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Island Pond Development Final Feasibility Study

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VOLUME 1

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

FINAL FEASIBILITY STUDY

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ISLAND POND DEVELOPMENT

EXECUTIVE SUMMARY

History

Construction of the Bay d'Espoir facilities at the Meelpaeg Reservoir in 1967 provided head and flow conditions in the region of the Ebbegunbaeg Control Structure for a possible power development. Several concepts for developing this potential were recognized and, as part of the 1986 Pre-Feasibility investigations, five alternative schemes were evaluated and the Island Pond concept confirmed as the most attractive.

This Final Feasibility Study has been carried out to confirm the viability of the concept and to more accurately establish the cost and benefit of developing the potential at the Island Pond site. The program of work for this study consisted of hydrological studies, site surveys and geotechnical investigations, and conceptual layout, preliminary design and optimization studies as required for optimization of construction and equipment details, costs and energy benefits for the project.

Summary of Findings

The study has effectively upgraded the concepts and parameters as developed by the Pre-feasibility Study and no substantial changes in the previously proposed details have been found necessary. The Island Pond Development is still considered to be technically feasible.

Regulation studies and the optimization of the hydraulic parameters and costs for the canals and channels within the proposed development have confirmed that no change in operating level in the Meelpaeg Reservoir should be considered. Operated under the existing storage regime for the reservoir, an average net head of 22.69 m can be provided at the power complex. The average flow available at Island Pond, including local runoff, would be 109.3 m^3/s.

The flood routing capability of the Meelpaeg Reservoir would not be altered by the addition of Island Pond. Floods on Island Pond would be routed back through the diversion canal into storage on the Meelpaeg Reservoir without significant increase in the maximum flood level of the Reservoir.

The development would raise the normal water level on Island Pond between 3 and 4 metres from its original level. Since the operating low water level on the combined reservoir would be below the present normal water level, there would be no requirement to fill dead storage. Staging of closure at the outlet of Island Pond would also be arranged to route local runoff into storage to provide an early benefit to the system.

EXECUTIVE SUMMARY (Cont'd)

Power Complex

The power development would consist of a 23 m high embankment dam across the North Salmon River valley about 600 m upstream from Crooked Lake, and an intake-penstock-powerhouse complex located in a rock cut on the east bank, adjacent to the dam. Discharge from the powerhouse would flow through a tailrace excavated along the original riverbed to Crooked Lake.

The powerhouse would have two 15 MW units supplied through twin intakes and 2 - 5.4 m diameter buried steel penstocks. The super-structure would house a 55 ton overhead crane, repair bay, control and office facilities and an enclosed draft tube gate gallery.

Access

Permanent access to the project site would require construction and upgrading of about 31 km of road from the existing North Salmon Road, starting at a point about 7 km south of the North Salmon Dam. Limited upgrading of the existing access road from Millertown would also be required for the work.

Schedule

The total duration of on site construction for this project would be 40.5 months. Assuming completion no later than December 15, of year four, construction must start not later than August of year one.

The construction and project schedules for this project are shown on Plates 17 and 18, respectively. The critical path for the construction schedule runs through the turbine and generator design, manufacture and installation activities and, as usual, these activities determine the on power date for the project. The engineering for these activities must start immediately following the project release in year one. Based on a project completion in December, 1991, a project release in early June of 1988 would be required.

Based on the construction schedule developed for the December, 1991 completion, two other activities must start early after project release to avoid extra cost and construction restraints imposed by winter work and the spring flood of 1988-1989. One of these activities is the excavation of the pilot channel at the forebay canal, to initiate drawdown of Island Pond, and thence the completion of the forebay canal excavation prior to the spring flood in 1989. The other activity is the construction of the permanent access road from Upper Salmon. Both of these activities

Schedule (Cont'd)

must start by early August, 1988. However, to enable construction to start in August, engineering for these activities would have to be carried out in the two months prior to project release, ie. April and May.

Cost and Benefit

The estimated total capital cost for the development, exclusive of transmission line and switchyard electrical/structure costs, would be $127,228,000. This total includes $11,565,000 for escalation and $22,026,000 for interest during construction, i.e. 12.35% and 23.52%, respectively, of the estimated project cost.

Assuming an overall plant efficiency of 89.4%, the average annual energy output of the development would be 191 gWh per year. Operation of the overall Bay d'Espoir system for maximum benefit, with the Island Pond Development in place, would result in a decrease in output from the downstream plants of 6 gWh per year. Therefore, the net benefit derived from addition of the Island Pond Development to the system would be 185 gWh per year.

Construction

The major quantities for construction would be:

Excavation:

--	Upstream canals and channel improvements	-	1,360,000 m^3
--	Dam Foundation	-	16,000 m^3
--	Power Complex Structures	-	95,000 m^3
--	Tailrace	-	118,000 m^3

Embankment Dam Fill: - 148,000 m^3

Concrete:

--	Intake	-	3,500 m^3
--	Powerhouse	-	5,200 m^3

The civil works construction which would involve major excavations for the upstream canals and channel improvements to divert flow from the Meelpaeg Reservoir, via Island Pond, to the forebay, would comprise over 60% of the total civil work cost.

Recommendations

Prior to final design, further preliminary design and site investigations would be required. This would include:

-- a survey of access road alignment and stream crossings, EXECUTIVE SUMMARY (Cont'd)

Recommendations (Cont'd)

-- surveys and subsurface investigations of the construction camp site and the Ebbegunbaeg freeboard dyke,
-- a survey of the intake, penstock and powerhouse site, during the early stages of construction to accurately delineate sound rock surfaces,
-- further testing and inventory of the T-1 and T-2 deposits to confirm borrow areas and access requirements, and
-- further inquiries and analysis to determine if horizontal axis ('S') turbines could result in cost savings.

ISLAND POND DEVELOPMENT

FINAL FEASIBILITY STUDY

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PART 1 - INTRODUCTION

1.1 AUTHORIZATION

The preparation of this report has been undertaken in accordance with the Terms of Reference given in Newfoundland and Labrador Hydro's request for proposals, dated May 7, 1987 and ShawMont Newfoundland Limited's proposal dated May 26, 1987. Newfoundland and Labrador Hydro awarded this work to ShawMont Newfoundland Limited by telex dated June 26, 1987.

1.2 BACKGROUND

Previous studies of the Island Pond Development included a desk study prepared by Acres Consulting Services Limited, as part of a Feasibility Study for the Upper Salmon Development, and a Pre-feasibility Study completed by ShawMont Newfoundland Limited in 1986. The Desk Study identified several alternative schemes for developing the 25 m head differential between the Meelpaeg Reservoir and the Upper Salmon development and recommended the Island Pond scheme. The Pre-feasibility Study reviewed these previously identified schemes and also confirmed Island Pond as the preferred scheme of development.

The Pre-feasibility Study included a preliminary field investigation program completed in 1986 comprising structure centerline profiles, surficial geological mapping, terrain analysis and a limited program of test pitting. The Study compared several alternative layouts for the development including alternative diversion canal routes, power complex structure layouts and powerhouse arrangements, with single and multiple units, as well as alternative types of units.

After consideration of the various concepts for development, the Pre-feasibility Report recommended a development comprising:

- A diversion canal excavated through the height of land between the northeast arm of Meelpaeg Reservoir and Island Pond.

- A zoned rockfill dam across the downstream end of the North Salmon River Valley, near Crooked Lake.

- A double water intake structure located within the body of the dam and on the west side of the valley.

- Twin 5.25 m diameter buried steel penstocks through the dam.

- A powerhouse located at the downstream toe of the dam containing two vertical axis, fixed blade propellor, turbine/generator units.

1.2 BACKGROUND (Cont'd)

Following award of the Study, a site investigation program was mobilized and during August and September of 1987, an intensive field survey and geotechnical program was carried out from a base camp located about 12 km west of the Ebbegunbaeg Control Structure. This program included detailed structure site surveys and topographic mapping, terrain analysis and surface geological mapping. In addition, the program included subsurface geological investigations which consisted of diamond drilling, subsurface probing, test pitting of structure locations and a construction materials investigation.

1.3 SCOPE OF WORK

This Report upgrades the details of the Pre-feasibility Report to feasibility status and, in accordance with the Terms of Reference, the following scope of work, except for items (e) and (f) as explained below, has been covered:

(a) Hydrological studies of the watershed to develop firm and average energy capabilities, design flood magnitude, construction flood magnitude, and reservoir filling procedures. (A separate study to develop a flow regulation model for all plants on the Bay d'Espoir system was undertaken by Acres International Limited and is referred to hereafter as the "Bay d'Espoir Regulation Study").

(b) Aerial photo interpretation of reservoir and all structure sites to obtain an overview of project geology and a field investigation program to confirm sources and quantities of rock, gravel and impervious material for construction.

(c) Geotechnical field investigations to evaluate foundation information for the structure locations, including necessary test pitting and boreholes.

(d) A field survey program to obtain topography of all construction sites (centerline and typical sections).

(e) A walkover and flagging of the access road route and identification of stream crossings.

(f) A field survey of all stream crossings including road centerline profile and stream profile.

(g) Confirmation of selected scheme including optimization studies with emphasis on the use of multiple generating units and review of F.S.L. of Meelpaeg Reservoir.

(h) Mitigative measures to eliminate icing problems in the diversion canal.

1.3 SCOPE OF WORK (Cont'd)

(i) Development of a detailed construction schedule and a monthly project schedule.

(j) A Capital Cost estimate of the project including quantities for each aspect of construction, along with monthly cost and cash flow schedules and a separate detailed cost estimate.

Environmental assessment studies and transmission line considerations were excluded from this study.

The foregoing items (e) and (f) were deleted by Newfoundland and Labrador Hydro from the scope of work when it was established that the proposed northern route should be abandoned.

During the site investigation phase of the study it was found that the originally proposed route passing to the north around Great Burnt and Crooked Lakes crossed a very difficult area of terrain which could not be economically by-passed. Following a comparative cost study of this route with another route that would extend westward across the Upper Salmon diversion canal to the Ebbegunbaeg Control Structure the northern route was abandoned. The selected route passing south of Great Burnt and Crooked Lakes had been previously investigated by Newfoundland and Labrador Hydro and a review of the details from that study confirmed it to be the more desirable route.

The Geotechnical and Terrain Analysis reports contained in Volume 2 of this report include details related to investigations of the original route which will not apply to the new proposed route as described in Part 5 of this volume.

PART 2 - DESCRIPTION OF SITE

2.1 GENERAL DESCRIPTION

The proposed Island Pond Development would be located on the North Salmon River within the watershed of the Bay d'Espoir Development, between the existing Meelpaeg Reservoir and the Upper Salmon Development. The proposed development would utilize the available head of approximately 25 m between the Meelpaeg Reservoir and the Upper Salmon Development.

The Bay D'Espoir Development comprises a number of dams and diversion canals which divert runoff from catchments of the Victoria River, the White Bear River and the Grey River into the catchment of the Salmon River. The Salmon River was dammed to create the Long Pond Reservoir. This reservoir supplies water to two powerplants at the head of Bay d'Espoir which operate under a gross head of 181 m and have a total installed capacity of 600 MW.

The Meelpaeg Reservoir, created by diverting the Grey River, regulates water from the two upstream diversions of White Bear River and Victoria River. The out-flow from the Meelpaeg Reservoir is regulated at the Ebbegunbaeg control structure and is used by the Upper Salmon Development before it flows into the Long Pond Reservoir.

The more recently completed Upper Salmon Development is situated between Great Burnt Lake, located downstream of Meelpaeg Reservoir, and Round Pond which is located immediately above the Long Pond Reservoir. Flows from the North Salmon River were diverted by a dam at the outlet of Great Burnt Lake where a headpond was created through a series of ponds extending from Crooked Lake through Great Burnt Lake to Cold Spring Pond. The Upper Salmon powerhouse, which is located near Godaleich Pond, develops approximately 52 m of the approximate total head of about 87 m between the two reservoirs (Meelpaeg and Long Pond) and has an installed capacity of 84 MW.

For the Island Pond Development, the flow from the Meelpaeg Reservoir would be utilized, together with the local inflow to Island Pond, to develop energy through the 25 m head between Meelpaeg Reservoir and Crooked Lake.

The Island Pond development would include construction of a 3,000 m long diversion canal between Meelpaeg Reservoir and Island Pond, which would raise Island Pond to the Meelpaeg Reservoir level. In addition, approximately 3,400 m of channel improvements would be constructed in Meelpaeg Reservoir and Island Pond. At the south end of Island Pond, a 750 metre long forebay canal would be excavated to pass water to the dam, intake and powerhouse, all located just upstream of the entrance of the North Salmon River into Crooked Lake. Water would discharge into Crooked Lake via a 550 metre long tailrace. A general layout of the project is shown on Plate 2.

2.1 GENERAL DESCRIPTION (Cont'd)

The Island Pond Development would also include construction of a freeboard dyke in a low saddle at the eastern extremity of the Meelpaeg Reservoir, to prevent loss of water during periods of high water levels.

A spillway is not required for the development since flood flows from the Island Pond watershed would be diverted back into the Meelpaeg Reservoir, via the diversion canal, and stored in the combined Meelpaeg-Island Pond Reservoir to ultimately be routed through the system as regulated discharge.

The principal parameters for the Island Pond Development are:

Installed Capacity	30 MW
Number of Units	2
Full Supply Level	266.55 m
Normal Operating Level	264.85
Tailwater Level	241.52 m
Rated Flow	152.0 m^3/s
Capacity Factor	73%
Average Generation*	191 gWh/year

* This is average Island Pond plant generation alone.

2.2 SERVICE AND ACCESS

The diversion canal is accessible from the Trans Canada Highway via Route 370 from Millertown. An existing service road, which extends from Millertown to Ebbegunbaeg Control Structure, crosses the proposed diversion canal route. The road is unimproved and would require upgrading and a bridge at Noel Paul's Brook.

To gain access to the power complex structures, two alternative routes were studied. These were:

1. Access from Bay d'Espoir via a new road from the North Salmon Dam proceeding north and then westward, passing to the north of Great Burnt and Crooked Lakes.
2. Access from Bay d'Espoir via a new road westward from the North Salmon Dam Road, across the Upper Salmon diversion canal and south of Crooked Lake to Ebbegunbaeg and thence via the existing Ebbegunbaeg road to a new road proceeding northward along the west side of Crooked Lake to the proposed development.

During the early phase of the study it became apparent that initiation of work in the diversion canal area at an early date would be critical to the project schedule. Accordingly it was agreed that access via the existing unimproved service road from Millertown should be considered.

2.2 SERVICE AND ACCESS (Cont'd)

Since site access from Bay d'Espoir only (via the Upper Salmon Development) would delay the start of the construction by as much as one year, it was agreed with Hydro's project group to base the schedule and project costs on the provision of temporary access from Millertown for initial construction of the diversion canal and to start construction of the western portion of the permanent access from Bay d'Espoir via the Upper Salmon Development.

The permanent access road from Bay d'Espoir, would be designed for transportation of all heavy equipment to the site. This would require the construction of a long span bridge across the diversion canal of the Upper Salmon Development between Great Burnt Lake and Cold Spring Pond. Possibly one other large bridge might be required on the new road between this diversion canal and the Ebbegunbaeg Control Structure. At the Ebbegunbaeg Control Structure, a temporary construction by-pass could be located downstream of the structure to enable heavy equipment to ford the channel. The permanent access route would be constructed across the Control Structure.

With permanent access from Bay d'Espoir, the existing road from Millertown would require only minimum upgrading by the diversion canal contractor, to suit his own requirements. A temporary bridge would be required across Noel Paul's Brook and this would be provided by the contractor for his own construction requirements.

2.3 SUMMARY OF TOPOGRAPHY AND GEOLOGY

The general area of the Island Pond Development is located within the Botwood zone, a tectono-stratigraphic unit that is a subdivision of the larger Dunnage zone. The Botwood zone is characterized by its general lack of volcanic rocks and is composed mainly of fine-grained, metamorphosed clastic sediments which have been modified by granitic intrusives.

In the area of the proposed dam site, the North Salmon River has exposed a northsouth cross section through the metasediments. Contacts between the metasedimentary package and the granitoids lie to the north of the dam site at Island Pond, and south of the dam site along the southern portion of the North Salmon River where it enters Crooked Lake.

Rocks within the sedimentary package have beem metamorphosed to amphibolite facies, and are represented by psammitic to semipelitic schist and gneiss, with minor migmatite. These are of Ordovician/Silurian age.

2.3 SUMMARY OF TOPOGRAPHY AND GEOLOGY (Cont'd)

Intrusive Devonian age plutonic rocks to the north and south of the North Salmon River consist mainly of pink and grey granodiorite and granite with minor foliated granite and granodiorite.

The development area is in the Atlantic Upland physiographic sub-division of the Island of Newfoundland. The whole of the area was glaciated by the last advance of the Wisconsin Glaciation and much of the preglacial surface has been scoured and subsequently covered by the discontinuous layer of till of varying thickness. The topography is generally comprised of gently undulating countryside with rounded hills and broad valleys. Abundant, large glacially-derived boulders cover the ground surface. Drainage is poor with numerous bogs present and no well defined stream drainage pattern.

The terrain and surficial geology in the development area is variable. In the diversion canal area the terrain is characterized by low relief and gently rolling hills with many large glacially-derived boulders scattered on the surface. The majority of the area along the overland section consists of lightly wooded areas and open bogs, with heavy forest cover westward around Meelpaeg Lake. The surficial geology comprises a nearly continuous veneer of gravel and boulder till on a rolling bedrock surface with several small ponds formed in depressions. Rock is exposed at many locations north and south of the canal route. A significant portion of the overland canal route is covered by a veneer of muskeg or peat.

The bedrock along the diversion canal route consists of granodiorite. It is a massive, medium-to coarse grained, grey rock with wide to very wide joint spacing. This granodiorite rock is the same unit in which the Ebbegunbaeg Canal was excavated.

In the shallow water section of the diversion canal in the Meelpaeg Reservoir, in the small pond northeast of Meelpaeg, and throughout the improved channel in Island Pond, the surficial geology comprises a discontinuous veneer of post-glacial sediments overlying gravel and boulder till. Large glacial erratics are very common in the Island Pond section. The bedrock throughout this section is granodiorite of the same unit present in the canal area.

The terrain in the area from the forebay canal to the dam and powerhouse locations varies from gently rolling hills and low relief at the outlet of Island Pond to a steep sided valley near the river at the powerhouse and dam locations which gives way to gently rolling upland area 100 to 200 metres from the river. In general, the area is covered by a heavy, mature forest with scrub occurring on the hill tops.

2.3 SUMMARY OF TOPOGRAPHY AND GEOLOGY (Cont'd)

The surficial geology is variable throughout the forebay area with soil cover ranging from a 0.3 m veneer to several metres. Surficial materials in low relief areas generally consist of topsoil overlying glacial till. On steep slopes a thin veneer of colluvium is sometimes present. Bedrock is exposed at several locations at the upstream end of the forebay canal with continuous bedrock exposure across the river bed in the area of the dam.

Further details are included in Volume 2.

2.4 CONSTRUCTION MATERIALS

The Island Pond, Meelpaeg Lake and Crooked Lake areas have been scoured by glaciers. Although a large portion of countryside is covered with a thin veneer of glacial till, much of the soil tends to be relatively low in fines and contains a high percentage of boulders. The fines content also has very little to no clay size particles.

Impervious Fill

The glacial till on the northwest side of Crooked Lake has the most potential as a source of impervious fill. A substantial impervious deposit was located about 1 km east of the proposed dam site. This deposit (T-1) consists of a relatively thin veneer of sand and gravel till with probably less than 10% oversize and averaging about 3 m thick. The fines content ranges from 15% to 20% in the samples tested and the clay content ranges from 2% to 3%. This deposit is estimated to contain up to 450,000 m^3 of impervious material, however, further testing and inventory of this deposit is required to be assured of this quantity. Considering the impervious fill requirement is less than 10% of the total deposit it is expected that adequate material could be obtained from the T-1 deposit.

Although only one area was tested close to the proposed dam site, several other deposits were identified and investigated by test pitting. These are located along the northwest side of Crooked Lake ranging from 3 to 5 km from the dam.

Filter and Gravel

A second fairly large deposit (T-2) located about 5 km from the proposed dam site contains sand and gravel soil with a significant fines content. This deposit is believed to be of glacial fluvial origin. It covers about 20 hectares, with a depth of about 3 m and is estimated to contain about 600,000 m^3 of material. Four combination test pit/probeholes were used to partially test and inventory this deposit. Two samples from this deposit have

2.4 CONSTRUCTION MATERIALS (Cont'd)

Filter and Gravel (Cont'd)

fines content ranging from 14 to 19%; however, based on the apparent mode of formation of this deposit the fines content is expected to be variable such that portions of the deposit should be suitable for filter material with some processing. An allowance has been made in the capital cost estimate for processing of material from this deposit if necessary, to obtain the estimated 13,000 m^3 required for the dam.

An additional deposit, designated as T-3, located about 15 km northeast of the development site contains considerable deposits of sand and gravel till similar to those in deposits T-1 and T-2. Since there would be no access route developed in this direction for other purposes, and in view of the substantial resources in the closer deposits, it is not expected this deposit would be required.

Concrete Aggregates

The glacial fluvial materials contained in deposits T-1 and T-2 are expected to include pockets with relatively high sand and gravel fractions from which suitable aggregates could be processed. The total quantity required (about 8,000 m^3) could probably be processed from this source in conjunction with the production of filter material as described above.

A possible alternate source would be the extensive sand and gravel till deposits located near the Upper Salmon diversion canal. This source would probably be developed for the access road construction and, if necessary, aggregates could be obtained from this area which is located approximately 28 km from Island Pond.

Rock Fill

Rockfill would be obtained by selection from structure excavations and quarries. An allowance has been made in the capital cost estimate for stockpiling and rehandling a portion of this material which cannot be placed immediately into the dam.

Further details on construction materials are provided in the Report on Geotechnical Investigations contained in Volume 2.

PART 3 - HYDROLOGY

3.1 DRAINAGE AREA

The Island Pond Development would utilize the flow from the Meelpaeg Reservoir, together with the inflow from the 155 km^2 of drainage area for Island Pond, to develop energy through approximately 25 m of head between Meelpaeg Reservoir and Crooked Lake. The water from the Meelpaeg Reservoir would be utilized by diverting flows into Island Pond through a diversion canal. This would not result in any net change to the total drainage area available to the Bay d'Espoir system, but would allow all the inflow to the Meelpaeg Reservoir, in addition to the inflow of Island Pond, to be utilized in developing energy through the available head. During floods, the inflow to Island Pond would be diverted back through the diversion canal and stored in the combined Meelpaeg - Island Pond Reservoir. Therefore, for flood routing purposes the Island Pond drainage area is considered an addition to the Meelpaeg Reservoir drainage area. The following table shows the reallocation of the drainage areas which would result:

Basin	Pre-Development Drainage Area (km2)	Post-Development Drainage Area (km2)
Victoria	1057	1057
Burnt	678	678
Granite	502	502
Meelpaeg	971	971
Island Pond	-	155
Upper Salmon	902	747
Round Pond	944	944
Long Pond	830	830
Total	5884	5884

3.2 HYDRAULIC COMPUTER MODELLING

The hydraulics of the canals and channels within the Island Pond development area were evaluated using the HEC-2 computer program. The HEC-2 model computes water surface profiles and permits the evaluation of headlosses, flow velocities and flow depths. The program was used to determine the headloss in the diversion canal for the alternative layouts considered in optimizing the canal. The details of the methodology used and the steps taken in the optimization are described in the separate optimization report.

3.2 HYDRAULIC COMPUTER MODELLING (Cont'd)

The model of the diversion canal initially used a simplified profile of the canal and, subsequently, field survey data. The channel improvements were evaluated using a model based on ground elevations and soundings taken during the field program. The channel improvements were put in the model by modifying the appropriate cross-sections.

Another model, of the North Salmon River and forebay canal, was used to evaluate the headlosses from Island Pond to the intake.

Each of the models were used separately to evaluate the headlosses in the different sections and then the models were linked to verify the total losses from the Meelpaeg Reservoir through to the intake.

The velocities at critical sections were examined to ensure velocities were low enough to allow development of a stable ice cover and headlosses were evaluated to determine if widening or deepening of the canal would improve the hydraulics.

The diversion canal was modelled in the greatest detail, as it would contribute the largest portion of the total headlosses and would have the biggest impact on energy generation at the Island Pond Plant.

The diversion canal model was also used to evaluate the losses for flows from Island Pond to Meelpaeg, which would occur during the routing of floods back through the diversion canal for storage in the Meelpaeg-Island Pond Reservoir.

The HEC-2 model was used to model the diversion canal flows over a wide range of water levels in Meelpaeg and Island Pond. This was necessary to develop a water level - flow table for the canal (Table 3.1) which could be used by the Bay d'Espoir regulation model to model the impact of the Island Pond Development on the Bay d'Espoir system.

3.3 REGULATION STUDY

As part of the Upper Salmon Feasibility Study, Acres Consulting Services Limited carried out a regulation study for evaluating the energy potential of the Upper Salmon Development. This study simulated the operation of the entire Bay d'Espoir system giving flows, reservoir volumes and water levels at key locations throughout the system.

3.3 REGULATION STUDY (Cont'd)

Concurrent with the Island Pond Final Feasibility Study, Acres completed a new regulation study (the Bay d'Espoir Regulation Study) utilizing a more sophisticated regulation model (ARSP) together with the latest system information and expanding the flow data base to 37 years (1950 to 1986). The new regulation model was calibrated against the existing Bay d'Espoir system and was used to simulate the impact of the Island Pond Development on the total system.

Since the 600 MW size of the Bay d'Espoir station is much greater than either Upper Salmon or Island Pond, water requirements at the Bay d'Espoir powerplant essentially 'drive' the system with the smaller plants utilizing available flow for energy production. Based on this, it was concluded in the Island Pond Pre-feasibility Report that the Island Pond Development would have little impact on the overall water management in the Bay d'Espoir system and that any impact could be adequately assessed by relatively simple manipulations of the results of the original regulation study. For the current Island Pond Final Feasibility Study, the new regulation model, which can incorporate the conceptual Island Pond plant, was used as a basis for the conclusions contained herein. This model verified the conclusions of the Island Pond Pre-feasibility Study and showed no substantial changes from that study.

In the Bay d'Espoir Regulation Study, operation of the Bay d'Espoir system was simulated on a monthly basis for a study period of 37 years. Releases from storage were computed to supply energy production requirements at Bay d'Espoir, as dictated by operational rule curves. Releases from storage were allocated on a priority basis, with upstream reservoirs drained first, Upper Salmon second and Long Pond last. Releases from the upstream reservoirs - Victoria and Meelpaeg were allocated on a proportionate basis so that both reservoirs were lowered 'in step'. Flows, reservoir volumes, water levels and energy production at key locations in the Bay d'Espoir system were recorded in tabulated print outs. These results provided data for the analysis of the impact of additions or changes to components in the Island Pond Development and for the optimization of the target level for the Meelpaeg Reservoir, the diversion canal size, the Island Pond channel improvements, the penstock diameter and the plant capacity.

The results of the Bay d'Espoir Regulation Study were examined in detail and the differences found in the conclusions of the Pre-feasibility Study and those inferred from the inital modelling results were investigated. The

3.3 REGULATION STUDY (Cont'd)

following sections describe some of the refinements made to the initial model, to improve the modelling of Island Pond, and the results obtained. Generally, it was found that the conclusions made in ShawMont's Pre-feasibility Study were upheld by the regulation study, although these were not necessarily obvious from the initial runs of the new regulation model.

3.3.1 Diversion Canal Headloss

The initial model assumed that the diversion canal between Meelpaeg Reservoir and Island Pond could be modelled as a single, constant headloss value. Since the canal would have considerable variation in head-loss due to the variation in flow and water levels between the two reservoirs, a constant headloss value provided incorrect results. A detailed analysis of the flows between the reservoirs was required to develop a waterlevel - flow table (Table 3.1) which was then provided for inclusion in the model.

3.3.2 Reallocation of Upstream Storage Releases

To enhance the output from Island Pond it would be desirable to maintain the water level in Meelpaeg Reservoir as high as possible. To do this, a change in the method of allocating releases from storage of the upstream reservoirs would be required. The preferred reservoir operating policy would be to empty the Victoria Reservoir initially, before releasing water from the Meelpaeg Reservoir, and to refill Meelpaeg and Island Pond Reservoirs on the filling cycle. In the Pre-feasibility Study, flows for Island Pond were based on an adjustment to the output of the original regulation study. For the current Final Feasibility Study, however, the model of the Bay d'Espoir system was used to assess the impact of the changes to the operating rules and the reallocation of storages.

The priorities for the reservoir releases were changed such that Victoria would be drained before Meelpaeg. The storage in Island Pond represents only a small portion of the total storage volume available to the Island Pond plant (Graph 1), it was therefore given a lower priority than the Meelpaeg Reservoir, even though it is a downstream reservoir. This means that the level on Meelpaeg is determined by down-stream demands, but the Island Pond level would be determined only by the level on Meelpaeg. This policy was then implemented for a study of the total energy output over a range of target levels on the Meelpaeg Reservoir.

3.3 REGULATION STUDY (Cont'd)

3.3.2 Reallocation of Upstream Storage Releases (Cont'd)

The results of this study indicated a small increase in spillage at Upper Salmon and Bay d'Espoir plants would occur when the reservoir target level is very high, resulting in energy losses at these plants. By lowering the target level below the full supply level, and thereby incorporating an additional storage "buffer" to reduce any flood discharge from Meelpaeg Reservoir, it was found that the downstream losses could be minimized. The energy production at each plant was calculated and plotted (Graph 2). This graph shows that a target level of 265.5 m on Meelpaeg Reservoir would give the highest total energy production for the Bay d'Espoir system as well as the highest production at Island Pond.

The simulated operation of the Bay d'Espoir system resulted in a long term average water level on Meelpaeg Reservoir of 265.62 m, with an average flow of 105.0 m^3/s which would be passed through the diversion canal. There would still be some spill through the Ebbegunbaeg structure, which would be required to meet the downstream demands and which would take priority over the demands at Island Pond. The water level duration curve for Meelpaeg was developed from these regulation study outputs (Graph 3) and was used to determine the headlosses through the diversion canal during the optimization studies. The output of the new regulation study also gave the simulated power flows at the Island Pond plant, and these were used to develop the flow duration curve for the Island Pond plant (Graph 4). The following table summarizes the water levels and flows provided by the new regulation study:

Average Flow - Diversion Canal	=	105.0 m^3/s
Average Spill at Ebbegunbaeg	=	3.6 m^3/s
Total Meelpaeg Outflow	=	108.6 m^3/s
Local Inflow - Island Pond	=	4.3 m^3/s
Total Island Pond Power Flow	=	109.3 m^3/s
Target level - Meelpaeg	=	265.50 m
Average Level - Meelpaeg	=	265.62 m
Target Level - Island Pond	=	264.85 m
Average Level - Island Pond	=	264.92 m

3.3 REGULATION STUDY (Cont'd)

During the study of target levels, it was found that the changes to the operating rules to reallocate the reservoir priorities resulted in violation of a flow limit in the Burnt Sidehill Canal. This canal requires a minimum flow of 42.5 m^3/s during the winter months to ensure a stable ice cover and thus avoid possible ice collapse and constriction of the channel. The suggested change in priority resulted in lower flow on a number of occasions and, after review by Hydro, it was determined that this minimum should not be reduced. By providing a buffer in the Victoria Lake Reservoir to retain sufficient water to maintain the required winter flow in the Burnt Sidehill Canal, the violations were reduced to an acceptable level. It was also determined that the change had only a minor impact on the energy production at Island Pond and did not change any of the conclusions concerning the target level.

The model of the Bay d'Espoir system was used to investigate the firm energy on the system and the changes caused by the Island Pond Development. The firm energy is defined as the maximum system energy which can be produced throughout the firm sequence of flows (June 1959 to March 1962) assuming the system storage is full at the start of the sequence and that no reservoir falls below its low supply level during the drawdown period. The results of the firm energy analysis are contained in the next section of this report.

The firm capacity is computed through a trial and error process in which the demand is increased until all reservoirs just reach empty while meeting the demand. This results in a critical period in which all reservoirs go from full to empty. For the Bay d'Espoir system, the simulaton shows this period to be 34 months, ending with all reservoirs empty in March 1962. This means that the conclusions drawn for the firm energy are based on a short period of simulation, compared to the average results which are based on 37 years of simulated flows and energy. The results cannot have the same reliability as the average but still represent a valid estimate of the system firm energy for comparison.

3.4 PROJECT DESIGN FLOOD

The project design flood for the Island Pond Development is the Probable Maximum Flood (PMF). The PMF for the Island Pond drainage area was based on the same rainfall

3.4 PROJECT DESIGN FLOOD (Cont'd)

excess (net runoff) values as used in the Acres' Bay d'Espoir Flood Analysis Report of 1985 (Table C-4 of that report). The runoff excess amount of 80% of combined probable maximum precipitation and snowmelt, gave a total runoff excess of 600 mm for an 84 hour design storm.

The resulting flood hydrograph was found to have a peak of 369 m^3/s which occurred 54 hours after the onset of the storm as shown in Table 3.2 and as illustrated on Graph 5.

3.5 FLOOD ROUTING

The project design flood was used for the flood routing computations for the development. The Island Pond Reservoir would not have its own spillway and the portion of the flood entering the Island Pond drainage area would flow back through the diversion canal to be stored in the joint Meelpaeg-Island Pond Reservoir.

Flood routing computations were made for two cases as follows:

Case 1 Meelpaeg Reservoir only

A check computation to compare results with Acres' Bay d'Espoir Flood Analysis Report.

Case 2 Combined Meelpaeg-Island Pond Reservoir

Flood computations to simulate the behaviour of the combined reservoir.

Flood routing computations were carried out using a single reservoir flood routing model. This approach implies that the small difference between water levels in the Meelpaeg Reservoir and Island Pond would not have a significant impact on flood routing computations. The combined storage volume curve for the two reservoirs (Graph 1) and the discharge curve for the Ebbegunbaeg Control Structure (Graph 6) were used in conjunction with the water level - flow table (Table 3.1) for the optimized canal, to carry out these computations.

The diversion of Island Pond into the Meelpaeg Reservoir reduces the area producing uncontrolled runoff into the Upper Salmon Development and hence would effectively reduce the spillway discharge at the Upper Salmon Development.

3.5 FLOOD ROUTING (Cont'd)

The results of the flood routing computations for the two cases considered are shown in the following table:

	Max. Outflow (m^3/s)	Max. Flood Level (m)
Case 1 - Meelpaeg Reservoir only	195	268.40
Case 2 - Combined Meelpaeg-Island Pond Reservoir	195	268.40
Bay d'Espoir Flood Analysis (1985)	197	268.40

The following observations were noted:

(1) The results of Case 1 reproduce the 1985 Flood Analysis results closely.

(2) Diversion of Island Pond into the Meelpaeg Reservoir does not have a significant impact on the flood handling capacity of the Reservoir. This result is not unexpected since the flood storage available in Island Pond should largely provide for handling flood inflows to Island Pond.

(3) A maximum transfer flow from Island Pond to Meelpaeg Reservoir was estimated to be in the order of 170 m^3/s. The head difference to produce a flow of this magnitude would be about 1.0 m, at the reservoir levels to be expected during the flood handling. Similarly the head differential between the Meelpaeg Reservior and Island Pond due to power production flow (152 m^3/s), prior to the onset of the storm (and power plant shutdown), was estimated to be about 0.9 m. As a result of this initial water level difference, a substantial volume of water would be held in storage in Island Pond. This would reduce the calculated maximum flood level in Meelpaeg Reservoir by a small amount. The timing of the flood peaks would be such that the Island Pond flood runoff would reach its peak prior to that of the much larger Meelpaeg flood and, consequently, the Island Pond runoff would add only a small amount to the flood peak which would occur in Meelpaeg without the Island Pond Development. Thus, the use of a single reservoir flood routing model gives conservative results which are satisfactory at this level of study.

3.5 FLOOD ROUTING (Cont'd)

The flood handling capabilities of the combined Meelpaeg-Island Pond Reservoir were further examined in the light of the similarity of this arrangement to that of the reservoirs immediately upstream of the Upper Salmon Development. The situation where Island Pond could route water back through a diversion canal to meet its flood handling requirement would be similar to the situation found with Cold Spring Pond routing flow back into Great Burnt Lake. In the latter case it was found that the storage capacity of Cold Spring Pond was not sufficient to absorb the volume of the local PMF, nor was there sufficient freeboard to develop adequate head between Cold Spring Pond and Great Burnt Lake to force the water back through the diversion canal. The Bay d'Espoir Flood Analysis Report (1985) recommended that, to overcome this problem, additional discharge capacity should be added by the construction of a new spillway on Cold Spring Pond. This spillway has since been constructed and is now operational.

The Meelpaeg Reservoir, unlike the reservoir areas at Upper Salmon, is designed to handle floods by storage. It is a very large reservoir and can store the entire PMF by being drawn down to a specified level prior to the flood. This level is referred to as the flood rule curve level (FRC). The governing FRC level is the late winter level of 266.33 m, which is only slightly below the full supply level of 266.55 m which was established, assuming that the low saddle dyke (Ebbegunbaeg Freeboard Dyke) at the eastern extremity of the Meelpaeg Reservoir is constructed. The normal operational scenario assumes that the Ebbegunbaeg Control Structure is open at the start of the flood as required to supply the downstream generating demands. Gates would then be closed as the flood on the lower watershed becomes sufficient to meet generating requirements, or when a major flood event becomes apparent. A major flood is detected by the rate of rise of the reservoir and would normally become apparent only about 48 hours after the start of the flood.

Gates at Ebbegunbaeg normally remain closed throughout floods to absorb the excess discharge and thus reduce the flood routing requirements on the downstream watershed.

The flood handling capacity of Island Pond can be initially examined assuming no attenuation of flood peaks through routing, and considering only the total volumes to be handled. The initial examination also neglects the interaction of Island Pond with the Meelpaeg Reservoir (it is assumed that the flow cannot be routed back through the

3.5 FLOOD ROUTING (Cont'd)

diversion canal and that the entire PMF volume would be absorbed by Island Pond). The following calculations show the volumes and levels which would be reached, assuming no discharge from Island Pond during the flood event and assuming the power station to be out of operation.

Storage Volume at FRC (266.33 m)	=	202.5 Mm3
Added Volume in local PMF	=	91.0 Mm3
Total Volume at end of flood	=	293.5 Mm3
Resulting Island Pond water level	=	268.60 m

This shows that the storage volume at Island Pond would be sufficient under these circumstances to absorb the entire PMF inflow with water rising only 0.20 m above the Design Maximum Flood Level of elevation 268.40 m.

In reality the routing effect of discharge back through the diversion canal, prior to peaking of the level on Meelpaeg would be sufficient to restrict the rise on Island Pond to below the Maximum Flood Level.

The actual maximum level reached on Island Pond would ultimately reflect the maximum level on the Meelpaeg Reservoir.

Further calculations can be made to determine the maximum level that would be reached on Meelpaeg, assuming no discharge through the Ebbegunbaeg Control Structure, to verify the capability of Meelpaeg to handle a flood through storage alone.

