Fisheries and Environment Canada

Canadian Environmental and Resource Concerns Dickey-Lincoln School Hydroelectric Development

DFE TECHNICAL COMMITTEE
DICKEY-LINCOLN SCHOOL HYDROELECTRIC PROJECT
HALIFAX, NOVA SCOTIA
SEPTEMBER, 1978.

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1. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Department of Fisheries and Environment established a Technical Committee in June of 1975 to identify and quantify the environmental and resource issues, of concern to Canada, associated with the proposed Dickey-Lincoln School Hydroelectric development on the Saint John River located within the State of Maine. Previous investigations and treaty negotiations in the mid-1960s had centered around energy and land compensation issues. This report identifies the environmental and resource issues of concern to Canada and outlines, in conceptual terms, the various studies required to assess those issues.

1.1 Summary and Conclusions

The Dickey-Lincoln School Hydroelectric development is designed to provide peaking power to the New England Power Pool and intermediate power to the State of Maine. The project would increase energy production at downstream hydroelectric plants in New Brunswick; estimated to be in the order of 280 to 350 gWh/year ($2.8 - $3.5 million/year @ 10 mils/kWh) during joint Canada-United States studies in the mid-1960s. During the reservoir impoundment phase of the development, however, there would be energy losses in New Brunswick; estimated between 2.3 gWh and 433 gWh ($0.02 - $4.3 million @ 10 mils/kWh) depending on hydrologic conditions during the filling period. It was proposed at that time to share downstream energy benefits on a 50-50 basis. Because of the difference between the existing New Brunswick energy system configuration and the assumed configuration in the mid-1960s, changes to the design and operating concepts of the project itself and a change in strategy respecting impoundment of the reservoir, it may be necessary to re-evaluate the impacts of the project on downstream energy. The Technical Committee considered that energy issues were not included in its terms of reference.

The project would consist of two large earthfill dams on the main stem of the Saint John River, each incorporating powerhouses, and five large earthfill dykes. The main dam at Dickey, which would be approximately 3,110 meters (10,200 feet) long and 102 meters (335 feet) high, would incorporate four turbines of equal size for a total installed capacity of 760 MW. One unit would be reversible thus providing pumped storage capability, a new concept relative to the mid-1960s. The Dickey powerhouse is being designed to accommodate future expansion to 1140 MW with a 50-50 split between conventional and pump/turbine units. This is also a new concept relative to the mid-1960s. The Lincoln School powerhouse would incorporate two 30 MW units and one 10 MW unit for a total installed capacity of 70 MW relative to a total installed capacity of 34 MW envisaged in the mid-1960s.

The Dickey Dam, in concert with five large earthfill dykes, two of which (Falls Brook and Hafey Brook) would prevent backflow into Canada, would impound a reservoir which would cover an area of 35,000 hectares (86,000 acres) and contain 9.5×10^9 cubic meters (7.7×10^6 acre-feet) of water at its full supply level of 277 meters (910 feet). Total live storage would be 3.6×10^9 cubic meters (2.9×10^6 acre-feet). The reservoir would flood approximately 20 miles of free-flowing streams and 1,640 hectares (4,050 acres) in Quebec. A further 670 hectares (1,700 acres) in Quebec would be affected as a result of erosion and raised groundwater tables. The reservoir would further affect 5 roads and 6 bridges in the St. Roch River Valley in Quebec and some 120 km (75 miles) of forest access roads. The Corps of Engineers proposes to clearcut a band, between elevations 252 meters (828 feet) and 278 meters (913 feet), above mean sea level, around the reservoir amounting to an area of 22,055 hectares (54,500 acres).

The Lincoln School Dam would impound a reservoir which would cover an area of 906 hectares (2,240 acres) and contain 8.3×10^7 cubic meters (67,150 acre-feet) of water at its full supply level of 186.5 meters (612 feet). Total live storage would be 4.0×10^7 cubic meters (32,450 acre-feet). Under the full development concept at Dickey (1,140 MW), the Lincoln School Reservoir would have a full supply level of 189 meters (620 feet) and provide live storage amounting to 7.3×10^7 cubic meters (59,100 acre-feet).

The project would require eight years to complete. Impounding would begin during the fifth construction year and continue through the first year of full operation. Initial power-on-line would occur during the sixth construction year. The riparian flow policy during the construction period has not been detailed by the Corps of Engineers.

The proposed project will alter the hydrologic regime on a seasonal basis by decreasing flows during the spring freshet, up to 425 cubic meters per second (15,000 cfs) on the average, increasing flows during winter months, up to 200 cubic meters per second (7,000 cfs) on the average and increasing flows during the summer and fall months by up to 40 cubic meters per second (1,400 cfs). Under typical daily operating conditions, flows below the Lincoln School Dam will vary from 28 to 453 cubic meters per second (1,000 to 16,000 cfs), while flows at Edmundston would fluctuate some 283 cubic meters per second (10,000 cfs). This would result in within-the-day fluctuations in water levels in the order of 1.8 meters (6 feet), at the confluence of the Saint John and St. Francis Rivers, and 1.1 meters (3.5 feet) at Edmundston. The above relates to the initial development (760 MW) at Dickey. The hydrologic impacts associated with full development (1,140 MW) at Dickey could be more severe.

The above impacts relate to typical operation of the Dickey Plant. It is stated that the project would provide "spinning reserve" capacity to the New England Power Pool system by being readily available to cover electrical loads in the event of forced outages in the system. The Lincoln School Reservoir is only capable of re-regulating Dickey releases for a short period of time, less than a day. It may, therefore, be concluded that flow variations in the order of 1,130 cubic meters per second (40,000 cfs), or 1,700 cubic meters per second (60,000 cfs) under the full development concept, can be expected to occur below the Lincoln School Dam. It has also been publicly stated that the Dickey Powerhouse could be operated as a base-load plant, at full capacity, for up to 45 days by using all available live storage.

Under typical operating conditions, the Dickey Reservoir will fluctuate some 6.0 - 7.6 meters (20-25 feet) thus exposing over 70% of the flooded land in Quebec. At its minimum operating level of 264 meters (868 feet), all land flooded in Quebec will be exposed. Fluctuations in reservoir level during the summer period will generally be less than 0.6 meters (2 feet).

Canadian negotiations, during the mid-1960s, successfully upheld the position that flood control benefits in Canada, as a result of the project, would be insignificant. The Saint John River Basin Board, however, has indicated that the peak stage at Fredericton would have been reduced by 0.8 meters (2.6 feet), had the project been in operation during the 1973 flood. The impact of the project on the ice regime of the river is uncertain. Warmer than normal release waters, up to 4°C, will likely mean that a reach, of unspecified dimensions, below the Lincoln School Dam will remain open during the winter. This may result in the attendant problem of frazil ice formation which would lead to the formation of anchor ice and/or hanging dams, thus increasing flood potential. The degree to which fluctuations in flow, which are likely to be more severe during the winter months, will prevent the formation of a stable ice cover, is uncertain. It would appear, therefore, that the risk of ice jam flooding and resulting damages to hydraulic structures would be increased above the Grand Falls headpond.

The impact of the project on downstream water quality, and the ecosystem it supports, will be significant during the construction period. Despite the mitigating erosion control measures contemplated by the Corps of Engineers, downstream waters will be enriched or contaminated with organics, nutrients, and possibly heavy metals. Typically, downstream water will be higher in dissolved and suspended solids and certain major ions than normal. During the reservoir filling period, the Corps of Engineers predicts that release waters will be anoxic. The Corps of Engineers predicts that downstream water quality conditions will improve to near normal some 6-9 years after construction. The Technical Committee supports this conclusion. The overall ultimate impact on downstream water quality could generally be favourable. Release waters will generally be 3° - 6° C cooler than the existing regime during the summer months and up to 4° C warmer during the winter months. Water temperatures will adjust, within an undetermined distance downstream, toward equilibrium with atmospheric conditions. The natural assimilative capacity of the Saint John River should increase as streamflows will be higher than natural during low-flow periods. Reductions in flood peaks, however, may reduce benthic scouring in the Grand Falls Headpond, thus increasing benthic oxygen demand. The alteration in the seasonal flow regime may affect the Saint John River estuary, and the ecosystem it supports, in that the location of the salt water wedge may change.

Certain long-term water quality characteristics of the Dickey Reservoir are uncertain at this time. The Corps of Engineers predicts that dissolved oxygen concentrations in shallow coves could be less than 2 mg/l. The possibility that the reservoir could become a sink for heavy metals, such as mercury, and persistent pesticides, has been mentioned by the Corps of Engineers.

The economic impact on the forestry resource remains to be determined. The St. Pamphile region of Quebec relies heavily on the importation of sawlogs from Maine, in particular the reservoir area. In the long term, some 2,000 hectares (5,000 acres) of land in Quebec, with a potential yield of some 4,000 cords annually, will be removed from production as will some 34,000 hectares (84,000 acres)in Maine, with a potential yield of some 40,000 to 50,000 cords annually. Plans respecting the disposal of wood cut from the reservoir area are uncertain. Should the majority of wood be slated for pulpwood, prices in the Madawaska County of New Brunswick could be depressed making it difficult for small woodlot owners to compete. The St. Pamphile region of Quebec could be affected should the flow of sawlogs from Maine be diminished. The 120 km (75 miles) of forest access roads, cut off by the project, will likely be replaced by new roads needed to clear the reservoir.

In Quebec, 33 km (20 miles) of free-flowing streams will be flooded. The flooded area will be exposed to large fluctuations in water level which,when coupled with higher-than-normal water temperatures and low dissolved oxygen levels, will promote a marginal fishery sustained only by recruitment from unaffected waters. There will likely be a shift from salmonid species to yellow perch and white sucker species which are not highly prized by fishing enthusiasts. The introduction of an exotic species of fish, as proposed by the Corps of Engineers, must be carefully reviewed by Canadian authorities. The proposed dams, which have no provisions for fish passage incorporated in their designs, will act as total barriers to salmon migration thereby limiting Canadian options for the management of the resource in the future. The major impacts on the downstream fishery are expected to occur during the construction period. Increased siltation will have a detrimental effect on biological productivity, blanket food organisms, cause clogging of gills and impair spawning beds. Anoxic release waters during the reservoir filling period may be lethal to certain fish species. During the operational phase of the development, large within-the-day fluctuations in flow and water levels may impair and possibly destroy potential salmonid spawning and rearing areas, at least as far downstream as Edmundston, by altering the siltation and sedimentation process and by stranding fish in littoral areas. The water temperature regime, which will be cooler in summer and warmer in winter, could offset these impacts to some extent, as natural temperatures during the summer months are warmer than optimum for fish. The reduction of streamflow during May and June of each year will reduce spillage at downstream hydroelectric plants increasing smolt mortality rates as more will be forced through the turbines than at present.

Apart from flooding one 16-head deer yard in Quebec and the indirect effects of flooding 53 deer yards in Maine (deer in Maine use certain areas in Quebec for habitat during some parts of the year), there are no major impacts on wildlife in Canada.

The project will flood land in Quebec which is used in part for agricultural purposes, the amount and value of which remains to be assessed. There will likely be downstream flood control benefits to the agricultural sector. The impact of the pulsating flow regime, resulting from the project, on bank erosion and stability remains to be seen. in Que.

The Saint John River provides a source of water supply to several communities and a number of industrial users. The degree to which these users will be affected by sedimentation and reduced water quality conditions during the construction period remains to be seen.

The project will have some social and economic impacts on Canada. The project will provide employment opportunities to Canadians, should the United States decide not to place restrictions on the use of non-immigrant workers. An influx of workers to Madawaska County on the other hand, may overtax certain community services. Of course, there will be downstream power benefits to Canada. The feasibility of expanding existing hydroelectric plants and/or developing new sites on the main stem of the Saint John River will be enhanced by the project. A stronger transmission tie with the

New England Power Pool may create a stronger and more reliable grid system in New Brunswick.

A number of studies are required to properly assess the impact of the project on the Canadian environmental and resource issues summarized above. An analysis of the hydrologic/hydraulic regime should be carried out to identify more clearly the changes in downstream flow and water level regimes and to define the water level regime on the proposed Dickey Reservoir. The impacts on the assimilative capacity of the Saint John River, particularly in the Grand Falls Headpond, should be analyzed. The impact of reduced spillage at each of the hydroelectric plants, particularly Beechwood and Mactaquac, located on the main stem of the Saint John River, on salmon migration and mortality should be assessed.

In view of the present Canada-New Brunswick agreements respecting flood risk mapping and, in particular, flood forecasting, studies should be carried out to determine the impact of the project on flooding in New Brunswick. The impact of the project on ice-jamming, with particular reference to frazil ice, should be investigated. The location and extent of land in Quebec affected by erosion and raised groundwater tables, should be assessed. The impacts of the failure of one or both dams should also be assessed. The final designs for each dam should be thoroughly reviewed to ensure that the utmost attention has been paid to public safety.

The impacts of the project on the aquatic ecosystem of the Saint John River, with emphasis on the reach from the Grand Falls Dam to the confluence of the Saint John and

St. Francis Rivers, should be assessed. The initial phases of this assessment would include a review of existing baseline data, a review of the literature on the effects on man-made impoundments on the downstream aquatic ecosystem and an identification of existing water uses and related water quality criteria. The next phase would involve the establishment of baseline data on water quality, aquatic biology and sedimentation. The impacts of the project on the downstream aquatic ecosystem could then be assessed, mitigating measures evaluated, residual impacts identified, and a long-term monitoring program defined.

A number of studies are required to assess the impacts of the project on the resource base. The principle objective of the studies would not only be to quantify the economic impacts, but to identify alternative strategies to minimize the impact. The economic impact on the forestry resource would be systematically studied by obtaining up-to-date plans on forest cutting and disposal methods, reviewing existing market and employment conditions, in Quebec and New Brunswick, and assessing the impacts on the project on the Canadian economy.

A number of studies are required to assess the impacts on the fishery resource in Quebec and New Brunswick. These include studies to assess the existing levels of exploitation, the distribution, abundance, age-composition and growth/mortality rates of each major species.

Information on populations and migration patterns of deer in the reservoir and surrounding area in Quebec should be collected, exploitation rates determined, and the impact on Canadian hunters assessed.

The impact of the project on employment in Canada should be studied in order to identify where and when opportunities exist. The strategies required to realize employment opportunities should be developed. Once employment possibilities are assessed, the infrastructure necessary to support increased populations in affected communities can be identified and assessed in economic terms. Studies will be required to assess the economic impacts of flooding some 2,310 hectares (5,700 acres) of land and associated infrastructure in Quebec.

1.2 Recommendations

1. This report offically represents the views of the D.F.E. Technical Committee although officials of the governments of Quebec and New Brunswick informally participated in its preparation. As such, it should only be regarded as a first step in establishing a federal position on environmental and resource issues associated with the Dickey-Lincoln School project.

2. Until such time as formal advances are made by the United States to reopen treaty negotiations or to reach some other form of agreement on the project, the Department of Fisheries and Environment through the Technical Committee should continue to monitor activities associated with the project in the United States and to advise all concerned federal and provincial agencies on significant developments.

3. Because of the uncertainty surrounding the project

in the United States, no additional resources should be committed to the studies defined in this report at this time. Each federal agency likely to be involved in these studies should, however, prepare itself for prompt action should the United States decide to go ahead with the project.

4. A copy of this report should be forwarded to other federal departments, in particular the Departments of External Affairs and Energy, Mines and Resources, likely to be involved in any aspect of future negotiations.

5. Should the United States decide to proceed with further studies without formally approaching Canada to reopen negotiations, the Canadian government should seek observer status on any technical working groups that relate to Canadian concerns as itemized in this report. This is particularly important for studies relating to Design Memorandum No. 2, Section V, Flood Analysis and Reservoir Regulation.

6. Should the United States formally approach Canada for discussions with a view to either reopen treaty discussions or reaching some form of agreement on the project, a federal-provincial committee structure should be established to develop, priorize, and implement the technical studies required to assess the environmental, resource and energy impacts of the project. The committee structure should represent the environmental/resource and energy sectors because of the interpendence between environmental/resource and energy issues associated with the project.

Sufficient time must be allowed to conduct the necessary studies before a rigid negotiating strategy is developed. The various studies which are conceptually described in this report, and those which might be developed on the energy side, must be analyzed in terms of resource requirements and priority.

7. The Corps of Engineers has not as yet specified the operating specifications for the full development phase of the project (i.e. 1,140 MW at Dickey). As indicated in this report, the environmental and resource impacts under full development will be significantly larger than for the initial development concept (760 MW at Dickey). It is recommended that any treaty, or agreement, be based on the initial development of 760 MW at Dickey. The full development scheme should be the subject of a separate treaty or agreement.

2. INTRODUCTION

2.1 History of the Project

The water resources of the Saint John River Basin have been the subject of numerous investigations by various government and private agencies since the turn of the century. The use of water for the generation of hydroelectric power has been the focus for many of these studies. In particular, favourable hydrologic and physiographic conditions, combined with the low intensity of land development, have prompted many investigations of the power potential of the upper Saint John River Basin in Maine.

