9 Small Hydroelectric Plants

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9.1 Island Pond Development

9.1.1 Project Background

The proposed Island Pond development is a 36 MW hydroelectric project that would be constructed in the southern part of Newfoundland as part of the Isolated Island Option. The in-service date for this development set out in the generation expansion plan is 2015.

The Island Pond development has been the subject of seven studies to date. The initial desktop study was followed by a pre-feasibility study in 1986 and a feasibility study in 1988. Following completion of the feasibility study, an optimization study was carried out in 1988 and two re-optimization and cost update studies were completed in 1997. Findings from the most recent study are described in a 2006 report by SNC Lavalin.[192]

9.1.2 Basis for Review

The primary considerations for determination of the CPW contribution from a hydroelectric project are the capital cost of the project, the operating and maintenance costs and expected energy production and project capacity. Since operating and maintenance costs for hydroelectric projects are relatively low and predictable, at the planning stage the greatest uncertainty typically lies in the capital costs and expected energy production. These issues were therefore the focus of MHI's review.

MHI's review was limited to the documents provided by Nalcor, in particular Exhibit 5b "Studies for Island Pond Hydroelectric Project", Confidential Exhibit CE-57 "Capital Cost Estimates", Exhibit 52 "Island Pond Granite Canal Re-Optimization", Exhibit 53 "Island Pond Final Feasibility Study", and Exhibit 69 "Geotechnical Site Investigations Proposed Island Pond Hydro Electric Development".

The earlier studies, as described in Exhibit 5b, were conducted in a logical process involving the advancement of the level of work, optimization to consider additional alternatives and updating of cost estimates. All of these studies were carried out by consulting firms that have a credible history in engineering for hydroelectric projects.

9.1.3 Project Description and Background

The Island Pond Hydroelectric project site is located on the North Salmon River in the south-central region of Newfoundland. The project would utilize most of the 25 m of undeveloped gross head between the Meelpaeg Reservoir and the existing Upper Salmon hydroelectric development.

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[192] Exhibit 5b, SNC Lavalin, "Studies for Island Pond Hydroelectric Project", December 2006

The Meelpaeg Reservoir serves as upstream storage for other plants and is already well regulated. Flow for the new project would be diverted from Meelpaeg Reservoir into Island Pond via a 3,000 m long Diversion Canal and 3,400 m of channel improvements within Meelpaeg Reservoir and Island Pond. A 750 m Forebay Canal would then convey water from Island Pond to the Island Pond Hydroelectric Project powerhouse. The powerhouse would discharge into a relatively short tailrace channel ending in Crooked Lake.

The powerhouse is envisaged to be close-coupled with the intake. It would contain a single vertical Kaplan turbine with a synchronous generator that would produce 36 MW at a rated head of 22.3 m. The powerhouse would be constructed in an excavation on the right bank of the channel between Island Pond and Crooked Lake and would abut a relatively short concrete dam.

A spillway is not required for the project since flood flows from Island Pond and Meelpaeg reservoir can be stored in the reservoir and routed through the existing regulated system.

9.1.4 Level of Site Investigations

Topography

Topographical mapping was considered adequate for a feasibility level study although further survey work was recommended prior to design.

Uncertainties in bathymetry would have the greatest potential impact on components that involve large areas and relatively shallow excavations. In the case of Island Pond, such structures include the canals, channel improvements, tailrace excavations and HADD (Harmful Alteration, Disruption or Destruction of fish) compensation areas. Since the estimated cost of these components form a significant portion of the total direct costs, any uncertainty in bathymetry could have a large impact. However it should be possible to mitigate the cost implications by redesign to accommodate the actual bathymetry and topography once this information has been established.

Subsurface Conditions

Site geotechnical investigations for the proposed Island Pond hydroelectric development were carried out as part of the 1988 studies and further investigations were carried out in conjunction with the 2006 studies. The 2006 investigation included a review of previous reports on geotechnical investigations and additional site investigations at the proposed site of the dam, powerhouse, access roads and camp.

The level of the site subsurface investigations is generally in keeping with feasibility level studies. Some areas where uncertainties remain include:

- The extent to which protection against acid generating rock, which impacts the integrity of the concrete, was uncertain. The geotechnical investigations confirmed the presence of acid generating rock in the area of the powerhouse and dam and suggested additional investigations to better delineate the extent of acid generating rock in the forebay canal and tailrace.
- The depth of overburden in the area of submerged excavations required further study. The 2006 investigations relied on the preliminary design and quantities from earlier studies due to

limitations in the 2006 scope. These quantities were reported to be based on a design that would minimize or eliminate rock excavation since rock excavation would be much more costly than overburden. Based on the results presented in Exhibit 53, it would appear that the depth to rock was only confirmed at six locations along the submerged portion of the diversion canal and the channel improvements. Given the length and large surface areas of the diversion canal and channel improvements, this leaves considerable uncertainty with respect to the profile of the top of rock in these areas. However, it should be noted that, at the final design stage and even at the construction stage, it should be possible to mitigate the impact of higher than anticipated rock elevations by modification of the design.

Construction Materials

The site investigations included an evaluation of the suitability of alternative sources of construction materials and the identification of material sources for concrete aggregate and fills.

Environmental

Exhibit 5b, the 2006 report, included updates to reflect the current requirements for key environmental issues. This included construction of HADD mitigation measures and allowance for treatment of acid generating rock.

The extent of HADD mitigation was based on an assessment of fish and fish habitat by Nalcor. In recognition of a relatively high level of uncertainty associated with the mitigation measures, a contingency of 30 % was included in the 2006 cost estimates for HADD compensation.

