From: bbarnes@nalcorenergy.com
Sent: Monday, January 23, 2012 11:22 AM
To: pharrington@nalcorenergy.com; ronpower@nalcorenergy.com; gregfleming@nalcorenergy.com; scotto'brien@nalcorenergy.com; ktucker@nalcorenergy.com; darrendebourke@nalcorenergy.com; phumphries@nalcorenergy.com; rhenderson@nlh.nl.ca; davidgreen@nalcorenergy.com; davepardy@nalcorenergy.com; markturpin@nalcorenergy.com; scottgillis@nalcorenergy.com; tonyscott@nalcorenergy.com; rkaushik@nalcorenergy.com; davidbrown@nalcorenergy.com; robertbesaw@nalcorenergy.com; marionorgan@nalcorenergy.com; jmallam@nalcorenergy.com; johnwalsh@nalcorenergy.com
Cc: colleensutton@nalcorenergy.com
Subject: Basis of Design to line up with DG-3
Attachments: #Basis of Design EN-RP-0001-01, Rev. B2 - circulated preliminary draft.doc

Folks,

Please find attached a preliminary draft, red line version, of the BOD as it relates to potential changes since the version aligned with DG-2. All the drawings will be changed and are presently removed from this version. Please review areas of the document that you believe you can impact and return comments to me, preferably by the start of business next Monday, 30-January-2012. The overall format of the document may change moving forward, so do not waste your time related to layout and format, we will agree on that down the road. What I need is people to reflect on the facts, what may be missing (remember detail does not go into the weeds), what is wrong, what doesn't align with DG-3, etc. I have included some specific questions (eg. SOBI - Greg Fleming); however, I ask that you look at the portions of the document that pertain to you and be liberal with your comments. While I have sent it with the track changes turned on, I suggest you may find it easier to review with them turned off - your choice. Feel free to return comments as you wish, hard copy marked up, separate word file, whatever works best for you.

Many thanks,

Bob

nalcor energy LOWER CHURCHILL PROJECT		Bob Barnes Engineering Manager Nalcor Energy - Lower Churchill Proje t. 709 737-1266 c. 709 685-5085 e. bbarnes@nalcorenergy.com w. nalcorenergy.com 1.888.576.5454

Nalcor Energy – Lower Churchill Project

nalcor energy
LOWER CHURCHILL PROJECT

Lower Churchill Project – Basis of Design

LCP-PT-ED-0000-EN-RP-0001-01

Comments:	Total # of Pages
Supersedes Document #: MSD-PM-006 **Issued for Decision Gate 23**	(Including Cover): 34

B2		**Issued For Use to reflect Gate 3 Estimate**	R. Barnes	J. Kean	R. Power	P. Harrington
B1		**Issued For Use**	R. Barnes	J. Kean	R. Power	P. Harrington
Status / Revision	Date	Reason For Issue	Prepared By	Checked By	Checked By	Project Director Approval

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Nalcor Energy – Lower Churchill Project

Professional Engineers Stamp:
(where required)

Additional Signatures (where required)

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Basis of Design

LCP-PT-ED-0000-EN-RP-0001-01

Comments: **Issued for Decision Gate 3**	Total # of Pages (Including Cover): 38

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B2		**Issued for Use to Reflect Gate 3 Estimate**	R. Barnes	J. Kean	G. Fleming	R. Power	P. Harrington
B1	**19-Feb-11**	**Issued for Use**	R. Barnes	J. Kean	G. Fleming	R. Power	P. Harrington
Status/ Revision	Date	Reason For Issue	Prepared By Engineering Manager	Checked By Deputy PM (Generation + Island Link)	Project Manager (Marine Crossings) Approval	Project Manager (Generation + Island Link) Approval	Project Director Approval
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Inter-Departmental / Discipline Approval (where required)

Department	Department Manager Approval	Date
	 Name	
	 Name	
	 Name	
	 Name	

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TABLE of CONTENTS

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1.0 Purpose

The purpose of this document is to establish a *Basis of Design* (BOD) for the Lower Churchill Project (LCP). This BOD will form the overarching project definition that will be used to prepare engineering design philosophies, project contract packaging, project estimates, project schedules, design briefs, detailed design specifications and drawings, construction planning, and all other project functions that depend on a clear definition of what is to be specifically financed and constructed.

Typically, this BOD is not changed or altered without major cost and schedule implications to the project as a whole and would only be considered and approved by LCP Executive Management, and then only after a clear recommendation from the Project Director.