Of the earlier studies, the most prominent and comprehensive was carried out by the International Saint John River Engineering Board[1] (1954). The Board examined some 62 sites within the Saint John Basin for storage and on-site hydroelectric generation potential. The largest of these sites was at Rankin Rapids, just upstream of Lincoln School. No attempt was made to estimate downstream benefits or costs associated with this development.

The New England - New York Inter-Agency Committee[2] (1955) examined a number of alternative hydroelectric power sites on the Saint John River in Maine. This Committee added two new elements to the discussion: 1) it recommended the Big Rapids site, just upstream of Dickey, in order to avoid flooding the Allagash River (famous for its white-water canoeing) and 2) it examined the Lincoln School site from the point of view of providing for the re-regulation of releases from the main powerhouse.

The International Passamaquoddy Engineering Board[3] (1959) investigated the hydroelectric power potential of the upper Saint John River Basin to supplement the varying output from the proposed Passamaquoddy tidal power project. Again, the Rankin Rapids site was selected over a number of alternative sites. This study made some preliminary estimates of the effects on downstream power plants. In light of this, the Saint John River Board[4] (Canada-New Brunswick), was established and charged with determining the effects of storage and hydroelectric power developments in the upper Saint John River Basin on river flows, existing and potential power developments and other water uses. This Board determined that the Rankin Rapids site, as proposed in the earlier investigations, would produce downstream power benefits in the order of $22 million, for the period 1968-1980, and $1.1 million annually thereafter.

During the early 1960s, the U. S. government undertook an independent review of the proposed Passamaquoddy tidal power project. The U. S. Army Corps of Engineers[5] investigated the Dickey-Lincoln School sites which, although not as economically attractive as the Rankin Rapids site, avoided flooding of the Allagash River. Based on the report[6] of the U. S. Department of the Interior, the Dickey-Lincoln School hydroelectric power project was authorized by U. S. Congress on October 27, 1965 (Public Law 89-289).

In December, 1964, a joint Canada-United States committee, comprised of officials of both federal governments and the New Brunswick Electric Power Commission, was established to consider the cooperative development of energy resources of the Saint John River Basin with particular reference to the Dickey-Lincoln School project. The study was to be carried out in two phases. The first phase addressed three issues: 1) the most probable sequence of power development for the Maritime Power Pool without the construction of Dickey and Lincoln School, 2) the magnitude of downstream benefits obtainable through the operation of the Dickey and Lincoln School projects without electrical interconnection with the Maritime Power Pool; the storage to be operated in accordance with an agreed upon plan, and 3) the method of initial filling of storage at Dickey, taking into account the effects on downstream plants. A preliminary report on the first phase of this study was completed in October 1965. Under an assumed sequence of development of downstream plants not unlike that which might be currently assumed, the Committee estimated that downstream energy benefits would be in the order of 280-350 gWh/year ($2.8 - $3.5 million/year @ 10 mils/kWh). The committee also investigated the loss of downstream energy during the initial filling of the Dickey Reservoir. Based on a two-year filling period, energy losses could vary from as low as 2.3 gWh to as high as 433 gWh ($.02 to $4.33 million), depending on the specific hydrologic conditions existing during that 2-year period. With respect to downstream flood control benefits, the Committee concluded that while any flood damage protection in New Brunswick would likely be minor, joint studies should be made of this aspect. The second phase of the study, which was to investigate the magnitude of downstream benefits obtainable through interconnection and co-ordinated operation of all storage facilities and hydroelectric plants in the Saint John River Basin when operated to optimize hydraulic resource utilization, was never initiated.

During the course of the joint energy investigations, a number of informal meetings were held between Canadian and U. S. officials. Based on an exchange of notes (December 18, 1965), formal negotiations were entered into involving officials of the Canadian, New Brunswick, Quebec and U. S. governments. Treaty negotiations were discontinued in 1966, when the project was shelved in the United States as a result of a powerful lobby by private power companies. The latest draft of the treaty was developed in Ottawa on April 12, 1966.

This draft included clauses covering energy losses in Canada during the filling period; constraints on streamflow below the Dickey Dam beneficial to downstream energy production; a 50-50 sharing of downstream energy benefits; and joint liaison and monitoring. Energy issues dominated the negotiations; there was no direct discussion of environmental issues. In terms of energy, provisions were made in the draft treaty for compensating Canada for energy that would be lost should the United States fail to meet downstream flow requirements. No agreement was reached during the negotiations respecting compensation for the flooding of Quebec lands.

The investigations carried out by the Corps of Engineers terminated in 1967 with the publication of several design memoranda[8]. These memoranda recommended installed capacities of 760 MW and 34 MW at the Dickey and Lincoln School sites, respectively.

2.2 Current Investigations in the United States

As a direct result of the oil embargo during 1973-74, the U. S. Congress restored funding for preconstruction investigations with the provision that an environmental impact assessment be carried out for the project to meet the requirements of the National (U.S.) Environmental Policy Act of 1969. The Corps of Engineers completed the draft Environmental Impact Statement[9] (EIS) on the project, held public hearings and is now in the process of finalizing studies required to address the various issues raised in the review process, primarily alternative energy sources. The U. S. Department of Energy completed a draft EIS[10] on transmission corridors associated with the project and has held public hearings. The Corps of Engineers is now in the process of preparing the final EIS on the project. This document is scheduled to be completed by September, 1978.

Apart from the environmental studies, the Corps of Engineers has conducted a number of investigations[11] required to update and in some cases revise earlier design work. Considerable effort has been dedicated to foundation and construction material investigations and to power marketing studies. Significant redesign of the powerhouse and generating facilities has been carried out to accomodate a proposed pumped storage scheme and options for future expansion. Both features are new relative to the mid-1960s.

2.3 Formation and Activities of the DFE Technical Committee

The renewed activities of the Corps of Engineers were informally monitored by the Inland Waters Directorate during 1974 and 1975. When it became apparent, early in 1975, that the Corps of Engineers and its consultant, Meta Systems Incorporated, were contacting federal and provincial officials in Canada for input to the EIS guidelines, the Government of Canada decided to develop a strategy to deal with the United States prior to any formal advances. It was felt that committments might be inadvertently made which could jeopardize future negotiations. At an interdepartmental meeting on February 11, 1975, attended by officials of the Department of Fisheries and Environment (DFE), Department of External Affairs, Department of Energy, Mines and Resources and the National Energy Board, Mr. V. C. Dohaney was identified as the Canadian contact to exchange information on the project with the Corps of Engineers. At a further DFE meeting on June 16, 1975, a DFE Technical Committee, under the charimanship of Mr. Dohaney, was established with a view toward identifying the environmental and resource issues of concern to Canada. An exchange of letters between the Minister of External Affairs, and the Premiers of Quebec and New Brunswick, confirmed this arrangement. The membership of the Technical Committee is detailed in Table 1.

The Committee held two meetings in 1975 (August 27, October 22), at which Canadian environmental and resource

Table 1

Membership
DFE Technical Committee
Dickey-Lincoln School Hydroelectric Project

Name	Affiliation
Mr. V. C. Dohaney (Chairman)	Regional Director - IWD Atlantic
Mr. Marcel Couture	IWD - Quebec
Mr. Wayne Draper	EPS - Headquarters
Mr. Robert Dryden[1]	FMS - Headquarters
Mr. C. L. Dominy[2]	FMS - Headquarters
Mr. Hugh Hall	EPS - Atlantic
Dr. A. D. J. O'Neill	AES - Atlantic
Dr. Frank Quinn	IWD - Headquarters
Mr. Rick Semple[3]	FMS - Atlantic FMS - Headquarters
Mr. Wesley White	FMS - Atlantic
Mr. J. D. Keefe (Secretary)	IWD - Atlantic

NOTES:

1. Replaced by Mr. C. L. Dominy

2. Replaced by Mr. Rick Semple

3. Coincident with (2), FMS - Atlantic was represented by Mr. Wes White.

LEGEND:

IWD - Inland Waters Directorate, Environmental Management Service

EPS - Environmental Protection Service

FMS - Fisheries Management Service

AES - Atmospheric Environment Service

concerns were raised and major information gaps concerning the project identified. Officials of the Inland Waters Directorate, Atlantic Region met with officials of the Corps of Engineers in Waltham, Mass., on November 18-19, 1975, to obtain more information on the project.

The Corps of Engineers held a briefing session on the project in Fredericton, New Brunswick, on May 6, 1976. Officials of the Technical Committee and the Provinces of New Brunswick and Quebec were brought up to date on the project with emphasis on the EIS investigations.

An informal meeting, between the Technical Committee and representatives of the Provinces of Quebec and New Brunswick, was held in Frederiction on August 25, 1976, to exchange information on the project. Provincial contacts were established to facilitate the future exchange of information. Since that time, all information obtained from the Corps of Engineers has been made available to the two provincial governments.

A review of the draft EIS and design memoranda was initiated by the Technical Committee in August, 1977. Comments were also solicited from a number of DFE elements and from the provincial governments (See Appendix 1). Comments were consolidated and discussed at a third meeting of the Technical Committee held in Fredericton on January 18, 1978. This meeting was attended by a number of representatives from the Provinces of New Brunswick and Quebec. A number of working groups, charged with further refining the Canadian environmental and resource concerns and conceptually identifying studies required to address those concerns, were formed.

In view of the uncertainty of the project in the United States, the Technical Committee felt that studies, for which resources would be required, should not be carried out at this time. The approach taken by the Technical Committee therefore was to identify and then to quantify, to the extent possible, all Canadian environmental and resource concerns associated with the project, based on a review of existing information. Therefore, many of the concerns outlined in this report are speculative in nature and require further assessment before they are used as a basis for Canada-U.S. negotiations on the project. The Technical Committee has conceptually identified a number of studies required to further assess the identified concerns. The Canadian energy issues arising from the project were not considered to fall within the terms of reference of the Technical Committee.

2.4 Organization of the Report

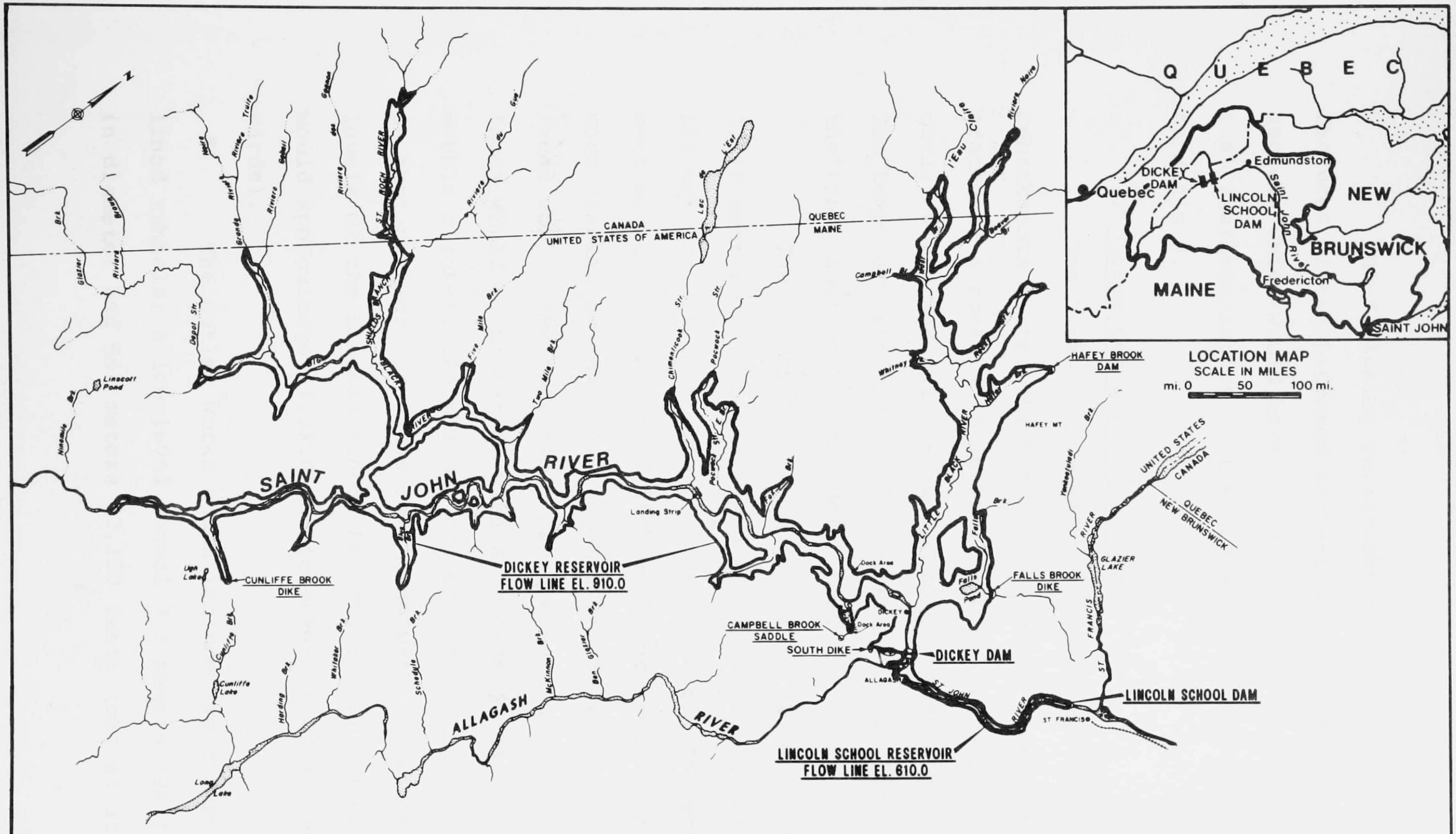
The Technical Committee's report which follows, is organized in six sections. The project is briefly described, with emphasis on those features which relate to Canada, in section 3. The environmental effects of the project in Canada are the subject of section 4 while the Canadian resource issues are presented in section 5. The environmental and resource studies required to assess the issues identified in sections 4 and 5 are described in section 6.

3. PROJECT DESCRIPTION

3.1 General

The proposed Dickey-Lincoln School Hydroelectric Project is located on the headwaters of the Saint John River in Aroostook County, Maine (Figure 1). The main dam, located at Dickey, Maine, some 21 km (13 miles) upstream of the International Boundary (confluence of the Saint John and St. Francis Rivers), would control a watershed of 7,060 km^2 (2,725 mi^2) or 12.8% of the Saint John River Basin. The Lincoln School Dam, located some 2 miles upstream of the International Boundary, would serve to partially re-regulate releases made from the Dickey Dam combined with the natural flow of the Allagash River. Both dams would incorporate powerhouses designed to provide peaking power to the New England States and intermediate power to the State of Maine.

The Dickey Dam in concert with five auxiliary dams (or dykes) would impound a reservoir with a total surface area of 34,800 hectares (86,000 acres) at maximum operating level, 1,640 hectares (4,050 acres) of which would be within the Province of Quebec. Portions of three river systems (Petite Riviere Noire, Ruisseau a l'Eau Clair and Riviere Saint-Roch) within the province of Quebec, would be flooded, thereby affecting five roads and six bridges in the St. Roch River Valley and a logging road in the Little Black River Valley.



DICKEY - LINCOLN SCHOOL HYDROELECTRIC PROJECT

SCALE IN FEET
10,000 0 10,000 20,000

FIGURE 1

The following paragraphs describe the principal features of the proposed project with emphasis on those aspects which would have a bearing on Canada. The physical characteristics of the project are detailed in Appendix 2.

3.2 Dickey Dam and Powerhouse

The Dickey Dam would consist of two earthfill embankments termed the North Dam and the South Dam, separated by a rock knoll in which the power facilities, outlet works and spillway would be located (Figure 2). The temporary river diversion works would be located in the right abutment of the North Dam.

The Dickey Dam would have a total length of 3,110 metres (10,200 feet) and a maximum height of 102 metres (335 feet) above the streambed. The embankment would be constructed with an impervious earth center core flanked by zones of random earth fill. The upstream faces would have rock slope protection and the downstream faces would be protected with a processed gravel and cobble blanket. Rock slope protection would be placed on that part of the downstream face within the operating levels of the Lincoln School Reservoir. Fill requirements would approximate $41.3X10^6$ cubic meters ($54X10^6$ cubic yards).

