overlooks.

Construction of these facilities not only would enhance visitors' enjoyment of the Passamaquoddy project, but would complement attractions of Maine's Quoddy Head Park and the Federal Government's Moosehorn National Wildlife Refuge.

The Bureau of Outdoor Recreation estimates the annual recreation visitation to Passamaquoddy at present is about 216,000 visitor-days and would be 500,000 visitor-days under 1975 conditions.

The number of visitors is expected to increase to 4,675,000 in the year 2025. The desirability of outdoor recreation is enhanced by such attractions as Acadia National Park, other State recreation

areas, and associated recreation activities in the Passamaquoddy project, shown on figure 6.

The average annual benefits associated with this recreation activity adjusted for the changes over time are estimated to be $2,065,000 based on recreational values of $0.80 per visitor-day. It is recognized that there are recreation benefits on the upper St. John River, but these have not been evaluated for inclusion in this study.

AREA REDEVELOPMENT BENEFITS

Both the Passamaquoddy and Dickey power developments are located within counties which are designated as "redevelopment areas" based on criteria set forth in the Area Redevelopment Act of 1961 (75 Stat. 47); therefore, construction of the potential project would significantly reduce unemployment in these two areas.

Current evaluation procedures require the measurement of benefits attributable to the value of labor required for the construction and operation of a project that otherwise would not be fully utilized. Such benefits are identified in this analysis as area redevelopment benefits.

In evaluating the benefits which would accrue from area redevelopment, wages paid to skilled and unskilled labor required for project construction, and salaries paid to personnel for project operation were considered. Labor inputs necessary for the construction of the potential project were estimated through use of information obtained from water resource projects recently constructed by the Bureau of Reclamation. Information on the present extent of unemployment in the affected labor-market areas and the character of the unemployed labor force was obtained from the Employment Security Commission, State of Maine. Utilizing this information, the available local unemployed labor force was compared with the projected construction work requirements by construction years to estimate the amount of increased employment of the local labor force creditable to project construction. The associated construction wages converted to annual equivalent values for a 100-year period of analysis were used as the construction employment component of the area redevelopment benefits.

Salaries and wages paid to the permanent operating personnel were estimated and used in evaluating the contribution of project operation to local employment. However, in accordance with current procedures of the Department of the Commerce, the overall employment period was established at 20 years from initiation of construction on the first phase of the project, and a declining scale of values reaching zero in the 21st year was utilized. The employment benefits associated with project operation were evaluated as the annual equivalent of this series of declining values when spread over the 100-year period of analysis for the project. The annual area redevelopment benefits creditable to the Passamaquoddy-Dickey power development as estimated in the manner described are $2,655,000.

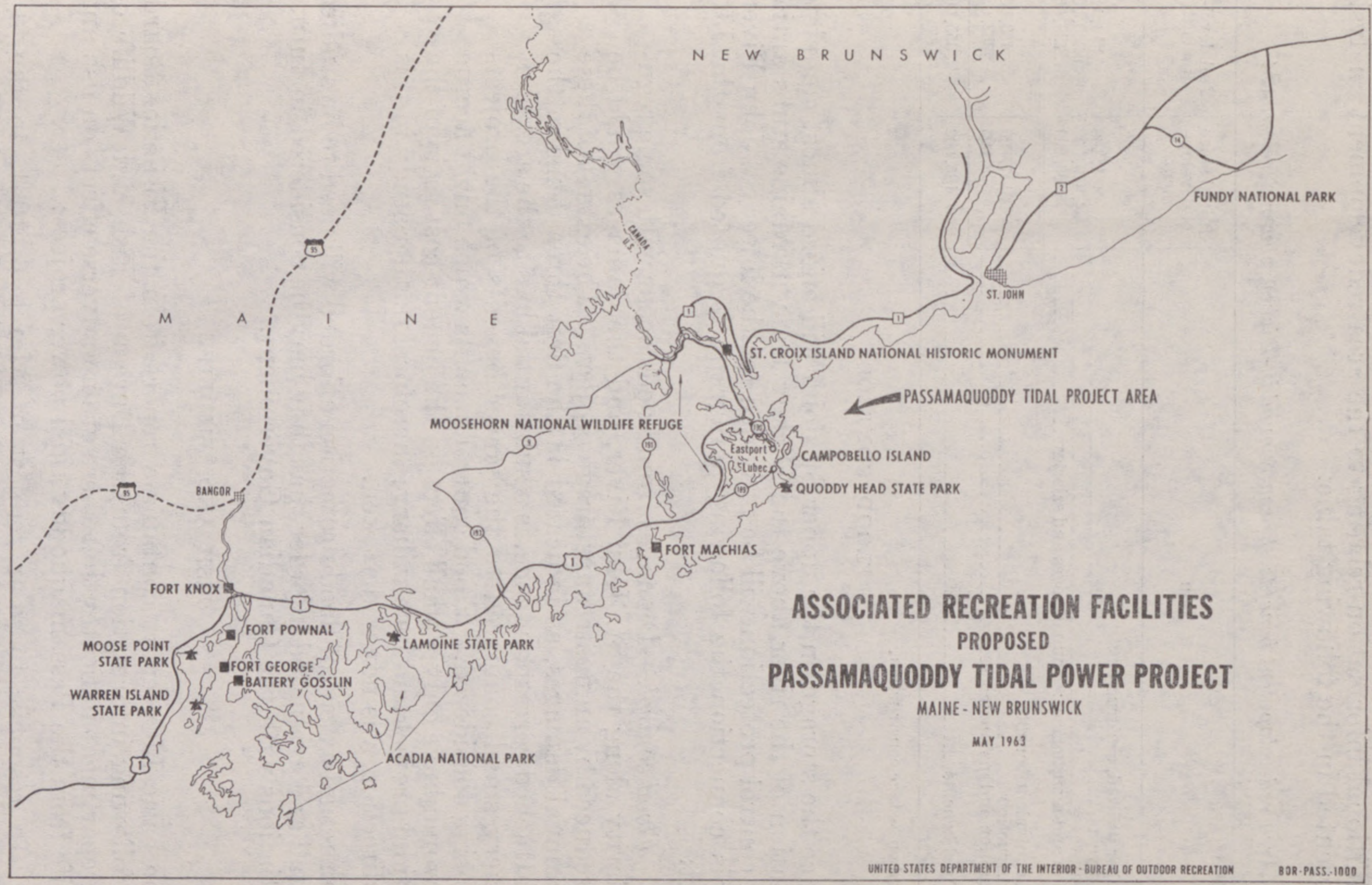

NEW BRUNSWICK
MAINE
CANADA
U.S.
FUNDY NATIONAL PARK
ST. JOHN
ST. CROIX ISLAND NATIONAL HISTORIC MONUMENT
PASSAMAQUODDY TIDAL PROJECT AREA
MOOSEHORN NATIONAL WILDLIFE REFUGE
Eastport
Lubec
CAMPOBELLO ISLAND
QUODDY HEAD STATE PARK
BANGOR
FORT MACHIAS
FORT KNOX
FORT POWNAL
LAMOINE STATE PARK
MOOSE POINT STATE PARK
FORT GEORGE
BATTERY GOSSLIN
WARREN ISLAND STATE PARK
ACADIA NATIONAL PARK
ASSOCIATED RECREATION FACILITIES
PROPOSED
PASSAMAQUODDY TIDAL POWER PROJECT
MAINE - NEW BRUNSWICK
MAY 1963
UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF OUTDOOR RECREATION
BOR-PASS.-1000

FIGURE 6

Additional information relating to the area redevelopment analysis is presented in the following table:

Area redevelopment benefits, Passamaquoddy-Dickey power development

Item	Initial stage of development	Full development
Local labor utilized, construction:		
Man-years	1,160	[1] 14,116
Total wages	$4,800,000	$80,360,000
Operation and maintenance: Annual wages and salaries	$200,000	$2,729,000
Annual equivalent benefits:		
Construction	$147,000	$2,453,000
Operation and maintenance	38,000	202,000
Total benefits	185,000	2,655,000

[1] Based on 3-stage construction.

FLOOD CONTROL

Since the storage on the upper St. John will afford almost complete regulation of the river above the Dickey Dam in Maine stubstantial flood control protection will be provided for the lower St. John River. In this connection the following paragraph is quoted from the IJC report:

> *Flood control.*—Damages from floods occur with some regularity along the St. John River, and the damages would be reduced by an upstream storage project. The extent of these annual damages, as indicated in the first three items in the attached correspondence, is a substantial loss to the area, but very small compared to the power benefits of the projects being considered. Flood control benefits which might accrue would have only a small effect on the benefit-cost ratio of the tidal project and its auxiliary; therefore, further study in this direction was not undertaken.

The actual extent of flood protection afforded will need to be studied in detail and evaluated in order that they may be considered in future negotiations with the Canadian Government.

FISH AND WILDLIFE

The basic IJC report contains a report from the Fisheries Board. The following information from the Bureau of Fish and Wildlife of the Department indicates that there are no adverse effects on fish and wildlife from the Passamaquoddy tidal power project:

> In response to your request of March 6, 1961, to the Bureau of Sport Fisheries and Wildlife, the Service has reviewed the report on the Passamaquoddy tidal power project. Personnel of the Bureau of Sport Fisheries and Wildlife in Boston and the Bureau of Commercial Fisheries in Gloucester have discussed the matter with the Passamaquoddy-St. John Study Committee. Based on this review and the discussions, the Fish and Wildlife Service concludes

that further studies of the marine fisheries or sport fisheries and wildlife as they would be affected by construction and operation of the Passamaquoddy project would not be required at this time. The Service reaffirms its opposition to any use of the Rankin Rapids Dam and Reservoir as a source of supplemental power because the construction of this project would flood the Allagash River.

The Passamaquoddy Committee believes that with the availability of Passamaquoddy power in eastern Maine and load factor power from the upper St. John River, the possibility is increased for restoring the once abundant Atlantic salmon to some of the small coastal streams in that part of the State. Most of these streams now contain small inefficient hydroelectric powerplants and upstream storage developments which block the migration of anadromous fish. These obstacles to fish migration could be eliminated with the development of the alternate sources of power envisioned in this report.

SUMMARY OF BENEFITS

The benefits presented above are summarized in the following tabulation:

Summary of estimated annual benefits

Item	Amount	
	Initial stage	Ultimate stage
Power	$9,660,000	$42,129,000
Recreation		2,065,000
Area redevelopment	185,000	2,655,000
Total	9,845,000	46,849,000

BENEFIT-COST RATIO

The ratio of benefits to costs for the first stage of development is 2.55 to 1, and for the full development, 1.27 to 1.

Cost allocation

The costs of the potential project have been allocated among the three functions of power, recreation, and area redevelopment using the alternative justifiable method of allocation, a 100-year period of analysis, and 2⅞ percent interest. The basic allocation in the following table, is summarized below.

Project purpose	Construction	Interest during construction	Operation maintenance, and replacements
Power	$847,119,000	$68,279,000	$5,482,000
Area redevelopment	57,322,000	4,584,000	41,000
Recreation	44,605,000	3,537,000	32,000
Total project	949,046,000	76,400,000	5,555,000

FEDERAL PROJECT COSTS

Annual Federal costs associated with the benefits for the potential Passamaquoddy-Dickey power development are estimated at $36,872,000 based on a 100-year analysis and 2⅞ percent interest. The comparable estimate for the initial level of development is $3,856,000. The derivation of these estimates is shown below.

	In total
Initial phase of development:	
Construction costs	$107,069,000
Interest during construction	6,156,000
Total investment	113,225,000
Annual equivalent investment cost	3,458,000
Annual operating costs	398,000
Total annual equivalent costs	3,856,000
Full development:	
Construction costs	949,046,000
Interest during construction	76,400,000
Total investment	1,025,446,000
Annual equivalent investment cost	31,317,000
Annual operating costs	5,555,000
Total annual equivalent costs	36,872,000

Cost allocation, Passamaquoddy-Dickey power development

[In thousands of dollars]

Item	Power	Area redevelopment	Recreation	Total project
Costs to be allocated:				
Construction	----	----	----	949,046
Interest during construction	----	----	----	76,400
Operation and maintenance	----	----	----	4,549
Replacements	----	----	----	1,006
Annual equivalent values:				
Benefits	42,129	2,655	2,065	46,849
Alternative costs	36,872	(1)	(1)	----
Justifiable expenditures	36,872	2,655	2,065	41,592
Specific costs:				
Construction	17,540	----	----	17,540
Interest during construction	1,420	----	----	1,420
Operation and maintenance	4,279	----	----	4,279
Replacements	1,006	----	----	1,006
Total	24,245	----	----	24,245
Remaining justifiable expenses	12,627	2,655	2.065	17,347
Percentage	(72.79)	(15.31)	(11.90)	(100.00)
Joint costs:				
Construction	8,330	1,752	1,362	11,444
Interest during construction	665	140	108	913
Operation and maintenance	197	41	32	270
Replacements	----	----	----	None
Total	9,192	1,933	1,502	12,627
Total allocated costs:				
Construction	25,870	1,752	1,362	28,984
Interest during construction	2,085	140	108	2,333
Operation and maintenance	4,476	41	32	4,549
Replacements	1,006	----	----	1,006
Total	33,437	1,933	1,502	36,872
Summary of allocated costs:				
Construction	847,119	57,322	44,605	949,046
Interest during construction	68,279	4,584	3,537	76,400
Operation and maintenance	4,476	41	32	4,549
Replacements	1,006	----	----	1,006

[1] Exceeds benefits.

PROJECT REPAYMENT

A financial repayment analysis was made using an interest rate of 2⅞ percent on the unpaid balance and a repayment period of 50 years after each power unit becomes revenue producing. The results of this study show that repayment could be accomplished by the following power rates:

Dependable peaking capacity: $24 per kilowatt-year.
Energy: 4 mills per kilowatt-hour.

PASSAMAQUODDY HYDROLOGIC STUDIES

The objective of the hydrologic studies was to determine the feasibility of operating the Passamaquoddy tidal power project as a peakload plant. The studies were based on the assumption that the project proposed by the International Passamaquoddy Engineering Board presented the most desirable plan except for installed capacity and method of powerplant operation.

The extensive studies performed by the Engineering Board were generally directed toward obtaining the greatest amount of energy from the tides. The selected project plan proposed the use of two tidal pools, a high pool and a low pool. The method of operation entailed filling the high pool during high tides and emptying the low pool during low tides, the energy being generated by continuously passing water from the high to the low pool through a 300,000-kilowatt powerplant. The generation of the greatest amount of energy severely limits the peaking capability of the project since at times minimum generation is produced during maximum energy demand. This results from the fact that the 24-hour and 50-minute tidal cycle is out of phase with the 24-hour solar day which governs energy demand.

The two-pool plan is easily adaptable to a peaking method of operation. The primary consideration is that the two pools be operated to provide the maximum amount of head on the powerplant turbines at the start of each peaking period. During the high tide prior to a peaking period, the high pool is filled to the highest possible elevation. Similarly, during the low tide prior to a peaking period, the low pool is emptied to the lowest possible elevation. These pool elevations are then maintained until the start of the peaking period. Following the peaking period, offpeak or secondary energy can then be produced until the time and tides are such that the pools must be filled or emptied in preparation for the next peaking period.

To determine the feasibility of a peaking method of operation, the project was analyzed using installed capacities ranging from 500 to 1,000 megawatts. The data used in the studies except for turbine performance curves were taken from the report to the IJC by the Engineering Board. The turbine performance curves were developed by the Office of Chief Engineer of the Bureau of Reclamation.

COMPUTER STUDIES

The basic operating plan for Passamaquoddy as a peaking powerplant involves the following basic steps:

(*a*) Filling the upper pool through the filling gates to the maximum height possible from the tide.

(*b*) Holding the water in the upper pool until power is desired; then releasing the water through the powerplant to the lower pool.

(*c*) Releasing the water in the lower pool to the ocean through the emptying gates whenever the tide is below the level in this pool.

This plan differs from the IJC plan only in the fact that water would be released as required to meet peaks rather than continuously to supply the base load.

The electricity utility load pattern for the New England-New Brunswick area to be served by Passamaquoddy-St. John has had only one sharp peak each day. Since there is at least one high tide each day, the Passamaquoddy plant can always meet this daily peak. Other alternate tides can be utilized for generation of offpeak power. Since the tides are predictable and dependable, the tide required to meet an anticipated peak load can be detected well in advance of its occurrence.

In view of the repetitious nature of the tides and the vast amount of labor which would be required for computations, an electronic computer was used for routine studies and power calculations. A sample printout from the computer is shown on figure 7.

There follows a series of output curves of the Passamaquoddy operation with installations of 50 to 100 units peaking power durations varying from 30 minutes to 1 hour and 30 minutes. These charts are shown on figure 8.

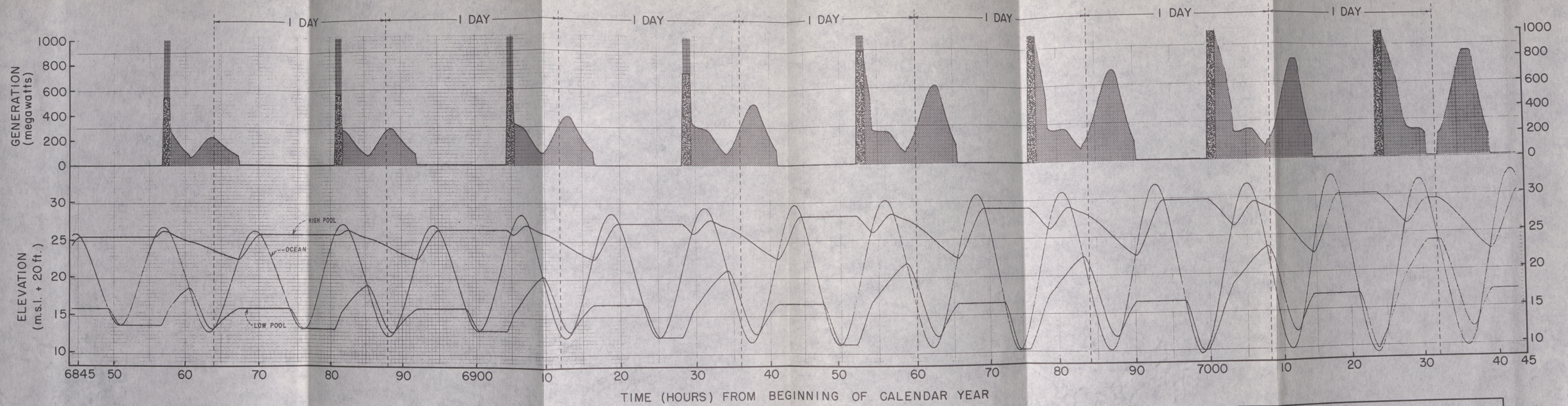
ST. JOHN RIVER HYDROLOGIC STUDIES

The objective of hydrologic studies of the St. John River was to evaluate the feasibility of a coordinated operation of the tidal powerplant with potential developments on the river. Such a coordinated operation would be desirable to integrate a large part of the tidal offpeak energy with the St. John energy making it possible that it could then be utilized as firm energy. Further, additional installed capacity could be provided in the river plant to meet the peaking requirement for the increased firm energy and to firm up the tidal peaking capability during neap tides.

Pertinent streamflow records available for studying the St. John River are as follows:

Station	Available record	Drainage area
		Square miles
St. John River below Fish River at Fort Kent, Maine	October 1926–60	5,690
Fish River near Fort Kent, Maine	September 1929–60	871
Allagash River near Allagash, Maine	September 1931–60	1,250
St. John River at Dickey, Maine	September 1946–60	2,700

For hydrologic studies, streamflow records for the Allagash River and St. John River at Dickey were extended back to September 1929 by correlation with other stations. The four records were then used to derive monthly runoff values for damsites at Big Rapids, Dickey, Rankin Rapids, and Lincoln School. Mass curves of runoff versus time, constructed for the main storage sites, indicate that the critical



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

PASSAMAQUODDY TIDAL POWER PROJECT

POOL OPERATION AND POWER GENERATION
DURING NEAP AND SPRING TIDES

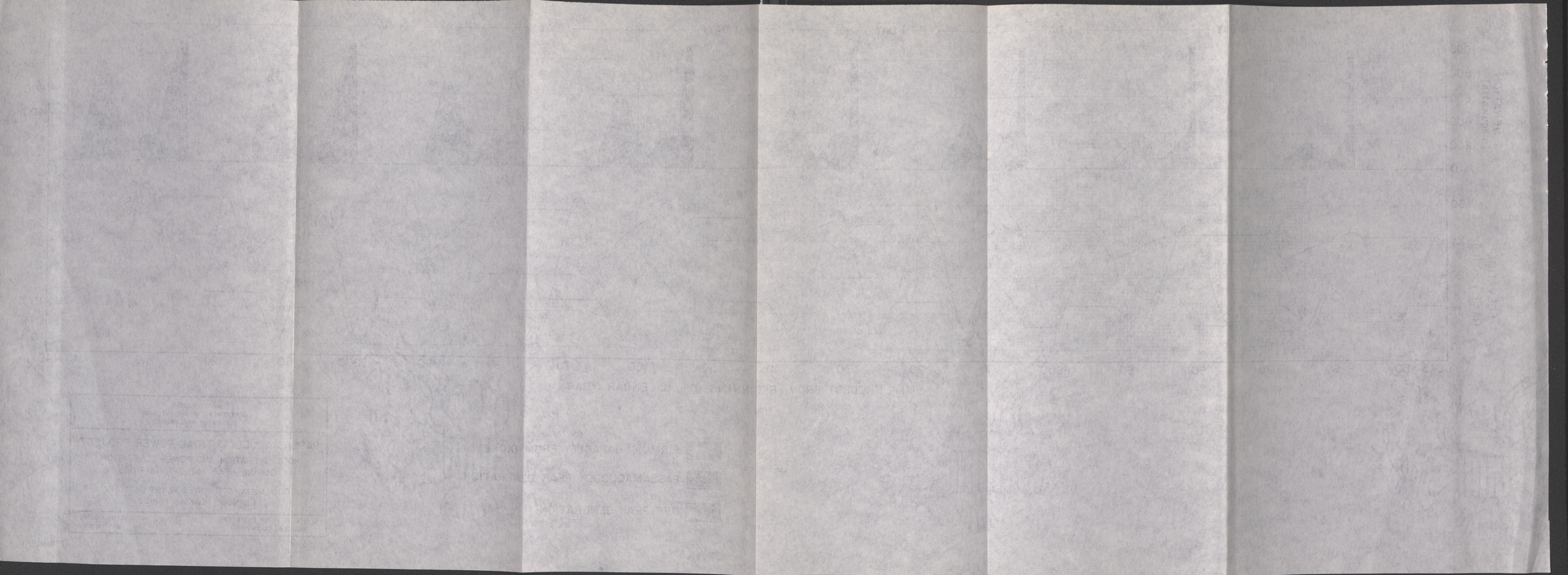
1000 MEGAWATT POWER PLANT CAPACITY
1.0 HOUR PEAKING PERIOD

OFFICE OF CHIEF ENGINEER
DENVER, COLORADO

REVISED WASHINGTON 6/21/63
MAY 14, 1963

FIGURE 7

36-986 O - 64 (Face p. 56)



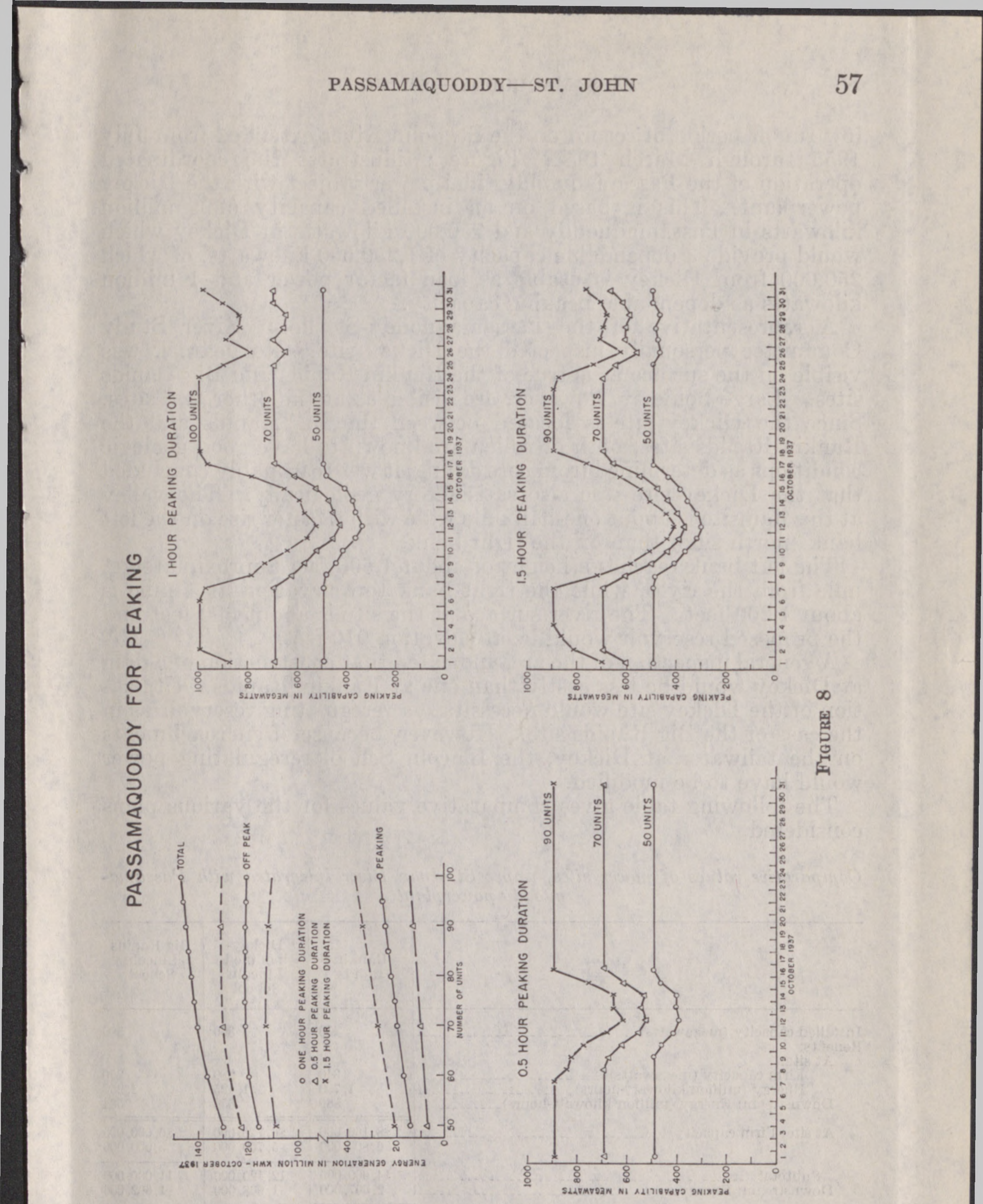

PASSAMAQUODDY FOR PEAKING
1 HOUR PEAKING DURATION
100 UNITS
70 UNITS
50 UNITS
PEAKING CAPABILITY IN MEGAWATTS
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
OCTOBER 1937
1.5 HOUR PEAKING DURATION
90 UNITS
70 UNITS
50 UNITS
PEAKING CAPABILITY IN MEGAWATTS
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
OCTOBER 1937
0.5 HOUR PEAKING DURATION
90 UNITS
70 UNITS
50 UNITS
PEAKING CAPABILITY IN MEGAWATTS
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
OCTOBER 1937
ENERGY GENERATION IN MILLION KWH - OCTOBER 1937
TOTAL
OFF PEAK
PEAKING
O ONE HOUR PEAKING DURATION
Δ 0.5 HOUR PEAKING DURATION
X 1.5 HOUR PEAKING DURATION
140
120
100
40
20
0
50
60
70
80
90
100
NUMBER OF UNITS

FIGURE 8

low runoff period of record on the St. John River extended from July 1955 through March 1958. Figure 9 illustrates the coordinated operation of the Passamaquoddy tidal power project with the Dickey powerplant. This is based on an installed capacity of 1 million kilowatts in Passamaquoddy and 750,000 kilowatts in Dickey which would provide a dependable capacity of 1,250,000 kilowatts, of which 250,000 from Dickey is usable as load factor power and 1 million kilowatts as dependable peaking capacity.

A representative of the Passamaquoddy-St. John River Study Committee personally inspected the Dickey site. No bedrock was visible on the surface as is true of the Rankin Rapids and Big Rapids sites. Large boulders, however, are visible as at the other two sites. Since the Dickey site is located between the Big Rapids and the Rankin Rapids sites, both of which are known to have good geologic conditions as determined from core dilling, it was reasonably concluded that the Dickey site was also satisfactory geologically. The valley at this damsite is about one-half mile wide with a faster rise on the left bank (north side) than on the right bank.

The left bank reaches a height of about 1,500 feet approximately 1 mile from the river, while the right bank top elevation at 1 mile is about 1,200 feet. The river surface at the site is about 600 feet and the proposed reservoir would be at elevation 910 feet.

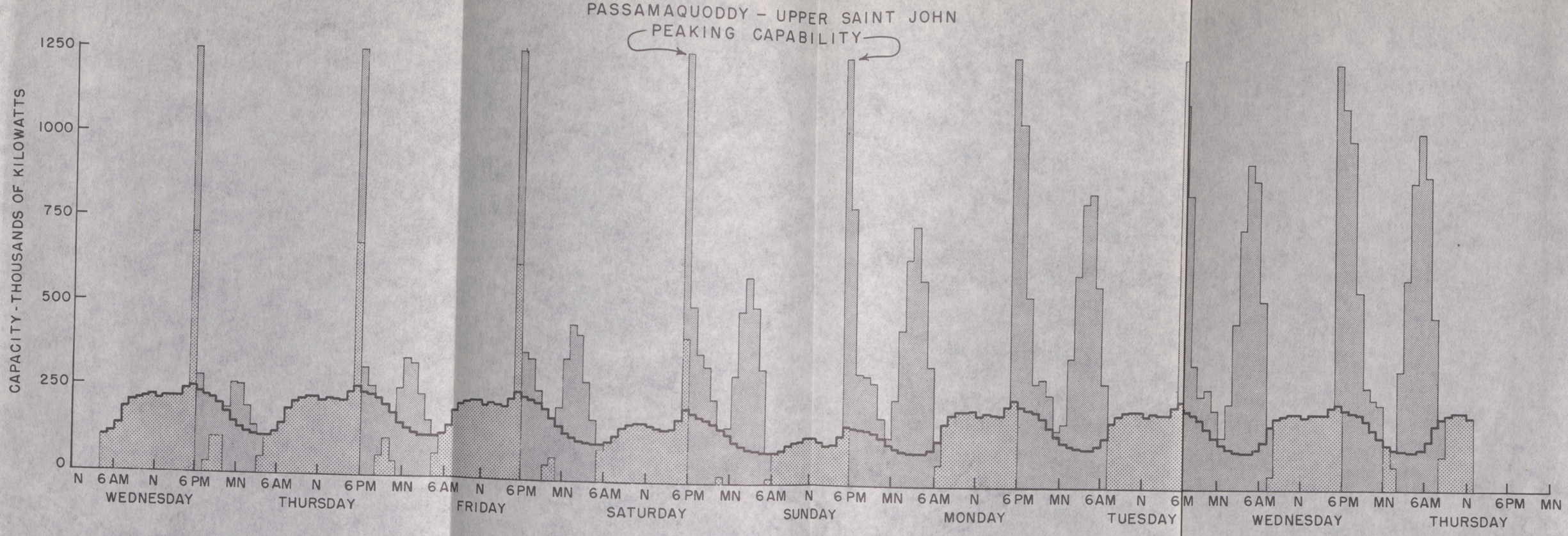
A general inspection of the area indicated that construction of a dam at Dickey would be less costly than one at Rankin Rapids. Utilization of the Dickey site would necessitate a reregulating reservoir as in the case of the Big Rapids site. However, because of encroachments on the tailwater at Dickey, the Lincoln School reregulating power would have to be modified.

The following table gives comparative values for the various plans considered.

Comparative values of power sites, upper St. John River integrated with Passamaquoddy powerplant

	Rankin rapids	Dickey-modified Lincoln School	Big Rapids Lincoln School
Installed capacity (megawatts)	410	360	390
Benefits:			
At site:			
Firm capacity (megawatts)	340	280	250
Energy (million kilowatt-hours)	1,700	1,425	1,250
Downstream: Energy (million kilowatt-hours)	889	656	534
At site: Firm capacity	$8,160,000	$6,720,000	$6,000,000
	6,800,000	5,700,000	5,000,000
Subtotal	14,960,000	12,420,000	11,000,000
Downstream: Energy	2,667,000	1,968,000	1,602,000
Total	17,627,000	14,388,000	12,602,000
Cost	135,000,000	135,000,000	130,000,000

NOTE.—Capacity and energy at site were estimated at $24 per kilowatt and 4 mills per kilowatt-hour, respectively. Energy at downstream sites was estimated at 3 mills per kilowatt-jour.



CAPACITY REQUIRED AVERAGE LOAD

CAPACITY FROM SAINT JOHN-DICKEY SITE

CAPACITY FROM TIDAL PLANT MW

PASSAMAQUODDY TIDAL POWER PROJECT

INTEGRATED OPERATION OF DICKEY DEVELOPMENT AND TIDAL PLANT DURING NEAP TIDES

1000 MEGAWATT TIDAL PLANT CAPACITY
750 MEGAWATT DICKEY PLANT CAPACITY

FIGURE 9

36-986 O - 64 (Face p. 58)

A series of operation studies was performed for the three main storage sites to determine the firm energy that could be produced during the critical period. The results of these studies were as follows:

Site	Normal water surface elevation (feet)	Active storage (acre-feet)	Drawdown in percent of maximum (percent)	Annual firm energy (megawatt-hours	Installed capacity (megawatts)
Big Rapids	910	1, 540, 000	13	514, 000	110
Dickey	910	2, 250, 000	10	719, 000	150
Rankin Rapids	860	2, 800, 000	12	958, 000	200

A comparable drawdown at the Dickey site to 12 percent of the maximum gross head would provide 750,000 megawatt-hours of firm energy annually.

Integration studies of the tidal and St. John plants were made on an hourly basis using the results from computer runs for 500-, 700-, and 900-megawatt tidal installation when operated to meet 1-hour peaking periods. Several studies were performed for each size of tidal installation. In each of these studies a firm energy requirement was assumed to determine the amount of tidal energy that could be used within the requirement and also to determine how much energy from St. John developments would be required to satisfy the remaining assumed firm energy load. From these results, estimates were made of installed capacities that fully utilized the firm energy available from St. John developments.

The coordinated operation studies indicate that firm energy available from upper St. John developments is not adequate to fully integrate all the tidal offpeak energy into a firm energy pattern. More integration would require the inclusion of other hydrodevelopments such as the potential Mactaquac development on the lower St. John. Another possibility indicates that the length of the peaking period for the tidal plant could be varied for different tide ranges thus changing the offpeak tidal energy generation. For example, during neap tide ranges the peaking capability would be provided for periods of 1 hour or less. The length of the peaking capability could then be increased with higher tide ranges. The tidal plant could then supply the portion of the peak load best utilizing its output which is highly dependable and predictable. Other plants in coordination could then be shifted to supply the remaining peak energy demand.

REREGULATION

Hydroelectric powerplant operating to serve a load with sharp peak characteristics requires a reservoir downstream to reregulate the flows so as to obtain as near continuous flow as possible. The reregulating reservoir must be placed downstream from the main reservoir and must have sufficient storage to accommodate the large influxes of water so they can be released in a uniform fashion. A powerplant such as Dickey on the upper St. John River would require a reregulating reservoir for its operation on a peaking power basis. This reregulating

36–986—64——5

reservoir can be located at the Lincoln School site; however, the capacity of the reservoir could not be as great as the Lincoln School arrangement described in the IJC's report. Under the plan herein proposed the water level for the Lincoln School reservoir would be restricted to an elevation that would not encroach on the tailwater from Dickey powerplant. However, sufficient reservoir capacity at Lincoln School must be provided for the necessary reregulation of water release from Dickey.

Further studies are required as to the precise location of Dickey powerplant site and the contemplated discharge from this plant. No cost estimates were included in the present study to cover the cost of an installation of the reregulating reservoir. Unquestionably such a reservoir will be necessary in the project plan. It is expected that power revenues from the reregulating reservoir will support the cost thereof. Hence, estimates were made.

Preliminary studies were made to determine the amounts of storage that would be required to provide daily and monthly reregulation. Following is the results of these studies:

St. John development	Reregulation storage in acre-feet	
	Daily regulation	Monthly regulation
Big Rapids	4,000	12,500
Dickey	5,000	15,500
Rankin Rapids	7,000	21,000

The following table summarizes the St. John developments.