Storage Volume at FRC (266.33 m)	=	1821 Mm3
Added Volume of PMF on Meelpaeg	=	708 Mm3
Total Volume at end of flood	=	2529 Mm3
Resulting Meelpaeg water level	=	268.52 m

This level is 0.12 m higher than the maximum flood level of elevation El. 268.40 m. A maximum level of 268.40 m would normally occur if the discharge through the Ebbegunbaeg Control Structure is taken into consideration, as follows:

Discharge through the Control Structure during flood	=	35 Mm3
Total volume in the reservoir at end of flood	=	2494 Mm3
Maximum Meelpaeg water level	=	268.40 m

3.5 FLOOD ROUTING (Cont'd)

The addition of Island Pond would, in reality, add storage volume above Ebbegunbaeg which would assist with the storage of the flood on Meelpaeg. If the case of unrestricted discharge through the interconnecting diversion canal is considered there would be only a slight change to the maximum flood level on Meelpaeg, considering a combined reservoir, as follows:

Volume at FRC (266.33 m)	=	2024 Mm3
Volume of PMF (Meelpaeg)	=	708 Mm3
Volume of PMF (Island Pond)	=	91 Mm3
Discharge through the Control Structure	=	-35 Mm3
Total volume	=	2788 Mm3
Water level (on each reservoir)	=	268.44 m

The above calculations show that the PMF on Island Pond could be handled entirely by storage on Island Pond and that the effect of discharge routed through the interconnecting canal would not alter the integrity of the Meelpaeg Reservoir.

3.6 RESERVOIR CHARACTERISTICS

3.6.1 Dead Storage

The minimum operating level of Island Pond would be 261.67 m. This level is nearly a metre below the existing water level on the pond of 262.5 m. To facilitate the construction of the Island Pond channel improvements and diversion canal, the level in the Pond would be lowered to about elevation 259 m, resulting in some dead storage which would have to be filled prior to commissioning of the plant. The volume in Island Pond which would have to be refilled is estimated to be 57.7 million cubic metres. In addition, there would be a small volume of water required to fill the forebay (below elevation 261.67 m). This volume is estimated to be 1.07 million cubic metres. Therefore the total volume of dead storage which would have to be filled would be about 58.8 million cubic metres.

This volume of water would represent a loss of about 3.2 gWh of energy production at the Island Pond Plant and a loss of about 33.1 gWh of energy production at the downstream plants; however, the initial drawdown of Island Pond would provide about 79.4 million cubic metres of water for energy production at Upper Salmon and Bay d'Espoir, representing a gain in energy production of about 44.6 gwh. This, therefore, would represent a net gain in energy production of about 8.3 gWh with a value of about $415,000 assuming a rate of 50 Mills/kWh.

3.6.2 Live Storage

The volume of live storage in Island Pond is the volume of water between the minimum operating level of 261.67 m (the level generated by sustained average discharge from elevation 264 m in Meelpaeg) and the Full Supply Level of 266.55 m. This volume is estimated from the storage volume curve (Graph 1) to be 153 million cubic metres. The live storage available to the Island Pond plant would also include that of the Meelpaeg Reservoir within this range, which is estimated to be a further 1323 million cubic metres, for a total live storage available of approximately 1476 million cubic metres.

3.6.3 Flooded Area

Upstream of the project, the operating water levels on Meelpaeg Reservoir would be unchanged and therefore the flood zone would not be affected. On Island Pond, however, the FSL would be approximately 4.00 m above the existing normal water level resulting in flooding of shoreline around the perimeter of the pond, submergence of some of the islands in the Pond and flooding of the forebay area between Island Pond and the Dam. The total land areas to be flooded, between the original shoreline and the FSL at Island Pond, and in the forebay area upstream of the dam would be 860 ha and 140 ha, respectively.

Downstream of the project, the waterlevel of Crooked and Great Burnt Lakes would be unchanged.

Most of the northern and western perimeter of Island Pond, as well as the southern shoreline west of the North Salmon River, are covered with bush with a limited growth of small scrub trees in low lying areas. The only wooded areas which would require clearing are along the river valley approaching the dam, and along the relatively steep southeast shoreline of Island Pond, east and north of the forebay channel. The total area to be cleared assuming clearing to 3 m horizontally above the FSL would be 83 hectares.

3.6.4 Reservoir Filling

The filling of Island Pond would be accomplished by closure of the outlet of Island Pond upon completion of the channel improvements through the Pond. This closure would occur prior to the spring flood of 1990, thereby impounding all of the inflow to Island Pond from 155 km^2 of drainage area throughout the last 18 months of the construction schedule, before "On Power". This would ensure complete filling of the live storage from local runoff, effectively precluding any charge against the project for filling from Meelpaeg storage.

3.6.4 Reservoir Filling (Cont'd)

Upon completion of the diversion canal at the end of 1990, and based on the average inflow, the Island Pond water level at the end of 1990 would be about elevation 263 m. If Meelpaeg Reservoir is higher than Island Pond at this time, the cofferdam at the Meelpaeg inlet of the diversion canal could be left in place until water levels are equal on each side, for ease of removal. With an average inflow, the Island Pond water level would be above elevation 265 m at the end of June, 1991.

Filling of the dead storage and live storage are discussed in conjunction with the unwatering and construction sequence for Island Pond and the forebay canal in Part 5.3.

3.6.5 Diversion Canal Flow

Although the low supply level (LSL) on the Meelpaeg Reservoir is 261.67 m, the operational low water level is 264.0 m. This would correspond to a water level of 262.0 m in Island Pond which, at average flow, would result in a water level of 261.67 at the intake. The diversion canal has been optimized to pass the average flow from Meelpaeg and could maintain this average flow with a water level as low as 264.0 m on the Meelpaeg Reservoir. Below a level of 264.0 m, the flow capacity of the canal would be reduced. At the low supply level of 261.67 m on the Meelpaeg Reservoir, the canal capacity would only be 36 m^3/s.

TABLE 3.1

WATER LEVEL - FLOW TABLE

OPTIMIZED DIVERSION CANAL

MEELPAEG WATER LEVEL (M)	I S L A N D P O N D W A T E R L E V E L (M E T R E S)									
	259.00	262.00	263.00	264.00	264.50	265.00	265.50	266.00	266.50	267.00
262.00	48.00	0.00	-59.00	-98.00	-119.00	-140.00	-167.00	-186.00	-210.00	-235.00
263.00	85.00	66.00	0.00	-84.00	-109.00	-133.00	-158.00	-182.00	-208.00	-233.00
264.00	122.30	110.00	89.00	0.00	-73.00	-108.00	-139.00	-169.00	-197.00	-226.00
264.50	143.50	133.00	116.00	76.00	0.00	-84.00	-121.00	-154.00	-187.00	-218.00
265.00	163.00	157.00	143.00	113.00	85.00	0.00	-91.00	-133.00	-171.00	-205.00
265.50	184.00	181.00	169.00	145.00	126.00	94.00	0.00	-101.00	-145.00	-187.00
266.00	208.00	205.00	195.00	176.00	160.00	138.00	102.00	0.00	-110.00	-161.00
266.50	226.00	230.00	223.00	212.00	194.00	176.00	151.00	113.00	0.00	-119.00
267.00	257.00	256.00	251.00	237.00	226.00	211.00	192.00	164.00	115.00	0.00

NOTES: 1. Flows are in cubic metres per second (M3/s).
2. Negative flow indicates flow upstream (from Island Pond to Meelpaeg).

TABLE 3.2

ISLAND POND PMF HYDROGRAPH

Time (Hours)	Unitgraph (M3/s per cm of rain)	(1) Direct Runoff (M3/s)	(2) cm of rain	2.47	2.47	2.47	2.47	3.82	5.54	5.63	5.5	4.78	5.24	5.24	5.28	4.16	4.16	0.5	0.5	Total Runoff (M3/s)
			Time (Hrs)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	
0	0	0.0		0.00																
6	11.3	23.4		27.91	0.00															0.0
12	22.6	32.4		55.82	27.91	0.00														51.3
18	15.1	38.0		37.30	55.82	27.91	0.00					(3)								116.1
24	7.5	46.4		18.53	37.30	55.82	27.91	0.00												159.0
30	0	58.3		0.00	18.53	37.30	55.82	43.17	0.00											185.9
36		73.9			0.00	18.53	37.30	86.33	62.60	0.00										213.2
42		72.9				0.00	18.53	57.68	125.20	63.62	0.00									278.6
48		65.5					0.00	28.65	83.65	127.24	62.15	0.00								338.0
54		64.5						0.00	41.55	85.01	124.30	54.01	0.00							367.1
60		68.3							0.00	42.23	83.05	108.03	59.21	0.00						369.4
66		68.8								0.00	41.25	72.18	118.42	59.21	0.00					360.8
72		64.5									0.00	35.85	79.12	118.42	59.66	0.00				359.9
78		52.4										0.00	39.30	79.12	119.33	47.01	0.00			357.6
84		23.4											0.00	39.30	79.73	94.02	47.01	0.00		337.1
90		3.7												0.00	39.60	62.82	94.02	5.65	0.00	283.4
96		0.9													0.00	31.20	62.82	11.30	5.65	205.8
102		0.9														0.00	31.20	7.55	11.30	111.9
108		0.9															0.00	3.75	7.55	51.0
114		0.9																0.00	3.75	12.2
120		0.9																	0.00	4.7

NOTES:
1. Figures represent runoff from Island Pond surface in M3/s.
2. Figures are cm of rain per time interval.
3. Figures represent runoff in M3/s.

PART 4 - ENERGY AND CAPACITY

4.1 PLAN OF DEVELOPMENT

Development of Island Pond would utilize the storage and flow available from the Meelpaeg Reservoir together with the storage and flow available from Island Pond. Water would be diverted from the Meelpaeg Reservoir, via an approximately 4 km long diversion canal, into Island Pond. Channel improvements would be required in Island Pond to reduce head losses across the Pond to where the flow would exit, via the forebay canal, to the forebay. The forebay would be created by construction of a 23m high dam across the North Salmon River valley near its exit into Crooked Lake. This would result in flooding of the valley and raising of the water level in Island Pond to the Full Supply Level (FSL) of the Meelpaeg Reservoir.

From the forebay, water would flow, via a double intake structure, through two 5.40 m diameter buried penstocks, to a powerhouse and discharged into a tailrace channel to Crooked Lake. The water level of Crooked Lake varies slightly since it is part of the forebay for the Upper Salmon plant. An average water level of 241.32 m on Crooked Lake provides an average gross head of 23.18 m for the Island Pond plant which would have an installed capacity of 30 MW.

There would not be a spillway in the Island Pond Development. Flood flows in excess of the plant capacity of 152 m^3/s would be discharged back through the diversion canal to to be stored in the joint Meelpaeg-Island Pond Reservoir.

A drainage area of 155 km^2 for Island Pond would be added to the upstream contributing drainage areas of the Meelpaeg Reservoir, Granite Lake, Burnt Pond and the Victoria Reservoir for a total drainage area of 3363 km^2. This would provide a total average flow into the storage upstream of the proposed Island Pond Development of 112.9 m^3/s, made up of 108.6 m^3/s flow into Meelpaeg and 4.3 m^3/s local inflow at Island Pond. With a deduction of 3.6 m^3/s for the average spill at Ebbegunbaeg, the total Island Pond power flow would be 109.3 m^3/s.

4.2 OPTIMIZATION OF DEVELOPMENT PARAMETERS

Four elements in the Island Pond Development have potential significant cost impacts which justify optimization of each element. These are:

a) Full supply level of Meelpaeg Reservoir/Island Pond, (the requirement for optimization of the FSL was deleted from this study by Newfoundland & Labrador Hydro considering that the existing FSL is probably the maximum practical).

4.2 OPTIMIZATION OF DEVELOPMENT PARAMETERS (Cont'd)

b) Size and invert elevation of the diversion canal,

c) Penstock diameter, and

d) Plant capacity (unit size).

Optimization of the canal, penstock and unit size was undertaken by considering the net benefit as the difference between the cost of the particular element and the cost of providing an equivalent amount of capacity and energy from the next best alternative source. The maximum net benefit occurs at the point where a small increase in capacity and/or energy could be provided as economically from an alternative source.

For this development, two alternative sources were considered, thermal generation and Labrador infeed. The present worth of one kilowatt hour of energy based on an assumed 60 year life for the plant was calculated for each alternative and an average present worth value (in 1987 $) of $0.76/kWh* was used in the optimizations. ?

The optimization was complex and is outlined in detail in a separate report titled "Optimization of Island Pond and Granite Canal Projects". The following is a summary of the results.

As the optimization process proceeded, it was realized that the "target" water level used for Meelpaeg Reservoir in the new regulation model had a significant effect on the system energy output. This element of the development was then included in the list of project elements to be optimized.

Meelpaeg Reservoir - Target Water Level = 265.5 m

Diversion Canal - Optimized Size

Canal invert widths:

-- upstream section in Meelpaeg Reservoir = 30 m
-- overland section = 12 m
-- channel improvements in Island Pond = 60 m

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* This value of energy is the average of the values given by Newfoundland and Labrador Hydro for the two alternative sources of energy.

4.2 OPTIMIZATION OF DEVELOPMENT PARAMETERS (Cont'd)

Diversion Canal - Optimized Size (Cont'd)

Canal invert elevations:

-- upstream section in Meelpaeg Reservoir	= 260.00 m
-- overland section (upstream end)	= 258.00 m
-- overland section (downstream end)	= 256.55 m
-- channel improvements in Island Pond	= 259.00 m

Canal invert slopes:

-- upstream section in Meelpaeg Reservoir	= 0 %
-- overland section	= 0.05%
-- channel improvements in Island Pond	= 0 %

Canal side slopes:

-- in rock cut	= 6V:1H
-- in overburden cut	= 1V:2H
-- overburden set back	= 5 m

Plant Capacity - Optimized

Two units @ 15 MW each	= 30 MW

Penstock - Optimized Size

Penstock diameter	= 5.40 m

4.3 PLANT ENERGY OUTPUT

With the Meelpaeg Reservoir/Island Pond FSL at elevation 266.55m and an average water level in Crooked Lake of 241.32 m, the flows determined in the Bay d'Espoir Regulation Study were converted to plant energy production as follows:

Average Annual Energy Output (gWh)

$$= 9.81 \times Q \times H \times e \times 8760$$

where Q = Average annual flow in m^3/s,
H = Average net head in m, and
e = overall plant efficiency.

An overall plant efficiency of 89.4% was computed as the product of the following individual efficiencies:

4.3 PLANT ENERGY OUTPUT (Cont'd)

Turbine	=	92.5 % (Peak efficiency)
Generator	=	98.6 %
Transformer	=	99.5 %
Plant Services	=	99.5 %
Water Utilization	=	99 %*
Overall	=	89.4 %

The plant energy output was based on the average water levels and the head losses in the diversion canal to Island Pond with an average flow of 105.0 m^3/s. Downstream of Island Pond, the head losses were based on operation at the peak efficiency flow of 140 m^3/s, and allowing for 0.10 m of storage in Island Pond to de-regulate the flow into a daily operation at the peak efficiency flow for 18.5 hours.

Plant energy output was computed based on the following:

Average HWL at Plant	=	264.61 m
Average TWL	=	241.52 m
Average Gross Head	=	23.09 m
Hydraulic losses intake, and penstock at peak efficiency flow	=	0.40 m
Average net head	=	22.69 m

Based on the foregoing, the average annual energy output would be

$$= 9.81 \times Q \times H \times e \times 8760$$
$$= 9.81 \times 109.3 \times 22.69 \times 0.894 \times 8760$$
$$= 191 \times 10^6 \text{ kWh}, \quad \text{i.e. } 191 \text{ gWh}$$

The average annual energy computed by the new regulation model agrees with the average annual energy output calculated above.

Since the proposed Island Pond Development would be operated as an integral part of the Bay d'Espoir System, firm and secondary energy were evaluated in the context of total system output. The firm energy of the Island Pond plant was determined using the new regulation model. A review of the Bay d'Espoir Regulation Study results indicated that the critical dry period occurred from June 1959 to March 1962.

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* A water utilization factor of 99% is included to adjust for spillage not accounted for in monthly simulations, and for periods when the plant would be run off the ideal efficiency setting of the turbine.

4.3 PLANT ENERGY OUTPUT (Cont'd)

The following table summarizes the simulated system energy output in gWh per annum, with and without the Island Pond Development:

A) System Output - Existing (without Island Pond)

	Firm	Secondary	Total
Island Pond	---	---	---
Upper Salmon	475	65	540
Bay d'Espoir	2,209	344	2,553
Total	2,684	409	3,093

B) System Output - (with Island Pond)

	Firm	Secondary	Total
Island Pond	155	36	191
Upper Salmon	477	59	536
Bay d'Espoir	2,218	333	2,551
Total	2,850	428	3,278

	Firm	Secondary	Total
Total Incremental:	166	19	185

This analysis indicates that although addition of the Island Pond Development to the system would result in a net increase in the annual energy from the system there would be a small decrease (6 gWh) in the amount of total annual energy produced at Bay d'Espoir and Upper Salmon when compared to the the predevelopment case. This decrease represents a very small percent of the total production which could probably be picked up by minor adjustments to the plant operation procedures. This decrease has therefore not been considered as a cost to the system in evaluating the energy output and in structure optimization.

Based on the output of the Bay d'Espoir Regulation Study, the firm energy was calculated by taking the average pre-development firm energy production over the drawdown period from June 1959 to March 1962. The total production over the 34 month period was 7,605 gWh which is equivalent to an average annual production of 2,684 gWh. With the addition of the Island Pond plant, firm energy production would increase to a total of 8,075 gWh, or an average annual production of 2,850 gWh. This would be an incremental increase in firm energy of 166 gWh above the pre-development production. Of this, 155 gWh would be produced at the Island Pond plant while an additional 11 gWh would be produced at the downstream plants due to the additional regulation of discharge as a result of the Island Pond Development.

4.4 PLANT CAPACITY

The rated plant capacity is based on the net head calculated with allowances for (1) average flow head losses from Meelpaeg into Island Pond, (2) the maximum flow head losses from Island Pond to the intake, and (3) maximum flow head loss through the water conduit from the trash racks to the tailrace.

The maximum plant output would occur when Meelpaeg is at full supply level and the maximum plant flow of 152 m^3/s is flowing through the system to Crooked Lake.

Net heads available under these conditions are:

	For Rated Capacity	For Max. Plant Output	Worst Operating Condition
Reservoir level	265.62 m	266.55 m	264.00 m
Loss in Diversion Canal	0.82 m*	0.97 m	2.00 m
Loss Across Island Pond	0.03 m*	0.02 m	0.35 m
Island Pd drawdown (Avg)	0.11 m	0.00 m	0.00 m
Loss in Forebay Canal	0.05 m	0.02 m	0.10 m
Intake Level	264.61 m	265.54 m	261.55 m
Tailwater Level	241.52 m	241.52 m	242.00 m
Gross Head	23.09 m	24.02 m	19.55 m
Loss in Intake & Penstock	0.45 m	0.45 m	0.45 m
Net Head	22.64 m	23.57 m	19.10 m
For Equipment Rating Purposes use	22.6 m	23.6 m	19.1 m

* Based on average flow head loss

There would be a difference of about 2.5% between turbine peak efficiency (92.5%) and efficiency at full gate (90.0%).

The generator would be rated at 98.6% of the turbine efficiency.

Turbine and generator ratings under average and maximum head conditions, therefore would be as follows:

	Average	Maximum	Worst
Turbine Rating kW	30300	31700	25600
Generator Rating kW	29900	31200	25300

4.4 PLANT CAPACITY (Cont'd)

and the plant capacity factor would be calculated as follows:

$$\frac{191 \times 10^6}{29{,}900 \times 8760} = 73\%$$

4.5 PLANT OPERATION

Due to the low head of about 23 m at Island Pond, when compared with the 190 m head at Bay d'Espoir, the Island Pond units should be operated as energy producers, not as peaking units. This has been confirmed in the Bay d'Espoir Regulation Study.

The inflow to Island Pond would be relatively constant at 105.0 m^3/s as illustrated by the flow - duration curve on Graph 4. Also, the head would be relatively constant at about 23 m as illustrated by the water level-duration curve for Island Pond on Graph 3. These factors favour the selection of either a propellor or a low head Francis unit which can be operated at its point of peak efficiency.

The Island Pond powerplant differs somewhat from other powerplants on the system due to the configuration of the upstream canal and reservoir system bringing water to the powerplant.

The optimization studies have indicated that it is not economic to design a canal system capable of delivering the full gate turbine flow at the low drawdown level. Instead the canal has been optimized to deliver the average regulated flow of 109.3 m^3/s at the average water level. Flow at extreme drawdown level is limited to only 36 m^3/s or about 25% gate opening on 2 units (or about 50% gate on one unit). Graph 7 shows the maximum flow in the diversion canal for water levels on Meelpaeg.

Since the powerplant would be designed as an energy producer, it should be operated to maximize energy production. This would require operation at the point of peak turbine efficiency.

In order to operate the propellor or Francis units at the peak efficiency point at all times, it would be necessary to de-regulate the regulated flow into a daily or weekly peak efficiency flow.

In the configuration proposed for the development, the regulated diversion canal discharge would be de-regulated by the relatively large secondary reservoir in Island Pond.

depending on the turbine model, the peak efficiency would occur with a turbine flow somewhere between 90% and 95% of full load flow. At the rated head of 22.6 m, full load flow of 152 m^3/s, and assuming a peak efficiency point at 92% of full load flow, peak efficiency flow would be around 140 m^3/s.

4.5 PLANT OPERATION (Cont'd)

As the net head on the turbine varies, the peak efficiency flow will also vary. A graph showing the relationship between peak efficiency flow and head for one particular propellor turbine model is shown on Graph 8. Also, as the head on the unit decreases, the maximum output would decrease, and the peak efficiency would also decrease. The exact change in output and efficiency would only be known on selection of the turbine, since such data would depend on the model selected by the manufacturer. An idea of the change can be obtained from data provided by DEW as follows:

Head (m)	Peak efficiency (%)	Output at peak eff. (MW)
22.6 (Rated)	92.3	14.8
19.6	90.5	12.5
17.6	89.3	10.9

Since the peak efficiency flow of about 140 m^3/s is higher than the average flow of 109.3 m^3/s, "de-regulation" of the average flow is required. This can be easily accomplished with Island Pond which has a surface area of about 33.4 km^2 at the average water level of 264.92 m.

For example, a 24 hour flow at 109.3 m^3/s can be de-regulated into a 140 m^3/s flow for 19 hours, and the fluctuation of Island Pond during this period would not exceed 0.10 m.

As the regulated flows decrease, more storage is required to de-regulate the flow to the peak efficiency flow. This requirement for additional storage can be accommodated by Island Pond. However, as the regulated flow approaches the extreme minimum of 36 m^3/s, the low water levels associated with this drought flow impose a restriction to operation of the powerplant, as illustrated by the following analysis.

At the extreme low average flow of 36 m^3/s, a storage volume of about 6 million cubic meters would be required to convert the average flow into a peaking flow of 140 m^3/s for 8.5 hours per day for 5 days per week.

Island Pond has a surface area of about 20 km^2 at low drawdown, hence a drawdown on Island Pond of 0.3 m would be adequate to de-regulate extreme low flows into the peak efficiency flow.

With two units installed at Island Pond, the same storage volume would be required to convert the average flow into a single unit peak efficiency flow of 70 m^3/s for 17 hours per day for 5 days per week.

4.5 PLANT OPERATION (Cont'd)

In order to obtain a flow of 36 m^3/s into Island Pond with Meelpaeg Reservoir at its LSL of 261.67 m, Island Pond must be drawn down to elevation 260.00 m. With Island Pond storage of 0.30 m, the low drawdown is elevation 259.70 at the inlet to the forebay canal which, with a peak efficiency flow of 70 m^3/s on 1 unit, would have a head loss of 0.33 m, producing a headpond level at the intake of elevation 259.37 m.

In order to operate at peak efficiency flow with an intake head pond at elevation 259.37 m, the intake gate sill would have to be lowered by approximately 2 m and additional excavation would be required in the forebay canal at a total cost in excess of $200,000.

This additional cost must be balanced against the incremental gain in energy. Based on an extreme low flow of 36 m^3/s for 2 months, only once in 36 years, incremental energy is about 1.8 million kwh, representing a single occurence present worth value of only $70,000. Hence the incremental cost of operating 'on peak' at extreme low flows cannot be justified, and the units should be operated 'off peak' when the average flow is below about 50 m^3/s.

This analysis is based on hydraulic turbine model data provided by DEW, for a vertical axis propellor unit. The numbers will change slightly for other turbine models, and somewhat more for a Francis unit, but not sufficiently to affect the basic design or economic evaluation.

Based on the foregoing, the following rules can be used to operate the Island Pond powerplant to maximize the energy output.

Meelpaeg Reservoir above elevation 265.7 m

This condition will occur when there is higher than average flow. Island Pond could be operated continuously at full load, about 30-32 MW depending on the head.

Meelpaeg Reservoir between elevation 265.7 and 265.0

This is the average condition. Island Pond could be operated to produce an average outflow of 109.3 m^3/s, by running both units at equal load for a total of about 19 hours per day at an output of about 28-30 MW, at the point of maximum efficiency.

Meelpaeg Reservoir below elevation 264.0

This represents the below average flow condition. Plant operation should change from a rule based on water level, to rules based on the daily average inflow to Island Pond through the diversion canal, as follows:

4.5 PLANT OPERATION (Cont'd)

Meelpaeg Reservoir below elevation 264.0 (Cont'd)

Daily average between 140 and 60 m^3/s

Operate both units at equal output, at point of peak efficiency, for a time period which would result in a total plant discharge equivalent to the average daily inflow. The peak efficiency would occur at a peak flow of about 140 m^3/s which would result in generation for about 10 hours per day with a 60 m^3/s inflow.

Daily average between 60 and 50 m^3/s

Operate one unit, at point of peak efficiency, for a time period which would result in a total plant discharge equivalent to the average daily flow. At the extreme low flow of 36 m^3/s, this would result in generation for about 8.5 hours per day.

Daily average less than 50 m^3/s

Operate one unit 'off peak' at the average flow.

Detailed analysis of the flow, water levels and energy output would be undertaken when the actual characteristics of the turbine are known. At that time it may be possible to develop a set of operating rules which depend only on water levels, thus simplifying operations.

4.6 FLOOD CONTROL

The permanent structures are designed to perform safely with the occurrence of a maximum probable flood as defined in Part 3 of this report.

Maximum probable flood hydrographs have been computed for the sub basins draining into the Meelpaeg Reservoir and Island Pond. The maximum probable flood from Island Pond would be passed through the diversion canal to the joint Meelpaeg-Island Pond Reservoir where it would be stored for subsequent release as regulated discharge through Island Pond and downstream plants.

The combined floods for Meelpaeg Reservoir and Island Pond were routed through the Ebbegunbaeg Control Structure assuming that the reservoir was at full supply level at the onset of the flood and that the gates were operated to equalize outflow and inflow until fully open. The table below summarizes these results.

4.6 FLOOD CONTROL (Cont'd)

Reservoir	Flood Peak m^3/s	Max. Control Str. Flow m^3/s	Max. Canal Flow m^3/s	Max Flood Level m
Island Pond	369	-	170	268.40
Meelpaeg	2535	209	-	268.40

4.7 CANAL WINTER OPERATION

In order to promote a stable ice cover, water velocities in a canal must be kept below 0.45 m/s for the ice cover to form, after which the velocity could be increased to 0.72 m/s. At higher velocities the underside of the ice cover would erode, and the cover would break up.

Due to the large flow area required to maintain these velocities, and the corresponding high cost of construction, it was not economic to design the diversion canal for a stable ice cover under all operating conditions. The following tabulation indicates the flow velocities at typical sections under selected conditions:

CANAL FLOW *	CANAL SECTION - VELOCITY (m/s)				
	Meelpaeg W.L. (m)	Meelpaeg Reservoir	Overland Section	Island Pond Channels	Forebay Canal
152.0 m^3/s	266.55	0.44	1.29	0.31	0.25
105.0 m^3/s	264.00	0.79	1.54	0.60	0.60
36.0 m^3/s	261.67	0.98	0.95	1.00	0.60

The overland portion of the diversion canal, between Meelpaeg Reservoir and Island Pond would have velocities in excess of that required for an ice cover under all conditions, hence would remain open all year. Under extreme winter conditions, frazil ice could form and be discharged into Island Pond. However, this is of no consequence, since the volume of water within Island Pond is far in excess of that required to absorb the maximum conceivable accumulation of frazil ice.

Flow velocities within Island Pond, through the channel improvements, and through the forebay canal would be safely below the 0.72 m^3/s limit at all times. Hence a stable ice cover would form, and no problems with frazil ice should be encountered at the intake.

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* For the significance of these conditions, refer to the explanatory footnote in Part 6.4.

4.7 CANAL WINTER OPERATION (Cont'd)

For the forebay canal, the flow velocity at low drawdown, based on the long-term average flow of 109.3 m^3/s would be 0.55 m/s. This velocity would increase to 0.72 m/s when the units are operated at the peak efficiency point, and this criterion becames the governing design condition for the forebay canal.

To develop a stable ice cover on the forebay canal the canal velocity would have to be reduced to 0.45 m/s, corresponding to operation of the units 'off peak' at 58% gate. As an alternative, in the event energy production is of prime concern, the units would be shutdown for a period of about 40 hours to allow the initial winter ice cover to form following which the units could be returned to peak efficiency flow.

PART 5 - ALTERNATIVES CONSIDERED

5.1 ACCESS ROADS

As noted in Section 2.2, two alternative access routes to the Island Pond Development were reviewed. These were:

1. Access from Bay d'Espoir via the North Salmon Dam and a new road extending north from the Dam and then west around Great Burnt and Crooked Lakes.
2. Access from Bay d'Espoir via a new road westward from the North Salmon Road, across the Upper Salmon diversion canal south of Crooked Lake to Ebbegunbaeg, and thence via the existing Ebbegunbaeg road to a new road extending northward along the west side of Crooked Lake to the proposed development.

The alternative routes are discussed in the following sections.

Alternative 1 - Access from Bay d'Espoir via the North Salmon Dam

This route for the permanent access road was the proposed route described in the Pre-feasibility Report. It would require the construction of approximately 27 km of new road, over very difficult terrain around the east and north sides of Great Burnt and Crooked Lakes, between the existing North Salmon Dam and the proposed powerhouse location. In addition, approximately 19 km of construction access roads would be required to gain access to other structures and borrow areas in the Development.

The estimated direct cost for this Alternative (exclusive of engineering and Owner's costs, contingencies, escalation and interest during construction) would be about $6,962,000.

Alternative 2 - Access from Bay d'Espoir via the North Salmon Road and Ebbegunbaeg

This route for the permanent access road was not considered seriously during the pre-feasibility study because it was originally thought to have a significant environmental impact as well as scarity of construction material compared with the Alternative 1 route. It was subsequently established that the difficult longer route required for Alternative 1 should not be used in the feasibility study.

This route for the permanent road would include the upgrading of approximately 8.5 km of existing road and the construction of approximately 22.5 km of new road between the Upper Salmon Diversion Canal bridge and the proposed powerhouse location. A large bridge would be required at the crossing of the existing diversion canal between Great Burnt Lake and Cold Spring Pond of the Upper Salmon Development. In addition, approximately 22 km of construction access roads would be required to gain access to other structures and borrow areas in the Development.

5.1 ACCESS ROADS (Cont'd)

Alternative 2 - Access from Bay d'Espoir via the North Salmon Road and Ebbegunbaeg (Cont'd)

The estimated direct cost for this Alternative would be about $5,638,000.

Based on the above comparative costs for the two alternative routes, Alternative 2 was selected due to the lower cost. The construction of this access route would require the sequential construction of the bridge across the Upper Salmon diversion canal, and construction (from one front only) of:

- 15.5 km of new road to the Ebbegunbaeg Control Structure,
- 7.0 km of new road from the existing Ebbegunbaeg access road to the powerhouse, and
- a temporary access road to the forebay canal.

The forebay canal excavation and subsequent lowering of the Island Pond water level (described in Part 5.3) are critical elements in the construction schedule and the sequence of work described for the development of access would require a construction period of about one year before work on the forebay canal could begin on August 1, 1989.

With this schedule for start of on site work, the on-power date for the first unit would be November 15, 1992.

A review of the construction schedule was carried out to determine if the provision of initial temporary access from Millertown would improve the project schedule and facilitate an earlier start of construction on the forebay canal and an earlier on-power date.

It was determined that provision of this temporary access would enable immediate access to the diversion canal and access to the forebay canal within one week. At the same time, the temporary access would facilitate construction of the permanent access road between Ebbegunbaeg and the North Salmon Road on two fronts. It would also accelerate construction of the permanent access road to the powerhouse and would facilitate an earlier start of construction in other areas than would otherwise be possible using only the permanent access.

To provide this temporary access from Millertown would require the upgrading of approximately 50 km of existing roads between the Red Indian Lake Dam at Millertown and the proposed diversion canal.

5.1 ACCESS ROADS (Cont'd)

The upgrading would include widening and resurfacing of the existing roads, repair or replacement of several culverts and bridges and construction of a temporary bridge at Noel Paul's Brook as required for the contractors access.

The estimated direct cost for provision of the temporary access from Millertown, combined with Alternative 2 would be about $7,074,000.

The options of: (a) providing permanent access only (Alternative 2 above) and, (b) provision of temporary access from Millertown, combined with Alternative 2 above, were cash flowed to determine the total cost difference between the two options. This analysis considered the effect of the different schedules on the total project cost. The difference in total project costs, including direct costs, engineering and Owner's costs, contingencies, escalation and interest during construction, was determined to be $3,285,000 in favour of the option with the temporary access. The results of the cash flow analysis is summarized as follows:

Option	Total Project Cost
Permanent Access Only (Alternative 2)	$130,513,000
Temporary Access from Millertown, combined with Permanent access	$127,228,000
Difference	$ 3,285,000

Based on the above result, the provision of temporary access from Millertown, combined with the permanent access from Bay d'Espoir, was selected as the scheme for site access to be included in the project planning, project cost estimate and construction schedule.

5.2 DIVERSION CANAL ROUTE

In the Pre-feasibility Report of the Island Pond Development, two alternative routes for the canal between the Meelpaeg Reservoir and Island Pond were described. One alternative, called the south route, required approximately 5.2 km of overland excavation and 0.1 km of underwater excavation in the Meelpaeg Reservoir. Because very deep overland excavation would be encountered on this route, a tunnel option to the excavated canal was reviewed. The other route, called the north route, required approximately 1 km of underwater excavation in the Meelpaeg Reservoir, approximately 3 km of overland excavation and approximately 1.5 km of underwater excavation in Island Pond.

5.2 DIVERSION CANAL ROUTE (Cont'd)

Comparative cost estimates of the two routes and the tunnel option determined that an excavated canal along the north route was significantly less costly and was therefore recommended as the preferred route.

During the 1987 field investigations, more topographic detail was collected along the north route and alternative alignments of the canal were investigated considering construction access, unwatering requirements and cost. Minor realignments of the overland section of the canal were made to minimize excavation quantities.

It was also established that the underwater excavation section of the route could be unwatered sufficiently that, with a minor section modification along this section of the route, cost could be further reduced.

In three areas of Island Pond the depth of water over the existing bottom during periods of low level operation would be insufficient to pass the turbine demand flow, therefore, channel improvements would be required to pass the flow from west to east through the Pond. One of these areas was identified in the Pre-feasibility Report whereas the other two areas are new, as a result of the 1987 field investigations.

Alternative routes for the improvements in the Pond were investigated to minimize the cost of excavation, considering available flow area and construction access.

At the first of these areas, just downstream of the canal entrance into the west end of Island Pond, two alternative routes for the channel improvement were considered (Plate 6). A north route would follow a relatively deep water channel along the west side of Island Pond with shallow excavation being required over a portion of the route to provide the required flow area. Near the downstream end of this improvement, an excavation through a narrow neck of land would be required to reach deep water to the east. The southern route through an existing shallow water passage (route identified in the Pre-feasibility Report) would require considerably more excavation than the north route and also presented a longer confined passage for the flow. The north route was therefore selected as the preferred route, based on economic as well as hydraulic considerations.

The other two areas requiring channel improvements were not previously identified in the Pre-feasibility Report. These areas, located to the east of the area described above and near the south shore of Island Pond, would require shallow excavations to increase the available flow area. Alternative routes, located north of these routes, were considered. The northern routes are more remote and difficult for construction access and were therefore deleted from further consideration.

5.3 UNWATERING OF DAM SITE

In the Pre-feasibility Report the proposed method for unwatering of the dam site was by a 4.1 m diameter diversion conduit through the dam. This conduit would be complete with a concrete intake and one-use closure gate. After completion of the diversion, the conduit would be filled with sand and gravel, except for the central portion through the dam core and filter zones which would have to be filled with concrete.

An alternative method for unwatering of the dam site, as well as the other construction sites, was developed which would take advantage of several unique features of the Island Pond site. These features are:

- The small difference in elevation between Island Pond and the Meelpaeg Reservoir.
- The large surface area of Island Pond compared to the Island Pond drainage area.
- The shallow depth of the North Salmon River at the outlet from Island Pond.

The unwatering method developed would eliminate the need for a diversion culvert at the site, and reduce the cost of constructing the forebay canal and Island Pond channel improvements. It would also permit early closure of the North Salmon River at the forebay canal entrance for construction of the dam and tailrace in the dry. This early closure would also provide for impoundment of local run-off to fill Island Pond up to the Meelpaeg Reservoir water level offering an additional energy benefit.

The proposed unwatering and construction sequence is shown on Plate 9 and is as follows:

Stage I - Drawdown Island Pond

- Excavate an initial pilot channel to lower Island Pond by approximately 1.5 m to elevation 261.0 m for construction of the forebay canal entrance behind low level cofferdams A and B at elevations 262 m and 261 m, respectively.

Stage II A - Impound in Island Pond

- Construct Stage II cofferdams C and D in the dry to elevation 265 m.

- Close pilot channel at cofferdam C and install the closure across the completed forebay channel entrance at cofferdam C to proceed with excavation of the downstream forebay canal.

- Construct a forebay filling conduit in cofferdam C for use at the end of stage III.

5.3 UNWATERING OF DAM SITE (Cont'd)

Stage II B - Drawdown Island Pond

- Open the canal closure structure at cofferdam D to pass the spring run-off and lower Island Pond to elevation 259 m for construction of the Island Pond channel improvements and the initial diversion canal excavation.

- Raise cofferdams C and D to elevation 268 m in the dry, across the forebay entrance, and stockpile fill for final closure at the excavated forebay canal.

- Proceed with excavation of diversion canal, with local drainage discharging through Island Pond, at elevation 259 m, to the North Salmon River.

Stage III - Impound in Island Pond

- Following completion of Island Pond channel improvements and, before the subsequent spring run-off, close the forebay canal cofferdam D and impound run-off to fill Island Pond to existing Meelpaeg level.

- The remaining diversion canal and Meelpaeg Reservoir entrance excavation would proceed behind an upstream cofferdam at the Meelpaeg entrance, and downstream closure fills or plugs as required to protect the work from rising water in Island Pond.

- When dam and intake construction permits, open the filling conduit in cofferdam C to fill the forebay and commission the first unit.

- Remove closure fill in cofferdam D over full width of the forebay canal.

This sequence of operations would effectively permit construction of the Power Complex Structures in the dry with only local runoff from the 1.3 km^2 drainage area, downstream from the forebay canal cofferdam, being handled by pumping and piping around the damsite as required.

A preliminary cost comparison of the two unwatering alternatives indicated a cost balance in favour of the early impoundment alternative. This alternative would require an advancement of the canal construction of about 6 months from that required with the conduit alternative; however, the interest during construction on this earlier work would be more than offset by the deletion of the unwatering conduit through the damsite and the expected saving in construction costs on the diversion canal and tailrace excavation. An additional benefit would also be derived from the impoundment of runoff from the Island Pond drainage area to fill the Island Pond storage.