The outlet works would include two concrete-lined tunnels; a low level tunnel 7.9 meters (26 feet) in diameter and 661 meters (2,170 feet) long at stream-

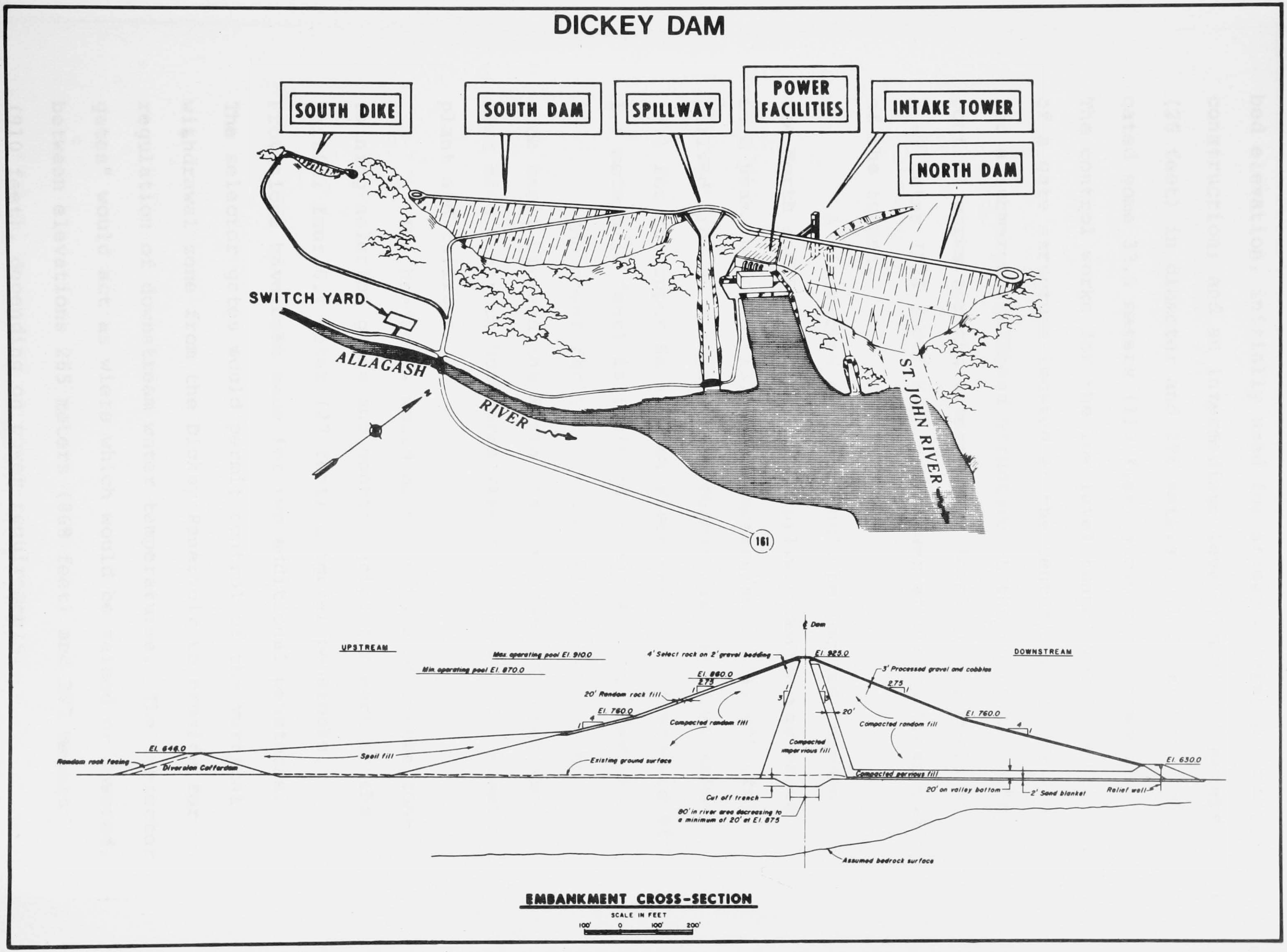

DICKEY DAM
SOUTH DIKE
SOUTH DAM
SPILLWAY
POWER FACILITIES
INTAKE TOWER
NORTH DAM
SWITCH YARD
ALLAGASH
RIVER
ST. JOHN RIVER
161
UPSTREAM
DOWNSTREAM
℄ Dam
Max. operating pool El. 910.0
Min. operating pool El. 870.0
4' Select rock on 2' gravel bedding
El. 925.0
3' Processed gravel and cobbles
El. 860.0
2.75
20' Random rock fill
El. 760.0
Compacted random fill
Compacted impervious fill
20'
El. 646.0
Random rock facing
Diversion Cofferdam
Spoil fill
Existing ground surface
Compacted pervious fill
El. 630.0
Cut off trench
80' in river area decreasing to a minimum of 20' at El. 875
20' on valley bottom
2' Sand blanket
Relief well
Assumed bedrock surface
EMBANKMENT CROSS-SECTION
SCALE IN FEET
100' 0 100' 200'

FIGURE 2

bed elevation, initially used for stream diversion during construction; and an intermediate level tunnel 7.9 meters (26 feet) in diameter and 296 meters (970 feet) long located some 33.5 meters (110 feet) above the streambed. The control works for the low level tunnel would consist of a gate structure located at the centerline of the dam and a submerged bulkhead structure at the entrance. The control works for the intermediate level tunnel would be a 69 meter (225 foot) high gate tower at the upstream end of the tunnel.

A chute-type spillway would be located between the North and South Dams. The spillway design was based on a peak inflow of 13,875 cu. meters/sec. (490,000 cfs) derived from an analysis of probable maximum storm rainfall for the upper Saint John River Basin. A freeboard of 1.8 meters (6 feet) is included in the spillway design.

The power facilities would be located in the rock knoll between the North and South Dams. These consist of a penstock headworks structure, penstocks, power plant and tailrace.

The headworks would be a concrete structure containing selector gates and control gates for each of the initial four 8.2 meter (27 foot) diameter penstocks. Provisions have been made for two additional penstocks. The selector gates would permit control of the vertical withdrawal zone from the Dickey Reservoir to provide for regulation of downstream water temperatures. The "selector gates" would act as wiers which would be raised or lowered, between elevations 265 meters (868 feet) and 277 meters (910 feet), depending on power requirements.

The powerhouse would include six operation bays, four for the initial generating units and two for future units. The first four generating units would be rated at 190 MW each, for a total initial installed capacity of 760 MW; one unit would be reversible. Inclusion of two additional 190 MW reversible units at some future date would increase the installed capacity to 1,140 MW.

There is no provision for fish passage facilities in the dam.

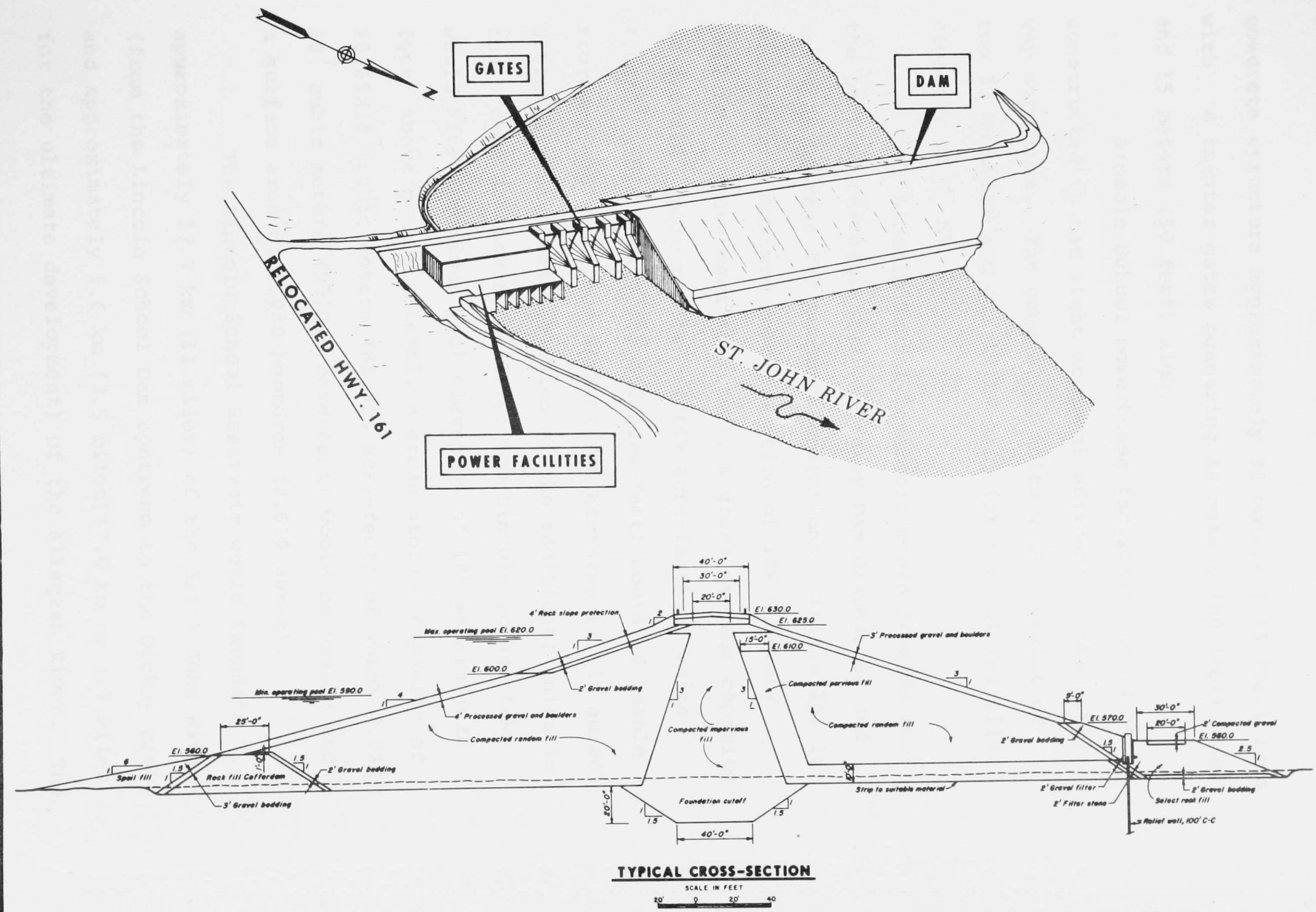
3.3 Lincoln School Dam and Powerhouse

The Lincoln School Dam would consist of an earthfill embankment across the Saint John River, a powerhouse on the right embankment and a gated spillway structure between the embankment and powerhouse (Figure 3). The overall length of the structure would be 640 meters (2,100 feet), including powerhouse and spillway structures, and the maximum height would be 27 meters (90 feet) above the existing streambed.

The embankment portion of the dam would be constructed with a central impervious earth core flanked by zones of random earthfill. Zones of pervious fill would be incorporated for seepage control. It would be approximately 463 meters (1,520 feet) long abuting the left bank of the Saint John River. The upstream face would be protected with rock and the downstream face would be protected with a processed gravel and cobble blanket.

Adjacent to the earth embankment would be the spillway structure and outlet works. This would be a

LINCOLN SCHOOL DAM



TYPICAL CROSS-SECTION

SCALE IN FEET

20' 0 20' 40

FIGURE

concrete structure approximately 90 meters (295 feet) long with 4 tainter gates measuring 18 meters (60 feet) wide and 15 meters (50 feet) high.

Lincoln School powerhouse facilities would be constructed in the right abutment adjacent to the spillway structure. The generating units would consist of two 30 MW units and one 10 MW unit for a total installed capacity of 70 MW.

The Lincoln School Reservoir would provide for the partial re-regulation of Dickey Dam discharges and serve as storage for pumpback operations. Initially, it would have a maximum pool elevation of 186.5 meters (612 feet) above mean sea level, a gross storage capacity of 8.28×10^7 cubic meters (67,149 acre-feet) of which 4.0×10^7 cubic meters (32,450 acre-feet) would be usable storage, and a surface area of 906 hectares (2,239 acres). Ultimately with the inclusion of the additional units in the Dickey Dam power facility, the Lincoln School Lake would have a maximum pool elevation of 189 meters (620 feet) above mean sea level, a gross storage capacity of 10.65×10^7 cubic meters (86,355 acre-feet) of which 7.28×10^7 cubic meters (59,090 acre-feet) would be usable and a surface area of 1,060 hectares (2,619 acres).

The Lincoln School Reservoir would inundate approximately 17.7 km (11 miles) of the Saint John River (from the Lincoln School Dam upstream to the Dickey Dam) and approximately 5.6 km (3.5 miles)(7.6 km or 4.7 miles for the ultimate development) of the Allagash River. The terminus of the Allagash Wilderness Waterway is six miles upstream from the confluence with the Saint John River; therefore, no part of the Allagash River protected by the Wild and Scenic River Act would be inundated.

3.4 Dykes

Five earthfill dykes, namely Falls Brook, Hafey Brook, Cunliffe Brook, Campbell Brook and South Dyke will close low saddle areas along the perimeter of the Dickey Reservoir. The Falls Brook and Hafey Brook dykes will not only be the largest but will also prevent backflow into Canada. In fact, the Falls Brook dyke will divert runoff from approximately 58.3 km^2 (22.5 $mi.^2$) of the St. Francis River watershed to the Dickey Reservoir.

The Falls Brook dyke would be 1,052 meters (3,450 feet) long with a maximum height of 43 meters (141 feet) above the existing streambed. The Hafey Brook dyke would be 655 meters (2,150 feet) long with a maximum height of 25 meters (82 feet) above the existing stream-bed. Both dykes would be constructed with compacted earthfill and protected with rip-rap. During the construction of the Falls Brook dyke, a 1.5 meter (5-foot) conduit will be used to pass local drainage.

3.5 Dickey Reservoir

At its maximum operating level of 277 meters (910 feet) above mean sea level, the Dickey Reservoir will flood an area of 34,803 hectares (86,000 acres). The total volume of water impounded would be 9.5×10^9 cubic meters (7.7 million acre-feet). The total live storage would amount to $3.6X10^9$ cubic meters (2.9 million acre-feet). The reservoir would flood approximately 20 miles of free flowing streams and 1,640 hectares (4,050 acres) of land within the Province of Quebec.

The land mass affected in Quebec can be considered in two blocks - the St. Roch River Valley and the Little Black River Valley (includes Ruisseau a l'Eau Claire). Approximately 485 hectares (1,200 acres) of land would be flooded in the St. Roch River Valley. The land is used in part for agriculture (grazing), forestry and contains a large bog. Three farm houses and associated outbuildings, several small sheds and a sportsmen's lodge, would be affected. Approximately 1,130 hectares (2,800 acres), used primarily for forestry, would be flooded out in the Little Black River Valley. The Corps of Engineers has assumed that the land would be purchased by the Province of Quebec (73% of this land is currently Crown) and remain under Canadian ownership. The Corps of Engineers also recognizes that additional lands will be affected by erosion and raised groundwater tables. Accordingly, they have assumed that a total of approximately 2,310 hectares (5,700 acres) in Quebec will be affected. This figure was agreed to during negotiations in the mid-sixties. For planning purposes, the Corps of Engineers has established that compensation for flooding of Canadian lands would be in the order of $3,000,000, a value which they estimate to be approximately double the market value.

The project would involve the relocation and construction of 5 roads and 6 bridges in the St. Roch River Valley. The Corps of Engineers has, for the purposes of obtaining cost estimates, undertaken conceptual design studies of the required work. The reservoir would also cut off approximately 120 km (75 miles) of forest access roads used by Quebecers to transport saw-logs from Maine. The Corps of Engineers states that the owners would be compensated in accordance with standard real estate practices in use within the United States. Cost estimates for relocation and/or compensation have not been detailed by the Corps of Engineer's report, but are inherent in the overall estimate.

The strategy developed by the Corps of Engineers respecting the clearing of the reservoir area is also of interest to Canada, in relation to future reservoir water quality conditions and to various socio-economic issues notably the short and long term effects on the Canadian forest industry. At the present time, the Corps of Engineers is still investigating a number of options. For planning purposes however, they propose to clearcut a band, between elevations 252 meters (828 feet) and 278 meters (913 feet) above mean sea level, around the Dickey Reservoir amounting to 22,055 hectares (54,500 acres).

3.6 Construction Scheduling

Construction of the project, including the acquisition and clearing of all necessary lands, would require approximately eight years to complete, as summarized on Figure 4. Initial power-on-line is expected to occur some 6 years after initiation of on-site construction and incrementally increased to total power-on-line during the 8th construction year. The project is expected to require 6,000 man-years of effort.