Summary of integrated operation of tidal plant and St. John developments

Development	St. John development installed capacity			Energy for month of October			
	Capacity for integrated firm energy	Capacity to firm tidal capability	Total installed capacity	Integrated firm energy	Energy from firmed tidal capability, 1-hr. peak	Total firm energy	Remaining available offpeak tidal energy
	Mw.	*Mw.*	*Mw.*	*Mw.-h.*	*Mw.-h.*	*Mw.-h.*	*Mw.-h.*
Big Rapids alone	110	0	110	44,800	0	44,800	0
With 500-mw. tidal	190	170	360	78,900	15,500	94,400	80,300
With 700-mw. tidal	180	280	460	76,500	21,700	98,200	86,800
With 900-mw. tidal	170	410	580	72,400	27,900	100,300	89,300
Dickey alone	150	0	150	62,600	0	62,600	0
With 500-mw. tidal	260	170	430	110,000	15,500	125,500	67,100
With 700-mw. tidal	250	280	530	106,300	21,700	128,000	74,900
With 900-mw. tidal	240	410	650	101,900	27,900	129,800	77,700
With 1,000-mw. tidal	240	480	730	106,300	30,000	136,300	82,000
Rankin Rapids alone	200	0	200	83,400	0	83,400	0
With 500-mw. tidal	340	170	510	144,300	15,500	159,800	53,600
With 700-mw. tidal	320	280	600	138,300	21,700	160,000	63,700
With 900-mw. tidal	310	410	720	133,800	27,900	161,700	66,600

DOWNSTREAM POWER BENEFITS

Considerable benefits in Canada would accrue to existing and potential downstream hydro developments by providing storage on the upper St. John. An estimate of these benefits was obtained from studies made of the St. John River by the St. John River Board of the New Brunswick Electric Power Commission. The objective of those studies was to evaluate and plan the sequence of power developments in New Brunswick and Nova Scotia. For that investigation, several series of studies were performed, with and without a tidal development.

To obtain estimates of downstream benefits resulting from development of the Big Rapids or Dickey sites, the values obtained by the St. John River Board for Rankin Rapids were proportioned on the basis of regulated annual flows. The benefits for Rankin Rapids were based on the assumption that Rankin Rapids would begin operation in 1968 and the tidal plant would go into operation in 1970. The following table shows the estimated downstream benefits for the upper St. John development from 1970 to 1980. After 1980 the benefits are constant.

Estimate of downstream benefit

[In millions of kilowatt-hours]

Year	Upper St. John development			Year	Upper St. John development		
	Rankin Rapids	Dickey	Big Rapids		Rankin Rapids	Dickey	Big Rapids
1970	+409.7	+299.0	+243.3	1976	+556.9	+406.4	+330.7
1971	+308.6	+225.2	+183.3	1977	+1,012.5	+748.8	+601.3
1972	+784.0	+572.1	+465.6	1978	+1,004.6	+733.0	+596.6
1973	+774.4	+565.1	+459.9	1979	+1,006.5	+734.4	+597.8
1974	+961.7	+701.8	+571.2	1980	+889.1	+656.1	+534.0
1975	+849.6	+620.0	+504.6				

LOAD AND RESOURCES STUDY

The marketing area visualized for adequate utilization of the potential power from Passamaquoddy and the St. John River embraces the New England States, upper New York State, and the Canadian Provinces of New Brunswick and Nova Scotia.

The electric power capacity of the electric power utilities operating in this area was 13.3 million kilowatts in 1960, of which 10 million kilowatts were from thermal plants. The Federal Power Commission and the New Brunswick Electric Power Commission estimated that the power requirements in 1980 would be 36 million kilowatts. To meet these forecasts, 23 million kilowatts of new capacity would be required.

The States of Maine, New Hampshire, and Vermont are supplied with significant amounts of hydro and thermal generation. Massachusetts, Connecticut, and Rhode Island are predominantly steam with hydro producing a negligible part of the supply. In view of the resources of the area, it is anticipated that future developments of Maine, Vermont, and New Hampshire will continue with hydro and

steam and these States would provide a market for the output development of proposed powerplants on the upper St. John River. The upstream storage provided by these developments would provide substantial downstream benefits on the lower St. John River in Canada at the plants of the New Brunswick Electric Power Commission.

Based on present planning and practice in the utility industry it appears that the future load requirements of Massachusetts, Connecticut, and Rhode Island will be met by generating units of large size, possibly in excess of 500 megawatts. This trend can be seen by the plans of the Boston Edison Co. to install a 340 megawatt thermal plant at its L Street station. With the increase in the number of large capacity units, which can reasonably be expected, it will be desirable to obtain peaking capacity from sources such as Passamaquoddy and the upper St. John River.

The large thermal generating units are essentially fixed-load units with no flexibility. River hydroelectric powerplants are inherently flexible and provide excellent sources of peaking capacity. The Passamaquoddy tidal development as presently conceived with a two-pool arrangement could ideally provide substantial peaking capacity, and in addition to possessing the virtues of a river hydroelectric powerplant, it would be perpetual, dependable, fully predictable, and suffer no periods of drought.

The type of peaking capacity that can be developed and delivered by suitable transmission system from Passamaquoddy would be readily marketable in the New England States and New Brunswick areas when the power could be made available.

The Federal Power Commission's task group of the New York regional office, northeastern regional advisory committee, working on the national power survey, states that—

> Peaking capacity requirements of New England are met with hydroelectric power and older, less efficient thermal capacity, including gas turbines and diesel units. As the load increases and much of the existing fuel-electric capacity is retired, new sources of peaking capacity will have to be developed. Historically speaking, New England has a long record of waterpower development. Although many of the more favorable sites have been developed, a substantial amount of undeveloped hydroelectric power still remains, principally in Maine. The task group has recognized this by including 1,300 megawatts of unidentified peaking hydropower in northern Maine as part of the area power supply in 1975. In addition they have identified three pumped-storage installations of 300 megawatts each. Thus, by 1980 a total of approximately 3,500 megawatts of hydroelectric may be expected to be available for serving the electric utility load in New England.

POWER COSTS

In order to appraise the power market for the area to be served by the Passamaquoddy-upper St. John River development, the committee made a complete listing of all powerplants operating in New England during 1961. The results of this study which is tabulated in the appendix are shown as average costs of capacity and energy on figure 10. Also shown is the estimated cost of producing power from the Passamaquoddy-St. John River development at an interest rate of 2⅞ percent. This clearly demonstrates the immediate market for these power developments, since power will be produced at $24 per kilowatt of capacity and energy at 4 mills per kilowatt-hour, whereas 1961 actual costs were $26 per kilowatt for capacity and 6.36 mills per kilowatt-hour for energy. These costs are at the point of generation in both cases.

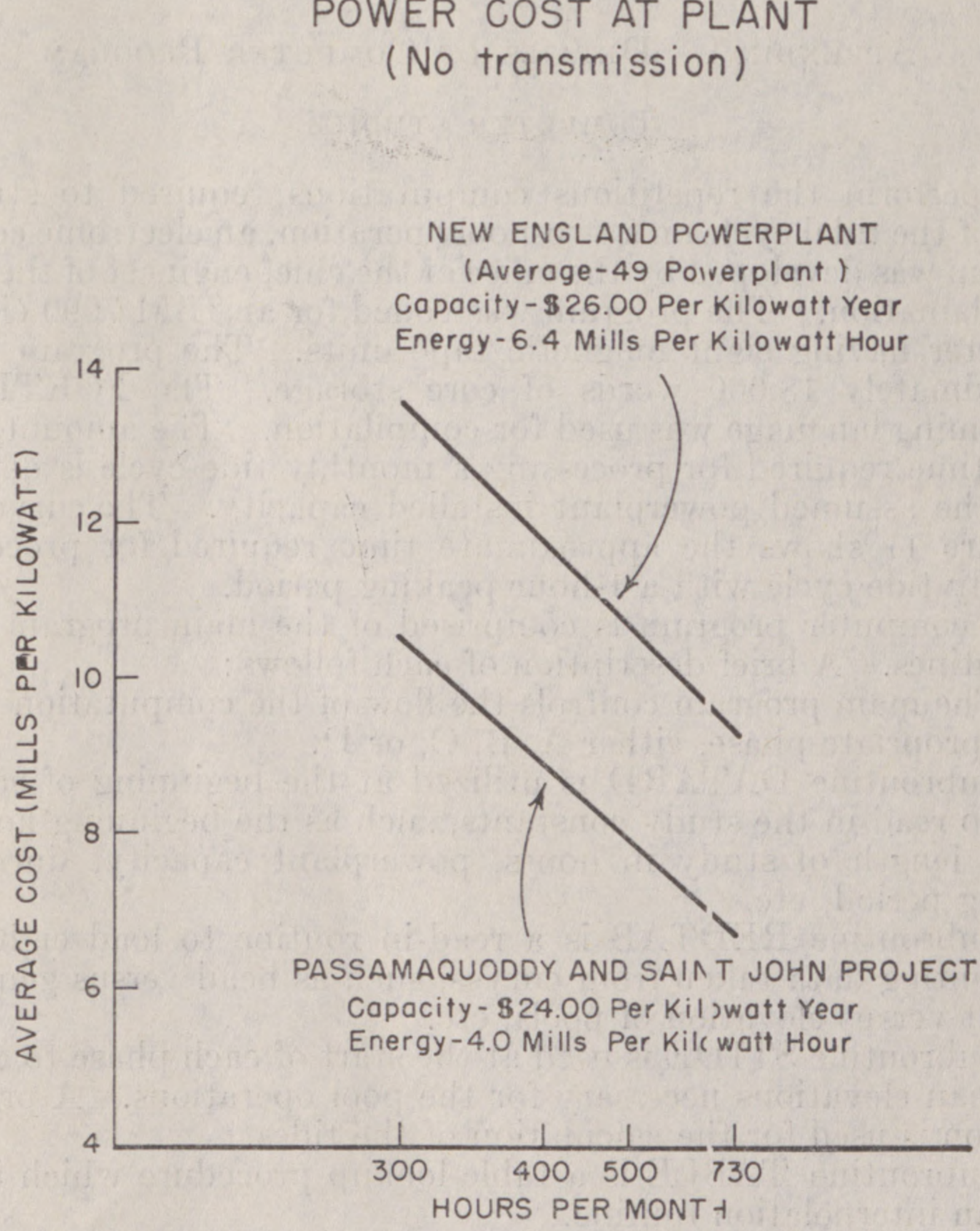


FIGURE 10

Also, the power values used herein for estimating power benefits for near future construction of alternate privately financed modern, high-eflciency thermal generation are (1) Maine area, $31.20 per kilowatt per year and 5 mills per kilowatt-hour, and (2) remaining New England area, $26.15 per kilowatt per year and 3.2 mills per kilowatt-hour.

The immediate development of power at the Passamaquoddy tidal project integrated with the upper St. John, Dickey, and modified Lincoln School projects would provide Maine, New England, and New Brunswick with a power supply at about 25 percent less han present cost. This would contribute greatly to the development of the area and the Nation.

The construction of these projects would also provide tremendous opportunities for employment and contribute national recreational benefits. The proposed plan would also forever protect the recreational values of the Allagash River.

Appendix I. Details of Computer Program

COMPUTER STUDIES

To perform the repetitious computations required to study the effect of the tidal cycle on a two-pool operation, an electronic computer program was developed by the office of the chief engineer of the Bureau of Reclamation. The program was coded for an IBM 7090 electronic computer having eight magnetic tape units. The program requires approximately 18,000 words of core storage. The FORTRAN II programing language was used for compilation. The amount of computer time required for processing a monthly tide cycle is dependent upon the assumed powerplant installed capacity. The curve shown in figure 11 shows the approximate time required for processing a monthly tide cycle with a 1-hour peaking period.

The computer program is comprised of the main program plus 13 subroutines. A brief description of each follows:

1. The main program controls the flow of the computation through the appropriate phase, either A, B, C, or D.

2. Subroutine DATARD is utilized at the beginning of somputations to read in the study constants, such as the beginning hour for a study, length of study in hours, powerplant capacity, duration of peaking period, etc.

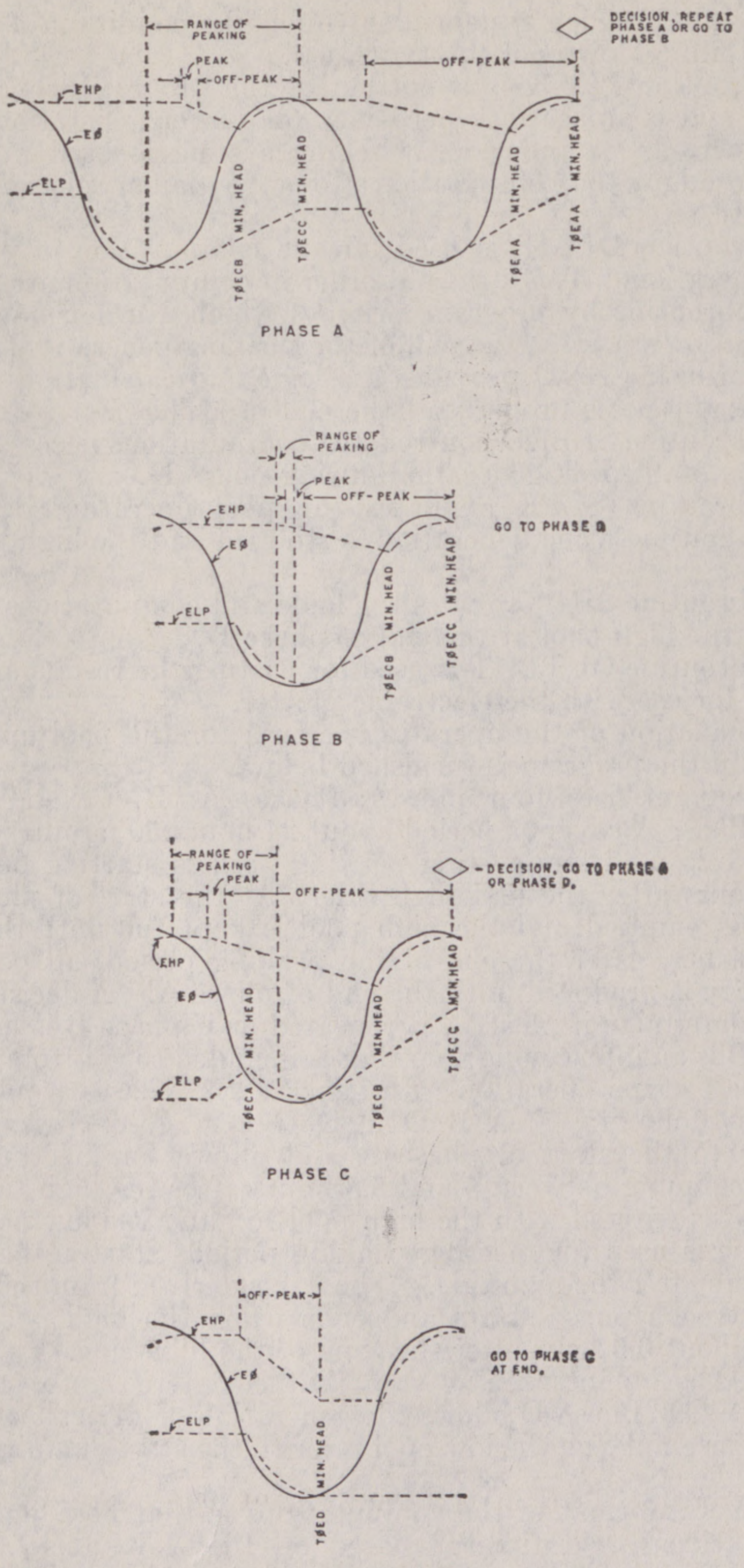
3. Subroutine REDTAB is a read-in routine to load eight tables representing data taken from curves, such as head versus generation, content versus elevation of pools, etc.

4. Subroutine STIDE is used at the start of each phase to compute the ocean elevations necessary for the pool operations. A prediction equation is used for the calculation of the tides.

5. Subroutine TABLE is a table-lookup procedure which incorporates an interpolation routine.

6. Subroutine FAMILY is a more sophisticated table-lookup procedure for tables representing a family of curves. Two arguments are necessary for this routine.

7. Subroutine EQTNS is used to solve equations to determine net heads on the turbines, heads on the filling gates, heads on the emptying gates, etc. The appropriate equations are solved by the use of a



NOTES: EHP = ELEVATION OF THE HIGH POOL
EØ = ELEVATION OF THE OCEAN
ELP = ELEVATION OF THE LOW POOL
TØECA, ETC. = NUMBER OF TURBINES OPERATING AT THE END OF THE VARIOUS SUBPHASES.

FIGURE 11

program switch which is dependent upon the condition of the pools, high pool filling, low pool emptying, etc.

8. Subroutine PEAK is a portion of the program which controls the logic and computations necessary for power generation during a peaking period. A program switching system is used in this subroutine to adapt the computations to a particular phase, pool conditions, etc.

9. Subroutine DUMP is used for the computation of off-peak or dump generation. The logic and order of computation are controlled in this subroutine by program switches which are dependent on the pool operation status at the end of the peaking generation.

10. Subroutine END provides the logic and calculations necessary to operate the pools properly at the end of a phase.

11. Subroutine SLPED controls the computations necessary for the production of off-peak generation during phase D.

12. Subroutine SLPE regulates the pool operation in phase D between the time when generation is stopped and the high pool filling begins.

13. Subroutine SHP provides the logic and computations necessary for filling the high pool at the end of phase D.

14. Subroutine OUTPUT is used for writing the results and punching cards for use with the electronic plotter.

An explanation of the operating criteria for the pool operation as provided in the program is furnished below.

The program uses four phases: Phases A, B, C, and D. (See fig. 2.) Phase A covers a period about 24 hours 50 minutes in length. This phase is used for meeting peaking periods starting between 5.8 and 13 hours after the first high tide. At the start of phase A, the low pool is emptied and the high pool is kept full until the peaking period starts. After the end of the peaking period, all possible off-peak energy is produced until the end of phase A. A decision is then made to determine if phase A is repeated or if phase B is entered.

Phase B is an intervening step that is included to get from a phase A to a phase C-type operation. In general, the phases would be performed as follows: –A–A–B–D–C–D–C–D–C–A–A–, etc. Phase B is similar to the start of phase A and allows for meeting peaking periods beginning between 5 and 5.8 hours after the high tide.

Phase C is entered with the high pool full and the low pool empty. This phase is used for meeting peaking periods starting between 0.6 and 5 hours after the high tide. The 0.6 is derived from the consideration that each phase starts and ends when the high pool is filled, which is about 0.6 hour after the time of the high tide.

Phase D is an intervening step that is entered into from either phase B or C. Phase D allows the generation of offpeak energy and provides for emptying the low pool prior to the start of a phase C type operation.

The general format of the computations is that new high and low pool elevations are estimated based on the elevations at the two preceding time intervals. The pool and ocean elevations are then used to compute discharges through the powerplant and/or filling or emptying gates. These discharges are then converted to volumes which are used to adjust the contents of the two pools. Content versus elevation tables are then used to determine the revised elevations of the pools. These determined elevations are then compared

with the estimated elevations for that time period. If the two sets of elevations are within the limits of ± 0.02 foot, the program proceeds to the next time interval.

The computations in the program are made for 3-minute time intervals. This short time interval is necessary because of the rapid change in pool elevations possible with the large installed powerplant capacities to be studied. The short time interval does, however, simplify the determination of the time when the pool elevations coincide with the ocean elevations. At these points the computations are changed to allow for emptying and filling of the pools.

The program was developed to allow for the study of peaking periods varying up to 4 hours in length. This variable length of peaking period complicates the program. In phase A, for example, the peaking generation can begin (1) when the low pool is emptying, (2) when the low pool is emptied, (3) when the high pool is filling additionally with the second high tide, or (4) when this additional filling is completed.

This allows the possibility of any one of four different computations being performed when the peaking starts. Depending upon the length of the peaking period, a period starting when the low pool has been emptied can end when (1) the high pool is emptying into the low pool, (2) when the high pool is obtaining additional filling from the ocean, (3) when the additional filling is completed and the only discharge is again from the high pool to the low pool, or (4) when the low pool is emptying to the ocean. The program was devised to allow the computations to follow through these various routes and combinations until the computations can become similar again in the offpeak generation during the second tidal cycle.

The minimum head selected for the operation of the turbines was 6 feet. This minimum head provides for the use of specific control points in each of the phases. In the various subphases the greatest possible off-peak energy is proudced without going below the minimum head. At each time interval, the program checks to determine whether the actual head is below the minimum permissible head. If the actual head is less than 6 feet, turbines are dropped off, energy production reduced, and the computations are repeated from the start of the subphases. At the control points at the end of the subphases, the program checks to determine if additional head above this minimum is available. If so, turbines are added on, energy production increased, and the computations are repeated from the start of the subphase. The number of turbines operating at the end of the subphases is stored in the computer and then used for the first trial when a similar subphase is entered again. These computations reflect a physical operation where a constant number of turbines would be operated during each off-peak period.

Somewhat similar computations are performed to insure that the maximum peaking capability is obtained. In this case, the program performs computations to check if the actual head is below the minimum head, or if more turbines are required to meet a "trial peaking capability" than would be available with the installed capacity being studied. If either of these occurrences is indicated, the program reduces the "trial peaking capability" and repeats the computations from the start of the peaking period. At the end of the peaking

period, the program checks to determine if all turbines are being used to meet the "trial peaking capability." If not, the trial value is increased and computations are repeated from the start of the peaking period. The peaking computations are stopped when the check at the end of the period indicates all turbines are being used or that the last adjustment of the trial value was a decrease. The trial value at the end of the peaking period, having been adjusted to the actual capability for that period, is then stored in the computer for use in the first trial in the next peaking period. These computations reflect a physical operation where there would be a continual increase in the number of turbines operating during a peaking period.

To insure that the pools are emptied or filled as much as possible, certain other provisions are included in the program. In phase A and the last time through phase C, for example, the minimum ocean elevations are checked. If the low tide of a neap tide is occurring, offpeak generation is stopped and the high pool is filled to the highest elevation possible. Similarly, during phase D in a neap tide, generation is limited to insure that the low pool is emptied to an elevation close to the minimum ocean elevation.

The discharge versus head tables that are used for the filling and emptying gates include allowances for the head losses through the gates and channels. Separate tables are included in the program to allow computation of head losses in the approach channel to and tailrace channel from the powerplant. An equation is used to compute head losses in the low pool due to slope of water surface. The equation is, however, considered to be only a reasonable approximation of the loss due to water surface slope in the low pool. A more accurate value could be obtained by making detailed routings of the movement of water in the low pool. This was not believed to be necessary for the present studies to evaluate the Passamaquoddy tidal power project for peaking capabilities.

The computer program output gives ocean and pool elevations, net turbine head, weighted turbine head, and powerplant output. A sample of the output is shown in figure 13. This information was used to develop curves showing peaking capability versus percent time, dependable capability versus installed capacity, and peak and offpeak generation versus installed capacity. The output can also be punched in cards so that a plotting machine can graphically plot the elevations and plant output for selected installed capacities. A sample plot for a 200-hour period showing both a neap and spring tide is shown in figure 7.

Appendix II. Tabulation of Power Cost in New England

The attached tabulation is based on the estimated Federal Power Commission procedures for determining fixed cost of powerplants and includes cost of money, depreciation, interim replacements, insurance, Federal income taxes, additional miscellaneous taxes,

and State and local taxes. The average figures for these were obtained from Federal Power Commission data. Other information shown was taken from the following publications:

"Hydroelectric Plant Construction Cost and Annual Production Expense," 4th annual supplement, 1960.

"Steam-Electric Plant Construction Cost and Annual Production Expenses," 14th annual supplement, 1961.

Powerplant	Capacity	Cost	Fixed charge	Fixed charge [1]	Production costs	Year installed	Plant factor
	Kilowatts	*Dollars per kw.*	*Percent*	*Dollars per kw.*	*Mills per kw.-hr.*		*Percent*
Maine:							
Graham (T)	28,000	170	13.0	22.10	7.4	1954	51
Mason (T)	139,000	169	10.5	17.50	6.4	1941	26
Wyman (T)	88,000	219	10.5	23.00	4.8	1957	86
Caribou (T)	19,000	209	11.3	23.60	9.3	1950	59
Gulf Island (H)	19,000	249	10.5	26.20	1.5	1926	79
Indian Pond (H)	76,000	219	10.5	23.00	.5	1954	34
Skelton (H)	16,000	450	10.5	47.30	.5	1948	79
Williams (H)	13,000	242	10.5	25.40	.6	1939	87
Wyman (H)	72,000	196	10.5	20.60	.3	1930	58
New Hampshire:							
Merrimack (T)	113,000	197	12.5	24.70	4.3	1960	74
Schiller (T)	190,000	180	12.5	22.60	5.8	1949	48
Amoskeag (H)	16,000	140	12.5	17.65	.8	1922	72
Smith (H)	15,000	273	12.5	34.20	.5	1948	88
Comerford (H)	140,000	112	13.2	23.50	1.1	1930	22
Moore (H)	140,000	216	13.2	28.60	1.5	1957	19
Wilder (H)	32,000	397	13.2	52.60	1.0	1950	45
Vermont:							
Lake Front (T)	30,000	----	----	----	9.8	1954	----
Rutland (T)	18,000	176	13.2	23.30	22.5	1954	27
Clarks Falls (H)	3,000	294	13.2	36.80	1.0	1937	57
Milton (H)	6,000	118	13.2	15.56	1.3	1928	66
Peterson (H)	5,000	261	13.2	34.60	.7	1948	52
Weybridge (H)	3,000	419	13.2	55.30	1.2	1951	50
Bellows Falls (H)	40,000	175	13.2	23.15	.8	1928	62
Harriman (H)	33,000	274	13.2	36.20	1.2	1924	44
Massachusetts:							
Edgar (T)	457,000	156	15.0	23.40	6.1	1925	46
"L" Street (T)	153,000	162	15.0	24.30	10.0	1906–19	42
Mystic (T)	618,000	161	14.4	23.20	4.8	1943	----
Mount Tom (T)	125,000	189	14.4	27.30	3.9	1960	95
Somerset (T)	290,000	170	11.5	19.50	4.9	1925	66
Cannon St. (T)	137,000	128	14.4	18.30	6.7	1916	46
Salem Harbor (T)	319,000	179	13.2	23.80	4.3	1952	74
West Water St. (T)	----	----	----	----	----	----	----
West Springfield (T)	209,000	159	14.4	22.90	4.4	1949	66
Sherman (H)	7,000	190	13.2	25.10	.6	1927	51
Connecticut:							
Danielson (T)	12,000	229	12.4	28.70	19.0	1953	9
Devon (T)	479,000	137	12.4	17.05	5.0	1923	52
Monville (T)	176,000	167	12.4	21.90	5.4	1919	52
Norwalk Harbor (T)	15,000	150	12.4	18.70	3.9	1919-24	82
Thompsonville (T)	12,000	239	12.4	29.80	54.0	1953	33
Housatonia Ave. (T)	20,000	129	12.4	16.10	14.0	1953	46
Middletown (T)	166,000	192	11.6	22.10	4.1	1954	88
South Meadow (T)	215,000	140	11.6	16.30	9.5	1921	----
Bridgeport Harbor (T)	225,000	190	13.5	21.90	4.3	1957	----
English (T)	135,000	185	13.5	21.40	8.9	1929	44
Steel Point (T)	146,000	163	13.5	18.90	8.9	1923	39
Rocky River (H)	31,000	208	12 4	25.80	27.7	1929	3
Shepang (H)	37,000	483	12.4	60.20	1.1	1955	38
Stevenson (H)	30,000	201	12.4	25.10	.3	1919	36
Rhode Island:							
Manchester St. (T)	147,000	165	11.6	19.10	7.2	1923	52
South Street (T)	213,000	171	11.6	19.90	7.3	1909–12	40
Average	----	----	----	26.00	6.36	----	----

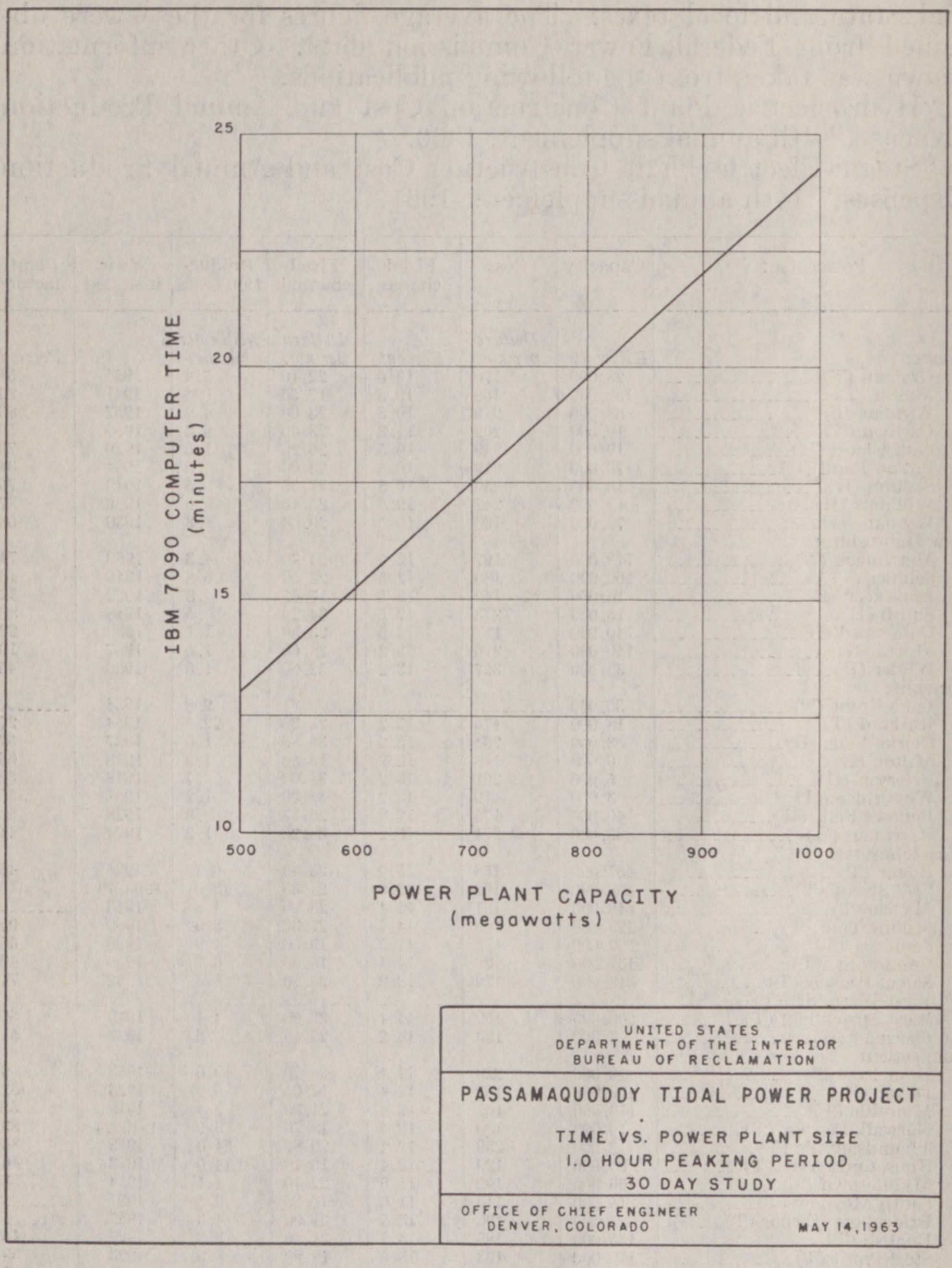

25
20
15
10
IBM 7090 COMPUTER TIME
(minutes)
500
600
700
800
900
1000
POWER PLANT CAPACITY
(megawatts)
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PASSAMAQUODDY TIDAL POWER PROJECT
TIME VS. POWER PLANT SIZE
1.0 HOUR PEAKING PERIOD
30 DAY STUDY
OFFICE OF CHIEF ENGINEER
DENVER, COLORADO
MAY 14, 1963

FIGURE 12

FIGURE 13.—*Passamaquoddy tidal power studies*

[30 days. Maximum gate. 90 turbines. Duration of peaking period=1.00 hours]

Time (hours)	Ocean elevation	Low pool elevation	High pool elevation	Net turbine head	Weighted head	Number of turbines operating	Power-plant generation (Megawatt)	Power-plant energy (Megawatt hours)	Cumulative peak energy (GWH)	Cumulative dump energy (GWH)
6963.90	11.43	11.76	24.29	12.24	9.80	66	586.615	29.331	12.290	54.332
6964.00	11.70	11.87	24.20	12.02	9.80	66	569.699	28.485	12.290	54.390
6964.10	11.99	12.03	24.11	11.81	9.80	66	553.940	27.697	12.290	54.446
6964.20	12.30	12.22	24.03	11.47	9.80	66	527.955	26.398	12.290	54.499
6964.30	12.63	12.47	23.94	11.16	9.80	66	504.176	25.209	12.290	54.550
6964.40	12.98	12.65	23.85	10.86	9.80	66	480.969	24.048	12.290	54.599
6964.50	13.35	12.89	23.77	10.56	9.80	66	458.176	22.909	12.290	54.645
6964.60	13.74	13.06	23.68	10.28	9.80	66	436.613	21.831	12.290	54.689
6964.70	14.14	13.30	23.60	10.00	9.80	66	415.219	20.761	12.290	54.731
6964.80	14.56	13.46	23.52	9.73	9.80	66	394.421	19.721	12.290	54.771
6964.90	14.99	13.70	23.44	9.46	9.80	66	373.831	18.692	12.290	54.809
6965.00	15.43	13.85	23.36	9.20	9.80	66	353.937	17.697	12.290	54.845
6965.10	15.88	14.06	23.29	8.95	9.80	66	334.870	16.744	12.290	54.879
6965.20	16.34	14.24	23.21	8.68	9.80	66	313.920	15.696	12.290	54.911
6965.30	16.81	14.43	23.14	8.44	9.80	66	296.043	14.802	12.290	54.941
6965.40	17.29	14.59	23.07	8.19	9.80	66	276.453	13.823	12.290	54.969
6965.50	17.78	14.76	23.00	7.99	9.80	66	261.222	13.061	12.290	54.996
6965.60	18.26	14.93	22.93	7.74	9.80	66	241.802	12.090	12.290	55.020
6965.70	18.76	15.08	22.86	7.54	9.80	66	226.462	11.323	12.290	55.043
6965.80	19.25	15.23	22.79	7.31	9.80	66	209.491	10.475	12.290	55.065
6965.90	19.75	15.37	22.72	7.13	9.80	66	195.437	9.772	12.290	55.085
6966.00	20.25	15.51	22.66	6.92	9.80	66	179.008	8.950	12.290	55.103
6966.10	20.75	15.64	22.63	6.78	9.80	66	168.496	8.425	12.290	55.120
6966.20	21.25	15.76	22.54	6.59	9.80	66	154.338	7.717	12.290	55.136
6966.30	21.75	15.89	22.53	6.45	9.80	66	143.698	7.185	12.290	55.150
6966.40	22.24	15.98	22.44	6.30	9.80	66	131.639	6.582	12.290	55.164
6966.50	22.73	16.02	22.46	0	9.80	0	0	0	12.290	55.170
6966.60	23.22	16.02	22.54	0	9.80	0	0	0	12.290	55.170
6966.70	23.70	16.02	22.66	0	9.80	0	0	0	12.290	55.170
6966.80	24.17	16.02	22.77	0	9.80	0	0	0	12.290	55.170
6966.90	24.64	16.02	22.96	0	9.80	0	0	0	12.290	55.170
6967.00	25.09	16.02	23.12	0	9.80	0	0	0	12.290	55.170
6967.10	25.54	16.02	23.29	0	9.80	0	0	0	12.290	55.170
6967.20	25.97	16.02	23.50	0	9.80	0	0	0	12.290	55.170
6967.30	26.39	16.02	23.70	0	9.80	0	0	0	12.290	55.170
6967.40	26.79	16.02	23.92	0	9.80	0	0	0	12.290	55.170
6967.50	27.18	16.02	24.14	0	9.80	0	0	0	12.290	55.170
6967.60	27.55	16.02	24.36	0	9.80	0	0	0	12.290	55.170
6967.70	27.91	16.02	24.58	0	9.80	0	0	0	12.290	55.170
6967.80	28.24	16.02	24.80	0	9.80	0	0	0	12.290	55.170

REPORT

ON

PRELIMINARY INVESTIGATIONS

TO THE

DEPARTMENT OF THE INTERIOR

PASSAMAQUODDY–ST. JOHN RIVER STUDY COMMITTEE

POWER LOAD AND RESOURCES STUDY

BY

JOSEPH E. GUIDRY

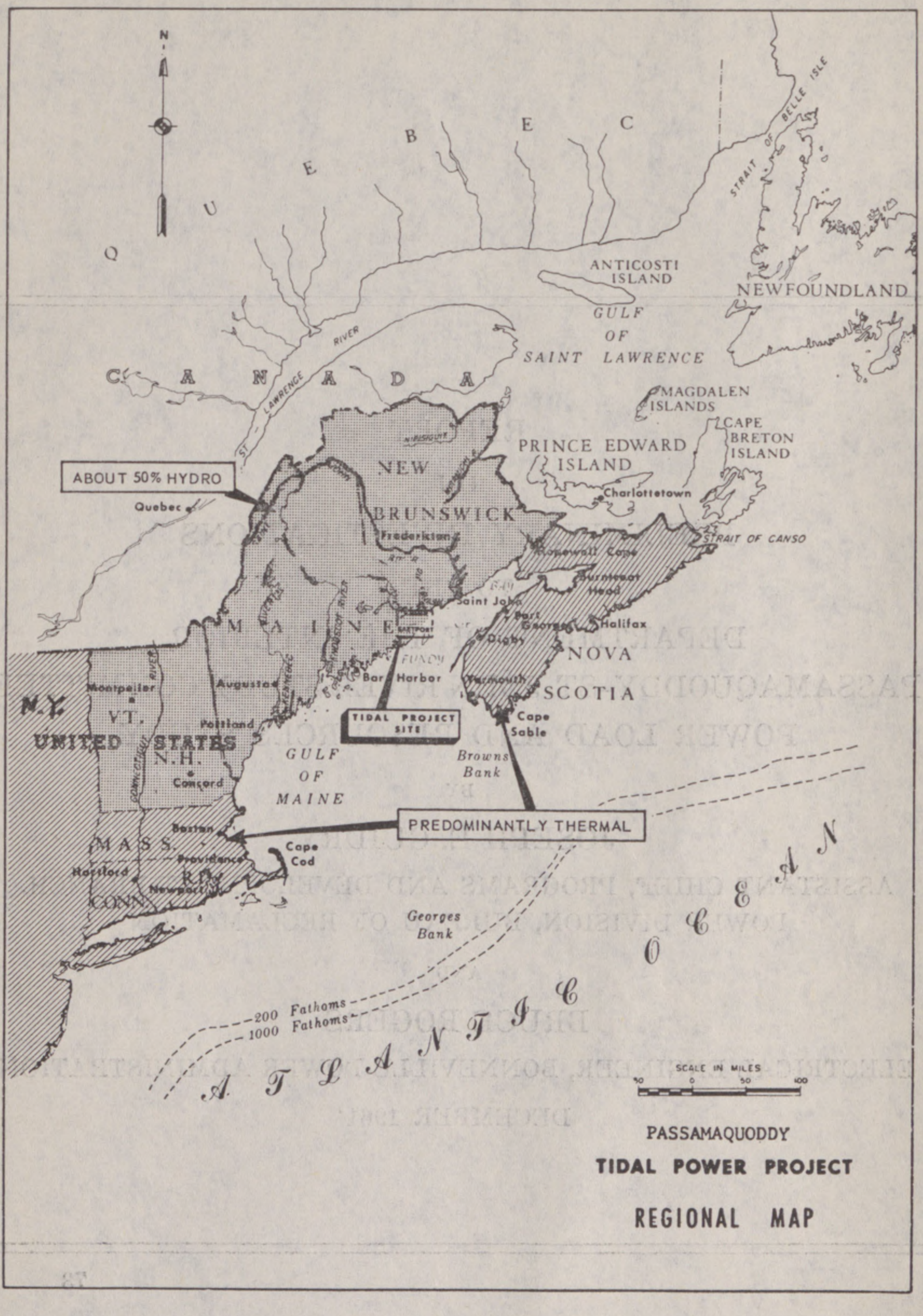
ASSISTANT CHIEF, PROGRAMS AND DEVELOPMENT BRANCH.
POWER DIVISION, BUREAU OF RECLAMATION

AND

BRUCE ROGERS

ELECTRICAL ENGINEER, BONNEVILLE POWER ADMINISTRATION

DECEMBER 1961


N
QUEBEC
ANTICOSTI ISLAND
GULF OF SAINT LAWRENCE
STRAIT OF BELLE ISLE
NEWFOUNDLAND
CANADA
ST. LAWRENCE RIVER
MAGDALEN ISLANDS
CAPE BRETON ISLAND
PRINCE EDWARD ISLAND
Charlottetown
ABOUT 50% HYDRO
Quebec
NEW BRUNSWICK
Fredericton
STRAIT OF CANSO
Canso
Burntcoat Head
Saint John
Port George
Halifax
Digby
NOVA SCOTIA
MAINE
Bar Harbor
Yarmouth
TIDAL PROJECT SITE
Cape Sable
Browns Bank
GULF OF MAINE
Montpelier
Augusta
Portland
N.Y.
VT.
N.H.
Concord
UNITED STATES
PREDOMINANTLY THERMAL
Boston
MASS.
Cape Cod
Providence
R.I.
Hartford
Newport
CONN.
Georges Bank
200 Fathoms
1000 Fathoms
ATLANTIC OCEAN
SCALE IN MILES
50 0 50 100
PASSAMAQUODDY
TIDAL POWER PROJECT
REGIONAL MAP

LETTER OF TRANSMITTAL

DECEMBER 13, 1961.