The 2006 report does not include any discussion of ramping effects on fish due to changes in discharge from the plant either under normal operating conditions or during an unplanned unit shut-down due to a fault. This could be due to the fact that the knowledge and emphasis on ramping effects has been dealt with only recently and was not known when the study was undertaken. While it would appear that ramping effects in the tailrace channel would not be large, this is a relatively complex issue and mitigation measures such as bypass flow release facilities could be quite costly if found to be necessary to meet current requirements.

9.1.5 Preliminary Designs

Level of Engineering

The 2006 study, Exhibit 5b, included a comprehensive review of earlier reports and files and was generally structured so as to build on work done in earlier studies. As such, the 2006 investigations had the benefit of the accumulated knowledge and engineering evaluations from previous work as well as the perspectives of the consultants who undertook those studies.

Project Arrangement

The selection of an appropriate project arrangement typically has an important impact on the technical feasibility, constructability and financial viability of a hydroelectric project.

The proposed Island Pond arrangement is relatively straightforward. The consultant that conducted the 2006 investigations states that the project is technically feasible and MHI's review did not reveal any issues that would suggest otherwise.

The 2006 studies did rely on earlier work or client decisions for some quite significant aspects of the preliminary design. These included:

Project Capacity

The project capacity of 36 MW was based on optimization studies conducted in 1997 and presented in Exhibit 52. These studies indicated that the optimum capacity for Island Pond would be about 36 MW based on 1996 energy and capacity values. The studies also showed that the relationship between Net Present Worth was quite insensitive to project capacity over a range of about 30 to 42 MW. Re-optimization of capacity for the 2006 studies would therefore not be expected to have resulted in changes to the CPW of the Isolated Island Option that would be significant in the context of the present evaluation.

Number and Type of Units

The 1997 Island Pond studies, Exhibit 52, included consideration of different unit types and numbers. Those studies indicated that,

- A plant with a single unit Francis turbine would be somewhat less costly than a two unit plant.
- A plant with two Francis units would be somewhat less costly than a plant with two Kaplan turbines.
- Comparative energy production estimates for the alternative sizes and types of units indicated that there would be little difference in annual energy production.
- If the Francis units were operated at peak efficiency, there would be little difference in energy production and this option could be chosen.

The selection of Kaplan type units for the 2006 studies is indicated to have been based on the need to allow operation at low flow during some parts of the year for environmental reasons. Based on the 1997 findings, the selection of a single Kaplan turbine as the basis for the 2006 studies would be expected to have had only a marginal impact on the project cost and energy production relative to other options.

Diversion Canal and Channel Improvements

The scope of the 2006 investigations required the consultant to use the diversion canal geometry and quantities from 1997 studies, Exhibit 52. The consultant that undertook the 2006 studies did recommend that further investigation of alternative canal and channel alternatives be investigated before final design. However, the 1997 studies, which included re-optimization of the diversion canal geometry using 1996 energy and capacity values, indicated that the Net Present Worth of the canal was relatively insensitive to the canal invert level. Based on these findings, reuse of the 1997 diversion canal parameters without re-optimization in 2006 would therefore not, for the purposes of systems planning, be expected to have significantly impacted the CPW of the Island Pond project.

Dam and Powerhouse Arrangement

The 2006 studies, Exhibit 5b, were restricted to consideration of zoned earth-fill, roller compacted concrete and conventional concrete dams or some combination of these three dam types.

The arrangement with a close-coupled intake/powerhouse in combination with a roller compacted dam was used as the basis for the 2006 quantity and cost estimates as presented in Exhibit 5b. Comparative quantities and costs were not included in the report. However, there are no obvious reasons to suggest that the selected arrangement would appear to be inappropriate and project cost estimates would not significantly impact the CPW for the Isolated Island Option.

The project arrangement as presented in the 2006 report, Exhibit 5b, is relatively straightforward. Construction sequencing and dewatering requirements have been considered, as have permanent and construction access roads, construction materials, construction facilities, reservoir clearing and mitigation of HADD. Transmission line interconnections, substations and communications arrangements were provided by the owner.

The preliminary arrangements and construction sequencing for the project are based on conventional approaches. However, it is possible that the 1988 concepts relating to the construction of the diversion canal and the channel improvements, and dewatering of Island Pond could be subject to more stringent environmental considerations than would have been applicable at the time the concepts were first developed.

9.1.6 Capacity and Energy Estimates

For a full description of capacity and energy estimates for Island Pond, see the Hydrology Report, section 2.4.

9.1.7 Construction Schedule

The 2006 report presented in Exhibit 5b, indicates that a duration of 3 ½ years would be required from commitment of the project to first power. This schedule is based on a multi-contract design/bid/build approach that allows preparatory work such as engineering and contracting to proceed in parallel with the regulatory approvals process. The 2006 schedule allows only one year for regulatory approvals based on expediting the process at every step. The schedule is also based on initiation of the process by late spring of year one in order to permit some construction activities to comply with seasonal constraints. Even a relatively small slippage in the early stages of the project could therefore result in a delay of a year. Given these constraints and the nature of the project, the schedule presented in the 2006 report is quite aggressive, especially given the ever increasing scrutiny during the regulatory process. The risk analysis carried out as part of the 2006 report identifies schedule delays as the key risk associated with the Island Pond project.

9.1.8 Estimated Costs

Capital cost inputs to the Strategist Model were entered in the form of direct capital costs in 2010 dollars and were distributed over the years in which expenditures are expected to occur in order to generate the cash flow in 2010 dollars. Escalation of the direct capital costs beyond January 2010 and the AFUDC were computed within the Strategist model.