5.4 DAM TYPE AND LOCATION

For the Pre-feasibility Report, three types of dams were considered:

- A concrete dam,
- An embankment dam, and
- A combination concrete and embankment dam.

Based on a cost comparison of the alternatives, the Pre-feasibility Report recommended an embankment dam in conjunction with an upstream intake, steel penstocks through the dam, and a powerhouse immediately downstream of the dam. This concept was based on the assumption that a sufficient quantity of impervious core material was available.

The 1987 field investigations confirmed that sufficient impervious core material is indeed available, however, it has a relatively low fines content and will require a broad core design for the dam. In view of this, together with the fact that a similar arrangement of the power complex structures is still considered most appropriate an embankment type of dam is still recommended. As described in Part 5.5 the power complex structure would, however, be relocated to the east abutment.

The location of the dam presented in the Pre-feasibility Report was reviewed in the light of new field topographic data. To minimize fill quantities, and to ensure that the dam would abut on converging trends in the valley walls, the location of the dam was moved slightly upstream from the original site. This move would also shift the toe of the dam upstream from a relatively steep section of the river bed.

5.5 INTAKE AND POWERHOUSE LOCATION

For the Pre-feasibility Report, several alternative locations of the intake/penstocks/powerhouse were reviewed. The recommended layout was with the intake upstream of the impervious core, in the west abutment of the dam, and with the powerhouse located immediately downstream of the toe of the dam, in the river channel. The tailrace was to be excavated along the existing river channel from the powerhouse to Crooked Lake.

For the Feasibility Report, the layout in the Pre-feasibility Report was reviewed, in conjunction with the problem of unwatering of the site. Considering new topographic data obtained during the 1987 field investigations, the site unwatering requirements, and the deep excavation required for the powerhouse at the toe of the dam, it was considered more practical, from a construction view point, to relocate the structures into the east abutment, adjacent to the dam. In this location, the intake could be constructed in a rock cut across a compartively flat area of topography with minimal concrete wing walls required to retain the upstream dam fill. Also, in this arrangement, the powerhouse could be constructed in an excavation adjacent to, but separated from the river channel, thereby reducing the site unwatering problems. This location would also reduce the impact of the power structures on the stability of the main dam.

On the east abutment, the powerhouse would be located close to the downstream toe of the dam as shown by the layout on Plate 9 and referred to as Layout A. This site would be somewhat confined for construction with all the structures associated with the powerhouse situated within a relatively narrow part of the original river channel having steep embankments.

To determine whether there could be any cost savings associated with an alternative location further down the river valley, another layout was developed, as shown on Plate 10. In this arrangement the penstock length would be increased by about 50%, however, the tailrace would be reduced in length by 50% and it would discharge almost directly into Crooked Lake. This arrangement is referred to as Layout B.

Comparative costs were estimated for both layouts as shown in Table 5.1. This comparison includes construction costs as well as costs associated with the hydraulic losses, and the additional generator inertia required with Layout B, due to the longer penstocks.

This analysis indicates a difference of about $1,700,000 in favour of Layout A. This difference could be reduced due to the more difficult construction work associated with Layout A, however, these additional costs are not expected to exceed about $250,000, hence Layout A is the preferred alternative.

In Layout A the intake, penstock and powerhouse have been located relative to the topography, based on the subsurface information available to date. This information is limited to one drill hole and four probe holes. Prior to detailed design, further exploratory work would be required to more accurately delineate sound rock surfaces. However, this additional data is not expected to result in major changes in structure locations, and only minor re-alignment of the structures would be required to optimize the design for final cost assessment.

5.6 TURBINE TYPE

At a net head of 22.6 m, four types of turbines could be installed at Island Pond, namely:

- Vertical axis fixed blade propellors
- Vertical axis moveable blade propellors (Kaplans)
- Vertical axis Francis turbines
- Horizontal axis, axial flow moveable blade propellor turbines (Tube or "S" units)

The factors which enter into the selection of the turbine unit are cost, efficiency, operating mode and previous experience. Each of these factors are discussed for the four types of units, based on data provided by manufacturers*, a summary which is included in Appendix II.

Comparison of Propellor and Francis Units

Propellor units operate at a higher speed than comparable Francis units and therefore require more submergence; the actual submergence depending on the turbine design. Based on data provided by three manufacturers (Table 5.2), it is apparent that a propellor unit would require a setting about 4.0 to 4.5 m lower than a Francis unit.

The deeper setting of the propellor unit would require additional rock excavation. Additional excavations for the penstock approach to the powerhouse, the powerhouse substructure, and the tailrace adjacent to the powerhouse, with a plan area of about 1680 m^2 and excavated a further 4.25 m deep, would result in an additional rock excavation volume of about 7140 m^3. For the same unit capacity, there is no appreciable difference in the size of the turbines for Propellor or Francis units, hence the powerhouse layout should not change. Since rock is relatively low in the proposed repair bay area, the floor level would be adjusted to limit any increased excavation outside the unit blocks. The total additional rock excavation required, therefore, would be about 8,000 m^3, which would increase the cost by about $200,000.

The cost saving associated with a propellor turbine, due to the higher speed, is in the region of $1,700,000 to $4,600,000 based on the Canadian budget prices received. The probable saving is likely to be in the region of $2,000,000, or more than sufficient to compensate for the additional rock excavation.

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* Budget data and prices were recieved from Dominion Bridge-Sulzer Inc. (DBS), Dominion Engineering Works (DEW) and Voith Hydro, Inc. (Voith).

5.6 TURBINE TYPE (Cont'd)

Comparison of Propellor and Francis Units (Cont'd)

The unit efficiency and operating mode should also be included in the comparison. In general, the efficiency curve of a propellor unit is more peaked than that for a Francis unit. This is of no consequence provided the units can be operated continuously 'on peak'; but does represent an advantage for a Francis unit if the occasional 'off peak' generation will occur, as often happens in practise.

Another advantage for a Francis unit is that the peak efficiency can be expected to be in the region of 92-93%, whereas that for a propellor unit will be in the region of 91.5-92.5%. Depending on the models selected by the manufacturers, peak efficiency for a Francis unit could be in the region of 0.25 to 1.25% more than that for a propellor unit. Assuming an average gain of 0.5% in efficiency this would represent an additional $775,000 of capitalized energy value.

The cost comparison for Propellor and Francis units, therefore, is as follows:

Saving in equipment cost (Propellor)	$2,000,000
Less extra cost of excavation	$ 200,000
Less value of capitalized energy	$ 775,000
Net saving about	$1,025,000

On this basis, a Propellor unit is more economical than a Francis unit.

However, this analysis depends on two factors which can vary by a considerable margin, namely:

- Equipment cost - Depending on the market situation at the time of bidding, the cost difference between Francis and Propellor units may not be as high as assumed.

- Efficiency - Depending on the models developed by manufacturers, the peak efficiency of a Francis unit could be over 1.2% higher than a propellor unit.

For example, if the analysis is confined to data provided by DEW, the difference in peak efficiency is 1.21%, and the cost comparison becomes:

Saving in equipment cost (Propellor)	$1,700,000
Less extra cost of excavation	$ 200,000
Less value of capitalized energy	$1,875,000
Net additional cost about	$ 375,000

5.6 TURBINE TYPE (Cont'd)

Comparison of Propellor and Francis Units (Cont'd)

On this basis, a Francis unit is slightly more economical than a propellor unit. This result is not unexpected, since DEW have developed hydraulic models for low head Francis runners, whereas other manufacturers do not recommend the use of Francis runners at a head of 22.6 m, and instead have concentrated on developing propellor models for this head.

In view of this indefinite cost margin a firm recommendation on unit type cannot be made at this time. Since the principle difference between the two types of units is the unit speed and setting, the decision should be deferred to the final bidding stage, by calling for bids on turbine-generators of either Francis or Propellor type, and then basing the decision on an analysis of cost, weighted efficiency, and turbine setting.

Comparison of Vertical Axis Propellor and Kaplan Units

Both these units have the same submergence requirements, and throat diameters are also about equal. However the Kaplan unit usually costs about 25% more than an equivalent propellor, for a cost increase of about $1,200,000.

The advantage of a Kaplan lies in the very flat efficiency curve, which is negated in this case by operation of the units 'on peak' by daily start-stop operation during periods of low flow, as discussed in Part 4.5.

On this basis, Kaplan units cannot be justified.

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines)

During the past decade, the energy crisis in the United States prompted a review of the hydro potential at existing low head dams. A large number of sites were found to be attractive, and manufacturers responded by developing the 'tube' or 'S' turbine. Also, due to the potential market, manufacturers developed a range of 'standard' units, where the basic hydraulic design was undertaken with computers. By using gear boxes between the generator and turbine, generator speeds became independent of turbine speeds, and manufacturers could then make use of industrial motors as the generating unit instead of 'hydro' generators; all in the interest of reducing the initial cost. In fact, DBS have also used motors when quoting budget prices for the vertical axis propellor, as will be evident by comparing the DEW and DBS generator prices. DEW quoted $5.2 million whereas DBS quoted $4.2 million, both based on 200 rpm units from CGE (Peterborough), with the higher cost being a 'hydro' generator and the lower cost being an industrial motor.

5.6 TURBINE TYPE (Cont'd)

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines) (Cont'd)

Of course there is a penalty to pay for the lower cost motor, in efficiency and inertia. Motors usually have an efficiency in the region of 97-98% and generators in the region of 98-99%. Motor inertia is usually about half that of an equivalent generator. No data on motor or generator efficiencies have been provided by the manufacturers. Instead, reference was made to the Cat Arm generator peak efficiency of 98.78% and the Paradise River motor peak efficiency of 97.0%, for a difference of 1.78%. A 1.5% difference in efficiency represents a capitalized cost of $2,325,000.

DBS have provided details on the equipment arrangement for a powerplant with two horizontal axis propellor units, and this data has been used to develop the powerhouse layout shown on Plate 14, wherein it will be noted that:

- The deep submergence, and area occupied by the units requires a larger excavation.
- The generators are below tailwater.
- The plan area of the powerhouse, and the powerhouse volume are larger than that required for equivalent vertical axis units.

A comparison of the differences between the horizontal and vertical layouts is given in Table 5.3, where the ancilliary electro-mechanical costs have been neglected as being almost equal. Table 5.3 indicates that the civil work costs associated with the horizontal units are about equal to those required for vertical axis units. The crane and draft tube gate costs are approximately equal, and the generating units cost about $2,200,000 less with horizontal units, for a total difference of $2,127,000, favouring the horizontal units. However, when the lower generation from horizontal units is included in the comparison, the analysis favours the installation of vertical axis units by a small margin of only $200,000, or just over 1% of the powerplant costs.

On the other hand, manufacturers advise that delivery of horizontal axis units will be much quicker than vertical axis units. This could result in a commissioning date about one year sooner, saving about $7,800,000 in interest during construction, based on a compounded quarterly rate of 2.5% (10.38% per annum), and an even cash flow. A more realistic assumption would be a 6-9 month saving for a difference of about $3.8 to $5.8 million.

5.6 TURBINE TYPE (Cont'd)

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines) (Cont'd)

A saving in cost of this magnitude would favour the horizontal units. The question now becomes one of risk, since manufacturers have not built horizontal axis units of 15 MW capacity at 23 m head. Manufacturers have built smaller units at 23 m head, and units of the same physical size (turbine throat diameter) at lower heads.

Some of the risk could be overcome by installing a larger number of smaller horizontal axis units. However, this would increase the cost, and negate the savings.

A conservative design philospophy would require selection of the vertical axis alternative. If cost savings are paramount, then a horizontal axis unit could be used provided:

a) Detailed discussions are held with manufacturers to confirm cost and delivery of the units.

b) Detailed engineering discussions are undertaken with manufacturers to review the speed regulation problem associated with using horizontal axis units on 100 m long penstocks with generators having low inertia.

Based on the information available to date, the vertical axis alternative is the recommended approach.

5.7 NUMBER OF UNITS

For a total installed capacity of 30 MW, there is the option of installing one 30 MW unit, or 2 at 15 MW or 3 at 10 MW.

Table 5.4 compares the cost of one, two or three units. The cost of one or two units was found to be identical, and the cost of a three unit installation would increase by about $1.0 million.

The comparison was undertaken for Layout B, since the longer penstocks in this layout would favour selection of a single unit. If a two-unit installation proves to be the recommended option with Layout B, it would be even more so with the shorter penstocks on Layout A.

Comparing one unit with a two unit installation, it will be noted that the additional cost of the turbines and generators associated with the two units, is countered by the lower cost of the powerhouse concrete.

A two unit installation is therefore the recommended option. A three unit installation cannot be justified due to the additional cost.

TABLE 5.1

COMPARISON OF LAYOUTS

POWER COMPLEX STRUCTURES

Item	LAYOUT A		LAYOUT B	
	Quantity	Cost	Quantity	Cost
Additional Fill at East Abutment of Dam	13,510 m^3	$ 209,400	28,150 m^3	$ 436,300
Intake Channel - Overburden	--	--	5,360 m^3	53,600
- Rock	--	--	15,280 m^3	305,600
Penstock Excavation - Overburden	5,690 m^3	56,900	8,250 m^3	82,300
- Rock	19,250 m^3	385,000	21,200 m^3	424,000
Pipe & Backfill	--	--	64 m	1,472,000
Tailrace - Rock	47,450 m^3	949,000	--	--
Access Road	210 m	26,300	--	--
Generator Inertia	--	--	+40%	650,000
Head Loss Difference	--	62,400	--	--
Total		1,689,000		3,423,800
Difference			1,733,900	

TABLE 5.2

COMPARISON OF POWERPLANT COSTS

TWO VERTICAL vs. TWO HORIZONTAL AXIS UNITS

Item	Vertical Axis		Horizontal Axis	
CIVIL WORKS				
	Quantity	Cost	Quantity	Cost
Rock Excavation	10,500 m^3	$ 263,000	15,860 m^3	$ 396,000
Concrete	5,468 m^3	3,729,000	5,303 m^3	3,617,000
Wall Area	1,642 m^2	205,000	1,680 m^2	210,000
Roof Area	933 m^2	80,000	1,176 m^2	100,000
Sub-Total		$4,277,000		$4,323,000
MECHANICAL EQUIPMENT				
	Data	Cost	Data	Cost
Crane	55 T, 14 m span	$ 530,000	35 T, 21.8 m span	$ 631,000
Draft tube gates (w x h)	2 x 5.15 x 3.8 m	246,000	6.4 x 4.441 m	171,000
Monorail hoist		97,000		123,000
Guides		85,000		60,000
Sub-Total		958,000		985,000
Generating unit (DBS prices)		10,100,000		7,900,000
Sub-Total		15,335,000		13,208,000
Efficiency, capitalized value		-		2,325,000
Total		$15,335,000		$15,533,000
Difference			$198,000	

TABLE 5.3

COMPARISON OF 1, 2, OR 3 UNITS

ITEM	1 UNIT		2 UNITS		3 UNITS	
	Data	Cost	Data	Cost	Data	Cost
Intake Gate	1 x 6.7 x 8.4 m	831,000	2 x 4.75 x 6 m	995,000	3 x 3.9 x 4.9 m	1,125,000
Penstock	605 tons	2,722,000	645 tons	2,902,000	684 tons	3,078,000
Penstock	7.6 0 20 mm	-	5.4 0 15 mm	-	4.4 0 13 mm	-
Penstock Rock Cut	10.0 m wide	234,000	14.2 m wide	332,000	17.6 m wide	411,000
P.H. Rock Excavation	19,700 m^3	591,000	14,300 m^3	429,000	12,300 m^3	369,000
P.H. Concrete	7980 m^3	5,442,000	5790 m^3	3,949,000	4980 m^3	3,396,000
Superstructure Steel	129 ton	452,000	113 ton	396,000	111 ton	389,000
P.H. Crane	105T, 17 m span	753,000	55T, 14 m span	530,000	43T, 12 m span	439,000
Turbine	30.26 MW	5,510,000	15.13 MW	6,500,000	10.09 MW	7,150,000
Generator	150 rpm	5,700,000	200 rpm	6,500,000	225 rpm	8,100,000
Draft Tube Gates	2 x 7.28 x 5.37	667,000	2 x 5.15 x 3.8	428,000	1 x 7.36 x 2.89	308,000
Total		22,902,000		22,961,000		24,765,000
Incremental Cost			$59,000		$1,804,000	

PART 6 - DESCRIPTION OF DEVELOPMENT

6.1 GENERAL

The selected alternatives for the various structures are described in the following sections. Preliminary designs as developed for the present study have established the basic types and configurations of the structures, however, small changes in size, elevation or alignment may occur prior to actual construction.

The extent of clearing in the reservoir is a subject of the environmental report. It has been assumed that the small quantity of treed and flooded area around the southeast perimeter of Island Pond and the forebay area would be completely cleared. The total area requiring clearing is approximately 83 hectares.

6.2 FREEBOARD ALLOWANCES

Freeboard allowances on the earth dams in the Island Pond Development (Island Pond Dam and Ebbegunbaeg Freeboard Dyke) have been designed using accepted formulae* which consider wave height, run up of waves, wind set up, fetch and the effect of surrounding topography.

Two conditions are envisaged for the selection of the freeboard allowances. There are:

i) set-up resulting from a design storm with wind speeds of 145 km/h on the full supply level; and

ii) set-up resulting from nominal storm wind speeds of 65 km/h on maximum flood levels.

The available freeboard allowances for the existing dams on the Meelpaeg Reservoir were checked using the above conditions and the new maximum flood level on the Reservoir as a result of the Island Pond Development.

The freeboard allowances for all dams were checked for a further extreme condition where one of the Ebbegunbaeg Control Structure gates was assumed to be inoperable. Since flood is handled by storage in Meelpaeg, having one gate inoperable would not affect the freeboard limit significantly.

The results of the freeboard calculations are summarized in Table 6.1

6.3 EBBEGUNBAEG FREEBOARD DYKE

This structure would be required to prevent uncontrolled loss of water from the Meelpaeg Reservoir, through a low saddle in the southeast perimeter of the reservoir and

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* "Freeboard Allowances for Waves in Inland Reservoirs" by Saville, McClendow and Cochran - Journal of the Waterways and Harbours Division Proceedings of the A.S.C.E. May 1962.

6.3 EBBEGUNBAEG FREEBOARD DYKE (Cont'd)

into the Upper Salmon Development watershed, during periods of high water level in the reservoir. The low saddle is a broad flat area located approximately 2.7 km from the Ebbegunbaeg Control Structure. It was not originally included in the scope of work for this study. Site survey details and a preliminary design using sheet steel piling as the water barrier were provided by Hydro's project staff for use in this study.

The dyke would have a crest elevation of 271 m, an average height above the original ground of 3.5 m with a maximum height of 6 m, and a total crest length of about 500 m. At the FSL elevation of 266.55 m the deepest section of the dyke would retain approximately 1.5 m of water above its foundation.

The dyke could be built using alternative designs such as:

- Sheet steel piling as the water barrier within a sand and rockfill shell.
- Butyl rubber or alternative synthetic membrane as the water barrier within a sand and gravel shell.
- A homogeneous sand and gravel till section, with rock facing.

Further work is necessary to determine the most economical alternative. The principle requirement for final design would be further knowledge of the local materials. From a cost standpoint, the homogeneous fill section with flexible synthetic membrane should be the most economic and this was included in the estimate.

A general layout and typical cross section of the dyke are shown on Plate 4.

6.4 DIVERSION CANAL

The diversion canal comprises an approximately 1,000 m long section in the northeast arm of the Meelpaeg Reservoir, an approximately 3,000 m long overland section between Meelpaeg Reservoir and Island Pond, and a total of approximately 2,400 m of channel improvements in three separate areas in Island Pond, as shown on Plates 5 and 6.

The section of canal in the Meelpaeg Reservoir (Plate 4) would be shallow and wide to minimize the requirement for rock excavation. By cofferdamming and pumping, this section could be unwatered to facilitate excavation essentially in the dry. Approximately 154,000 m^3 of earth excavation and 16,000 m^3 of rock excavation would be required in this portion of the canal. To minimize difficulties with excavation of mud throughout this section, and to prevent ice problems in the winter, dykes would be constructed of excavation spoil along both sides of the excavation to prevent mud and ice from the adjacent slack water areas from migrating into the canal.

6.4 DIVERSION CANAL (Cont'd)

The overland section of the canal (Plate 5) would be a deep and narrow excavation extending across the higher ground and through a low saddle at the height of land between the Reservoir and Island Pond. This section of canal would have an invert width of 12 m and would require the excavation of approximately 446,000 m^3 of earth and 298,000 m^3 of rock. Unwatering would be achieved by selective cofferdamming, pumping and free drainage toward Island Pond which would be lowered to approximately elevation 259 during most of the work.

The channel improvements through Island Pond are required to increase the available flow area and reduce head losses through the Pond. Excavations are required in 3 areas as shown on Plate 6. A total of approximately 300,000 m^3 of shallow earth excavation would be required. Primary unwatering of the areas of channel improvements would be accomplished by lowering the water level of Island Pond as much as practical by earlier excavation of the forebay canal at the outlet of the Pond. Secondary unwatering, as required, would be accomplished by selective cofferdamming and pumping.

The optimized canal design resulted in the following design criteria for the different sections of canal:

Meelpaeg Reservoir Section - Winter ice cover 0.5m thick.

Invert width	30.0 m
Side slopes	6V:1H, in rock cut 1V:2H, in earth cut
Invert elevation	260.0 m
Length	1000 m
Friction coefficient	Manning's n = 0.035

Flow*	Meelpaeg W.L.*	Flow Depth**	Velocity
152 m^3/s	266.55 m (FSL)	6.55 m	0.44 m/s
105.0 m^3/s	264.00 m	4.00 m	0.79 m/s
36 m^3/s	261.67 m (LSL)	1.67 m	0.98 m/s

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* The flows and water levels shown are values selected for illustrative purposes because of their significance:

WL 266.55 m	=	full supply level of Meelpaeg Reservoir
152 m^3/s	=	maximum plant flow
WL 264.00 m	=	minimum WL at which average flow from Meelpaeg Reservoir can be maintained
105.0 m^3/s	=	average flow from Meelpaeg Reservoir
WL 261.67 m	=	low supply level of Meelpaeg Reservoir
36 m^3/s	=	maximum flow possible with LSL on Meelpaeg Reservoir

** Flow depth is below ice cover.

6.4 DIVERSION CANAL (Cont'd)

Approximately 2.6 km upstream of the inlet to the diversion canal, there is a natural constriction around several islands in the passage through the northeast arm of the reservoir. During the 1987 field investigations, water soundings were taken in this area and the data was analysed in a hydraulic model. The results of the modelling indicated that, with the water level and flow criteria established for the diversion canal (refer to Part 4.1), there would be ample flow area available at this site and no significant head loss would occur.

Overland Section - Free flow, no ice cover.

Invert width	12.0 m
Side slopes	6V:1H, in rock cut 1V:2H, in earth cut
Gradient	0.0005 m/m
Invert El. at Meelpaeg	258.0 m
Length	3000 m
Friction coefficient	Manning's n = 0.035

Flow	Meelpaeg WL	Island Pond WL	Flow Depth	Velocity
152 m^3/s	266.55 m	265.58 m	8.4 m	1.29 m/s
105.0 m^3/s	264.00 m	262.00 m	5.8 m	1.54 m/s
36 m^3/s	261.67 m	260.00 m	2.9 m	0.95 m/s

Graph 9 shows the water delivery curves for the diversion canal, relating the water levels on the Meelpaeg Reservoir and Island Pond for the above flows.

Island Pond Channel Improvements - Winter ice cover 0.5 m thick.

Invert width	60 m
Side slopes	6V:1H, in rock cut 1V:2H, in earth cut
Invert El.	259.0 m
Length	2400 m (total-3 areas)
Friction coefficient	Manning's n = 0.035

6.4 DIVERSION CANAL (Cont'd)

Island Pond Channel Improvements (Cont'd)

Flow	Island Pond WL Inlet	Island Pond WL Outlet	Flow Depth*	Velocity
152 m^3/s	265.58 m	265.55 m	6.58 m	0.31 m/s
105.0 m^3/s	262.00 m	261.67 m	2.60 m	0.60 m/s
36 m^3/s	260.00 m	259.50 m	1.00 m	1.00 m/s **

6.5 FOREBAY CANAL

The forebay canal is a channel improvement at the outlet of Island Pond where the North Salmon River flows into the North Salmon River valley. The canal will have an invert width of 30 m, an invert elevation of 257 m at the outlet of Island Pond and will be approximately 750 m in length. It will require the excavation of approximately 2,300 m^3 of earth and 77,000 m^3 of rock.

The forebay canal would be excavated early in the project schedule to enable lowering of the Island Pond water level and allow early access to the Island Pond channel improvements, as outlined in Part 5.3.

The following design criteria apply:

Invert width	30.0 m
Side slopes	6V:1H, in rock cut
Invert elevation	257.0 m
Friction coefficient	Manning's n = 0.035

Flow	Island Pond WL	Intake WL	Flow Depth	Velocity
152 m^3/s	265.55 m	265.54 m	8.54 m	0.25 m/s
140 m^3/s	264.70 m	264.60 m	7.70 m	0.40 m/s
109.3 m^3/s	261.67 m	261.55 m	4.55 m	0.60 m/s
36 m^3/s	259.50 m	259.37 m	2.37 m	0.60 m/s

The flow of 140 m^3/s is peak efficiency flow.

The flow of 109.3 m^3/s includes 105.0 m^3/s from Meelpaeg Reservoir and 4.3 m^3/s local inflow to Island Pond.

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* Flow depth is below ice cover.
** Velocity is too great to allow a stable ice cover at the extreme low flow condition.

6.5 FOREBAY CANAL (Cont'd)

Graph 10 shows the water delivery curves relating the water levels on the Meelpaeg Reservoir and at the intake.

6.6 DAM

The Island Pond Dam would be constructed across the North Salmon River valley at a site which is approximately 1,500 m downstream of the outlet of Island Pond and approximately 600 m upstream of its exit into Crooked Lake.

The dam would have an 8 m wide crest at elevation of 271 m, a maximum height above the river bed of about 23 m and a total crest length of about 400 m.

The dam would be a zoned earth-rockfill embankment built on dense till or bedrock. The central core (Zone 1) would be of impervious glacial till. Because of the possibility of low precentage of fines in the glacial till, the core would be kept relatively wide, at about 100% of the water head at the foundation level. The impervious core would be bounded by 1.8 m and 2.2 m thick zones of filter material (Zone 2) on the upstream and downstream side, respectively. Select fine rockfill (Zone 3A), 3 m thick, would function as a secondary filter and the main rockfill (Zone 3) would provide stability to the embankment. A riprap zone (Zone 4) on the upstream slope would function as slope protection against wave action. An initial fill across the upstream toe to control local runoff would be impervious fill with a rockfill face which would be incorporated into the final embankment.

The dam side slopes, 1.0V:2.5H for the upstream and 1.0V:2.25H for the downstream were selected to suit the quality of rockfill. It is envisaged that the rockfill which would be obtained from the required excavations may not be of high quality, containing an excessive amount of fines. As the rockfill may not be free draining, a horizontal drainage blanket would be provided above the foundation underneath the downstream shell. This blanket would be constructed of the same material as the filter and its function would be to intercept and drain any seepage through the core or the foundation.

The foundation for the core and the filter zones would be taken to sound bedrock. A cement grout curtain extending to 50% of the water head would be provided for the bedrock at the centre of the core. A grout blanket consisting of shallow grout holes would also be provided underneath the core. Details of the dam design are contained in the Dam Stability Analysis in Appendix I.

The general layout and typical cross section of the dam are shown on Plate 12.

6.7 INTAKE

The intake would be located in a rock cut located in the east abutment of the dam where the top of the intake structure, at elevation 271 m, would be about 4 m above the existing ground at that location. It will comprise two water passages, each sized for the full load discharges of 76 m^3/s for the turbines in the powerhouse.

Closure of each water passage would be effected by means of a 4.90 m wide by 6.20 m high wheeled head gate, operated by an overhead wire rope hoist. A single emergency slide gate would be provided for installation on the upstream side of either headgate and this would be maneuvered by means of a monorail hoist.

Trashracks would be provided at the face of the intake and these would be removable by means of a mobile crane.

The intake gate sill has been set at elevation 252 m, low enough to suppress vortices at the normal low drawdown of elevation 262 m, when operating at full load. At the extreme low drawdown of elevation 259.37 m, vortices could occur when operating at peak efficiency flow of 71 m^3/s per unit unless an ice cover was present at the time (vortices are suppressed by an ice cover). Without an ice cover at the extreme low drawdown, vortices could only be avoided by providing an additional 2.0 m of submergence on the gates. This would mean lowering the gate sill at an additional cost of about $ 170,000. Considering the infrequency of occurrence of the extreme low drawdown (approximately once in 36 years), this extra cost cannot be justified.

A layout of the intake structure is shown on Plate 10.

6.8 PENSTOCKS

The twin penstocks would be of continuously welded steel construction and provided with a protective coating against external corrosion. They would be fully buried, being laid on a drained sand bed, and covered with granular and rock fill. They are designed to withstand internal pressures up to 50% greater than the static head from the forebay in order to safeguard against any surge pressures caused by stopping and starting of the unit or a change in load. The penstocks would be constructed of 15 mm thick steel plate and would each be 5.4 m diameter and 83 m long. The total weight of the penstocks would be approximately 328 tonnes.

An alternative arrangement using a single large penstock and bifurcation was considered briefly and rejected for the following reasons:

6.8 PENSTOCKS (Cont'd)

1. The large diameter pipe and bifurcation would require costly site fabrication and testing.

2. Little or no saving in excavation and backfill would be possible.

3. A single intake with large passages and headgate would offer little if any saving.

4. The smaller diameter conduit could be transported to site in full cans offering considerable advantage in fabrication and installation costs, particularly in view of the short length required.

These aspects, together with the substantial operating advantage offered with a two intake penstock installation, have precluded any further consideration of a single penstock alternative.

A plan and profile of the selected penstock arrangements are shown on Plate 10 and a typical cross section is shown on Plate 12.

6.9 POWERHOUSE

The powerhouse would be located on the east side of the North Salmon River channel, just downstream of the toe of the dam. The tailrace would be excavated along the alignment of the original river channel, to Crooked Lake.

The powerhouse would be set deep into a rock cut. The substructure would be of massive reinforced concrete construction and would be surmounted by an insulated and metal clad building.

The powerhouse would be about 45 m long by 21.5 m wide and would comprise a generator and repair bay floor at elevation 248 m. The control room and office would be located on the downstream side of the powerhouse on a second floor at elevation 253 m. The repair bay, electrical switchgear, generator excitation equipment and diesel generator would be located on the main floor at elevation 248 m. The governor and mechanical services would be on a lower floor at elevation 243.3 m, while the mechanical pump room would be on a floor at elevation 236 m.

Provision has been made for access by the auxiliary crane hook to all floor levels, and via floor hatches down to the sump level. All floors would be accessible by stairs and, in addition, ladders would be provided for emergency exit.

6.9 POWERHOUSE (Cont'd)

The two draft tubes as presently envisaged will be split with central piers. Closure of either draft tube will be effected by one set of two draft tube gates and an overhead monorail hoist hung from a steel frame in a gate gallery along the downstream side of the powerhouse. The draft tube gates would normally be stored above the draft tube deck level at 243.3 m.

Details of the powerhouse and tailrace site layout are shown on Plate 10. Plate 13 shows typical plans and cross sections of the powerhouse and major equipment locations.

The powerhouse would contain two vertical axis propellor or Francis turbines and generator sets, spaced 14.0 m apart. The turbine distributor centreline would be set at about elevation 239.3 m, approximately 2 m below the normal water level of Crooked Lake. However, the precise setting of the distributor would depend on the cavitation characteristics of the turbine, which would only be known at time of contract award. The setting would be established in conjunction with the manufacturer, to avoid cavitation.

A 55 tonne capacity overhead crane would be provided within the building for maintenance of the generator and turbine. Lower capacity auxiliary hoists would be provided on the overhead crane for maintenance of other components within the powerhouse.

6.9.1 Turbines

Each of the two turbines would be a 15.1 KW vertical axis fixed blade propellor or Francis unit discharging a maximum of 76 m^3/s at 22.6 m rated net head.

The layout selected has a penstock length which is less than four times the head. A generator with normal inertia would be adequate to maintain speed rise to below about 50% on full load rejection. Waterhammer would be limited to 50%. Design parameters are:

Unit flow (max.)	76 m^3/s
Rated head	22.6 m
Penstock diameter	5.4 m
Penstock velocity	3.3 m/s
Conduit LV (total)	402 m^2/s
Waterhammer (max.)	50%
Water start time	1.8 secs.
Effective governor time	4.8 secs.
Full load speed rise	50%
Unit start time	4.1 secs.
Generator H value	2.0

The units would be able to contribute towards frequency regulation on a large system.

6.9.2 Generators

Each of the two (2) generators would be a 16 MVA, 0.95 p.f., 13.8 kV, 200 rpm vertical unit. The generators would have brushless exciters with static type automatic voltage regulators. They would be totally enclosed and air cooled, the air being cooled by air/water heat exchangers.

The generators would be complete with generator terminal cubicles with neutral grounding transformer and all necessary instrumentation mounted on turbine/generator gauge panels.

6.9.3 Powerhouse Electrical System

Each generator output would be cabled to a 13.8 kV metalclad switchboard with vacuum type circuit breaker cubicle. A third vacuum type circuit breaker cubicle would be connected by cable to a single main power transformer located in the substation at the west end of the powerhouse.

The 13.8 kV metalclad switchboard would be located on the main floor of the powerhouse and adjacent to this board would be an automatic control board for the remote automatic control of the plant.

The 600 volt station service would be fed from the 13.8 kV metalclad switchboard via a 13.8 kV manual isolation device located in one cubicle and an indoor dry type station service transformer.

A diesel generator would be provided as a backup supply for essential services.

The DC system would consist of a sealed type 129 V DC battery, battery charger and panelboard.

6.9.4 Powerhouse Mechanical System

The mechanical system would meet the specific station requirements as well as incorporating a standby concept to ensure maximum reliability at minimum cost.

Service water for unit cooling would be tapped off the penstocks. Fire protection water, however, would be pumped directly from the tailrace. The fire protection system would utilize FM approved, fire pumps, controllers and strainers.

Other auxiliaries would include a central compressed air system as well as a common dewatering sump located between the units, domestic water system, service water ancilliaries, heating, ventilation, waste handling, fire protection ancilliaries, diesel generator services, roof and floor drainage and oil interceptor pit.

6.9.4 Powerhouse Mechanical System (Cont'd)

Special features that would be included are duplication or standby equipment for all services vital for generation, e.g. cooling water, compressed air, auxiliary powerhouse heating from the generators, automatic ventilation system, air conditioning for the control room and for the tele-control room if required, and fully remote or local operation of all mechanical systems as required.

6.10 TAILRACE

The tailrace would be designed to pass the maximum plant discharge of 152 m^3/s to Crooked Lake with a minimum of head loss. It would require excavation of about 36,000 m^3 of earth and about 47,000 m^3 of rock in a relatively shallow and wide channel.

The following design criteria apply:

Invert width	28 m
Invert elevation	237 m
Gradient	0 m/m
Side slopes	6V:1H, in rock cut 1V:2H, in earth cut
Flow depth	4.50 m
Friction Coefficient	Manning's n = 0.035
Water Velocity	1.2 m/2
Head loss	0.22 m

Water levels in Crooked Lake vary over a range of 1.45 m from elevation 240.50 m to elevation 241.95 m. Tailwater at the powerhouse would therefore vary from the low level to elevation 241.96 m.

6.11 SWITCHYARD

The switchyard would be located at the west end of the powerhouse and immediately downstream of the dam.

The ringbus layout (Plate 15) for the switchyard would require a large level surface for the structures. This necessitated moving the yard area downstream and at an angle to the powerhouse, away from the toe of the dam, so that the switchyard would fit into the river valley as shown on Plate 10.

There would be a large surplus of rock excavation, principally from the tailrace excavation. In order to avoid unsightly disposal areas, surplus excavation material would be placed in the area between the dam toe and the switchyard and the elevation of the yard itself would be adjusted to accommodate all surplus materials.

6.11 SWITCHYARD (Cont'd)

A single main power transformer would be rated at 25 MVA/33.3 MVA ONAN/ONAF 13.8 kV/230 kV, 950 kV BIL. This transformer would be complete with 230 kV lightning arresters and would be connected to a 230 kV ring bus system with three (3) 230 kV outdoor type SF_6 circuit breakers, 230 kV disconnect switches and a 230 kV disconnect switch and grounding switch on the outgoing lines to Godaleich and Granite Canal. There would also be a 230 kV air break switch on the high voltage side of the transformer.

The main transformer foundation would be constructed with a curb and drainage system to collect and divert drainage to an oil interceptor for protection in the event of an oil spill due to leakage or fire.

All switchyard control and protection panels would be located in the powerhouse.

The study design and costing as covered by this report has considered that all electrical installations outside of the high voltage bushings of the main power transformer will be covered separately by Newfoundland and Labrador Hydro.

6.12 INFRASTRUCTURE

6.12.1 Access Roads

Permanent access to the Island Pond site would be established by construction of a permanent 7 m wide all weather road from the Upper Salmon Development (Plate 3). Temporary access would also be established from Millertown by upgrading existing roads between Millertown and the site.

The permanent access road would include the upgrading of approximately 8.5 km of two sections of existing roads which will be incorporated into the permanent road, the construction of a large bridge over the Upper Salmon diversion canal and the construction of approximately 23 km of new road. Approximately 4 km of an existing construction access road between the North Salmon Road and the Upper Salmon diversion canal, as well as approximately 4.5 km of the existing Ebbegunbaeg Control Structure service access road from the Control Structure to the powerhouse intersection (the intersection of this existing road and the new road to the powerhouse), would be upgraded. The upgrading would include widening and resurfacing.

6.12.1 Access Roads (Cont'd)

The 65 m long single span bridge required across the Upper Salmon diversion canal would be designed for the heaviest load to be transported to site including all anticipated construction equipment.

New road to be constructed would include approximately 15.5 km between the new bridge and the Ebbegunbaeg Control Structure, plus approximately 7.5 km between the powerhouse intersection and the power complex site.

In addition to the permanent access roads, temporary construction roads will be required to facilitate construction of each structure. The nature and extent of these roads will be dictated by the construction requirements and they will be constructed by the contractors engaged in the works. The Civil Works contractor will be required to construct an access route parallel to the penstock for use both by his forces and those of the penstock erector.

6.12.2 Borrow Areas

Borrow deposits for acquistion of till, sand and gravel for the construction have been identified by the geotechnical investigations and are described in Part 2 of Volume 2 of this report.

The deposits designated as T-1 and T-2 are situated approximately 1 km and 5 km, respectively, from the Project Site along the shoreline of Crooked Lake northeast of the construction area. These two deposits are considered to contain ample materials such that, with some processing, all materials required for the work could be obtained from these areas. A third deposit (T-3) considerably more remote from the project site is not expected to be required for the work.

Approximately 5 km of temporary haul roads and about 10 hectares of clearing and stripping of borrow areas will be required for access to these materials.

6.12.3 Construction Camps

It is envisaged that two construction camps would be required on this Project. Due to the early start date and relatively small number of workmen required for the construction of the canals, the canal contractor would be required to provide his own camp. This camp could be established at an early date near the existing road. As the contractor's activities increase, with the opening up of several work fronts, the camp would be expanded as required.