SEQUENCE OF CONSTRUCTION OPERATIONS — PRINCIPAL COMPONENTS

FEATURE	1st Fiscal Year	2 nd.	3 rd.	4 th.	5 th.	6 th.	7 th.	8 th.
Lands & Relocation	Initiate acquisition of lands & re-establish residents. 1st priority Rt. 161 and site of main features at Dickey. Initiate const. Rt. 161.	Continue acquisition of lands & re-establishment of residences. Cont. const Rt. 161. Initiate const. Allagash bridge & cemetery relocations.	Continue acquisition of lands & re-establishment of residences. Complete: Const. Rt. 161; Allagash bridge; Cemetery relocations	Continue acquisition of lands. Complete re-establishment of residences.	Complete acquisition of lands			
DICKEY Low Level Diversion & Control Works	Clear sites.	Excavate tunnel inlet and outlet portals. Initiate and complete tunneling excavation. Initiate concrete tunnel lining. Excavate tunnel inlet channel.	Complete: Tunnel lining; Intake structure; Outlet structure	Construct cofferdam, divert river through tunnel after spring run-off (June).	Install bulkhead gate in inlet structure after spring runoff. Place concrete and install gates in gate chamber. To be completed and bulkhead removed before next spring runoff.			
Upper Level Tunnel & Control Works	Clear sites.	Excavate tunnel inlet and outlet portals. Initiate tunneling excavation.	Complete tunneling excavation; commence concrete lining. Start intake and outlet structure.	Complete: Tunnel Lining; Intake structure to El 760; Outlet Structure; Tunnel to be available for emergency flood release during winter & spring of 5th year.	Complete intake structure to El 815.	Gates to be installed & completed by spring. Intake tower to be completed.		
South Dam	Early land acquisition. Clear and strip site.	Excavate, grout & backfill cutoff trench. Initiate embankment.	Continue w/placement of embankment. Reach El 760 by end of construction season.	Continue w/embankment construction, reach El 815 by end of season. If bad year weatherwise concentrate on North Dam embankment slack off on South Dam.	Continue w/embankment placement-attain El 890	Complete embankment placement-El 925		
North Dam		Clear abutments.	Strip abutments. Excavate, grout and backfill cutoff trench along abutments.	Immediately after river diversion and bottom cleanup, start embankment construction in areas upstream and downstream from the cut-off trench, concurrently with excavation and back-filling of the trench across the river bottom. After completion of backfill, concentrate placement in the center zone until leveled off with the upstream and downstream fills. By the end of the season, complete the upstream slope and an adjacent partial cross-section to El. 735.	Continue embankment construction, complete upstream slope and adjacent partial cross-section of embankment to El 815.	Continue embankment construction, completing upstream slope and adjacent partial cross-section of embankment to El 890.	Complete embankment construction.	
Saddle Dams			Construct South Dike & Campbell Brook dike. Start Falls Brook saddle dam and complete to El 835.	Continue Falls Brook saddle dam and complete to El 890.	Complete Falls brook saddle dam. Construct - Hafey Brook and Cunliffe Brook dikes.			
Spillway			Start excavation.	Continue excavation	Complete excavation. Start concrete in stilling basin	Complete weir and stilling basin		
Power House & Appurtenances		Clear & Strip Sites. Initiate excavation tailrace channel	Continue excavation of tailrace channel	Complete excavation tailrace channel. ← See Plate 4A-36 for Powerhouse Construction Schedule →				
Forebay & Headwalls Penstocks				Excavate power intake and forebay. Start excavation for penstocks	Initiate placing concrete in headworks. Start fabrication and installation of penstocks. complete excavation of penstocks	Complete installation of penstocks		
Impoundment of Waters					Start impoundment of dead storage after spring run-off. Accumulate to El 700 (Invert upper level tunnel) from June to October	Impound spring run-off. Accumulate to El 802 during the period April-July inclusive	Impound spring run-off. Accumulate to El 856 during the period April-July inclusive.	Fill live storage to El 890 during April-July inclusive
LINCOLN SCHOOL River Diversion						Divert river through diversion channel and block out in spillway after spring runoff	Divert river during Nov and Dec thru sluice gate and one skeleton generating unit.	
Dam & Spillway			Clear area for structures. Excavate for spillway structures	Excavate forebay and tailrace sufficient for diversion. Initiate placement of spillway concrete.	Complete spillway concrete with provisions for diversion of river flows through spillway	Initiate construction of embankment in June. Complete excavation of forebay & tailrace. Utilize material in embankment. Install Tainter gates.	Complete embankment by 1 Nov. Place concrete plug in diversion channel during Nov-Dec & set gate sill.	
Powerhouse			← See Plate 4A-37 for Powerhouse Construction Schedule →					

FIGURE 4

4. ENVIRONMENTAL EFFECTS OF THE PROJECT IN CANADA

This section addresses the physical effects of the project on both upstream and downstream water resources in terms of hydrology and climatology, water quality and flooding and, as such, establishes the basis for the various resource concerns to be discussed in section 5.

4.1 Hydrology and Climatology

4.1.1 Construction Period

The Corps of Engineers plans to begin impounding water at the Dickey damsite during the 5th construction year in accordance with the following schedule:

Construction Year	Filling Period	Reservoir Elevation After Filling Period meters (feet) amsl*	Total Volume in Storage $m^3 \times 10^{-9}$ (acre feet $\times 10^{-6}$)
5	June-October	213 (700)	0.6 (0.5)
6	April-July	244 (802)	2.8 (2.3)
7	April-July	262 (858)	5.3 (4.3)
8	April-July	271 (890)	7.6 (6.2)

* amsl - above mean sea level

During the first year of operation, the reservoir will be brought up to its full supply of 277 meters (910 feet) which corresponds to a total volume of 9.5×10^9 m^3 (7.7×10^6 acre-feet).

Filling during the summer period of the fifth year is a new concept relative to investigations and treaty discussions carried out in the mid-sixties. The riparian flow policy for this and subsequent years of impoundment are not detailed in existing reports.

During the treaty negotiations in the mid-sixties, considerable attention was paid to the impact of impounding waters on downstream energy. If, during the filling period, the United States did not discharge water up to the natural flow of the river as necessary to permit the production of energy at downstream plants to meet system demands, the plan was to have the United States compensate Canada either in the form of supplying equivalent energy or through a monetary arrangement. Other water uses were virtually ignored.

The strategy developed by the Corps of Engineers respecting impoundment of waters differs from that which was developed in the mid-sixties in that a 32-month period, over 3 spring freshets, was considered. The concept of filling during the summer months of the 5th construction year is new as is the period April-July, which was previously April-May.

The impact of impounding waters on downstream flows will very much depend on the hydrologic regime over the filling period.

The impact of burning slash and debris on air quality is viewed by the Technical Committee to be minor and temporary.

4.1.2 Post-Construction Period

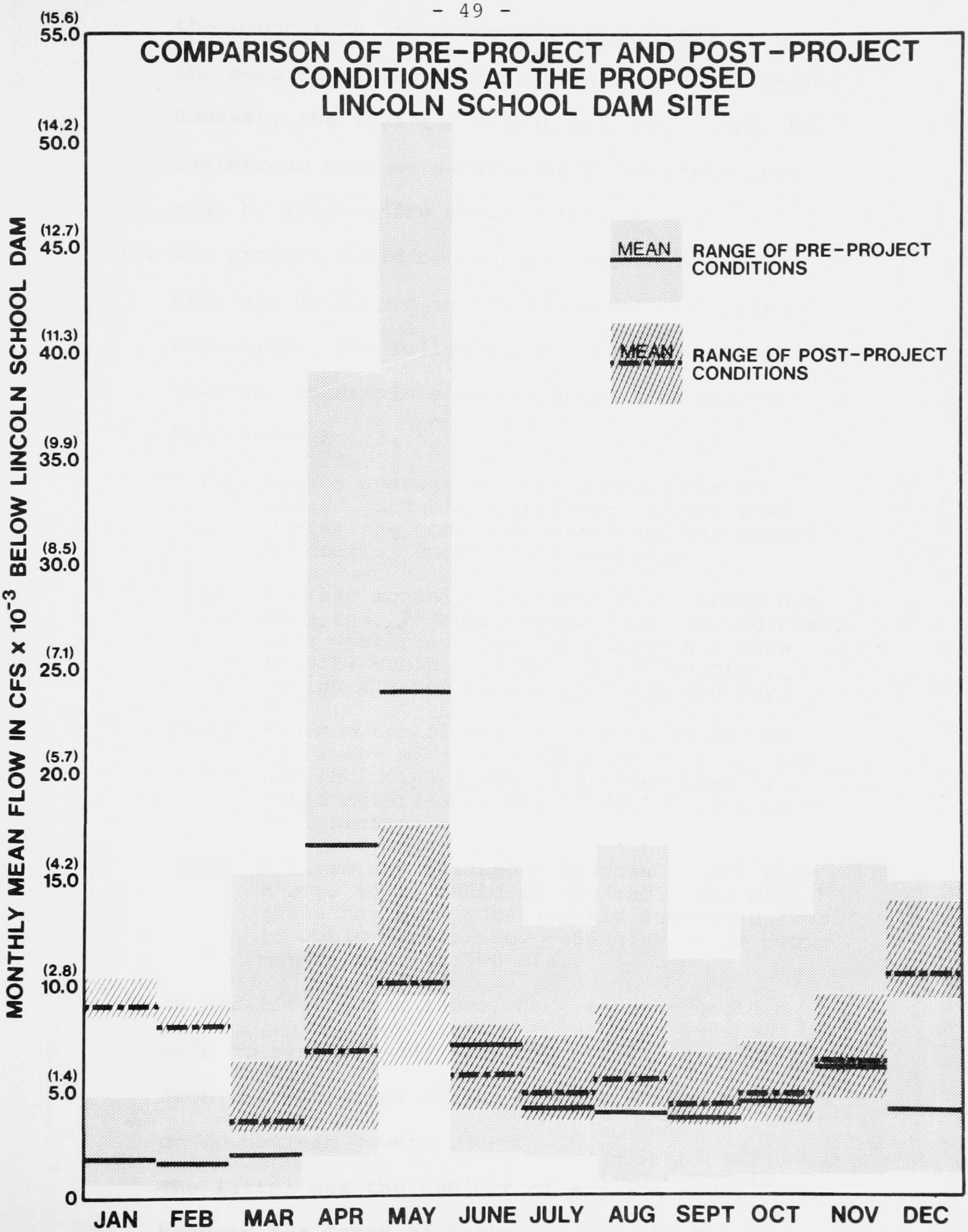
In its normal operating mode, the Dickey-Lincoln School Hydroelectric Project, in its initial configuration, will alter the hydrologic regime of the Saint John River in the following manner:

(a) When power demands are high during the winter months, December through February, and natural flows are low, the mean flow of the Saint John River will be increased by some 184-198 cubic meters/sec. (6,500-7,000 cfs)

(b) During the spring months, April and May, when power demands are low and natural flows are high, the mean flow of the Saint John River will be decreased by some 283-425 cubic meters/sec. (10,000-15,000 cfs). Mean monthly flow during the month of June will be decreased by some 40 cubic meters/sec. (1,400 cfs).

(c) During the remainder of the year, streamflows will be increased in the downstream reaches of the Saint John River ranging from 2.8 cubic meters/sec. (100 cfs) in October to 40 cubic meters/sec. (1,400 cfs) in August. A comparison of pre-project and post-project flow regimes is shown on Figure 5.

(d) Because of the relatively small amount of live storage (5.2×10^8 m^3 - 425,000 acre-feet) in the three headponds of the existing power dams (Grand Falls, Beechwood and Mactaquac) on the main stem of the Saint John River, efficiencies associated with generating under full reservoir levels (e.g. maximum head) and a similarity in demand curves for NEPOOL and the NBEPC, there will be an insignificant seasonal re-regulation of Dickey outflows. Thus, seasonal impacts of



Note: (1.4) Flow in Cubic Meters / Sec. X 10^{-4}

FIGURE 5

the project on the downstream flows will be of the same magnitude described in (a) to (c) above. However, the relative effect will be smaller in downstream reaches because of the contribution made by intervening watersheds.

(e) The project would be operated within the constraints developed in the mid-sixties with one exception. The following is a summary of the relevant constraints as extracted from Design Memorandum No. 3:

" (i) Dickey average monthly outflow not to exceed 71 cubic meters/sec. (2,500 cfs) during the months of April and May except to control unavoidable spillage.

(ii) Average monthly discharge from Dickey not less than 71 cubic meters/sec. (2,500 cfs), with weekly average discharges not less than 57 cubic meters/sec. (2,000 cfs), during all months except April and May.

(iii) Minimum annual discharge from Dickey of 3.3×10^9 m^3 (2.7 million acre-feet), but not including flows of greater than 71 cubic meters/sec. (2,500 cfs) during refill season.

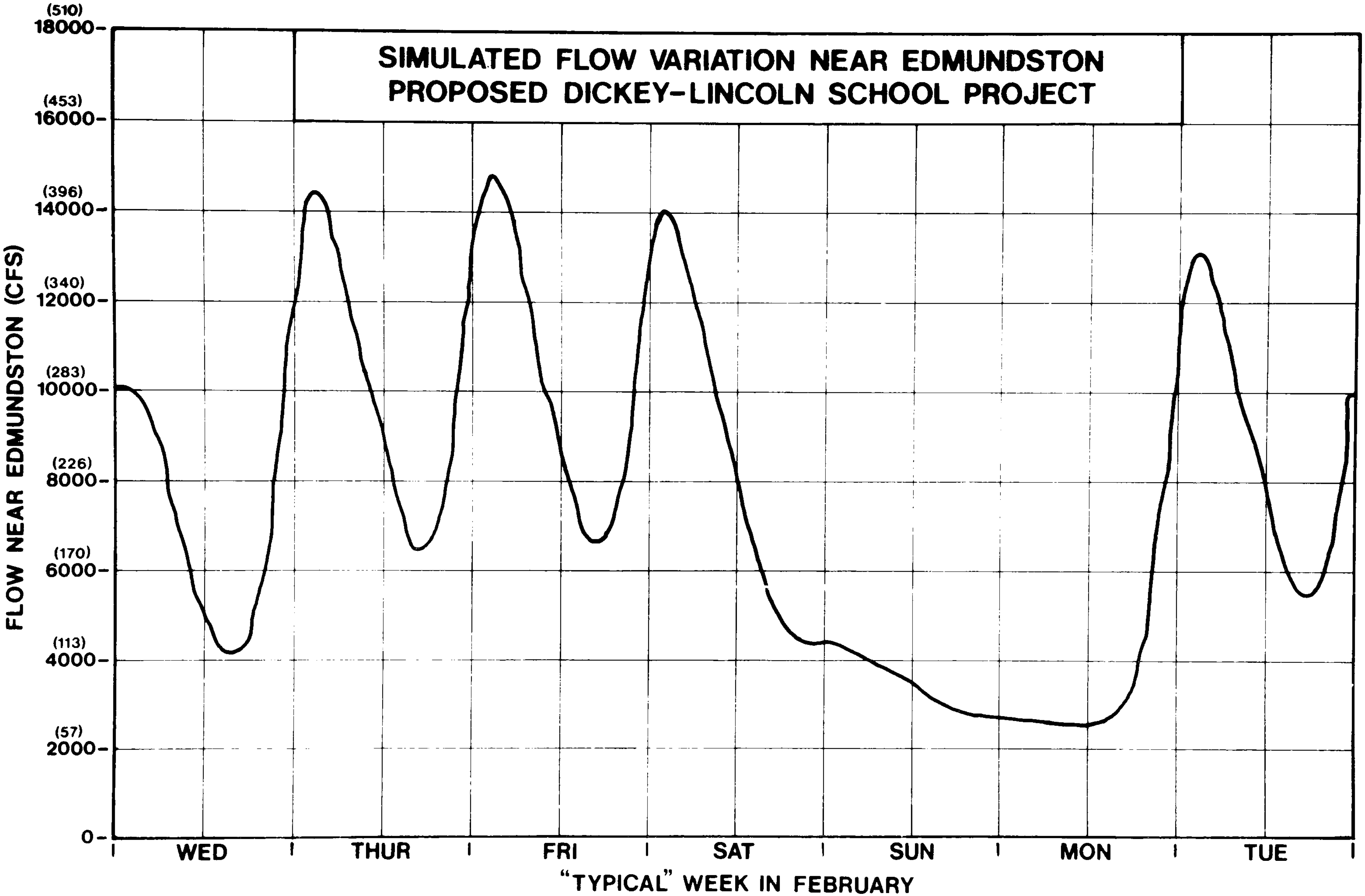
(iv) Minimum instantaneous Lincoln School discharge of 13 cubic meters/sec. (465 cfs)." (This has been subsequently increased from 13 cubic meters/sec. (465 cfs) to 28 cubic meters/sec. (1,000 cfs).

In addition to the above, best efforts would be made to minimize any negative effects resulting from the operation of the Lincoln School plant on downstream power.

The latter was the subject of a joint study[12] between the Corps of Engineers and the New Brunswick

Electric Power Commission on which a draft report was prepared in 1967 just before treaty negotiations were broken off.

(f) More germane to the impacts of the project on the downstream flow regime, is the weekly and daily operation of the project. The main powerhouse at the Dickey site will normally be operated as a peaking plant with hourly changes in discharge being directly related to electric power loads. This would result in streamflow variations ranging from 0 to 1133 cubic meters/sec. (40,000 cfs). The Lincoln School reservoir does not have adequate storage to completely re-regulate Dickey releases even during times of minimal contribution from the uncontrolled Allagash River. Typically, flows will vary from 28 to 453 cubic meters/sec. (1,000 to 16,000 cfs) during each day of the week except Saturday and Sunday. This would be attenuated to some extent at downstream locations by the natural channel and by inflow from intervening watersheds. Results of studies by the Corps of Engineers using a simplified routing model, indicate that during a typical week in February, as shown on Figure 6, flows near Edmundston would vary from 71 cubic meters/sec. (2,500 cfs) to 425 cubic meters/sec. (15,000 cfs) and as much as 283 cubic meters/sec. (10,000 cfs)



Note : (57) Flow in Cubic Meters / Sec.