The original scope for the 2006 study presented in Exhibit 5b called for the development of capital cost estimates with a requirement for an accuracy of ±10%. This requirement was replaced by a requirement to undertake a risk analysis of the final cost estimate. The scope of work was otherwise not specific with respect to the class or level of estimate that was to be prepared.

The estimated capital cost contained in Exhibit 5b and Exhibit CE-57 is presented in December 2006 dollars. The direct capital cost estimates for the project included:

- The various project components and an estimate for HADD mitigation measures.
- The project estimate included costs for those aspects of the project to be undertaken by the owner; primarily the telecommunications, transmission, switchyard, and control and protection required to interconnect the project to the grid. A contingency allowance of 10% was applied to these items.
- An estimate for management and engineering fees was based on 12.5 % of the direct capital costs plus contingency for the work estimated by the consultant. No separate allowance for engineering and management was provided for the work estimated by the owner.
- An estimate for owner's costs was based on 8.7% of all direct capital costs plus contingencies.[193]

The total estimated cost of the project with escalation and AFUDC was $166 million in 2010 dollars.[194]

The cost estimates are based on a fairly detailed and comprehensive breakdown of the construction quantities, equipment and facilities including construction support facilities. The estimates also include costs for management, engineering and owner's costs. Some contractor overheads such as mobilization and demobilization are not separately identified so these are assumed to be distributed amongst the unit prices for construction.

Exhibit 5b indicates that the capital cost estimates for civil works were developed with input from a contractor with experience in construction of hydroelectric plants including plants in Newfoundland. Estimates for major components such as the turbine-generator, transformers and electrical and mechanical equipment were based on enquiries to suppliers and the experience of the consultant. The consultant did conduct a risk analysis to assess the likely range of project costs. Based on this analysis it was concluded that there was less than a 10% probability that the final costs would vary from the estimated costs by more than about plus 2.6% to minus 2.4%. This would suggest a very high level of confidence. The consultant indicated that the level of engineering was considered to be at the feasibility level although quantities for the diversion canal and channel improvements were based on earlier studies. The consultant has noted some discrepancies relative to more recent survey work. The definition of environmental mitigation measures also involves significant uncertainty as does the construction schedule which is based on an aggressive methodology for regulatory approvals.

The cost estimate was not otherwise defined in terms of industry recognized class or level designations.

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[193] Exhibit 5b, SNC Lavalin, "Studies for Island Pond Hydroelectric Project", December 2006, pg. 80
[194] Nalcor's Submission to the Board of Commissioners of Public Utilities with respect to the Reference from the Lieutenant-Governor in Council on the Muskrat Falls Project, November 2011, pg. 39

Nalcor advised that the estimate for Island Pond is considered to be at the screening level or feasibility level which would suggest a much broader range of projected costs.[195] The uncertainty with respect to Island Pond would not appear to be inordinately high relative to a typical feasibility study, although reliance on work from previous studies for significant components of the work and lack of certainty with respect to some environmental and schedule related issues does introduce additional uncertainty. Given these considerations, the levels of contingency included in the Island Pond estimates appear to be quite modest. Under those circumstances and given the nature of some of the key uncertainties, the likelihood of an increase in project costs would appear to be substantially greater than the likelihood of a decrease.

The escalation applied by Nalcor to obtain 2010$ direct cost inputs for the Strategist model was compared with the Nalcor escalation factors for the Muskrat Falls project as presented in Exhibit 3. Application of the escalation factors in Exhibit 3 to the various categories of the 2006 capital cost estimates in Exhibit 5b yielded a total 2010 capital cost that was within 1.2% of the Strategist input. This difference might well be explained by differences in allocating costs to the various escalation indices presented by Nalcor.

9.1.9 Other Inputs to the System Planning Process

The feasibility study, Exhibit 5b, indicates that the rated capacity of Island Pond would be 36 MW. This corresponds to the Strategist input indicated in Exhibit 14 for the Isolated Island options.

Energy inputs have been defined in the Hydrology Study. See section 2.4 for details.

Exhibit 12 indicates that a forced outage rate of 0.9% was used for all new hydro developments in the Strategist inputs. This rate is based on the average reported forced outage rate for Newfoundland and Labrador Hydro units for the five year period prior to 2006.

An outage rate of 0.9% is somewhat lower than the average rate for units of comparable size operated by members of the CEA for the five year period prior to 2006. Outage rates do vary significantly amongst operators of hydroelectric plants due to a number of factors including maintenance practices, control and protection schemes, size and design of units, and site specific conditions amongst others. However, there is no obvious reason that maintenance practices for Island Pond should be different than for other hydroelectric plants in the NLH system. The 36 MW Island Pond turbine-generator unit would be about one half the capacity of the majority of NFL's hydro units and smaller units do generally tend to have higher outage rates. However, the Canadian Electrical Association does not distinguish between outage rates for units in the range of 24 to 99 MW. This range encompasses most of the existing NLH units as well as Island Pond. In summary, the use of an outage rate of 0.9% for Island Pond is appropriate for planning purposes.

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[195] Response to RFI MHI-Nalcor-34

9.2 Round Pond Development

9.2.1 Project Background

Round Pond is a proposed 18 MW hydroelectric project that would be constructed in the Bay d'Espoir drainage basin in Newfoundland. The project is included in the Isolated Island expansion plan with an in-service date of 2020.