6.12.3 Construction Camps (Cont'd)

Once the permanent access road is constructed to the powerhouse site, a main camp, would be installed on a site located about 3.5 km southwest of the powerhouse location and beside the new access road (Plate 3). The site designated is relatively flat and would have ample space on either side of the road with suitable ground conditions for construction of the facilities. Nearby ponds on higher ground southwest of the site are expected to be suitable for development of a water supply and a general slope in the ground to the northeast (toward Crooked Lake) would be appropriate for development of a sewerage system and treatment facility.

The potential work force at the main camp is estimated to be approximately 200 men. The camp provided by Newfoundland and Labrador Hydro would include water and sewage treatment plants capable of meeting the demands of the potential work force, accommodation in the form of bunkhouse units, kitchen/dining facilities for up to 200 men, and associated offices, first aid and warehouse facilities.

It is envisaged the camp would provide bunkhouse accommodation for the main work force and single status staff house accommodation for engineering staff and equipment erectors. It is envisaged that engineering and supervisory staff with families would be housed in mobile homes provided on an adjacent site.

Upon completion of the project the mobile components of the camp would be removed and permanent type buildings would be dismantled.

In addition to the above camps, smaller independent camps would also be required for access road construction and for construction of the Ebbegunbaeg freeboard dyke. In view of the limited staff and short duration for work in these areas it is proposed that, in each case, the contractors would be required to provide their own camps as required for the work.

6.12.4 Construction Power

Power required to maintain the construction camp would be provided by diesel-generator sets installed with the camp. The generator sets would be sized for the potential construction camp size.

Power required at each of the construction sites would be the responsibility of each contractor.

TABLE 6.1

FREEBOARD ALLOWANCES

Condition	Structure	Flood Surcharge*	Set-up & Wave Runup*	Required Freeboard*	Crest Elevation Required
Design Storm & FSL (wind speed 145 kph)	Island Pond Dam	-	.89	.89	267.44
	Ebbegunbaeg Freeboard Dyke	-	1.67	1.67	268.22
Max. Probable Flood + Nominal Storm (wind speed 65 kph)	Island Pond Dam	1.85	.38	2.23	268.78
	Ebbegunbaeg Freeboard Dyke	1.85	.70	2.55	269.10

* m above FSL elevation 266.55

EXISTING AND PROPOSED CREST LEVELS

STRUCTURE	IMPERVIOUS CORE	TOP OF DAM
Island Pond Dam	269.0	271.0
Ebbegunbaeg Freeboard Dykes	269.0	271.0
Existing Ebbegunbaeg Dykes	269.0	269.9
Ebbegunbaeg Control Structure	270.8	270.8
Pudop's Dam	270.1	271.0

PART 7 - CONSTRUCTION SCHEDULE AND PROCEDURES

7.1 CONTRACT PACKAGES

7.1.1 Civil Construction Contracts

In consideration of the variety in nature and scope of the works, the geographical locations of the structures, and the construction schedule, it is proposed to divide the civil works portion of the Project into the following contract packages:

Contract G1 - Permanent Access Road

Construction of a new permanent road to link the Island Pond Project with the Upper Salmon Development. Work under this contract would include:

a) Upgrading of those portions of the road already in existance; namely, between the existing North Salmon Road and the Upper Salmon diversion canal and for approximately 1 km further west of the canal, and between the Ebbegunbaeg Control Structure and the intersection of Ebbegunbaeg access road with the new road to the powerhouse (hereafter called the powerhouse intersection).

b) Supply and installation of a new bridge across the Upper Salmon diversion canal.

c) Supply and installation of bridges and/or culverts for all stream crossings.

d) Construction of a new road from the powerhouse intersection to the powerhouse and intake.

Contract G2 - Construction Camp

Supply, operate and remove the construction camp located near the powerhouse site, including provision of water, sewage and garbage disposal and power supply.

Contract C1 - Canals

Excavation of the diversion canal, the Island Pond channel improvements and the forebay canal. The contract will include:

a) The upgrading of the existing road from the Red Indian Lake Dam at Millertown to the diversion canal crossing.

b) Supply and installation of a temporary bridge at Noel Paul's Brook.

7.1.1 Civil Construction Contracts (Cont'd)

Contract C1 - Canals (Cont'd)

c) Repair and/or replacement of bridges and culverts as required for contractor's own use.

d) Supply and installation of a new permanent bridge at the diversion canal.

e) All temporary roads and road maintenance needed during construction of the work under this contract.

f) Provision of all unwatering facilities, including pumps, cofferdams, plugs, temporary diversions, settling ponds and structures to keep the work sites dewatered.

g) Supply and operate a construction camp for contractor's own resources, and Manager's and Owner's staff.

Contract C2 - Meelpaeg Reservoir Freeboard Dyke

Construction of the freeboard dyke, including temporary access road.

Contract C3 - Civil Works for Power Complex Structures

This is the main civil works contract and would include the civil works for the dam, intake structure, penstocks, powerhouse, tailrace and switchyard. It would also include:

a) Installation of hydraulic gates for the intake and powerhouse.

b) The intake enclosure building.

c) Installation of the powerhouse crane.

d) All work related to exploitation of borrow pits and quarries and site dewatering.

e) All work related to the exterior finishing, grading and fencing at the intake and powerhouse.

Contract C4 - Powerhouse Structural Steel

Supply and erection of the powerhouse structural steel.

7.1.1 Civil Construction Contracts (Cont'd)

Contract C5 - Powerhouse Roofing and Cladding

Supply and erection of the powerhouse roofing and wall cladding, including all metal decking for roof and floors.

Contract C6 - Powerhouse Architectural

Supply and installation of the interior finishes and painting of the powerhouse.

Contract R1 - Reservoir Clearing

Clearing of the Island Pond southeast perimeter Reservoir and the forebay.

7.1.2 Mechanical and Electrical Contracts

In addition to the civil construction contracts, the following associated mechanical and electrical contract packages are proposed:

Contract M1 - Turbines and Governors

Design, supply and installation of the turbines, governors and related equipment.

Contract M2 - Penstocks

Design, supply and installation of the penstocks.

Contract M3 - Hydraulic Gates

Design, supply and provision of erection supervision for the intake head gate, intake bulkhead gate and the powerhouse draft tube gates.

Contract M4 - Powerhouse Crane

Design, supply and provision of erection supervision for the powerhouse crane.

Contract M5 - Mechanical and Auxiliary Equipment

Supply and installation of all the mechanical services and systems for the intake and powerhouse.

Contract E1 - Generators and Exciters

Design, supply and installation of the generators, exciters and auxiliary equipment.

This contract could be combined with Contract M1 above to encourage bids by joint ventures in expectation of a better price.

7.1.2 Mechanical and Electrical Contracts (Cont'd)

Contract E2 - Power Transformer

Supply and installation of the power transformer.

Contract E3 - Electrical and Auxiliary Equipment

Supply and installation of the electrical services and systems for the intake and powerhouse.

Owner's Supply and Installation

The Owner would supply and install the switchyard structures and electrical equipment and would provide other services related to the power transmission in and out of the plant to ensure that grid power is available at the time of commissioning.

Local Participation

With the proposed breakdown of contracts given above, it is anticipated that Newfoundland contractors would be able to participate fully in the Island Pond project (except for the specialized mechanical and electrical components).

7.2 PROJECT PLANNING

7.2.1 Access and Facilities

Although there is no access at present to the actual work site the existing service road to the Ebbegunbaeg Control Structure from Millertown crosses the alignment of the diversion canal. It is envisaged that the C1 Contractor would improve this road to meet his needs and would set up his own camp in the vicinity of the diversion canal and accordingly he would not require the main camp.

The permanent access road to the project would be from the Upper Salmon Development. The C3 Contractor would improve the parts of the roads in the area which are common to the new road alignment and construct approximately 16 km of new link road. This contractor would also construct the access road to the powerhouse, intake and main camp. He would establish his own camp and would not use the main camp.

The main camp would be set up in the spring to permit occupation by the C3 Contractor. It would be located approximately 4 km west of the powerhouse site and adjacent to the new access road (Plate 3).

7.2.1 Access and Facilities (Cont'd)

It is also considered that, as an alternative, a second road contract to construct roads on the western part of the region would be advantageous. This would appreciably accellerate the schedule and should offer some cost advantage.

Large pieces of equipment arriving by sea would be off-loaded at St. Alban's and trucked overland via the Provincial and Hydro's existing road network.

7.3 CONSTRUCTION SCHEDULE

The proposed construction schedule is shown on Plate 16. It was assumed that the project would be released in early June, 1988. It was further assumed that some engineering work would be completed beforehand to have the first two contracts ready to issue for tender at the earliest possible date after project release. First power could be achieved by mid-November, 1991 and commissioning of both units would be completed by December 15, 1991.

The overall schedule is governed by the turbine and generator contracts, which have a total duration (including front end engineering, tendering and review periods) of 42 months. If an improved schedule could be realized from these suppliers, the schedule could be shortened, as the civil works have some flexibility.

The forebay canal was scheduled for completion prior to the spring flood of 1989 so that the Island Pond water level could be lowered prior to the start of Island Pond channel improvements in 1989. The channel improvements were scheduled for completion by the end of 1989 to allow impoundment of Island Pond inflows with the onset of the spring flood in 1990, by placing a cofferdam at the outlet of Island Pond. Dam construction would then be completed by the end of 1990. The diversion canal would be opened immediately after the spring flood of 1991 to allow Meelpaeg Reservoir and Island Pond water levels to equalize and the forebay would be filled, in preparation for commissioning of the first unit.

The critical path, as mentioned above, runs through the entire turbine and generator design, manufacture and installation activity. At the time of writing, additional information had been obtained regarding an installation using horizontal turbines, which could be less expensive and have a shorter manufacture and installation period; 18 months versus 26 for the vertical turbines. It appears that if this alternative was adopted, two critical paths would exist; one through the turbine and generator sequence and the other through the civil works.

7.4 CONSTRUCTION PROGRAM

7.4.1 Key Dates

In order to achieve the commissioning dates for the plant and to meet the on-power date for both units of December 15, 1991, it would be necessary to award contracts and construct the works in accordance with the schedules shown in Plates 13 and 14. In accordance with these schedules, key dates for tendering and construction or installation are as shown in Table 7.1.

7.4.2 Particular Site Requirements

The Island Pond Development would be a conventional hydro-electric plant, similar to others on the Island. However, there are a few aspects which should be noted:

a) As already mentioned, no construction power would be supplied by the Owner until late in the project.

b) The canal contractor starts before the main camp is ready. Therefore, it has been assumed that the canal contractor would set up a camp and be independent of the main camp.

c) No allowance has been made for any environmental restrictions on disposal of spoil. It has been assumed that spoil could be disposed of within an economical dozer push, or a short truck haul.

d) The borrow pits do not contain high quality material and the contractor must be prepared to carry out selective exploitation and/or processing of his materials to meet the quality requirements. This may require early development of borrow and stockpiling of dam filter, impervious core material and concrete aggregates.

e) There is no particular requirement regarding impoundment; Island Pond will be filled quickly by inflows from Meelpaeg Reservoir. To enable controlled removal of the diversion cofferdam in the forebay canal, the forebay will be filled via a double culvert filling structure constructed in the bypass channel and west section of the second stage cofferdam at the outlet of Island Pond.

7.4.3 Construction Methodology

Since the Island Pond Development is of conventional design, no unconventional methodology or special equipment requirements are foreseen at this stage of design. The civil contracts anticipated are typical of this type of work, involving open cut excavations and concrete structures. The nature of the terrain will present continuous dewatering requirements which would have to be dealt with by means of local diversion and pumping.

The contracts will allow maximum flexibility with respect to methods and selection of construction equipment. The open cut excavation work in the diversion canal, Island Pond channel improvements and structural excavations allows the contractor to supplement his equipment spreads easily, should he so choose or should it become necessary to maintain schedules.

The concrete quantities are not large and a small portable batch plant would suffice for the construction. All the concrete work would be confined to the main civil contractor to avoid conflicts in the borrow pit and unnecessary duplication of concrete equipment.

TABLE 7.1

ISLAND POND FINAL FEASIBILITY STUDY

PROJECT SCHEDULE KEY DATES

CONTRACT NUMBER	DESCRIPTION	TENDERING: CALL	TENDERING: PERIOD *	TENDERING: CLOSE	TENDERING: AWARD	CONSTRUCTION/MANUFACTURE: START	CONSTRUCTION/MANUFACTURE: DURATION *	CONSTRUCTION/MANUFACTURE: FINISH
G1	Permanent Access Road	88-06-01	7.5	88-07-22	88-07-29	88-08-01	20	88-12-16
G2	Construction Camp	88-09-30	8.5	88-11-23	88-11-30	89-04-03	15	89-07-14
C1	Canals	88-06-01	7.5	88-07-22	88-07-29	88-08-01	152	91-06-29
C2	Meelpaeg Freeboard Dyke	89-10-02	8	89-11-24	89-12-01	90-05-31	19	90-10-13
C3	Civil Works - Power Complex Structures	88-10-31	14	89-02-01	89-02-15	89-07-17	120	91-10-31
C4	Powerhouse Structural Steel	89-12-01	11.5	90-02-21	90-02-28	90-03-01	30	90-09-29
C5	Powerhouse Roofing & Cladding	90-05-01	7.5	90-02-22	90-06-29	90-07-02	21.5	90-11-30
C6	Powerhouse Arch-itectural & Painting	91-02-15	8	91-04-12	91-04-19	91-04-22	34	91-12-14
R1	Reservoir Clearing	90-05-01	6.5	90-06-22	90-06-29	90-07-02	17	90-10-31
M1	Turbines & Governors	88-09-12	23	89-02-17	89-03-17	89-03-20	119	91-06-29
M2	Penstocks	89-09-15	9	89-11-16	89-11-30	89-12-01	45	90-10-13
M3	Hydraulic Gates	89-06-16	9	89-08-17	89-08-31	89-09-01	95	91-06-29
M4	Powerhouse Crane	89-09-01	9	89-11-03	89-11-17	89-11-20	44	90-09-22
M5	Mechanical & Aux-illary Equipment	90-10-12		91-01-17	91-01-31	91-03-25		
E1	Generators & Exciters	88-09-12	23	89-02-17	89-03-17	89-03-20	139	91-11-16
E2	Power Transformer	89-02-17	13	89-05-17	89-05-31	89-06-01	117	91-08-31
E3	Electrical & Aux-ilary Equipment	90-10-12	14	91-01-17	91-01-31	91-03-25	34	91-11-16

* Designated periods and durations in weeks.

PART 8 - COSTS

8.1 COST ESTIMATING

Heavy civil works predominate in the Island Pond Development in common with the majority of hydroelectric projects. Due care has been taken with estimating the various units making up the civil works and appropriate allowances based on past experience have been made for inconsistencies in quantities where it is not possible to accurately cover such factors as overbreak, compaction, and variances in quantity calculations. Basic material quantities used in preparing the estimate have been determined from reasonably detailed layouts of each major structure, the field survey and geological information. The less important quantity items were estimated from previous experience.

The unit rates used in estimating the civil works have also been selected with care, with rates mainly based on actual bid prices for similar heavy construction works obtained in recent years in the Province, adjusted as necessary to reflect up to date manhour rates, material and equipment costs and conditions particular to this project.

The costs of major items of equipment are based on general enquiries to the various specialized suppliers and reference to past cost data for similar projects on the Island. For electrical and mechanical auxiliaries, costs are either estimated from experience on recent projects adjusted to reflect the latest cost trends, or based on manufacturer's quotations.

Escalation has been allowed for civil works, supply and installation of equipment, management and engineering, owner's costs, project support costs and contingencies. Annual escalation rates (mid year to mid year) of 5.37%, 5.08%, 5.16%, 3.84% and 2.98% have been assumed for the respective years of 1987-1988, 1988-1989, 1989-1990, 1990-1991, and 1991-1992. Escalation factors based on the above rates were applied to monthly total unescalated costs, which were based on the cost estimate and construction schedule, to derive monthly total escalation costs. The cost estimate for the Development is based on December 1987 prices with escalation effective the beginning of 1988.

Interest during construction has been calculated based on an annual interest rate of 12.683% compounded monthly on the total escalated costs. Allowances are made for a one month delay in processing of invoiced costs.

8.1 COST ESTIMATING (Cont'd)

An overall contingency allowance of 10% of direct construction costs is provided for all civil works, except the diversion canal excavation in Meelpaeg Reservoir and the Island Pond channel improvements where 15% is provided, to cover the cost of extra work for unpredictable ground conditions and unforeseen foundation problems which might become evident during construction. The percentage for this contingency allowance is based on past experience on unknowns associated with the anticipated type of heavy civil works construction and which cannot readily be assessed from available site investigation results. For major electrical and mechanical equipment, 5% of the supply and installation costs has been added on the quotations received from representative equipment manufacturers to account for uncertainties on transportation, handling and erection and for changes in particular design and fabrication features.

8.2 CAPITAL COST ESTIMATE

A summary of the estimated capital cost for the development is provided in Table 8.1.

The capital costs, including allowances for contingency, escalation and interest during construction, are based on a construction program starting in 1988 with completion scheduled for December 15, 1991 as shown on Plate 16. These costs will vary with the overall rates for escalation and interest during construction, if the rates used are different from those assumed, and if the starting date for construction is changed.

The estimate includes the cost of the following:

.1 Total clearing of the forebay, the forebay canal and the south and southeast perimeter shorelines of Island Pond between elevations 262.2 m and 266.55 m, plus 3 m horizontally from the 266.55 m contour in each area, for a total of 83 hectares. No allowance has been included in the cost estimate for salvage value of the timber.

.2 Construction of the works which are essential to the development defined in this report.

.3 Project support costs associated with the project such as the construction camp, warehousing, site vehicles, quality assurance laboratories, laboratory and field office supplies and equipment, site communications, camp and road maintenance, safety and security, first aid and ambulance services.

8.2 CAPITAL COST ESTIMATE (Cont'd)

.4 Management and Engineering costs have been included as 15% of direct costs (Construction costs, including contingency allowances, and project support costs) and include:

- Management and Engineering directs costs which include the cost of management services, office design, field engineering and construction supervision, including fees.

- Management and Engineering indirect costs which consist mainly of head office and field office expenses not included in the foregoing, cost of board and lodging for field personnel, and field transport for the field contract engineering personnel.

.5 Owner's costs have been included as 3.5% of direct costs and include Owner's overhead costs such as legal, financial, engineering and management costs, commissioning and construction insurance premiums.

.6 Interest during construction on the required borrowing is computed at an annual interest rate of 12.683% compounded monthly.

.7 Retail sales tax at 12% for all purchases of equipment and materials. The tax is included in the unit prices for the civil works.

.8 Contingency allowances of 10% of direct construction costs provided for civil works. For major equipment contracts, 5% of the supply and installation costs added on the quotations received from suppliers.

.9 Escalation allowed for civil works, electrical and mechanical equipment, general overheads, contingencies, management and engineering and Owner's costs.

The following annual escalation rates have been assumed (mid year to mid year):

Year	Rate
1987-1988	5.37%
1988-1989	5.08%
1989-1990	5.16%
1990-1991	3.84%
1991-1992	2.98%

8.2 CAPITAL COST ESTIMATE (Cont'd)

.10 Civil works for the switchyard, including an allowance for concrete foundations.

The estimate does not include the following:

.1 Cost of any special environmental considerations except reservoir clearing and construction methods that conform to the environmental protection clauses outlined under the "General Conditions" of current Newfoundland and Labrador Hydro's specifications.

.2 The above ground structures or electrical aspects of the switchyard.

.3 Transmission lines.

.4 Telecontrol systems.

8.3 CONTRACT VALUES AND CASH FLOW

The values of the major contracts, civil works and equipment are given in Table 8.2. This gives an appreciation of the magnitude of the various components of work.

Table 8.3 provides a summary of the estimated cash flow for the project. This summary presents the cash flow on a quarterly basis and is based on monthly calculations.

8.4 ESTIMATE OF CONTRACTOR'S WORK FORCES

The estimated number of workmen to be engaged on the construction and erection work at the site each month during the construction period is shown on Plate 19. An average of 77 men per month would be required during the construction period of approximately 41 months. The work force would peak to about 200 men for approximately 4 months during the construction period.

The estimate is based on the construction schedule shown on Plate 17 and on the assumption that the work would be carried out on a single 10 hour shift per day for 6 working days a week, excluding legal holidays.

8.5 ESTIMATE OF CONTRACTOR'S WORK FORCES (Cont'd)

The following tabulation summarizes the manpower requirements:

	*Contractor's Work Force
1988	310 man months
1989	610 " "
1990	1,445 " "
1991	580 " "
TOTAL	2,945 man months

* Includes: Reservoir Clearing
Civil Works
Turbine & Generator
Others

A readily available common labour force familiar with general construction trades can be expected to be available within the Province.

TABLE 8.1

CAPITAL COST ESTIMATE SUMMARY

x $1000

ITEM	COST CODE	DESCRIPTION	CIVIL WORKS	EQUIPMENT	TOTAL
1		RESERVOIR CLEARING - ACCESS ROADS			
1.1	1.100	Reservoir Clearing	415	---	415
1.2	1.110	Access Roads	7,014	---	7,014
2	2.100	MEELPAEG RESERVOIR FREEBOARD DYKE	767	---	767
3		CANALS & CHANNEL IMPROVEMENTS			
3.1	3.100	Diversion Canal	12,776	---	12,776
3.2	3.200	Island Pond Improvements	4,562	---	4,562
3.3	3.300	Forebay Canal	2,513	---	2,513
4		POWER COMPLEX			
4.1	4.103	Dam	2,749	---	2,749
4.2	4.105	Intake	3,902	2,559	6,461
4.3	4.106	Penstock	668	1,642	2,310
4.4	4.107	Powerhouse	6,571	16,677	23,248
4.5	4.108	Tailrace	2,200	---	2,200
4.6	4.109	Switchyard	573	---	573
		Sub-Totals:	44,710	20,878	69,588
5.		PROJECT SUPPORT			
5.1		Construction Camp & Services			3,050
5.2		Camp Power Supply			1,880
6.3		Road Maintenance			930
6.4		Vehicles & Supplies, Communications			700
		Total:			
		Before Contingencies			72,148
		Management & Engineering Costs			11,853
		Owner Costs			2,766
		Contingencies			6,870
		Sub-Total:			93,637
		Escalation			11,565
		Interest During Construction			22,026
		TOTAL:			127,228

TABLE 8.2

ESTIMATE OF CONTRACT PACKAGES

CONTRACT		TOTAL	CONTINGENCY
G1	Permanent Access Road	$ 4,794,000	$ 479,400
G2	Construction Camp (Powerhouse)		
C1	Canals (including upgrading of existing roads, Diversion Canal, Island Pond Channel Improvements and Forebay Canal)	21,971,000	2,477,700
C2	Meelpaeg Reservoir Freeboard Dyke	821,000	82,100
C3	Civil Works for Power Complex Structures	16,328,500	1,632,900
C4	Powerhouse Structural Steel	733,000	73,300
C5	Powerhouse Roofing and Cladding	246,000	24,600
C6	Powerhouse Architectural	200,000	20,000
R1	Reservoir Clearing	415,000	41,500
M1	Turbines and Governors	6,000,000	300,000
M2	Penstocks	1,641,500	164,200
M3	Hydraulic Gates	2,808,900	280,900
M4	Powerhouse Crane	410,000	41,000
M5	Mechancial and Auxilary Equipment	1,103,000	110,300
E1	Generators and Exciters	6,500,000	325,000
E2	Power Transformer	450,000	45,000
E3	Electrical and Auxilary Equipment	2,049,000	204,900

TABLE 8.3

PROJECT CASH FLOW SUMMARY ($1,000)

January 29,1988

ITEM	TOTALS	1988 1st	1988 2nd	1988 3rd	1988 4th	1989 1st	1989 2nd	1989 3rd	1989 4th	1990 1st	1990 2nd	1990 3rd	1990 4th	1991 1st	1991 2nd	1991 3rd	1991 4th	1992 1st
SITE ESTABLISHMENT	6,093.2			1,516.4	3,957.1	369.8	0.0	0.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RESERVOIR CLEARING	415.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	311.3	103.8	0.0	0.0	0.0	0.0	0.0
EBBEGUNBAEG FREEBOARD DYKE	821.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	325.0	496.0	0.0	0.0	0.0	0.0	0.0
DIVERSION CANAL	17,670.5			0.0	0.0	0.0	44.4	2,698.5	5,663.8	1,824.3	2,753.4	2,923.2	1,553.0	105.0	0.0	105.0	0.0	0.0
FOREBAY CANAL	2,596.5			87.7	1,314.6	746.2	63.0	0.0	110.0	0.0	110.0	0.0	0.0	0.0	0.0	165.0	0.0	0.0
DAM	3,199.1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	701.6	1,098.3	1,399.1	0.0	0.0	0.0	0.0	0.0
INTAKE AND APPROACH CHANNEL	6,461.0			0.0	0.0	0.0	0.0	3.9	914.9	372.7	773.7	2,456.2	1,210.9	388.6	113.3	226.7	0.0	0.0
PENSTOCK	2,309.9			0.0	0.0	0.0	0.0	0.0	150.2	135.8	621.2	701.1	464.1	237.6	0.0	0.0	0.0	0.0
POWERHOUSE	23,248.2			0.0	0.0	0.0	133.1	798.4	1,083.3	1,409.9	1,991.1	2,784.1	2,996.0	2,241.0	3,352.4	2,686.7	1,683.4	2,088.7
TAILRACE	2,200.5			0.0	0.0	0.0	0.0	0.0	10.5	0.0	679.7	906.2	604.1	0.0	0.0	0.0	0.0	0.0
SWITCHYARD	573.2			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.6	131.3	0.0	177.2	177.2	0.0	0.0
PROJECT SUPPORT	6,560.0			2.3	9.0	11.0	1,456.5	956.4	440.7	440.7	441.6	443.5	443.5	443.5	443.5	443.5	440.1	144.0
TOTAL (BEFORE CONTINGENCIES)	72,148.1			1,606.4	5,280.7	1,127.0	1,697.0	4,457.1	8,623.3	4,183.4	8,072.3	12,036.5	9,401.9	3,415.8	4,086.5	3,804.0	2,123.6	2,232.7
CONTINGENCIES	6,870.4			160.6	528.1	112.7	163.0	497.0	959.3	378.4	767.3	1,150.2	916.0	275.5	330.0	321.7	187.4	123.3
TOTAL DIRECT COST	79,018.5			1,767.0	5,808.8	1,239.7	1,860.0	4,954.2	9,582.5	4,561.8	8,839.7	13,186.7	10,317.9	3,691.3	4,416.4	4,125.7	2,310.9	2,356.0
MANAGEMENT AND ENGINEERING	11,852.8			551.3	1,102.6	826.9	826.9	826.9	826.9	826.9	826.9	826.9	826.9	826.9	826.9	826.9	826.9	275.6
OWNER'S COSTS	2,765.6			61.8	203.3	43.4	65.1	173.4	335.4	159.7	309.4	461.5	361.1	129.2	154.6	144.4	80.9	82.5
TOTAL UNESCALATED COST	93,636.9			2,380.1	7,114.6	2,110.1	2,752.1	5,954.5	10,744.9	5,548.4	9,976.0	14,475.2	11,505.9	4,647.4	5,397.9	5,097.0	3,218.7	2,714.1
ESCALATION	11,565.2			83.3	303.8	118.5	196.5	502.1	1,042.4	618.6	1,251.4	2,000.4	1,698.7	746.4	929.2	924.6	612.5	536.7
INTEREST DURING CONSTRUCTION	22,025.7			0.0	122.9	308.6	383.8	499.5	746.8	1,075.3	1,328.5	1,733.0	2,285.0	2,686.7	2,934.1	3,224.6	3,485.9	1,211.0
TOTALS	127,227.7			2,463.5	7,541.3	2,537.2	3,332.4	6,956.1	12,534.1	7,242.3	12,555.9	18,208.6	15,489.7	8,080.4	9,261.2	9,246.2	7,317.1	4,461.8
CUMULATIVE TOTAL				2,463.5	10,004.8	12,542.1	15,874.4	22,830.5	35,364.6	42,606.9	55,162.8	73,371.4	88,861.0	96,941.4	106,202.6	115,448.8	122,765.9	127,227.7

PART 9 - RECOMMENDATIONS FOR FURTHER WORK

9.1 RECOMMENDATIONS FOR FURTHER WORK

As early as possible following project release, and prior to final design, further preliminary design and site investigations would be required as follows:

9.1.1 Access Road

A field survey of the selected permanent access road route including profile and cross-sections along the route center line for alignment design, and at individual stream crossings for bridge and culvert design. This survey would complement the aerial photo interpretation and desk study, which have been completed by Hydro's personnel, and provide the basis for preparation of contract drawings and specifications.

9.1.2 Construction Camp

A field survey and subsurface investigation of the construction camp site. This would include collection of topographic details by level survey and collection of subsurface information by test pitting.

9.1.3 Ebbegunbaeg Freeboard Dyke

A field survey and a limited subsurface investigation of the dyke location. It is understood that some preliminary work has been completed by Hydro personnel in this area and only additional detail, to complement existing site information, would be required.

9.1.4 Intake, Penstock and Powerhouse

As noted in Part 5.5, the proposed location of these structures was chosen to fit the topography, with limited subsurface information. As the clearing and stripping progresses a survey program would be required to accurately delineate sound rock surfaces for final design.

9.1.5 Construction Materials

A source of impervious glacial till for dam core construction was located close to the dam site in deposit T-1. The volume of material available was estimated to be up to 450,000 m^3 and the fines content was somewhat variable (15% to 20%) in a limited number of samples. Further testing and inventory of this deposit would be required prior to preparation of contract documents for work in this area to confirm the borrow areas and access route requirements.

9.1.5 Construction Materials (Cont'd)

Further testing should also be carried out on the deposit T-2 proposed for the source of filter material. The material in this deposit appears to have a higher fines content than that required for filter material. Further sampling and testing should be carried out to determine the extent of processing that will be required.

9.1.6 Turbine Type

As noted in Part 5.6, there is a possibility for cost savings associated with an installation using horizontal axis ('S') turbines. Several problems have been experienced with earlier installations of these units and accordingly further investigations would be required to evaluate the risks associated with these turbines.

Further inquiries and analysis would be required to:

a) confirm cost and delivery of these units,

b) review speed regulation aspects of this design for low head long penstock applications with generators having low inertia, and

c) review seal leakage problems associated with early installations using these units.

PLATES

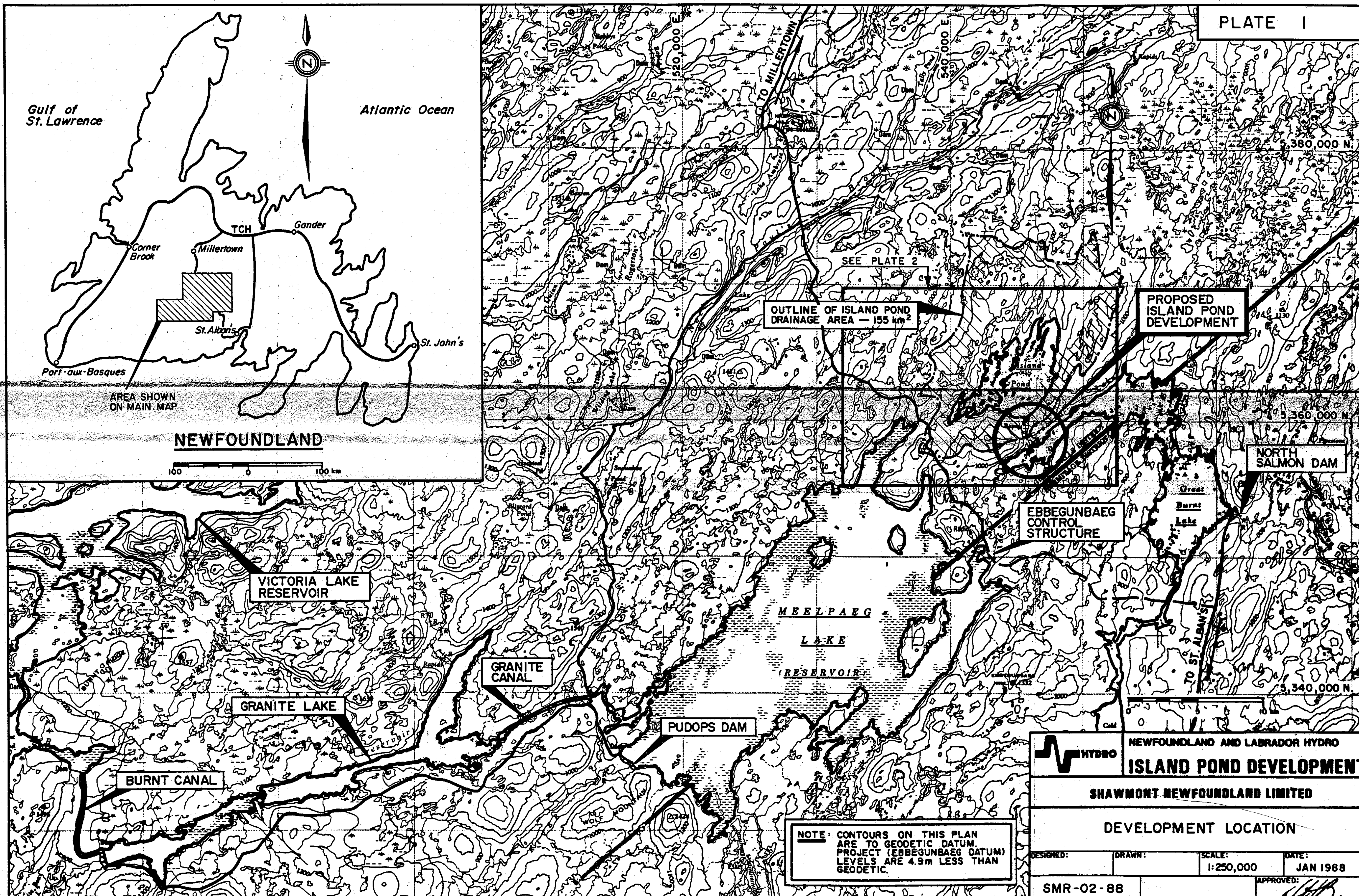


PLATE I
Gulf of St. Lawrence
Atlantic Ocean
Corner Brook
Millertown
TCH
Gander
St. Alban's
St. John's
Port-aux-Basques
AREA SHOWN ON MAIN MAP
NEWFOUNDLAND
100 0 100 km
520,000 E.
540,000 E.
TO MILLERTOWN
5,380,000 N.
5,360,000 N.
5,340,000 N.
SEE PLATE 2
OUTLINE OF ISLAND POND DRAINAGE AREA — 155 km²
PROPOSED ISLAND POND DEVELOPMENT
Island Pond
NORTH SALMON DAM
Great Burnt Lake
EBBEGUNBAEG CONTROL STRUCTURE
VICTORIA LAKE RESERVOIR
MEELPAEG LAKE (RESERVOIR)
GRANITE CANAL
GRANITE LAKE
PUDOPS DAM
BURNT CANAL
TO ST. ALBANS
NOTE: CONTOURS ON THIS PLAN ARE TO GEODETIC DATUM. PROJECT (EBBEGUNBAEG DATUM) LEVELS ARE 4.9m LESS THAN GEODETIC.
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
DEVELOPMENT LOCATION
DESIGNED:
DRAWN:
SCALE: 1:250,000
DATE: JAN 1988
SMR-02-88
APPROVED:

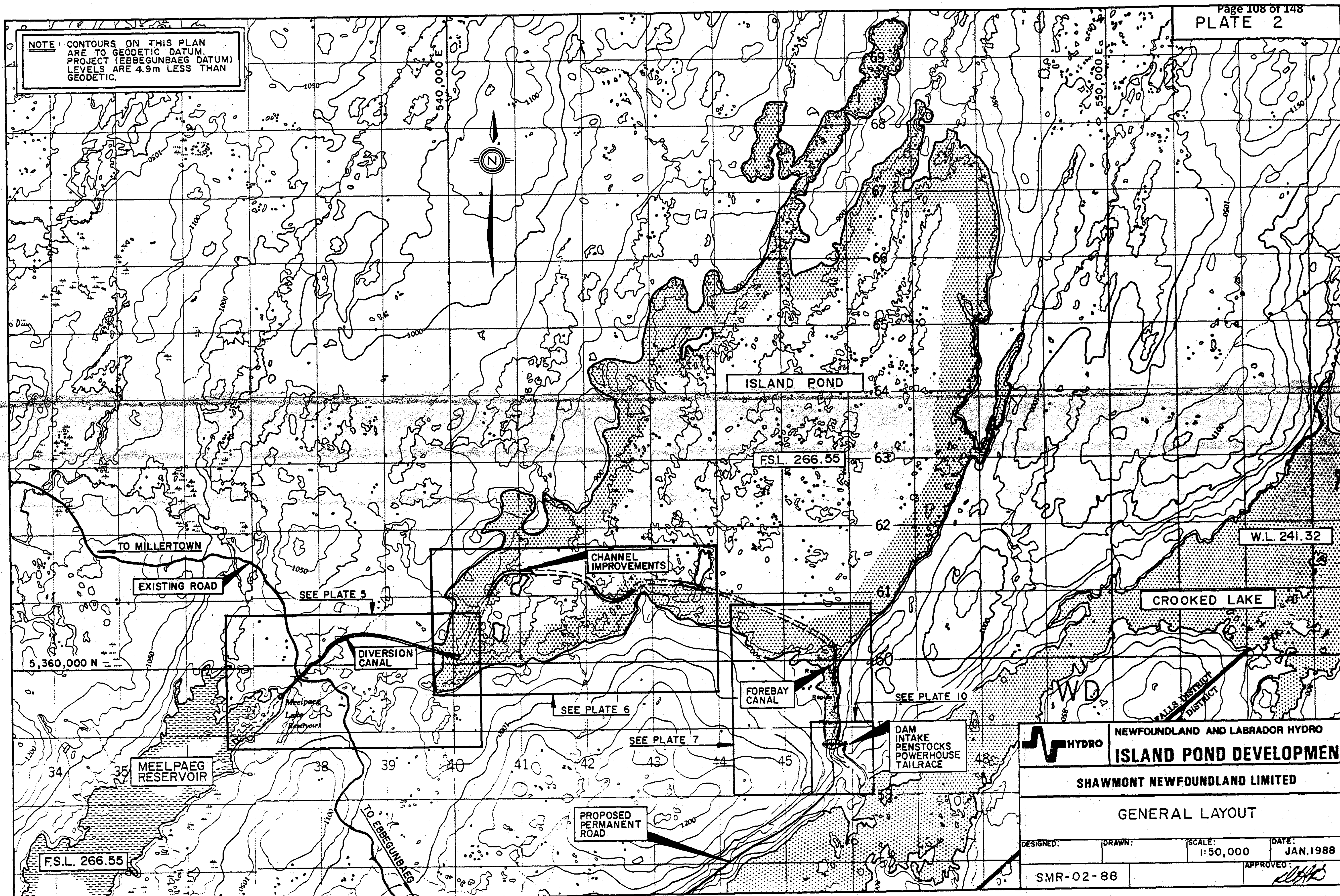


PLATE 2
NOTE: CONTOURS ON THIS PLAN ARE TO GEODETIC DATUM. PROJECT (EBBEGUNBAEG DATUM) LEVELS ARE 4.9m LESS THAN GEODETIC.
540,000 E
550,000 E
ISLAND POND
F.S.L. 266.55
W.L. 241.32
CROOKED LAKE
CHANNEL IMPROVEMENTS
TO MILLERTOWN
EXISTING ROAD
SEE PLATE 5
DIVERSION CANAL
5,360,000 N
SEE PLATE 6
SEE PLATE 7
SEE PLATE 10
FOREBAY CANAL
DAM
INTAKE
PENSTOCKS
POWERHOUSE
TAILRACE
MEELPAEG RESERVOIR
Meelpaeg Lake (Reservoir)
F.S.L. 266.55
TO EBBEGUNBAEG
PROPOSED PERMANENT ROAD
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
GENERAL LAYOUT
DESIGNED:
DRAWN:
SCALE: 1:50,000
DATE: JAN.1988
APPROVED:
SMR-02-88