MEMORANDUM

To: Mr. Morgan D. Dubrow, Chairman, Passamaquoddy-St. John River Study Committee.
From: Messrs. Joseph E. Guidry and Bruce Rogers.
Subject: Passamaquoddy-St. John River powerload and resources study.

The attached report of powerloads and resources for the Northeastern United States and the Maritime Provinces of the Dominion of Canada has been prepared consistent with the instructions of your committee.

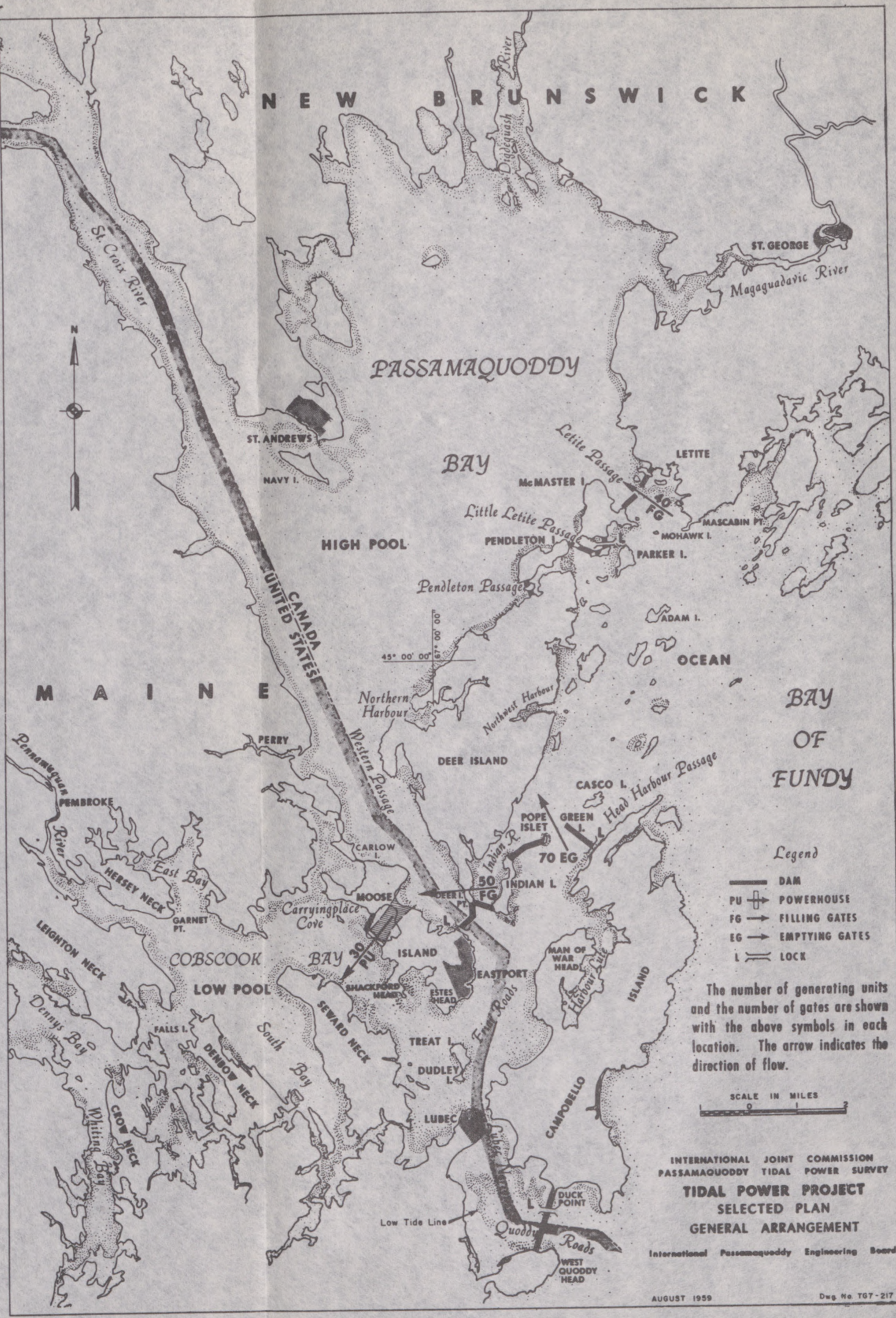
The report contains data pertaining to the present and future (to 1980) loads and generating facilities of the utilities in the area, our impressions toward sound development of the Passamaquoddy tidal power project and the upper St. John River hydroelectric power resources, and recommendations for further investigations required to realize the potentials of these assets which have remained undeveloped for such a long period.

We are firmly convinced that Passmaquoddy should be developed to provide peaking power in the magnitude of 1 million kilowatts and its operation should be coordinated with the full development of the St. John River hydroelectric system, inluding upstream storage in the State of Maine.

JOSEPH E. GUIDRY,
Assistant Chief, Programs and Development Branch, Power Division, Bureau of Reclamation.

BRUCE ROGERS,
Electrical Engineer, Bonneville Power Administration.

36-986—64——6



36-986 O - 64 (Face p. 77)

Passamaquoddy-St. John River Powerload and Resources Study

INTRODUCTION

By letter of May 20, 1961, President John F. Kennedy requested the Secretary of the Interior, Stewart L. Udall, to review the report on the international Passamaquoddy tidal power project and the advisability of hydroelectric power development on the upper St. John River.

A committee was appointed by the Department to study the report prepared by the International Joint Commission. This Committee is made up of expert officials from various bureaus and it is chaired by Mr. Morgan D. Dubrow, Assistant and Chief Engineering Research Adviser to Mr. Kenneth Holum, Assistant Secretary of the Interior for Water and Power Development.

The Committee appointed Messrs. Joseph E. Guidry, Assistant Chief, Programs and Development Branch, Power Division, Bureau of Reclamation, and Bruce Rogers, electrical engineer, Bonneville Power Administration, to conduct a powerload and resource study of the New England area of the United States and the Maritime Province area of the Dominion of Canada.

To date the load and resource study has included a physical inspection of the Passamaquoddy tidal power project site and the Canadian portion of the St. John River. In addition, these projects were discussed and pertinent data were obtained from the Washington, D.C., and Boston, Mass., offices of the Corps of Engineers, the Washington, D.C., and New York, N.Y., offices of the Federal Power Commission, and the New Brunswick Electric Power Commission at Fredericton, New Brunswick. The fullest cooperation was received from all personnel contacted. A listing of their names is attached to this report, appendix I. We gratefully acknowledge our appreciation of this ready cooperation and exchange of information which has enabled us to formulate in a short period of time the impressions contained in this report.

After viewing the Passamaquoddy project and the St. John River areas, we are impressed with the potentials that exist for the development and utilization of these resources. The inspection of the Quoddy site was accomplished by flights over the site arranged by the New Brunswick Electric Power Commission, a cruise of the water areas by the U.S. Coast Guard, and a tour of the coastline by automobile. The St. John River was viewed by air and automobile tours on both sides of the river.

The flights arranged by the New Brunswick Electric Power Commission included a view of a large portion of the Provinces of New Brunswick and Nova Scotia including the tidal power sites located on the upper Bay of Fundy in the vicinity of the proposed Chignecto

Canal. This comprehensive coverage of the water resources of the area enabled us to view the potentials in their true perspective.

Based on the above observations and the data obtained, we report the following:

AREA STUDIED

The area selected for proper utilization of power from potential generation by the Passamaquoddy tidal power project and the St. John River consists of the New England States and upper New York State and the Canadian Provinces of New Brunswick and Nova Scotia. The Province of Quebec is considered in our analysis, but as this Province was not included in our field trips, detailed information is lacking. A map of the area considered is included in this report.

LOAD STUDIES

Load estimates for 1960, 1970, and 1980 were obtained from the New York regional office of the Federal Power Commission and the Fredericton, New Brunswick, office of the New Brunswick Electric Power Commission. These estimates for the utilities only are for peakloads that are expected to occur in December and are based on historical load growth patterns and do not include any accelerating factors such as availability of lower cost power or any advanced technological changes. The load estimates plus the power requirements for 1980, including reserves of 12 percent for the United States and 15 percent for Canada, are shown in the following tabulation:

[In megawatts]

	1960 peak demand	1970 peak demand	1980		
			Peak demand	Reserves	Requirements
United States:					
Maine	575	920	1,390	167	1,557
New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut	5,820	9,740	15,170	1,820	16,990
Upper New York State	4,900	8,800	12,900	1,548	14,448
Canada:					
New Brunswick	227	520	1,190	178	1,368
Nova Scotia	258	610	1,460	219	1,679
Total	11,780	20,590	32,110	3,932	36,042

POWER SUPPLY

The capacity of the generating plants presently installed and scheduled for installation by the utilities of the United States and Canada was obtained from the New York regional office of the Federal Power Commission and the New Brunswick Electric Power Commission. Existing individual generating plants are listed in appendix II and the scheduled and planned additions are listed in appendix III.

A. Existing generation

A summary of the maximum installed utility capacities for the United States as of December 31, 1960, and the utility nameplate

generating capacities for Canada as of December 1959 are shown in the following tabulation:

[In megawatts]

	Hydroelectric	Thermal	Total
United States:			
Maine	323	406	729
New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut	887	5,664	6,551
Upper New York State	1,833	3,555	5,388
Canada:			
New Brunswick	176	99	275
Nova Scotia	110	228	338
Total	3,329	9,952	13,281

B. Scheduled and planned generating additions

Scheduled additions for utility generating plants in the United States were obtained for the 5-year period ending in 1965. This is the latest date for which utility forecasts are available. The generating additions for the interconnected Provinces of New Brunswick and Nova Scotia are planned for 20 years in the future, ending in 1980. These forecasts do not include any development of the Passamaquoddy tidal power project or any upstream storage on the St. John River.

C. Planned supply, 1980

The present installed generating capacity plus the scheduled and planned additions as discussed previously are summarized in the following tabulation:

[In megawatts]

	Existing generation	Planned additions	Estimated 1980 supply
United States:		*1960–65*	
Maine	729	70	799
New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut	6,551	1,307	7,858
Upper New York State	5,388	2,194	7,582
Canada:		*1920–60*	
New Brunswick	275	1,083	1,358
Nova Scotia	338	1,340	1,678
Total	13,281	5,994	19,275

LOAD AND RESOURCE ANALYSIS

Inspection of the load studies and planned supply for 1980 reveals the following:

1980 future conditions

[In megawatts]

	Estimated requirements	Estimated supply	Deficiency
United States:			
Maine	1,557	799	758
New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut	16,990	7,858	9,132
Upper New York State	14,448	7,582	6,866
Canada:			
New Brunswick	1,368	1,358	----------
Nova Scotia	1,679	1,678	----------

This tabulation points up the fact that Canada is well along with its plans to meet future requirements based upon the present rate of growth. The United States, on the other hand, must provide 758 megawatts in the State of Maine; 9,132 megawatts in the other New England States; and 6,866 megawatts in upper New York State in order to meet the 1980 load forecast.

The States of Maine, New Hampshire, and Vermont are now supplied in about equal amounts of hydro and thermal generation. Massachusetts, Connecticut, and Rhode Island are predominantly steam with hydro producing a negligible part of the supply. In view of the resources of the area we anticipate that the future developments of Maine, Vermont, and New Hampshire will continue in about the same ratio and these States would provide a market for the development of powerplants such as Big Rapids and Lincoln School. The upstream storage thus provided by these developments would provide substantial downstream benefits on the St. John River which the New Brunswick Electric Power Commission indicates would enhance their plants and provide benefits for which they are willing and expect to pay for on an equitable basis. Based on present planning and practice in the utility industry it appears that the future load requirements of Massachusetts, Connecticut, and Rhode Island will be met by generating units of large size, possibly in excess of 500 megawatts. This trend can be seen by the plants of the Boston Edison Co. to install a 350-megawatt thermal plant at its L Street station. With the increase in the number of units of 500 megawatts capacity and larger, which can be reasonably expected, it will be necessary to obtain peaking capacity from flexible sources. The 500-megawatt generating units are essentially fixed-load units with no flexibility. River hydroelectric powerplants are inherently flexible and provide excellent sources of peaking capacity. We believe the Passamaquoddy tidal development as presently conceived with a two-pool arrangement could ideally provide peaking capacity in the magnitude of 1 million kilowatts and in addition to having all the virtues of a river hydroelectric powerplant, it would have complete dependability as the tides are fully predictable and suffer no periods of drought.

The type of peaking capacity that can be developed and delivered by suitable transmission system from a tidal project such as Quoddy should find a ready market in the Massachusetts, Connecticut, and Rhode Island areas provided the price is competitive.

QUODDY FOR PEAKING

In the initiation of our broad and quick review of the Passamaquoddy tidal power development we carefully considered the facts contained in the report of the International Joint Commission, docket 72, dated April 1961. We believe that the plan is well conceived and has engineering feasibility. Perhaps the economics are questionable when developed from the maximum energy production standpoint on which the study was premised.

In view of the intensive interest of the electric power industry in the United States for economical peaking power sources necessitated by the greater use of fixed-capacity larger generating units, we concentrated consideration of Quoddy as a peaking power development. In our discussions with various individuals who have been associated

with studies on this project over the years, we have not been able to discover any fundamental reason why Passamaquoddy cannot be considered as a source of peaking capacity. We have discussed this aspect from a hydrologic, hydraulic, structural, and electrical viewpoint. In view of the greater market value for peaking capacity than straight energy, it appears from our limited review of this proposed project of long standing, that possibly capacities in the magnitude of 1 million kilowatts are well within reason. Such capacity, when developed with suitable transmission for delivery to essentially thermal generation areas, will find a ready market if produced as we expect at competitive prices. These statements are premised on the assumption that the horizontal axial flow turbines prove practicable at a sufficiently low cost. To the best of our knowledge the French so-called "bulb-type turbine units" and the research of the Allis Chalmers Co. in this direction afford the most encouraging outlook at the present time. However, we must reserve final judgment until further information becomes available as to cost, operating characteristics, and the engineering feasibility of developing a powerplant with approximately 100 turbine units in the magnitude of 10 megawatts each—for tidal operation.

Using a 13.2-foot tidal range, which occurs 98 percent of the time, we estimate that it would be possible to provide peaking capacity of 1 million kilowatts for a duration of approximately 1 hour every day for all practicable purposes. This is assured by the utilization of the reserve capacity in the large system under consideration in our area study.

If the mean tidal range of 18.1 feet is considered, we estimate that it will be possible to provide a daily peak of over 2 hours in duration. It must be recognized, however, that for one-half the time the tidal range will be below the 18.1-foot average and for the balance of time it will exceed this amount. In order to assure the equivalent of the 2-hour peaking operation under the mean tidal range it will be necessary to interconnect the tidal power project with other developments such as the upper St. John River hydroelectric development (Big Rapids and Lincoln School) to provide integrated operation to firm the peaking capacity. Energy supplied to the upper St. John River development would in effect increase the upstream storage capacity and improve the dependable output and will permit this development to supply peaking capacity to the Quoddy project when needed at times to supplement the below-average tides.

It appears to us that based on a 13.2-foot tidal range with a two-pool arrangement, which can permit a release of water at any time during the day, the tidal development may be operated as an independent peaking plant for the sale of power at competitive prices. Because of the higher priced commodity afforded by peaking output the economic and financial feasibility of Quoddy are greatly exhanced.

The flights over the Passamaquoddy and St. John River areas and other portions of New Brunswick and eastern Maine emphasize the tremendous importance of the recreational asset which nature has provided in this region. The awareness of the populace to the recreational aspect is evidenced by the great number of picnic areas that have developed in the past year on the Canadian portion of the St. John River. We visualize a tremendous impetus to such activities as air-observation flights, increased boating, and other recreational and

sporting pursuits. We believe that with the greater emphasis on outdoor recreation, which we are presently transcending, the recreational aspect of the Quoddy project will increase and the estimated figure of 800,000 visitors to the project area for 1957 is ultraconservative and will be exceeded by many times when the project is built. Recreation is a distinct financial benefit to both the United States and Canada and should be fully evaluated as a monetary return in the repayment analysis of the Passamaquoddy tidal power project.

In view of the depressed economic conditions of Washington County, Maine, which would be directly affected by the Quoddy development and the fact that tidal power represents a nonconventional development, we believe that consideration be given to a subsidy in the form of financial assistance. Possibly this could be accomplished through the provision of non-interest-bearing advancements for capital investment during the first 15 years following initiation of construction. This would eliminate any interest expense during construction and early development period of the project.

We are firmly convinced, predicated on the successful development of the horizontal axial-flow turbine, that the value of Passamaquoddy tidal power project rests in a peaking-plant operation, providing a nominal quantity of load-factor energy. Such operation is dependent on the accomplishment of a fully interconnected and coordinated operation with the St. John River development and other resources in the area. It appears that the Quoddy project should be financed and developed solely by the United States with appropriate treaty and operational agreements with Canada. This would further cement the solidarity of our Governments and would provide benefits far in excess of what could be realized by either country operating independently and alone.

Mr. Tweeddale, general manager of the New Brunswick Electric Power Commission, in a speech to the Charlotte County Board of Trade at St. Andrews, New Brunswick, on August 24, 1961, indicated the possibility that if the United States might wish to proceed with the development of Quoddy power, then treaty arrangements could be arranged. Mr. Tweeddale stated in this same speech that if storage were developed on the upper St. John River then New Brunswick would expect to pay its fair share for any downstream benefits that they would receive. We believe this is a realistic approach and most pertinent to the U.S. development of Passamaquoddy.

ST. JOHN RIVER HYDROELECTRIC DEVELOPMENT

The St. John River development was referred to in numerous instances in the above, particularly concerning the upstream storage aspect in the United States. Any upstream development will immediately improve the downstream generation at the numerous plants, more or less run of the river, presently existing or planned for construction by the New Brunswick Electric Power Commission. Fully coordinated operation between Quoddy and the full reach of the St. John River would provide benefits far in excess of what could be accomplished by each country operating independently and alone. The New Brunswick Electric Power Commission indicates that full development of the Canadian portion of the St. John River without any upstream storage will amount to 921,000 kilowatts. With upstream storage this figure could be materially increased.

OTHER AREA RESOURCES

Our load and resource study concentrated on the Passamaquoddy tidal power project and the St. John River hydroelectric development. No investigations were made of other rivers such as the Kennebec, Pennobscot and so forth.

We did have an opportunity to fly over the potential tidal power developments in the upper Bay of Fundy in the vicinity of the proposed Chignecto Canal. The sites noted were impressive in the fact that mean tidal ranges of approximately 35 feet are experienced in contrast to the 18.1-foot mean range at the proposed Quoddy development. The recreational aspects of this area do not appear comparable with Quoddy due to the high silting by adjacent rivers and the greater expanse of water regions.

The preliminary figures for this tidal development are in the same order of magnitude as appears feasible to us for Quoddy. This is in the neighborhood of 1 million kilowatts of installed capacity.

RECOMMENDATIONS

Within the framework of our basic assignment to make a load and resource study of the Passamaquoddy tidal power project and the St. John River, we have contacted numerous individuals. Based on the knowledge gained from these sources, our own knowledge and experience, and the future need for marketable power in the area developed by our load and resource study, we are firmly convinced that Quoddy should be developed to provide peaking power in the magnitude of 1 million kilowatts. Its operation should be coordinated with the full development of the St. John River hydroelectric system, including upstream storage in the State of Maine. Consistent with the above, we respectfully submit the following:

1. In order to determine the optimum capacity that should be installed, firm data must be obtained regarding the operating characteristics and the cost of horizontal axial flow turbine units. We understand from statements made to us by representatives of the New Brunswick Electric Power Commission that Professor Danielle, one of the pioneers of the French bulb-type turbines, stated that increases in energy could be contributed by utilization of such units. We further understand from the commission's discussions presently in progress on the Chignecto Canal development that the cost of the turbine units has been conservatively estimated at $150 per kilowatt. It was stated that this cost figure was considered to be conservative because the French patents have expired and there is the possibility of costs reductions through mass production of the units in Canada.

2. Upon the availability of the new turbine characteristics and costs, it is recommended that computer studies be programed and run to determine the energy available under various conditions with Quoddy operated under (*a*) isolated conditions, (*b*) coordinated operation with the upper St. John River storage development, (c) coordinated operation with existing and proposed Canadian St. John River hydroelectric plants in New Brunswick, and (*d*) with various combinations thereof to determine optimum system operation and the preferable sequence of development. The computer studies should be conducted for the average year duration of tidal cycles. With simulated

operation of Quoddy as a peaking plant and the installation of horizontal axial flow turbine units, the capabilities and maximum energy generation will be provided for annual operation along with the optimum size of power development.

3. We believe that some concept of a powerplant in the magnitude of 1 million kilowatts should be developed and an estimate of cost be prepared.

4. We believe a committee composed of construction experts should be appointed to investigate and advise of any possibilities which might exist for modifying the design or reducing the cost of the water structures in the Western Passage, Indian River, and Head Harbour Passage.

5. An appropriate transmission system should be designed and the cost estimated of delivering the capacity and energy to usable load centers. These costs would then readily determine the marketability of Quoddy and the St. John River upstream storage developments.

6. We recommend that an estimate be prepared on the basis of the United States financing and constructing the Passamaquoddy tidal power project coordinated with the upstream St. John River hydroelectric development taking advantage of the technological advances in the design of the horizontal axial flow turbine unit and crediting the development with recreational benefits plus an appropriate subsidy for area development. Possibly this subsidy could be in the form of eliminating the interest charges during the initial 15 years of the project.

JOSEPH E. GUIDRY,
Assistant Chief, Programs and Development Branch, Power Division, Bureau of Reclamation.

BRUCE ROGERS,
Electrical Engineer, Bonneville Power Administration.

DECEMBER 12, 1961.

APPENDIXES

Appendix I

List of Individuals Contacted

U.S. Army, Corps of Engineers:
Office of Chief of Engineers, Washington, D.C.:
John W. Roche, Special Projects Branch.
Donald Curtis, Chief of Policy Branch, Planning Division.
Fred L. Thrall, Assistant Chief of Policy Branch, Planning Division.
Karl Wessl, engineer, Policy Branch, Planning Division.
A. B. Taylor, Chief of Hydro Power, Engineering Division.
New England Division, Boston, Mass., office:
Link Reid.
A. G. Carpenter.
Al Stewart.
Southwestern Division, Dallas, Tex., office.
George Makela.
Dave Hendrickson.
Federal Power Commission:
Washington, D.C., office:
Francis L. Adams, Chief, Bureau of Power.
Stewart P. Crum, Chief, Division of River Basins.
Edgar T. Hughes, Chief, Electric Resources and Requirements.
Dr. J. J. A. Jessel, Transmission and Coordination Section.
New York, N.Y., regional office:
Day J. Wait, regional engineer.
John H. Spellman, deputy regional engineer.
L. B. Woll, supervisory electrical engineer
Angelo M. Monaco, supervising hydraulic engineer.
K. W. Ross, hydraulic engineer.
O. A. Arnold, supervising hydraulic engineer.
M. Syed, supervising hydraulic engineer.
T. D. Carlson, electrical engineer.
The New Brunswick Electric Power Commission:
D. C. Harper, chairman.
R. E. Tweeddale, general manager.
A. J. O'Connor, manager, engineering.
H. E. Marshall, system planning engineer.
W. B. Cuthbertson, hydraulic development engineer.
L. J. Breneol, planning engineer.

Appendix II

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury. Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
MAINE				
			Megawatts	
Bangor Hydroelectric Co	Private	East Machias	1.3	Hy
Do	do	do	2.0	Ic
Do	do	Eastport	2.0	Ic
Do	do	Ellsworth	8.9	Hy
Do	do	Grahams Station	30.3	St
Do	do	do	12.0	Gt
Do	do	Howland	1.9	Hy
Do	do	Medway	3.4	Hy
Do	do	do	8.0	Ic
Do	do	Milford	6.4	Hy
Do	do	do	2.0	Ic
Do	do	Orono	2.3	Hy
Do	do	Standford	3.8	Hy
Do	do	Stillwater	2.0	Hy
Do	do	Veazie	8.4	Hy
Casco Bay Light & Power Co	do	Peaks Island	1.8	Ic
Central Maine Power Co	do	Androscoggin No. 3	3.6	Hy
Do	do	Bar Mills	4.0	Hy
Do	do	Biddeford	11.5	St
Do	do	Bonny Eagle	7.2	Hy
Do	do	Brunswick	1.5	Hy
Do	do	Bucksport No. 2	12.5	St
Do	do	Burnham	1.1	Hy
Do	do	Cape	22.5	St
Do	do	Cataract	6.7	Hy
Do	do	W. F. Wyman	88.0	St
Do	do	Deer Rips	6.5	Hy
Do	do	Farmingdale	4.0	Gt
Do	do	Fort Halifax	1.5	Hy
Do	do	Gulf Island	19.2	Hy
Do	do	Harris	75.0	Hy
Do	do	Hiram	2.4	Hy
Do	do	Mason	139.0	St
Do	do	North Gorham	2.3	Hy
Do	do	Oakland	2.8	Hy
Do	do	Rice Rips	1.6	Hy
Do	do	Rockland	2.0	Ic
Do	do	Shawmut	4.7	Hy
Do	do	Skelton	16.8	Hy
Do	do	South Berwick	1.2	Hy
Do	do	Union Gas	1.5	Hy
Do	do	West Buxton	6.6	Hy
Central Maine Power Co	do	Weston	12.0	Hy
Do	do	Williams	13.0	Hy
Do	do	Wyman	72.0	Hy
Cornish & Keeler Falls Light & Power Co	do	Cornish & Keeler Falls	.4	Hy
Do	do	do	1.2	St
Eastern Maine Electric Cooperative	Cooperative	Calais	1.2	Ic
Lubec	Municipal	Whitney	.1	Hy
Do	do	Lubec	1.3	Ic
Maine Public Service Co	Private	Caribou	.8	Hy
Do	do	do	19.0	St
Do	do	do	8.1	Ic
Do	do	Flo's Inn	6.0	Ic
Do	do	Houlton	1.0	Ic
Do	do	Squa Pan	1.5	Hy
Public Service Co. of New Hampshire	do	Great Falls (lower)	1.6	Hy
Do	do	Swans Falls	3.0	Ic
Rumford Falls Power Co	do	Lower Station	12.8	Hy
Do	do	Upper Station	3.8	Hy
U.S. Air Force	Federal	Loring AFB	15.4	Ic
U.S. Navy	do	Maine (Portsmouth, N.H.).	11.3	St
Vinalhaven	Municipal	Vinalhaven	1.0	Ic
Breakdown by type of generation:				
Hydro			322.6	
Steam			335.3	
Internal combustion			54.8	
Gas turbine			16.0	
Total			728.7	

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960—Continued

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
			Megawatts	
NEW HAMPSHIRE				
Concord Electric Co	Private	Sewalls Falls	2.0	Hy
Granite State Electric Co. (New England Power Co.).	do	Grafton No. 4	1.3	Hy
New England Power Co	do	Comerford	140.4	Hy
Do	do	McIndoes	10.6	Hy
Do	do	Samuel C. Moore	140.4	Hy
Do	do	Vernon	24.4	Hy
Public Service Co. of New Hampshire	do	Amoskeag	16.0	Hy
Do	do	Ayers Island	8.4	Hy
Do	do	Merrimack	113.6	St
Do	do	Eastman Falls	3.0	Hy
Do	do	Garvins Falls	7.2	Hy
Do	do	Gorham	2.2	Hy
Do	do	Great Falls (upper)	2.6	Hy
Do	do	Greggs Falls	3.0	Hy
Do	do	Hooksett	1.6	Hy
Do	do	Jackman	3.2	Hy
Do	do	Kelley's Falls	1.0	Hy
Do	do	do	18.8	St
Do	do	Manchester	20.0	St
Do	do	Minnewawa	1.6	Hy
Do	do	Daniel Street	21.0	St
Do	do	Resistance	30.0	St
Do	do	Salmon Falls	2.0	Hy
Do	do	Schiller	175.0	St
Do	do	do	15.0	Me
Do	do	Smith	15.0	Hy
Wolfeboro	do	Wolfeboro	3.0	Ic
Breakdown by type of generation:				
Hydro			385.9	
Steam			378.4	
Internal combustion			3.0	
Mercury			15.0	
Total			782.3	
VERMONT				
Barton Village	Municipal	West Charleston	1.4	Hy
Do	do	do	1.4	Ic
Burlington (Green Mountain Power Co.)	do	Lake Street	30.0	St
Central Vermont Public Service Co	Private	Cavendish	1.4	Hy
Do	do	Clarks Falls	3.0	Hy
Do	do	Fairfax Falls	2.9	Hy
Do	do	Glen	2.0	Hy
Do	do	Lower Middlebury	2.3	Hy
Do	do	Milton	6.0	Hy
Do	do	do	4.0	St
Do	do	Peterson	5.0	Hy
Do	do	Pittsford	3.6	Hy
Do	do	Rutland	18.0	Gt
Do	do	St. Albans	2.5	Ic
Do	do	Salisbury	1.3	Hy
Do	do	Silver Lake	2.2	Hy
Do	do	Weybridge	3.0	Hy
Citizens Utilities Co	do	Newport	4.6	Hy
Do	do	do	7.0	Ic
Green Mountain Power Corp	do	Essex No. 19	4.8	Hy
Do	do	do	4.0	Ic
Do	do	Gorge No. 18	3.0	Hy
Do	do	Marshfield No. 6	5.0	Hy
Do	do	Middlesex No. 2	3.2	Hy
Do	do	Montpelier No. 3	6.0	St
Do	do	Vergennes No. 9	2.6	Hy
Do	do	Waterbury Dam No. 22	5.5	Hy
Do	do	West Danville No. 15	1.0	Hy
Hardwick	Municipal	Hardwick No. 1	.7	Hy
Do	do	do	.7	Ic
Morrisville	do	Cady Falls	1.3	Hy
Do	do	Morrisville	1.8	Hy
New England Power Co	Private	Bellows Falls	40.8	Hy
Do	do	Harriman	33.6	Hy
Do	do	Searsburg	4.0	Hy
Do	do	Wilder	32.4	Hy

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960—Continued

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury. Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
VERMONT—continued				
			Megawatts	
Public Service Co. of New Hampshire	Private	Canaan	1.1	Hy
Do	do	Lyman Falls	1.2	Hy
Swanton	Municipal	Highgate Falls	4.6	Hy
Do	do	Swanton	1.2	St
Breakdown by type of generation:				
Hydro			185.3	
Steam			41.2	
Internal combustion			15.6	
Gas turbine			18.0	
Total			260.1	
MASSACHUSETTS				
Boston Edison Co	Private	Edgar	457.9	St
Do	do	L Street	249.8	St
Do	do	Mystic (Units 1-5)	462.5	St
Braintree	Municipal	Allen Street	23.0	St
Do	do	Potter Street	12.5	St
Brockton Edison Co. (Eastern Utilities Association).	Private	East Bridgewater	20.0	St
Cambridge Electric Light Co	do	Blackstone Street	24.8	St
Do	do	Kendall Square	67.4	St
Cape & Vineyard Electric Co	do	Vineyard Haven	1.4	Ic
Do	do	Provincetown	1.2	Ic
Fall River Electric Light Co. (Eastern Utilities Association).	do	Hathaway Street	14.3	St
Fitchburg Gas & Electric Light Co	do	Fitchburg	32.6	St
Holyoke	Municipal	Holyoke	2.3	Hy
Do	do	do	30.0	St
Holyoke Water Power Co	Private	Hadley Falls	15.0	Hy
Do	do	Holyoke No. 1 (Riverside Station).	7.6	Hy
Do	do	Holyoke No. 1	42.5	St
Do	do	Holyoke No. 2 (Boatlock Station).	2.9	Hy
Do	do	Mount Tom	136.0	St
Hudson	Municipal	Cherry Street	12.3	Ic
Ipswich	do	Ipswich	7.8	Ic
Lynn Gas & Electric Co. (New England Power Co.).	Private	Lynnway	60.0	St
Marblehead	Municipal	Marblehead	1.1	Ic
Metropolitan District Commission (Boston).	do	Oakdale	3.5	Hy
Do	do	Sudbury	.7	Hy
Do	do	Wachusett	3.2	Hy
Do	do	Winsor	1.2	Hy
Merrimack-Essex Electric Co. (New England Power Co.).	Private	Gloucester	5.9	St
Do	do	Lawrence	1.4	Hy
Do	do	do	12.5	St
Do	do	Newburyport	6.5	St
Do	do	Peabody Street	27.5	St
New England Power Co	do	Lowell	32.8	St
Do	do	Haverhill	10.0	St
Montaup Electric Co. (Eastern Utilities Association).	do	Somerset	325.0	St
Nantucket Gas & Elec. Co	do	Nantucket	1.0	St
Do	do	do	3.2	Ic
New Bedford Gas & Edison Light Co	do	Cannon Street	145.5	St
New England Power Co	do	Deerfield No. 2	4.8	Hy
Do	do	Deerfield No. 3	4.8	Hy
Do	do	Deerfield No. 4	4.8	Hy
Do	do	Deerfield No. 5	15.0	Hy
Do	do	Salem Harbor	319.9	St
Do	do	Sherman	7.2	Hy
Do	do	Three Rivers	2.2	Hy
Peabody	Municipal	Peabody	7.4	Ic
Quinnehtuk Co. (Western Massachusetts Electric Co.).	Independent	Dwight	2.1	Hy
Springfield	Municipal	Cobble Mountain	33.0	Hy
Taunton	do	Taunton	50.5	St
U.S. Navy	Federal	Boston Navy Yard	22.0	St