The Round Pond development was first investigated in a desktop study by Acres International in 1985. The investigations were upgraded in a 1987/1988 feasibility study conducted by Shawinigan/Fenco and the findings were documented in Volume 1 of a September 1988 report entitled "Feasibility study Round Pond Hydroelectric Development". The engineering department of Newfoundland and Labrador Hydro undertook companion studies of transmission, telecontrol and environmental issues and prepared a Summary Report dated February 1989 that incorporated the findings from Shawinigan/Fenco's investigations.

9.2.2 Basis for Review

The primary considerations for determination of the CPW contribution from a hydroelectric project are the capital cost of the project, the operating and maintenance costs and expected energy production and project capacity. Since operating and maintenance costs for hydroelectric projects are relatively low and predictable, at the planning stage, the greatest uncertainty typically lies in the capital costs and expected energy production. These issues were therefore the focus of MHI's review.

The required level of review was judged in the context of scale of the projects relative to the overall expenditures.

MHI's review of Round Pond focussed on:

- Exhibit 5d (i) - The February 1989 report entitled "Feasibility Study Round Pond Development, Summary Report".[196]
- Exhibit 5d (ii) - The September 1988 report entitled "Feasibility Study Round Pond Hydroelectric Development, Volume 1".[197]

The 1987/1988 investigations leading to the Exhibit 5d (ii) report by Shawinigan/Fenco commenced with a pre-feasibility study. After review of the preliminary pre-feasibility results by the client, the consultant was authorized to undertake a full feasibility study. The scope of the consultants work was modified by shifting some field investigations from the feasibility to the pre-feasibility stage and by deletion of the survey work for access routes.

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[196] Exhibit 5d(i), NLH, "Feasibility Study Round Pond Development, Summary Report", February 1989
[197] Exhibit 5d(ii), NLH, "Feasibility Study Round Pond Hydroelectric Development, Volume 1", September 1988

9.2.3 Project Description and Background

The Round Pond hydroelectric project site is located in the Bay d'Espoir catchment area at the outlet of Round Pond. The project would utilize about 11.3 of the 12 m of undeveloped head between Godaleich Pond and Long Pond Reservoir. Inflows to the project would consist of the regulated discharge from the existing Upper Salmon generating station into Godaleich Pond, which in turn discharges into Round Pond through the West Salmon River, as well as natural inflows to the Round Pond drainage basin.

Some of the head at the site would be developed by construction of a dam at the outlet of Round Pond and three saddle dams to raise Round Pond about 6 m above its natural level. The remaining head would be captured by the construction of a canal to divert outflow from Round Pond around a set of downstream rapids to the Long Pond reservoir.

The powerhouse was envisaged to be close-coupled with the intake. It would contain a single horizontal pit type turbine with a synchronous generator that would produce 18 MW at a net head of 10.8 m. The powerhouse would be constructed in an excavation downstream, at the end of the canal. Discharge from the powerhouse would be conveyed to Long Pond reservoir through a short tailrace channel. A fish passage would connect Long Pond Reservoir to a point in the intake channel just upstream of the powerhouse.

The dam at the outlet of Round Pond would take advantage of an island in the river. The island would also be used to facilitate diversion and the construction of a gated spillway that would release excess inflows to Round Pond.

9.2.4 Level of Site Investigations

Topography

Filed surveys were initially carried out for the pre-feasibility studies and subsequently advanced for the feasibility studies. The surveys were simplified by using Round Pond water levels to carry a datum established from Long Pond to a point in Round Pond that was near the outfall of the West Salmon River. This datum was then used to confirm levels between Round Pond and the upstream Godaleich Pond in order to establish the available head. The surveys indicated that the available head was almost 13 m versus the 5.8 m head assumed in the earlier desktop studies. This very significant discrepancy in datum levels substantially altered the project capacity and layout.

Ground surveys were conducted along the centerline of the power canal, powerhouse and closure dykes, and cross sections were taken at selected areas. River bed profiles were also taken at the control sections of the rapids. Long Pond water levels were used to establish a datum as there was no geodetic datum near the site. Additional ground surveys were also carried out at one of the saddle dams and the dam/causeway location.

Topographic mapping at a scale of 1:2500 was developed using the ground surveys and photographic restitution. A ground survey was used to establish control points at several locations. The consultant considered the level of topography to be adequate for a feasibility level study although further survey work on access roads, the camp area, and the east channel of the Round Pond outlet was recommended before final design. Currently, available survey techniques might result in some improvement in absolute levels but there are no obvious shortcomings with the survey data used in Exhibit 5d(ii) that would be expected to create uncertainties atypical of those at the feasibility study level.

Geological Mapping and Subsurface Conditions

Subsurface conditions frequently represent one of the major areas of uncertainty and risk for hydroelectric developments. Round Pond, Exhibit 5d (ii) indicates that initial surficial geological mapping covering most of the project was prepared from aerial photographs.

Site ground reconnaissance was combined with aerial reconnaissance using a helicopter for the access routes. An aerial reconnaissance of the proposed flooded area was also undertaken. The extent of surficial cover was examined by site probing and found to be quite thin. Samples were taken from potential borrow areas. Test pits were also excavated in the powerhouse, canal and causeway areas, and peat probing was undertaken along alternative alignments of the east saddle dam. Subsurface drilling and testing programs with six holes covering the main structure alignments, one in a saddle dam location and one in the proposed quarry area were also undertaken. Additional test pits were excavated in the two potential sources of construction materials.

The level of the site subsurface investigations was generally in keeping with feasibility level studies. One issue not covered in the report is the potential for acid generating rock. It is uncertain if the rock had the potential for acid generation or because the issue was considered to be insignificant at the time.