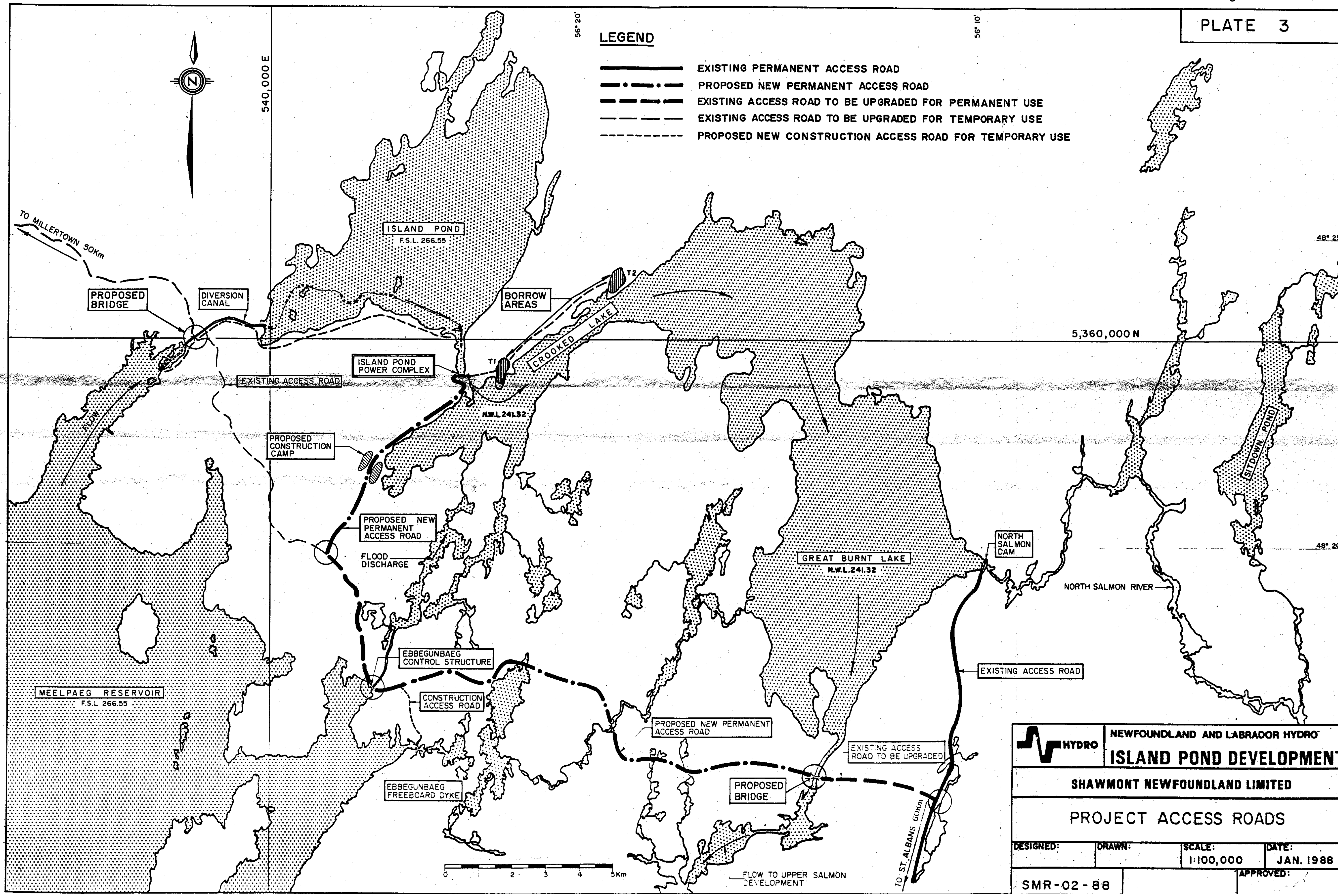
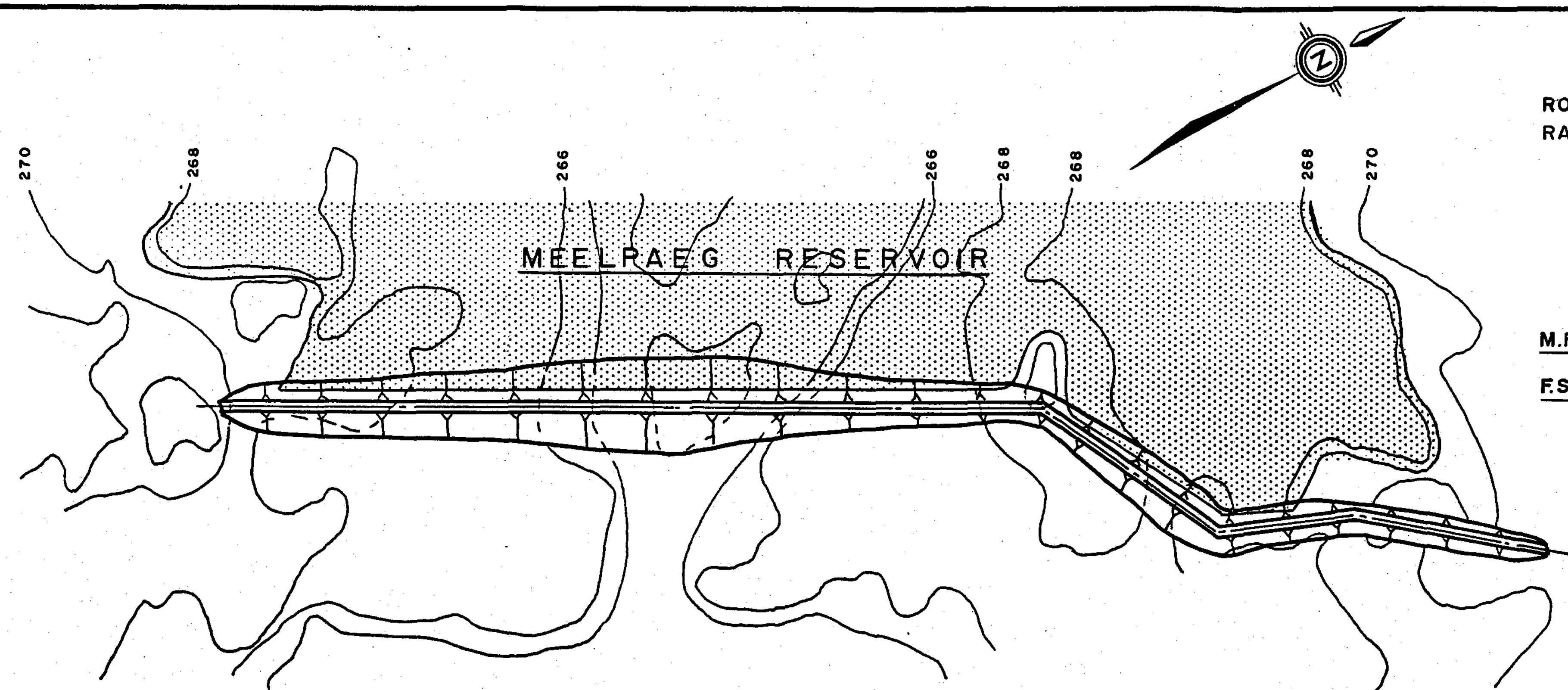


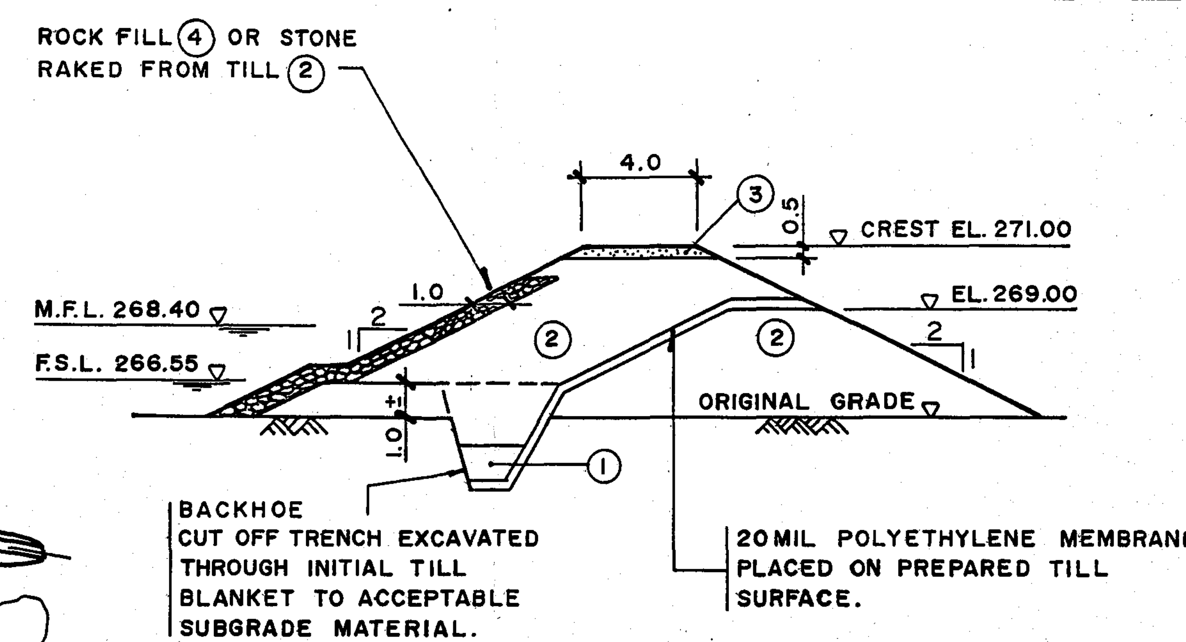
PLATE 3
LEGEND
EXISTING PERMANENT ACCESS ROAD
PROPOSED NEW PERMANENT ACCESS ROAD
EXISTING ACCESS ROAD TO BE UPGRADED FOR PERMANENT USE
EXISTING ACCESS ROAD TO BE UPGRADED FOR TEMPORARY USE
PROPOSED NEW CONSTRUCTION ACCESS ROAD FOR TEMPORARY USE
56° 20'
56° 10'
540,000 E
5,360,000 N
48° 25'
48° 20'
N
TO MILLERTOWN 50Km
ISLAND POND
F.S.L. 266.55
PROPOSED BRIDGE
DIVERSION CANAL
BORROW AREAS
T1
T2
CROOKED LAKE
ISLAND POND POWER COMPLEX
EXISTING ACCESS ROAD
N.W.L. 241.32
FLOW
PROPOSED CONSTRUCTION CAMP
PROPOSED NEW PERMANENT ACCESS ROAD
FLOOD DISCHARGE
GREAT BURNT LAKE
N.W.L. 241.32
NORTH SALMON DAM
NORTH SALMON RIVER
SITDOWN POND
EBBEGUNBAEG CONTROL STRUCTURE
CONSTRUCTION ACCESS ROAD
MEELPAEG RESERVOIR
F.S.L. 266.55
EXISTING ACCESS ROAD
PROPOSED NEW PERMANENT ACCESS ROAD
EXISTING ACCESS ROAD TO BE UPGRADED
PROPOSED BRIDGE
EBBEGUNBAEG FREEBOARD DYKE
TO ST. ALBANS 60Km
FLOW TO UPPER SALMON DEVELOPMENT
0 1 2 3 4 5Km
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
PROJECT ACCESS ROADS
DESIGNED:
DRAWN:
SCALE: 1:100,000
DATE: JAN. 1988
APPROVED:
SMR-02-88

PLATE 4



PLAN

10 0 10 20 30 40 50

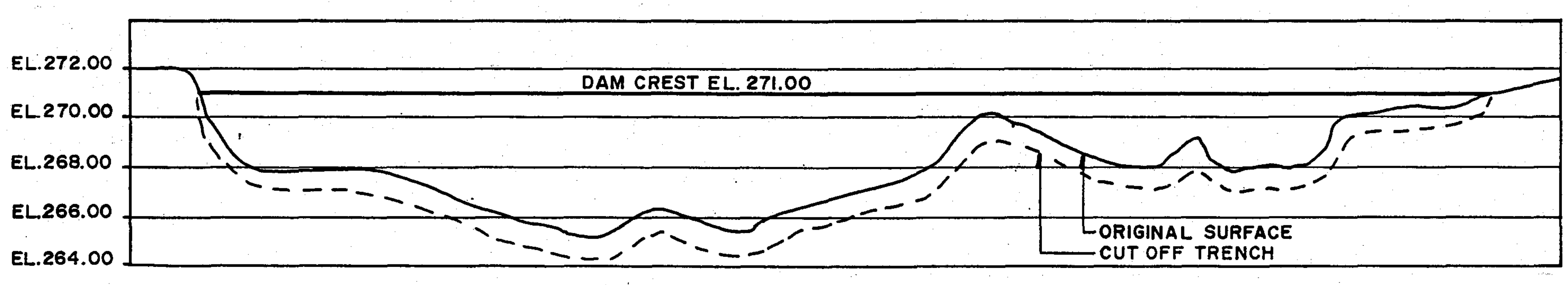


SECTION A-A

SCALE: 1:250

LEGEND

1. SELECTED TILL - HAND COMPACTED
2. IMPERVIOUS FILL —— TRACTOR COMPACTED
3. ROAD GRAVEL
4. ROCK FILL OR COBBLES FROM TILL



PROFILE ALONG ℄ OF DAM

10 0 10 20 30 40 50

FOR LOCATION OF STRUCTURE SEE
PROJECT ACCESS ROADS - PLATE 3

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

EBBEGUNBAEG
FREEBOARD DYKE

DESIGNED:	DRAWN:	SCALE:	DATE: JAN. 1988
SMR-02-88			APPROVED:

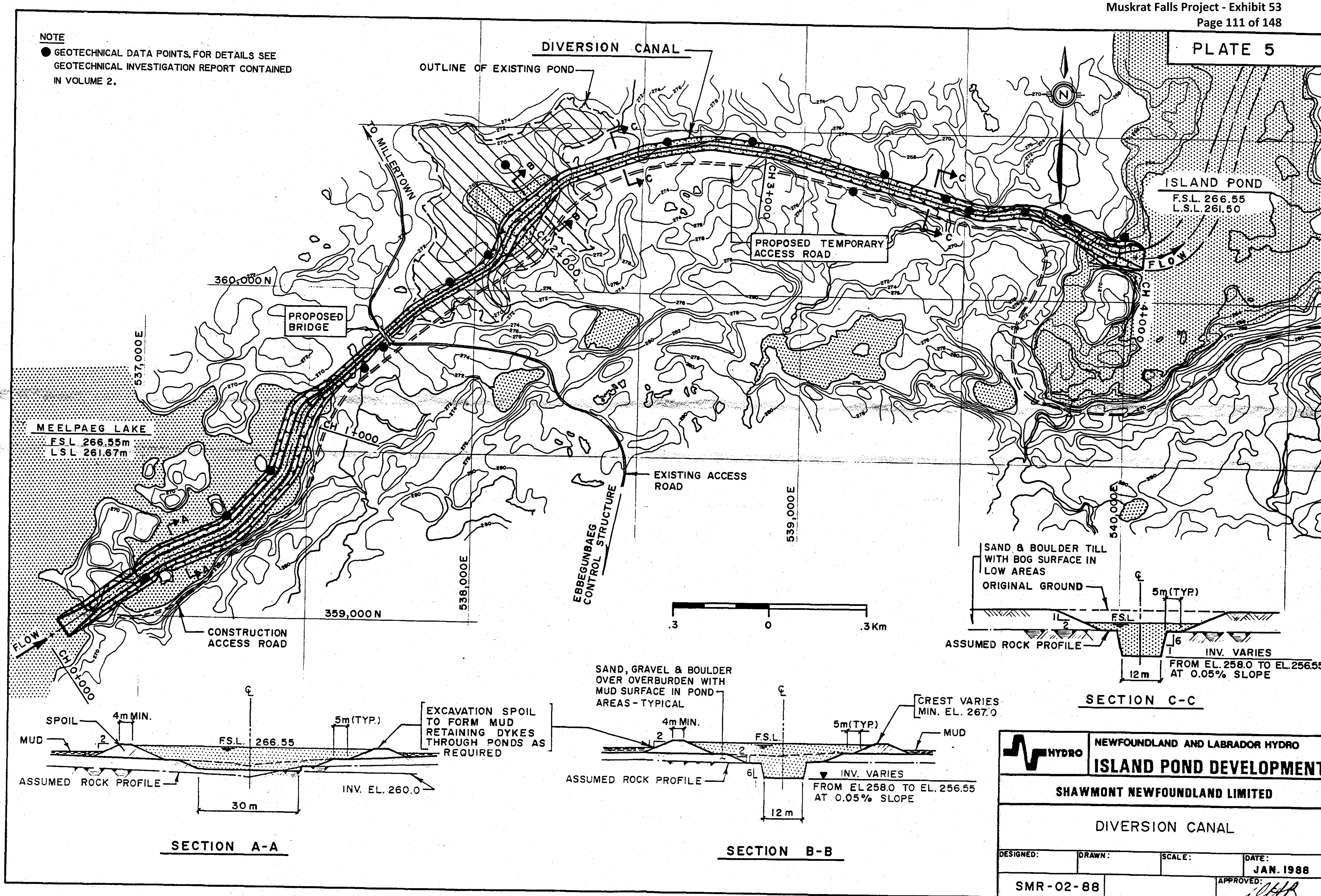


PLATE 5
NOTE
GEOTECHNICAL DATA POINTS. FOR DETAILS SEE GEOTECHNICAL INVESTIGATION REPORT CONTAINED IN VOLUME 2.
DIVERSION CANAL
OUTLINE OF EXISTING POND
TO MILLERTOWN
ISLAND POND
F.S.L. 266.55
L.S.L. 261.50
FLOW
CH 3+000
CH 2+000
CH 4+000
CH 1+000
CH 0+000
PROPOSED TEMPORARY ACCESS ROAD
360,000 N
359,000 N
PROPOSED BRIDGE
537,000 E
538,000 E
539,000 E
540,000 E
MEELPAEG LAKE
F.S.L 266.55m
L.S.L 261.67m
EXISTING ACCESS ROAD
EBBEGUNBAEG CONTROL STRUCTURE
CONSTRUCTION ACCESS ROAD
.3 0 .3 Km
SAND & BOULDER TILL WITH BOG SURFACE IN LOW AREAS
ORIGINAL GROUND
5m (TYP.)
F.S.L.
ASSUMED ROCK PROFILE
INV. VARIES FROM EL. 258.0 TO EL. 256.55 AT 0.05% SLOPE
12 m
SECTION C-C
SPOIL
4m MIN.
MUD
F.S.L. 266.55
5m (TYP.)
EXCAVATION SPOIL TO FORM MUD RETAINING DYKES THROUGH PONDS AS REQUIRED
ASSUMED ROCK PROFILE
INV. EL. 260.0
30 m
SECTION A-A
SAND, GRAVEL & BOULDER OVER OVERBURDEN WITH MUD SURFACE IN POND AREAS - TYPICAL
4m MIN.
F.S.L.
5m (TYP.)
CREST VARIES MIN. EL. 267.0
MUD
ASSUMED ROCK PROFILE
INV. VARIES FROM EL. 258.0 TO EL. 256.55 AT 0.05% SLOPE
12 m
SECTION B-B
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
DIVERSION CANAL
DESIGNED:
DRAWN:
SCALE:
DATE: JAN. 1988
SMR-02-88
APPROVED:

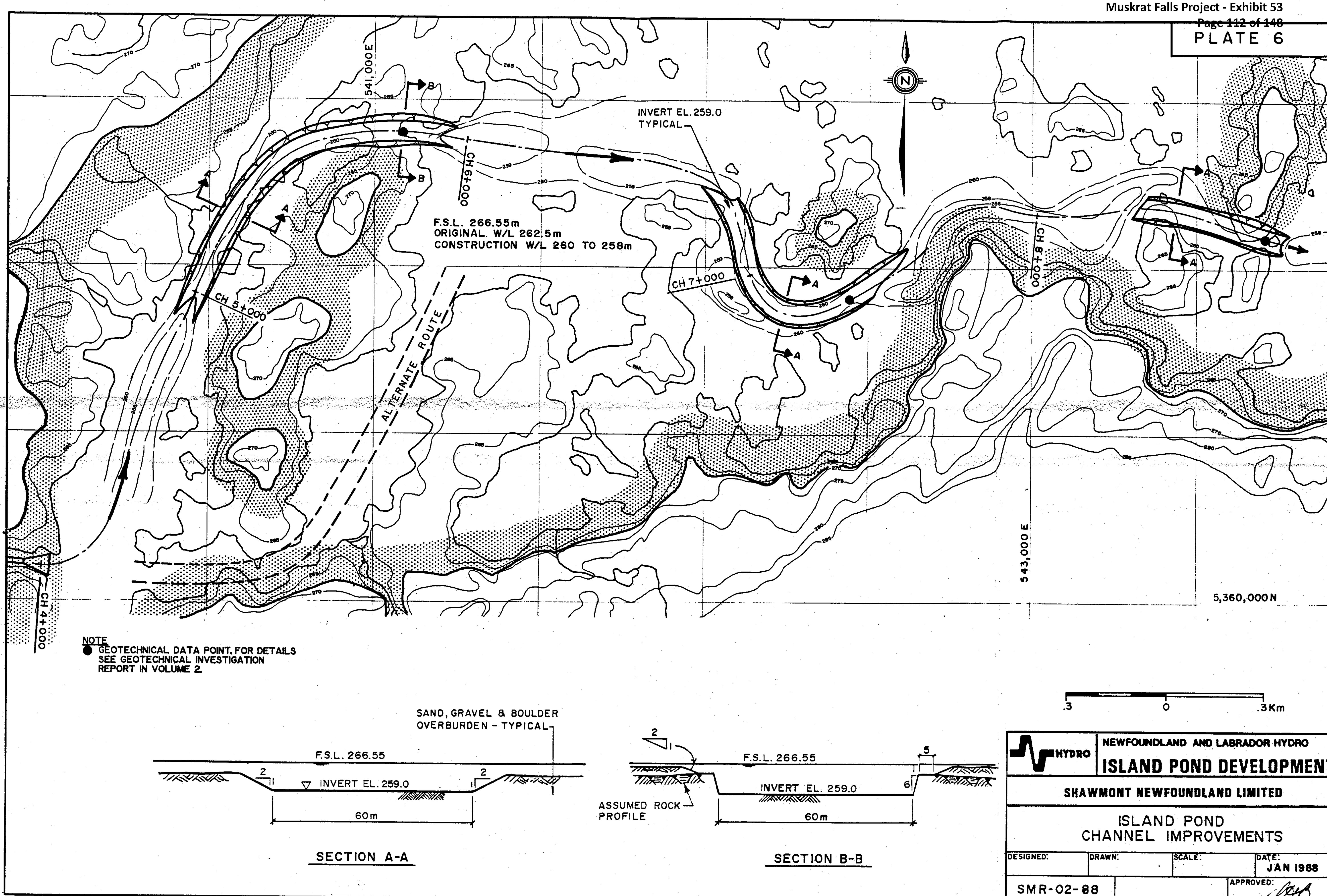
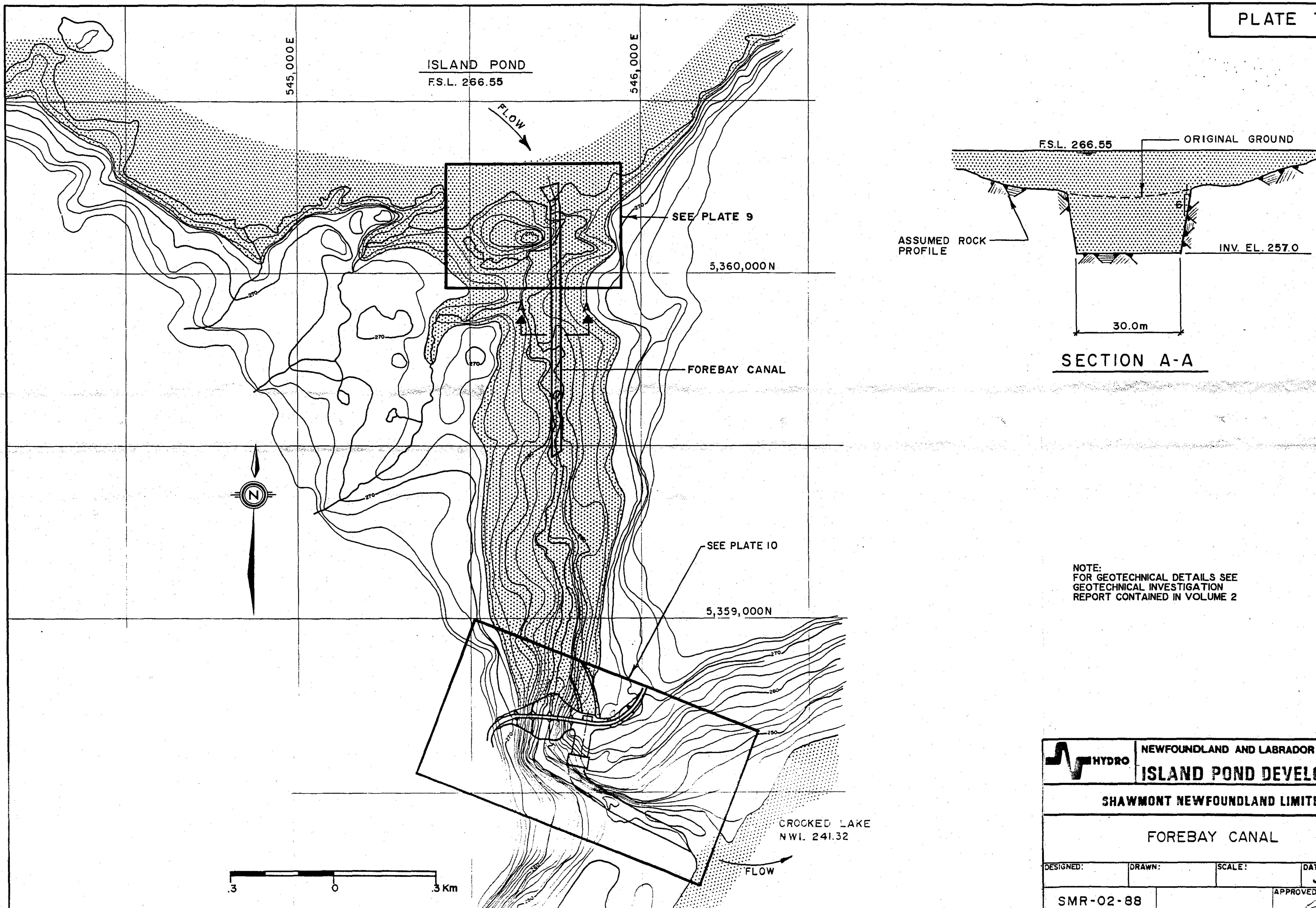


PLATE 6
541,000 E
543,000 E
5,360,000 N
CH 4+000
CH 5+000
CH 6+000
CH 7+000
CH 8+000
INVERT EL. 259.0
TYPICAL
F.S.L. 266.55m
ORIGINAL. W/L 262.5m
CONSTRUCTION W/L 260 TO 258m
ALTERNATE ROUTE
NOTE
GEOTECHNICAL DATA POINT, FOR DETAILS SEE GEOTECHNICAL INVESTIGATION REPORT IN VOLUME 2.
.3
0
.3 Km
SAND, GRAVEL & BOULDER
OVERBURDEN - TYPICAL
F.S.L. 266.55
INVERT EL. 259.0
60m
SECTION A-A
ASSUMED ROCK
PROFILE
INVERT EL. 259.0
60m
SECTION B-B
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
ISLAND POND
CHANNEL IMPROVEMENTS
DESIGNED:
DRAWN:
SCALE:
DATE:
JAN 1988
SMR-02-88
APPROVED:

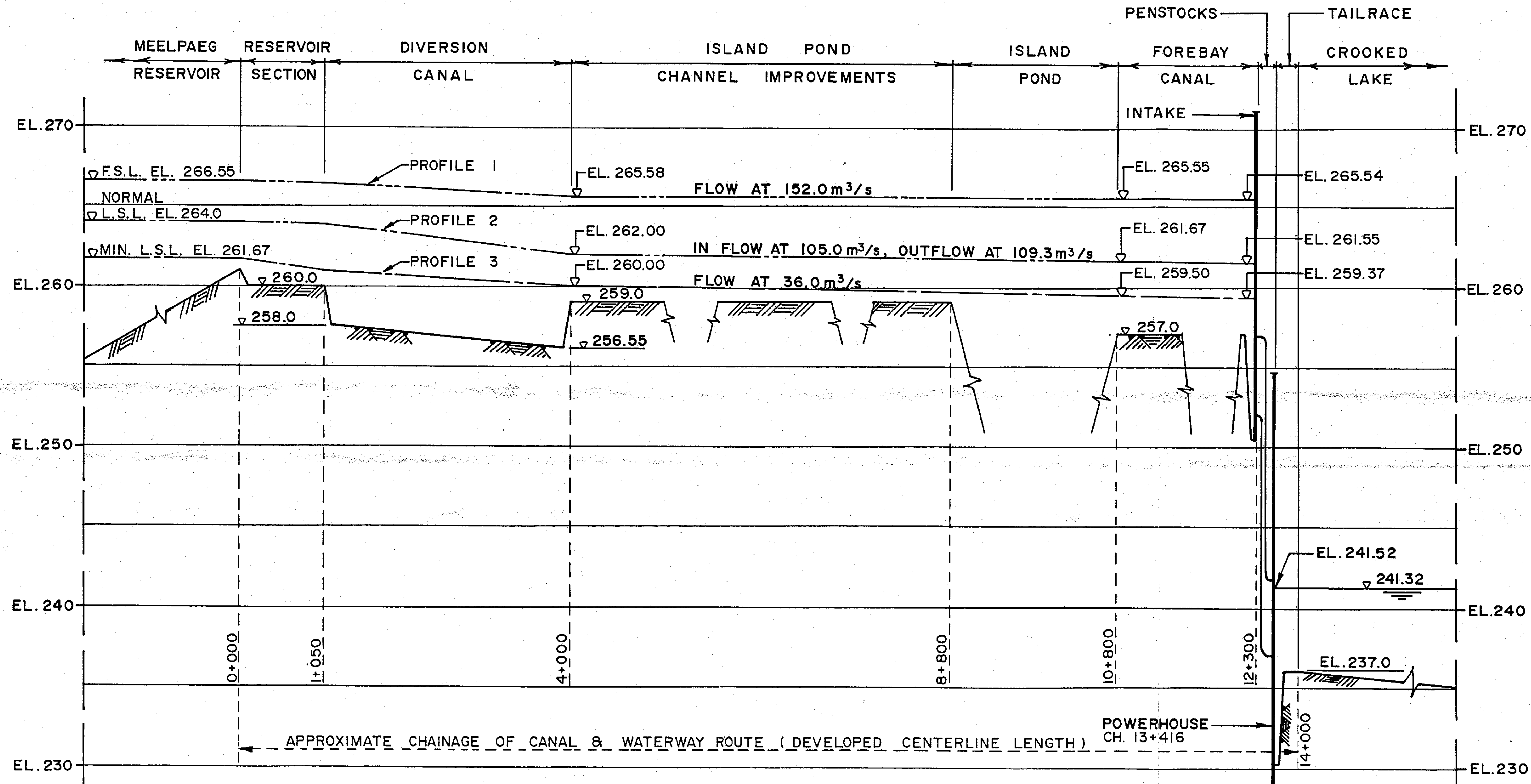
PLATE 7



NOTE:
FOR GEOTECHNICAL DETAILS SEE GEOTECHNICAL INVESTIGATION REPORT CONTAINED IN VOLUME 2

HYDRO	NEWFOUNDLAND AND LABRADOR HYDRO
	ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED	
FOREBAY CANAL	
DESIGNED:	DRAWN:
SCALE:	DATE: JAN 1988
SMR-02-88	APPROVED:

PLATE 8

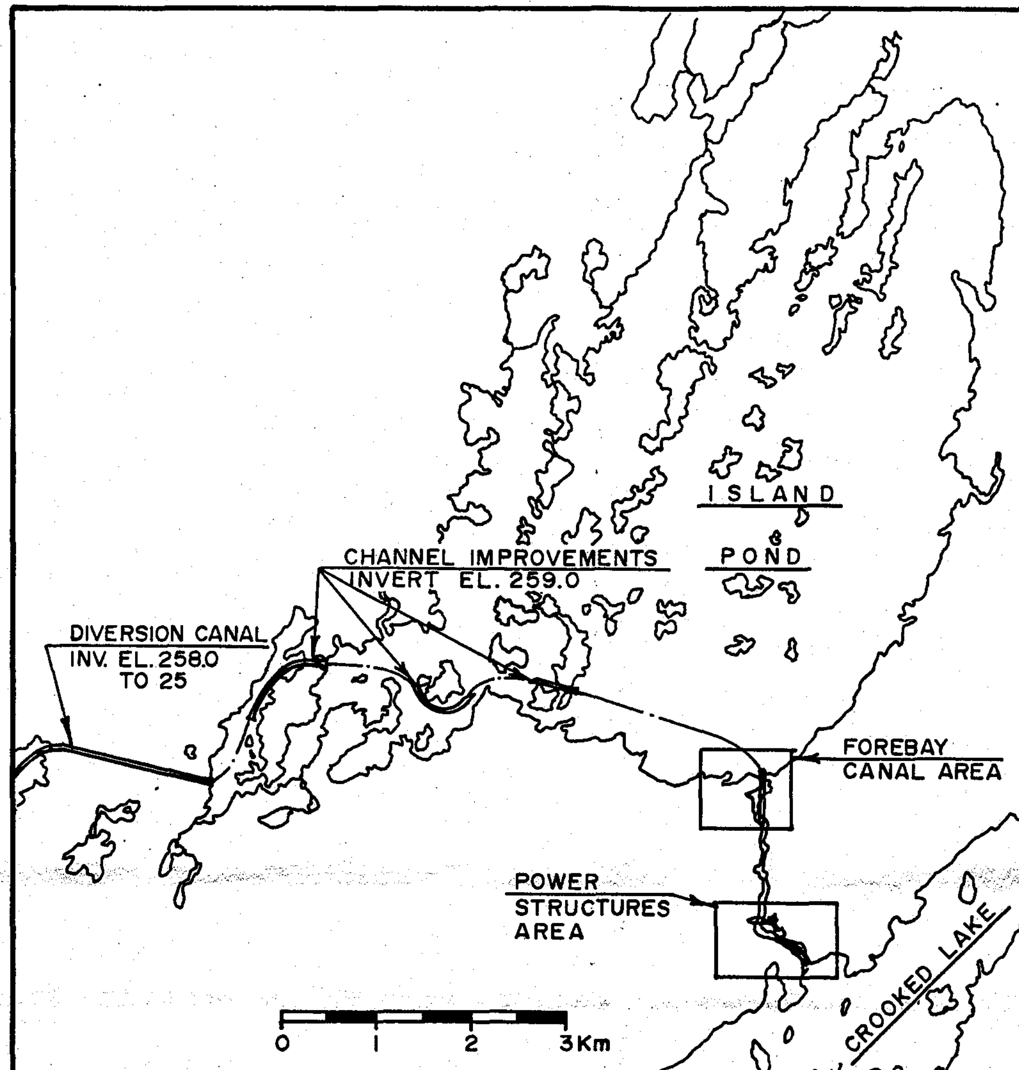


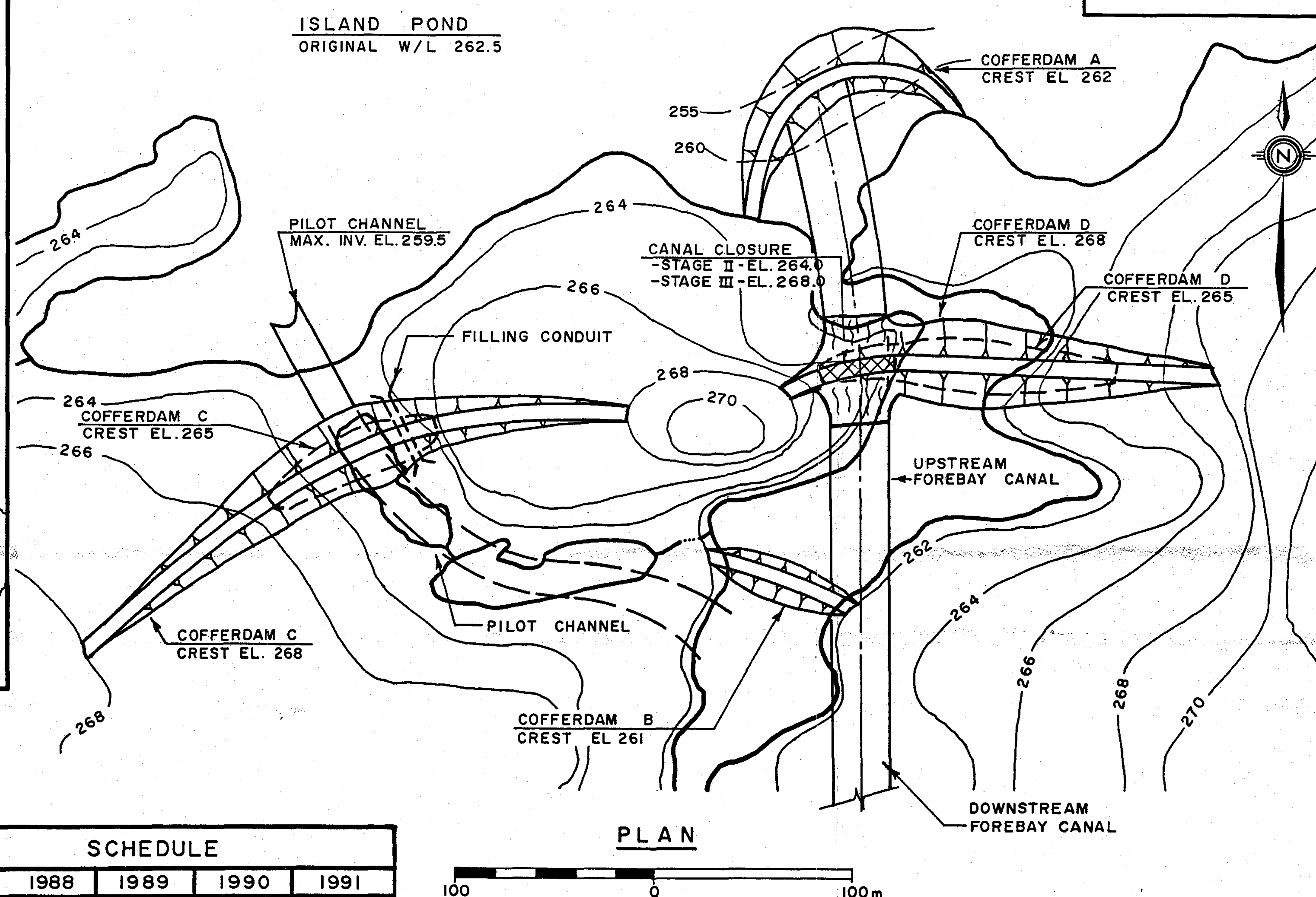
NOTES:
1. PROFILES AS SHOWN REPRESENT WATER LEVELS THAT WOULD DEVELOP UNDER SUSTAINED FLOW FROM MEELPAEG RESERVOIR AT LEVELS AS INDICATED.
2. PROFILES 1 & 2 ASSUME FULL DISCHARGE IS DRAWN FROM MEELPAEG STORAGE.
3. PROFILE 2 REPRESENTS 105 m^3/s AVERAGE FLOW FROM MEELPAEG INCREASED BY 4.3 m^3/s LOCAL CONTRIBUTION FROM ISLAND POND WATERSHED TO PROVIDE TOTAL POWER FLOW OF 109.3 m^3/s.
4. NORMAL OPERATING PROCEDURE WOULD BE TO RUN UNITS SPORADICALLY WHEN SUSTAINED FLOW IS BELOW MAX. EFFICIENCY FLOW TO PROVIDE MAX. UTILIZATION OF WATER. DURING PERIODS OF SHUT-DOWN ISLAND POND WILL RISE ABOVE SUSTAINED WATER PROFILES INDICATED.