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960—Continued

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
MASSACHUSETTS—continued				
			Megawatts	
Western Massachusetts Electric Co	Private	Cabot	51.0	Hy
Do	do	Gardner Falls	4.0	Hy
Do	do	Hampden	30.0	St
Do	do	Indian Orchard	4.9	Hy
Do	do	Ludlow	3.2	Hy
Do	do	State St	44.1	St
Do	do	Turner Falls No. 1	4.8	Hy
Do	do	West Springfield	209.6	St
Do	do	Red Bridge	.6	Hy
Worcester County Electric Co. (New England Power Co.).	do	Webster Street	83.7	St
Yankee Atomic Electric Co	do	Rowe	145.0	Nu
Breakdown by type of generation:				
Hydro			183.2	
Steam			2959.8	
Internal combustion			34.4	
Nuclear			145.0	
Total			3,322.4	
RHODE ISLAND				
Bird & Son, Inc	Independent	Phillipsdale	3.0	St
Blackstone Valley Gas & Electric Co. (Eastern Utilities Association).	Private	Pawtucket No. 1	33.5	St
Do	do	Pawtucket No. 2	0.6	Hy
Island Light & Power Co	do	Block Island	1.0	Ic
Narragansett Electric Co., The (New England Power Co.).	do	Manchester Street	147.0	St
Do	do	South County	10.0	Ic
Do	do	South Street	213.8	St
Newport Electric Corp	do	Newport	10.5	St
Do	do	Jepson	4.0	Ic
Providence	Municipal	Fields Point	2.5	St
Do	do	Gainer Dam	1.5	Hy
U.S. Navy	Federal	Quonset Point	5.0	St
Do	do	Gould Island	2.8	Ic
Breakdown by type of generation:				
Hydro			2.1	
Steam			415.3	
Internal combustion			17.8	
Total			435.2	
CONNECTICUT				
Connecticut Light & Power Co., The	Private	Bulls Bridge	8.4	Hy
Do	do	Danielson	12.0	Gt
Do	do	Deron	479.0	St
Do	do	Montville	176.0	St
Do	do	Norwalk Harbor	150.0	St
Do	do	Rocky River	31.0	Hy
Do	do	Scotland Dam	2.0	Hy
Do	do	Shepaug	37.2	Hy
Do	do	Stevenson	30.5	Hy
Do	do	Thompsonville	12.0	Gt
Do	do	Tunnel	2.0	Hy
Farmington River Power Co	do	Rainbow	8.0	Hy
Hartford Electric Light Co., The	do	Dutch Point	26.0	St
Do	do	Falls Village	9.0	Hy
Do	do	Middletown	166.0	St
Do	do	South Meadow	215.0	St
Do	do	do	15.0	Me
Do	do	Stamford	63.7	St
Do	do	Torrington	3.5	St
Housatonic Public Service Corp	do	Housatonic Avenue	.8	Hy
Do	do	do	20.0	St
Norwich	Municipal	Second Street	.8	Hy
Do	do	Occum	.8	Hy
Do	do	Greenville	14.3	St
South Norwalk	do	South Norwalk	10.3	Ic
United Illuminating Co., The	Private	Bridgeport Harbor	81.5	St
Do	do	English	146.3	St

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960—Continued

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury. Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
			Megawatts	
CONNECTICUT—continued				
U.S. Navy	Federal	New London Sub Base	7.5	St
Wallingford	Municipal	Pierce	22.5	St
Breakdown by type of generation:				
Hydroelectric			130.5	
Steam			1,571.3	
Internal combustion			10.3	
Gas turbine			24.0	
Mercury			15.0	
Nuclear			145.0	
Total			3,332.4	
NEW YORK				
Central Vermont Public Service Co	Private	Carvers Falls	1.6	Hy
Do	do	Hoosick Falls	1.1	Hy
Fishers Island Electric Corp	do	Fishers Island	1.7	Ic
Beaver River Power Corp	do	High Falls	4.8	Hy
Beebee Island Corp	do	Beebee Island	8.0	Hy
Dexter Hydro Electric Corp	do	Dexter	1.7	Hy
Do	do	Pyrites	1.2	Hy
Herkimer (Niagara Mohawk Power Corp.)	Municipal	Herkimer	4.5	St
Do	do	do	4.1	Ic
Jamestown	do	Steele Street	57.5	St
Moreau Manufacturing Corp. (Niagara Mohawk Power Corp.)	Independent.	Feeder Dam	6.0	Hy
New York State, Department of Public Works.	State	Vischer Ferry	5.6	Hy
Do	do	Crescent	5.6	Hy
New York State Electric & Gas Corp	Independent.	Colliers	3.8	Hy
Do	do	Waterloo	1.9	Hy
Do	do	Keuka Lake	2.0	Hy
Do	do	Seneca Lake	8.0	Hy
Do	do	Cadyville	2.4	Hy
Do	do	Mill C	2.3	Hy
Do	do	Rainbow Falls	2.6	Hy
Do	do	Kents Falls	6.4	Hy
Do	do	Walden	1.5	Hy
Do	do	High Falls	14.1	Hy
Do	do	Goudey	156.3	St
Do	do	Greenidge	160.0	St
Do	do	Milliken	270.0	St
Do	do	Hickling	70.0	St
Do	do	Jennison	60.0	St
Do	do	Riverside	21.5	St
Do	do	Cadyville	2.3	Ic
Niagara Mohawk Power Corp	Private	Taylorsville	4.5	Hy
Do	do	Theresa	1.6	Hy
Do	do	Victory Mills	1.3	Hy
Do	do	Waterport	4.7	Hy
Do	do	Sewalls Island	2.0	Hy
Do	do	South Edwards	2.7	Hy
Do	do	South Glens Falls	3.8	Hy
Do	do	Stuyvesant Falls	2.8	Hy
Do	do	Sugar Island	4.8	Hy
Do	do	Port Henry	1.8	Hy
Do	do	Raymondville	2.0	Hy
Do	do	Schuylerville	1.2	Hy
Do	do	Norfolk	4.5	Hy
Do	do	Norwood	2.0	Hy
Do	do	Parishville	2.4	Hy
Do	do	Little Falls	1.2	Hy
Do	do	Macomb	1.0	Hy
Do	do	Middle Falls	1.0	Hy
Do	do	Moreau	4.8	Hy
Do	do	Varick	8.8	Hy
Do	do	Burt	1.0	Hy
Do	do	Allens Falls	4.4	Hy
Do	do	Bakers Falls	2.3	Hy
Do	do	Belfort	1.8	Hy
Do	do	Trenton Falls	23.6	Hy
Do	do	Stewarts Bridge	30.0	Hy
Do	do	Spier Falls	44.4	Hy
Do	do	South Colton	19.4	Hy

Major utility generating plants, 1 megawatt and over, 60 cycle, as of Dec. 31, 1960—Continued

[Key to symbols: St=Steam. Hy=Hydro. Ic=Internal combustion. Gt=Gas turbine. Me=Mercury. Nu=Nuclear]

State and company	Owner	Plant name	Maximum installed capacity	Type
NEW YORK—continued				
			Megawatts	
Niagara Mohawk Power Corp	Private	Soft Maple	15.0	Hy
Do	do	Sherman Island	28.8	Hy
Do	do	E. J. West	20.0	Hy
Do	do	Beardslee	20.0	Hy
Do	do	Adams	80.0	Hy
Do	do	Browns Falls	15.0	Hy
Do	do	Black River	6.0	Hy
Do	do	Bennets Bridge	12.8	Hy
Do	do	Eagle Falls	6.1	Hy
Do	do	Deferiet	10.8	Hy
Do	do	Colton	29.5	Hy
Do	do	Dolgeville	1.9	Hy
Do	do	Chasm	3.4	Hy
Do	do	Diamond Isle	1.2	Hy
Do	do	Heuvelton	1.0	Hy
Do	do	Higley Falls	4.5	Hy
Do	do	Prospect	17.3	Hy
Do	do	Hydraulic Race	4.7	Hy
Do	do	Johnsonville	4.8	Hy
Do	do	Fort Edward	2.9	Hy
Do	do	Fultons	1.3	Hy
Do	do	Glenwood	1.5	Hy
Do	do	Granby	1.7	Hy
Do	do	East Norfolk	3.0	Hy
Do	do	Eel Weir	2.7	Hy
Do	do	Effley Falls	3.0	Hy
Do	do	Elmer Falls	1.5	Hy
Do	do	School St	38.8	Hy
Do	do	Schaghticoke	13.1	Hy
Do	do	Moshier	8.0	Hy
Do	do	Minetto	8.0	Hy
Do	do	Lighthouse Hill	7.5	Hy
Do	do	Kamargo	5.4	Hy
Do	do	Inghams	6.4	Hy
Do	do	High Dam	7.6	Hy
Do	do	Herrings	5.4	Hy
Do	do	Hannawa Falls	7.2	Hy
Do	do	Flat Rock	6.0	Hy
Do	do	Five Falls	22.5	Hy
Do	do	Ephratah	5.2	Hy
Do	do	Blake	14.4	Hy
Do	do	Stark	22.5	Hy
Do	do	Schoellkopf	89.5	Hy
Do	do	Rainbow Falls	22.5	Hy
Do	do	C. R. Huntley	940.0	St
Do	do	Albany	400.0	St
Do	do	Dunkirk	592.0	St
Do	do	Oswego	420.0	St
Oswegatchie Light & Power Co	do	No. 4 plant	1.3	Hy
Do	do	No. 7 plant	.9	Hy
Paul Smith's Electric Light & Power & RR. Co.	do	Franklin Falls	2.3	Hy
Do	do	Piercefield	2.7	Hy
Do	do	Union Falls	2.4	Hy
Do	do	Piercefield	2.0	Ic
Plattsburgh	Municipal	Plattsburgh	3.2	Ic
Power Authority of New York State	State	Robert Moses	912.0	Hy
Rochester Gas & Electric Corp	Private	Station No. 2	6.5	Hy
Do	do	Station No. 5	38.3	Hy
Do	do	Station No. 26	3.0	Hy
Do	do	Station No. 170	1.1	Hy
Do	do	Station No. 3	177.0	St
Do	do	Station No. 7	200.0	St
Do	do	Station No. 8	8.0	St
Do	do	Station No. 9	3.0	St
Watertown Municipal Light & Power Department.	Municipal	Watertown	5.4	Hy
Wellsville, Village of	do	Wellsville	2.0	St
Breakdown by type of generation:				
Hydro			1,832.7	
Steam			3,541.8	
Internal combustion			13.3	
Total			5,387.8	

Canadian maritime provinces—nameplate generating capacity (utility) megawatts as of December 1959

Province and company	Owner	Plant name	Nameplate capacity	Type
NEW BRUNSWICK			*Megawatts*	
The New Brunswick Electric Power Commission.	Public	Musquash	7.0	Hy
Do	do	Tobique	20.0	Hy
Do	do	Beechwood	72.0	Hy
Do	do	Milltown	2.7	Hy
Do	do	Grand Falls	63.0	Hy
Do	do	Saint John	16.0	St
Do	do	Grand Lake No. 1	18.8	St
Do	do	Grand Lake No. 2	25.0	St
Do	do	Chatham	32.5	St
Maine & New Brunswick Electrical Power Co., Ltd.	Private	Tinker Falls	10.0	Hy
Do	do	do	1.0	Ic
City of Edmundston	Municipal	Second Falls	1.1	Hy
Do	do	do	3.0	Ic
City of Campbellton	do	Campbellton	2.7	Ic
Breakdown by type of generation:				
Hydro			175.8	
Steam			92.3	
Internal combustion			6.7	
Total			274.8	MW
NOVA SCOTIA				
Nova Scotia Power Commission	Public	Barrie Brook	.4	Hy
Do	do	Dickie Brook	3.8	Hy
Do	do	Liscomb	.4	Hy
Do	do	Malay Falls	3.6	Hy
Do	do	Ruth Falls	7.0	Hy
Do	do	Trenton No. 1	10.0	St
Do	do	Trenton No. 2	10.0	St
Do	do	Trenton No. 3	20.0	St
Do	do	Trenton No. 4	20.0	St
Do	do	Upper Lake Falls	5.4	Hy
Do	do	Lower Lake Falls	7.4	Hy
Do	do	Big Falls	9.0	Hy
Do	do	Lower Great Brook	4.5	Hy
Do	do	Deep Brook	9.0	Hy
Do	do	Cowie Falls	7.2	Hy
Do	do	Gulch	6.0	Hy
Do	do	Ridge	4.0	Hy
Do	do	Harmony	.6	Hy
Do	do	Roseway	.9	Hy
Do	do	Sissiboo Falls	6.0	Hy
Do	do	Weymouth	9.0	Hy
Do	do	Tusket Falls	2.2	Hy
Do	do	Mill Lake	2.6	Hy
Do	do	Sandy Lake	3.2	Hy
Do	do	Tidewater	4.6	Hy
Do	do	Cheticamp	.2	Ic
Do	do	Ingonish	.8	Ic
Nova Scotia Light & Power Co., Ltd	Private	Avon No. 1	3.8	Hy
Do	do	Avon No. 2	3.0	Hy
Do	do	Methals	3.4	Hy
Do	do	Hollow Bridge	5.3	Hy
Do	do	Lumsden	2.8	Hy
Do	do	Hells Gate No. 1	3.3	Hy
Do	do	Hells Gate No. 2	3.6	Hy
Do	do	White Rock	3.2	Hy
Do	do	Nictaux	6.8	Hy
Do	do	Paradise	3.6	Hy
Do	do	Lequille	.2	Hy
Do	do	Bloody Creek	.3	Hy
Do	do	Fall River	.4	Hy
Do	do	St. Croix	3.0	Hy
Do	do	Salmon Hole	2.0	Hy
Do	do	Water Street No. 2	10.0	St
Do	do	Water Street No. 3	20.0	St
Do	do	Water Street No. 4	20.0	St
Do	do	Water Street No. 5	25.0	St
Do	do	Water St. No. 6	45.0	St
Do	do	Water Street No. 7	45.0	St
Do	do	Yarmouth	2.0	Ic
Breakdown by type of generation:				
Hydro			141.5	
Steam			225.0	
Internal combustion			3.0	
Total			369.5	

Canadian maritime provinces—nameplate generating capacity (utility) megawatts as of December 1959—Continued

Province and company	Owner	Plant name	Nameplate capacity	Type
NOVA SCOTIA—continued				
			Megawatts	
31.9 megawatts of Nova Scotia Power Commission Mersey hydro system is supplied to Bowater's Mersey Pulp & Paper Co., Ltd. Therefore, total Nova Scotia generating capacities shall be as follows:				
Breakdown by type of generation:				
Hydro			109.6	
Steam			225.0	
Internal combusion			3.0	
Total			337.6	

APPENDIX III

Scheduled capacity changes as of Jan. 1, 1961

Utility	Plant	Mega-watts	Type	Date in service
PSA 1				
Bangor Hydroelectric	Youngs Corner No. 1	2.0	Ic	October 1961.[1]
	Youngs Corner No. 2	2.0	Ic	Do.
	Youngs Corner No. 3	2.0	Ic	Do.
	Youngs Corner No. 4	2.0	Ic	Do.
	East Machias No. 2	2.0	Ic	June 1963.
	East Machias No. 3	2.0	Ic	October 1963.
	East Machias No. 4	2.0	Ic	Do.
	East Machias No. 5	2.0	Ic	Do.
	East Machias No. 6	2.0	Ic	November 1963.
	Graham No. 5	16.5	St	October 1965.
Maine Public Service Co	Caribou No. 3	16.5	St	October 1963.
	Flo's Inn	2.0	Ic	October 1962.
	Undetermined	16.5	St	October 1964.
Cornish and Kezar Falls	Parsonfield No. 2	.3	St	1961.
Total		69.8		
PSA 2				
Boston Edison Co	Mystic No. 6	137.5	St	July 1961.
	"L" St	350.0	St	
Central Vermont Public Service	East Georgia No. 1	5.0	Hy	(2).
	East Georgia No. 2	5.0	Hy	
	Ascutney No. 4	13.2	Gt	December 1961.
	Not Determined No. 5	13.2	Gt	November 1962.
Connecticut Light & Power	Norwalk Harbor No. 2	150.0	St	September 1963.
Hartford Electric Light	South Meadows	10.0	Gt	1963.
New England Power Co	Brayton Point No. 1	225.0	St	May 1963.
	Brayton Point No. 2	225.0	St	July 1964.
Newport Electric Co	Arnold No. 1 (Portsmouth)	10.0	St	No date given.[1]
	Jepson No. 3	2.0	Ic	October 1961.
	Jepson No. 4	2.0	Ic	Do.
United Illuminating Co	Bridgeport Harbor No. 2	150.0	St	August 1961.
Norwich Department of Public Works	Greenville No. 5	7.5	St	Undecided.
Ipswich Water & Light Department	High St. No. 9	1.4	Ic	October 1961.
Total		1,306.8		

See footnotes at end of table, p. 94.

Scheduled capacity changes as of Jan. 1, 1961—Continued

Utility	Plant	Mega-watts	Type	Date in service
PSA 3				
New York Power Authority	Lewiston Nos. 1 to 5, 150.3 each.	751.5	Hy	February to June 1961.
	Lewiston No. 6	150.3	Hy	August 1961.
	Lewiston No. 7	150.3	Hy	September 1961.
	Lewiston No. 8	150.3	Hy	October 1961.
	Lewiston No. 9	150.3	Hy	November 1961.
	Lewiston No. 10	150.3	Hy	December 1961.
	Lewiston No. 11	150.3	Hy	January 1962.
	Lewiston No. 12	150.3	Hy	March 1962.
	Lewiston No. 13	150.3	Hy	April 1962.
	Tuscarora No. 1	20.0	Hy	December 1961.[1]
	Tuscarora No. 2	20.0	Hy	Do.
	Tuscarora No. 3	20.0	Hy	Do.
	Tuscarora No. 4	20.0	Hy	Do.
	Tuscarora No. 5	20.0	Hy	February 1962.
	Tuscarora No. 6	20.0	Hy	March 1962.
	Tuscarora No. 7	20.0	Hy	May 1962.
	Tuscarora No. 8	20.0	Hy	June 1962.
	Tuscarora No. 9	20.0	Hy	August 1962.
	Tuscarora No. 10	20.0	Hy	September 1962.
	Tuscarora No. 11	20.0	Hy	November 1962.
	Tuscarora No. 12	20.0	Hy	December 1962.
Potsdam Municipal Works	Potsdam No. 2	.2	Hy	Indefinite.
Total		2,194.1		

[1] 1st unit in new plant.
[2] License application pending.

Key to symbols: Ic—Internal combustion; St—steam; Hy—hydro; Gt—gas turbine.

Maritime Province scheduled and planned additions

Date in service	Plant	Megawatts	Type
1961	St. John No. 1	48.2	Steam.
1962	Beechwood No. 3	31.5	Hydro.
1963	St. John No. 2	72.5	Steam.
1965	Nova Scotia	96.3	Do.
1966	do	96.3	Do.
1966	Mactaguac Nos. 1 and 2	115.0	Hydro.
1968	Nova Scotia	143.4	Steam.
1969	Mactaguac No. 3	55.0	Hydro.
1970	Mactaguac No. 4	53.6	Do.
1971	Mactaguac No. 5	49.4	Do.
1971	Nova Scotia	143.4	Steam.
1972	Mactaguac No. 6	47.0	Hydro.
1973	Bathhurst No. 1	143.4	Steam.
1974	Nova Scotia	143.4	Do.
1975	Mactaguac Nos. 7 and 8	94.0	Hydro.
1975	Nova Scotia	143.4	Steam.
1976	Grand Falls Nos. 1, 2, 3, and 4	159.2	Hydro.
1977	Nova Scotia	143.4	Steam.
1978	do	143.4	Do.
1978	Bathhurst No. 2	143.4	Do.
1979	Nova Scotia	143.4	Do.
1980	Grand Falls Nos. 5 and 6	69.8	Hydro.
1980	Nova Scotia	143.4	Steam.

REPORT OF THE
INTERNATIONAL JOINT COMMISSION
UNITED STATES AND CANADA
ON THE
INTERNATIONAL PASSAMAQUODDY TIDAL
POWER PROJECT
(April 1961)

REPORT OF THE INTERNATIONAL JOINT COMMISSION, UNITED STATES AND CANADA, ON THE INTERNATIONAL PASSAMAQUODDY TIDAL POWER PROJECT

April 1961

INTERNATIONAL JOINT COMMISSION

United States	*Canada*
Edward A. Bacon, Chairman	A. G. L. McNaughton, Chairman
Eugene W. Weber	J. Lucien Dansereau
Francis L. Adams	D. M. Stephens
Harry J. Donohue, Secretary	D. G. Chance, Secretary

REFERENCE TO THE INTERNATIONAL JOINT COMMISSION

The Governments of the United States and Canada forwarded on August 2, 1956, to the International Joint Commission identical letters requesting the Commission to conduct investigations and to submit a report on the proposed international Passamaquoddy tidal power project. This request was made in accordance with the Boundary Waters Treaty of 1909 and with U.S. Public Law 401, 84th Congress, 2d session, approved January 31, 1956. The full text of the reference of the two Governments is quoted below:

> In accordance with the provisions of article IX of the Boundary Waters Treaty of January 11, 1909, the Governments of Canada and the United States have agreed to refer, and do hereby refer, to the International Joint Commission the following matters for joint examination and advisory report, including conclusions and recommendations:
>
> (*a*) It is desired that the Commission determine the estimated cost of developing the international tidal power potential of Passamaquoddy Bay in the State of Maine and the Province of New Brunswick, and determine whether such cost would allow hydroelectric power to be produced at a price which is economically feasible;
>
> (*b*) The Commission is requested to determine the effects, beneficial or otherwise, which such a power project might have on the local and national economies in the United States and Canada, and to this end, to study specifically the effects which the construction, maintenance, and operation of the tidal power structures might have upon the fisheries in the area.
>
> In the discharge of its responsibilities under this reference, the Commission is requested to review and, insofar as is practicable, make advantageous use of existing reports and plans such as the report of March 15, 1950, submitted by the International Passamaquoddy Engineering Board to the

Commission and the supplemental report of May 1952 prepared by the U.S. Army Corps of Engineers on the details of estimate of cost of a comprehensive investigation of the Passamaquoddy tidal power project. Having regard to the foregoing, the Commission should determine the most desirable general project design from the viewpoint of the public interest in United States and Canada respectively, such design to include plans for structure and appurtenant works in sufficient detail to form the basis of dependable cost estimates and considerations of economic feasibility.

In the conduct of its investigations, and otherwise in the performance of its duties under this reference, the Commission may utilize the services of specially qualified engineers and other experts of the technical agencies of the United States and Canada and will, so far as possible, make use of any pertinent data that may be available in such agencies or which may become available during the course of the investigations, thus avoiding duplication of effort and unnecessary expense.

The U.S. Government is willing, subject to the availability of funds, to incur cost in connection with this survey up to $3 million and the Canadian Government is willing to incur costs up to $300,000. Each Government has the right to participate at its own expense in all aspects of the survey to an extent appropriate with its interest. In making administrative arrangements for the necessary surveys and studies, the Commission should give suitable effect to these responsibilities.

The costs incurred by the Governments of the United States and Canada, respectively, under this reference will be credited against the costs to be borne by each of the Governments in the event that the project should be constructed as a joint undertaking by the two Governments. The decision of the two Governments to refer this study to the Commission does not imply any commitment regarding the eventual construction of the project.

It is the desire of both Governments that the Commission endeavor to complete its various surveys, investigations, studies, and other activities under the reference within a 3-year period. Upon completion, it is requested that the Commission prepare and submit to the Governments of the United States and Canada a comprehensive report covering the subject matter of this reference. The Commission's report should include the details of the specific design, cost estimates, and an estimate of the benefits to be derived or the losses to result from this project.

BACKGROUND OF THE PROJECT

Power from the tides

The ocean tides have long been envisioned as a source of power. Tide mills were constructed in Europe as early as the 11th century and in America as early as 1617. Such small tidal hydromechanical power developments were practical for grinding corn or spices as the

work could be adjusted to the periodic and varying power from the tides. Electrification and the rapid industrial and economic growth of the 20th century, however, have established a heavy growth in demand for electric power, and today the economic utilization of power requires its availability on a controlled schedule. Therefore, a tidal power project must be capable of sustaining dependable power production from the tides or be interconnected with other power sources and so operated that the coordinated capability would conform to the needs of the powerload.

Utilization of the tides to generate a substantial quantity of power requires provision for the storage of large quantities of water so that discharges may be made from a higher to a lower elevation through hydraulic turbines. A large single pool may be built to entrap or exclude water from the ocean, but generation of power is limited to those times in the tidal cycle when the differential in elevation between the ocean and the pool is sufficient for operation of the turbines. A combination of two storage pools for simultaneous entrapment and exclusion of water from the ocean can, however, provide for some generation at all times. Also, either single or two-pool projects may be arranged to accommodate reversible units capable of pumping or generating from flow in either direction, thus further increasing the power potential and providing greater flexibility for coordinated operation with other power sources. As compared to most river hydroelectric projects the potential average hydraulic head of tidal projects is quite small; but the very large quantities of water available for power production are accurately predictable for many years in the future.

Passamaquoddy Bay located near the mouth of the Bay of Fundy experiences smaller tidal ranges than those occurring in the head of that bay in Canada. The site, by reason of adjacent Cobscook Bay and the narrow passages among islands with interspaced shoal areas, offers many alternatives for one or two pool schemes. The large area of Passamaquoddy Bay with the substantial additional area of Cobscook Bay is favorable for a two-pool plan.

Prior surveys of the Passamaquoddy project

From 1924 to 1934 Dexter P. Cooper, Inc., prepared plans originally for an international tidal power project at Passamaquoddy and Cobscook Bays, but later for a project located wholly in the United States. The U.S. Federal Power Commission in its review of the Dexter P. Cooper, Inc., loan application to the Federal Emergency Administration of Public Works reported adversely on the project in January 1934, and the loan was not approved. The project as finally revised would have had an initial installation of 235,000 kilowatts with provision for an additional 100,000 kilowatts.

In 1927 Murray & Flood, engineers, of New York, N.Y., reported on the international project proposed by Cooper. They estimated that an installed capacity of 400,000 kilowatts with a firm capacity of 122,000 kilowatts could deliver 1,594 million kilowatt-hours annually to Woburn, Mass., at an average cost of 8.09 mills per kilowatt-hour. The total estimated cost of the project at 1926–27 price levels, was $125 million.

In 1935 the Passamaquoddy Bay Tidal Project Commission of the U.S. Federal Emergency Administration of Public Works recom-

mended construction of an initial Cobscook Bay project, all within the State of Maine, at an estimated cost of $30 million. An ultimate project was contemplated to embrace the Passamaquoddy Bay. The recommended initial project was approved by the U.S. Government and $10 million (later reduced to $7 million) was allotted to the U.S. Army Corps of Engineers to start construction.

The Corps of Engineers estimated that the initial project with a modified design would cost $61,500,000. A review board raised this estimate to $68,158,000. Work progressed until August 1936 with an expenditure of about $7 million, and was discontinued due to lack of further appropriations by the Congress.

In 1941, the Federal Power Commission in a report prepared pursuant to Senate Resolution 62, 76th Congress, 1st session, concluded that Passamaquoddy tidal power (development of U.S. waters only) could not compete successfully at that time with river hydroelectric power potentially available in the State of Maine, or with power from modern, efficient steam-electric plants. The Commission stated, however, that this conclusion should not preclude thorough exploration of the possibilities of a large international tidal power project at Passamaquoddy by the Governments of the United States and Canada.

Prior activities of IJC relative to the Passamaquoddy project

The Governments of the United States and Canada by a formal reference dated November 9, 1948, requested the International Joint Commission to review the then existing plans for the construction of tidal powerplants at Passamaquoddy and Cobscook Bays and report on the scope and cost of a survey necessary to determine whether the plans then proposed or any other plans for using these waters for generation of electric power would be practicable and desirable.

The Commission appointed an International Passamaquoddy Engineering Board to advise it on the technical phases of the study. In its report to the two Governments dated October 20, 1950, the International Joint Commission concluded that the economic feasibility of an international tidal power project at Passamaquoddy Bay could be determined only after careful and detailed investigations had been made. The cost of the necessary survey was estimated to be about $3,900,000, including $300,000 for investigation of the fisheries problem.

Subsequent to completion of the Commission's 1950 report on the Passamaquoddy project, the Corps of Engineers and the U.S. Geological Survey concluded from experiments with modern techniques in underwater foundation exploration that the overall survey cost could be reduced. Accordingly, the corps submitted in May 1952 to the International Joint Commission a revised cost estimate of $3 million, including $300,000 for fisheries investigations.

Objectives of the current survey

The objectives of the current survey are to determine the cost of developing an international tidal power project in Passamaquoddy and Cobscook Bays and whether such a project would be economically feasible. More specifically: to determine the most desirable general project design in sufficient detail for preparation of dependable cost estimates; to determine the effects which such a project might have

on the local and national economies in the United States and Canada; to determine the present and future electric power requirements in Maine and New Brunswick and the ability of the tidal project to supply these requirements; to determine the value of the tidal power in the market area, as compared to the cost of its development; and to study the effects which the construction, maintenance, and operation of the tidal power structures might have upon the fisheries in the area.

INVESTIGATION PROCEDURE

International Passamaquoddy Engineering Board and International Passamaquoddy Fisheries Board

To assist in the investigation, the Commission established two separate boards, the International Passamaquoddy Engineering Board and the International Passamaquoddy Fisheries Board. Membership on the Boards included two representatives each from Canada and the United States. On October 3, 1956, the International Joint Commission issued the following directive to the two boards:

> (*a*) The Engineering Board will carry out all the engineering investigations and studies necessary to enable the Commission to prepare and submit to the Governments of the United States and Canada a comprehensive report on the proposed Passamaquoddy tidal power project, as requested by the two Governments in a reference to the Commission dated August 2, 1956.
>
> (*b*) The Fisheries Board will study specifically the effects which the construction, maintenance and operation of the tidal power structures, proposed, might have upon the fisheries in the area.
>
> (*c*) In order to enable the Fisheries Board to commence its studies and investigations without delay, the Engineering Board is requested to forward to the Commission as soon as possible, for transmittal to the Fisheries Board, an outline of the various project plans which the Engineering Board proposes to investigate. Pending the submission of this information it is suggested that the Fisheries Board proceed with its studies on the basis of the general plans outlined in the March 15, 1950, report of the previous International Passamaquoddy Engineering Board.
>
> (*d*) In order that each of the Boards may be fully aware at all times of the progress being made in the investigations and studies carried out by the other Board, each Board is requested to keep the Commission currently informed regarding the investigations and studies it is conducting. The Commission will undertake responsibility for promtply transmitting the information thus received to the other Board, together with such suggestions or instructions as may appear to be appropriate.
>
> (*e*) In accordance with the desire of the two Governments as evidenced by the terms of the reference, the Engineering Board is requested to review and to utilize, insofar as is practicable, existing reports and plans such as the report of

March 15, 1950, submitted to the Commission by the previous International Passamaquoddy Engineering Board, and the supplemental report of May 1952 prepared by the Corps of Engineers, U.S. Department of the Army.

(*f*) Each Board is authorized to establish such committees and working groups as may be required to effectively discharge the Board's responsibilities.

(*g*) In accordance with the desire expressed by the two Governments, the Commission will endeavor to complete its various investigations and studies under the reference within a 3-year period and submit a comprehensive report covering the subject matter of the reference as soon as possible thereafter. In order that this may be done, the Commission would appreciate receiving the final reports of both Boards prior to October 1, 1959.

(*h*) Each Board will prepare and submit semiannual progress reports to the Commission on or about March 31 and September 30 of each year and such other reports from time to time as the Commission may direct or as the Board may consider desirable.

The Engineering Board established an Engineering Committee to supervise the detailed engineering studies of the tidal power project. These studies were carried out primarily by the U.S. Army Engineer Division, New England, Corps of Engineers, and the regional office of the U.S. Federal Power Commission, New York. Canadian aspects of the engineering studies were conducted by the Department of Public Works, the Department of Northern Affairs and National Resources, and other agencies of the Governments of Canada and New Brunswick. The Fisheries Board appointed a Research Committee of Canadian and U.S. scientists to develop plans and to conduct the necessary research on the fisheries of the Passamaquoddy region.

A joint Engineering and Fisheries Committee of the Engineering and Fisheries Boards was set up in accordance with directions from the International Joint Commission dated October 4, 1957. That Committee established an appropriate and practicable line of demarcation between the work of the two Boards and outlined the methods of measuring benefits and damages in matters of common interest to the fisheries and engineering investigations.

Referral of reports of the Engineering Board and Fisheries Board to interested parties for review and comment

On November 13, 1959, the International Joint Commission issued a public notice stating that the comprehensive technical investigations and studies necessary for the preparation of the Commission's report were completed, and that the final reports of the two Boards had been formally presented to the Commission. In order to obtain the views of interested parties prior to formulation of the Commission's report and recommendations to the two Governments, the Commission made the reports of the Boards available for examination at convenient places in both countries. In addition, copies of the report were sent to the Maine delegation in the U.S. Congress; the New Brunswick Members of the Canadian Parliament; interested agencies of each Government; State, Provincial, and local governments and officials concerned; and others.

In response the Commission's public notice inviting comments on the reports of the Boards, numerous communications were received. Most of these communications favored the tidal power project in principle but dealt only in very general terms with the details of the Board's reports.

Commission hearing on findings of Engineering and Fisheries Boards reports

On April 22, 1960, the International Joint Commission conducted a public hearing in the Calais Memorial High School, Calais, Maine, for the purpose of receiving testimony and evidence bearing on the findings and conclusions set forth in the reports of the International Passamaquoddy Engineering Board and the International Passamaquoddy Fisheries Board.

The Calais hearing was attended by a total of about 200 persons from the United States and Canada, including a Representative of the U.S. Congress, the Governor of the State of Maine, representatives of Federal, State, Provincial, county, and municipal agencies, local civic groups, and other interested individuals. Twenty-nine persons presented briefs or oral testimony at the hearing. About two-thirds of these were favorably inclined toward the tidal power project. In addition to the testimony presented at the hearing, several communications commenting on the tidal power project were received by the Commission and included in the record of the hearing. These communications, for the most part, were favorable to the tidal power project. The views expressed at the hearing are covered more fully in the section dealing with the public hearing.

REPORT OF THE ENGINEERING BOARD

Scope of the survey

The report of the International Passamaquoddy Engineering Board sets forth the results of a comprehensive survey to determine the engineering and economic feasibility of developing the international tidal power potential of Passamaquoddy Bay in Maine and New Brunswick and the effects which such a project might have on the local and national economies in the United States and Canada. It includes within its scope the results of investigations of the following subjects: the engineering and economic aspects of the tidal project by itself; the engineering and economic aspects of the tidal project combined with an auxiliary source of power supply to supplement the varying output of the tidal powerplant; the market for and value of the power from the tidal power project with and without an auxiliary; and the possible beneficial and damaging effects that construction of the tidal project may have on the regional and national economies.

Field investigations

In order to formulate the best plan of development for the tidal power project, it was necessary for the Engineering Board to conduct a series of field investigations and studies of site conditions in the Passamaquoddy-Cobscook Bay area. These investigations included aerial mapping, deep and shallow water drilling, land drilling, underwater mapping, analysis of soils, and tide gaging. Core drilling in great water depths and high tidal velocities and underwater mapping

by newly developed sonic equipment constituted two of the most costly and difficult undertakings of the survey. Highly specialized sonic equipment was utilized to chart the bottoms of the bays and determine depths of overburden.