The results of the investigations were documented in Volume II of the feasibility study. This volume was not reviewed although the findings were incorporated in Exhibit 5d (ii).

Construction Materials

The site investigations included an evaluation of the suitability of alternative sources of construction materials and the identification of material sources for concrete aggregate and fills.

Environmental

The report contained in Exhibit 5d (i) indicates that concerns had been expressed concerning waterfowl breeding habitat, caribou, raptors, and moose. It also indicates that the potential impact of the project on fish passage. The Long Pond spawning habitat on the West Salmon River was one of the major concerns.

NLH decided to defer initiation of most environmental impact studies although a small amount of work was done on the fish passage issues. Estimated costs for environmental work included provision for fish passage at the generating station and estimated costs for conducting an environmental impact assessment and monitoring. Since environmental requirements have generally become more onerous since 1988, it is quite likely that the scope of work envisaged in 1988 would have been less comprehensive than dictated by current requirements. In addition, there does not appear to be any provisions for mitigation aside from the fish passage facilities. Consequently, this is an area where there would appear to be a need for additional work in order to meet current practices for a feasibility level study.

9.2.5 Preliminary Designs

Level of Engineering

The 1988 study documented in Exhibits 5d (i) and 5d (ii) initially involved prefeasibility level studies followed by advancement of the engineering to a level that is presented as feasibility level.

Project Arrangement

The selection of an appropriate project arrangement typically has an important impact on the technical feasibility, constructability and financial viability of a hydro-electric project.

The proposed Round Pond arrangement is relatively straightforward. The consultant that conducted the 1988 studies states that the project is technically feasible and MHI's review did not reveal any issues that would suggest otherwise.

The 1988 studies included the investigation of alternative arrangements and project parameters, some of which are summarized below.

Reservoir Level and Project Capacity

The maximum reservoir level was established on the basis of environmental considerations arising from work done for the next most upstream project. The selected reservoir level sacrificed about 1 m of the available gross head. While this came at the expense of project capacity and energy, any benefits arising from a higher capacity would have been offset at least to some extent by the costs for higher and more extensive water retention structures at Round Pond. Optimization of the reservoir level indicated that a higher reservoir level would not reduce the cost of energy although the benefit cost ratio for the project would be somewhat improved.

A capacity optimization study indicated that an 18 MW plant would provide the lowest cost energy at the selected reservoir level.

Updating of the 1988 studies using present day costs and values for energy and capacity may produce different conclusions regarding the optimum capacity and reservoir level.

Number and Type of Units

The pre-feasibility studies included investigation of alternative unit types and numbers. Those studies indicated that a single pit turbine would provide the best solution and would provide a savings of about 5% of the direct project costs relative to a single vertical Kaplan unit. Pit turbines were a relatively recent development in 1988. Updating of the unit selection to consider the most recent developments could result in some changes to the unit. However, it is expected that these changes would not have a major impact on the project economics.

Overall Project Arrangement

The investigations included consideration of a range of alternative arrangements for the causeway, saddle dams and main structures. These investigations provided a basis for selection of a cost effective and technically acceptable arrangement for the feasibility study although the consultant did recommend the investigation of additional arrangements if the project proceeded to final design.

The project arrangement as presented in the 1988 report is relatively straightforward. Construction sequencing and dewatering requirements have been considered as have permanent and construction access roads, construction materials, construction facilities and reservoir clearing. The project arrangement was however developed without the benefit of environmental studies. Developments since 1988 would likely increase the potential impact of environmental considerations since the project involves significant inundation and creates a barrier to fish passage.

Requirements for the transmission line interconnection, substations and communications arrangements were provided by the client. These requirements and the associated estimates of costs are documented in Exhibit 5d (i).

Aside from the selection of a relatively new type of turbine for the application, the preliminary arrangements and construction sequencing are based on approaches that are fairly conventional. Experience subsequent to 1988 has confirmed the pit turbine concept for many applications although these have tended to be in projects with lower capacities. One of the major uncertainties with respect to the Round Pond project is that it could well be subject to more stringent environmental considerations than would have been applicable at the time the concepts were first developed.

9.2.6 Energy Estimates

The capacity and energy estimates for Round Pond are contained in the hydrology report, section 2.3.

9.2.7 Construction Schedule

The schedule presented in Exhibit 5d (ii) indicates that a duration of 33 months would be required from commitment of the project to first power. This schedule is based on a multi-contract design/bid/build approach that allows preparatory work such as engineering and contracting to proceed in parallel with the environmental investigations and regulatory approvals process. The schedule assumes that regulatory approvals would be achieved in year one of the program. It is also assumes that some construction would start in Year one. Since the schedule will also be governed by seasonal constraints on several construction activities, a slippage in the early stages of the project could result in a delay of one year.

Given the nature of the project, the schedule developed for the 1988 studies is very aggressive, especially given the trend towards increased scrutiny during the regulatory process. However, since Isolated Island Option does not require commercial operation of the Round Pond project until 2020, a substantially longer project development schedule could be readily accommodated.

9.2.8 Estimated Costs

Capital cost inputs to the Strategist Model were entered in the form of direct capital costs in January 2010 and were distributed over the years in which expenditures are expected to occur in order to generate the cash flow in January 2010. Escalation of the direct capital costs beyond January 2010 and the AFUDC were computed within the Strategist model.

The consultant's scope for the 1988 study presented in Exhibits 5d (II) called for the development of capital cost estimates. The scope of work was otherwise not specific with respect to the class or level of estimate that was to be prepared.