HYDRO NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
CANAL AND WATER LEVEL PROFILES

DESIGNED:	DRAWN:	SCALE:	DATE: JAN. 1988
SMR-02-88			APPROVED:

PLATE 9





STAGE	FEATURES	ELEV.
I	1 PILOT CHANNEL	MAX. INV. 259.5
	2 COFFERDAM A	CREST 262.0
	3 COFFERDAM B	CREST 261.0
	4 FOREBAY CANAL - U.S.	INV. 257.0
II	5 FILLING CONDUIT	℄ 263.0
	6 COFFERDAM C	CREST 265.0
	7 CANAL CLOSURE STRUCTURE	CREST 264.0
	8 COFFERDAM D	CREST 265.0
	9 FOREBAY CANAL - DS.	INV. 257.0
III	10 COFFERDAM C	CREST 268.0
	11 CANAL CLOSURE FILL	CREST 268.0
	12 COFFERDAM D	CREST 268.0

SCHEDULE

STAGE	1988	1989	1990	1991
I	OPEN PILOT CHANNEL	CLOSE COFFERDAM - (STAGE II A); OPEN COFFERDAM - (STAGE II B)		ON POWER
II A			CLOSE COFFERDAM (STAGE III)	
II B			OPEN TO MEELPAEG	
III				

DESCRIPTION OF OPERATIONS

STAGE I	DRAWDOWN - EL. 262.5 TO 261.0 EXCAVATE FOREBAY CANAL ENTRANCE
STAGE II A	IMPOUND - EL. 261.0 TO 263.5 EXCAVATE BALANCE OF FOREBAY CANAL
STAGE II B	DRAWDOWN - EL. 263.5 TO 259.0 EXCAVATE ISLAND POND CHANNEL IMPROVEMENTS
STAGE III	IMPOUND - EL. 259 TO MEELPAEG WATER LEVEL CONSTRUCT POWER COMPLEX STRUCTURES

HYDRO NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

ISLAND POND — FOREBAY CANAL
UNWATERING & CONSTRUCTION SEQUENCE

DESIGNED:	DRAWN:	SCALE:	DATE: JAN. 1988
SMR-02-88			APPROVED:

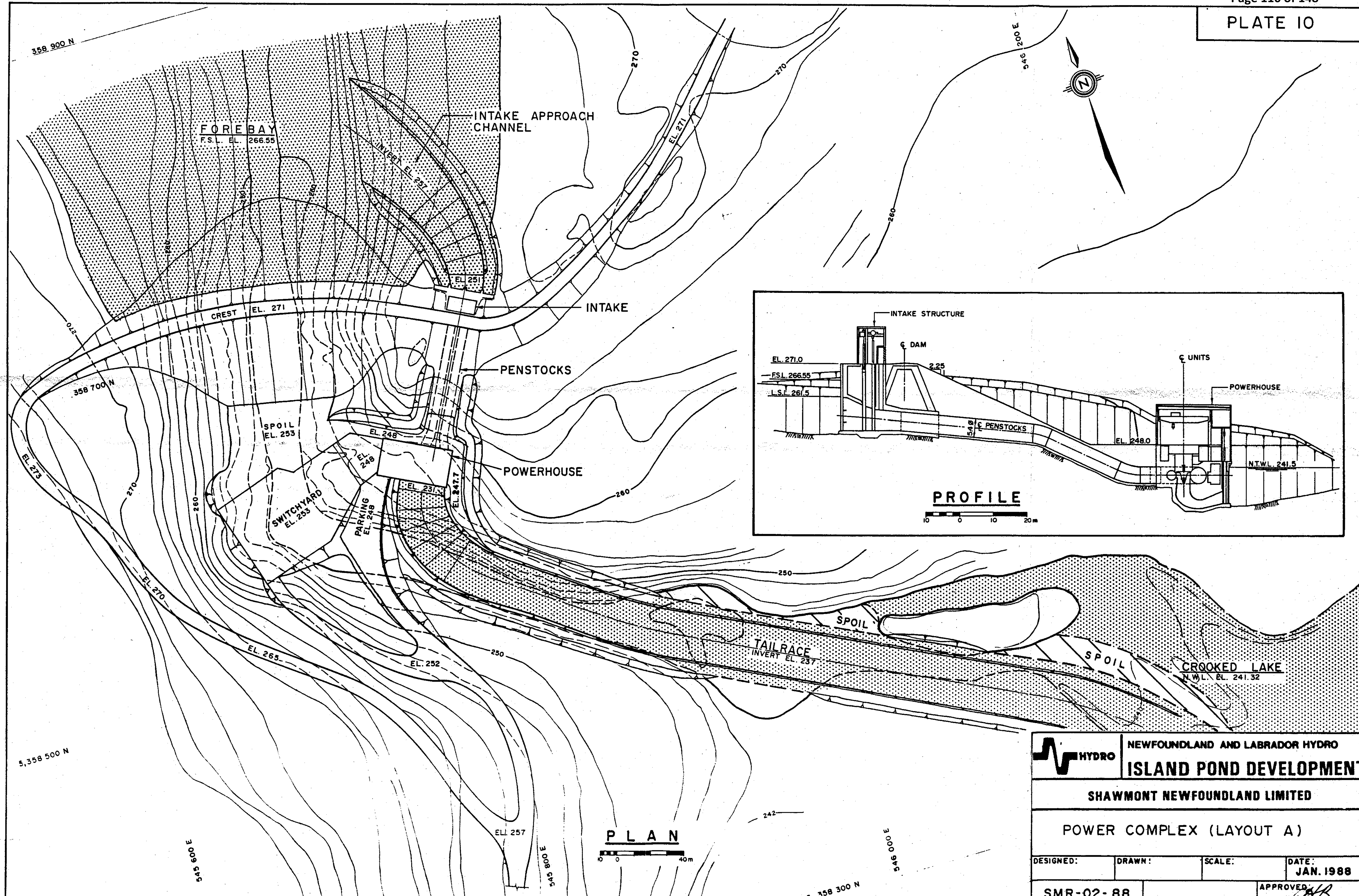
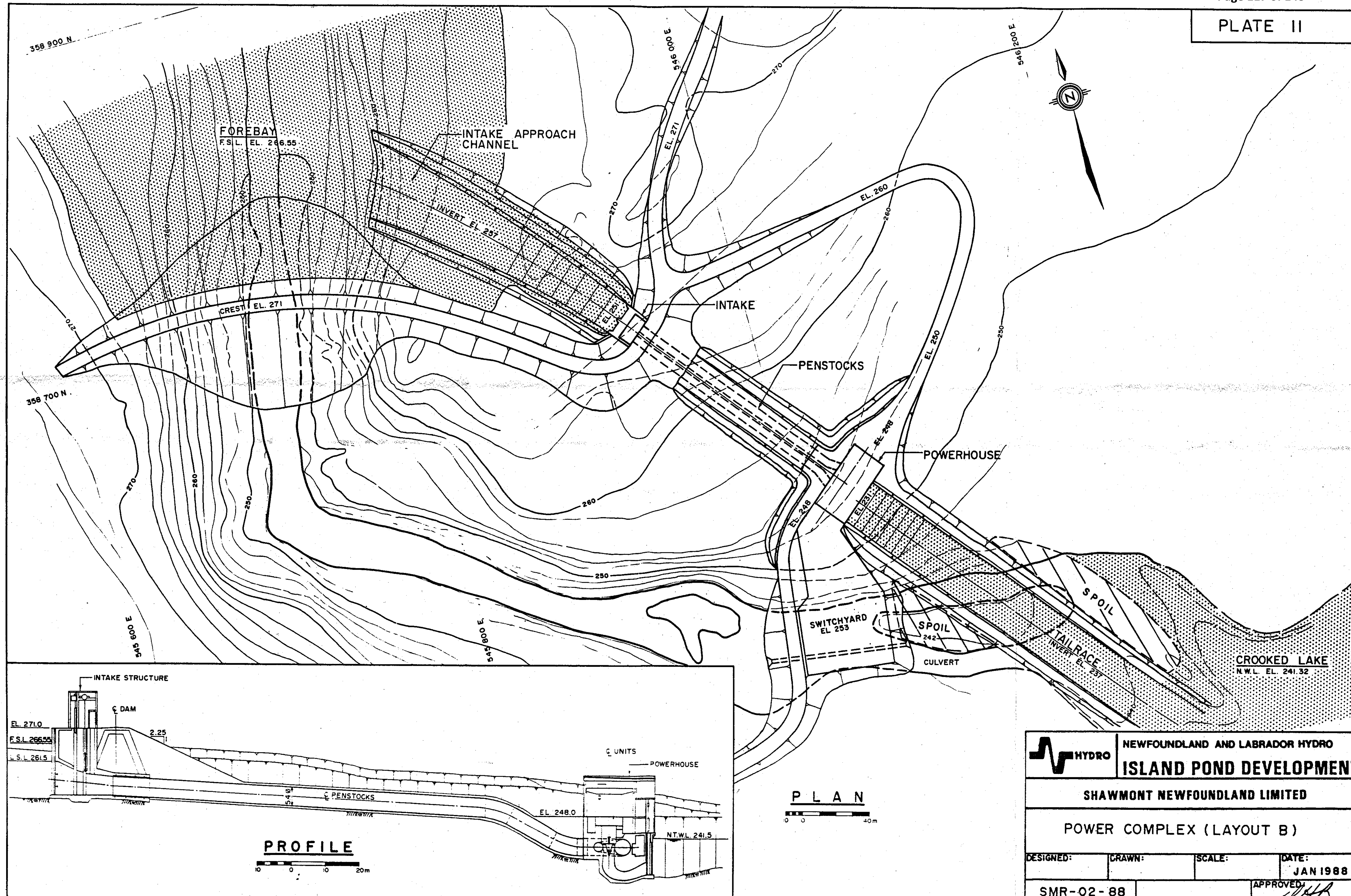


PLATE 10
FOREBAY
F.S.L. EL. 266.55
INTAKE APPROACH CHANNEL
INVERT EL. 257
INTAKE
CREST EL. 271
PENSTOCKS
POWERHOUSE
SPOIL EL. 253
SWITCHYARD EL. 253
PARKING EL. 248
TAILRACE
INVERT EL. 237
SPOIL
CROOKED LAKE
N.W.L. EL. 241.32
INTAKE STRUCTURE
℄ DAM
℄ UNITS
POWERHOUSE
EL. 271.0
F.S.L. 266.55
L.S.L. 261.5
℄ PENSTOCKS
EL. 248.0
N.T.W.L. 241.5
PROFILE
PLAN
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
POWER COMPLEX (LAYOUT A)
DESIGNED:
DRAWN:
SCALE:
DATE: JAN. 1988
SMR-02-88
APPROVED:



NEWFOUNDLAND AND LABRADOR HYDRO

HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

POWER COMPLEX (LAYOUT B)

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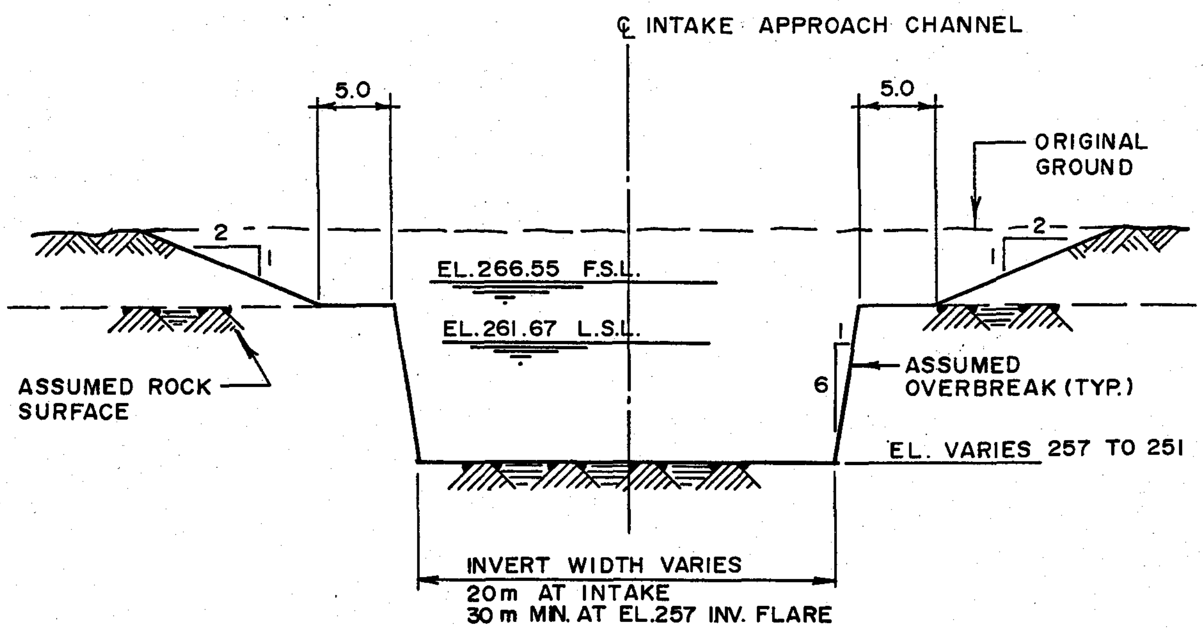
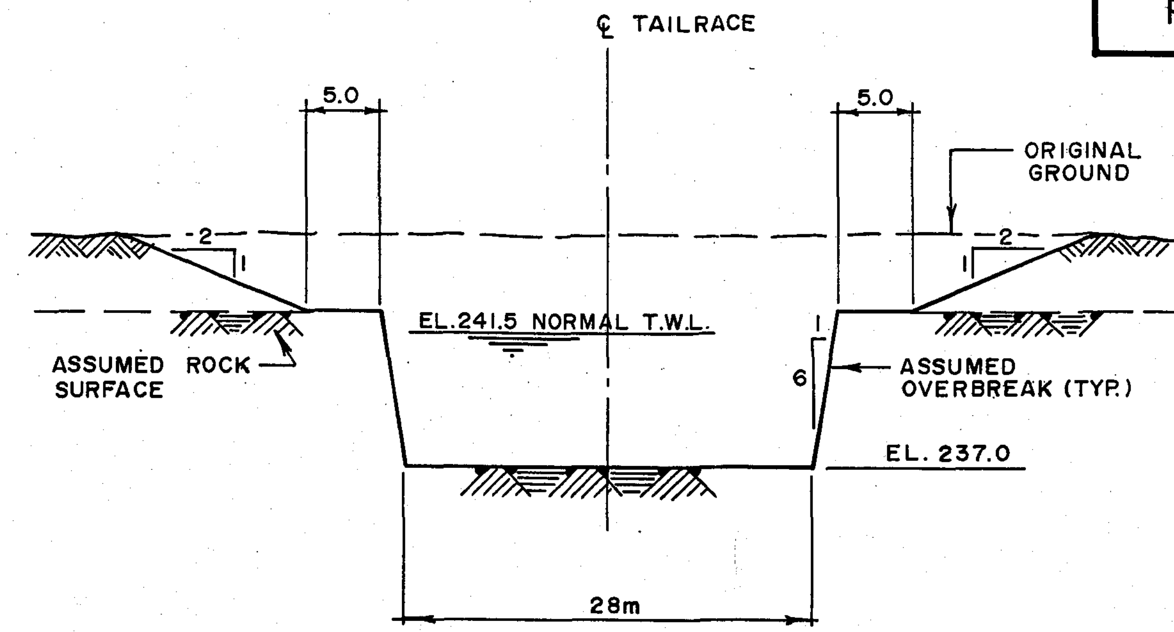
SMR-02-88			APPROVED:

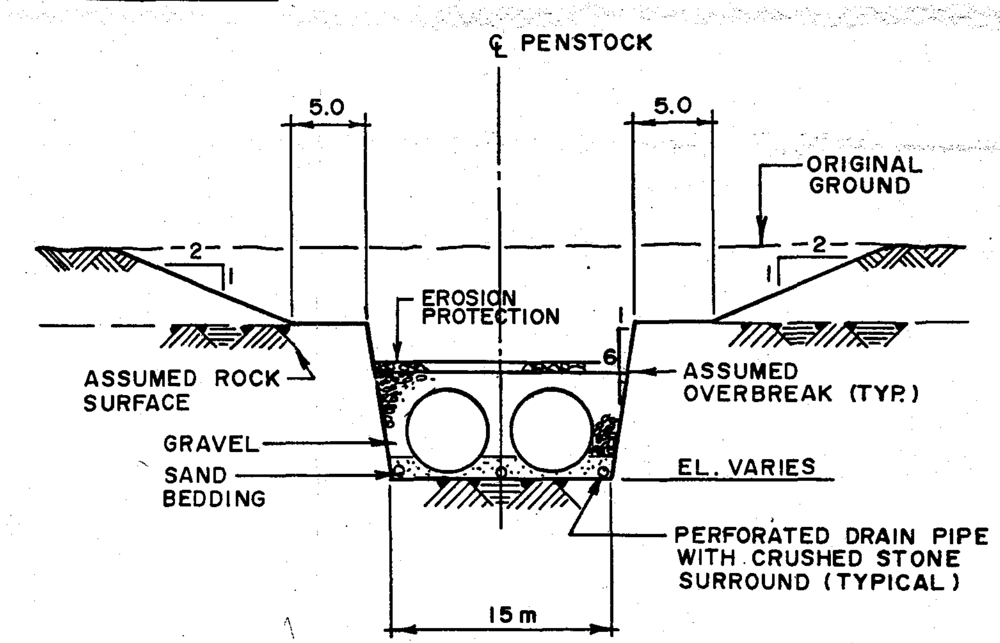
PLATE 12



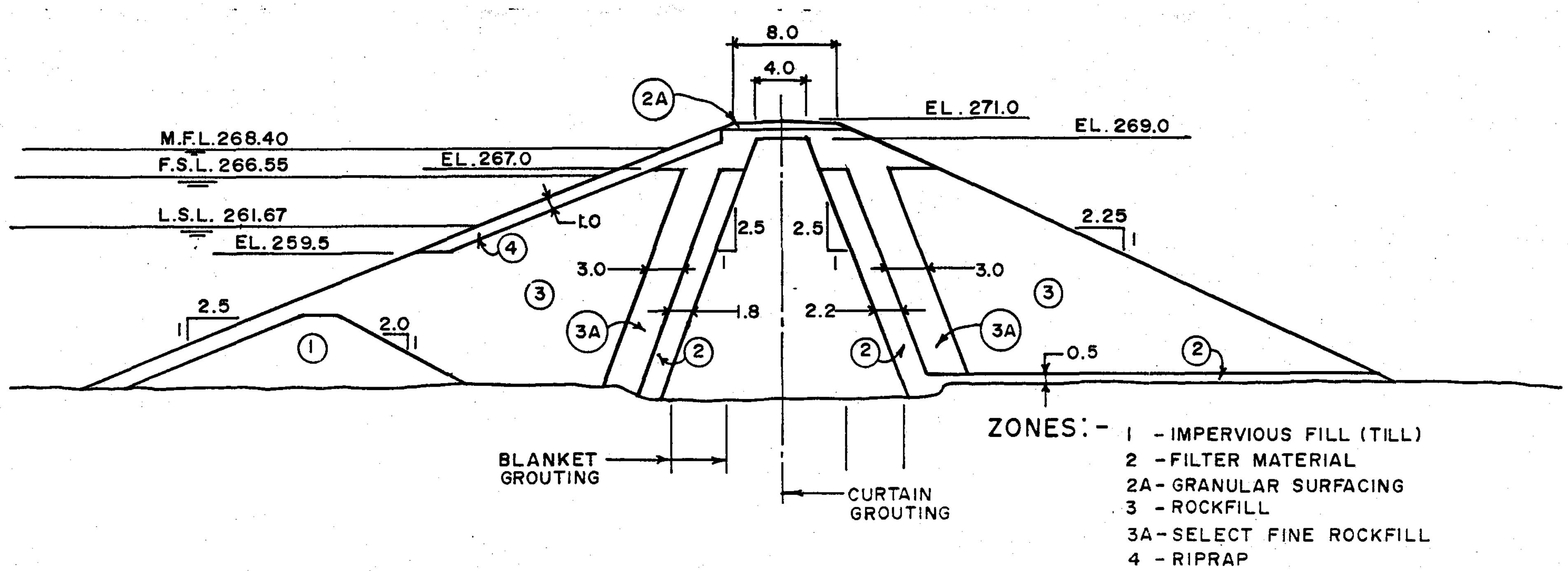
TYPICAL SECTION THRU
INTAKE APPROACH CHANNEL



TYPICAL SECTION THRU
TAILRACE



TYPICAL SECTION THRU
PENSTOCKS



TYPICAL SECTION THRU
DAM

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

POWER COMPLEX — SECTIONS

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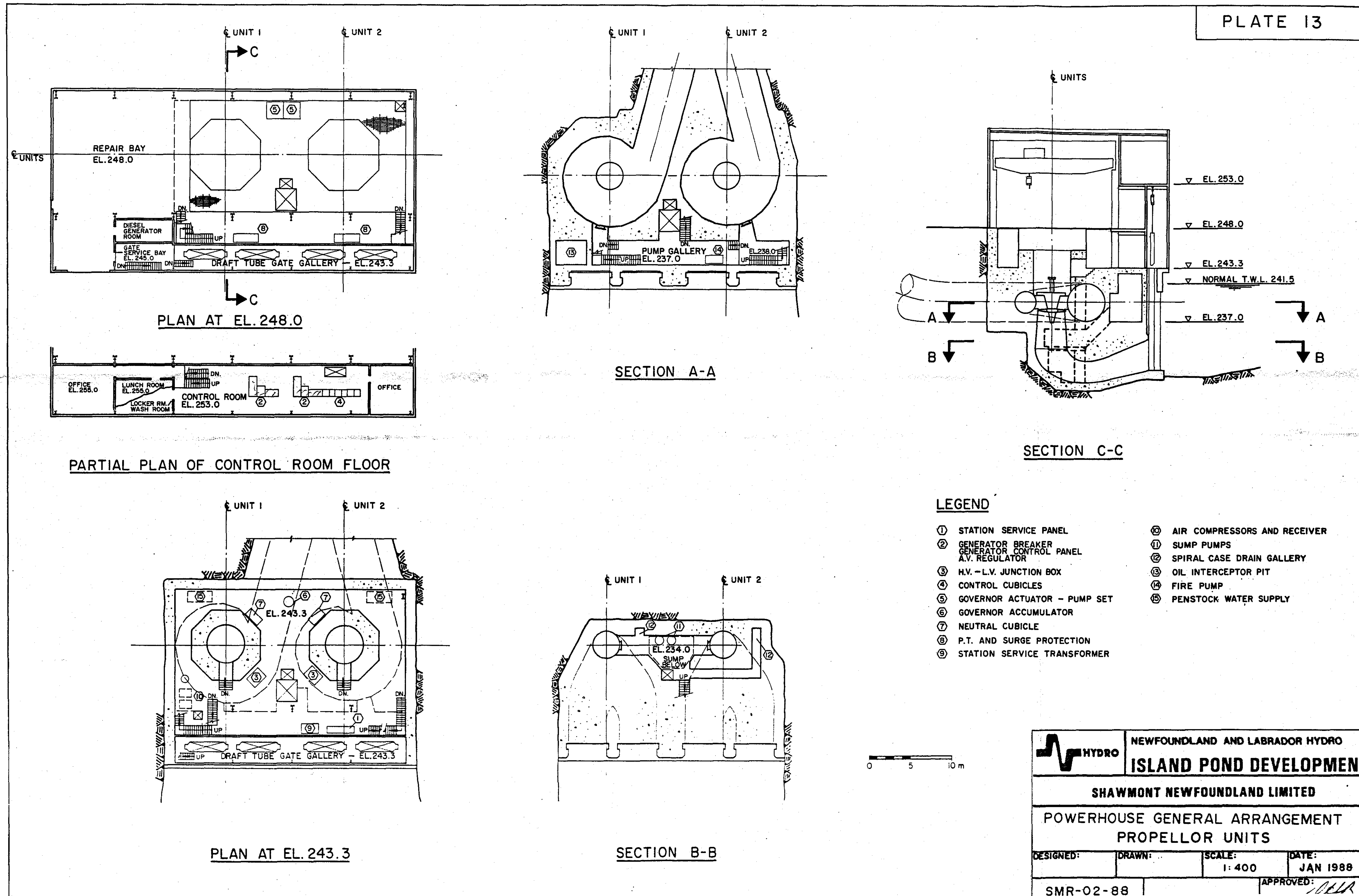
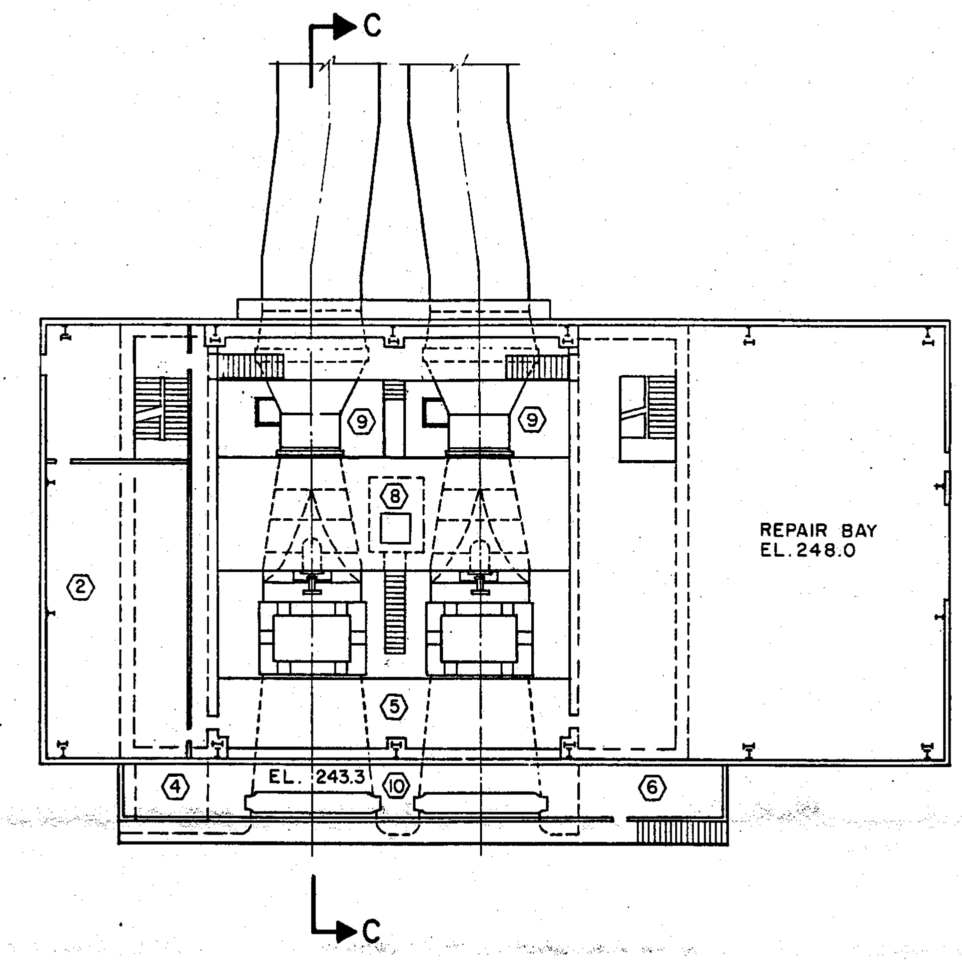
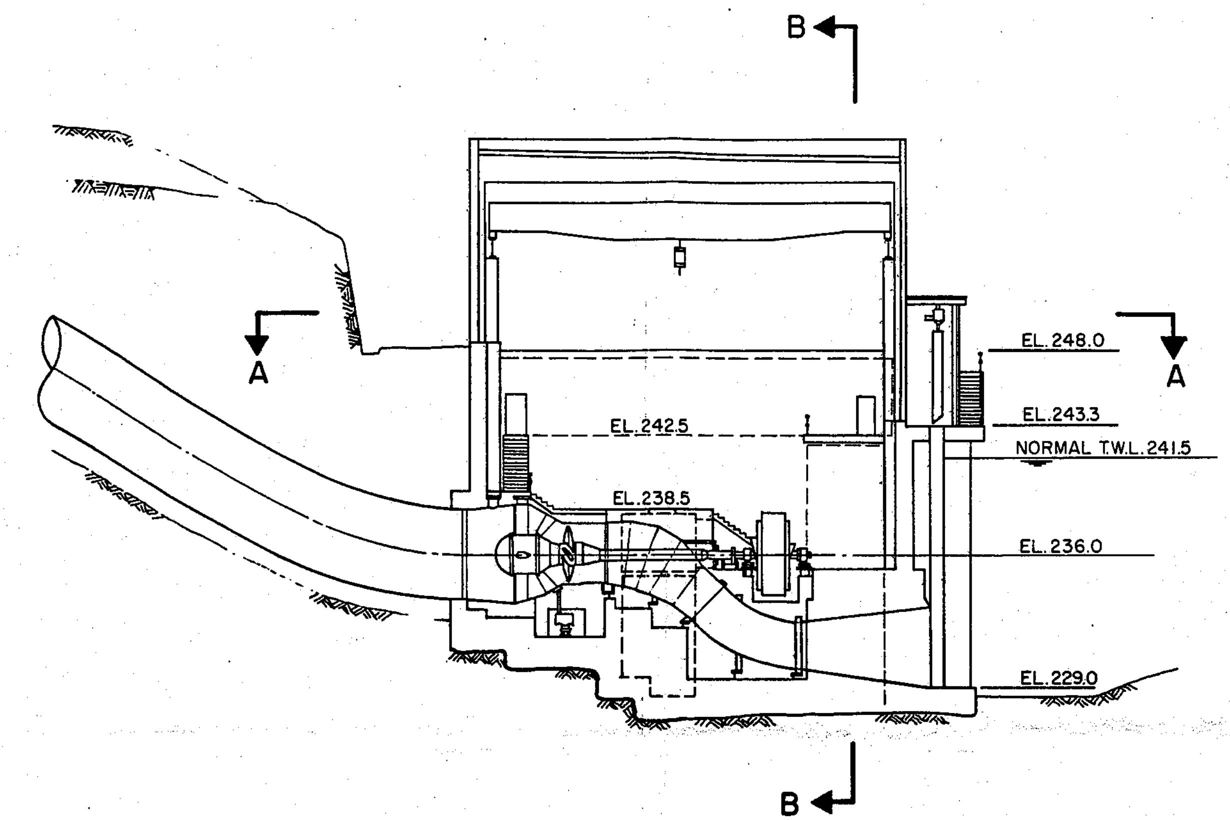


PLATE 13
PLAN AT EL. 248.0
REPAIR BAY EL. 248.0
DIESEL GENERATOR ROOM
GATE SERVICE BAY EL. 245.0
DRAFT TUBE GATE GALLERY - EL. 243.3
PARTIAL PLAN OF CONTROL ROOM FLOOR
OFFICE EL. 255.0
LUNCH ROOM EL. 255.0
LOCKER RM./ WASH ROOM
CONTROL ROOM EL. 253.0
OFFICE
PLAN AT EL. 243.3
EL. 243.3
SECTION A-A
PUMP GALLERY EL. 237.0
EL. 238.0
SECTION B-B
EL. 234.0
SUMP BELOW
SECTION C-C
EL. 253.0
EL. 248.0
EL. 243.3
NORMAL T.W.L. 241.5
EL. 237.0
LEGEND
① STATION SERVICE PANEL
② GENERATOR BREAKER GENERATOR CONTROL PANEL A.V. REGULATOR
③ H.V. - L.V. JUNCTION BOX
④ CONTROL CUBICLES
⑤ GOVERNOR ACTUATOR - PUMP SET
⑥ GOVERNOR ACCUMULATOR
⑦ NEUTRAL CUBICLE
⑧ P.T. AND SURGE PROTECTION
⑨ STATION SERVICE TRANSFORMER
⑩ AIR COMPRESSORS AND RECEIVER
⑪ SUMP PUMPS
⑫ SPIRAL CASE DRAIN GALLERY
⑬ OIL INTERCEPTOR PIT
⑭ FIRE PUMP
⑮ PENSTOCK WATER SUPPLY
0 5 10 m
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
POWERHOUSE GENERAL ARRANGEMENT PROPELLOR UNITS
DESIGNED:
DRAWN:
SCALE: 1:400
DATE: JAN 1988
APPROVED:
SMR-02-88

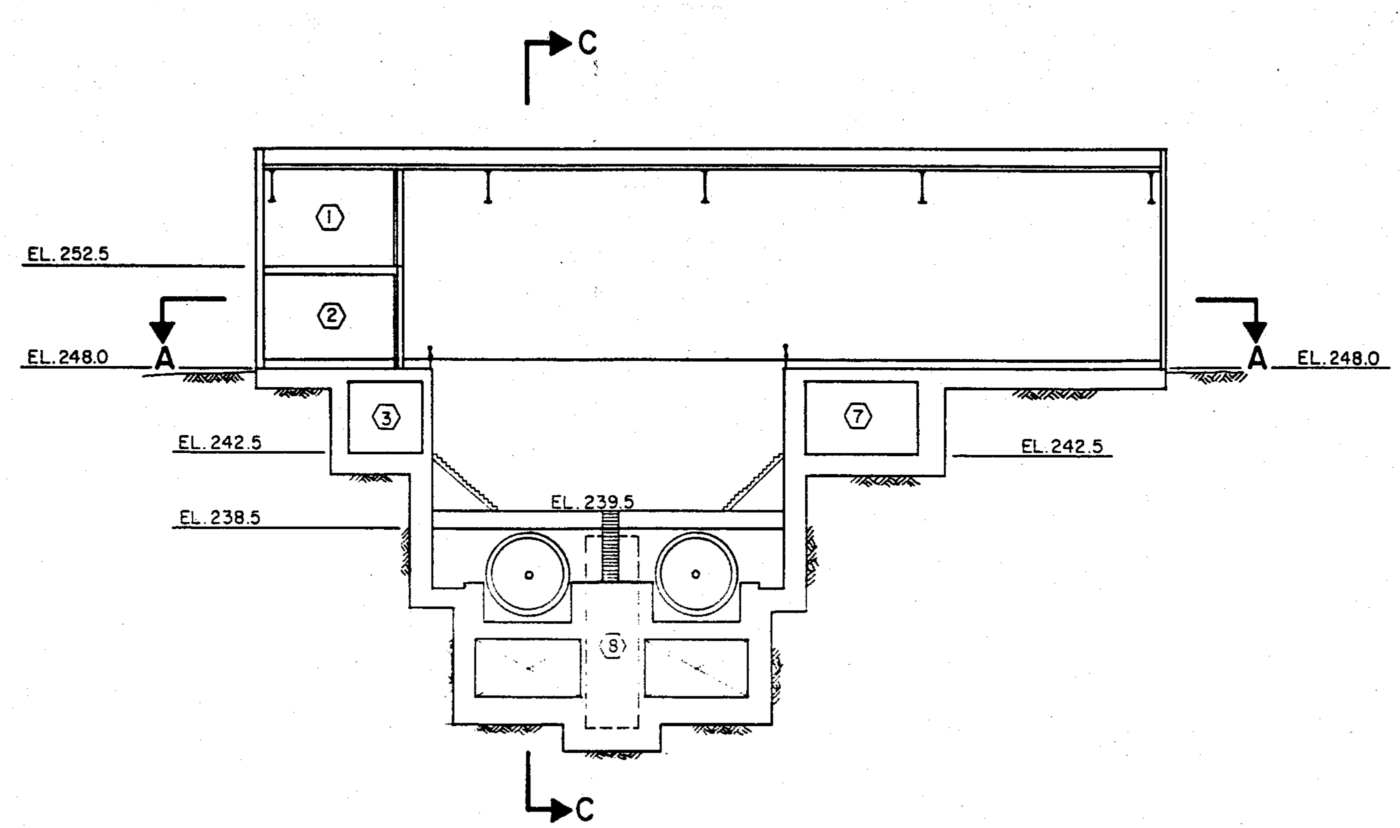
PLATE 14



PLAN-SECTION A-A



SECTION C-C



SECTION B-B

LEGEND

1. CONTROL ROOM & OFFICES
2. ELECTRICAL SERVICES ROOM
3. SWITCHGEAR & CABLE GALLERY
4. OIL INTERSEPTOR PIT
5. SWITCHGEAR & CONTROL PANEL MEZZANINE
6. GATE SERVICE BAY
7. MECHANICAL SERVICES ROOM
8. SUMP PIT
9. GOVERNOR PIT
10. DRAFT TUBE GATE GALLERY

HYDRO	NEWFOUNDLAND AND LABRADOR HYDRO ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED	
POWERHOUSE GENERAL ARRANGEMENT HORIZONTAL UNITS	
DESIGNED:	DRAWN:
SCALE: 1:400	DATE: JAN 1988
SMR-02-88	APPROVED:

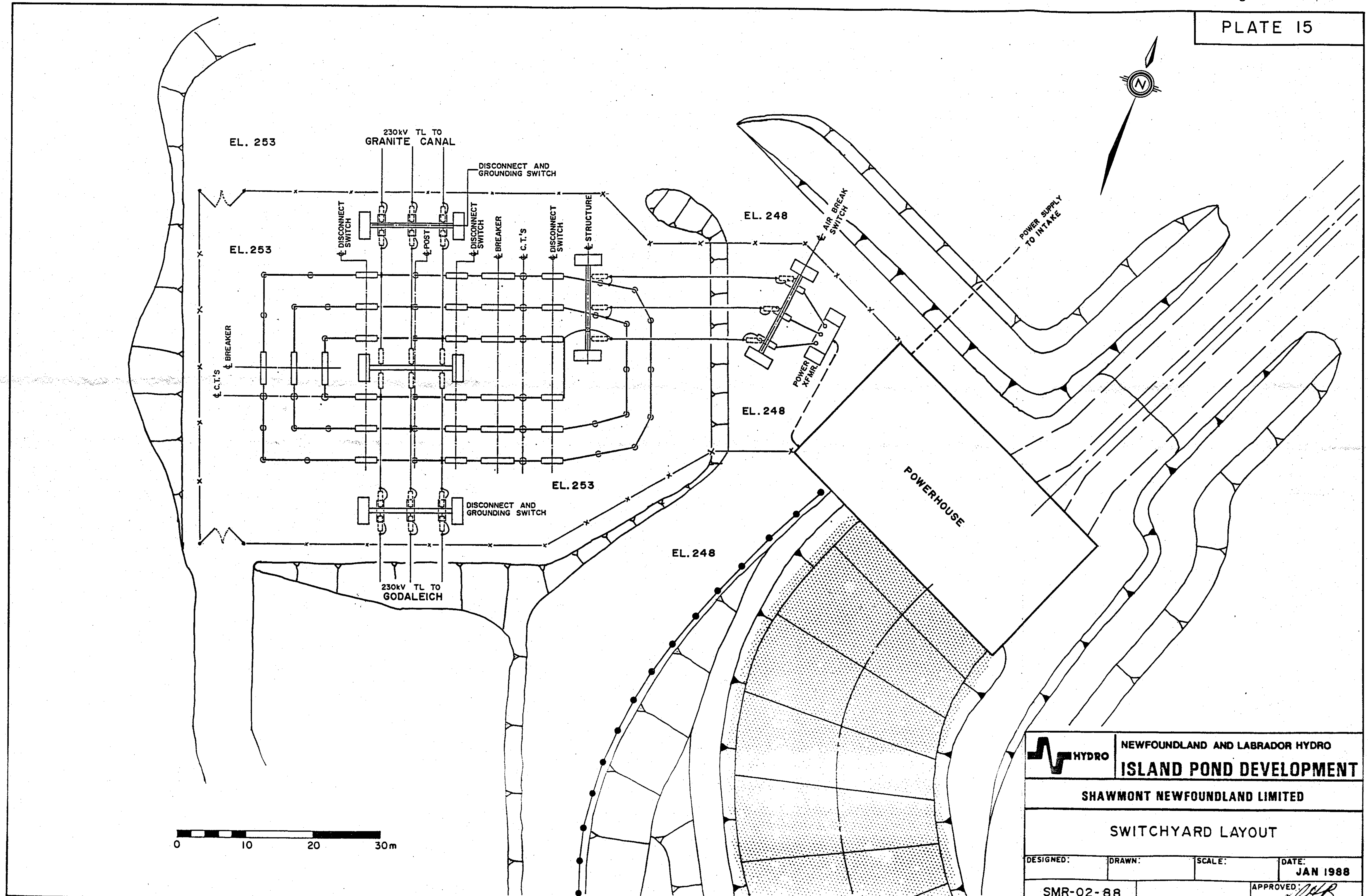
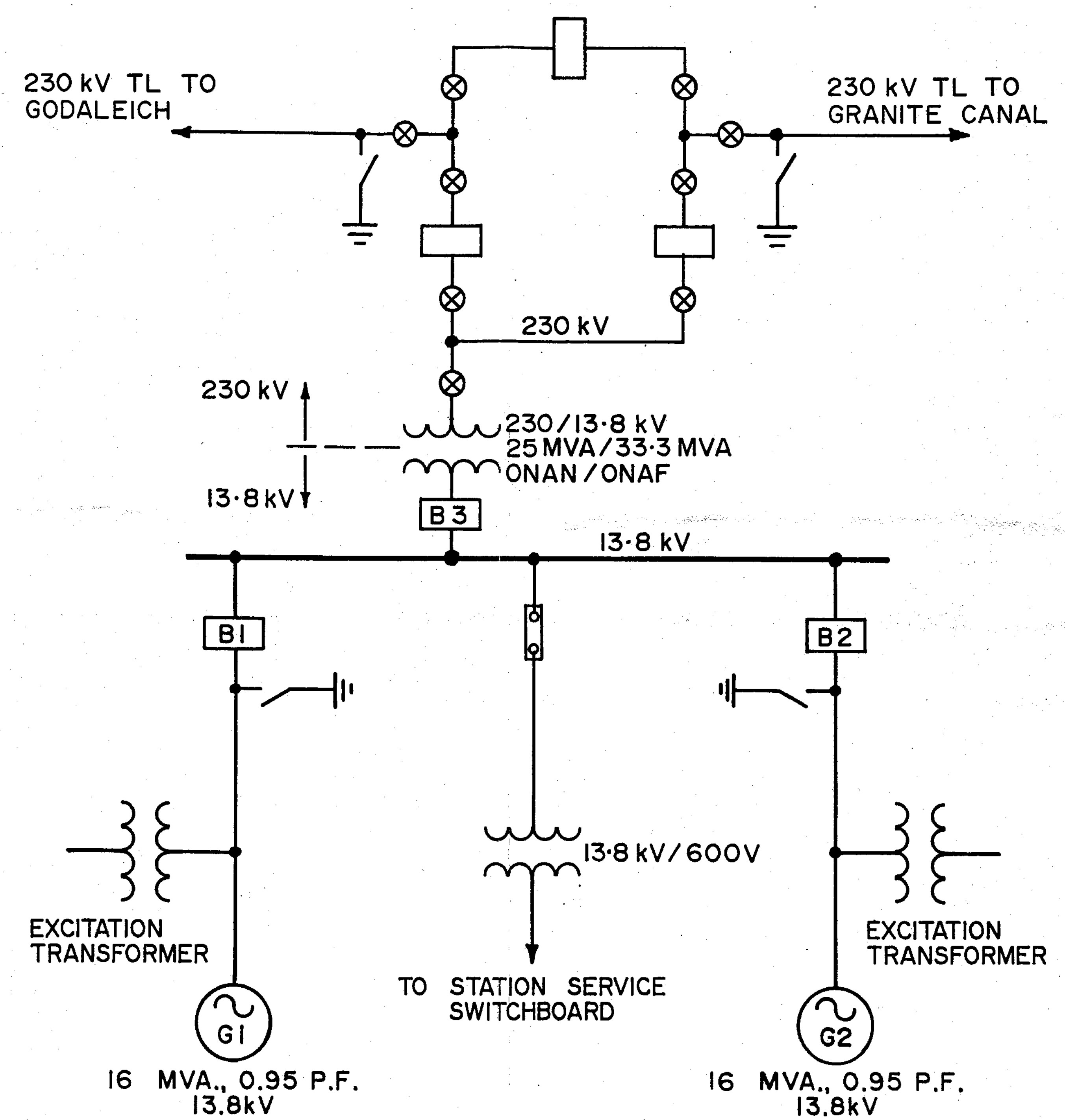


PLATE 15
EL. 253
230kV TL TO
GRANITE CANAL
DISCONNECT AND
GROUNDING SWITCH
EL.253
DISCONNECT SWITCH
POST
BREAKER
C.T.'S
STRUCTURE
EL. 248
AIR BREAK SWITCH
POWER SUPPLY TO INTAKE
POWER XFMR.
EL. 248
POWERHOUSE
EL.253
DISCONNECT AND
GROUNDING SWITCH
EL. 248
230kV TL TO
GODALEICH
0
10
20
30m
HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
ISLAND POND DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED
SWITCHYARD LAYOUT
DESIGNED:
DRAWN:
SCALE:
DATE:
JAN 1988
SMR-02-88
APPROVED:

PLATE 16



HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

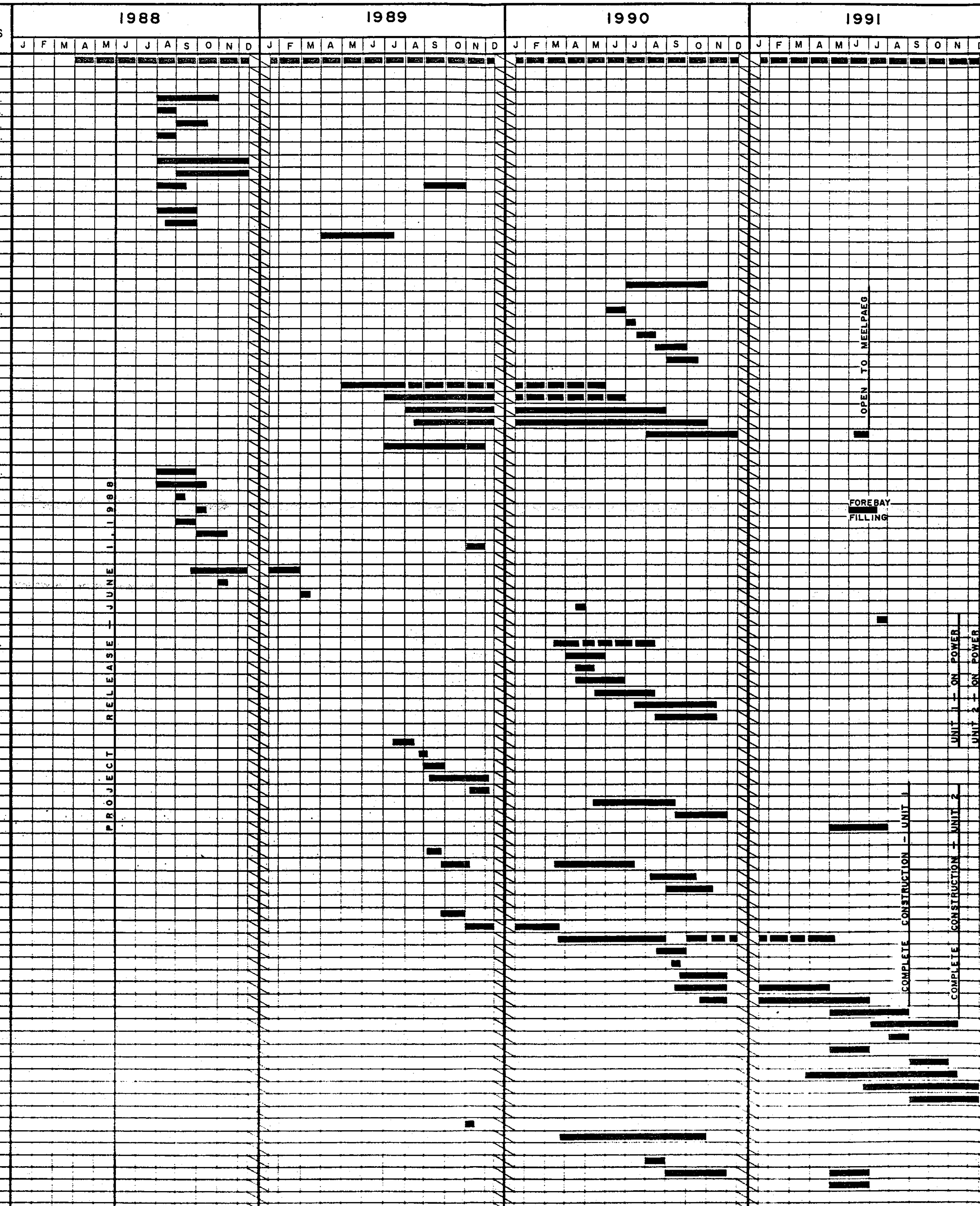
SHAWMONT NEWFOUNDLAND LIMITED

SINGLE LINE DIAGRAM

DESIGNED:	DRAWN:	SCALE:	DATE: JAN 1988
SMR-02-88			APPROVED:

PLATE 17

STRUCTURE	ITEM	MAJOR QUANITIES
	ENGINEERING	
SITE ESTABLISHMENT	UPGRADE EXISTING ROADS	
	- MILLERTOWN TO DIVERSION CANAL	50.0 km.
	- DIVERSION CANAL TO PH. INTERSECTION	9.2 km.
	- PH. INTERSECTION TO EBBEGUNBAEG	4.5 km.
	- UPPER SALMON ROAD TO U.S. DIV. CANAL	4.0 km.
	PERMANENT ROADS	
	- U.S. DIVERSION CANAL TO EBBEGUNBAEG	15.5 km
	- PH. INTERSECTION TO POWERHOUSE	7.0 km.
	BRIDGES - NOEL PAULS BROOK	
	- DIVERSION CANAL	
	- U.S. DIVERSION CANAL	
	CONSTRUCTION CAMP - DIVERSION CANAL	
	- POWERHOUSE	
RESERVOIR CLEARING	CLEARING (INCLUDING ACCESS ROADS REQUIRED FOR CLEARING)	83 ha
EBBEGUNBAEG FREEBOARD DYKE	ACCESS ROAD	1.8 km.
	CLEARING AND STRIPPING	
	FOUNDATION PREPARATION	3,000 m³
	HOMOGENEOUS FILL & IMPERV. MEMBRANE	18,000 m³
	RIPRAP	2,000 m³
DIVERSION CANAL	ACCESS ROAD	
	CLEARING AND STRIPPING	54,500 m³
	OVERLAND SECTION - EXCAV. OVERBURBEN	515,000 m³
	OVERLAND SECTION - EXCAVATE ROCK	314,000 m³
	MEELPAEG RESERVOIR SECTION	100,000 m³
	ISLAND POND CHANNEL IMPROVEMENTS	301,200 m³
FOREBAY CANAL	ACCESS ROAD	3.4 km.
	CLEARING AND STRIPPING	
	EXCAVATE PILOT CHANNEL	2,000 m³
	FOREBAY FILLING STRUCTURE	
	COFFERDAMS - STAGE I	7,600 m³
	- STAGE II	9,700 m³
	- STAGE III	22,000 m³
	EXCAVATE CANAL	78,300 m³
	CANAL CLOSURE - INSTALL STAGE II	3,700 m³
	- REMOVE STAGE II	4,200 m³
	- INSTALL STAGE III	—
	- REMOVE STAGE III	11,000 m³
DAM	ACCESS ROAD	0.5 km.
	CLEARING AND STRIPPING	15,500 m³
	COFFERDAM	3,650 m³
	FOUNDATION PREPARATION	—
	FOUNDATION GROUTING	—
	IMPERVIOUS CORE, FILTERS & GRAVEL	49,500 m³
	ROCKFILL AND RIPRAP	98,000 m³
INTAKE AND APPROACH CHANNEL	ACCESS ROAD	—
	CLEARING AND STRIPPING	—
	EXCAVATE OVERBURDEN	8,750 m³
	EXCAVATE ROCK	38,000 m³
	FOUNDATION PREPARATION	—
	CONCRETE & EXTERIOR FINISHING	3,460 m²
	HYDRAULIC GATES & TRASHRACKS	—
	ENCLOSURE BLD., ELECTRICAL & MECHANICAL	—
PENSTOCK	CLEARING AND STRIPPING	—
	EXCAVATION	27,500 m³
	STEEL PIPE	330 T
	DRAINAGE SYSTEM AND BACKFILL	
POWERHOUSE	CLEARING AND STRIPPING	
	EXCAVATION AND BACKFILL	21,000 m³
	CONCRETE	5,200 m³
	STRUCTURAL STEELWORK	
	OVERHEAD CRANE	
	ROOFING AND CLADDING	
	TURBINE - UNIT 1	
	- UNIT 2	
	GENERATOR - UNIT 1	
	- UNIT 2	
	POWER TRANSFORMER	
	DRAFT TUBE GATES	
	EXTERNAL WORK	
	ELECTRICAL & MECHANICAL AUXILIARIES	
	ARCHITECTURAL FINISHING & PAINTING	
	COMMISSIONING	
TAILRACE	CLEARING AND STRIPPING	
	EXCAVATION	8,200 m³
SWITCHYARD	CLEARING AND STRIPPING	
	EXCAV., GROUNDING, BACKFILL & FENCING	33,100 m³
	CONCRETE FOOTINGS	235 m³



HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

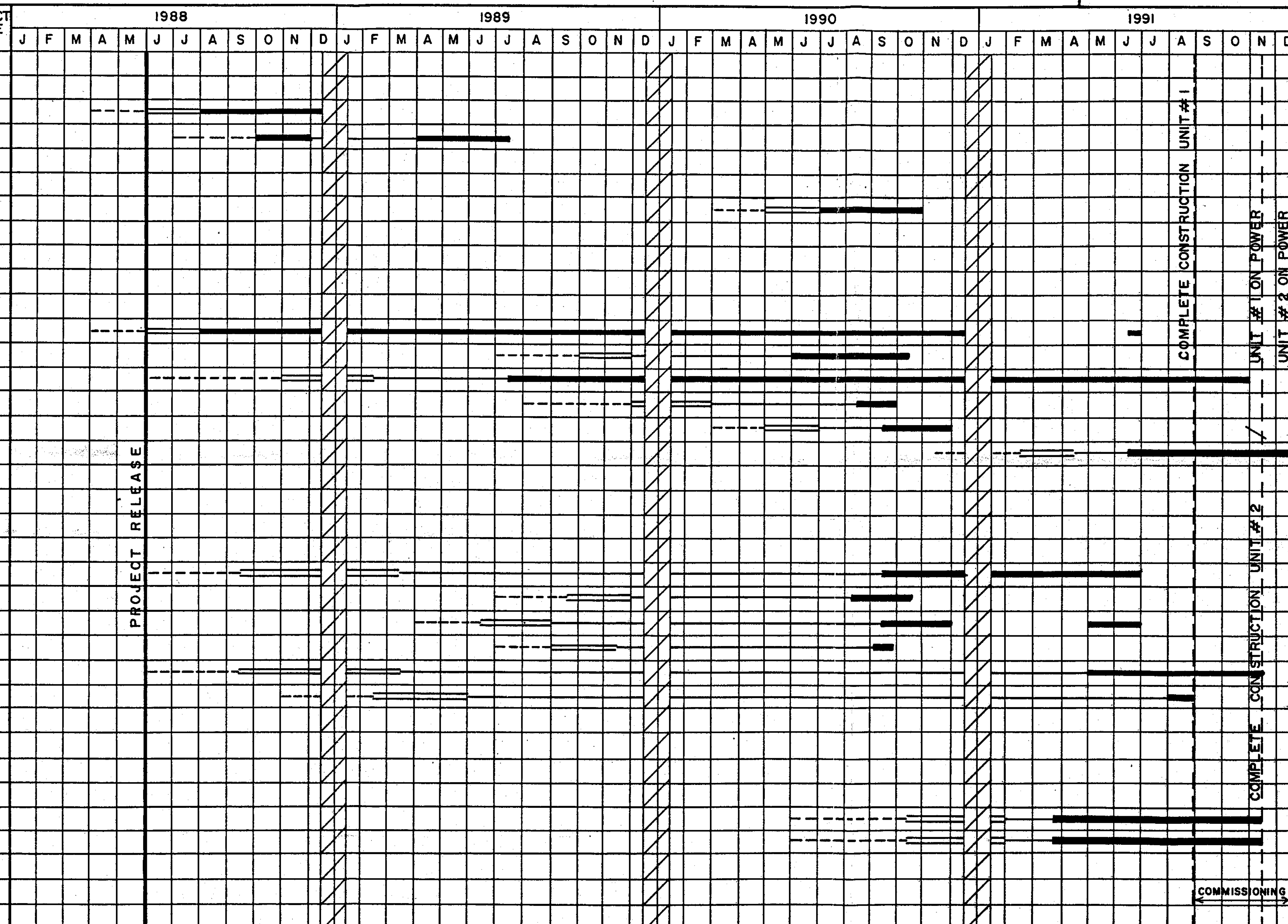
SHAWMONT NEWFOUNDLAND LIMITED

CONSTRUCTION SCHEDULE

DESIGNED:	DRAWN:	SCALE:	DATE: JAN 1988
SMR-02-88			APPROVED:

PLATE 18

CONTRACTS	CONTRACT PACKAGE Nº
GENERAL	
PERMANENT ACCESS ROAD	G1
CONSTRUCTION CAMP – POWERHOUSE SITE	G2
RESERVOIR CLEARING	R1
CIVIL WORKS	
CANALS & UPGRADING OF EXISTING ROADS	C1
MEELPAEG RESERVOIR FREEBOARD DYKE	C2
POWER COMPLEX STRUCTURES	C3
POWERHOUSE STRUCTURAL STEEL	C4
POWERHOUSE ROOFING & CLADDING	C5
POWERHOUSE ARCHITECTURAL & PAINTING	C6
MAJOR EQUIPMENT	
TURBINES & GOVERNORS	M1
PENSTOCKS	M2
HYDRAULIC GATES	M3
POWERHOUSE CRANE	M4
GENERATORS & EXCITERS	E1
POWER TRANSFORMER	E2
OTHERS	
MECHANICAL SERVICES & AUXILIARY EQUIPMENT	M5
ELECTRICAL SERVICES & AUXILIARY EQUIPMENT	E3



LEGEND

- DESIGN & PREPARATION OF TENDER DOCUMENTS
- TENDER / AWARD — TENDERING, EVALUATION & AWARD
- SITE CONSTRUCTION
- MANUFACTURING

KEY DATES

PROJECT RELEASE	1988·06·01
COMMENCEMENT OF CONSTRUCTION	1988·08·01
COMPLETION OF INSTALLATION & CONSTRUCTION	1991·12·15
ON POWER – UNIT 1	1991·11·15
– UNIT 2	1991·12·15

NOTE:

SCHEDULE IS BASED ON PROJECT TIME SPAN OF 42.5 MONTHS WITH PROJECT RELEASE ON 1988·06·01.

HYDRO NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

PROJECT PLANNING SCHEDULE

DESIGNED: | DRAWN: | SCALE: | DATE: JAN 1988

SMR-02-88 | APPROVED:

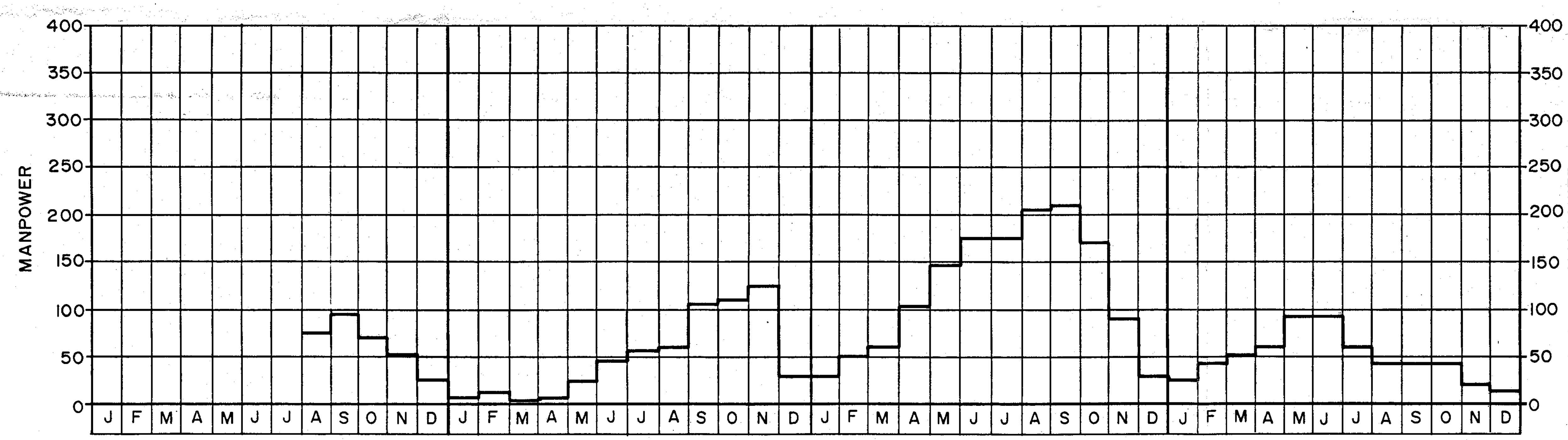
PLATE 19

CONTRACTOR	1988 J	F	M	A	M	J	J	A	S	O	N	D
PERMANENT ACCESS ROAD								50	50	30	30	15
CANALS & ACCESS ROADS								25	40	40	20	10
POWER COMPLEX STRUCTURES												
TURBINES & GOVERNORS												
GENERATORS & EXCITERS												
HYDRAULIC GATES												
MECHANICAL & AUXILIARIES												
ELECTRICAL & AUXILIARIES												
OTHERS												
TOTAL								75	90	70	50	25

CONTRACTOR	1989 J	F	M	A	M	J	J	A	S	O	N	D
PERMANENT ACCESS ROAD									5	5		
CANALS & ACCESS ROADS	10	15	5	5	5	5	40	65	75	75	80	20
POWER COMPLEX STRUCTURES									25	25	40	10
TURBINES & GOVERNORS												
GENERATORS & EXCITERS												
HYDRAULIC GATES									5	10	5	
MECHANICAL & AUXILIARIES												
ELECTRICAL & AUXILIARIES												
OTHERS				5	20	35	20					
TOTAL	10	15	5	10	25	40	60	65	110	115	125	30

CONTRACTOR	1990 J	F	M	A	M	J	J	A	S	O	N	D
PERMANENT ACCESS ROAD												
CANALS & ACCESS ROADS	20	35	35	35	40	40	40	40	30	30	10	5
POWER COMPLEX STRUCTURES	10	15	30	70	105	120	120	125	125	110	60	15
TURBINES & GOVERNORS									5	15	15	10
GENERATORS & EXCITERS												
HYDRAULIC GATES												
MECHANICAL & AUXILIARIES												
ELECTRICAL & AUXILIARIES												
OTHERS						15	15	40	50	15		
TOTAL	30	50	65	105	145	175	175	205	210	170	85	30

CONTRACTOR	1991 J	F	M	A	M	J	J	A	S	O	N	D	TOTAL MAN/MONTHS
PERMANENT ACCESS ROAD													185
CANALS & ACCESS ROADS							10						905
POWER COMPLEX STRUCTURES	15	25	25	25	25	20	10		5	5			1,160
TURBINES & GOVERNORS	10	15	15	15	15	15							130
GENERATORS & EXCITERS					10	15	15	15	15	15	5		90
HYDRAULIC GATES					10	10							40
MECHANICAL & AUXILIARIES			5	10	15	10	10	5	5	5	5	5	75
ELECTRICAL & AUXILIARIES			5	15	15	20	20	20	15	15	10	10	145
OTHERS													215
TOTAL	25	40	50	65	90	90	65	40	40	40	20	15	2,945



NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

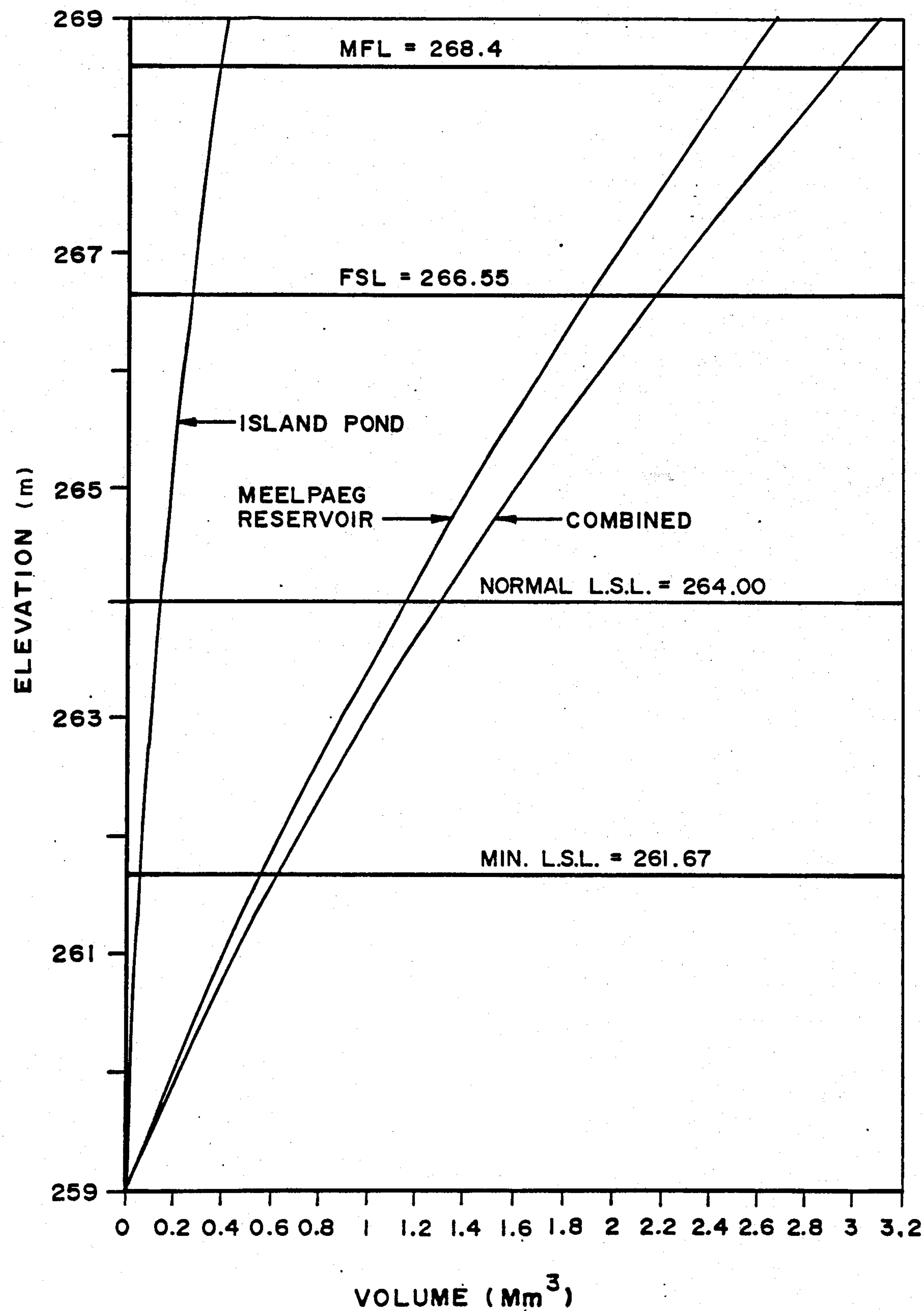
SHAWMONT NEWFOUNDLAND LIMITED

ESTIMATED MANPOWER REQUIREMENTS

DESIGNED:	DRAWN:	SCALE:	DATE: JAN 1988
SMR-02-88			APPROVED:

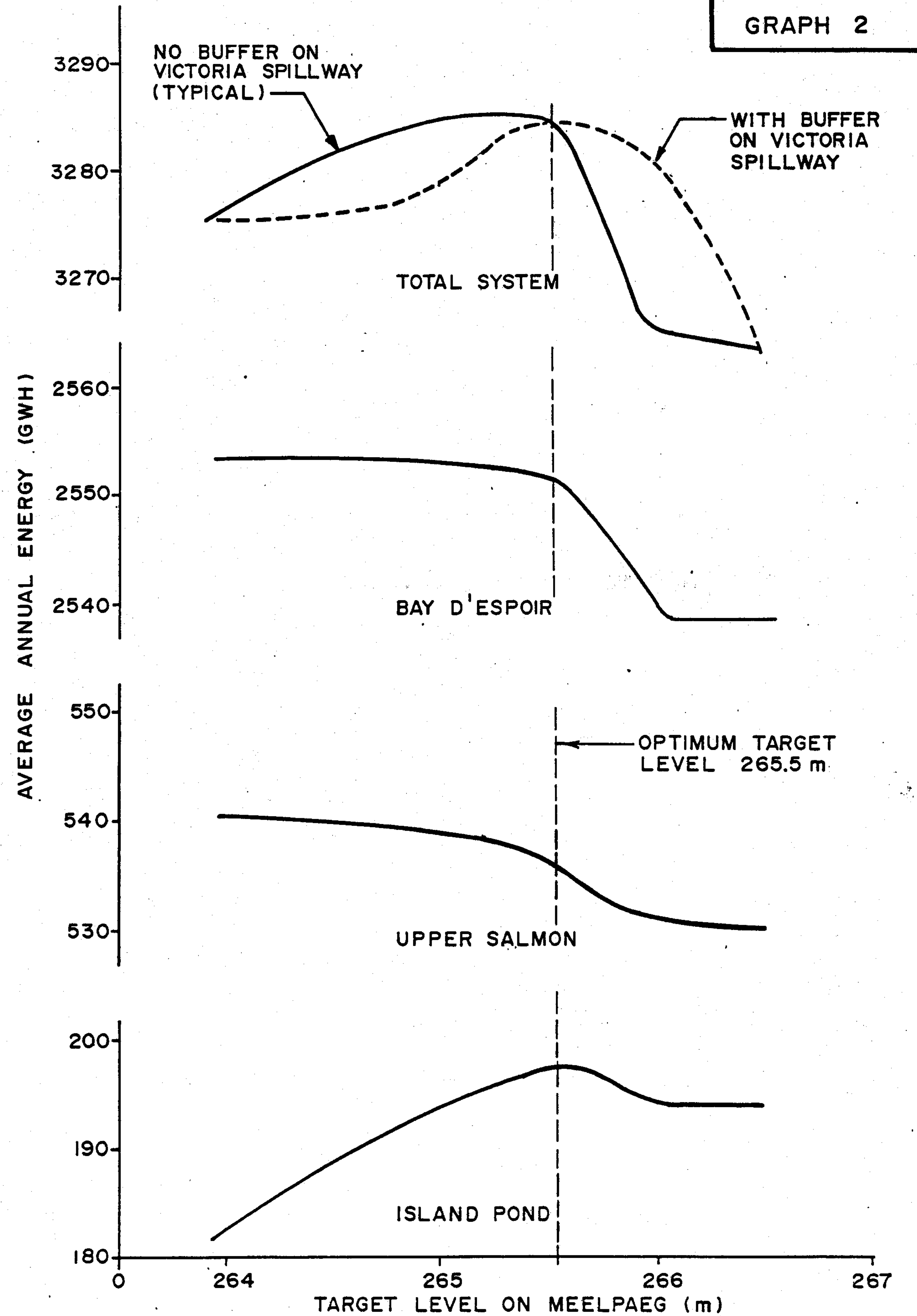
GRAPHS

GRAPH I



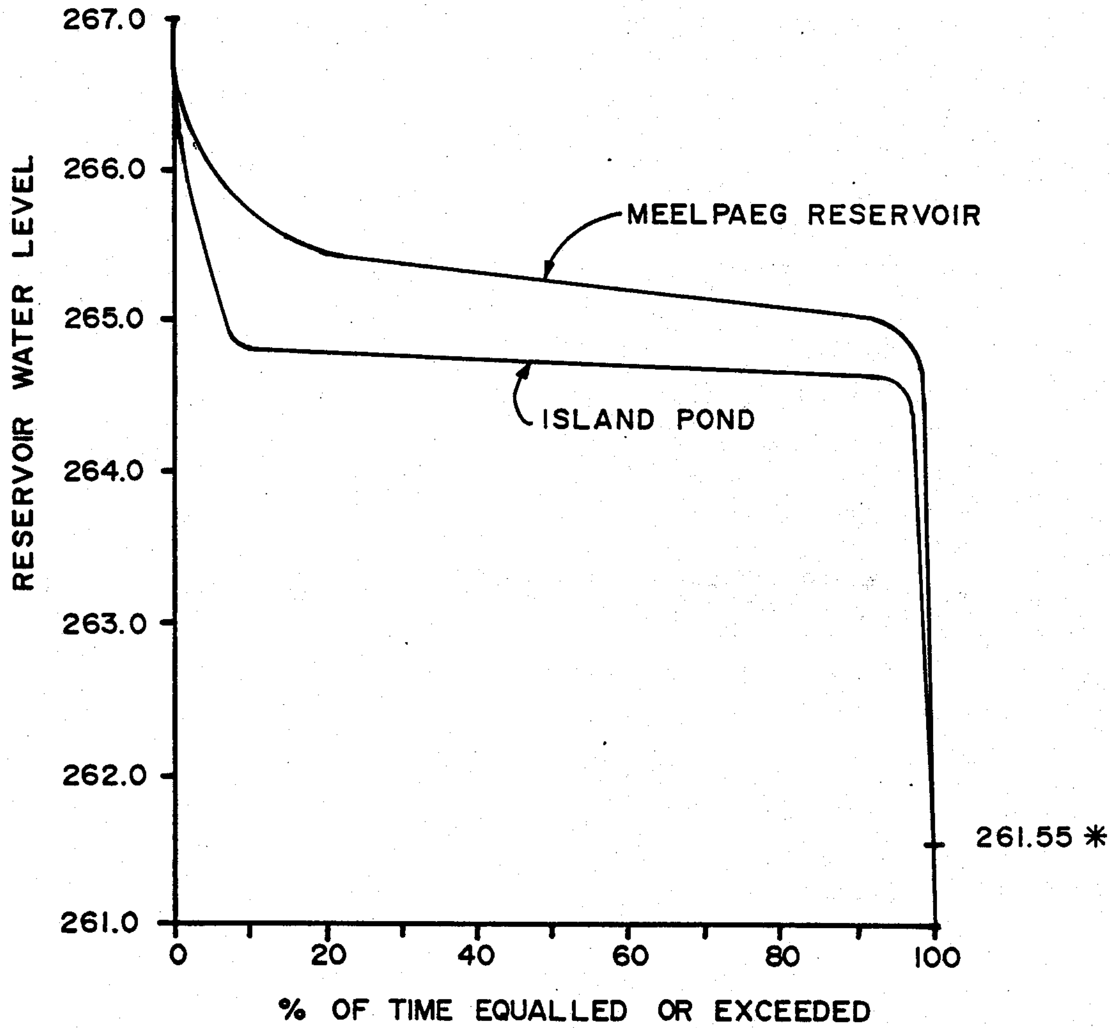
STORAGE VOLUME CURVES

GRAPH 2



TARGET LEVEL OPTIMIZATION

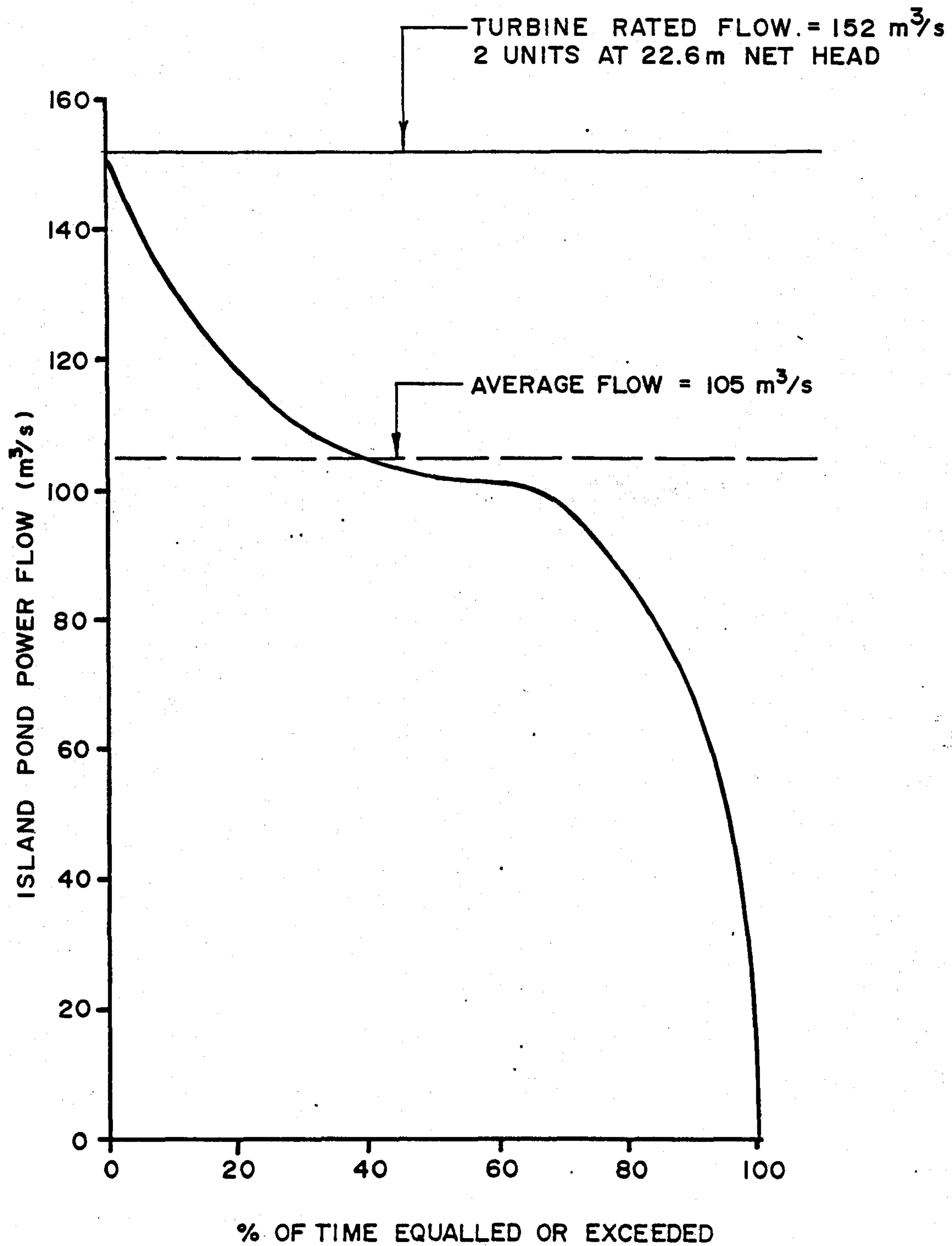
GRAPH 3



* ISLAND POND RESERVOIR:
EXTREME LOW WATER LEVEL WHICH OCCURS AT INTAKE LESS THAN 1 % OF THE TIME AND USED TO DETERMINE THE INTAKE SETTING.