The selected tidal power project

In order to determine the most efficient arrangement of works for the tidal power project, estimates were made by the Engineering Board to determine the average annual energy available and the construction cost of a considerable number of alternative arrangements. Since the time required for manual computation of the annual energy output of each of the numerous possible project arrangements was prohibitive, these computations were performed electronically by digital computer. In this way, annual energy generation could be determined for any project arrangment, once its pool areas, number of generating units, and number of filling and emptying gates were established. The project arrangment that revealed the best relationship of power output to cost was selected for detailed design.

The project arrangement thus selected for design includes the 101 square miles of Passamaquoddy Bay as the high pool and the 41 square miles of Cobscook Bay as the low pool, with a powerhouse located at Carryingplace Cove. The location of the tidal power project is shown on plate 1 and the general arrangement of the selected plan of development is shown on plate 2.

The selected plan would provide an installed generating capacity of 300,000 kilowatts, a dependable capacity of 95,000 kilowatts, and an average annual generation of about 1,843 million kilowatt-hours.

Components of the project selected for detailed design

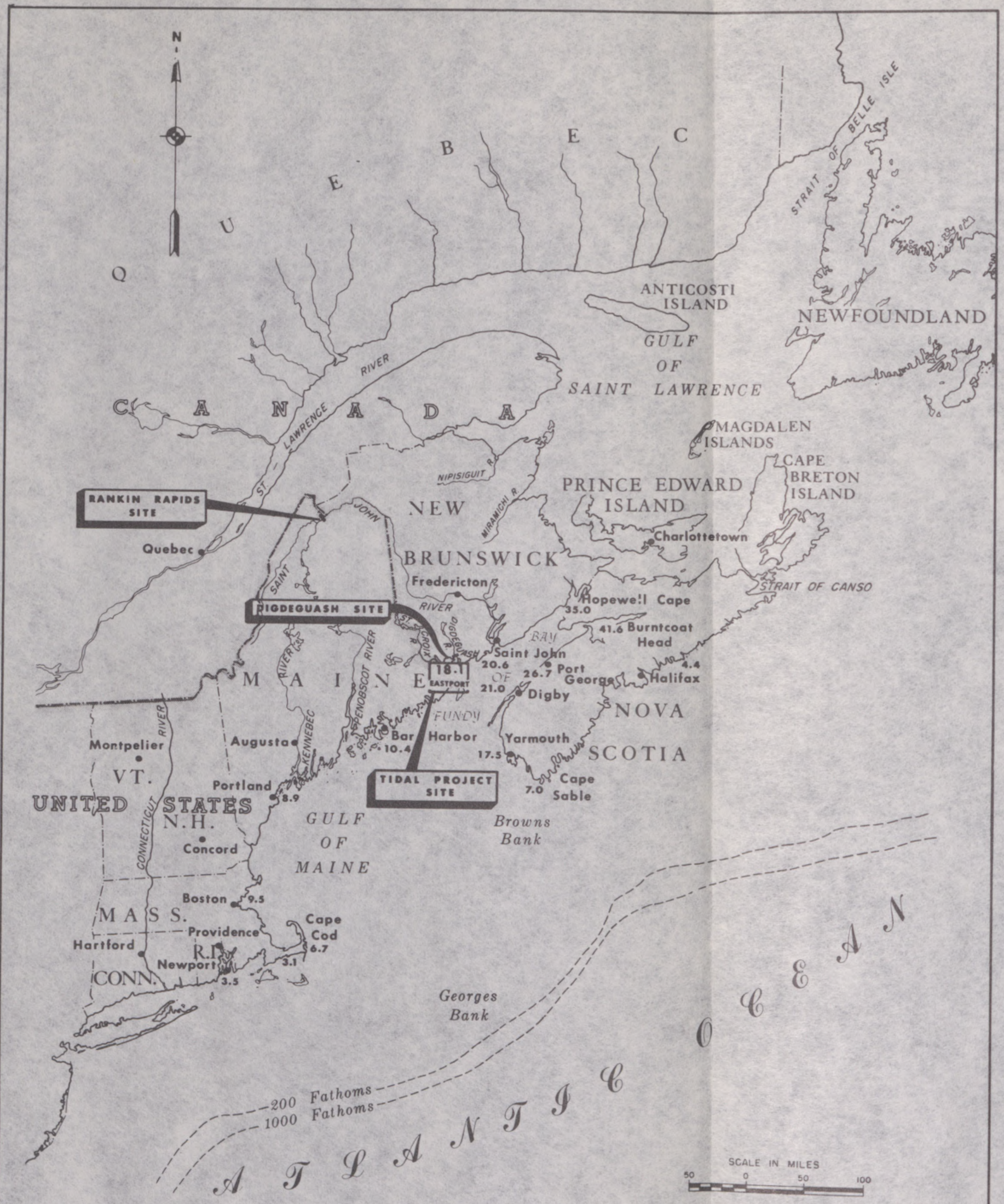
With the major aspects of the project layout determined, design studies were undertaken by the Engineering Board of each component of the selected plan—tidal dams and cofferdams, filling and emptying gates, navigation locks, powerhouse, turbines, and generators—in sufficient detail to permit reliable cost estimates.

The 35,700 linear feet of tidal dams are located as far as practicable on foundations of bedrock or granular material to avoid clay overburden. The tidal dams, composed of clay core supported by flanking dumped-rock fills, are designed to permit greatest possible use of materials excavated for the gate structures, navigation locks, and the powerhouse.

Cofferdams of several different types, depending on the depths to be unwatered, would be used to excavate for the foundations of the powerhouse, filling and emptying gates, and navigation locks. Cofferdam designs include embankments, log cribs with timber sheathing, and steel sheet piling of both circular and cloverleaf design.

The selected plan calls for 90 filling gates, 40 in Letite Passage and 50 between Western Passage and Indian River. In the reach between Pope and Green Islets 70 emptying gates, similar to the filling gates but set at a lower elevation, would empty the lower pool. Comprehensive study of all types of gates led to selection of a 30- by 30-foot vertical-lift gate set in a venturi throat. The venturi throat permits maximum discharge for a given gate area.

Four navigation locks are planned for the selected tidal project. Two locks, one at Little Letite Passage and one at Quoddy Roads,



AVERAGE TIDE RANGE SHOWN IN FEET AT SPECIFIC LOCATIONS

INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY

TIDAL POWER PROJECT

REGIONAL MAP

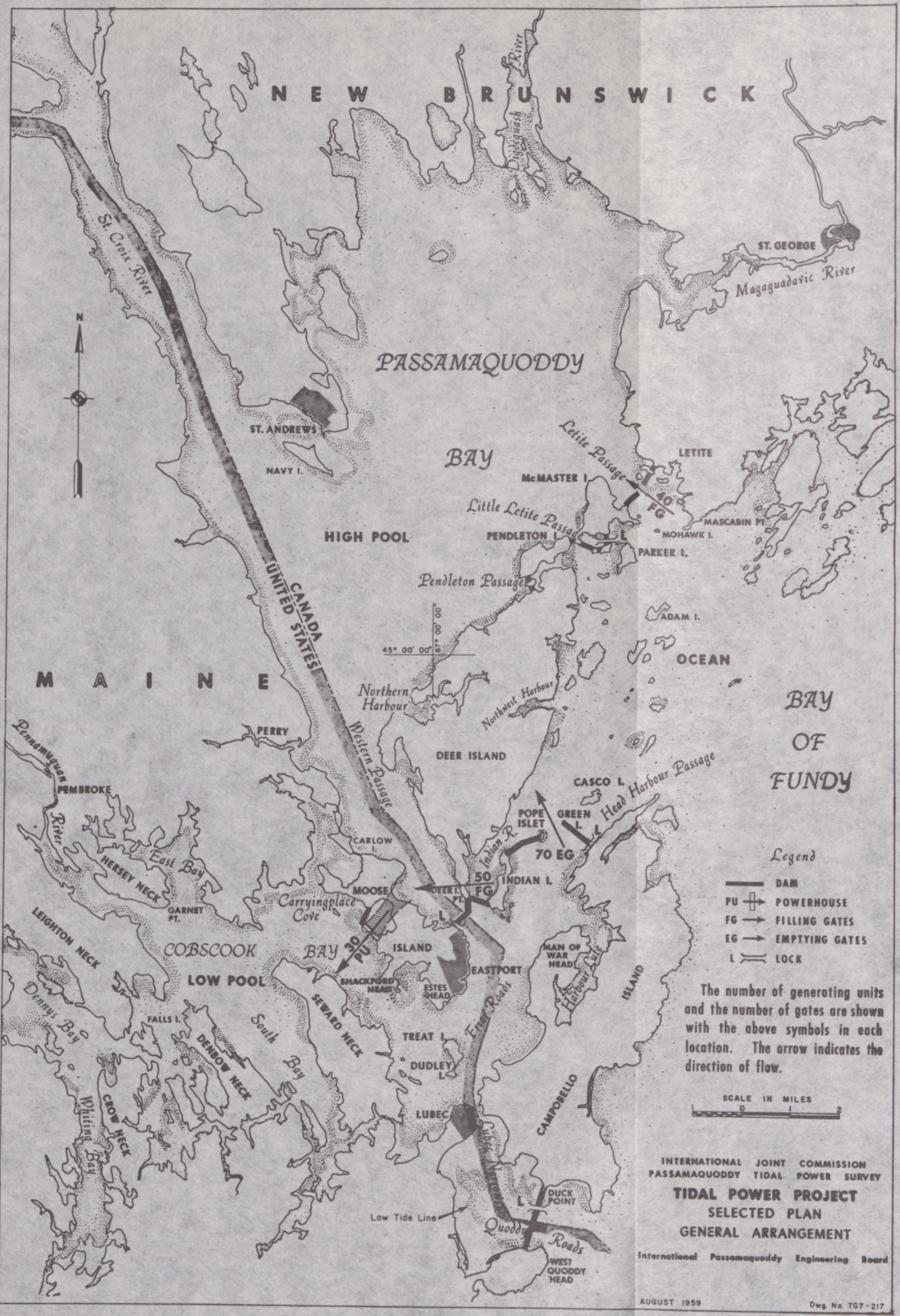
International Passamaquoddy Engineering Board

AUGUST 1959

Dwg. No. TG7-211

PLATE 1

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PLATE 2

would have clear dimensions of 95 by 25 by 12 feet to pass fishing vessels. Two locks, one at Head Harbour Passage immediately east of the emptying gates and one at Western Passage north of Eastport, would have clear dimensions of 415 by 60 by 21 feet to pass vessels somewhat larger than the present traffic.

The powerhouse would be of the outdoor type and would contain 30 generating units of 10,000 kilowatts rated capacity each with an overload of 15 percent. The turbines selected for the project are the fixed-blade propeller type with a maximum diameter of 320 inches and a speed of 40 revolutions per minute. The generators would be connected in banks of 7 and 8 to four 90,000 kilovolt-ampere transformers located on the upstream side of the powerhouse and connected to the switchyard by oil-filled high-voltage cables. Two transformers would operate at 230 kilovolts for supply to the United States and two at 138 kilovolts for Canada.

A comparison of the performance of fixed-blade and Kaplan turbines indicated that the greater efficiency of the Kaplan turbine over a wide range of heads was offset by its greater cost. A new type of horizontal-axis, bulb-type turbine-generator unit recently developed in Europe and adopted for use in the single-pool tidal project in LaRance Estuary on the northwest coast of France was also studied by the Engineering Board for possible use in the Passamaquoddy project. This unit can be used as a turbine, pump, or sluiceway, with flow in either direction. Studies by the Board showed that the bulb-type turbine-generator develops approximately as much power as the Kaplan, and structural studies indicated that the powerhouse structure would cost about $300,000 less per unit than with conventional units. This saving, however, was offset by the greater cost of the bulb-type turbine-generator set and the need to compensate for low rotative inertia. For these reasons, and because of unresolved maintenance problems, the Board adopted the conventional fixed-blade type unit for cost estimates of the Passamaquoddy prohect.

Auxiliary power sources considered

In order to supplement the varying output of the tidal power project. the Engineering Board considered several different types of auxiliary power sources to determine the type best suited for meeting the power loads of the region. These studies included river hydro-electric plants, pumped-storage plants, and steam-electric auxiliaries.

Among a number of river hydroelectric sites examined, Rankin Rapids, on the upper St. John River in Maine, was selected by the Board as the best source of auxiliary power. The Rankin Rapids project would provide 2.8 million acre-feet of usable storage capacity. Operated in conjunction with the tidal plant, the combined project would provide 555,000 kilowatts of dependable capacity and 3,063 million kilowatt-hours of average annual generation.

As a possible alternative plan of development, Rankin Rapids could be constructed, initially, to carry part of the load in Maine, with provision for later installation of additional generating capacity which could be used as an auxiliary power supply for the tidal project. Energy thus borrowed from the Rankin Rapids project when using the "incremental capacity" would be repaid when tidal output is greater than the load. This combination would provide 355,000 kilowatts of dependable capacity and 1,843 million kilowatt-hours of

average annual generation without a serious effect on the basic Rankin Rapids project (200,000 kilowatts and 1,220 million kilowatt-hours).

Tidal power also could be supplemented by means of a pumped-storage plant. Using power from the tidal plant at times when it is not required to meet load demands, water could be pumped to a higher storage basin and released through turbines as required to meet the load. Since the output of the tidal plant alone would vary from 95,000 to 345,000 kilowatts, a pumped-storage plant with 260,000 kilowatts of installed capacity would provide a dependable capacity of 323,000 kilowatts from the combined project. The average annual generation would be 1,759 million kilowatt-hours. A pumped-storage site on the Digdeguash River near its outlet into Passamaquoddy Bay east of St. Andrews was adopted by the Engineering Board for detailed study.

A steam-electric plant also could be used to firm the potential power output of the tidal plant up to its rated capacity of 300,000 kilowatts. Since the tidal plant would have a dependable capacity of 95,000 kilowatts, a steam-electric plant would need to supply a maximum of 205,000 kilowatts. This combination would provide about 2,143 million kilowatt-hours of electric energy annually. Since a steam-electric plant was found to be economically the least favorable type of auxiliary for the tidal power project, this combination was not considered further by the Engineering Board.

In summary, four project combinations were selected by the Engineering Board for evaluation of costs and benefits. These are: (1) The Passamaquoddy tidal project alone; (2) the tidal project operated in combination with all the Rankin Rapids project; (3) the tidal project supplemented by incremental capacity only at Rankin Rapids; and (4) the tidal project supplemented by the Digdequash pumped-storage auxiliary. Pertinent data for these four project combinations, as determined by the Board, are summarized as follows:

Project combination	Installed capacity	Dependable capacity	Average annual generation	Capital investment (at site)	Capital investment (including transmission to market)
	Thousand kilowatts	*Thousand kilowatts*	*Billion kilowatt-hours*	*Millions*	*Millions*
(1) Tidal project alone	300	95	1.843	$532.1	$546.8
(2) Tidal project and all of Rankin Rapids	700	555	3.063	687.7	732.1
(3) Tidal project and incremental capacity only at Rankin Rapids	526	355	1.843	565.7	600.0
(4) Tidal project and Digdeguash pumped-storage project	560	323	1.759	568.9	586.4

The Board concluded that the second of the above combinations, the tidal project and all of Rankin Rapids, would provide the most favourable project.

Conclusions of the Engineering Board

On the basis of its comprehensive studies, the International Passamaquoddy Engineering Board reached the following conclusions:

(1) A tidal power project using the waters of Passamaquoddy and Cobscook Bays can be built and operated. The two-pool type of project is best suited for the site conditions in the area and the power markets it would serve. The tidal project arrangement selected makes best use of the site conditions.

(2) The first cost (construction cost) of the tidal power project by itself would be $484 million. With interest during construction, the investment would be $532.1 million. The tidal power project would have an installed capacity of 300,000 kilowatts and a dependable capacity of 95,000 kilowatts. Average annual energy would be 1,843 million kilowatt-hours. However, for maximum power benefits, the tidal power project would have to be combined with an auxiliary power source.

(3) The most favorable project combination is the tidal power project operated in conjunction with a river hydroelectric auxiliary built at the Rankin Rapids site on the upper St. John River in Maine. The combined cost of the tidal project and the Rankin Rapids auxiliary is $630 million. With interest during construction, the investment would be $687.7 million. The dependable capacity of this combination would be 555,000 kilowatts, and average annual generation would be 3,063 million kilowatt-hours.

(4) Construction of the tidal project-Rankin Rapids combination would increase low flows in the lower St. John River by a considerable amount, thus increasing substantially the usefulness of the river for downstream generation of power. Downstream benefits accruing to existing powerplants were included in the economic evaluation.

(5) The combination of the tidal power project and the installation and use of 260,000 kilowatts of capacity only at Rankin Rapids for firming up the output of the tidal power project would cost $515.5 million. With interest during construction, the investment would be $565.7 million. This combination would provide a total dependable capacity of 355,000 kilowatts and an average annual generation of 1,843 million kilowatt-hours.

(6) The tidal power project and the Digdeguash pumped-storage auxiliary would cost $518.5 million. With interest during construction, the investment would be $568.9 million. The dependable capacity would be 323,000 kilowatts, and average annual generation would be 1,759 million kilowatt-hours.

(7) The total output from the tidal power project and Rankin Rapids hydroelectric plant can be absorbed readily by the growing utility markets of Maine and New Brunswick.

(8) Because of differences in interest rates prevailing in the two countries, and because of different values of alternative power, it was necessary to compute separate benefit-cost ratios for the United States and Canada. Economic evaluations, assuming 50- and 75-year amortization periods, and assuming that power output and project

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first cost would be equally divided between the United States and Canada, are tabulated below:

	50-year amortization		75-year amortization	
	Benefit-cost ratio	Cost per kilowatt-hour (mills)	Benefit-cost ratio	Cost per kilowatt-hour (mills)
Tidal project alone:				
United States	0.60	10.8	0.70	9.3
Canada	.34	14.9	.37	13.7
Tidal project and all of Rankin Rapids:				
United States	1.31	8.4	1.53	7.2
Canada	.58	11.5	.63	10.6
Tidal project and incremental capacity only at Rankin Rapids:				
United States	.93	11.5	1.08	9.9
Canada	.42	15.8	.45	14.5
Tidal project and Digdeguash pumped-storage auxiliary:				
United States	.91	12.2	1.06	10.5
Canada	.42	16.8	.46	15.4

(9) The inclusion of taxes forgone with project costs is not the practice in the economic justification of public projects in Canada, and due to the international nature of the project, such taxes have not been applied to the U.S. costs. However, if they were included in the U.S. costs, the benefit-to-cost ratio of the most favorable project combination would be reduced to 1.10 for the 50-year amortization period and to 1.25 for the 75-year period.

(10) By including appropriate remedial measures in the design of the tidal power structures, the construction, maintenance, and operation of the tidal power project would have only a minor residual effect on the fisheries of the region.

(11) Considerable annual recreation benefits would grow out of the construction and operation of the tidal power project. However, the monetary value of these benefits was not included in the economic evaluation.

(12) Assuming an equal division of power output and of first costs between United States and Canada, construction of the tidal power project with all of Rankin Rapids as auxiliary is not an economically justified project for Canada.

(13) The Passamaquoddy tidal project and Rankin Rapids combination, if built entirely by the United States at an interest rate of 2½ percent, is economically justified.

REPORT OF THE FISHERIES BOARD

Scope of the fisheries investigation

The investigations of the Fisheries Board were directed primarily toward determination of the effect the tidal power project might have on the fisheries of the area. Consideration was given not only to the sardine industry which accounts for most of the landings in the area, but also to the fisheries for cod, haddock, flounder, redfish, hake, pollock, salmon, alewives, clam, smelt, scallops, and lobsters. The Board's report presents results of studies of the present oceanographic, biologic, and economic features of the area; investigations pertaining

to temperature, salinity, tides and tidal currents in the bays, in the approaches, and outside the bays; and biological studies of fish populations, breeding grounds, nursery areas, food and feeding habits, and interrelationship of fish and their environment.

Conclusions of the Fisheries Board

On the basis of its studies, the Fisheries Board reached the following conclusions:

1. The construction of dams in the tidal passages will change the oceanographic features of the Quoddy region. Major changes are anticipated inside Passamaquoddy and Cobscook Bays and immediately outside the dams. Effects outside the Head Harbor-Bliss Island line will likely be insignificant.

2. The mean water level of Passamaquoddy Bay will be raised about 6 feet while the mean level of Cobscook Bay will be lowered about 5 feet. The mean "tidal" range in the high pool and low pool will be reduced to approximately 4 and 8 feet, respectively. The tidal range of the Bay of Fundy may increase approximately 1 percent with a maximum increase at the head of this bay of less than 1 foot.

3. Current patterns in Passamaquoddy and Cobscook Bays and in the approaches will be altered markedly since the emptying and filling gates will be closed for about 9 and 9½ hours, respectively, during each tidal cycle of 12½ hours. When the gates are open, velocities in most areas should be only slightly lower than at present. The residual counterclockwise circulation in Passamaquoddy Bay will likely be more pronounced. Tidal streams in the outer Quoddy region will probably be altered by not more than 20 percent. No change in nontidal circulation is anticipated for the Bay of Fundy.

4. Reduced velocities in Passamaquoddy and Cobscook Bays will result in decreased vertical mixing, giving rise to increased stratification and hence to greater seasonal variations in surface water temperature. The summer maximum is likely to be in the vicinity of 68° Fahrenheit while in winter an ice cover is expected over part of the bays. Outside, little change is expected adjacent to the emptying and filling gates where there will be a slightly greater seasonal variation.

5. Mean surface salinities for both pools will be lowered, but bottom salinities are likely to be altered only slightly. It is doubtful if fresh water will penetrate below 30 to 50 feet. Flushing time is expected to increase substantially. Outside, no significant change is expected except near the emptying gates where there will be a slight reduction in salinity.

6. Oxygen concentrations of the deep water inside the dams may be lowered somewhat, especially during periods of maximum fresh water discharge. However, it is unlikely to fall below 50-percent saturation.

7. The herring population is produced outside the Quoddy region, probably off southwest Nova Scotia. The general abundance of herring in the Bay of Fundy and the Gulf of Maine is unlikely to be affected.

8. Echo-sounder records show that a large proportion of herring are in the open waters of Passamaquoddy Bay where no fishing takes place. Tagging experiments show that herring move freely throughout the Quoddy region during the fishing season.

9. Since there are unlikely to be any significant changes in oceanographic conditions outside the dams, herring should arrive in this area as before. Little change is expected in current velocities in the approaches to the filling gates when open. Since velocities are well above the maximum sustained swimming speed of herring, the fish will be carried through the filling gates. Since the filling gates are open for about 6 hours each day, movement of herring into Passamaquoddy Bay is expected to be delayed. This is also true for Cobscook Bay where entry will be chiefly through turbines. Although the rate at which herring accumulate will be slower, there should be no reduction in overall abundance inside the bays.

10. Predicted changes in temperatures and salinities are expected to make the areas inside the dams no less favorable for herring except in isolated areas where high temperatures and low salinities may cause some mortality. Predicted pressures and rates of pressure change between the turbine intakes and exits are within limits which herring can withstand.

11. No relationship between herring landings and various meteorological and oceanographic conditions including surface drift, river discharge, wind speed and direction, zooplankton, temperatures, and salinities is apparent.

12. Long-term statistics of herring landings show year-to-year variations in individual weir catches and in total catches in various parts of the Quoddy region. These are of far greater magnitude than the changes that can be forecast as resulting from the dams.

13. No measurable change in groundfish landings in the Quoddy region is anticipated, but a change in species composition of the fraction of the catch taken inside the dams is expected. Inside the dams, winter flounder fisheries may increase while haddock and pollock fisheries will be greatly reduced. Clam fisheries will be greatly reduced for a period of 10 years and then may become reestablished at a lower level of production. Scallop stocks should increase substantially. Inside the dams, a modest increase in production of lobsters is anticipated. Conditions for anadromous species such as Atlantic salmon and alewives may be improved. Smelt, shad, and sea-run trout stocks should increase. Striped bass and tom cod thrive in areas where conditions of temperature and salinity are similar to those predicted for Passamaquoddy and Cobscook Bays. Some reduction is expected in the availability of marine worms and rockweed.

14. Six existing herring weir sites will be eliminated by the construction of dams. Other weirs must be relocated or altered to suit the new oceanographic environment. Weir stakes and nets will have to be increased in size to suit new water levels. The resultant fixed costs are estimated at $129,000. Wood-borer activity is expected to increase. Ice will cause some damage to weir materials during the winter. The annual cost of weir operations will rise approximately $10,000. It is conceivable that weir owners may discontinue their investments in weirs inside the dams. A shift to alternative methods of fishing could be expected to maintain the fishery, at least at its present level.

15. Lobster fishermen are not expected to be adversely affected, but physical damages due to relocation of lobsters pounds, refrigeration of water, or extension of intake pipes are expected to cost $450,000.

Changes in the clam fishery may result in a loss of capital investment in plants valued at $100,000 and an annual loss in primary production of $104,000 for 10 years. The disappearance of some groundfish from inside the dams will result in an annual loss of approximately $3,000.

16. Fish passage facilities for anadromous species were estimated by fisheries engineers to cost $3 million.

On completion of the preliminary engineering design, which complied with the criteria set down by the Fisheries Board, the Engineering Board determined that incorporation of the fish passage facilities in the initial design and construction would increase the project costs by only $919,100.

PUBLIC HEARING

Public hearing at Calais, Maine

On April 22, 1960, the International Joint Commission conducted a public hearing in Calais, Maine, for the purpose of obtaining the views of all parties concerned with the international Passamaquoddy tidal power project.

Many of the witnesses at the hearing urged construction of the Passamaquoddy tidal power project with the Rankin Rapids project as an auxiliary. They stressed that this combination project could be expected to have a favorable impact upon the efforts of Maine and New Brunswick to expand industrially, and that construction and operation of the project would greatly enhance the economy of the region. They asserted that the Rankin Rapids project is the logical source of power for firming the power output of the tidal plant, and that construction of the project would not destroy the Allagash wilderness area in Maine as some alleged. Some proponents expressed the view that recreational patronage accorded the Allagash area in recent years was slim and unprofitable, and that overall recreational use of the area could be expected to increase with construction of the Rankin Rapids project. Members of the State of Maine's delegation in the Congress, the Governor of Maine, the Maine Governor's Committee on Passamaquoddy Bay, and representatives of local governments in the region went on record in support of the combination Passamaquoddy-Rankin Rapids project presented in the report of the Passamaquoddy Engineering Board.

On the other hand, several witnesses raised objections to the tidal power project alone and to the tidal project combined with the Rankin Rapids project. A spokesman for privately owned electric utility companies in New England argued that neither the tidal plant alone nor the tidal plant with an auxiliary is economically feasible. A similar view was expressed by a representative of a Special Committee of Maine Engineers. This committee included representatives of the Maine section of the American Society of Civil Engineers, the Maine section of the American Institute of Electrical Engineers,[1] and the Maine Association of Engineers. A spokesman for the New Brunswick Electric Power Commission expressed the view that the tidal power project with or without an auxiliary was not economically justified insofar as Canada is concerned.

[1] The Acting Secretary-Treasurer of the Maine section of the American Institute of Electrical Engineers informed the Commission by letter dated May 16, 1960, that the findings of the Special Committee of Maine Engineers do not necessarily represent the opinions of all members of that section.

Several witnesses from Canada urged further consideration of the Cumberland Basin-Shepody Bay tidal power scheme and of potential developments in the St. John and Hamilton Rivers with the suggestion that these possibilities should be considered in evaluating future sources of power supply for the region.

Conservationists raised objections to the Rankin Rapids project because of inundation of the Allagash wilderness area. They advocated the alternative Big Rapids-Lincoln School development if this reach of the St. John River is to be utilized as a source of firming power for the tidal project. This alternative was favored by the Maine Department of Inland Fisheries, the U.S. Bureau of Sports Fisheries of the Department of the Interior, and numerous organizations interested in conservation.

Representatives of fishery interests in the Passamaquoddy Bay region expressed concern that their sources of sardine supply might be damaged by construction of the tidal project. They asserted that the risk to the fishery inherent in the development of the tidal power project is so great as to outweigh any indicated benefits to the region. They expressed the hope that the fishing industry would be compensated for any damages that might result from construction of the tidal power project.

PROBLEMS OF PROJECT FORMULATION AND ECONOMIC EVALUATION

The problem of tidal power production

As indicated previously, tidal power can be produced by passing water from a higher to a lower elevation through hydraulic turbines. Unaffected by droughts, floods, or ice jams, the tides provide a dependable source of power and can be predicted with accuracy. One of the principal disadvantages of tidal power production is that four times a day the tides reverse direction, thus causing variations in available power. Development of a workable method of producing continuous power from such a varying flow constitutes one of the principal problems of formulation of a tidal power project.

The generation of large amounts of tidal power requires one or more storage pools. A single pool has the serious disadvantage of producing varying and intermittent power, because no power can be generated when there is insufficient difference between the level of the storage pool and the level of the ocean. Thus no generation is possible until the ocean has receded sufficiently to obtain this difference in water levels, or the power head; nor is generation possible on the rising tide after the level of the ocean becomes too high to provide this necessary minimum head. This disadvantage is reduced in the two-pool plan adopted by the Engineering Board, which generates varying power but a certain minimum amount of continuous power.

Need for an auxiliary source of power to supplement the variable output of the tidal project

Another disadvantage of the tides as a source of power is that the tides, following the gravitational pull of the moon as it passes overhead every 24 hours and 50 minutes, are out of phase with the 24-hour solar day. This 50-minute daily lag is fundamental to the economics of tidal power for, since power output varies with the tides, tidal power is out of step with the normal pattern of power demands. Therefore,

unless the tidal plant is supplemented by an auxiliary powerplant, such varying power would be of limited value. The different types of auxiliary power sources studied by the Engineering Board to determine the type best suited for making the combined power output of the tidal project and its auxiliary match the characteristic load pattern are discussed elsewhere in this report.

The Rankin Rapids-Allagash problem

The Rankin Rapids site is located in Maine downstream from the junction of the Allagash River and the main stem of the St. John River. Development of this site would flood a series of rapids in the lower reaches of the Allagash River. These rapids are esteemed by many sportsmen for the trout fishing and the white water canoeing they afford although the number of visitors has not been great in recent years. Their flooding by construction of the Rankin Rapids Reservoir is strongly opposed by associations and agencies concerned with preservation of recreation and wildlife resources.

An alternative to the Rankin Rapids project was considered by the Engineering Board in order to determine the best means of comprehensive development of the upper St. John River with due consideration to all the uses of the water resources. The alternative would consist of a two-dam project, with a high dam at the Big Rapids site, upstream from the mouth of the Allagash River, and a low dam at the Lincoln School site, a short distance downstream from the Rankin Rapids site. The two-dam plan would greatly reduce the extent of inundation of the lower Allagash River and also mitigate possible losses to fish and wildlife.

The Engineering Board estimated that the Rankin Rapids project would produce 68,000 kilowatts of capacity and 215 million kilowatt-hours a year more than the Big Rapids-Lincoln School project. The Board also estimated that the unit cost of power would be 20 percent more at the Big Rapids-Lincoln School project than at Rankin Rapids. Because of the greater drainage area, usable storage capacity, and regulated outflow, Rankin Rapids would improve conditions for further power development on the downstream St. John River to a greater extent than the alternative Big Rapids-Lincoln School project. Moreover, the larger installed generating capacity at Rankin Rapids permits greater utilization of the tidal power potential. In view of these findings, the Engineering Board selected the Rankin Rapids project as the river hydro auxiliary for the tidal power project.

Because of the opposition of certain groups in the United States to the development of the Rankin Rapids site, the Engineering Board undertook to secure the views of the Bureau of Sports Fisheries and Wildlife, Fish and Wildlife Service of the United States Department of the Interior. The Bureau stated that the Rankin Rapids project would injure the fish and wildlife assets of the area more than the Big Rapids-Lincoln School combination. It recommended a series of measures for the protection of the fish and wildlife resources of the area regardless of the auxiliary project selected. The measures recommended by the Bureau are as follows:

(1) Establishment of a framework for management of fish and wildlife resources.

(2) Provision of public access.

(3) Purchase of additional lands for wildlife management purposes.

(4) Modification of land-clearing plans.
(5) Construction of barrier dams.
(6) Provision for minimum flows as required to benefit downstream fisheries.
(7) Provision for a fish hatchery and rearing facilities.
(8) Management of tributary streams.
(9) Subimpoundments for waterfowl within reservoir maximum flow line.
(10) Control of reservoir pool elevations and provisions for spawning beds.
(11) Control of release temperatures.

Consideration should be given to all the measures listed above if construction of either the Rankin Rapids or Big Rapids-Lincoln School auxiliary is undertaken.

Disparity of interest rates and other economic factors between the United States and Canada

For the purpose of selecting the most favorable tidal project plan, the Engineering Board compared the ratios of construction cost to average annual generation for the various possible plans considered. Estimates of the capital costs of the tidal project combinations made by the Engineering Board were based on U.S. currency and January 1958 price levels.

In computing the annual costs of project plans, it was found that there are differences between the two countries in interest rates and other economic factors. In the United States, projects such as this are assumed to be financed by the Federal Government. Thus, the Engineering Board computed interest during construction and annual power costs for the U.S. portion of development using interest at 2½ percent, since that was the rate recommended, at the time of the survey, by the U.S. Bureau of the Budget for use by Federal agencies in evaluating water resource development projects.[2] For the Canadian share of development, which was assumed to be financed by an agency of the Province of New Brunswick, an interest rate of 4⅛ percent was used, because that was the rate used in January 1958 by the Federal Government of Canada on loans to crown corporations and Provincial governments. No amount for taxes was included in the annual project costs applicable to either country.

The annual power benefits of the tidal project combinations were measured by the Engineering Board on the basis of the cost of power from modern steam-electric plants in Maine and New Brunswick. In view of the present ownership and predominant type of generating plants of the respective electric power systems, it was deemed appropriate to assume that the most likely alternative power supply, in the absence of the tidal project, would be privately financed steam-electric plants in Maine and publicly financed plants in New Brunswick. In computing the annual costs of the steam-electric plants in Maine, the Engineering Board used 6 percent as the cost of money and included an amount for taxes equal to 4.44 percent of the capital investment. Annual costs of steam-electric plants in New Brunswick were based on an interest rate of 4⅛ percent and on including no

[2] On July 26, 1960, the Bureau of the Budget recommended that this rate be increased to 2⅝ percent.

amount for taxes since the public power agency of the Province does not pay taxes.

In view of these disparities in practices, the Engineering Board prepared separate economic analyses showing ratios of benefits to costs applicable to each country's share of the development. These analyses assumed that the capital costs and project power would be divided equally between the two countries. In addition to comparing the U.S. share of project costs, using interest at 2½ percent and excluding taxes, with the cost of providing equivalent power by steam-electric plants, using cost of money at 6 percent and including taxes, the Engineering Board showed benefit-cost ratios for the U.S. share with an item of "taxes foregone," amounting to about $9 per kilowatt of dependable capacity, included as an economic cost of the project.

Economic impact of the tidal power project on the region

An evaluation was made by the Engineering Board of all possible beneficial and damaging effects that construction of the tidal project, with and without an auxiliary source of power, may have on the regional and national economies. The Board concluded from these studies that the tidal project and its auxiliary would have a favorable impact on all segments of the economy of Maine; and that the effect on the general economy of New Brunswick would be the same as that of any other block of power of equal size and cost developed to satisfy the growing power demand. Power-market studies by the Engineering Board indicate that the anticipated load growth in the region will be sufficient to absorb a block of power equal to the output of the tidal plant and its auxiliary by 1980 or earlier.

Construction of the tidal power project would produce an important short-term economic impact on the economy of Maine and New Brunswick. Estimates by the Engineering Board indicate that during the 6-year construction period of the tidal project alone, total investment outlays in Maine and New Brunswick would amount to about $200 million. The spending of this money would probably stimulate an additional $200 million expenditure which would have a beneficial effect on the region's wholesale and retail trade.

The Passamaquoddy tidal power project would attract a great many visitors. The Engineering Board estimates that had the tidal project been in existence in 1957, about 800,000 visitors from the United States and Canada would have been attracted to the area. In accordance with a practice that has been followed in some cases by the U.S. Army Corps of Engineers water resources projects might be credited with recreational benefits ranging from $0.50 to $1.50 per visitor-day. Using a median value of $1 per day, and assuming that each visitor spends 1 day at the project, the recreation benefits would would be at least $800,000 per year. In addition to recreation benefits, other benefits undoubtedly would result from the increased local economic activities due to a greater number of visitors.