The estimated capital costs contained in Exhibit 5d (ii), the report by the consultant, and Exhibit 5d (i), the summary report with additional cost components developed by the owner are presented in July 1988 dollars. The direct capital cost estimates for the project included:

- $53.7 million for the direct capital costs for the project components within the consultant's scope. This included an estimate for a fish passage facility at the powerhouse but no other allowances for environmental costs.
- $6.8 million for the direct capital costs for those aspects of the project included in the owner's scope; primarily the telecommunications, transmission, switchyard and control and protection required to interconnect the project to the grid. This also included an estimated cost of $870,000 for environmental investigations and preparation of an EIS and environmental monitoring and estimates for engineering and management for the items described above.
- An estimate for management and engineering of $6.4 million based on a 12% of the direct capital costs before contingency for the work estimated by the consultant only.
- An estimate of $3.4 million for owner's costs based on 5.1% of all direct capital costs plus contingencies.
- An estimate of $6.4 million for contingencies. This corresponds to 10.5% of direct capital costs.[198]

The total estimated cost of the project before escalation and AFUDC was $76.8 million in July 1988. Estimates of escalation and AFUDC were also presented in Exhibit 5d (i) and 5d (ii) but these were not used in the Strategist input for the CPW calculations.

The estimates include costs for management, engineering and owner's costs. Some contractor overheads such as mobilization and demobilization are not separately identified so these are assumed to be distributed amongst the unit prices for construction.

The cost estimates are not defined in terms of industry recognized class or level designations but have been presented as feasibility level estimates. The application of only a 10.5% contingency would typically suggest that the consultant had a fairly high level of confidence in the estimates but there is little basis to judge whether or not this confidence is justified. The fact that environmental requirements have changes so dramatically since 1988, it is expected that the contingency is low. The discussion of the estimating methodology in Exhibit 5d (ii) indicates that the capital cost estimate was based on cost trends and unit prices that had been observed in Newfoundland as well as "target estimates" from manufacturers and suppliers. The cost estimates are only presented in Exhibit 5d (i) and (ii) at a summary level. Nalcor advised that neither further breakdowns of the construction quantities, equipment and facilities nor other back-up was available. Consequently, it is not possible to comment on the level of detail that was considered in developing the estimate. No major omissions were evident. However the following observations are noted:

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[198] Exhibit 5d(ii), NLH, "Feasibility Study Round Pond Hydroelectric Development, Volume 1", September 1988, pg. 9-7

- Since 1988 there has been significant evolution of environmental standards and the associated regulatory processes. Since the project would involve significant construction activities, significant inundation and the creation of a barrier to fish passage amongst other possible environmental issues, it is quite possible that the project arrangement could be impacted and additional expenditures could be required for mitigation.
- The allowances for owner's costs as a proportion of total costs are significantly lower than for Portland Creek or Island Pond.
- The impoundment of Round Pond would result in a onetime reduction in energy production from downstream plants. The value of lost production was estimated to be $2.3 million based on 1988 values for energy.
- The schedule is fairly aggressive, especially in light of the current regulatory environment.

All of these factors would suggest that developments since the time of the study would lead to increased project costs.

The escalation of costs from 1988 to 2010 involves a substantial level of uncertainty, especially when relatively broad escalation indices are applied. In order to confirm that the escalation factors applied to the 1988 estimates are generally in line with escalation experience in the industry, the escalation applied by Nalcor to obtain 2010$ direct cost inputs for the Strategist model was compared with:

- The Nalcor escalation factors for the Muskrat Falls project as presented in Exhibit 3 were used for the period from 2000 to 2010.
- As Exhibit 3 did not contain data for periods prior to 2000, actual industry escalation data compiled by Manitoba Hydro was used for the period from 1988 to 1999.

Application of the above escalation factors to the July 1988 capital cost estimates in Exhibit 5d (II) yielded a total 2010 capital cost that was within 2.4% of the Strategist input of $142 million. This indicates that the escalation applied to the cost estimates for the Strategist input is in line with general industry experience.

9.2.9 Other Inputs to the System Planning Process

The feasibility study, Exhibit 5d, indicates that the rated capacity of Round Pond would be 18 MW. This corresponds to the Strategist input indicated in Exhibit 14 for the Isolated Island Option.

Exhibit 12 indicates that a forced outage rate of 0.90% was used for all new hydro developments in the Strategist inputs. This rate is based on the average reported forced outage rate for Newfoundland and Labrador Hydro units for the five year period prior to 2006.

An outage rate of 0.90% is somewhat lower than the average rate for units of comparable size operated by members of the CEA for the five year period prior to 2006. Outage rates do vary significantly amongst operators of hydroelectric plants due to a number of factors including maintenance practices, control and protection schemes, size and design of units and site specific conditions amongst others. There is no obvious reason that maintenance practices for Round Pond should be different than for other hydroelectric plants in the NLH system. Of perhaps more significance is the fact that the 18 MW Round Pond unit would be much smaller than the majority of NFL's hydro units. Smaller units tend to have higher outage rates. For example, for units of 5 to 23 MW the 2006 CEA report indicates a Derating Adjusted Forced Outage Rate (DAFOR) of 3.19% versus 1.54% for units in the range 24 to 99 MW. Use of a 0.90% outage rate for Round Pond could prove to be somewhat optimistic. A higher outage rate would tend to reduce energy generation and thus the benefits associated with the project.