FIGURE 6

on a daily basis. Downstream of Edmundston, the daily and weekly variation in flow will depend on the operational characteristics of the Grand Falls, Beechwood and Mactaquac power plants.

(g) Coincident with and as a result of changes in the downstream flow regime, water levels will undergo change relative to present conditions. Seasonally, water levels will tend to be lower than natural during the refill period (April through June) and slightly higher than normal during the remainder of the year. However, of more significance will be the within-the-day fluctuations which will result. Investigations by the Corps of Engineers have shown that within-the-day fluctuations of 1.8 meters (6 feet) and a maximum hourly rate of change of 0.45 meters (1.5 feet) can be expected at the confluence of the Saint John and St. Francis Rivers. As with the flow regime, water levels will be attenuated as one moves downstream. For example, based on Corps of Engineers' studies, water levels near Edmundston can be expected to fluctuate by as much as 1.1 meters (3.5 feet) daily and by as much as 0.23 meter (0.75 foot) hourly. As with the downstream flow regime, fluctuations in stage downstream of Grand Falls will be further attenuated by the river, by flow from intervening watersheds and by the operation of the main power stations.

The above effects are keyed to the initial development concept at Dickey (760 MW - 3 conventional turbines and 1 Francis pump/turbine). Under the full development concept, the Dickey plant would have nameplate capacity of 1,140 MW composed of 3 conventional and 3 pump/turbine Francis units of equal size. The Dickey plant would then produce flows ranging from 0 to 1700 cubic meters/sec. (60,000 cfs). Pumped storage studies undertaken by the Corps suggest that under optimum energy production conditions and the fully developed plant (1,140 MW), natural flows from the Allagash would be pumped into the reservoir, thereby lowering weekly and daily low flow releases. There has been no documented evaluation to date of the downstream impacts on flow and stage related to this concept. It is fair to say, however, that downstream fluctuations will be more marked than for the initial development concept. The Corps of Engineers is also investigating seasonal pumped storage in which a portion of Allagash River floodwaters would be pumped into the Dickey Reservoir for later release. This would further modify downstream flows on a seasonal basis.

The within-the-day impact of the project on the hydrologic regime below Grand Falls will depend on the operational strategy adopted by the New Brunswick Electric Power Commission for existing plants and/or new or redeveloped sites.

Despite the fact that the project is designed to operate as a peaking plant, the Corps of Engineers states that output from the plant will not be uniform and may vary depending on demand. The Corps of Engineers also states that the project can provide valuable "spinning reserve" capacity for the NEPOOL system in the event of forced outages in the system. The implications of this possibility are far reaching. The worst case would be the discharge of 1133 cubic meters/sec. (40,000 cfs) or 1700 cubic meters/sec. (60,000 cfs) for an extended period of time. The latter flow corresponds to the full development scheme. This would have to be followed by a period of 2 to 3 years or more during which downstream flow would be reduced since the reservoir would have to be brought up to full operating levels. It is anticipated, however, that fluctuations in flow, downstream of the Lincoln School Dam, could range from 28 cubic meters/sec. (1,000 cfs) to 1133 cubic meters/sec. (40,000 cfs), under the initial development concept, and from 28 cubic meters/sec (1,000 cfs) to 1700 cubic meters/sec. (60,000 cfs), under the ultimate development concept, on a more frequent basis. The phenomena results from the relatively small live storage capacity available within the Lincoln School reservoir. While it may be possible to develop a business agreement respecting compensation for lost energy at downstream plants, it is very difficult to compensate for or mitigate adverse environmental impacts.

In view of the number of dam failures in recent years, downstream interests must be concerned with this possibility.

In Quebec, the Dickey Reservoir will flood approximately 20 miles of free flowing streams and 1640 hectares (4050 acres) of land at its maximum operating level of 277 meters (910 feet) above mean sea level. During a typical year, reservoir levels will fluctuate by 6.0 - 7.6 meters (20-25 feet), thus exposing over 70% of the flooded land in Quebec. This is further amplified by the fact that the reservoir will only attain its maximum elevation 50% of the time on an annual basis. At its minimum elevation (264 meters (868 feet) above mean sea level), the flooded land within Quebec will be completely exposed. The negative impacts of this will be partially offset by the fact that fluctuations during the period June to October will be approximately 0.6 meters (2 feet) on the average.

In addition to the direct flooding of 1640 hectares (4,050 acres) of land in Quebec, an additional land mass, estimated to be approximately 690 hectares (1,700 acres), along the periphery of the proposed reservoir, will be affected as a result of raised groundwater tables, erosion/slumping and the flooding of root systems.

The Technical Committee has also identified a number of other concerns including: a) the Falls Brook dyke will divert the runoff from 58 km^2 (22.5 mi^2) of the Saint Francis River Basin; b) the reservoir will increase evaporation losses, relative to existing evapotranspiration levels, thus reducing mean annual streamflow by approximately 2.5 cubic meters/sec. (90 cfs); c) local meso-climatic impacts around the reservoir will tend to moderate the temperature regime and increase precipitation; and d) on the positive side, the proposed facility would displace thermal plants, thus reducing air pollutants and environmental impacts related to cooling water system.

4.2 Flooding and Ice Jamming

The Saint John River has had a long history of flooding, dating back to the early settlers. The most recent major flood occurred in 1973, resulting in federal-provincial compensation amounting to $10.8 million. The center of flood damage potential in the Saint John River Basin lies in the reach below the Mactaquac dam, specifically from Fredericton to Maugerville where losses during the 1973 flood were estimated at $7.1 million. The Saint John River Basin Board estimated that the average annual flood damages attributable to flooding in the Saint John River Basin in Canada was in the order of $750,000/year (1972 price levels) which when converted to present day dollars (1978), would exceed $1.25 million. This conversion ignores development on the flood plain since 1972.

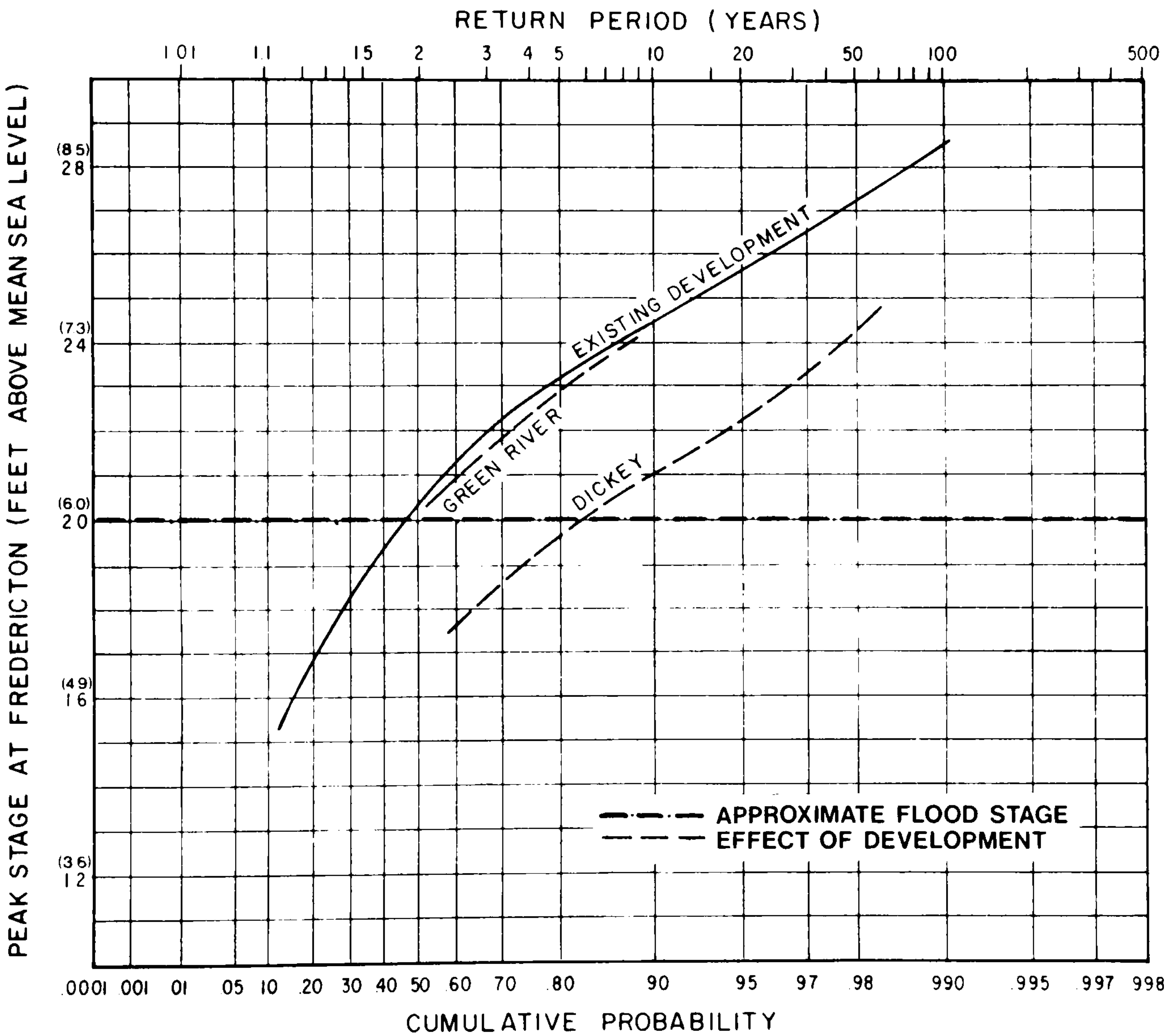
Floods on the Saint John River are caused by rainfall, snowmelt, ice jams and tropical storms, with the more serious events resulting from a combination of these factors. The 1973 flood was caused by a combination of rainfall and snowmelt, while the 1976 flood, for example, was largely caused by ice jams triggered by mild weather, rainfall and consequent snowmelt.

The Corps of Engineers' studies, which are confined to the U. S. portion of the Saint John River, indicate that significant flood control benefits would be accrued within the United States (approximately $700,000 annually), should the project be built despite the construction of 1:100 year flood protection for a portion of the Town of Fort Kent, historically the center of flood damages in the U. S. portion of the basin. Quantitative references in the various Corps of Engineers' reports are difficult to find, although at one point it is stated that flood flows at Fort Kent would be reduced by 50%, implying little or no spill at the Dickey dam during high runoff events.

The Saint John River Basin Board in its report[13] "Electric Power and Water Management in the Saint John River Basin" indicated that if Dickey-Lincoln School had been in full operation during the 1973 flood, the peak stage at Fredericton could have been reduced by about 0.8 meters (2.6 feet). For smaller floods, the reduction in stage would be even greater - typically about 1.1 meters (3.5 feet). (See Figure 7).

During the draft-treaty discussions in the mix-sixties, the Canadian negotiators successfully upheld the Canadian position that there would be no significant flood control benefits in Canada in view of the pattern and timing of major flood producing storms. That is, major flooding has occurred in the lower Saint John River Valley with little or no contribution from the watershed above Dickey. Without jeopardizing the position taken in the mid-sixties, which may be renewed should another round of negotiations proceed, it does seem reasonable to conclude that the project would have a tendency to lower the magnitude of flooding; significantly in the immediate reach below the project and to a lesser extent in and downstream of the Fredericton-Maugerville reach.

EFFECT OF POTENTIAL STORAGES ON PEAK STAGE AT FREDERICTON



SOURCE - "AN APPRAISAL OF THE POWER DEVELOPMENT POTENTIAL OF THE SAINT JOHN RIVER BASIN", ACRES CONSULTING SERVICES LIMITED, NOV 1973

Note : (3.6) Stage in Meters

While the project would be of some benefit to Canada under typical open water flooding events, the impact of the project on ice jamming is uncertain. Ice jam floods have occurred at a number of locations in the Saint John River, generally during spring breakup but occasionally during the early winter months. Ice jam floods in 1976 caused flooding in the Perth-Andover and Woodstock areas several feet above what would be expected under 1:100 year open water flooding events. The largest losses associated with ice jam floods are usually associated with hydraulic structures such as highway and railway bridges.

The increased streamflow conditions resulting from the project during the winter months combined with higher-than-normal temperatures associated with the release waters, predicted between $0^{o}C$ and $4^{o}C$, may prevent ice formation for some distance downstream. While there may be less ice formed in the river, the existence of open water may promote the formation of frazil ice. This could conceivably lead to the formation of anchor ice and hanging dams in and above the Grand Falls headpond. Also, the large within-the-day fluctuations in streamflow may prevent the formation of a stable ice cover. Considering all of these factors, the modified ice regime that would be created by the proposed project should be of concern to Canada.

4.3 Water Quality

The replacement of a free flowing largely natural stream environment with a man-made reservoir together with the construction activities associated with the physical works will, without question, substantially alter the environment, both in Quebec and New Brunswick. The environmental impact will, of course, be transitional in nature with the most serious impacts occurring during construction and for some time thereafter. Estimates of the Corps of Engineers, based on physical and mathematical modelling studies, point to the fact that water quality should approach background levels some 6-9 years after initial filling. It is anticipated that certain water quality parameters including specific conductance and total solids may increase concurrent with the aging process of the reservoirs themselves.

4.3.1 Construction Period

Despite the deployment of mitigating measures, planned but not detailed by the Corps of Engineers, increases in dissolved and suspended solids, with attendant increases in turbidity and specific conductance, will occur during the construction phase as a result of reservoir clearing, borrow material aquisition and dam/dyke construction. This will impact on the main stem of the Saint John River and to a lesser extent on the lower reaches of the St. Francis River, the latter resulting from construction of the Falls Brook dyke. The sediment load which will reach canadian waters as a result of the construction activity has not been quantified.

Associated with the erosion/sedimentation process, organics, nutrients and possibly heavy metals will be leached from disturbed areas and/or transported with the sediment causing enrichment or contamination of downstream waters. Typically, downstream waters would be high in suspended and dissolved solids, turbid and higher in certain major ions than normal.

During the reservoir filling period, i.e. between the 5th and 8th construction year, waters which will be released from the low level diversion channel could be anoxic. Associated with this phenomena, release waters could be low in dissolved oxygen, high in organics, nutrients and temperature and possibly high in heavy metals. It is felt that this change in water quality could have an impact downstream where an increase in nutrients could compound eutrophication problems.

Existing sediments in the Grand Falls headpond are highly organic in nature. These are normally flushed out during the spring freshet. Reduced spring flow during the filling period could reduce the benthic scouring and flushing action and lead to an increase in benthic oxygen demand.

Reduced spring flows during the construction period combined with a degradation of water quality will affect the assimilative capacity of the Saint John River, thus compounding the problem downstream.

4.3.2 Post-Construction Period

Many of the impacts described above will persist, as acknowledged by the Corps of Engineers, for some 6-9 years after the project is brought on line. In the long term, however, water quality conditions should improve to approximate natural conditions with the exception of temperature, and possibly the downstream benthic regime. The temperature of water released immediately below the Lincoln School Dam will, on the average, be 3^{o} - $6^{o}C$ cooler during the summer months. The variation in summertime water temperatures downstream of Lincoln School will be reduced from $11^{o}C$ to $5^{o}C$. Waters released during the winter period will be warmer than natural by up to $4^{o}C$. Temperatures will adjust, with distance downstream, toward equilibrium with atmospheric conditions.

Reduced spring flows may reduce benthic scouring in the Grand Falls Headpond, which could result in an increase in benthic oxygen demand. This may, to some extent, be counteracted by the pulsating characteristics of the new flow regime.

The natural assimilative capacity of the Saint John River will be affected. The compliance schedule, developed by the federal and provincial environment departments with Fraser Companies Limited for their pulp and paper mill at Edmundston, is based on maintaining dissolved oxygen concentrations in the river of 6 ppm under 1:20 year, 5-day low flows. It is anticipated that the proposed power project will detrimentally affect the natural assimilative capacity of the river during the construction period and for a period thereafter. However, the assimilative capacity of the river may be increased over the long term in view of the higher than natural low flows and predicted high quality of water released.

Seasonal alterations in the downstream flow regime may affect salt water intrusion into the Saint John River estuary and possibly change ecosystem dynamics. This aspect should be studied to determine if there will be a shift in the location of the salt water wedge both during construction and post-construction periods, and if so, the implications of any shift.

The draft EIS indicates that mercury, which was observed in the watershed in erratic and somewhat high levels, may be transported to the deeper portions of the Dickey Reservoir through adsorption on fine-grained sediments and may be available for biological uptake concurrent with circulation periods. The existence of mercury at the levels indicated by the Corps of Engineers in what is largely natural waters is open to question. The Canadian experience, on a series of triplicate water samples collected over a ten-month period in 1977, indicated a mercury range from less than 0.05 ug/l to 0.13 ug/l with 80% of the samples at or below the detection limit of 0.05 ug/l. Nevertheless, the Corps of Engineers indicated that the Environmental Protection Agency, in a 1976 report, found mercury and selenium concentrations in sport fishes in the project area which exceeded the U. S. Federal Department of Agriculture human consumption limits. This is similar to the Canadian mercury experience as reported[14] in "Mercury in the Atlantic Provinces", dated November 17, 1976, where fish from the Saint John River system were found to have elevated mercury levels.