The Passamaquoddy tidal project would require no fuel. On the basis of estimates by the Engineering Board, the tidal project in combination with the Rankin Rapids hydroelectric plant would produce power equivalent to that from 1,280,000 tons of coal, or approximately 5,700,000 barrels of oil a year.

Construction of the dams, locks, and gates would provide foundations on which 7 miles of public highways could be built to connect

the Canadian coastal highway in New Brunswick with the U.S. coastal highway in Maine. Although the desirability of such a new link in the highway systems of the two countries is evident, the monetary benefits have not been estimated. Other benefits stemming from construction of the highway would be the increased recreational use of Campobello and Deer Islands that should follow the provision of a ready access to these attractive areas.

The Passamaquoddy tidal project, the Rankin Rapids project, and the Digdeguash pumped-storage project each would affect the fisheries in the waters they would control. The Fisheries Board studies the effects that the tidal project would have on the fisheries in the Bay of Fundy and within the tidal project in Passamaquoddy and Cobscook Bays. The Board found that the tidal project would have very little effect on the important sardine industry in the region, and only a minor effect on other fisheries. It should be noted that the estimated cost of the tidal project includes approximately $450,000 for modifications in or relocation of the lobster pounds at St. Andrews. The Rankin Rapids project would flood substantial reaches of the Allagash and St. John Rivers in Maine which now support an important trout fishery, particularly on the Allagash River. Changing portions of the St. John or Allagash Rivers from fast-water streams to hydroelectric project reservoirs would change the type of fish and fishing which would prevail. Other wildlife habitat would also be affected. As indicated previously, the Bureau of Fisheries and Wildlife of the U.S. Department of the Interior considered the problem and recommended that remedial measures be taken it the project is built. The Digdeguash River now supports a small run of Atlantic salmon which would be destroyed by construction of the pumped-storage auxiliary. Methods of restoring this run were not determined.

The firm of Arthur D. Little, Inc., of Cambridge, Mass., was engaged by the Engineering Board to make an economic survey of Maine to determine all possible potential uses for the power from the Passamaquoddy project. One of the principal aims of this survey was to identify industries that might be attracted to the area by the availability of a new source of dependable power at a price they would be willing to pay. These studies indicated that the economic impact of the availability of the project's power would not be significant unless power were made available to industry at a cost considerably less than the current estimate of the cost of power from the project. The firm of Arthur D. Little, Inc., concluded that the course of economic development in the State of Maine as a whole would not be significantly affected by construction of the tidal project.

A similar economic survey of New Brunswick was made by Prof. Eugene Grasberg and Prof. H. J. Whalen of the Department of Economics of the University of New Brunswick. This survey indicated that the mere availability of electric power from the Passamaquoddy project cannot be expected to spark and propel economic growth in New Brunswick.

FEASIBILITY OF THE PASSAMAQUODDY TIDAL POWER PROJECT AS VIEWED BY THE COMMISSION

The Commission has carefully reviewed the conclusions of the Engineering Board with respect to the engineering and economic feasibility of developing the international tidal power potential of

Passamaquoddy Bay and the findings on which these conclusions are based. The Commission is in general agreement with the engineering findings of the Engineering Board. However, as regards the economic analysis, the Commission considers it appropriate to modify certain of the Board's assumptions in considering the tidal project alone and in conjunction with auxiliary power sources in the area.

The feasibility of the Passamaquoddy tidal power project as viewed by the Commission in the light of the findings of the Engineering Board will be discussed in this section, first from the standpoint of its engineering feasibility and secondly its economic feasibility. The economic analysis of the tidal power project alone and of each of the project combinations studied by the Board will be discussed separately with particular attention given to points on which the Commission differs from the Board in the determination of benefit-cost ratios. The unit cost of power also will be developed to show the relative cost of Passamaquoddy power either alone or with an auxiliary source compared with the cost of power from alternative steam-electric plants that are likely to be constructed in the absence of the project.

To assist the two Governments in appraising certain public values of the tidal project beyond those normally considered in determination of benefit-cost ratios for proposed hydroelectric developments, the Commission will, in concluding its feasibility analysis, discuss the effect that consideration of these values might have on the economics of the project.

Engineering feasibility

The tidal project plan selected by the Engineering Board poses difficult engineering problems which, although challenging, are not insurmountable. Small portions of the tidal dams are in water depths ranging from 125 to 300 feet. The difficulties of closing these dams in the face of restricted and greatly increased velocity heads pose engineering and design problems without precedent. In view of these problems, several outstanding experts in the fields of hydraulic engineering and soil mechanics were consulted by the Engineering Board and model studies were made of deep tidal dams to determine the best and most economical design and methods of construction. The Board concluded from these studies that tidal dams could be built in the deep-water passages by use of a granular core placed by special bottom-dump buckets, and that all other tidal dams could be built with conventional land and marine equipment. To overcome the increased tidal velocities during construction, the progress of work on the dams could be scheduled so that the filling and emptying gates would handle part of the tidal ebb and flood.

The cofferdams required for construction of the filling and emptying gates, as well as for navigation locks and the powerhouse, would be subjected to heads as high as 60 feet, whereas the heads on the completed structures would not exceed 26 feet. Construction of cofferdams of this magnitude constitutes one of the major engineering and construction tasks of the Passamaquoddy tidal power project. While they will be expensive, there appear to be no grounds for apprehension that these cofferdams cannot be built.

Based on its review of the studies by its Engineering Board, the Commission is of the opinion that a tidal power project using the waters of Passamaquoddy and Cobscook Bays could be built and operated.

Economic analysis

Determination of the economic feasibility of a proposed hydroelectric development, whether in a conventional river project or a tidal project, involves a comparison of the value of the power, or power benefits, with the power costs. Normally, a proposed power development is not considered to be economically feasible if the benefit-cost ratio is less than 1.

Power benefits are usually measured by or limited in value by the cost of power from the most likely alternative source in the market area, giving due consideration to any differences in transmission costs and losses and in operating characteristics between the alternative plant and the proposed hydroelectric project. In the Mine and New Brunswick area, as well as in many other areas of the United States and Canada, the alternative power source is considered to be a modern steam-electric plant. It is considered also that such an alternative plant in Maine would be privately financed, and in New Brunswick publicly financed, consistent with the present and expected future practice in these two areas.

In analyzing the economic feasibility of the several tidal project combinations considered by the Engineering Board, the Commission has assumed that the capital costs and the project power would be divided equally between the two countries.

The annual cost of power assigned to the United States is determined on the basis of Federal financing, assuming an interest rate of 2½ percent and an amortization period of 50 years. "Taxes forgone," defined as the amount of taxes which would not be collected as a result of a Federal power development rather than the most likely alternative development, are included in the hydroelectric power costs in an amount approximately equal to the taxes included in the estimated steam-electric power costs used in deriving power benefits. Such inclusion places the U.S. costs of the tidal project combinations and of alternative steam-electric plants on a comparable basis for purposes of economic analysis. The above criteria are in accord with those used by Federal agencies in the United States concerned with water resource development.

The annual cost of power assigned to Canada is determined on the basis of non-Federal public financing, assuming an interest rate of 4⅛ percent and an amortization period of 50 years. No tax item is included in the hydroelectric power costs since none would be paid on alternative steam-electric plants. These criteria are in accord with the practice of New Brunswick.

As indicated in the foregoing, there are differences between United States and Canadian practices in deriving both the annual power values and annual power costs. For this reason, it is necessary to compute separate benefit-cost ratios for the two countries, each applicable to that country's share of the project power. The overall economic feasibility of the tidal project combinations, United States and Canada, may be determined by comparing the total benefits and costs of the combinations.

Under the conditions and criteria discussed above, and on the basis of information in the Engineering Board's report, the Commission has considered the economic feasibility of the tidal project alone and in combination with the several sources of firming power studied by the

Board. The results of this economic analysis are discussed in the following paragraphs and summarized in table 1.

TABLE 1.—*Power and economic data as derived by the International Joint Commission*

	Tidal project alone	Tidal project and steam-electric plant	Tidal project and Digdeguash pumped storage	Tidal project and incremental capacity only at Rankin Rapids	Tidal project and all of Rankin Rapids
Power data (entire project):					
Installed capacity:					
Tidal project—thousand kilowatts	300	300	300	300	300
Auxiliary—do	----------	220	260	226	400
Dependable capacity—do	95	300	323	355	555
Average annual generation million kilowatt-hours	1,843	2,143	1,759	1,843	3,063
Economic data (U.S. half of project):					
Capital investment—million dollars	271.6	297.5	292.6	300.5	367.6
Annual power benefits—do	5.977	10.365	9.719	9.779	16.782
Annual power costs—do	10.343	13.615	12.134	12.154	15.302
Benefit-cost ratio	.58	.76	.80	.80	1.10
Economic data (Canadian half of project):					
Capital investment—million dollars	275.2	297.6	293.8	299.5	364.5
Annual power benefits—do	4.663	6.900	6.177	6.043	10.235
Annual power costs—do	13.665	16.014	14.669	14.527	17.610
Benefit-cost ratio	.34	.42	.42	.42	.58
Economic data (entire project):					
Capital investment—million dollars	546.8	595.1	586.4	600.0	732.1
Annual power benefits—do	10.640	17.265	15.896	15.822	27.017
Annual power costs—do	24.008	29.629	26.803	26.681	32.912
Benefit-cost ratio	.44	.58	.59	.59	.82

NOTE.—Capital investment includes cost of transmission lines. Benefit-cost ratios are determined at the project sites, with appropriate allowance for transmission costs.

Tidal project alone

This project would have an installed capacity of 300,000 kilowatts, of which 95,000 kilowatts would be dependable. Average annual generation would amount to 1,843 million kilowatt-hours. The project investment, including transmission, would be $546,800,000.

For the United States, the annual power benefits would amount to $5,977,000 and the annual power costs $10,343,000, resulting in a benefit-cost ratio of 0.58. For Canada, the annual power benefits would be $4,663,000; the annual power costs, $13,665,000; and the benefit-cost ratio, 0.34. For the entire project, United States and Canada, the benefit-cost ratio would be 0.44.

Studies by the Engineering Board, based on somewhat different economic assumptions, also failed to provide a ratio of unity.

It is evident that construction of the tidal power project by itself is economically infeasible by a wide margin.

Tidal project combined with steam-electric capacity

Under this plan, the 300,000-kilowatt installed capacity at the tidal project is assumed to be combined with 220,000 kilowatts of steam-electric capacity to provide a total dependable capacity of 300,000 kilowatts. The average annual generation would amount to about 2,143 million kilowatt-hours. The project investment would be $595,100,000.

For the United States, the annual benefits would amount to $10,365,000; the annual costs, $13,615,000: and the benefit-cost ratio,

0.76. For Canada, the annual benefits and costs would amount to $6,900,000 and $16,014,000, respectively, and the benefit-cost ratio, 0.42. For the entire project, United States and Canada, the benefit-cost ratio would be 0.58. None of the studies using less rigorous criteria resulted in a ratio as high as unity.

Tidal project combined with Digdeguash pumped-storage project

The installed capacity of this combination project would be 560,000 kilowatts, of which 323,000 kilowatts would be dependable. Average annual generation would amount to 1,759 million kilowatt-hours. The total project investment, including transmission, would be $586,400,000.

For the United States, the annual power benefits would total $9,719,000 and the annual power costs $12,134,000, giving a benefit-cost ratio of 0.80. For Canada, the annual power benefits and costs would amount to $6,177,000 and $14,669,000, respectively, and the benefit-cost ratio, 0.42. For the entire project, United States and Canada, the benefit-cost ratio would be 0.59.

The only favorable benefit-cost ratio (1.06) derived in the Engineering Board's studies in this combination was for the U.S. share of the power, assuming a 75-year amortization period and excluding taxes foregone from project costs.

The Commission is of the opinion that the Digdeguash pumped-storage project could be used as a realistic auxiliary to the tidal power project, and that the combination of the two in a single economic analysis is sound in principle. Combined with the tidal project, the Digdeguash pumped-storage project could utilize offpeak power from the tidal plant to pump water from Passamaquoddy Bay to the reservoir. However, power from the tidal project combined with the Digdeguash pumped storage project would be more costly than power from available alternative sources.

Tidal project combined with incremental capacity at Rankin Rapids

The concept of using incremental capacity only at Rankin Rapids as an auxiliary to the tidal project assumes that the Rankin Rapids site would be developed first with 200,000 kilowatts of dependable capacity to serve loads wholly in the State of Maine. An additional 260,000 kilowatts of dependable capacity (226,000 kilowatts installed) would be provided at this site specifically for firming the tidal project output. The combined dependable capacity of this combination (the tidal project plus 260,000-kilowatt incremental capacity at Rankin Rapids) would be 355,000 kilowatts, capable of generating 1,843 million kilowatt-hours of electric energy annually. Under this combination, when the tidal plant output drops below the load to be carried, the energy deficiency would be borrowed from the basic Rankin Rapids project, using the 260,000-kilowatt incremental dependable capacity provided for this purpose, and repaid when tidal energy exceeds load. Thus, there would be no net energy withdrawal from the basic Rankin Rapids project (20,000 kilowatts and 1,220 million kilowatt-hours). In this way, Rankin Rapids and the tidal project could provide 355,000 kilowatts of dependable power for the load at a 60-percent annual load factor. Accordingly, the Commission believes that incremental capacity at Rankin Rapids constitutes a realistic auxiliary to the tidal project, and that the treatment of the combination in a single economic analysis is valid.

The project investment, including transmission, would be $600 million. Only the incremental cost of additional (260,000 kilowatts) capacity installation at Rankin Rapids is charged against the combination project.

For the United States, the annual power benefits would amount to $9,779,000; the annual power costs, $12,154,000; and the benefit-cost ratio is 0.80. For Canada, the annual power benefits would be $6,043,000; the annual power costs, $14,527,000; and the benefit-cost ratio, 0.42. For the entire project, United States and Canada, the benefit-cost ratio would be 0.59.

As in the case of the combination with the Digdeguash pumped-storage project, the only favorable benefit-cost ratio for this combination (1.08) in the Engineering Board's studies was that for the U.S. share of the power, assuming a 75-year amortization period and excluding taxes foregone from project costs.

Tidal projects combined with all Rankin Rapids

In this plan, as proposed by the Engineering Board, 300,000 kilowatts installed capacity at the tidal project would be combined with all of the capacity and energy available at Rankin Rapids (400,000 kilowatts installed, 460,000 kilowatts dependable, and 1.22 billion kilowatt-hours) to provide a total dependable capacity of 555,000 kilowatts and an average annual generation of 3,063 million kilowatt-hours. The project investment would be $732,100,000.

For the United States, the annual power benefits would be $16,782,000; the annual power costs, $15,302,000; and the benefit-cost ratio, 1.10. For Canada, the annual benefits would be $10,235,000; the annual costs, $17,610,000; and the benefit-cost ratio, 0.58. For the entire project, United States and Canada, the benefit-cost ratio would be 0.82. Downstream benefits estimated to be $953,000 annually were assumed in deriving these ratios.

Although the criteria used in certain studies by the Engineering Board resulted in a higher benefit-cost ratio for the U.S. share of the power from this combination, no studies made by the Board gave a favorable benefit-cost ratio for the Canadian share.

The Engineering Board found that, with a 50-year amortization period, the benefit-cost ratio for the tidal project combined with all of Rankin Rapids would be greater than unity (1.31), and concluded that this combination, if built entirely by the United States at an interest rate of 2½ percent, would be economically justified. However, the Commission believes there is an economic fallacy in the concept of such a combination project.

The facts presented in the Engineering Board's report and in this report show that, when considered alone, the tidal project is clearly uneconomic. Its benefit-cost ratio with a 50-year amortization period is considerably less than unity both for the United States and Canadian shares of the project power. On the other hand, the Rankin Rapids project with 200,000 kilowatts installed when considered alone has a benefit-cost ratio somewhat in excess of unity; i.e., 2 for Federal development. In the Board's economic analysis, the costs and benefits of the uneconomic tidal project are added to those of the economically feasible Rankin Rapids project to determine the benefit-cost ratio of this possible combination project. The Commission is of the opinion that a benefit-cost ratio determined on this

basis is not a valid representation of the economic worth of the tidal project, and the ratio of 1.31 determined by the Engineering Board for the combination project cannot be construed as indicating economic feasibility for the tidal power project. Hence, the findings of the Commission do not include consideration of this combination project.

Unit cost of power

While the benefit-cost ratios summarized in table 1 for the tidal project alone and the proposed project combinations provide a ready comparison of their relative economic value, they do not reveal the relative unit costs of power. Energy cost per kilowatt-hour furnishes a more direct basis for comparison of the cost of tidal power with other sources of power in the area. Unit costs of energy from tidal project combinations are summarized later. The cost of energy from alternative steam-electric plants is shown for comparison since such plants are the most likely alternative source of a comparable block of power for Maine and New Brunswick in the absence of the tidal project. In accordance with present practice, alternative steam-electric plants in Maine are assumed to be privately financed and in New Brusnwick, publicly financed.

For the purpose of this comparison, "taxes foregone" are not included in the U.S. share of the tidal project costs (as was done in the economic analyses summarized in table 1) because rates for the sale of power from federally financed projects are customarily established on the basis of returning only the power costs actually incurred. Unit energy costs for both the tidal project and the alternative steam-electric plants are calculated on the basis of about 60-percent load factor, to present them on a uniform basis. This is the approximate present annual load factor of the utility systems in the area.

It will be noted that the unit costs of energy for the tidal project alone are considerably higher than the 10.8 and 14.9 mills shown in the Engineering Board's report for the United States and Canadian shares of the power. Since the Board's figures were determined without regard to the 60-percent load factor limitation placed on the combination projects, they do not provide a proper basis for comparison of unit costs. The Commission has, therefore, adjusted the Board's figures to a 60-percent load factor basis, and credited to the project costs (at a steam-energy replacement value of 5 mills per kilowatt-hour in the United States and 4.4 mills in Canada as derived by the Engineering Board) all energy that could be produced in excess of a 60-percent load factor. This adjustment results in unit at-site costs of 26.2 mills for the U.S. share and 42.8 mills for the Canadian share of the tidal project power. It may be expected, however, that in actual operation, the dependable capacity (95,000 kilowatts) of the tidal project would be used at about 100-percent load factor. Under such operation, the unit cost of energy would be 18.2 and 27.5 mills in Maine and New Brunswick, respectively.

Comparison of unit cost of power from tidal project and from alternative steam-electric plants

[In mills per kilowatt-hour]

Power source	Unit cost of energy			
	At site		At market [1]	
	United States	Canada	United States	Canada
1. Tidal project alone	26.2	42.8	28.9	43.8
2. Tidal project and steam-electric capacity	13.5	18.6	15.0	19.6
3. Tidal project and Digdeguash pumped-storage project	12.2	16.8	13.5	17.4
4. Tidal project and incremental capacity at Rankin Rapids	11.5	15.8	13.4	17.3
5. Alternative steam-electric plants	10.6	7.3	11.6	7.4

[1] Includes cost of transmission of power from project site to the market.

It will be observed from the preceding tabulation that alternative steam-electric plants in Maine and New Brunswick, financed in accordance with present practices, could produce power at a lower cost than either the tidal project alone or any of the project combinations. It may be noted that this tabulation does not include the combination of the tidal project and all of Rankin Rapids for the reasons indicated in this report. In comparing the U.S. costs, it should be noted that the tidal project and the project combinations are assumed to be federally financed, while the alternative steam-electric plants are assumed to be privately financed, as previously pointed out.

In the discussion of the combination of the tidal projects with all of Rankin Rapids as proposed by the Engineering Board, the Commission points out that, if constructed alone to serve powerloads in the State of Maine, the Rankin Rapids project could provide 200,000 kilowatts of dependable capacity and 1,220 million kilowatt-hours' average annual energy. If this project were constructed with private financing, power could be produced at a unit cost of about 11 mills per kilowatt-hour at the damsite and 13 mills per kilowatt-hour delivered to the market. On the basis of Federal financing at the 2½-percent interest rate used in this report and 50-year amortization of the investment, the unit cost would be about 3.8 mills at site and 5.3 mills at market. In addition to supplying a large block of relatively low cost power for the State of Maine, the Rankin Rapids project would provide substantial benefits to downstream hydroelectric plants in New Brunswick.

Economic feasibility

On the basis of the foregoing economic analyses, the Commission finds that the tidal project alone is not economically feasible and could not provide firm power at a unit cost as low as the cost of power from new alternative steam-electric plants that could be built in the area to meet its future power requirements. None of the proposed combination projects considered by the Commission to be valid would provide an economic development for either the United States or Canada if they are evaluated on the basis of the usual practices

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followed in the two countries in determining the economic feasibility of proposed hydroelectric projects.

The Commission notes, however, that the tidal project could provide certain public benefits in addition to those which have been evaluated in monetary terms in determining benefit-cost ratios as previously described. Important among such benefits would be the recreation value of the project. It is believed that the uniqueness of the tidal project would make a substantial contribution to the large recreation industry of the area by attracting many visitors. The Engineering Board points out that on the basis of evaluation procedures currently used by the Corps of Engineers, the potential recreation benefits of the project would be at least $800,000 per year. Inclusion of these benefits in the foregoing analyses would improve slightly the benefit-cost ratio but would not alter the indicated conclusions as to economic feasibility of the project.

Other potential project benefits not evaluated in the benefit-cost analyses include those to navigation and to the highway systems of Maine and New Brunswick. The cost estimates prepared by the Engineering Board include navigation locks adequate for the volume of current traffic and for a moderate increase in vessel size. While the Board made no attempt to determine the future ship traffic in the project area, the Commission recognizes that the availability of an upper pool having considerably less range in its levels than now occurs with normal ebb and flood of the tides might stimulate greater traffic to shipping points on Passamaquoddy Bay. These possibilities may justify further study of navigation values in the future.

A highway system built on the approximately 7 miles of tidal dams could replace the present ferries serving the Passamaquoddy Bay area and provide a connecting link between United States and Canadian coastal highways that would shorten the highway distance between Whiting, Maine, and St. George, New Brunswick, by about 40 miles. Ready access would also be provided to Campobello and Deer Islands thereby increasing their recreational value. Neither the Engineering Board nor the Commission has attempted to estimate in monetary terms the potential highway value of the tidal dams.

Other factors, largely subject to policy determination, that could have an effect on the economics of the tidal project are possible changes in interest rates, allowance of a longer amortization period. and exclusion of taxes foregone from the U.S. costs. In addition, it may be noted that any increase in fuel costs in the projected area would have a favorable effect on the benefit-cost ratio by increasing the value of the tidal project power.

Table 2 illustrates the cumulative effect on the project's benefit-cost ratios of assumed variations from the project benefits and costs determined by the International Joint Commission. The cumulative effects are shown in relation to the Commission's basic analyses presented in table 1 using conventional evaluation practices in the United States and Canada. The assumed variations from the basic assumptions are as follows: (1) A uniform interest rate of 3 percent for both the United States and Canada; (2) amortization of the project

investment in 75 years instead of 50 years; (3) allowance of $800,000 for annual recreational benefits (one-half to each country); and (4) taxes foregone eliminated from U.S. costs.

TABLE 2.—*Effect on benefit-cost ratio of assumed variations from the project benefits and costs determined by the International Joint Commission*

Assumptions for determination of benefit-cost ratios	Tidal project alone			Tidal project and incremental capacity only at Rankin Rapids [1]		
	United States	Canada	United States and Canada	States States	Canada	United States and Canada
Basic analysis using conventional evaluation practices in United States and Canada (from table 1)	0.58	0.34	0.44	0.8	0.42	0.59
Cumulative effect of successive variations from basic analysis:						
1. Annual costs based on uniform interest rate of 3 percent for both countries	.52	.42	.47	.72	.52	.63
2. Amortization of capital investment in 75 years	.60	.49	.54	.83	.59	.72
3. Allowance of $800,000 annual recreation benefits ($400,000 to each country)	.64	.53	.58	.86	.63	.75
4. With taxes foregone eliminated from U.S. costs	.66	.53	.60	.99	.63	.81

[1] This combination project is shown in the table for illustrative purposes. The combination with Digdeqaush pumped-storage would give approximately the same results.

It may be seen from table 2 that none of the assumed variations from the basic evaluation made by the Commission would result in a benefit-cost ratio of unity for the tidal project alone or in combination with either incremental capacity at Rankin Rapids or the Digdeguash pumped-storage project. An increase as great as 25 percent in fuel costs would still not provide a benefit-cost ratio of unity for the Canadian share or for the entire project.

As to other possible effects of future trends on the economics of the project, the Commission notes that improvements in equipment design and construction methods may result in some saving in project costs. It is possible, for example, that further experience with bulb-type generating units may lead to savings through their adoption and use in the tidal project.

The Commission recognizes the existence of other tidal power potentials in the area and that their construction might provide sufficient diversity of power production to enhance the marketability of power from the international project considered for Passamaquoddy Bay.

The Commission also recognizes that factors other than strict economic feasibility based on tangible benefits and costs, and which were not taken into account by the Commission, may be of importance to the two Governments in arriving at decisions to undertake resource development projects such as this. Such factors might include the development of new and unique sources of power, the conservation of fossil fuel resources, and the provision of employment opportunities in economically depressed areas.

FINDINGS OF THE INTERNATIONAL JOINT COMMISSION ON SPECIFIC POINTS OF THE REFERENCE

The reference to the International Joint Commission by the Governments of Canada and the United States requested findings on certain specific points with respect to development of the international tidal power potential of Passamaquoddy Bay in the State of Maine and the Province of New Brunswick. These findings follow:

(a) *The estimated cost of developing the international tidal power potential of Passamaquoddy Bay*

On the basis of the detailed studies of the Engineering Board, the Commission finds the estimated costs, using U.S. currency and January 1958 price levels, of the tidal project alone and in combination with several possible sources of firming power to be as follows:

Project	Generating capacity (1,000 kilowatts)		Average annual energy (million kilowatt-hours)	Capital investments including transmission to market (million dollars)
	Installed	Dependable		
1. Tidal project alone	300	95	1,843	546.8
2. Tidal project and steam-electric capacity	520	300	2,143	595.1
3. Tidal project and Digdeguash pumped storage	560	323	1,759	586.4
4. Tidal project and incremental capacity at Rankin Rapids	526	355	1,843	600.0

The at-site unit costs per kilowatt-hour of producing electric energy from the tidal project alone is estimated to be 26.2 mills for the U.S. share of the power and 42.8 mills for Canada's share based on a 60-percent annual load factor. Based on a 100-percent load factor the unit costs would be 18.2 and 27.5 mills for the United States and Canada, respectively.

The unit costs per kilowatt-hour of energy of power from a combination of the tidal project with either incremental generating capacity at the Rankin Rapids Reservoir site in Maine or the Digdeguash pumped-storage site in New Brunswick would be approximately 12 mills for the U.S. share of the power and 16 mills for Canada's share. The Rankin Rapids and Digdeguash sites are considered the lowest cost means available of supplying auxiliary power for the tidal project.

(b) *Whether such costs will allow hydroelectric power to be produced at a price which is economically feasible*

The Commission finds that the tidal project either alone or in combination with auxiliary power sources is not economically feasible if it is evaluated in accordance with the conventional methods of economic analysis of hydroelectric projects in the United States and Canada. On the basis of such evaluation standards, the benefit-cost ratios for the tidal project alone would be 0.58 for the United States and 0.34 for Canada. For the project as a whole, the benefit-cost ratio would be about 0.44. Using either the Digdeguash pumped-storage auxiliary in Canada or incremental generating capacity at the Rankin Rapids project in the United States, the benefit-cost ratio for each combination project would be 0.80 for the United States and 0.42 for Canada. The overall benefit-cost ratio for each of these combinations would be about 0.59.

If, as a matter of policy applicable to this international project, the Governments of the United States and Canada wish to adopt criteria different from the conventional concepts of economic analysis with respect to such factors as interest rates, amortization period, taxes forgone, and allowance of recreation benefits, the benefit-cost ratios for the combination project (tidal project and Digdeguash or tidal project and incremental capacity at Rankin Rapids) would, as shown in table 2, become 0.99 for the United States, 0.63 for Canada, and 0.81 for the two countries combined.

Construction of the Rankin Rapids Dam and Reservoir on the upper St. John River in the State of Maine would be prerequisite to its use to supply incremental firming capacity for the tidal project. The Rankin Rapids project could be constructed initially with an installed generating capacity of 200,000 kilowatts to supply economic hydroelectric power to the State of Maine and downstream benefits to hydroelectric plants on the St. John River in New Brunswick. Such a plan of development would not preclude later use of Rankin Rapids as a source of firming power by construction of 260,000 kilowatts of additional dependable capacity at the site to be operated in coordination with and as an auxiliary to the tidal project. The Commission is of the opinion, however, that it would not be consistent with sound practices of economic analysis of hydroelectric projects to combine the basic Rankin Rapids project (200,000 kilowatts and 1,220 million kilowatt-hours) with the tidal project to determine the economic worth of the tidal project.

In short, the Commission finds that the tidal project, either alone or in combination with auxiliary power sources will not permit power to be produced at a price which is competitive with the price of power from alternative available sources.

(c) *The effects, beneficial or otherwise, which such a power project might have on the local and national economies in the United States and Canada*

Because of the relatively high cost of development of the tidal power potential, the Commission finds that construction of the tidal project would not appreciably affect industrial development in the project area.

Construction of the project would have substantial, although short-term, beneficial effect on the economies of Maine and New Brunswick during the 6-year construction period resulting from expenditures of over $200 million for goods and services.

The uniqueness of the tidal project and the creation of two large salt water lakes in an area where recreation is already an important industry would result in the provision of additional recreation benefits.

Since the tidal project would raise the level of the Passamaquoddy Bay high pool and decrease the tidal range, navigation conditions would be improved in the St. Croix River estuary and at St. Andrews and other ports on Passamaquoddy Bay. In the low pool, on the other hand, the beneficial effects of decreasing the tidal range would be partially offset by lowering the maximum level of Cobscook Bay to a point below the level of normal high tide. Navigation conditions in the lower pool in the Falls Island and Lubec areas, in which rapid tidal currents now occur, would be improved during a considerable portion of the tidal cycle. In general, tidal velocities in the project area would be reduced, except in areas immediately adjacent to the gates when open.

Construction of the tidal dams, locks, and gates would provide foundations on which an international highway could be built connecting the present coastal highways in Maine and New Brunswick, reducing the travel distance from Whiting, Maine, to St. George, New Brunswick, by about 40 miles. Ready access to the recreational advantages of the large islands in Passamaquoddy Bay also would be provided by this highway.

(*d*) *Specifically, the effects which the construction, maintenance, and operation of the tidal power project might have upon the fisheries in the area*

On the basis of the extensive studies of the Fisheries Board, the Commission finds that by providing for relocation and modification of existing fisheries facilities and by including appropriate remedial measures in the design of the tidal power structures, construction and operation of the tidal power project would have very little effect on the important sardine industry in the region and only a minor effect on other fisheries.

The Rankin Rapids project would flood substantial reaches of the Allagash and St. John Rivers in Maine which now support an important trout fishery. Construction of this project would change the type of fishing which now prevails. Other wildlife habitat would also be affected.

The Digdeguash River now supports a small run of Atlantic salmon which would be destroyed by construction of the pumped-storage auxiliary. Methods of restoring this run were not determined.

RECOMMENDATIONS

In view of the finding that the Passamaquoddy tidal power project is not economically feasible under present conditions, the Commission recommends that development of the project be viewed as a long-range possibility having better prospects of realization when other less costly energy resources available to the area are exhausted. In making this recommendation, the Commission wishes to point out that the economic feasibility of the project may be affected by future changes in the costs and benefits considered in the present evaluation of the project. The two Governments may wish to give consideration to the desirability of crediting the tidal project with certain public benefits that have not been included in the economic feasibility determination presented in this report.

The Commission recommends, further, that this report with the accompanying reports of the Engineering and Fisheries Boards be made available to all interested parties as a valuable source of relevant engineering and economic data for use in any future study of the possibilities for development of the international tidal power potential of Passamaquoddy Bay.

Signed at Washington this 4th day of April 1961.

EDWARD A. BACON.
A. G. L. MCNAUGHTON.
EUGENE W. WEBER.
J. LUCIEN DANSEREAU.
FRANCIS L. ADAMS.
D. M. STEPHENS.

LETTERS AND REMARKS OF PRESIDENT JOHN F. KENNEDY PERTAINING TO THE PASSAMAQUODDY TIDAL POWER PROJECT

LETTERS AND REMARKS OF PRESIDENT KENNEDY PERTAINING TO PASSAMAQUODDY

REMARKS OF THE PRESIDENT IN CONNECTION WITH THE PRESENTATION OF THE REPORT TO THE PRESIDENT ON THE PASSAMAQUODDY TIDAL POWER PROJECT AND THE ST. JOHN RIVER HYDRO DEVELOPMENT FOR CANADA AND THE UNITED STATES IN THE NEW FLOWER GARDEN

JULY 16, 1963

I am pleased to meet today with Members of the Senate and the House of Representatives from New England to discuss the report on the international Passamaquoddy tidal project submitted by Secretary Udall. Two years ago, I asked Secretary Udall, in cooperation with the Corps of Engineers, to restudy the proposed project, and the hydroelectric potential of the St. John River in Maine to determine whether recent developments in electric power technology had enhanced the economic feasibility of these projects.

This report has been presented to me this morning, and its major conclusions are most encouraging. The report reveals that this unique international power complex can provide American and Canadian markets with over a million kilowatts for the daily peak period in addition to 250,000 kilowatts of firm power. Electric power rates in the New England region are among the highest in the United States, and the survey indicates that a massive block of power can be produced and delivered at a cost of about 4 mills, approximately 25 percent below the current wholesale cost of power in the region.

I am pleased to note also that the development plan proposed would preserve the superb recreational areas of the Allagash River from flooding, and that an area suitable for a new national park would be preserved in this scenic part of Maine.

Any proposed resource development project must, of course, meet the national interest test. It must strengthen the economy of the whole Nation and enable America to better compete in the marketplaces of the world. I understand that, measured by the customary feasibility standards, the Passamaquoddy-St. John project now meets the national interest test.

During the last three decades American taxpayers, through their Federal Government, have invested vast sums of money in developing the water resources of the great rivers of this country—the Columbia, the Missouri, the Colorado, the Tennessee, and others. These investments are producing daily dividends for our country, and it is reasonable to assume that a similar investment in conserving the resources of New England will also benefit the Nation. It is also reasonable to assume that a New England development will stimulate more diversified industry, increase commerce, and provide more jobs.

Our experience in other regions and river valleys shows that private

utility customers as well as public agency power users benefit from lowering the basic cost of electric energy.

Harnessing the energy of the tides is an exciting technological undertaking. France and the Soviet Union are already doing pioneering work in this field. Each day over a million kilowatts of power surge in and out of the Passamaquoddy Bay. Man needs only to exercise his engineering ingenuity to convert the ocean's surge into a national asset. It is clear, however, that any development of this magnitude and new approach must also be considered in the context of the national energy study currently being undertaken by an interdepartmental committee under the chairmanship of the Director of the Office of Science and Technology, Dr. Wiesner.

These projects involve international waters, and equitable agreements must therefore be reached with the Canadian Government. Therefore, I am requesting the Secretary of State to initiate negotiations immediately with the Government of Canada looking toward a satisfactory arrangement for the sharing of the benefits of these two projects. Also, to insure full consideration of these proposals, I am directing that the Interior Department and the Corps of Engineers accelerate their work on the remaining studies of details.

The power-producing utilities of the United States are second to none in the world. The combined effort of science, private industry, and Government will surely keep this Nation in the forefront of technological progress in energy and electric power.

I think that this can be one of the most astonishing and beneficial joint enterprises that the people of the United States have ever undertaken and, therefore, I want to commend the Department of the Interior for its initiative in working on this matter the past 2 years, the congressional delegation from Maine which has been interested in this for many years, and the Members of Congress from New England who have supported this great effort. I think it will mean a good deal to New England and a good deal to the country.

Secretary Udall, do you have any comment you might want to make on this?

Secretary UDALL. Only, Mr. President, that I think that as a westerner and one who has been in the Congress for many years and who has watched the development of all parts of the country go forward, the one area of the United States that it seems to me we pass by in our national effort, where we have not invested in water development, has been in the New England area. I think this is a very fine project, and I am sure that with the type of support we have here this morning that we can perfect the reports on it and Congress can have an opportunity to vote this very fine project. So we are very encouraged by it.

President KENNEDY. Mrs. Smith, why don't you speak for New England?

Senator SMITH (Maine). Mr. President, you can well imagine how I feel this morning. Since 1948, when I reintroduced or revived this project, we have been working so hard and then find ourselves at the point where there is renewed interest and really a prospect for development of this great project.

Mr. President, I do thank you very much for your interest, and we look forward to the time when we can see the development completed.

Senator MUSKIE (Maine). The President suggested that I close the meeting with a prayer. I would say that at this moment Quoddy

needs a prayer less than at any time since the idea was first conceived by Dexter Cooper.