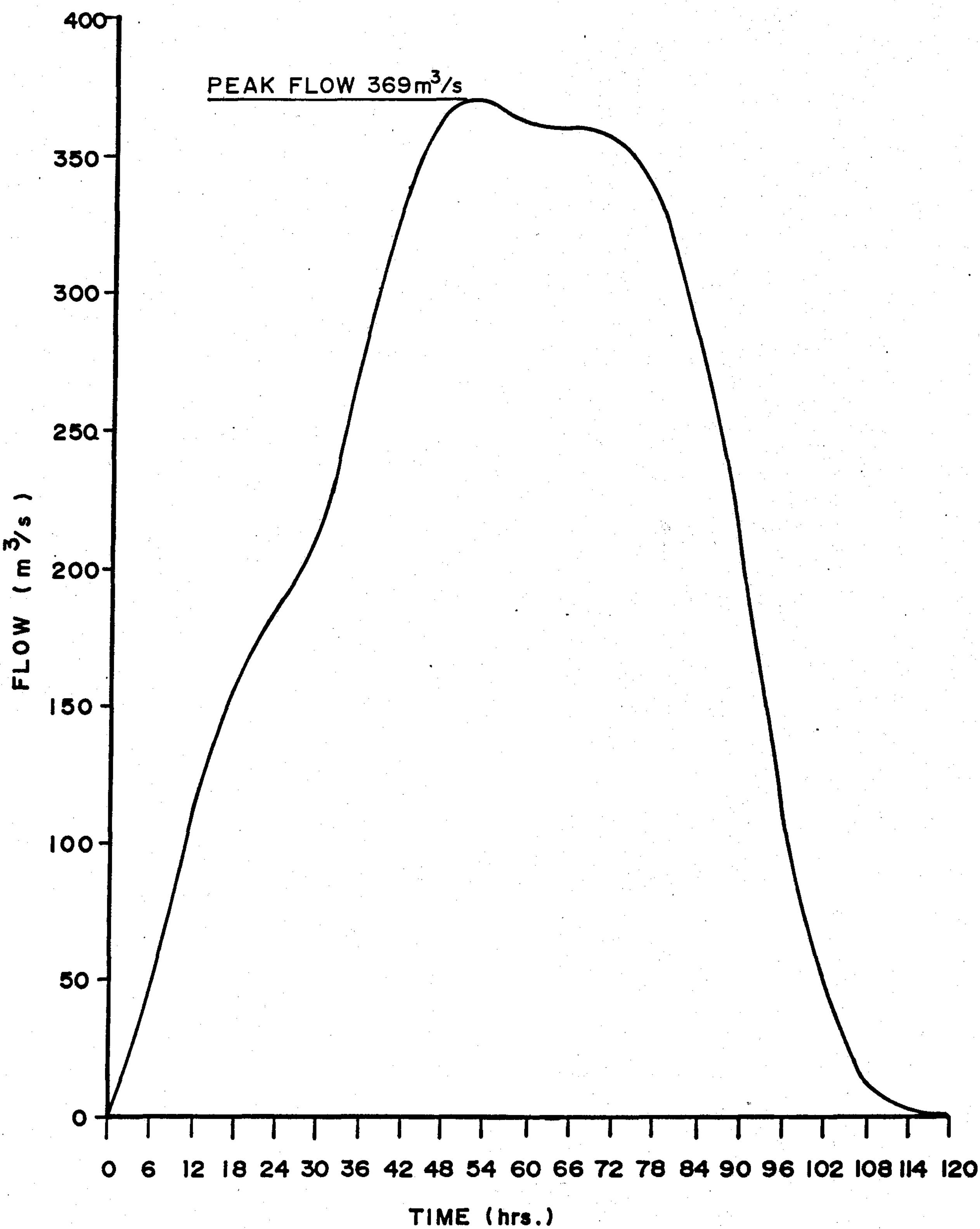
WATER LEVEL - DURATION CURVES

GRAPH 4



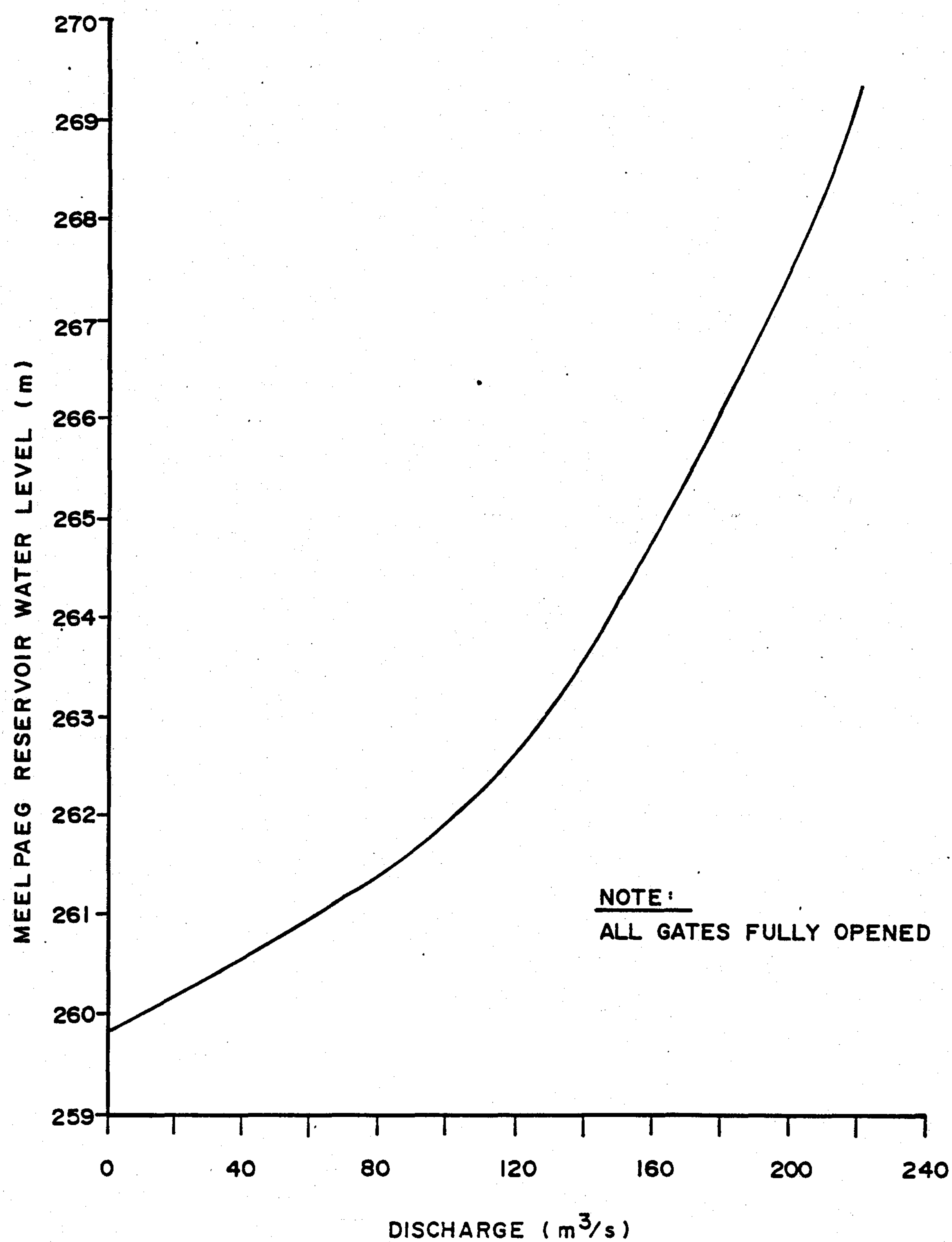
FLOW DURATION CURVE

GRAPH 5



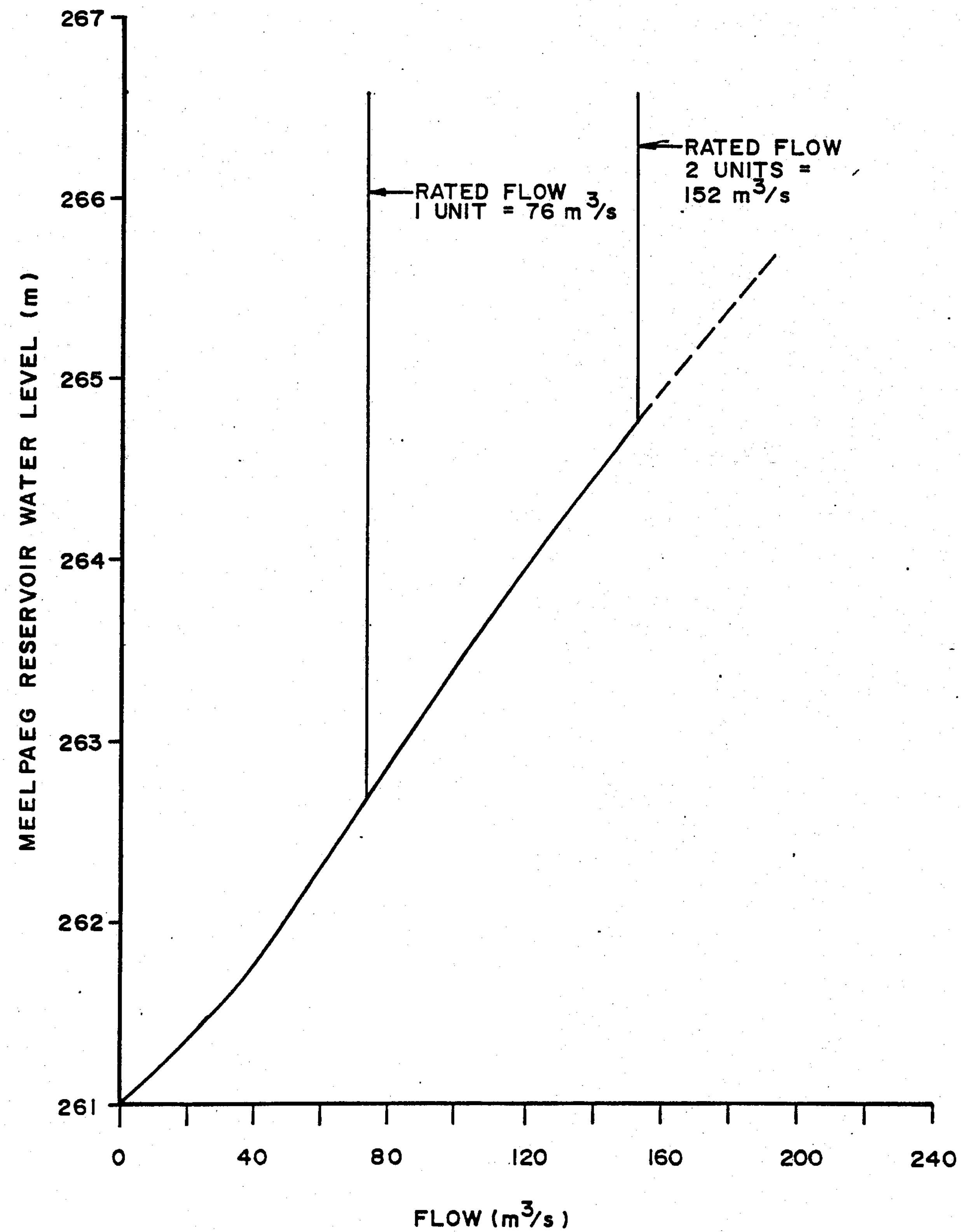
ISLAND POND PMF HYDROGRAPH

GRAPH 6



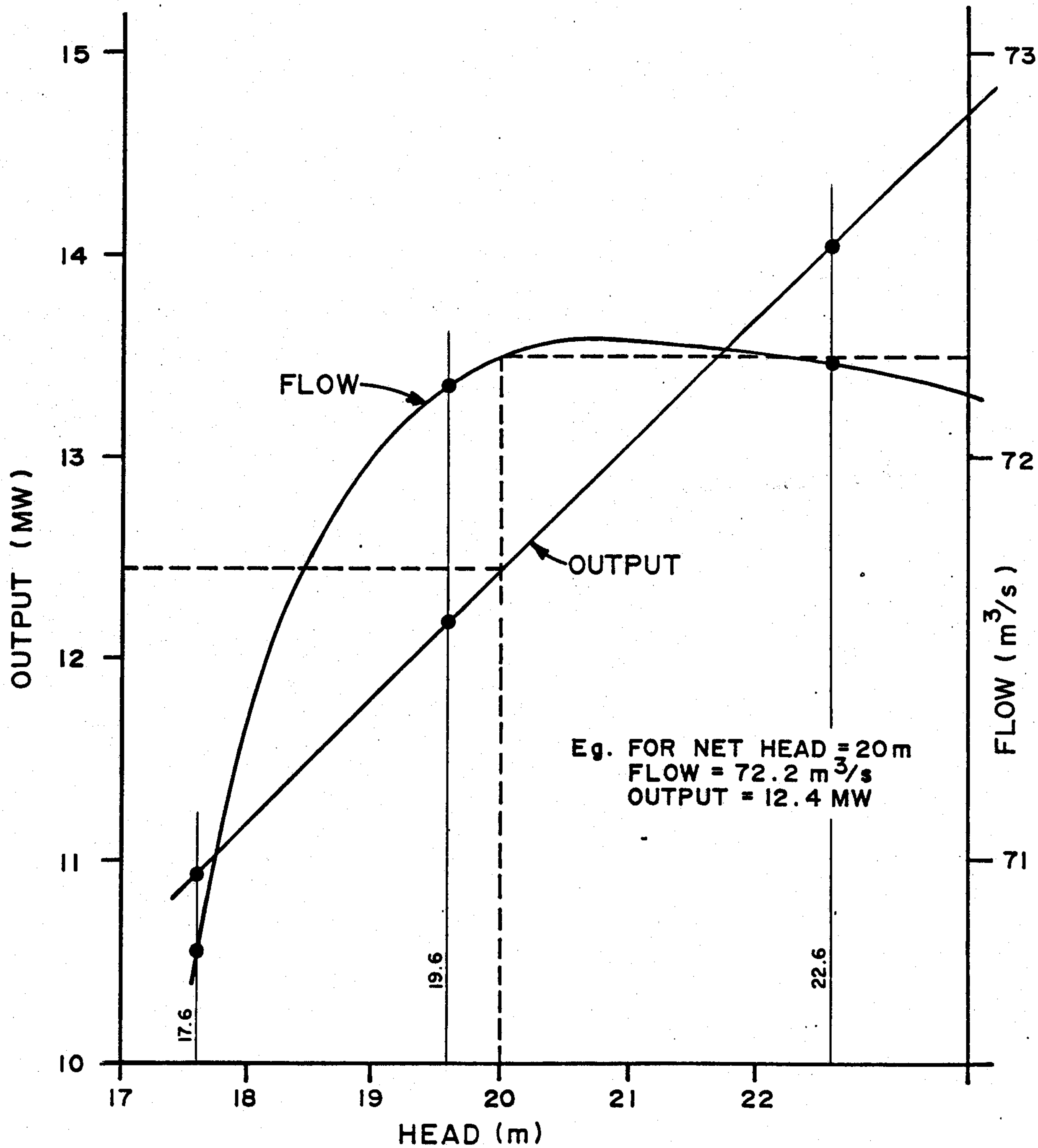
EBBEGUNBAEG CONTROL STRUCTURE
DISCHARGE CURVE

GRAPH 7



WATER LEVEL Vs. MAXIMUM FLOW IN DIVERSION CANAL

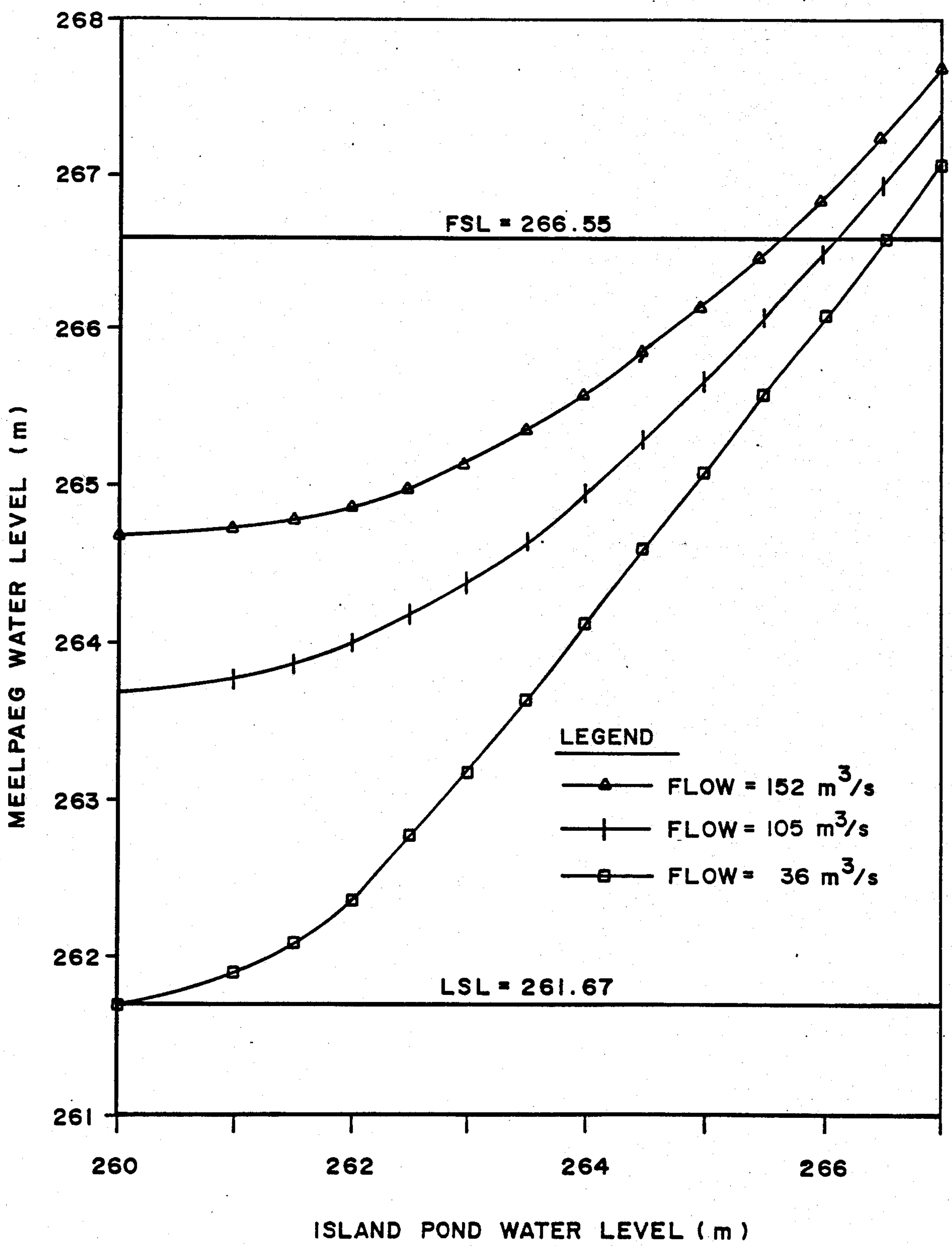
GRAPH 8



NOTE: TURBINE PERFORMANCE BASED ON VERBAL DATA PROVIDED BY D.E.W. PERFORMANCE OF ACTUAL UNIT MAY DIFFER SLIGHTLY FROM THAT SHOWN.

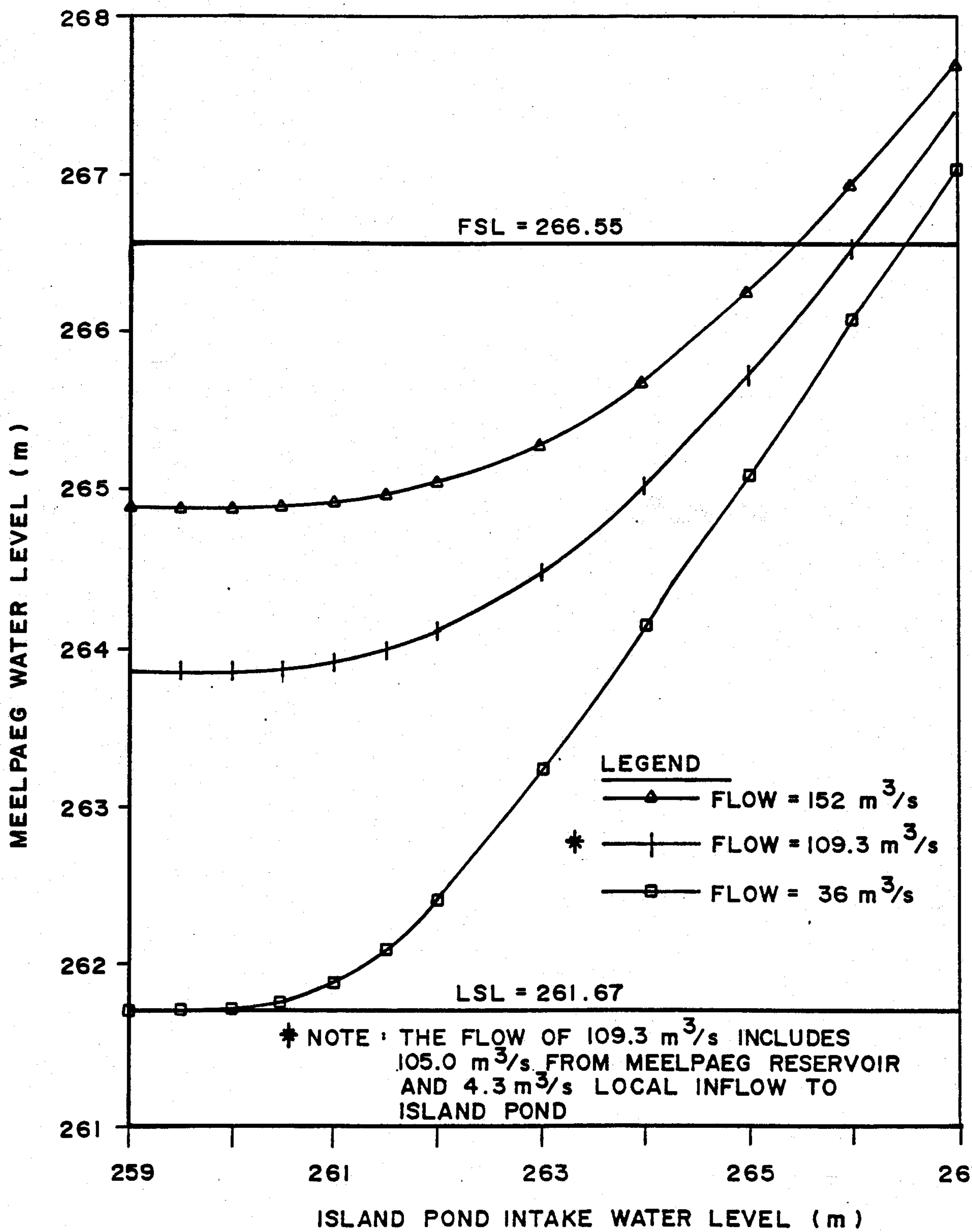
TURBINE OUTPUT (AT PEAK EFFICIENCY) Vs. NET HEAD

GRAPH 9



WATER DELIVERY CURVE - MEELPAEG RESERVOIR TO ISLAND POND

GRAPH 10



WATER DELIVERY CURVE - MEELPAEG RESERVOIR TO INTAKE

APPENDIX I

ISLAND POND DEVELOPMENT
DAM STABILITY ANALYSIS

APPENDIX I

ISLAND POND DEVELOPMENT
DAM STABILITY ANALYSIS

Table of Contents

APPENDIX I

ISLAND POND DEVELOPMENT
DAM STABILITY ANALYSIS

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

1.0 GENERAL

The design of the dam is described in Section 6.6 and shown on Plate 12 of Volume 1 of the Report. The sources of various construction materials are summarized in Section 2.4 with more detailed descriptions provided in volume 3. In order to evaluate strength characteristics of various embankment zones, the following tentative construction requirements have been selected for the materials.

All embankment materials would be required to be well graded. The impervious fill (Zone 1) would have a maximum size of 150 mm and contain a minimum of 15 percent fines passing through sieve No. 200. It would be placed in 300 mm lifts and compacted to achieve a minimum of 95% Standard Proctor maximum dry density.

The filter material (Zone 2) would have a maximum size of 50 mm and contain less than 5% fines passing through sieve No. 200. It would be compacted by a vibratory roller to a minimum relative density of 70%.

The fine rockfill (Zone 3a) would have a maximum size of 300 mm and would be compacted by a vibratory roller, or by 3 to 4 passes of a 10 ton roller with the material placed in 500 mm lifts. The main rockfill (Zone 3) would have a maximum size of 600 mm, placed in 800 mm lifts and compacted by 4 passes of a 10 ton vibratory roller.

2.0 SELECTION OF DESIGN PARAMETERS

No comprehensive laboratory testing was performed on the various embankment materials to determine their shear strength characteristics. However a detailed review was carried out of relevant data published in literature and of similar dams constructed elsewhere.

The most critical design parameters relevant to the stability of Island Pond Dam are shear strength characteristics of impervious and rockfill materials.

A review of geotechnical properties of impervious fill materials used in some Canadian dams show that the effective angle of internal friction for non plastic glacial tills having up to 30% fines (silt size, ie % passing sieve No 200) and compacted at optimum moisture content, varied from 28 degrees to 35 degrees (1). For Cat Arm Dam, the angle of internal friction for the glacial till having an average of 25% fines was taken as 35 degrees (2).

2.0 SELECTION OF DESIGN PARAMETERS (Cont'd)

For Island Pond Dam, the gradation of the glacial till impervious fill would be somewhat simlar to that used at Cat Arm though the fines content may be somewhat less. In the absence of shear strength testing date, and considering the low fines content, the angle of internal friction for the impervious fill was conservatively assumed to be 32 degrees and cohesion was neglected in the analysis.

The shear strength of rockfill mainly depends on gradation, density and soundness of particles. In addition, the shear strength also depends upon the applied stress level, i.e. the shear strength is higher for lower stress levels. As described in Section 6.6, the rockfill may not be of high quality at Island Pond since it would be mainly derived from Biotite Schist having relatively low compressive strength. An attempt was made to deduce the shear strength parameters for the Island Pond rockfill from the results of tests performed on similar rockfills used in other dams.

The angle of internal friction for Mica Dam rockfill containing Schist varied from 33 degrees to 37 degrees for confining pressures varying from 2.5 MPa to 0.5 MPa (3). These low values of shear strength were attributed to the crushability fo the Schist. For low density, poorly graded weak rockfills Leps (4) quoted values of shear strength somewhat higher than those obtained at Mica. For Island Pond the maximum dam height is about 23 m and the stress levels would be relatively low. For example the maximum confining pressures would be less than 0.2 MPa. A value of angle of internal friction of 34 degrees was considered appropriate for the rockfill to be used in Island Pond Dam.

The shear strength of filter material had little influence on the Island Pond dam stability. Nevertheless an angle of internal friction of 35 degrees was used in the analyses.

Following is a summary of the parameters used in the stability analysis. Note that the selected density for impervious fill was based on actual testing.

TABLE 1

SUMMARY OF DESIGN PARAMETERS

MATERIAL	ANGLE OF INTERNAL FRICTION (DEGREES)	COHESION	UNIT WEIGHT (KN/m^3)
Impervious Fill	32	0	20.5
Filter	35	0	19.5
Rockfill	34	0	18.0

2.0 SELECTION OF DESIGN PARAMETERS (Cont'd)

The dam was assumed to be founded on solid bedrock in the area of core and filter zones while the rockfill shells were assumed to be founded on 1.5 m thick dense till overlying bedrock. The strength characteristics of foundation till were assumed to be the same as that of the impervious core till.

3.0 CASES CONSIDERED

The cases considered for stability evaluation included "end of construction" and "steady seepage at full supply level" conditions. Rapid drawdown from full supply level (El 266.55 m) to low supply level (El 261.67 m) was also checked though the drawdown at Island Pond is expected to be gradual over the winter months. It was assumed that there would be pore pressure built up in the rockfill and in the impervious fill upon drawdown. A pore pressure ratio of 0.25 was used for the impervious fill and rockfill in the drawdown area since, as stated earlier, the rockfill would probably contain excessive fines and may not be free draining.

Earthquake loading was also taken into account. The Building Code of Canada recommends that probability of earthquake exceedence of 10% to 50 years be employed as the design loading. For Island Pond this corresponds to 0.08 g (5).

The following loading conditions and corresponding factors of safety were selected from standard practice (6).

TABLE 2

MINIMUM FACTORS OF SAFETY REQUIRED

DESIGN CONDITION	MINIMUM FACTORS OF SAFETY	APPLICABLE ZONE
End of Construction	1.3	Upstream and Downstream Slope
Steady Seepage with maximum storage pool	1.5	Downstream Slope Only
Earthquake Loading End of Construction and Full Reservoir	1.0	Upstream and Downstream Slope

4.0 METHOD AND RESULTS OF ANALYSIS

The stability analysis was carried out employing the computer program 'Slope II' run on a PC. Slope II is a flexible and comprehensive slope stability program to encompass a wide range of conditions encountered in slope stability evaluation. There are a number of methods which can be used in the Slope II program to get the factors of safety against sliding. For Island Pond the factors of safety were obtained by using the Fellenius, the Simplified Bishop and the Janbu methods.

In the process of searching the potential slip surfaces, clusters of imaginary centres of circles and radii were fed into the computer. The factors of safety for each slip surface generated from the radii of each centre of rotation were calculated and recorded in the computer output.

The factors of safety obtained by the three methods (Fellenius, Simplified Bishop, Janbu) were quite comparable. The following Table summarizes the minimum factors of safety indicated by the three methods.

TABLE 3

FACTORS OF SAFETY FOR ISLAND POND DAM

	MINIMUM FACTORS OF SAFETY	
CASE	NO EARTHQUAKE	WITH EARTHQUAKE (0.08 g)
UPSTREAM SLOPE		
End of Construction	1.9	1.6
DOWNSTREAM SLOPE		
End of Construction	1.6	1.3
Steady Seepage	1.6	1.3

For steady seepage, the reservoir level was assumed at full supply level El. 266.55 m.

For rapid drawdown between full supply and low supply levels, the minimum factor of safety for the upstream slope was found to be 1.4 without earthquake and 1.3 with earthquake.

4.0 METHOD AND RESULTS OF ANALYSIS (Cont'd)

In addition to the circular sliding surfaces, a number of straight line wedges were also considered. These cases were all found to be less critical.

The sliding surfaces showing the minimum factors of safety are shown on Figure 1 attached.

5.0 CONCLUSIONS

The factors of safety summarized in the preceding Table 3 are higher than the required minimum factors of safety for the dam as given in Table 2. The slopes are therefore safe against the various loading conditions to which the dam would be subjected.

Some minor refinements would be made during the final dam design when more properties of the construction materials are known. For example the upstream slope may be steepened to 2.25 H:1.0 V, i.e., the same as the downstream slope. This change could be made since the upstream slope would not be subjected to rapid drawdown and the quality of rockfill may be found to be higher than considered in this initial design.

REFERENCES

(1) "Geotechnical Properties of Impervious Fill Materials in Some Canadian Dams" by MacDonald et al, Fifth International Conference on Soil Mechanics and Foundation Engineering, Paris July 1961.

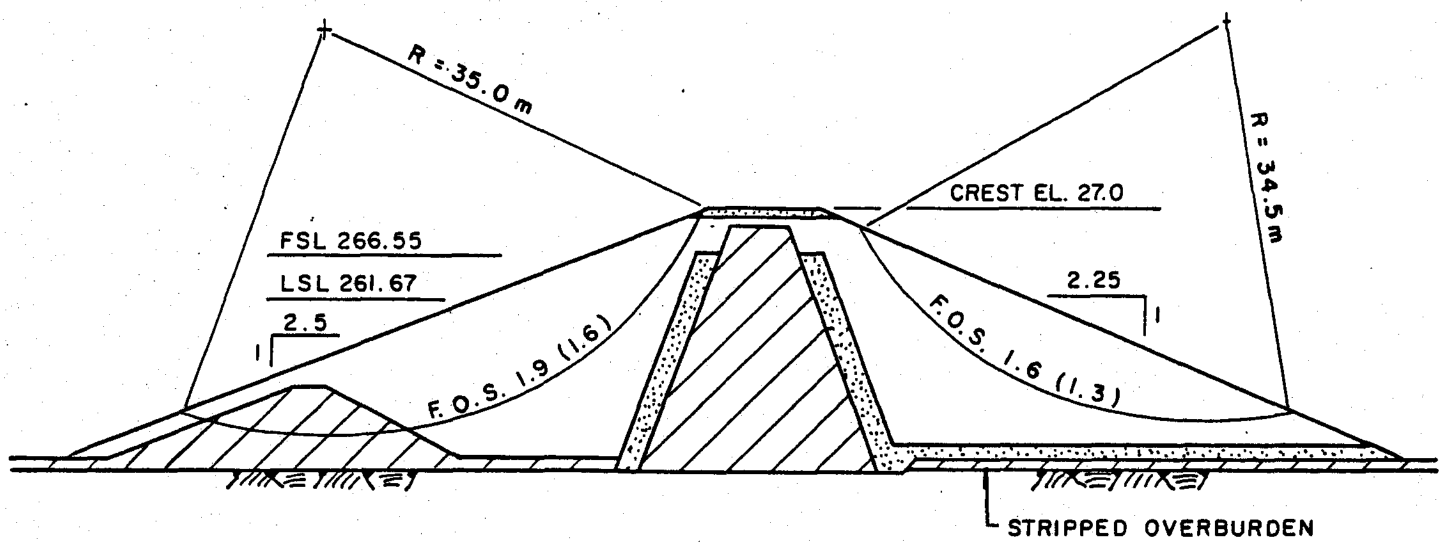
(2) "Cat Arm Development, Large Dams Design Transmittal:" Report No. CACR-6-83 by Cat Arm Consultants, October 1983.

(3) "Copalar Hyrdo Project, Design brief" Canadian International Project Managers Ltd., January 1978.

(4) "Review of Shearing Strength of Rockfill" T.M. Leps. ASCE Journal of Soil Mechanics and Foundation Engineering, July 1970.

(5) "Canadian Foundation Engineering Manual", 2nd edition, Canadian Geotechnical Society, 1985.

(6) "Stability of Earth and Rockfill Dams" US Corps of Engineers Engineering Manual Em 1110-2-1902, Washington 1970.



NOTES:

1 THIS PLATE SHOWS THE MOST CRITICAL LOCATION OF SLIDING SURFACE.

2 THE FACTORS OF SAFETY (F.O.S.) SHOWN ARE FOR END OF CONSTRUCTION CONDITIONS. THE VALUES WITHIN PARENTHESIS ARE F.O.S. WITH EARTHQUAKE.

3. FOR STEADY SEAPAGE THE F.O.S. FOR THE D/S SLOPE ARE THE SAME AS FOR END OF CONSTRUCTION I.E. 1.6 AND 1.3 WITHOUT AND WITH EARTHQUAKE RESPECTIVELY.

LEGEND

GLACIAL TILL OR IMPERVIOUS FILL

FILTER MATERIAL

ROCKFILL / RIP RAP

BEDROCK

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

FINAL FEASIBILITY
RESULTS OF DAM FEASIBILITY ANALYSIS

DESIGNED:	DRAWN:	SCALE:	DATE:
M. AFIF			JAN. 88
APPENDIX I	FIGURE I	APPROVED:	

APPENDIX II

TURBINE - GENERATOR DATA

TURBINE GENERATOR DATA

1. INQUIRIES

For the purpose of obtaining up to date equipment details and costs for the study, inquiries were made for layout details and estimating costs from the following suppliers:

- Dominion Bridge Sulzer Inc., Montreal
- Dominion Engineering Works Ltd., Montreal
- Voith Hydro Inc., York, Pennsylvania

2. PRELIMINARY SPECIFICATIONS

Equipment layout dimensions, costs and delivery details were requested based on the following parameters as developed from the initial study:

	Island Pond
a) Rated Flow	152.0 m^3/s
b) Water Levels (Above mean sea level)	
- Max. HWL	267.0 m
- Min. HWL	262.0 m
- Max. TWL	241.8 m
- Min. TWL	241.3 m
c) Rated Net Head	22.6 m
d) Type of Operation	Base Load
e) Plant Capacity Factor	71 Percent
f) Plant Connected to Large Grid	

3. EQUIPMENT PARTICULARS

The following is a summary tabulation of pertinent equipment characteristics and estimating costs as analyzed from details received as a result of the inquiries.

TURBINE DATA

Data		Vertical Propellor DEW	Vertical Propellor DBS	Vertical Francis DEW	Vertical Francis Voith	Horizontal Tube DBS	Vertical Kaplan Voith
Net Head		22.6	22.6	22.6	22.6	22.6	22.6
Speed	rpm	200.00	200.00	128.57	124.14	211.77	200.00
Throat 0	m	3.219	3.55	3.219	3.30	3.20	3.176
Submergence	m	-1.97	-1.92	+2.50	+2.00	-5.24	N/A
Budget prices (10^6\$)							
Turbine	\$	5.20	4.70	5.70	16.50	3.40	17.20
Generator	\$	5.20	4.20	6.00		3.80	
Installation	\$	2.60	1.20	3.00	1.70	0.65	1.70
Total	\$	13.00	10.10	14.70	18.20	7.85	18.90

Note

DBS = Dominion Bridge-Sulzer Inc.
DEW = Dominion Engineering Works
Voith = Voith Hydro, Inc.