The Corps of Engineers also paid a passing remark to the possibility that the reservoir could become a sink for persistent pesticides. The subject of baseline pesticide levels in the water and sediments has not been addressed in the EIS.

5. RESOURCE SECTOR EFFECTS OF THE PROJECT IN CANADA

This section outlines the impacts that construction and operation of the Dickey-Lincoln School project will likely have on Canadian resources. In some cases, these impacts will be immediate. In others, their effects will take time to become fully apparent. In all cases, the impacts outlined below will affect current or potential exploitation of Canadian resources, thereby causing shifts in the nature of local and provincial economic activity. For discussion purposes, the section has been organized into six subject areas - forestry, fisheries, agriculture, wildlife, water supply, and indirect effects.

5.1 Forestry

All major impacts on the forestry sector are expected to occur upstream of the Lincoln School damsite. The focus of the physical impacts will be in the immediate vicinity of the reservoirs while the majority of the economic impacts will occur in the St. Pamphile region of Quebec.

The St. Pamphile region relies heavily on the forest resource. The area contains several sawmills which receive their logs primarily from cutting operations in Maine. The draft EIS suggests that 90% of timber utilized by sawmills in this part of Quebec is imported from Maine.

The project will flood a total of about 35,610 hectares (88,000 acres). Of this, approximately 21,850 hectares (54,000 acres) will be clearcut. The reservoir will eliminate 1,620 hectares (4,050 acres) of land in Quebec, the majority of which is forested. The Corps of Engineers proposes to clearcut the entire 1,620 hectares (4,050 acres), thereby salvaging the existing stand. An additional 690 hectares (1,700 acres) in Quebec will be affected by shoreline erosion/slumping and raised groundwater tables. The total loss to Quebec of productive woodland will be in the order of 2,000 hectares (5,000 acres). This implies an annual loss in productive potential of approximately 4,000 cords.

On the Maine side of the reservoir, the project will flood approximately 34,000 hectares (84,000 acres). Although this area is not quite as productive as that on the Quebec side, it is estimated that the annual loss in production potential will be in the order of 40,000 - 50,000 cords. Present plans call for the establishment of a 91-meter (300-foot) debris control area around the circumference of the reservoir, and a 12,140-hectare (30,000-acre) wildlife management area in Maine. Both of these factors would have a depressing effect on the forestry potential of northern Maine and southern Quebec and would therefore limit the amount of wood available for processing in Quebec mills.

There will be a number of implications for the Quebec sawmilling industry as a result of these project design factors. For example, since hardwoods dominate the upland areas, it is possible that the quality of sawlogs imported from Maine will decline, with a corresponding increase in costs.

As a result of clearing the reservoir there could be large quantities of pulpwood entering the New Brunswick market (particularly at Edmundston). This could cause significant short-term price declines, thereby making it more difficult for small Canadian woodlot operators to compete effectively. The fact that clearcutting would be the technique employed means that the majority of the wood would likely go as pulpwood rather than sawlogs, thereby starving the St. Pamphile area of necessary raw materials to some extent.

Some 120 km (75 miles) of logging roads now serving the St. Pamphile Region will be disrupted by the project. Presumably, the network of logging roads required to clear the reservoir area could be designed to minimize adverse impacts.

Five public roads and six bridges in the St. Roch River Valley, including a very important concession road connecting the villages of St. Pamphile and St. Omer, will require considerable reconstruction.

5.2 Fisheries

It is expected that the construction of a barrier of the magnitude proposed for the Dickey-Lincoln School project will have deleterious effects on the fisheries resources of the Saint John River. However, because of the difficulty in quantifying these impacts, it has been necessary to be rather qualitative in the approach to this section of the report. Wherever possible, quantitative concerns have been identified, but the issues must remain largely qualitative until resources are made available to study each one individually.

In its draft EIS, the Corps of Engineers has addressed a number of, but not all, the impacts identified below, but its treatment of these issues has not always been satisfactory from the Canadian viewpoint. The concerns identified in this section are discussed in terms of upstream and downstream effects. These are further discussed in terms of construction and post-construction period impacts.

5.2.1 Upstream

(a) Construction Period: There will be no major impacts on the fishery resources in Quebec during the construction period apart from some 32.8 km (20.4 miles) of Quebec streams which will eventually be flooded.

(b) Post-Construction Period: Associated with the flooding of the reservoir, approximately 32.8 km (20.4 miles) of stream environment will be transformed into a lake environment subject to large fluctuations in water level. As a result, an unknown quantity of brook trout spawning and nursery area will be destroyed.

As a result of water impoundment and reduced stream velocity, sedimentation, water temperature and macrophytic vegetation will increase favoring a succession from a salmonid habitat to a yellow perch - white sucker environment not highly prized by fisheries enthusiasts. Standing crops of benthic invertebrates will be depressed. The flooding of vegetation, organic soils and forest litter in the Quebec reaches could conceivably lead to reduced dissolved oxygen concentrations and result in a marginal fishery sustained only by recruitment from unaffected waters. In fact, the Corps of Engineers has suggested that a fish species capable of adapting to the hydrologic characteristics of the proposed reservoir could be introduced. The Corps of Engineers has indicated, at public hearings, that this aspect would be discussed with and ratified by Maine State Authorities before implementation. However, the introduction of an exotic fish species could be expected to impact on both Quebec and New Brunswick streams but the nature of this impact has not been discussed in the draft EIS. The introduction of a species of fish into international waters should be subjected to Federal and Provincial fisheries regulations.

Extreme drawdown during the winter months, which would under normal operating and hydrologic conditions expose 70% of the area flooded in Quebec, will prevent the development of benthic fauna and will destroy eggs and larvae of fish species which spawn near shorelines in the fall.

The Dickey Reservoir, which would act as a sink for heavy metals and pesticides, may make those contaminants available for biological uptake, thereby harming the fishery resource as well as creating a potential health hazard for the human population.

5.2.2 Downstream

The Dickey and Lincoln School Dams, which to date do not provide for fish passage facilites in their basic designs, will be total barriers to salmon migration, thereby limiting Canadian options for the management of the resource in the future.

(a) Construction Period: As previously indicated, erosion/sedimentation processes will be dramatically accelerated during the 8-year construction period and for some time thereafter. While the draft EIS gives some recognition to this concern, it fails to bring out either the time-frame or the downstream extent of the sedimentation process. Also, it is felt that the draft EIS recommendations concerning mitigating measures dismiss this concern far too lightly. The following paragraphs identify the major concerns relative to downstream sedimentation:

The increased siltation of the Saint John River will have detrimental effects on biological productivity at the primary and secondary levels due to reduced light penetration, and physical impairment caused by the blanketing of the organisms and interference with the respiratory and digestive processes of filter feeders. Tertiary production will be depressed by the loss of food organisms, physical impairment due to the clogging of gills, and reproductive impairment due to siltation of spawning gravel. In addition, increased turbidity could reduce angling success and affect the aesthetic quality of the environment to such an extent that fishing these waters may no longer appeal to the angler.

As discussed in section 4, water released during the reservoir filling period (3 years) will be anoxic. It is not known how far downstream this condition will prevail and to what extent it will be a problem for living organisms. While the river will provide some natural aeration during open water conditions, little or no re-aeration is provided under ice conditions.

Associated with the sedimentation process, organics and nutrients will be transported downstream and coupled with low levels of dissolved oxygen in the water released during construction, could lead to a general lowering of dissolved oxygen in downstream reaches, thereby affecting fish survival.

(b) Post-Construction Period: As previously discussed, there will be substantial alterations to the seasonal and daily downstream flow and water level regime. Firstly, regarding seasonal flows, there will be an average flow reduction at Lincoln School of about 425 cubic meters/sec. (15,000 cfs) in the spring when Atlantic salmon smolts are moving seaward past hydroelectric dams at Mactaquac and Beechwood. This decrease in spring flows could have serious effects on smolt escapement at these installations by causing more fish to pass through hydroelectric turbines than surface outlets at the spillway gates. Also, reduced velocities may cause orientation problems in the headpond reaches of the river. This will have an adverse effect on adult salmon returns to the Saint John River. Even though fisheries would experience some improved flow condition during the remainder of the year, the net effect on the resource would likely be deleterious.

Wide within-the-day changes in river stage downstream from Lincoln School will occur. At the confluence of the Saint Francis and Saint John Rivers, within-the-day fluctuations in stage of from 1.7 to 1.8 meters (5.5 to 6.0 feet) will prevail depending on hydrologic conditions. Proceeding downstream from Lincoln School, local flow increases and natural attenuation will generally cause fluctuations in stage to diminish. As a result, any potential salmonid spawning and rearing area at least as far downstream as Edmundston could be damaged or even destroyed. This could occur through the exposure of spawning redds and the smothering of same through siltation and the redistributuion of sediments. Rapid changes in stage (0.5 meters or 1.5 feet per hour at the Saint John-St. Francis confluence) and fluctuations in stage and flow already referred to will have a depreciating effect on the diversity and abundance of salmonid food organisms and will result in slower growth of salmonids. On the other hand, cooler water temperatures during the summer months may favour salmonid habitat and growth as natural ambient stream temperatures regularly exceed 20°C during July and August.

Downstream fish populations will also suffer generally from a reduction of food supply as a result of being cut off from natural organic drift in their diet. In downstream reaches, a vital part of the food cycle system of a river is constantly being renewed in the form of invertebrates via drift from the more productive upstream areas. The extent to which this contributes to the diet of fish is difficult to quantify but invertebrate drift unquestionably contributes to productivity of fisheries.* The reservoirs at Dickey and Lincoln Schools will be virtual deserts, in terms of production, compared to the stream system presently in existence.

Rapid changes in downstream water stages will undoubtedly result in fish being stranded in littoral areas probably as far downstream as the upper end of the Grand Falls headpond but getting progressively more severe as one proceeds upstream to Lincoln School Dam.

As a result of impoundment and the levels from which downstream maintenance flows will be drawn, water temperatures below Lincoln School will be warmer in winter and cooler in summer. This change in thermal regime could cause the premature emergence of benthic invertebrate insect fauna thereby making this food source unavailable to salmonids venturing into these waters from tributary streams.

5.3 Wildlife

The draft EIS has predicted that there will be a 50% reduction in the number of deer present in the watershed as a result of the flooding of 53 deer yards. It has been observed that at least some of these deer utilize the area to be flooded in Quebec for habitat during part of the year. This flooded area is capable of providing habitat for an estimated 15-65 deer.

The reservoir will flood only one 16-head deer yard in Quebec. The project is not expected to have any major impacts on the wildlife resources of New Brunswick.

5.4 Agriculture

The project will have both upstream and downstream impacts on the agricultural resource base. These impacts relate primarily to the permanent flooding of agricultural lands in the area of the Dickey Reservoir and to reductions in flood hazards downstream.

The reservoirs will flood lands along the St. Roch River Valley which are used, in part, for agricultural purposes. Although it appears that this usage is of low intensity, the annual value of production on this land has not yet been adequately determined, nor has the agricultural potential of the remainder of the lands to be flooded in Quebec.

The Corps of Engineers has estimated that annual losses in the reach from Allagash to Hamlin, Maine, due to the sustained flooding of agricultural crops (primarily potatoes) are in the order of $179,000. Of this amount, an estimated 95% ($170,000) will be eliminated when the project is completed. This project will likely reduce crop losses to some extent on the New Brunswick side of this reach as well. This aspect will, however, require careful analysis.

Despite the fact that the Corps of Engineers has estimated a small benefit ($21,000 - $31,000/year or about 10% of current annual losses on the U. S. side) as a result of reduced streambank scour and erosion, it is anticipated that the pulsating character of the streamflow could even accelerate existing erosional processes. The degree to which the new regime will impact on agriculture and other uses along the riverbank is not known at this time.

5.5 Water Supply

The waters of the Saint John River are used as a source for private, municipal, agricultural, industrial and commercial water supply. At present, there are eight known major users of the water resource either directly or indirectly through gravel infiltration galleries. These users include villages, towns and cities along the river as well as major industries at Florenceville, Grand Falls, and Nackawic.

The increased sediment loads which will occur downstream of the dams during the construction phase could have a negative effect on infiltration galleries located above

Grand Falls by blocking the galleries or reducing their hydraulic efficiency. Water shortages could result if flows are not maintained at a sufficient rate.

Below Grand Falls the major concern centers on the McCains supply at Florenceville, where both increased sediment loads and low flows would create problems. This plant had experienced at least one shutdown in the past due to excessive sediment and low-flow conditions.

It is not anticipated that water supplies below Florenceville would be adversely affected by the project.

5.6 Indirect Effects

The preceding paragraphs of this section have described the major direct effects that the project will have on the freshwater and terrestrial environments of New Brunswick and Quebec. The Dickey-Lincoln School project will also have some indirect effects in Canada. In some cases, these effects will be of relatively short duration but in others they will create longer-term shifts in economic activity.

Because logging activities will inevitably shift from existing areas to the reservoir area, less attention will be paid to the management and exploitation of surrounding forested areas both in Quebec and Maine. This could have significant impacts on the long-term structure of the forest industry in these areas.

It is conceivable that construction of the Dickey-Lincoln School Dams could result in redevelopment of existing downstream power plants such as Grand Falls or in the development of additional sites such as at Morrill. The project could also result in a stronger transmission tie with the New England area, thereby creating a stronger and more reliable grid system for New Brunswick.

There has been no attempt in the draft EIS to assess the impact of construction of the Dickey and Lincoln School Dams on New Brunswick communities. In the north-western portion of New Brunswick, the movement of labor across the international boundary is common. The labor intensive construction phase of the Dickey-Lincoln project could increase this labor force movement on a daily basis, depending on the degree to which the United States restricts non-immigrant workers. While the draft EIS states that workers could possibly come from Canada, no quantitative estimate is provided. If an influx of New Brunswick labourers is expected and/or required, then the project would have an economic, social and physical impact on Madawaska County. These impacts could result from changes in growth affecting community services such as fire and police, retail services, social welfare services, schools, medical services, road networks, etc. (For example, the sewage and water systems at St. Francis de Madawaska and Clair are being used at or near capacity at the present time.) Since present community plans do not take into account any growth which could occur during the construction phase of the Dickey-Lincoln School Project, these plans may have to be reviewed and/or adjusted.

6. STUDY REQUIREMENTS

In view of the uncertainty surrounding the project within the United States and the absence of any formal advances to reopen treaty negotiations, the Technical Committee decided that it would not be practical to secure the necessary resources to proceed with studies at this time. Rather, it was decided that study requirements should be presented only in conceptual terms. This approach will serve to advise water managers concerning the nature and extent of environmental studies which should be carried out before a treaty would be finally negotiated. This section is designed to provide an outline of these studies. It is organized into four major sectors dealing with hydrology, flooding, the aquatic ecosystem and resource investigations.

6.1 The Hydrologic Regime

The impact of the proposed project on the hydrologic regime of the Saint John River lies not only at the heart of many of the environmental and resource concerns addressed in sections 4 and 5 of this report, but also at the center of energy generation at existing and proposed hydroelectric plants on the main stem of the Saint John River. Should hydrologic studies be required to assess the impact of the project on downstream energy generation, it would be desirable to coordinate the study requirements for such a study with those identified below. Furthermore, the Corps of Engineers plans to undertake Design Memorandum No. 2, Section V, Flood Analysis and Reservoir Regulation. It would be advantageous to phase any studies carried out in Canada with this latter investigation inasmuch as previous Corps of Engineers' investigations have heretofore not addressed real time operation of the project. Canadian involvement in the Corps of Engineers' investigation could range from observer status to joint participation. The former would ensure the accurate and timely transmittal of data while the latter would foster the integration of design criteria necessary to protect Canadian interests.

The hydrologic studies required to assess the impact of the project on Canadian environmental and resource concerns could be carried out in two phases. The first phase would be general in nature, involving the analysis of monthly and seasonal hydrologic regimes. The second phase would evaluate specific concerns and generally would assess the impact of the project on an hourly and weekly basis.

6.1.1 Phase One Investigations

Phase one investigations are primarily concerned with evaluating the effect of the project on the monthly and seasonal hydrologic regimes during the filling and post-construction (i.e. operational) periods for each scale of development at Dickey (initial development of 760 MW and ultimate development of 1140 MW). The following is a brief outline of each of the main components:

(a) Simulated monthly mean flows at the Lincoln School dam, for the period 1932-present, would be obtained from the Corps of Engineers for both the initial and ultimate design concepts.