I would like to thank the President and the Secretary of the Interior, and my colleagues on the Maine delegation during my tenure in the Congress and previously for the dedicated effort and interest which has brought this moment about, and I am most grateful, Mr. President, for your taking this means of dramatizing your interest in the project.

President KENNEDY. Thank you.

LETTER FROM PRESIDENT KENNEDY TO HON. STEWART L. UDALL, DATED MAY 20, 1961, AND REPLY THERETO

THE WHITE HOUSE, *May 20, 1961.*

Hon. STEWART L. UDALL,
Secretary of the Interior,
Washington, D.C.

MY DEAR MR. SECRETARY: As you know, the International Joint Commission, United States and Canada, has submitted its report on the international Passamaquoddy tidal power project to the Governments of the United States and Canada. I am informed that the report has now been circulated by the Secretary of State to the interested Federal agencies, including the Department of the Interior, for comment.

This project has challenged engineers and students of water resources for many years, and I am hopeful that the current report and the related studies of the International Passamaquoddy Engineering Board and the New England-New York Interagency Committee can be as useful as possible in formulating a sound policy for the development of resources in the area covered by the report. I would, therefore, appreciate it if, following your review and evaluation of the report, you would advise me of your judgment about what changes in fuel, engineering, and financing costs might result in making the project economically feasible. I would also appreciate your advice on the advisability of hydroelectric power development on the upper St. John River at this time and on any other relevant matters relating to the report.

I have notified the Secretary of State of my request for your advice on this project and have asked that he give particular attention to your views on these matters in his report on the project.

Sincerely,

JOHN F. KENNEDY.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., May 31, 1961.

The PRESIDENT,
The White House.

DEAR MR. PRESIDENT: This is in response to your May 20 letter requesting that this Department review the report by the International Joint Commission, United States and Canada, on the international Passamaquoddy tidal power project. Your letter also requests advice on the advisability of hydroelectric power development on the upper

St. John River and states that you have notified the Secretary of State of your request.

This is to inform you that we are proceeding with such a review and study. I have directed Under Secretary Carr to be personally responsible for initiating these studies and completing a review as soon as practicable.

Sincerely yours,

STEWART L. UDALL,
Secretary of the Interior.

LETTERS FROM PRESIDENT KENNEDY TO HON. DEAN RUSK AND HON. STEWART L. UDALL, DATED MAY 20, 1961

THE WHITE HOUSE,
May 20, 1961.

Hon. DEAN RUSK,
Secretary of State,
Department of State,
Washington, D.C.

MY DEAR MR. SECRETARY: I am informed that you have requested the comments of interested Federal agencies on the report of the International Joint Commission, United States and Canada, on the Passamaquoddy tidal power project.

This project has challenged engineers and students of water resources for many years, and I am hopeful that the current report and related studies can be as useful as possible in formulating a sound policy for the development of resources in the area covered by the report. I have, therefore, asked the Secretary of the Interior to advise me on the power and natural resource aspects of the report. A copy of my request to Secretary Udall is enclosed for your information.

I wish you would give particular attention to his views on these matters prior to submitting your report to the Bureau of the Budget for clearance.

Sincerely,

JOHN F. KENNEDY.

MAY 20, 1961.

Hon. STEWART L. UDALL,
Secretary of the Interior,
Washington, D.C.

MY DEAR MR. SECRETARY: As you know, the International Joint Commission, United States and Canada, has submitted its report on the international Passamaquoddy tidal power project to the Governments of the United States and Canada. I am informed that the report has now been circulated by the Secretary of State to the interested Federal agencies, including the Department of the Interior, for comment.

This project has challenged engineers and students of water resources for many years, and I am hopeful that the current report and the related studies of the International Passamaquoddy Engineering Board and the New England-New York Interagency Committee can

be as useful as possible in formulating a sound policy for the development of resources in the area covered by the report. I would, therefore, appreciate it if, following your review and evaluation of the report, you would advise me of your judgment about what changes in fuel, engineering, and financing costs might result in making the project economically feasible. I would also appreciate your advice on the advisability of hydroelectric power development on the upper St. John River at this time and on any other relevant matters relating to the report.

I have notified the Secretary of State of my request for your advice on this project and have asked that he give particular attention to your views on these matters in his report on the project.

Sincerely,

JOHN F. KENNEDY.

PROGRESS REPORTS OF THE DEPARTMENT OF THE INTERIOR RELATING TO PASSAMAQUODDY TIDAL POWER PROJECT

PROGRESS REPORTS

[August 6, 1963]

Joint Army-Interior Passamaquoddy Board Appointed

Appointment of an Army-Interior Advisory Board on Passamaquoddy and upper St. John River was announced today by the Departments of the Interior and the Army.

The Board will advise and guide the field offices of the two agencies in the preparation of additional studies needed to augment and refine the data contained in a report, "International Passamaquoddy Tidal Power Project and Upper St. John River Hydroelectric Power Development," presented by Secretary of the Interior Stewart L. Udall at the White House on July 16, 1963.

This action was taken in response to President Kennedy's directive, also made on July 16, when he said, "To insure full consideration of these proposals, I am directing that the Interior Department and the Corps of Engineers accelerate their work on the remaining studies of details."

Secretary Udall named as the Department of the Interior's representatives on the Board, Morgan Dubrow, chief engineering adviser to the Assistant Secretary for Water and Power Development, Kenneth Holum; N. B. Bennett, Assistant Commissioner of Reclamation; B. P. Bellport, chief engineer, Bureau of Reclamation; and J. E. Guidry, Passamaquoddy project engineer.

The Army's representatives will be four men from the civil works organization of the Corps of Engineers, appointed by Lt. Gen. W. K. Wilson, Jr., Chief of Engineers. They are: W. E. Johnson, Chief of the Engineering Division; H. C. C. Weinkauff, Acting Chief of the Planning Division; F. L. Thrall, of the Policy Branch; and J. W. Leslie, Chief of the Engineering Division of the Corps' New England Division.

Mr. Johnson will be Chairman of the Board, and J. W. Roche, of the Corps of Engineers, will serve as Secretary.

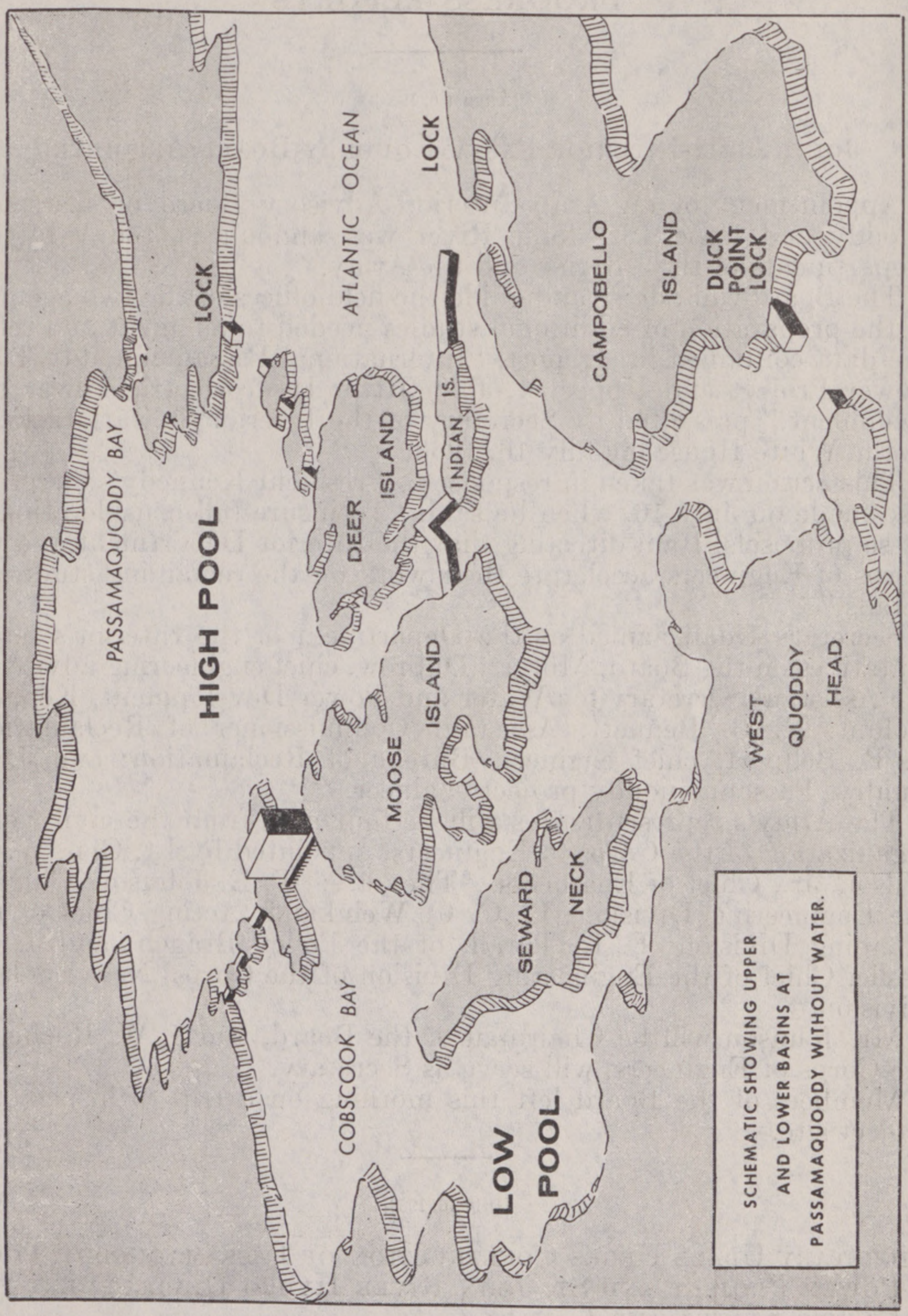
Members of the Board left this morning on a trip to inspect the project site.

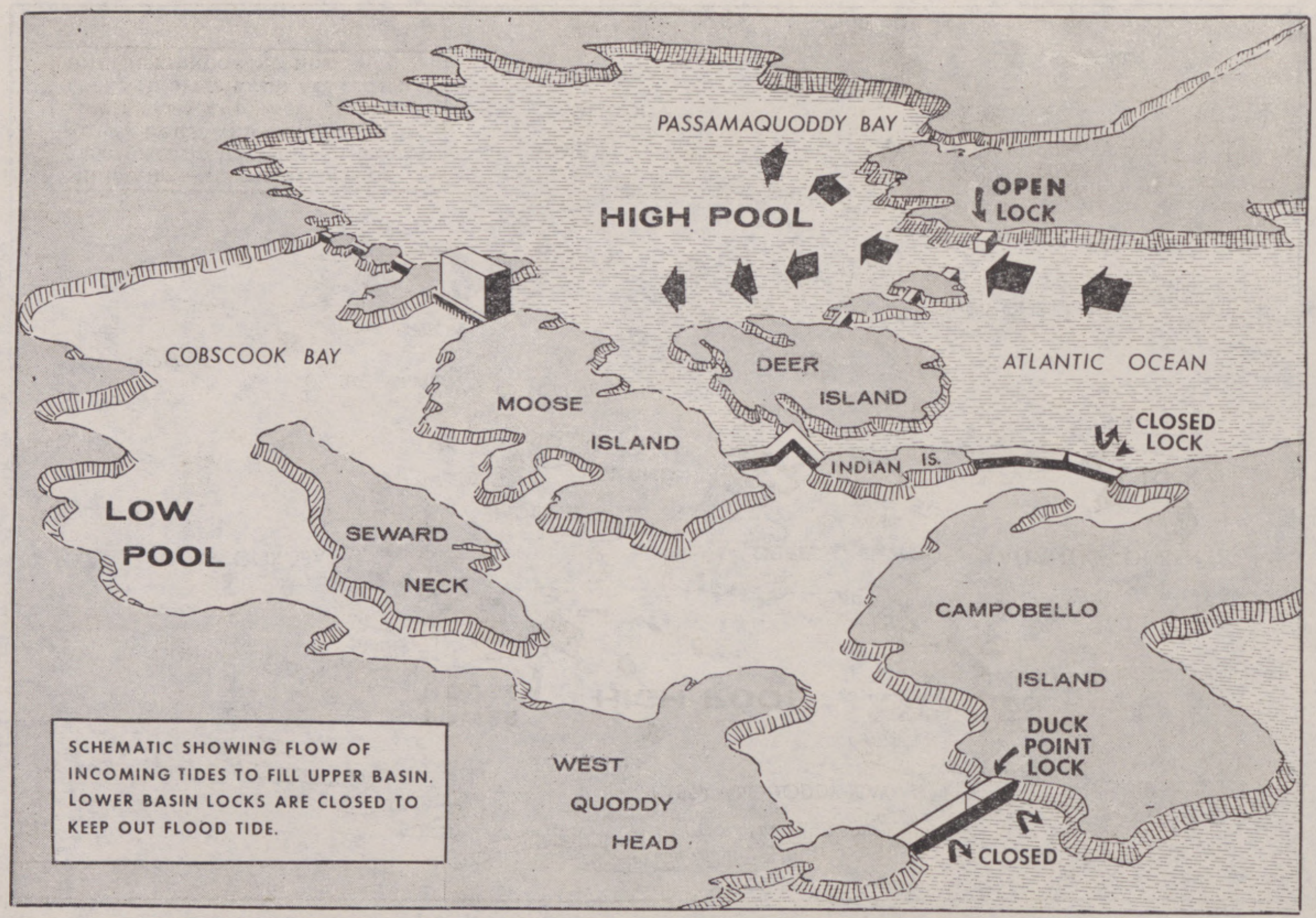
[July 16, 1963]

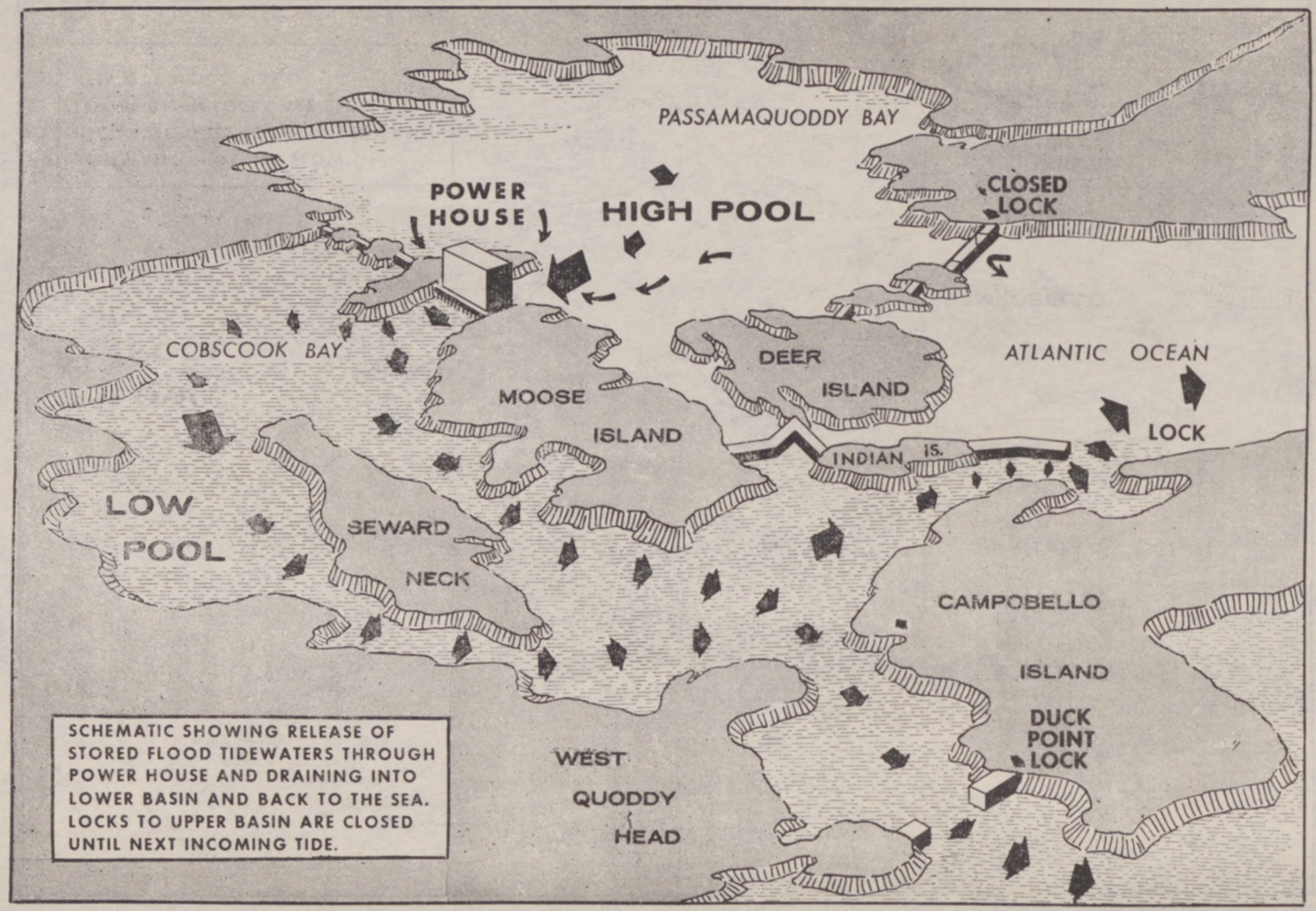
Secretary Udall Urges Construction of Passamaquoddy Tidal Power Project and St. John River Hydro Development for United States and Canada

Secretary of the Interior Stewart L. Udall said today he has reported to President Kennedy that the international Passamaquoddy tidal power project and the companion upper St. John River hydroelectric power development, both in Maine, are economically feasible and

36-986—64——10


PASSAMAQUODDY BAY
LOCK
HIGH POOL
ATLANTIC OCEAN
LOCK
DEER ISLAND
INDIAN IS.
CAMPOBELLO
ISLAND
DUCK POINT LOCK
MOOSE ISLAND
SEWARD NECK
COBSCOOK BAY
LOW POOL
WEST QUODDY HEAD
SCHEMATIC SHOWING UPPER AND LOWER BASINS AT PASSAMAQUODDY WITHOUT WATER.


PASSAMAQUODDY BAY
HIGH POOL
OPEN LOCK
COBSCOOK BAY
DEER ISLAND
ATLANTIC OCEAN
MOOSE ISLAND
CLOSED LOCK
INDIAN IS.
LOW POOL
SEWARD NECK
CAMPOBELLO ISLAND
DUCK POINT LOCK
WEST QUODDY HEAD
CLOSED
SCHEMATIC SHOWING FLOW OF INCOMING TIDES TO FILL UPPER BASIN. LOWER BASIN LOCKS ARE CLOSED TO KEEP OUT FLOOD TIDE.


PASSAMAQUODDY BAY
POWER HOUSE
HIGH POOL
CLOSED LOCK
COBSCOOK BAY
DEER ISLAND
ATLANTIC OCEAN
MOOSE ISLAND
INDIAN IS.
LOCK
LOW POOL
SEWARD NECK
CAMPOBELLO ISLAND
DUCK POINT LOCK
WEST QUODDY HEAD
SCHEMATIC SHOWING RELEASE OF STORED FLOOD TIDEWATERS THROUGH POWER HOUSE AND DRAINING INTO LOWER BASIN AND BACK TO THE SEA. LOCKS TO UPPER BASIN ARE CLOSED UNTIL NEXT INCOMING TIDE.

should be constructed for the benefit of the United States and Canada.

Basing his recommendations on findings by a special study committee of Interior experts, Secretary Udall urged that the committee's favorable report, just completed, be used "as a basis for early authorization" for the U.S. Army Corps of Engineers to build structures to harness the tides and the river and for the Department of the Interior to market the great blocks of urgently needed electric energy that will be made available.

Secretary Udall said power features of the billion-dollar project would be self-liquidating and that far-reaching economic and recreational benefits will result in the New England-Canadian Maritime Provinces area. He pointed out that extensive studies, dating back to 1922, had been made on the project and there still is time for any additional required engineering work preliminary to actual construction.

In recommending construction of the international Passamaquoddy tidal power project to President Kennedy, Secretary Udall emphasized that realization of this tide-taming project would permit the addition to the national park system of the famed Allagash River area.

Threatened by other dam proposals, one of which would inundate it for virtually its entire 100-mile length, the Allagash River links a series of major lakes in a wild river setting flanked by vast areas of the great north woods of spruce and fir that at one time blanketed the eastern seaboard.

"The Allagash, this living remnant of a historical wilderness canoe route, has no equal anywhere in the United States," Secretary Udall said. "Its loss would be a national fatality."

The proposed protection and enhancement of the Allagash area, which has been under detailed study by the Department of the Interior, would include—

1. Establishment of an Allagash National Riverway in northern Maine to be created by Congress.

2. Management of the area primarily for canoeists, and associated activities such as camping, fishing, hunting and other outdoor recreation activities.

3. Division of the area into two zones. The first would be a primary zone with a maximum of 192,000 acres of land and water, not to exceed a strip one-half mile from water's edge. (This recommendation represents a reduction in size of the area from the 296,500 acres recommended in a 1960 National Park Service report.) A second zone would be created to encircle and protect the primary zone with a buffer strip not to exceed a half mile. Here scenic easements rather than full title would be acquired to permit sustained-yield logging while still protecting the irreplaceable wilderness area of the one primary zone.

4. Administration of the riverway by the Department's National Park Service.

5. Hunting and fishing in accordance with the laws of the State of Maine.

6. Administration of fish, game, fire, and insect protection in association with appropriate agencies of the State of Maine.

In a letter to President Kennedy, Secretary Udall asked that Secretary of State Dean Rusk be requested to begin immediate negotiations

with the Canadian Government "looking toward a satisfactory arrangement" for the sharing of the power and flood-control benefits of the St. John River, an international stream, and the development of the Passamaquoddy tidal power project, part of which would be on Canadian soil.

The Passamaquoddy tidal powerplant is designed chiefly to provide 1 million kilowatts of peaking output for 1 hour daily, this output occurring simultaneously with the peak demands of the New England States and to be available for the Maritime Provinces, as desired by Canada. When coupled with the St. John output, the daily dependable electrical peaking capacity for the two installations would be 1,250,000 kilowatts.

Annual power benefits are expected to reach $47 million. In addition, the report said, the developments would assure more than $2 million annually in recreation benefits, improve fishery conditions, and speed economic growth in a broad area. Construction alone would generate more than 14,000 man-years of employment.

[March 6, 1962]

Secretary Udall Releases Interior Report on Load and Resources Study on Proposed Passamaquoddy-St. John Hydroelectric Development

Secretary of the Interior Stewart L. Udall today made public a Department of the Interior interim report recommending that future planning for the proposed Passamaquoddy tidal power project in Maine be based on an anticipated peaking capacity of 1 million kilowatts instead of the 330,000 kilowatts previously considered.

He said the report, known as a load and resources study, also proposes that the project be coordinated with maximum development of hydroelectric resources of the upper St. John River between Maine and New Brunswick, Canada.

The report is part of an evaluation requested by President Kennedy in May 1961, of the International Joint Commission's earlier findings regarding development of the area's power potential. The evaluations are being made under the direction of Under Secretary James K. Carr by a five-man committee of Interior experts headed by Morgan D. Dubrow, engineering assistant and chief research adviser to Kenneth Holum, Assistant Secretary, Water and Power.

Secretary Udall added that the study also will consider recreational values, particularly the proposed Allagash Wilderness Area.

The Department of the Interior's report was prepared by two Interior engineers, Joseph E. Guidry and Bruce Rogers, in close consultation with interested Canadian and U.S. Government representatives, including the Washington and Northeast field offices of the Corps of Engineers and the Federal Power Commission.

On the basis of this study, Mr. Carr commented that the Passamaquoddy project could probably be developed "in the magnitude of 1 million kilowatts" peaking capacity and that its operation should be coordinated with the full development of the St. John River hydroelectric system, including upstream storage in the State of Maine. However, Mr. Carr said the report cautions that additional studies are necessary along these lines:

Obtain reliable information about the cost and operating characteristics of horizontal axial-flow hydraulic turbines which are proposed in the report for use at Passamaquoddy;

If the turbine information is favorable, conduct power studies to analyze operation of the project under several assumed operating conditions;

Consult with construction experts to see if the cost of water structures in the Western Passage, Indian River, and Head Harbour Passage can be reduced;

Design a transmission system and estimate the cost of delivering power to load centers to market Passamaquoddy and St. John power;

Prepare an estimate on the basis of the United States financing and constructing the Passamaquoddy project coordinated with the upstream St. John River hydroelectric development "taking advantage of the technological advances in the design of the horizontal axial-flow turbine unit and crediting the development with recreational benefits, plus appropriate consideration for area development."

Subsequent to preparation of the load and resources study, the Department has taken a firm position against waiving interest in the financial justification of a project. Therefore, the suggestion in the report on the load and resources study to eliminate interest during the initial 15 years of the project should be disregarded. Future financial feasibility and economic studies will include appropriate estimates to cover interest.

The Interior Department engineers said that computer studies regarding the project should be made under such varying possibilities as the Passamaquoddy portion operating under isolated conditions; when coordinated with the operation of the upper St. John River storage development; when coordinated with existing and proposed Canadian St. John River hydroelectric plants in New Brunswick; and various combinations of these. Other computer studies would center on varying conditions that might be encountered in the operation of turbines at Passamaquoddy under different tidal ranges.

BIOGRAPHIES OF MEMBERS OF THE ARMY-INTERIOR ADVISORY BOARD ON PASSAMAQUODDY AND UPPER ST. JOHN RIVER AND OF DR. LORENZ G. STRAUB AND DR. ARTHUR CASAGRANDE

BIOGRAPHIES OF MEMBERS OF THE ARMY-INTERIOR ADVISORY BOARD ON PASSAMAQUODDY AND UPPER ST. JOHN RIVER

(The Joint Army-Interior Advisory Board was created to advise and provide guidance to the field agencies in the preparation of additional studies needed to augment and refine the data contained in the Department of Interior's report dated July 1963. The agency representatives contributed their technical skills but did not participate in drafting of the final conclusions and recommendations contained in the report.)

WENDELL E. JOHNSON

Chief, Engineering Division, Civil Works, in the Office of the Chief of Engineers, U.S. Army, in which position he has supervised the engineering of all water resource projects of the Corps of Engineers since April 1961. For 12 years, prior to the time, he was chief of the engineering division of the corps division office at Omaha supervising civil and military construction programs that averaged about $200 million per year. In his varied career he has also been chief of the engineering division of the corps Omaha office and was in charge of civil engineering design and construction of the third lock project of the Panama Canal. He has had design and construction assignments on John Martin and Conchas Dams, the canalization of the upper Mississippi River, and on highway location and construction projects. He was an engineer officer in the European theater in World War II and rose to the rank of major. Mr. Johnson received his B.S. degree in civil engineering from the University of Minnesota in 1931.

HENRY C. C. WEINKAUFF

In his present position as Chief, Planning Division, Civil Works, Office, Chief of Engineers, U.S. Army, Mr. Weinkauff supervises planning aspects of the billion-dollar-a-year water resource development program of the Corps of Engineers. He has had a long and varied career with the Corps of Engineers extending over a period of some 33 years and including responsible positions in the Office, Chief of Engineers, the Board of Engineers for Rivers and Harbors, and the New York district. He was in the European theater during World War II, served as commandant of the Engineer Depot at Liege, Belgium, and advanced to the rank of colonel.

Mr. Weinkauff received the degree of civil engineer (CE) from the Polytechnic Institute of Brooklyn, followed by graduate studies in indeterminate structures. He is also a graduate of the Command and General Staff College at Fort Leavenworth, Kans.

FRED L. THRALL

Specialist on hydroelectric power policy and planning matters in the Office, Chief of Engineers, U.S. Army. He has been engaged in the planning and design of large water resource and power projects for 23 years. Prior to joining the staff of the Chief of Army Engineers in 1949, he served with the Little Rock, Savannah, and Dallas offices of the Corps of Engineers, and with the International Engineering Co. at Denver. He was with the Army Air Corps in Europe during World War II and was discharged with the rank of captain. Mr. Thrall has a B.S. degree in civil engineering from the University of Arkansas and a certificate of competence in professional meteorology from the University of Chicago.

JOHN W. LESLIE

John W. Leslie has been an employee of the Corps of Engineers in New England for 28 years, the last 8 as chief, engineering division, New England division. In this capacity he has directed the design of a multimillion-dollar civil works and military construction program with broad experience in dam, hurricane barrier, and navigation projects. He was in direct supervision of the Passamaquoddy engineering investigation for the International Joint Commission report of 1961 and directed the engineering studies of the Department of Interior report of August 1964. Mr. Leslie has prepared many technical papers including a presentation on Passamaquoddy at the World Power Congress in Madrid, Spain, in 1960. He is a member of the Boston Society of Civil Engineers, a member of the U.S. Committee on Large Dams, and a national director of the Society of American Military Engineers. Mr. Leslie is a graduate of Massachusetts Institute of Technology.

MORGAN D. DUBROW

Morgan D. Dubrow, Chief Engineering Research Adviser to the Assistant Secretary for Water and Power, has over 25 years' experience in engineering and hydrology, specializing in electrical generation, nuclear power generation, pumped-back-storage electrical generation, and the interconnection of electrical power systems. Prior to his present position, Dubrow was associated with the Department's Bonneville Administration and Bureau of Reclamation. He has also served with the U.S. Army Corps of Engineers and the Federal Power Commission. Mr. Dubrow holds a degree in civil engineering from The Citadel and a master's degree in engineering from the University of Iowa. He was chairman of the evaluation study. He is also chairman of the U.S. negotiating team which will conduct negotiations with the Canadian Government to obtain their agreement with Canada on Passamaquoddy.

N. B. BENNETT, JR.

N. B. Bennett, Jr., was appointed Assistant Commissioner for Engineering and Power in the Bureau of Reclamation on June 15,

1959, after serving since 1953 as Chief of the Division of Project Development.

Mr. Bennett began his public career in construction work for the Bureau on the Kendrick, then Alcova, project in Wyoming in 1933, after receiving a B.S. degree in civil engineering from the University of Nebraska. Later he entered private business, engaging in the planning, design, and construction of municipal water supply systems in Sheridan and Cody, Wyo., and buildings in Denver, Colo.

In April 1939 Mr. Bennett became assistant State engineer of Wyoming Conservation Board. He returned to the Bureau of Reclamation in 1942 as an assistant engineer in Oregon and Colorado.

In July 1945 he was transferred to Washington, D.C., as Assistant Chief of the Division of Engineering Surveys. He was promoted to Assistant Director, Branch of Project Planning, in 1946 and became its Director in October 1953. He then became Chief of the Division of Project Development.

Mr. Bennett is chairman of the U.S. section of an international engineering board with Canada on water problems of the Souris-Red Rivers, and the Waterton-Belly Rivers.

JOSEPH E. GUIDRY

Joseph E. Guidry, electrical engineer on the staff of the Assistant Secretary for Water and Power, served as the project engineer on the Passamaquoddy evaluation study. He started a 25-year career in electrical power engineering in 1938, serving with the Federal Power Commission and the Department of the Navy before joining the Department's Bureau of Reclamation in 1946. He joined the Office of the Secretary in 1962. Mr. Guidry holds a B.S. and M.S. degree from Tulane University and is also a lecturer at the Engineering School of George Washington University.

B. P. BELLPORT

B. P. Bellport was named Chief Engineer of the Bureau of Reclamation in February 1963.

Bellport's career with the Bureau spans 27 years. He was Associate Chief Engineer in the Bureau's engineering headquarters at Denver for 3½ years prior to being named Chief Engineer. He was regional director at Sacramento, Calif., from September 1957 until 1959.

He was construction engineer on the 304-foot-high Solano project in California and served in various supervisory engineering capacities on the Central Valley project. His work included the Contra Costa Canal, Delta-Mendota Canal, Delta Cross Channel, and the Tracy pumping plant.

A graduate of Polytechnic College of Engineering in California, Bellport is a registered professional engineer of the State of Colorado. He is a member of the American Society of Civil Engineers, the International Commission on Irrigation and Drainage, and the U.S. Committee on Large Dams.

F. STEWART BROWN

Mr. F. Stewart Brown, Chief, Bureau of Power, Federal Power Commission, was appointed as the Commission's representative to the Army-Interior Advisory Board on Passamaquoddy and Upper St. John River.

Mr. Brown has devoted a large part of his career to the planning and development of multiple-purpose water resource projects. Prior to his coming to the Commission in 1962, he served with the Corps of Engineers for 29 years in several widely distributed areas and for 2 additional years with the Panama Canal on special studies for a sea level canal. Mr. Brown has had previous association with the development of Passamaquoddy tidal power, working in 1935–36 on plans for the single-pool development then under study. During his last 10 years with the Corps of Engineers, he was Chief of the Engineering Division of the North Pacific Division and had general supervision of the planning, engineering and in part, the construction programs of the corps in the four Northwestern States and Alaska. During this period, major projects were planned or constructed on the Columbia River and its tributaries which will have an ultimate hydroelectric capacity of 10 million kilowatts. During the treaty negotiations for the international development of the Columbia River, Mr. Brown served on the technical staff assisting the negotiators for the United States.

He is a civil engineering graduate of the University of Illinois, a registered engineer in the State of Oregon, member of the National Society of Professional Engineers, a fellow member of the American Society of Civil Engineers, and past president of the Oregon section, member of the Society of American Military Engineers, and, currently, Chairman of the U.S. Committee on Large Dams.

DAVIS A. PORTNER

Deputy Assistant Administrator for Industrial Analysis, Business and Defense Services Administration, Department of Commerce (1 year).

Assistant Director for Area Economic Analysis and Development, U.S. Employment Service, Bureau of Employment Security, Department of Labor (2 years).

Seattle regional economist (and Labor Department representative on Columbia River Basin Interagency Committees), Bureau of Employment Security, Department of Labor (9 years).

Industry—labor economist for Detroit metropolitan area, Michigan Employment Security Commission (7 years).

B.A., M.A. (social sciences), University of Arizona, 1938.

JOHN W. ROCHE

Engineer, Policy, and Legislative Branch, Office, Chief of Engineers. For the past 15 years has been associated with the work of the International Joint Commission, serving as a member or associate of international engineering boards concerned with water and land resource developments along the Canadian-United States border. Received B.S. in engineering from the University of Maine in 1932. In 1933, as a staff member of the Maine State Planning Board, aided in the preparation of a preliminary report on Passamaquoddy for the President. In 1935–37 worked at Eastport, Maine, on the Quoddy project and with the exception of military service in World War II has been with the Corps of Engineers.

BIOGRAPHY OF DR. LORENZ G. STRAUB

Dr. Lorenz G(eorge) Straub, a hydroelectrical engineer, was born in Kansas City, Mo., on June 7, 1901. He died October 27, 1963, in Minneapolis, Minn.

Professionally he was known as the river doctor because of his lifelong identification with the problems of rivers which he pursued as director of the St. Anthony Falls Laboratory, Minnesota. This agency, the "clinic for sick rivers," is the center for studying and dealing with rivers in trouble, anywhere in the world.

Dr. Straub was educated at the University of Illinois; receiving the B.S. in 1923, the M.S. in 1924, and the Ph. D. in 1927. He also studied at Karlsruhe and Charlottenburg.

He began his professional career as a fellow at Illinois. After receiving the doctorate, he traveled in Europe for 2 years investigating and reporting on river improvements and hydraulic practices as the first Freeman traveling scholar of the American Society of Civil Engineers. He was to receive the Normal Medal from that organization in 1961.

Following the return from Europe, he joined the faculty of the University of Minnesota in 1930 as associate professor of mathemactics and mechanics. He became a full professor in 1935 and head of the department of civil engineering in 1945.

Because of his outstanding ability with the problems of rivers, he was consulted by various foreign governments, traveling abroad to India, Pakistan, Iraq, Iran, El Salvador, Colombia, the former Belgian Congo, and Canada to assist these Governments with their "sick river" problems. Also, he was a member of the International Board of Consultants for the Aswan High Dam on the Nile River in Egypt.

Nationally, he consulted with various departments of the Federal Government on programs which included the Missouri River, the St. Lawrence Seaway, the Santa Anna River, and the Passamaquoddy power project. In 1952 he originated and supervised the unprecedented "friction control" closure of the Missouri River at the Fort Randall Dam.

He was a member of several engineering and scientific fraternities and he held various posts with professional societies. These included: President (1954–1956) of the International Association of Hydroelectric Research; chairman of the editorial advisory committee of the civil engineering textbook series and president of the Hydrology Section, the American Geophysical Union, of which he was also a fellow.

Honors included the diploma as Officier d'Académie and the medal of the Ordre des Palmes Académiques from the French Government.

Additional professional affiliations included the Society of American Military Engineering and the American Concrete Institute.

The following are some of the projects which bear the mark of his outstanding ability:

1. The stabilization of the natural dam across the Madison River created by the 1959 Yellowstone Park earthquake.
2. The design of one of the world's largest dams to be constructed on the Caroni River in Venezeula.
3. Development of the river control project in the jungles of east Pakistan.
4. Design of spillways for dams on the Indus River control system on the India-Pakistan border.