9.3 Portland Creek Development

9.3.1 Project Background

The proposed Portland Creek development is a 23 MW hydroelectric project that would be constructed in the northwestern part of Newfoundland in conjunction with both the Isolated Island and the Island Interconnected Options. The on-line dates set out in the generation expansion plan are 2018 for the Isolated Island Option and 2036 for the Infeed Option.

Since the Portland Creek project costs are included in the CPW calculation for both generation expansion options, the impact of changes in the projected cost for Portland Creek will, except for the secondary effect of differences in timing of the project, impact both options equally. Accordingly, the review of Portland Creek focussed on identification of factors that could have a very large impact on costs or energy production.

The Portland Creek development was the subject of a pre-feasibility study in 1987 and a feasibility study that was completed in 2007[199] . The only other reported investigation was a 2004 pre-feasibility study conducted as a student study project.

9.3.2 Basis for Review

The primary considerations for determination of the CPW contribution for the Portland Creek project are the capital costs, the operating and maintenance costs and the expected energy production and project capacity. Since operating and maintenance costs for hydroelectric projects are relatively low and predictable at the planning stage, the greatest uncertainty typically lies in the capital costs and expected energy production. These issues were therefore the focus of MHI's review.

MHI's review of Portland Creek focussed on Exhibit 5c, which includes the text of the 2007 report entitled "Feasibility Studies for Portland Creek Hydroelectric Project", and Exhibit CE-58 which includes Appendix A, Capital Cost Estimate, from the 2007 feasibility study report. The work leading to the 2007 report included a review of the previous studies conducted in 1987. Both the 1987 and 2007 studies were carried out by a consulting firm with a credible history in engineering for hydroelectric projects.

The scope of the consultant's work for the 2007 feasibility study, when considered in conjunction with the scope of work to be undertaken by the owner, is typical of the scope for a feasibility study with the following exceptions:

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[199] Exhibit 5c, SNC Lavalin, "Feasibility Study for Portland Creek Hydroelectric Project", January 2007

- The scope included essentially no environmental investigations to support the expected schedule for regulatory approvals or the potential costs for mitigation, such as fish habitat.
- There was no geotechnical drilling done on site to confirm the existing sub terrain for concrete work.

9.3.3 Project Description and Background

The Portland Creek hydroelectric project site is located on Main Port Creek, a tributary of Portland Creek on the west side of the Great Northern Peninsula of Newfoundland. The project would involve the creation of a diversion pond on Portland Creek by the construction of a 110 m long, 12 m high concrete gravity diversion dam and overflow spillway. Flow would be diverted from the diversion pond to a main storage reservoir through a 320 m long diversion canal. The diversion pond overflow spillway would return excess flow to Portland Creek.

A 45 m long, 16 m high storage dam would regulate outflow from the diversion pond to the headpond which would be created by a 143 m long, 15 m high headpond dam. The headpond dam would include an overflow spillway and a power intake structure leading to a 2,900 m long penstock to the powerhouse.

The powerhouse would be equipped with two Pelton turbine generator units utilizing a net head of about 39.5 m to produce 23 MW. Access to the site would be via about 27 km of new or improved roads and the project would be connected to the grid via a 27 km long, three phase, 66 kV transmission line.

9.3.4 Level of Site Investigations

Topography

Topographical mapping with contours at 2 metre intervals for key areas of the project was developed from aerial photography. Ground survey was used to establish control points at several locations. Ground topographical surveys were also carried out for each of the major structures and incorporated into the contour mapping.

Subsurface Conditions

Subsurface conditions frequently represent one of the major areas of uncertainty and risk for hydroelectric developments. The proposed subsurface drilling program was deleted from the scope of work for the Portland Creek feasibility studies. Field investigations included a geological assessment and probing or test pitting to determine the depth of bog or overburden. Overburden is thin or intermittent in the areas of most of the major structures with significant areas of exposed bedrock outcrops. Based on the geological assessment, the consultant judged the dam foundations to be suitable for founding concrete dams. The area of greatest uncertainty would appear to be the foundations for the powerhouse and the lower portion of the penstock where there is a greater depth of overburden and the depth to bedrock is not accurately known.

Construction Materials

Tentative sources of construction materials were identified but not investigated in detail to confirm suitability for concrete aggregate.

Environmental

Based on the 2007 report, it is understood that environmental investigations had not been initiated at the time of reporting. An allowance was made for replacing altered, disturbed or destroyed fish habitat. There is no discussion of other environmental considerations and no specific allowances for environmental mitigation. The absence of environmental investigations represents a greater level of uncertainty than would be typical for feasibility level studies based on current practice.

9.3.5 Preliminary Designs

Level of Engineering

The 2007 study was identified as a feasibility level study. The original scope was reduced after award of the contract to eliminate the proposed subsurface drilling program. The lack of subsurface investigations would usually be considered a gap in the information required for a feasibility level study except in atypical cases where the subsurface conditions could be deduced from other available information. The absence of environmental investigations also represents a gap relative to current practice.

In the feasibility study report, the consultant did indicate that the level of engineering was "close to Feasibility Stage". However, the consultant concluded that, while some geotechnical data is missing, that drilling investigations would not likely produce results that would adversely affect the budget and the overall assessment of the project.

Project Arrangement

The selection of an appropriate project arrangement typically has an important impact on the technical feasibility, constructability and financial viability of a hydro-electric project. The 2007 report indicates that a number of alternative layouts were considered although the alternatives are not presented. The study does present the optimization studies that were done for project capacity as well as several of the key project components. Construction logistics including access provisions, cofferdams and de-watering were considered. The preliminary arrangements and construction sequencing are based on conventional approaches.