As studies within the United States would be ongoing, this would likely be an iterative process as several sets of data could conceivably be developed,

(b) Monthly streamflow data would be obtained from the United States Geological Survey and Water Survey of Canada for the various hydrometric stations on the Saint John River and its major tributaries. Duration analysis would be carried out on a monthly basis using a common period.

(c) A simplified hydrologic model, based on water balance principles, would be developed for the Saint John River.

(d) Simulated outflows described in (a) above would be routed to each of the main stem hydrometric stations using the simplified hydrologic model. Monthly duration analysis would be carried out on the routed data and compared to natural conditions as determined from (b).

(e) The monthly streamflow regime at Dickey would be analyzed using a mass curve approach to determine critical refill periods in the historical hydrologic record. The Corps of Engineers would be requested to simulate monthly mean outflows during the filling period using each of the critical periods developed. The impact on monthly streamflow regimes would be analysed in a manner similar to that described above.

(f) Using rating curves at each hydrometric station on the main stem of the Saint John River, monthly mean water levels would be developed for each scale of development and compared to the historical water level regime using monthly water level duration analysis techniques.

(g) Monthly mean water levels for the Dickey Reservoir would be obtained from the Corps of Engineers for each scale of development and analyzed to determine (i) monthly regime and (ii) change in level on a yearly and seasonal basis. As with streamflows, several sets of data will require evaluation as alternative rule curves are developed.

Each of the hydrologic concerns referred to in sections 4 and 5 of this report would be assessed to determine whether or not there is in fact a basis for concern. Some of the concerns can be evaluated directly while others would require more detailed study.

6.1.2 <u>Phase Two Investigations</u>

It is difficult at this time to define requirements for detailed studies. The following is a conceptual outline of studies required should each of the concerns discussed in sections 4 and 5 of this report be justified by phase one studies described above. In view of the fact that many of the studies will require considerable data, e.g. hourly streamflows, it is suggested that U. S. investigations be well advanced before the following is implemented.

(a) Within-the-Day Variations in Flows and Water Levels

Many of the concerns, ranging from basic issues such as public safety/aesthetics to the stranding of fish in littoral areas, are highly dependent on within-the-day variations in streamflow and water levels; principally in the reach from the St. Francis River to the Grand Falls hydroelectric dam. In order to minimize the effort required to appreciate the modified hydrologic regime resulting from the project, it is suggested that representative periods, based on a review of phase one studies, be selected for further analysis. This might be accomplished by selecting high, median and low-flow periods for each of the four seasons. The Corps of Engineers would be asked to provide hourly flow estimates below the Lincoln School Dam for each of these conditions.

The Corps of Engineers has developed a hydrologic/hydraulic routing model for the reach between the proposed Lincoln School Dam and the Grand Falls hydroelectric dam. The model should be reviewed to determine whether it can be successfully applied and tested to ensure that it is properly calibrated. The Lincoln School hourly streamflows would then be routed through the model or a modified version thereof, to determine (i) water surface elevation and flow hydrographs at selected locations, (ii) average velocity vs time plots at selected locations, and (iii) river width vs time plots at selected locations. These data would then be analyzed to determine regime changes over specified periods.

On a daily basis, the impact of the proposed project on the hydrologic regime of the Saint John River downstream of Grand Falls will depend more on the operation of the main stem hydroelectric plants in New Brunswick than on the proposed project.

(b) Spillage at Main Stem Hydroelectric Plants

With the increased degree of regulation resulting from the proposed project, the amount of water spilled at downstream hydroelectric plants will be reduced. This hypothesis has led to a concern that smolts migrating downstream will suffer a higher mortality rate because more would pass through hydroelectric turbines than at present. Should phase one studies verify this concern, a more detailed study should be carried out. This would involve selecting the period of concern, reviewing hydrologic data to select typical years, and using models described above, to route daily flows to each of the main stem hydroelectric dams (Grand Falls, Beechwood and Mactaquac) under both pre-project and post-project conditions. Results would be interfaced with the fisheries investigations.

(c) Assimilative Capacity

In the long term, it is anticipated that the proposed project will increase the assimilative capacity of the river as a result of higher than normal streamflows during low-flow periods. However, during the filling period, anoxic release water coupled with lower than natural streamflow (yet to be substantiated) may reduce the assimilative capacity of the river. The nature and extent of hydrologic studies required to assess this issue is uncertain at this time. Monthly analysis of data may suffice. At the very minimum, a low-flow frequency analysis should be carried out for the Saint John River at Edmundston under pre-project, during construction and post-project conditions.

6.2 Flooding and Ice Jamming

Since the mid-sixties there has been a major thrust on the part of both the federal and provincial governments, toward the reduction of flood damage. Under the provisions of the Canada-New Brunswick Flood Damage Reduction Agreement signed on March 31, 1976, the two governments undertook to carry out flood risk mapping and flood forecasting studies in several flood prone areas along the main stem of the Saint John River as well as at other locations throughout the province. Should the Dickey-Lincoln School project be seen to significantly affect the flood risk in any or all areas along the main stem, it seems reasonable to conclude that both levels of government should investigate this aspect in more detail. The same reasoning applies to the possibility of aggravating or reducing flooding due to a change in the processes of ice formation and movement, especially since ice jams have produced some of the worst flooding events on record at several points along the main stem. Furthermore, flood forecasting activities presently rely on international co-operation to some extent. Should the Dickey-Lincoln School project proceed, international cooperation will be a pre-requisite for the successful implementation of flood forecasting in New Brunswick.

The Corps of Engineers plans to undertake Design Memorandum No. 2, Section V, Flood Analysis and Reservoir Regulation, should funds be appropriated by the U. S. Congress for further work. At this stage, regulation plans would be developed for the project including strategies to operate the Dickey and Lincoln School Reserviors for flood control.

The nature and scope of studies to be carried out in Canada will very much depend on the position taken respecting flood control benefits. Should Canada take a similar position to that taken in the mid-sixties, internal studies carried out by a Canada-New Brunswick Committee would be desireable. The Canada-New Brunswick Committee should have observer status on the Corps of Engineers' studies to ensure prompt and accurate transmittal of data and methodology. If, on the other hand, Canada takes the position that the project could result in significant flood control benefits, joint Canada-U. S. studies would be desirable. In the latter case, Canada would be in a position to jointly establish criteria for reservoir regulation, a technically superior alternative. The economic implications associated with the latter alternative remain to be established. Accordingly, the following strategy is recommended:

(a) Obtain the Corps of Engineers' hydrologic/hydraulic routing model for the reach from Lincoln School to Grand Falls.

(b) Check the calibration of the model by carrying out verification runs using selected historical floods. Re-calibrate the model if necessary.

(c) Develop a simplistic routing model for the

Saint John River from Grand Falls to Mactaquac. Use the hydrologic model for the Saint John River below Mactaquac developed by the Canada-New Brunswick Technical Committee on flood risk mapping.

(d) Review historical flood hydrographs at or near the various damage centers along the Saint John River in New Brunswick, probably Fredericton to Maugerville, and select several for further analysis.

(e) Request the Corps of Engineers to provide regulated daily mean flows at the Lincoln School Dam for each of the selected flood events.

(f) Using the models referred to above, route both pre-project and post-project flows to the damage center and analyze the effect of the project on the magnitude and duration of flooding.

(g) Assess alternative operating strategies to determine if added benefits can be derived.

At this point, a preliminary assessment can be made as to whether or not it would be economically feasible to pursue a joint Canada-U. S. study on flood control. Should it be decided not to pursue this avenue, more comprehensive studies within Canada may be desirable depending on the magnitude of flood control benefits perceived for Canada. This could range from the refinement of a hydrologic routing model to the establishment of a mechanism for future joint Canada-U. S. flood forecasting strategies. At the very minimum, it would be desirable to assess the various regulation strategies as and when they are developed by the Corps of Engineers.

The above relates to flooding downstream of the project. In Quebec, a substantial amount of land will be directly flooded (1640 hectares - 4050 acres). In the mid-sixties, an additional 690 hectares (1700 acres) were used as an estimate of the land mass that would be further affected by raising groundwater tables, erosion processes, etc. A study of the impact of the project on the surrounding land mass should be carried out to more precisely identify the amount and location of the land involved. This would involve (a) the topographical mapping of the area, (b) an analysis of the characteristics of the soils and surficial deposits involved and (c) an analysis of the wind/wave climate. This information would be used to determine the erosion potential of the land mass adjacent to the reservoir and the extent to which groundwater tables may be raised.

The above strategy is applicable to open water flooding. The impacts of the project on ice formation, ice movement and ice jamming are not very well understood at this time. The types of studies required to assess the impact of the project can range from "expert opinion" to cold laboratory physical modelling. As a starting point, it is suggested that a "panel of experts" be convened to examine the project from an ice perspective with specific reference to the reach above Grand Falls. The experts would obtain relevant data from the Corps of Engineers, the New Brunswick Electric Power Commission and the federal and provincial Environment departments. If the panel felt that ice would be problematic, the terms of reference for more detailed studies could be developed and implemented.

In recent years, the incidence of dam failures has increased which has in turn caused public concern. It is well known for example that residents along the Saint John River Valley have been concerned about the stability of the three hydroelectric dams during times of flooding. In fact, rumors during the 1976 ice jam flood concerning a crack in the Grand Falls dam, although unsubstantiated in fact, caused great concern for those people living in the river valley. It therefore seems reasonable that the impact of one or both of the proposed dams failing should be evaluated. It is also felt that a thorough review of final designs be carried out to ensure that the utmost attention is paid to the safety of the Canadian public.

6.3 The Aquatic Ecosystem

6.3.1 General

It is anticipated that the project will have major impacts on the water quality and aquatic ecosystem regimes of the Saint John River. As with the flow regime, it is expected that impacts will decrease proportionately to distance downstream of the project, the most affected area being the reach between the Dickey Dam and the Grand Falls Hydroelectric Dam. It is further anticipated that the major impacts will be associated with the construction period and for some 6-9 years thereafter. It is possible that over the long term, however, that overall water quality conditions could be improved relative to existing "natural" conditions.

Changes to the water quality and aquatic ecosystem regimes will depend on a number of key factors including the extent and method of reservoir clearing, the erosion control practices employed and the riparian flow policy adopted during both the construction and operational phases. The draft EIS touches on these issues but does not make specific recommendations. The "selector gate"* concept will provide a tool for the management of downstream water quality.

Despite the numerous monitoring programs undertaken on the Saint John River in the past, the physical, chemical and biological characteristics of the water resource is yet poorly documented. The strategy outlined below therefore incorporates the development of a water quality data base, to be initiated as soon as the decision is made to proceed with the project, and the monitoring of selected water quality and aquatic biology parameters during and after construction to provide a basis for water quality management. The strategy also includes an assessment component to provide a basis for negotiations on mitigating measures and residual impacts.

6.3.2 Review of Existing Information

The first phase of the program would involve a thorough review of existing data on water quality and aquatic biology for the Saint John River Basin with emphasis placed on the river upstream of Grand Falls. This will include a review of the final EIS prepared by the Corps of Engineers for the project. It would be necessary to hold discussions with the Corps of Engineers to obtain more detailed information, to explore critical areas and to discuss management options. Discussions would be held with Canadian water managers to discuss existing and intended

* See Section 3.2

water resource uses of the Saint John River.

Many studies exist relating the effects of man-made impoundments on the downstream aquatic ecosystem. A thorough literature review should be carried out to optimize monitoring programs and to assist in the preparation of guidelines for the assessment phase.

6.3.3 Baseline Monitoring Program

Based upon the review of existing information as described in 6.3.2 above, a baseline monitoring program would be designed and implemented. The importance of implementing such a program as soon as it is feasible and practical to do so must be emphasized. Ample time must be allowed to conduct the necessary assessment studies, as described in 6.3.4 below, which are required to assist water managers in decisions respecting mitigating measures and in developing a negotiating position.

The monitoring program would conceptually involve: a) the intensive monitoring of selected chemical, physical and biological parameters at representative locations; predominantly in the reach between the Grand Falls Dam and the confluence of the Saint John and St. Francis Rivers, b) the seasonal monitoring of species abundance and diversity of periphytes, macrophytes, invertebrates and fish and certain abiotic factors such as stream width, depth, substrata, gradient, shading and water temperature at selected representative locations; predominately in the reach between the Grand Falls Dam and the confluence of the Saint John and St. Francis Rivers,

c) the monitoring of the sediment regime at each of the hydrometric stations in the Saint John River upstream of the Mactaquac Dam including the Green, Aroostook and Tobique Rivers, and d) a volumetric survey at selected locations, with bed and streambank material sampling, along the main stem of the Saint John River, at its junction with major tributaries and in the headponds.

6.3.4 Assessment of Impacts

The basis for the prediction of the impacts of the project on the water quality and aquatic biology regimes has been established in sub-sections 6.3.2 and 6.3.3 above. The objectives of the assessment phase would include: a) prediction of water quality, sediment and aquatic biology regimes during each of the following periods, (i) construction prior to filling, (ii) construction during filling, (iii) post-construction prior to system equilibrium and (iv) post-construction subsequent to system equilibrium; b) the assessment of the impacts of alterations to the existing water quality regime on the various water users, c) the assessment of the impacts of alterations to the existing erosion/sediment regime on various water users, d) the evaluation of mitigating measures as proposed by the Corps of Engineers and the identification and evaluation of mitigating measures not proposed by the Corps of Engineers, but which could form a basis for a negotiating strategy and e) the identification of monitoring programs required to assess changes in the water quality, sediment and aquatic biology regimes as a result of the project.

6.4 Resource Investigations

Preceding paragraphs of this section have described the studies that will be required to assess the physical, chemical and biological impacts of the project in Canada. This paragraph identifies the studies required to evaluate the impacts on the resources discussed in section 5. In many ways, the study requirements are similar, the major difference being that the focus of this paragraph relates to the economic impacts on resources in the impact area, whilst preceding paragraphs have dealt essentially with physical impacts on the environment.

6.4.1 Forestry

A significant impact of the project will occur on the forest economies of Quebec and New Brunswick. In Quebec, these impacts will be related primarily to the loss of forest resources due to flooding and to employment considerations. In New Brunswick, the impacts are projected to occur largely in terms of a temporarily overloaded market and disruptions to normal employment patterns. It will be necessary to conduct studies of these impacts in order to minimize their effects or to suggest alternative strategies that should be followed during construction. The studies that will be required in this context are as follows:

1. Determine from the Corps of Engineers how much of the headpond area will be cleared and over what period; obtain an accurate estimate of the volume of wood products to be produced each cutting year from clearing the headpond (pulpwood

and sawlogs); assess alternative plans for disposal of this wood.

2. Determine the present employment and income structure of boundary communities in Quebec and New Brunswick, including labor participation and seasonality of employment.

3. Determine the present dependence of each boundary community on timber supply from Maine and from domestic sources, assess existing trends in log importation and in market prices for wood.

4. Estimate possible changes in the rate of importation of sawlogs during project construction phase, probable effects on market price of wood in these communities and the competitive position of provincial woodlot owners.

5. Estimate present and possible increased employment for Canadian labor in harvesting the reservoir area in Maine and Quebec. (In light of U. S. Immigration restrictions on non-immigrant workers, access to Canadian workers to such employment opportunities will depend on arrangements that can be reached in any treaty negotiations.)

6. Estimate subsequent impacts on the price of wood and employment in Canada to be caused by reduced access to Maine timber.

6.4.2 Fisheries

Most of the studies required to address fisheries concerns have been outlined in preceding sections dealing with hydrology and water quality, simply because many of the impacts foreseen relate to these two areas. However, there are some concerns for which studies have not yet been described.

For example, more information will be required on the extent of the resource and on the number and type of people exploiting it. To this end, baseline surveys of fish habitat, fish populations and existing fisheries should be carried out on the reach from the Lincoln School Dam to Grand Falls and on the reaches affected by the project in Quebec. The habitat characteristics measured should include aquatic and bank vegetation. A fish sampling program should be carried out during the summer. The distribution, abundance, age-composition, growth rates and mortality rates of valuable species should be estimated from this program. The distribution of other species should also be noted. Included in this survey should be a detailed study of the exact timing of smolt migration past each hydroelectric dam downstream of the Lincoln School Dam.

A survey of anglers should be carried out on the Saint John River, between Grand Falls and the confluence of the Saint John and St. Francis Rivers and on the streams affected by the project in Quebec, throughout at least one summer in order to assess the amount of angling effort that could be affected by the project. The data collected should include amounts and locations of fishing effort, residence of fishermen, species taken, and anglers' success. The catches should be sampled to obtain biological data.

6.4.3 Wildlife

Information should be obtained on existing wildflife populations and migration patterns in the area upstream of the proposed dam sites in Quebec. Estimates of local exploitation of this resource should also be made. These data should then be evaluated in terms of the changes that would occur if the project were to proceed.

6.4.4 Agriculture

The major concerns related to agriculture are flooding and the possibility of labor shortages in the agricultural sector. The former has been covered in the previous section outlining flood studies and the latter is considered as part of the employment study outlined below.