His specific research interests were broad and included investigations in fluid mechanics, potamology, sediment problems on rivers, experimental hydraulics, drainage, and concrete structures.

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BIOGRAPHY OF DR. ARTHUR CASAGRANDE

Dr. Arthur Casagrande is the Gordon McKay professor of soil mechanics and foundation engineering at Harvard University, Cambridge, Mass.

He was born in 1902 at Haidenschaft, Italy, formerly Austria, and naturalized a U.S. citizen in 1931.

Early collegiate education was secured in Austria, and he obtained a degree in civil engineering from the Technical University of Vienna in 1924, and the doctorate in 1933. In addition, he holds an honorary S.M. from Harvard, and an honorary doctorate from the National University of Mexico, 1952.

Dr. Casagrande's professional career spans many years. He began as a draftsman at the Department of Public Works, Leeuwarden, Holland. From there he was a junior engineer in tunnel construction, Austrian Alps, and assistant in hydraulics and sanitary engineering at the Technische Hochschule, Vienna. He also had the distinction of serving as private assistant to Professor Terzaghi, and as a research assistant at the U.S. Bureau of Public Roads.

He began his career at Harvard as a lecturer in soil mechanics in the Graduate School of Engineering. He became assistant professor in chemical engineering at Harvard in 1934; associate professor in 1940, and in 1946, the Gordon McKay professor of soil mechanics and foundation engineering.

Dr. Casagrande has served as a consultant to numerous municipal, State, and Federal agencies on foundation and earth dams in the United States, Latin America, and Canada. Special projects included: Consultation on the Panama Canal and work with the U.S. Corps of Engineers.

The following is a brief list of his professional societies and activties: The Boston Society of Civil Engineers, of which he was president in 1957; the American Society of Electrical Engineers; the American Society of Civil Engineers; the American Academy of Arts & Sciences; International Society of Soil Mechanics & Foundation Engineering; U.S. Committee on Large Dams; Harvard Engineering Society; the Highway Research Board; the Geophysical Union; and the Society of the Sigma Xi.

Dr. Casagrande's interests are broad within his field and are concerned with theoretical and experimental investigations in soil mechanics, hydromechanics of seepage and groundwater movement, frost action on soil, the stability of dams, and problems in foundation engineering.

His outstanding ability has been recognized by the award of the Fitzgerald Medal and the Clemens Herschel Prize by the Boston Society of Civil Engineers. He is the recipient of the U.S. War Department's Certificate of Appreciation for his service during World War II. The American Society of Civil Engineers has also awarded him the Wellington Prize.

USE AND DEVELOPMENT OF WATER RESOURCES

SENATE RESOLUTION 148, 85TH CONGRESS

SENATE DOCUMENT 97, 87TH CONGRESS

USE AND DEVELOPMENT OF WATER RESOURCES

On July 26, 1956, in the 84th Congress, the Senate expressed its sense relative to the conservation and development of water and related land resources in Senate Resolution 281, which stated:

> Land and water resources development should be planned on a comprehensive basis and with a view to such an ultimately integrated operation of component segments as will insure the realization of the optimum degree of physical and economic efficiency.

Pursuant to the direction provided in Senate Resolution 281 of the 84th Congress, studies and hearings on the matter were conducted jointly by the Committees on Interior and Insular Affairs and on Public Works over a period of a year. These led to a resolution proposing standards and criteria for the authorization of projects. On January 28, 1958, after full debate for 2 days, that resolution—Senate Resolution 148 of the 85th Congress—was agreed to by the Senate.

Senate Resolution 148 sets forth in considerable detail the Senate's concept of proper standards and criteria for evaluation of water and land resource projects proposed for authorization.

Four years later, on May 15, 1962, President John F. Kennedy approved for application by the agencies of the executive branch, including the Bureau of the Budget, policies, standards, and procedures for the formulation, evaluation, and review of plans for water and related land resource projects. Those standards had been developed the President's direction by the Secretaries of the Departments of the Army; Agriculture; Health, Education, and Welfare; and Interior with the latter serving as chairman.

Provisions of Senate Resolution 148 and the statement of "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources," are set forth below. (The statement has previously been published as S. Doc. 97, 87th Cong.)

SENATE RESOLUTION 148, 85TH CONGRESS

Whereas the sense of the Senate, stated in S. Res. 281, Eighty-fourth Congress, is that the Congress will continue to exercise its constitutional powers to encourage the comprehensive conservation, development, and utilization of the land and water resources of the Nation, and that reports to the Congress in support of authorization of such projects should (a) include evaluations made in accordance with criteria prescribed by the Congress, and (b) fully disclose the results of studies and analyses of the potential utilizations, costs, allocations, payout, and benefits, both direct and indirect; and

Whereas pursuant to said S. Res. 281, the Committee on Interior and Insular Affairs and the Committee on Public

Works jointly have reported to the Senate that, in order to evaluate projects proposed for authorization, certain information is needed in addition to that regularly submitted by the executive branch in support of proposed projects, such information being related to selection of plans of development, costs, benefits, reimbursements, or contributions required of local interests; and

Whereas such information is needed also for consideration by the Senate in connection with legislation to establish policies and criteria regarding allocations of project costs, and for evaluations of project benefits, which policies and criteria the Comptroller General of the United States, the Bureau of the Budget, and the Secretary of the Army have recommended should be established by the Congress: and

Whereas the program for conservation, development, and utilization of the land and water resources of the Nation is impaired by delay in the delivery to the Congress of reports on projects proposed for authorization and for clearance pursuant to the provisions of the Watershed Protection and Flood Prevention Act (68 Stat. 666, as amended): Now, therefore, be it

Resolved, That it is the sense of the Senate that procedures for evaluation of land and water resource projects should be improved, and that the agencies of the executive branch of the Government responsible for the preparation of reports relative to the authorization of land and water resource projects be, and are hereby, requested to furnish, in connection with such reports, the following information in addition to the data now presented in support of project authorizations:

Information relative to alternative plans for the water resource projects that may reasonably be considered physically feasible of construction consistently with the advice of the Department of the Army, or the Department of the Interior, or the Department of Agriculture, including enough of the information enumerated in subparagraphs (1) to (10) inclusive to show why each alternative was dropped in favor of the recommended plan. With respect to the project recommended for authorization, the information should include, but not be limited to—

(1) Complete description of project, including an estimate of the economic life of the major project facility.

(2) Estimated costs of construction, operation, maintenance, and replacement, together with a plain and succinct statement of the basis upon which all such estimates are made.

(3) Benefit-cost ratios calculated by using total tangible benefits and total tangible costs for 100 years, and for 50 years, except where the economic life of the major project facility is less.

(4) Description and, to the extent possible, computation or other evaluation of indirect and intangible net benefits including but not limited to (a) protection of life and property; (b) improvement of transportation; (c) conservation

of water, soil, and forest resources; (d) wildlife conservation; (e) recreation; (f) abatement of pollution, including salinity; (g) control of sedimentation; (h) maintenance and enhancement of the agricultural, commercial, and industrial economy of the area affected.

(5) Physical feasibility and costs of providing capacity in the project works for current needs and future uses that may reasonably be anticipated to develop during the useful life of such project works.

(6) Allocations of costs, to be calculated (a) by at least three methods, namely, the separable costs-remaining benefits method, the priority of use method, and the incremental cost method; and (b) on at least two time periods for amortization, namely, fifty years or the useful life of the facilities, whichever is the lesser, and one hundred years or the useful life of the facilities, whichever is the lesser.

(7) Description of the extent to which the Federal, State, and local governmental agencies, and nongovernmental entities have evidenced interest in participating in the construction or operation and maintenance of the potential project, or in obtaining its benefits, including, in the case of electric energy, information relative to the preference status of governmental agencies, municipalities, and cooperatives; and the manner in which it is proposed to accomplish coordination and cooperation, and the estimated Federal costs of such participation.

(8) Estimated schedules of repayments of reimbursable costs that would be within the estimated financial resources of the potential use area, such schedules to show also the deferred repayment of the portion of the costs allocated to uses that may be anticipated to develop in the future.

(9) Probable effects of the potential project on State and local governments, including, but not limited to (a) the costs of local government services; and (b) the enhancement or reduction of tax revenues, together with the amount of potential tax revenue that would be foregone by Federal development in lieu of non-Federal development of the project. The estimated amounts of tax revenue enhancement and tax revenue foregone as a result of the project should be shown in calculations of project benefits and costs.

(10) In support of proposed increases in the authorizations of appropriations for continuation of the construction of basinwide projects, proposed schedules of investigations and construction should be supplied, including descriptions of the units to be undertaken, and deviations in schedules of construction supplied in support of prior authorizations.

SEC. 2. That reports on surveys and investigations or project reports relative to the authorization of land and water resource projects should be delivered to the Congress not later than 6 calendar months after the date on which such reports are circulated to the Federal agencies and to the affected States pursuant to section 1 of the Act of December 22, 1944 (58 Stat. 887). The agencies of the executive branch responsible for preparation of such project reports be, and

are hereby, requested to deliver to the Congress such reports not later than 6 months after they have been submitted for comments to the Governors of the affected States.

SEC. 3. That reports on projects recommended for construction by the Secretary of Agriculture pursuant to the Watershed Protection and Flood Prevention Act (68 Stat. 666), as amended, should be transmitted to the Congress not later than three calendar months after their approval by said Secretary of Agriculture, and the officials of the executive branch responsible for such transmittal pursuant to said Act be, and are hereby, requested to so deliver such reports not later than three months after their approval by said Secretary of Agriculture.

SEC. 4. That authorizations of multiple-purpose water resource projects should (1) specify the method by which the allocation of costs shall be determined, the period of time allowable for repayment of the power investment, and the formula for determining the rate of interest on it that is to be returned; and (2) require that prior to the time that any major facility of such multiple-purpose project is placed in operation the construction agency shall report the allocation of costs in accordance with the criteria of section 1 of this resolution together with its recommendations and the comments of the power marketing agency if that be other than the construction agency.

SEC. 5. That the Committee on Interior and Insular Affairs and the Committee on Public Works be, and they hereby are, directed to continue the study instituted pursuant to Senate Resolution 281, 84th Congress, and to recommend to the Senate as early as practicable in the second session of the 85th Congress such further measures as may be appropriate to provide for full and effective conservation, development, and utilization of the Nation's land and water resources.

SENATE DOCUMENT 97, 87TH CONGRESS

POLICIES, STANDARDS, AND PROCEDURES IN THE FORMULATION, EVALUATION, AND REVIEW OF PLANS FOR USE AND DEVELOPMENT OF WATER AND RELATED LAND RESOURCES

I. PURPOSE AND SCOPE

The purpose of this statement is to establish Executive policies, standards, and procedures for uniform application in the formulation, evaluation, and review of comprehensive river basin plans and individual project plans for use and development of water and related land resources. Problems of cost allocation and of reimbursement or cost sharing between the Federal Government and non-Federal bodies will be covered subsequently.

These provisions shall govern, insofar as they are consistent with law and other applicable regulations, all formulation, evaluation, and review of water and related land

resources plans. Any proposed variation from these policies and standards shall be specified in planning reports and the reasons therefor indicated.

II. OBJECTIVES OF PLANNING

The basic objective in the formulation of plans is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs. In pursuit of this basic conservation objective, full consideration shall be given to each of the following objectives and reasoned choices made between them when they conflict:

A. Development

National economic development, and development of each region within the country, is essential to the maintenance of national strength and the achievement of satisfactory levels of living. Water and related land resources development and management are essential to economic development and growth, through concurrent provision for—

Adequate supplies of surface and ground waters of suitable quality for domestic, municipal, agricultural, and industrial uses—including grazing, forestry, and mineral development uses.

Water quality facilities and controls to assure water of suitable quality for all purposes.

Water navigation facilities which provide a needed transportation service with advantage to the Nation's transportation system.

Hydroelectric power where its provision can contribute advantageously to a needed increase in power supply.

Flood control or prevention measures to protect people, property, and productive lands from flood losses where such measures are justified and are the best means of avoiding flood damage.

Land stabilization measures where feasible to protect land and beaches for beneficial purposes.

Drainage measures, including salinity control where best use of land would be justifiably obtained.

Watershed protection and management measures where they will conserve and enhance resource use opportunities.

Outdoor recreational and fish and wildlife opportunities where these can be provided or enhanced by development works.

Any other means by which development of water and related land resources can contribute to economic growth and development.

B. Preservation

Proper stewardship in the long-term interest of the Nation's natural bounty requires in particular instances that—

There be protection and rehabilitation of resources to insure availability for their best use when needed.

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Open space, green space, and wild areas of rivers, lakes, beaches, mountains, and related land areas be maintained and used for recreational purposes; and

Areas of unique natural beauty, historical and scientific interest be preserved and managed primarily for the inspiration, enjoyment and education of the people.

C. Well-being of people

Well-being of all of the people shall be the overriding determinant in considering the best use of water and related land resources. Hardship and basic needs of particular groups within the general public shall be of concern, but care shall be taken to avoid resource use and development for the benefit of a few or the disadvantage of many. In particular, policy requirements and guides established by the Congress and aimed at assuring that the use of natural resources, including water resources, safeguard the interests of all of our people shall be observed.

III. PLANNING POLICIES AND PROCEDURES

A. National, regional, State, and local viewpoints

1. All viewpoints—national, regional, State, and local—shall be fully considered and taken into account in planning resource use and development. Regional, State, and local objectives shall be considered and evaluated within a framework of national public objectives and available projections of future national conditions and needs. Similarly, available projections of future conditions and needs of regions, States, and localities shall be considered in plan formulation.

2. Significant departures from a national viewpoint required to accomplish regional, State, or local objectives shall be set forth in planning reports by those charged with their preparation. Such reports shall also describe the present economy of the locality, State, and region, changes which can be expected on the basis of current trends, specific economic problems of the area, and the manner in which the project is expected to contribute to the sound economic growth and well-being of the locality, State, and region.

3. Comprehensive plan and project formulation shall be based upon an analysis of the relationship of goods and services to be provided by a proposed resource use or development to available projections of National, regional, State, and local requirements and objectives. From a national point of view, the analysis shall include, within practical limits, a comparison of the proposed resource use and development with alternative means available for providing similar goods and services to the area and other areas and an indication of its relationship, if any, to specific considerations of national security.

B. Multiple-purpose planning

Planning for the use and development of water and related land resources shall be on a fully comprehensive basis so as to consider—

(1) The needs and possibilities for all significant resource uses and purposes of development, including, but not limited to domestic, municipal, agricultural, and industrial uses of water; water quality control; navigation in relation to the Nation's transportation system; hydroelectric power; flood protection control or prevention; land and beach stabilization; drainage, including salinity control; watershed protection and management; forest and mineral production; grazing and cropland improvement; outdoor recreation, as well as sport and commercial fish and wildlife protection and enhancement; preservation of unique areas of natural beauty, historical and scientific interest; and

(2) All relevant means (including nonstructural as well as structural measures) singly, in combination, or in alternative combinations reflecting different basic choice patterns for providing such uses and purposes.

C. River basin planning

River basins are usually the most appropriate geographical units for planning the use and development of water and related land resources in a way that will realize fully the advantage of multiple use, reconcile competitive uses through choice of the best combination of uses, coordinate mutual responsibilites of different agencies and levels of government and other interests concerned with resource use. Planning use of water and related land resources, therefore, shall be undertaken by river basins, groups of closely related river basins, or other regions, and shall take full cognizance of the relationships of all resources, including the interrelationship between surface and ground water resources. Despite this primary confinement to an area, the fact should be recognized that such planning also requires consideration of pertinent physical, economic, and social factors beyond the area.

D. Individual project planning

To the extent feasible, programs and projects shall be formulated as part of a comprehensive plan for a river basin or other area, and the report proposing development shall indicate the relationship to the comprehensive plan. When a program or project has been formulated independently and not as part of a comprehensive plan, the report shall indicate, to the extent practicable, the relationship of the program or project to the probable later developments needed or to be undertaken in the basin and the reasons for proposing to proceed with the proposed program or project independently.

E. Coordination within the Federal Government and with non-Federal interests

1. Federal planning shall be carried out on a coordinated basis from the earliest steps of investigation, survey, and planning through the entire planning and review process. When any Federal agency initiates an investigation or survey, it shall arrange for appropriate coordination and consideration of problems of mutual concern with other Federal agencies and with interested regional, State, and local public agencies and interests. When warranted, joint consideration of such problems shall be arranged. Full advantage is to be taken of all existing organizations and arrangements for coordination, such as river basin commissions, interagency committees, interstate bodies, and State and local agencies.

2. When plans for resource use or development affect the interests and responsibilities of other Federal agencies, the sponsoring agency shall, to the maximum extent practicable, consult with such agency or agencies in the field and at headquarters in conducting its investigation and preparing its report. When specific project proposals are contemplated, each affected agency shall be afforded an opportunity to participate in the investigations and surveys in an effort to develop fully coordinated proposals. Project reports shall include a statement of the extent of coordination achieved.

3. Before a report is submitted to the President and the Congress, each department or independent agency interested in the project and the concerned States shall be provided with copies of the proposed report, and given an opportunity to furnish a statement concerning the project proposal from the viewpoint of its interest and responsibility. Such statements shall be included in the reports submitted by a sponsoring agency. If such statements propose variations from the policies and standards specified herein, the reasons for each variation shall be stated. A sponsoring agency may submit a report without the views of any agency or State when a statement from that agency or State has not been received within 90 days after receipt of the project report or within such other period specified by law.

4. Planning by Federal agencies shall also be carried out in close cooperation with appropriate regional, State, or local planning and development and conservation agencies, to the end that regional, State, and local objectives may be accomplished to the greatest extent consistent with national objectives. When a proposed resource use or development affects the interest and responsibility of non-Federal public bodies, those bodies shall be furnished information necessary to permit them to evaluate the physical, economic, and social effects. Their views shall be sought, considered in preparation of reports and included in the final reports submitted to the President and the Congress or other approving authority.

F. Relation to existing law and Executive orders

The policies, standards, and procedures set forth herein shall not be regarded as authorizing any deviation from general or specific requirements of law or Executive order. Whenever a plan or proposal varies from such policies, standards, or procedures because of a requirement of existing law or Executive order, the variation shall be indicated, and reference made to the section of law or Executive order imposing such requirements.

IV. REVIEW OF COMPREHENSIVE PLANS AND PROJECT PROPOSALS

With a view to arriving at general and specific independent judgments upon comprehensive plans, programs, and project proposals, and parts thereof, as well as recommendations concerning such plans and proposals, review at all appropriate levels shall be based upon a thorough appraisal of planning reports and upon the following criteria:

(*a*) Compliance with the statement of purpose and scope, objectives of planning, and planning policies and procedures set forth herein.

(*b*) Compliance with law, legislative intent, and Executive policies and orders.

(*c*) Compliance with recognized technical standards.

(*d*) Compliance with standards for the formulation of plans and evaluation of tangible and intangible effects as set forth herein.

V. STANDARDS FOR FORMULATION AND EVALUATION OF PLANS

A. General setting, viewpoint, and procedures

1. Formulation of comprehensive and project plans, and evaluation of tangible and intangible effects shall reflect full consideration of, and adherence to the purpose and scope, objectives of planning, planning policies and procedures and criteria for review, as set forth herein.

2. Formulation and evaluation shall normally be based on the expectation of an expanding national economy in which increasing amounts of goods and services are likely to be required to meet the needs of a growing population, higher levels of living, international commitments, and continuing economic growth. Such an environment will necessitate relatively high and efficient levels of resource employment and a pattern of production in balance with the anticipated demand for goods and services.

3. Formulation and evaluation of plans or alternative plans shall be accomplished in such a way as to permit timely application of standards appropriate to conditions of: (*a*) Less than "full employment" nationally, and (*b*) chronic and persistent unemployment or underemployment in designated areas. Standards appropriate to (*a*) shall be those adopted at the time of existence of such condition and authorized by

the President. Standards appropriate to condition (*b*) shall be used where an area has been so designated under the Area Redevelopment Act of 1961 (75 Stat. 47) or other authorized procedures relating to resource underemployment. In condition (*b*) project benefits shall be considered as increased by the value of the labor and other resources required for project construction, and expected to be used in project operation, project maintenance, and added area employment during the life of the project, to the extent that such labor and other resources would—in the absence of the project—be unutilized or underutilized. Such benefits should be clearly identified as redevelopment benefits for the purposes of cost allocation, cost-sharing procedures, and to indicate their significance for project justification.

4. A comprehensive public viewpoint shall be applied in the evaluation of project effects. Such a viewpoint includes consideration of all effects, beneficial and adverse, short range and long range, tangible and intangible, that may be expected to accrue to all persons and groups within the zone of influence of the porposed resource use or development. The adequacy of the coverage depends on how completely all effects can be traced and evaluated in comparable terms.

5. Full consideration shall be given to the opportunity and need for outdoor recreational and fish and wildlife enhancement in comprehensive planning for water and related land use and development, and project formulation and evaluation. Project plans shall include provision for public acquisition of lands and rights-of-way adjacent to proposed Federal or Federal-assisted water resource projects (additional to those needed for other uses and for public access) for administration by Federal, State, or local public bodies, as appropriate, to insure full ultimate realization of the outdoor recreational, fish and wildlife, and related resource enhancement opportunities of the project area. Plans shall indicate, in appropriate detail, all facilities needed for full development of the recreation and fish and wildlife potential, as well as specific indication of basic facilities required initially for access, health, safety, fire prevention, and use of the area.

6. Full consideration shall also be given in survey, investigation, and planning to the need for acquisition of lands necessary for all purposes of water resource development in advance of construction, so as to preserve these areas from encroachment by residential, commercial, industrial, and other development. Proposals to this end shall be set forth in special reports, or included in regular planning reports, when deemed necessary. Measures proposed should represent the minimum necessary action consistent with the objective of site preservation. Reliance should be placed, where feasible, on zoning and other measures by non-Federal authorities to keep lands on local tax rolls and control development until sites are needed for project purposes. Such measures should also include provisions for advance participation in construction or reconstruction of transportation

facilities, when necessary, to avoid increased costs for relocation.

7. When there are major differences among technically possible plans conceived as desirable on the basis of consideration of intangible benefits and costs, in comparison with optimum plans based on tangible benefits and costs, alternative combinations of projects within a river basin or alternative projects, giving expression to these major differences, shall be planned. Comparison of their economic and financial costs shall be set forth in reports to provide a basis for selection among the alternatives by reviewing authorities in the executive branch and by the Congress. Minor differences, with regard to intangible considerations, shall be handled, to the extent practicable and economically feasible, by adjustments in plans. Planning reports shall clearly indicate alternatives, their consequences, and adjustments made to take account of these minor differences.

8. When secondary benefits are included in formulation and evaluation of a project proposal, planning reports shall indicate—

(*a*) The amount of secondary benefits considered attributable to the project from a national viewpoint. Such benefits, combined with primary benefits, shall be included in the computation of a benefit-cost ratio.

(*b*) Secondary benefits attributable to the project from a regional, State, or local viewpoint. Such benefits shall also be evaluated, when this procedure is considered pertinent, and an additional benefit-cost ratio computed.

(*c*) Presentations in planning reports shall include an explanation of the nature of each type of secondary benefit taken into account from either viewpoint and the methods used in the computation of each of their values. The implications, from the national viewpoint, of considering secondary benefits of the project from a regional, State, or local viewpoint shall be set forth.

B. Specific setting for area under consideration

1. Reports on proposed plans shall include an analysis of present and projected future economic conditions in the project area and the contribution that comprehensive or project development may be expected to make toward the alleviation of problems and the promotion of economic growth and well-being within the zone of influence. Economic projections will be made to provide a basis for appraisal of conditions to be expected with and without the plans under consideration, and an estimate of the contribution that comprehensive development may make to increased national income and welfare, and regional growth and stability. Such analyses will frequently require a general economic study of the area, a study of all of its resources, an assessment of their functional relationships, their development potentials, possible adverse effects, and the locational situation with reference to resources, markets, transportation,

climate, and social factors. Analyses should indicate the significance of the locality and the region in producing increased goods and services to meet foreseeable needs.

2. These analyses should be as extensive and intensive as is appropriate to the scope of the project being planned. They should provide essential information for identifying both immediate and long-range needs in economic and social terms and these needs should be expressed in a form useful for program formulation. Presentations in reports should identify—

(*a*) The relationship between economic development needs and opportunities and potential water and related land resource use and development;

(*b*) The economic and social consequencies of complete or partial failure to satisfy these needs; and

(*c*) The possible improvements in economic efficiency, alleviation of unemployment, stabilization of production and income, community well-being, and the quality of goods and services that will be forthcoming.

C. Standards for formulation of plans

1. All plans shall be formulated with due regard to all pertinent benefits and costs, both tangible and intangible. Benefits and costs shall be expressed in comparable quantitative economic terms to the fullest extent possible.

2. Comprehensive plans shall be formulated initially to include all units and purposes which satisfy these criteria in quantitative economic terms:

(a) Tangible benefits exceed project economic costs.

(b) Each separable unit or purpose provides benefits at least equal to its costs.

(c) The scope of development is such as to provide the maximum net benefits.

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

3. Net benefits are maximized when the scope of development is extended to the point where the benefits added by the last increment of scale (i.e., an increment of size of a unit, an individual purpose in a multiple-purpose plan or a unit in a comprehensive plan) are equal to the costs of adding that increment of scale. The increments to be considered in this way are the smallest increments on which there is a practical choice of omission from the plan.

4. Reports or plans shall indicate the scale of development that would result from application of the foregoing criteria considering tangible benefits and project economic costs expressed in comparable terms. This will provide a baseline from which the effect of considering intangibles can be judged.

5. Reports and plans shall also indicate the extent to which departures from that scale of development are proposed in order to take into account intangibles or other considerations warranting a modification in scale not reflected in the tangible benefits and project economic costs. For example, a higher degree of flood protection, particularly in urban areas, than is feasible on the basis of tangible benefits alone may be justified in consideration of the threat to lives, health, and general security posed by larger floods. Also, when long-range water needs are foreseeable only in general terms and where alternative means of meeting the needs are not available and inclusion of additional capacity initially can be accomplished at a significant savings over subsequent enlargement, such considerations may justify the additional cost required. Similarly, long-range power needs, in the light of generally expected economic growth of an area, may justify measures initially to insure later availability of the full power potential.

D. Definitions of benefits

1. Benefits: Increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. Benefits include tangibles and intangibles and may be classed as primary or secondary.

2. Tangible benefits: Those benefits that can be expressed in monetary terms based on or derived from actual or simulated market prices for the products or services, or, in the absence of such measures of benefits, the cost of the alternative means that would most likely be utilized to provide equivalent products or services. This latter standard affords a measure of the minimum value of such benefits or services to the users. When costs of alternatives are used, as a measure of benefits, the costs should include the interest, taxes, insurance, and other cost elements that would actually be incurred by such alternative means rather than including only costs on a comparable basis to project costs as is required when applying the project formulation criteria under paragraph V–C–2(*d*).

3. Intangible benefits: Those benefits which, although recognized as having real value in satisfying human needs or desires, are not fully measurable in monetary terms, or are incapable of such expression in formal analysis. Each type of benefit usually has a part which is readily measurable and may have a part which is not measurable or not readily measurable. The significance of this latter part shall be based upon informed judgment.

4. Primary benefits: The value of goods or services directly resulting from the project, less associated costs incurred in realization of the benefits and any induced costs not included in project costs.

5. Secondary benefits: The increase in the value of goods and services which indirectly result from the project under conditions expected with the project as compared to those

without the project. Such increase shall be net of any economic nonproject costs that need be incurred to realize these secondary benefits.

E. Types of primary benefits and standards for their measurement

1. Domestic, municipal, and industrial water supply benefits: Improvements in quantity, dependability, quality, and physical convenience of water use. The amount water users should be willing to pay for such improvements in lieu of foregoing them affords an appropriate measure of this value. In practice, however, the measure of the benefit will approximated by the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project. Where such an alternative source is not available or would not be economically feasible, the benefits may be valued on such basis as the value of water to users or the average cost of raw water (for comparable units of dependable yield) from municipal or industrial water supply projects planned or recently constructed in the general region.

2. Irrigation benefits: The increase in the net income of agricultural production resulting from an increase in the moisture content of the soil through the application of water or reduction in damages from drought:

3. Water quality control benefits: The net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality. The net contribution may be evaluated in terms of avoidance of adverse effects which would accrue in the absence of water quality control, including such damages and restrictions as preclusion of economic activities, corrosion of fixed and floating plant, loss or downgrading of recreational opportunities, increased municipal and industrial water treatment costs, loss of industrial and agricultural production, impairment of health and welfare, damage to fish and wildlife, siltation, salinity intrusion, and degradation of the esthetics of enjoyment of unpolluted surface waters, or, conversely, in terms of the advantageous effects of water quality control with respect to such items. Effects such as these may be composited roughly into tangible and intangible categories, and used to evaluate water quality control activities. In situations where no adequate means can be devised to evaluate directly the economic effects of water quality improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value.

4. Navigation benefits: The value of the services provided after allowance for the cost of the associated resources required to make the service available. For commodities that would move in the absence of the project, the benefit is measured by the saving as a result of the project in the cost of providing the transportation service. For com-

modities that will move over the improved waterway but would not move by alternative means, the measure of the benefit is the value of the service to shippers; that is, the maximum cost they should be willing to incur for moving the various units of traffic involved. Navigation improvements may also provide benefits in other forms, such as reduction in losses due to hazardous or inadequate operating conditions and enhancement in land values from the placement of dredged spoil.

5. Electric power benefits: The value of power to the users is measured by the amount that they should be willing to pay for such power. The usual practice is to measure the benefit in terms of the cost of achieving the same result by the most likely alternative means that would exist in the absence of the project. In the absence of economically feasible alternative means, the value of the power to users may be measured by any savings in production costs, increase in value of product that would result from its use, or its net value to consumers.

6. Flood control and prevention benefits: Reduction in all forms of damage from inundation (including sedimentation) of property, disruption of business and other activity, hazards to health and security, and loss of life; and increase in the net return from higher use of property made possible as a result of lowering the flood hazard.

7. Land stabilization benefits: Benefits accruing to landowners and operators and the public resulting from the reduction in the loss of net income, or loss in value of land and improvements, through the prevention of loss or damage by all forms of soil erosion including sheet erosion, gullying, flood plain scouring, streambank cutting, and shore or beach erosion, or, conversely in terms of advantageous effects of land stabilization.

8. Drainage benefits: The increase in the net income from agricultural lands or increase in land values resulting from higher yields or lower production costs through reduction in the moisture content of the soil (exclusive of excessive moisture due to flooding), and the increase in the value of urban and industrial lands due to improvement in drainage conditions.

9. Recreation benefits: The value as a result of the project of net increases in the quantity and quality of boating, swimming, camping, picnicking, winter sports, hiking, horseback riding, sightseeing, and similar outdoor activities. (Fishing, hunting, and appreciation and preservation of fish and wildlife are included under par. V–E–10.) In the general absence of market prices, values for specific recreational activities may be derived or estimated on the basis of a simulated market giving weight to all pertinent considerations, including charges that recreationists should be willing to pay and to any actual charges being paid by users for comparable opportunities at other installations or on the basis of justifiable alternative costs. enefits also include the intangible values of preserving areas of unique natural beauty and scenic, historical, and scientific interest.

10. Fish and wildlife benefits: The value as a result of the project of net increases in recreational, resource preservation, and commercial aspects of fish and wildlife. In the absence of market prices, the value of sport fishing, hunting, and other specific recreational forms of fish and wildlife may be derived or established in the same manner as prescribed in paragraph V–E–9. Resource preservation includes the intangible value of improvement of habitat and environment for wildlife and the preservation of rare species. Benefits also result from the increase in market value of commercial fish and wildlife less the associated costs.

11. Other benefits: Justification of the recognition of any other benefits and of the standard used in their measurement shall be set forth in reports. Unless included under one or more of the above categories, reports should show the net economic effects of changes in transportation capability, or changes in productivity of forest, range, mineral, or other resources. A project's contribution toward meeting specific needs for servicing international treaties or for national defense may also be included.

F. Definition of costs

1. Project economic costs: The value of all goods and services (land, labor, and materials) used in constructing, operating, and maintaining a project or program, interest during construction, and all other identifiable expenses, losses, liabilities, and induced adverse effects connected therewith, whether in goods or services, whether tangible or intangible and whether or not compensation is involved. Project economic costs are the sum of installation costs; operation, maintenance, and replacement costs; and induced costs as defined below.

2. Installation costs: The value of goods and services necessary for the establishment of the project, including initial project construction; land, easements, rights-of-way, and water rights; capital outlays to relocate facilities or prevent damages; and all other expenditures for investigations and surveys, and designing, planning, and constructing a project after its authorization.

3. Operation, maintenance, and replacement costs: The value of goods and services needed to operate a constructed project and make repairs and replacements necessary to maintain the project in sound operating condition during its economic life.

4. Induced costs: All uncompensated adverse effects caused by the construction and operation of a program or project, whether tangible or intangible. These include estimated net increases, if any, in the cost of Government services directly resulting from the project and net adverse effects on the economy such as increased transportation costs. Induced costs may be accounted for either by addition to project economic costs or deduction from primary benefits.

5. Associated costs: The value of goods and services over and above those included in project costs needed to make the

immediate products or services of the project available for use or sale. Associated costs are deducted from the value of goods and services resulting from a project to obtain primary benefits.

6. Taxes: Allowances in lieu of taxes or taxes foregone will not be included in project economic costs, except as required by law.

G. Time considerations

1. *Period of analysis.*—The economic evaluation of a project shall encompass the period of time over which the project will serve a useful purpose. Thus, the period of analysis should be the shorter of either the physical life or the economic life of the structure, facility, or improvement. However, because of the difficulty in defining the more remote future conditions and the discount of long-deferred values, 100 years will normally be considered the upper limit of the period of analysis.

2. *Discount rate.*—The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs, or otherwise converting benefits and costs to a common time basis shall be based upon the average rate of interest payable by the Treasury on interest-bearing marketable securities of the United States outstanding at the end of the fiscal year preceding such computation which, upon original issue, had terms to maturity of 15 years or more. Where the average rate so calculated is not a multiple of one-eighth of 1 percent, the rate of interest shall be the multiple of one-eighth of 1 percent next lower than such average rate.

This procedure shall be subject to adjustment when and if this is found desirable as a result of continuing analysis of all factors pertinent to selection of a discount rate for these purposes.

3. *Price levels.*—The prices used for project evaluation should reflect the exchange values expected to prevail at the time costs are incurred and benefits accrued. Estimates of initial project costs should be based on price relationships prevailing at the time of the analysis. Estimates of benefits and deferred costs should be made on the basis of projected normal price relationships expected with a stabilized general price level and under relatively full employment conditions for the economy. Pending development of mutually acceptable long-term price projections of this type, normalized current price relationships may be used in estimating deferred project effects. When benefits are measured in terms of the cost of an alternative, the prices should be those expected to prevail at the time such costs would have been incurred. Whenever project production is expected to influence prices significantly, the use of a price about midway between those expected with and without the project may be justified to reflect the public values involved. Appropriate price adjustments should be made where there is a limited foreseeable need or demand for the products or services to be provided by the project.

VI. RELATION TO COST ALLOCATION, REIMBURSEMENT AND COST-SHARING POLICIES, STANDARDS, AND PROCEDURES

Cost allocation, reimbursement and cost-sharing policies, standards, and procedures, as indicated in the section on "Purpose and Scope," above, are not generally included herein. Nevertheless, certain such matters of special importance in relation to the foregoing are included, as follows:

(*a*) All project purposes shall be treated comparably in cost allocation and each is entitled to its fair share of the advantages resulting from the multiple-purpose project or program. Project purposes to which costs may be allocated on a par with all other purposes, without restrictions regarding reimbursement or cost-sharing policies, shall include (but not be limited to) the following:

Domestic, municipal, or industrial water supply.
Irrigation.
Water quality control.
Navigation.
Hydroelectric power.
Flood control and prevention.
Land and beach stabilization.
Drainage, including salinity control.
Outdoor recreation development.
Fish and wildlife development.

Other purposes, such as area redevelopment and the servicing of international treaties and national defense when specific, quantifiable benefits are provided for such purposes by a project or program.

(*b*) Allocated costs, determined in accordance with principles and procedures to be established subsequently, shall provide a basis for consideration of reimbursement and cost-sharing arrangements.

(*c*) The period of analysis and discount rate established herein for purposes of formulation and evaluation of comprehensive plans and project plans (sec. V–G–1 and 2) shall not be construed as establishing the payout period or rate of interest to be used in reimbursement and cost-sharing arrangements.

(*d*) Planning reports of each department shall include appropriate recommendations covering reimbursement and cost-sharing arrangements and provide a detailed explanation of the basis used in arriving at the recommendations in consideration of the laws and administrative provisions in effect at the time.

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