Each element of the proposed Portland Creek arrangement is relatively straightforward from a technical perspective. The overall project is not complex in spite of the remote locations of some of the structures required for diversion and water management.

Transmission line interconnections, substations and communications arrangements and related cost estimates were provided by Nalcor.

9.3.6 Energy Estimates

For information on capacity and energy please refer to the Hydrology Report, section 2.5.

9.3.7 Construction Schedule

The schedule presented in the 2007 report indicates a duration of 37 months from commencement of environmental approvals to first power. This schedule is based on a multi-contract design/bid/build approach that allows preparatory work such as engineering and contracting to proceed in parallel with the regulatory approvals process. The schedule allows only one year for regulatory approvals, a duration that appears to be quite optimistic unless environmental investigations have advanced since 2007. However, since the earliest online date indicated in either of the expansion plans is 2018, schedule constraints should not be an issue with respect to the development of Portland Creek.

9.3.8 Estimated Project Costs

Capital cost inputs to the Strategist model were entered in the form of direct capital costs in 2010$ and were distributed over the years in which expenditures are expected to occur in order to generate the cash flow. Escalation of the direct capital costs beyond 2010 and the AFUDC were computed within the Strategist model. The total estimated cost of the project with escalation and AFUDC was $90 million in 2010 dollars.[200]

The scope of work for the Portland Creek feasibility study included preparation of a capital cost estimate. The scope was not specific with respect to the class or level of estimate that was to be prepared.

The estimated capital cost contained in Exhibit 5c and Exhibit CE-58 is presented in December 2006 dollars.

The cost estimates are based on a fairly detailed and comprehensive breakdown of the construction quantities, equipment and facilities including construction support facilities. The estimates also include estimates of costs for management, engineering and owner's costs. Some contractor overheads such as mobilization and demobilization are not separately identified so these are assumed to be distributed amongst the unit prices for construction.

Exhibit 5c indicates only that the capital cost estimate was developed on the basis of historical prices for earthworks construction and quantities that were developed from survey information and the concept design as presented in the report. The basis for pricing of work other than earthworks was not provided. The consultant did conduct a risk analysis to assess the likely range of project costs. Based on this analysis it was concluded that there was less than a 10% probability that the final costs would vary from the estimated costs by more than about plus or minus 3%. This would suggest a very high level of confidence. However, the consultant also indicates that the level of engineering is only "…close to Feasibility Stage…".

The cost estimate was not otherwise defined in terms of industry recognized class or level designations.

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[200] Nalcor's Submission to the Board of Commissioners of Public Utilities with respect to the Reference from the Lieutenant-Governor in Council on the Muskrat Falls Project, November 2011, pg. 39

In a response an RFI[201], Nalcor advises that the estimate for Island Pond is considered to be screening level or feasibility level. The estimate for Portland Creek was prepared by the same consultant using what appears to be the same methodology and in a similar time frame. The uncertainty with respect to Portland Creek would appear to be higher than for Island Pond given the lack of sub-surface investigations and the absence of even preliminary environmental investigations. Given these considerations, the levels of contingency included in the Portland Creek estimates appear to be low and there is a likelihood of an increase in project costs.

9.3.9 Other Inputs to the System Planning Process

The feasibility study indicates that the rated capacity of Portland Creek would be 23 MW. This corresponds to the Strategist Inputs indicated in Exhibit 14 for both the Isolated Island and Infeed options[202].

Exhibit 12 indicates that a forced outage rate of 0.9% was used for all new hydro developments[203]. This rate is based on the 5 year average reported forced outage rate for Newfoundland and Labrador Hydro units for the five year period prior to 2006.

An outage rate of 0.9 % is somewhat lower than the average rate for units of comparable size operated by members of the CEA for the five year period prior to 2006.

With respect to Portland Creek, there is no obvious reason that maintenance practices would be different than for other hydroelectric plants in the NLH system although the plant would be somewhat more remote. Perhaps more significance is the fact that the 11.5 MW Portland Creek units would be much smaller than the majority of NLH's hydro units. Smaller units tend to have higher outage rates. For example, for units of 5 to 23 MW the 2006 CEA report indicates a DAFOR rate of 3.19% versus 1.54% for units in the range 24 to 99 MW. Use of a 0.9% outage rate for Portland Creek could prove to be optimistic and a higher outage rate would tend to reduce the energy production and thus the benefits associated with the project.

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[201] Response to RFI MHI-Nalcor-34
[202] Exhibit 14 Rev.1, Nalcor, "2010 PLF Strategist Generation Expansion Plans"
[203] Exhibit 12, Nalcor, "Forced Outage Rates Summary Sheet", June 2011

9.4 Conclusions and Key Findings

The three small hydroelectric generation projects of Round Pond, Portland Creek, and Island Pond are part of the Isolated Island Option generation resource plan. For the Infeed Option, only Portland Creek is specified with an in-service date of 2036. Each of the plants has been the subject of one or more studies which were conducted by consulting engineering firms with extensive experience in the engineering of hydroelectric projects.

Key findings from the small hydroelectric plant reviews are as follows:

- A review of the capital cost estimates for the three small hydroelectric plants indicated that the level of engineering and investigations were consistent with a feasibility level study. Considering the age of some of the studies, the review also indicated that the development schedules and cost estimates used as inputs to Strategist for the three projects were optimistic due to more stringent current regulatory processes.
- It is expected that resolution of these uncertainties would generally result in increases rather than decreases in the CPW of the three projects. However, the magnitude of any changes would not be expected to significantly alter the difference in CPW between the Isolated Island and Infeed Options.