6.4.5 Water Supply

It will be necessary to gather baseline data concerning water users in those areas of Canada where significant hydrologic or water quality changes will occur. Discussions should be held with each user to determine the characteristics of each system including treatment processes and quantity used. Each system would then be evaluated to determine the impacts of the project and economic costs involved.

6.4.6 Other Studies

6.4.6.1 Manpower

To assess the social and economic effects of the project, it will be important to obtain information on the manpower status in the impact area. This will include the present labor situation, as well as the likely effects on employment, wages, and geographic mobility of Canadian workers. The type of information required would be recent data on labor supply and demand by occupational classification, recruitment rates, participation rates, employment rates, seasonality, and an accurate estimate of surplus manpower by occupational classification. In addition, there should be a review of the trades training facilities in the area to get some appreciation of how quickly people could be trained (and in what number) for key construction occupations. Appropriate Canadian labor unions should be informed and consulted on the possibilities of increased or decreased opportunities. The same type of data will then need to be requested from the U. S. Labor Department to obtain a comprehensive picture of the labor situation in the impact area.

It would then be necessary to develop a detailed labor demand projection for each construction year by occupation. At lease three labor supply scenarios should be developed:

1. a forecast that includes existing ratios of U. S.: Canadian workers in Maine for those occupations where currently and historically there has been an importation of Canadians, e.g. "fallers" in the wood industry;

2. a forecast that includes an increase in Quebec and Madawaska workers from the impact area for both clearing and construction work, on the theory that a U. S./ Canada treaty the project could include a provision that gives priorities to workers from the Canadian impact area since they would suffer the negative consequences of the project; and

3. a forecast that includes a decrease in existing ratios of Canadian : U.S. workers in Maine based on the proposition that Canadian labor will be curtailed for the project due to fairly high unemployment roles of the north eastern U.S.

From these scenarios and the estimated labor requirements of the project, estimates of possible employment opportunities for workers from Canada could be developed. This information will then be used as a basis for determining whether there will be an influx of workers into the construction area. Once this has been established, the social impacts of the project will be easier to predict.

6.4.6.2 Municipal Services and Facilities

If it appears there will be substantial worker influx into the construction zone, (either from elsewhere in Canada or from the United States), comprehensive profiles of the affected communities in Canada should be developed. These profiles would inventory present services/facilities and estimate the capacity of each to expand,at what cost, and the economic impact after construction workers leave. This could include such items as housing, water supply, sewage disposal, and other amenity services such as retail outlets and schools. Local attitudes to the project should also be sampled in order to obtain a better understanding of how the social and economic changes implied by the project will be received.

6.4.6.3 Reservoir Creation

The Dickey Reservoir will effectively eliminate the use of approximately 2,310 hectares (5,700 acres) of land in Quebec. The land required for the reservoir and its buffer zone will mean the relocation of several homes (particularly in the St. Pamphile area); the elimination of some land uses; a change in relative property values, and some forested crown land, as well as marginal farmland, thereby resulting in the loss of revenue to the province. Several roads and bridges will have to be rebuilt or re-routed, and there may be a need for upgraded sewage systems because of the creation of the reservoir.

In order to assess these possible impacts, it will be necessary to obtain baseline information on land use, population (specifically those who would be displaced), property values, and water supply and sewage disposal systems in the vicinity of the reservoir in Canada. It will then be necessary to project changes in each of these paramaters based on the creation of the Dickey Reservoir. The costs and other implications of rebuilding or re-routing roads and bridges should be identified. The preferred method of compensating private and public lands to be flooded should also be outlined. The possibilities of reducing flooding (i.e. a lower reservoir elevation) and minimizing reservoir fluctuations should not be overlooked.

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APPENDIX 1

DFE Technical Committee

Individuals and Agencies Involved

Name	Agency
M. Arif	N. B. Municipal Affairs
W. Ayer	N. B. Environment
G. E. Beanlands	Lands Directorate - Atlantic Fisheries & Environment Canada
L. Bernier-Arcand	Inland Waters Directorate - Quebec Fisheries & Environment Canada
K. Browne	N. B. Environment
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A. L. Couillard	Quebec Environment
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P. Mathieu	Quebec Natural Resources
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J. Merser	N. B. Electric Power Commission
D. Neilson	N. B. Agriculture
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W. R. Trenholm	N. B. Agriculture
Y. Vigneault	Inland Waters Directorate - Quebec Fisheries & Environment Canada
G. M. Weaver	N. B. Liaison Officer Agriculture Canada

Appendix 2

Proposed Dickey-Lincoln School Hydroelectric Project

Summary of Physical Characteristics

WATER RESOURCES DEVELOPMENT PROJECT

SAINT JOHN RIVER BASIN

DICKEY-LINCOLN SCHOOL LAKES

MAINE, USA AND QUEBEC, CANADA

DESIGN MEMORANDUM NO. 4A

GENERAL DESIGN (REVISED)

A. PERTINENT DATA

1. DICKEY DAM.

a. Purpose. — Multipurpose power

b. Location.

State	Maine
County	Aroostook
River	Saint John
Distance from Fort Kent, Maine	28 miles

c. Streamflow.

Average annual runoff	3,309,300 acre-ft.
Maximum discharge	87,200 cfs
Minimum discharge	129 cfs
Average annual discharge	4,600 cfs

d. Reservoir.

Drainage area	2,725 sq. mi.
Maximum operating level	910 ft. msl
Minimum operating level	868 ft. msl
Total storage	7,700,000 acre-ft.
(Inactive storage)	(4,800,000)
(Useable storage)	(2,900,000)
Water area at maximum operating level	86,000 acres

e. Embankments.

North Dam

Type: Rolled earth fill with rock fill protection on upstream face and processed gravel and cobbles on downstream face

DICKEY DAM (Cont'd)

Elevation, top of embankment	925 ft. msl
Top width	30 ft.
Length	3,860 ft.
Maximum height above streambed	335 ft.
Maximum base width	2,240 ft.
Slope, upstream above Elev. 760 ft. msl	1 on 2.75*
Slope, upstream below Elev. 760	1 on 4
Slope, downstream above Elev. 760	1 on 2.75
Slope, downstream between Elev. 760 and 630	1 on 4
Slope, downstream below Elev. 630	1 on 2.5

South Dam

Type: Rolled earth fill with rock fill protection on upstream face and processed gravel and cobbles on downstream face

Elevation, top of embankment	925 ft. msl
Top width	30 ft.
Length	4,380 ft.
Maximum height	280 ft.
Maximum base width	1,750 ft.
Slope, upstream	1 on 3
Slope, downstream above Elev. 650 ft. msl	1 on 3
Slope, downstream below Elev. 650	1 on 2.5

f. Penstock Headworks

Type: Concrete non-overflow section with selective withdrawal gate structure

Elevation, top of wall		925 ft. msl
Top width		110 ft.
Length		560 ft.
Invert elevation at intake		801 ft. msl
Invert elevation at penstock		810 ft. msl
Selector gates:	Number	16 (initial) 8 (future)
	Size	20 ft. wide x 86 ft. high
Tractor gates:	Number	4 (initial) 2 (future)
	Size	21.25 ft. wide x 27 ft. high
Bulkhead gates:	Number	4 (initial) 2 (future)
	Size	21.25 ft. wide x 27 ft. high

*All slopes expressed in ratio of vertical to horizontal dimension

g. Non-overflow Wall

Type:	Concrete Gravity Wall
Elevation, top of wall	925 ft. msl
Top width	30 ft.
Length	830 ft.
Maximum height	145 ft.
Slope, upstream	12 on 1
Slope, downstream	2 on 1
Grout Gallery	6 ft. wide x 8 ft. high

h. Spillway

Type: Uncontrolled, concrete ogee overflow with converging chute channel

Crest elevation	910 ft. msl
Crest length (net-excludes piers)	600 ft.
Maximum design surcharge	8.8 ft.
Design discharge	60,000 cfs

i. Diversion Works - Low Level Outlet Works

Type: Concrete-lined tunnel with mid-tunnel control

Diversion tunnel:	Size (inside diam.)	26 ft.
	Length	2,170 ft.
	Invert Elev. at Intake	589 ft. msl
Access tunnel:	Size (inside diam.)	14 ft.
	Length	750 ft.
Bulkhead gate:	Number	1
	Size	26 ft. x 26 ft.
Operating gates:	Number	6
	Emergency	(3)
	Service	(3)
	Size	5 ft. wide x 10 ft. high
	Type	Hydraulically-operated slide
Capacity of tunnel, diversion period		33,000 cfs
Capacity of gates (w/spillway crest head)		19,000 cfs

j. Outlet Works - Upper Level

Type: Concrete-lined tunnel with upstream gate tower

Tunnel:	Size (inside diam.)	26 ft.
	Length	970 ft.
	Invert Elev. at Intake	700 ft. msl
Bulkhead gate:	Number	1
	Size	7.5 ft. wide x 15 ft. high

Operating gates:	Number	6
	Emergency	(3)
	Service	(3)
	Size	7.5 ft. wide x 15 ft. high
	Type	Hydraulically-operated slide
Capacity of gates (w/spillway crest head)		32,000 cfs

k. Power Plant

Powerhouse:	Type	Indoor type, concrete

Initial Installation

Penstocks:	Number	4
	Type	Steel pipe
	Size (inside diam.)	27 ft.
	Length, total	3,100 ft.
Turbines/Generators:	Number	4
	Type	3-Francis turbines direct-connected to 190,000 KW, 3 phase, 60 cycle generators (144 RPM) 1-Francis pump/turbine direct-connected to 190,000 KW, 3 phase, 60 cycle, generator/motor (85.7 RPM)

Future Installation

Penstocks:	Number	2
	Type	Steel pipe
	Size	27 ft.
	Length, total	1,400 ft.
Turbines/Generators:	Number	2
	Type	Francis pump/turbine direct-connected to 190,000 KW, 3 phase, 60 cycle, generator/motor (85.7 RPM)

Design Head (Gross)	295 ft.
Rated Head (Gross)	248 ft.

Proposed Nameplate Capacity:

Initial Installation

3 Conventional Units @ 190,000 KW	570,000 KW
1 Reversible Unit @ 190,000 KW	190,000 KW
Total Initial	760,000 KW

Future Installation

2 Reversible Units @ 190,000 KW	380,000 KW
Total Ultimate Capacity	1,140,000 KW

Per Unit Hydraulic Capacity:

Generating @ Design Head	9,500 cfs
Pumping @ Average Head	8,000 cfs

1. Principal Quantities - North and South Dams

Common Excavation	8,520,000 c.y.
Rock Excavation	4,950,000 c.y.
Earth Fill	53,940,000 c.y.
Rock fill and slope protection	2,130,000 c.y.
Concrete	630,000 c.y.

2. LINCOLN SCHOOL DAM

a. Purpose — Stream flow reregulation, hydroelectric power, lower pool storage for pump back.

b. Location

State	Maine
County	Aroostook
River	Saint John
Distance from Fort Kent, Maine	17 miles
Distance downstream from Dickey Dam	11 miles

c. Streamflow

Average annual runoff	4,780,300 acre-ft.
Maximum discharge	110,000 cfs
Minimum discharge	220 cfs
Average annual discharge	6,600 cfs

LINCOLN SCHOOL DAM (Cont'd)

d. Reservoir

	Initial	Ultimate
Drainage area		4,086 sq. mi.
Maximum operating level	612	620 ft. msl
Minimum operating level	595	590 ft. msl
Total storage	67,150	86,355 acre-ft.
Inactive storage	(34,700)	(27,265)
Useable storage	(32,450)	(59,090)
Area at maximum operating level	2,240	2,620 acres

e. Embankment

Type: Rolled earth fill with rock slope protection, processed gravel and cobbles on upstream face and processed gravel and cobbles on downstream face

Elevation, top of embankment	630 ft. msl
Top width	40 ft.
Length	1,520 ft.
Maximum height above streambed	90 ft.
Maximum base width	670 ft.
Slope, upstream above Elev. 625 msl	1 on 2
Slope, upstream between Elev. 625 and 590	1 on 3
Slope, upstream between Elev. 590 and 560	1 on 4
Slope, upstream below Elev. 560	1 on 6
Slope, downstream above Elev. 625	1 on 2
Slope, downstream between Elev. 625 and 560	1 on 3
Slope, downstream below Elev. 560	1 on 2.5

f. Spillway

Type:		Gated
Gates:	Number	4
	Type	Tainter
	Size	60 ft. wide x 50 ft. high
Sill elevation		570 ft. msl
Elevation, top of gates		620 ft. msl
Maximum design surcharge elevation		625 ft. msl
Design discharge		318,500 cfs

g. Power Plant

Powerhouse: Type	Indoor type, concrete
Turbines/Generators: Number	3
Type	Kaplan turbines direct-connected to 3 phase, 60 cycle generators - 2 rated at 30,000 KW (94.7 RPM) and 1 rated at 10,000 KW (163.6 RPM)
Design Head (Gross)	64 ft.
Rated Head (Gross)	50 ft.
Proposed Nameplate Capacity	
2 @ 30,000 KW	60,000 KW
1 @ 10,000 KW	10,000 KW
TOTAL	70,000 KW
Total Hydraulic Capacity	16,000 cfs
Minimum Release (Instantaneous)	1,000 cfs

h. Principal Quantities - Lincoln School Dam

Common Excavation	780,000 c.y.
Rock Excavation	1,573,000 c.y.
Earth fill	1,214,000 c.y.
Rock fill and slope protection	242,000 c.y.
Concrete	94,000 c.y.

3. DIKES

Falls Brook Dike

Type: Rolled earth fill with rock slope protection and gravel fill on upstream face and rock slope protection and rock fill on downstream face

Elevation, top of embankment	925 ft. msl
Top width	25 ft.
Length	3,450 ft.
Maximum height	141 ft.
Minimum base width	840 ft.
Slope, upstream	1 on 3
Slope, downstream	1 on 2.5
Embankment volume	2,264,000 c.y.

DIKES (Cont'd)

Hafey Brook Dike

Type: Rolled earth fill with rock slope protection and gravel fill on upstream face and rock slope protection and rock fill on downstream face

Elevation, top of embankment	924 ft. msl
Top width	25 ft.
Length	2,150 ft.
Maximum height	62 ft.
Maximum base width	390 ft.
Slope, upstream	1 on 3
Slope, downstream	1 on 2.5
Embankment, volume	985,000 c.y.

South Dike

Type: Rolled earth fill with rock fill protection on upstream face and processed gravel and cobbles on downstream face

Elevation, top of embankment	924 ft. msl
Top width	25 ft.
Length	1,170 ft.
Maximum height	15 ft.
Maximum base width	120 ft.
Slope, upstream	1 on 3
Slope, downstream	1 on 2.5
Embankment volume	58,300 c.y.

Cunliffe Brook Dike

Type: Rolled earth fill with rock fill on upstream face and select gravel and cobbles on downstream face

Elevation, top of embankment	924 ft. msl
Top width	25 ft.
Length	1,050 ft.
Maximum height	26 ft.
Maximum base width	170 ft.
Slope, upstream	1 on 3
Slope, downstream	1 on 2.5
Embankment volume	64,600 c.y.

Campbell Brook Dike

Type: Rolled earth fill with rock fill on upstream face and select gravel and cobbles on downstream face

Elevation, top of embankment	924 ft. msl
Top width	25 ft.
Length	700 ft.
Maximum height	9 ft.
Maximum base width	73 ft.
Slope, upstream	1 on 3
Slope, downstream	1 on 2.5
Embankment volume	16,600 c.y.

4. REAL ESTATE

Estimated Lands in Fee (U.S. only)	121,680 acres
Improved properties	256

5. RELOCATIONS

State and local highways	8.9 miles
Cemeteries:	5 (281 graves total)
Telephones and electric lines	8 miles

6. ESTIMATED PROJECT COSTS

01.	Lands and Damages	$ 32,300,000
02.	Relocations	7,700,000
03.	Reservoir	32,000,000
04.	Dams	243,400,000
07.	Power Plants	169,000,000
08.	Roads and Bridges	2,500,000
14.	Recreation	950,000
18.	Cultural Resources Preservation	900,000
19.	Buildings, Grounds and Utilities	1,750,000
20.	Permanent Operating Equipment	900,000
30.	Engineering and Design	23,900,000
31.	Supervision and Administration	28,700,000
	TOTAL ESTIMATED PROJECT COST (CORPS)	$544,000,000
	TOTAL ESTIMATED TRANSMISSION COST (DOI)	146,300,000
	TOTAL	$690,300,000

7. <u>ECONOMIC ANALYSIS</u>

	3-1/4%	6-3/8%
a. Initial Development		
Annual Benefits	77,969,000	78,930,000
Annual Costs	37,696,000	63,586,000
Benefit-to-Cost Ratio	2.1 to 1	1.2 to 1
b. Ultimate Development		
Annual Benefits	100,905,000	97,202,000
Annual Costs	48,282,000	73,756,000
Benefit-to-Cost Ratio	2.1 to 1	1.3 to 1

8. CONSTRUCTION PERIOD 7.5 years