2.0 Scope

The objectives of this document are to establish the Basis of ODesign for the following:

- Gull Island Hydroelectric FacilityGenerating Facility Project.
- Muskrat Falls Hydroelectric FacilityGenerating Facility Project.
- Island Link SystemLabrador Transmission Asset.
- Maritime Link SystemLabrador – Island Transmission Link Project.

3.0 Definitions

3.0Throughout this document, the following defined words are italicized.
3.0

Basis of Design	A compilation of the fundamental criteria, principles and/or assumptions upon which Dddesign Pphilosophies and Eengineering Dddesign Bbriefs will be developed.
Bulkhead Gates	Steel gates used to isolate water passages for inspection or maintenance andmaintenance, which are installed and removed under balanced pressures.
Cavitation Resistant Design	A design to prevent the formation of the vapour phase in a liquid flow when the hydrodynamic pressure falls below the vapour pressure of the liquid.
Change Control Board	A panel within the Project Management Team that is responsible for making the ultimate decision to approve,approve reject or elevate a Project Change

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	Notice~~. is to become a Project Change, as explained in~~See LCP-PT-MD-0000-PM-PL-0002-01, Project Change Management Plan.
Cofferdam	A temporary barrier for excluding water from an area that could otherwise be submerged.
Construction Flood	The seasonal peak river flow that the diversion facilities are designed to pass during construction of the dam. Accepted practice is based on a 5% risk of exceedence for the duration of the operation of the diversion facilities.
Converter Station	A ~~C~~*converter* ~~S~~*station* consists of equipment that converts power from ac to dc (rectifier) and dc to ac (inverter).
Counterpoise	Steel wire installed along the length of the overhead line and bonded (connected) to each tower. Used to reduce resistivity between the overhead line structures and the ground for lightning protection.
Electrode	A grounded means to provide a return path for unbalanced dc current for HVdc transmission system, enabling it to operate in mono-polar mode.
Electrode Line	A transmission line connecting the ~~E~~*electrode* site to the *converter station*.
Fail Safe Design	A design that in the event of the failure of equipment, processes or systems, the event will produce minimum propagation beyond the immediate environment of the failing entity. In addition, the failure will be economically acceptable, and those devices in the system will perform their intended function and eliminate danger upon the loss of actuating power.
Fish Compensation Flow	Minimum flow required downstream of the dam sites during reservoir impoundment which will be required to maintain fish habitat and reduce the effects of salt water intrusion into the Churchill River.
Flip Bucket	A formed geometrical shape at the downstream end

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	of a spillway discharge for the purpose of throwing the water clear of the hydraulic structure and into a *Pplunge Ppool* for energy dissipation.
Francis Turbine	A mixed flow reaction turbine with fixed runner vanes that converts hydraulic energy to mechanical energy where the water flow is controlled by the setting of the adjustable *wicket gates*.
Generator	An assembly of stationary and rotating components coupled to the turbine, converting mechanical energy to electrical energy.
Good Utility Practice	The practices, methods and acts engaged in, or approved by, a significant portion of the electrical utility industry in North America, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, are expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. *Good Utility Practice* is not intended to be limited to optimum practice, method or act to the exclusion of all others, but rather to include all practices, methods or acts generally accepted in North America.
Kaplan Turbine	A reaction type, axial flow, adjustable blade turbine that converts hydraulic energy to mechanical energy.
Life Cycle Cost Analysis	The process of selecting the most cost-effective approach from a series of alternatives so that the least long-term cost of ownership is achieved where life cycle costs are total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of an asset over its anticipated useful life from inception to disposal.
Mass Impregnated (MI)	An electrical insulation method used for power cables. The conductor is tightly wrapped with porous paper and saturated with oil, installed under pressure, to provide electrical insulation.
Mitigation	Measures implemented during the design, construction and operations phases of the project which are intended to avoid or reduce known or

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	predicted impacts to the existing environment.
Overhead Ground Wire (OHGW)	Provides lightning protection for the power conductors. When used, direct lightning strikes are minimized, and potential disturbances due to lightning are reduced.
Optical Ground Wire (OPGW)	Performs the same function as *Overhead Ground Wire*; however, it also carries a fibre optic communication system within the wire strands.
Penstock	A conduit that conveys water from the intake to the turbine.
Plunge Pool	A deep depression downstream of a spillway into which spilled water "plunges" to dissipate energy.
Probable Maximum Flood (PMF)	Canadian Dam Association terminology for "an estimate of hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe 'reasonably possible' at a particular location and time of year, based on relatively comprehensive hydro meteorological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrologic factors favourable for maximum flood runoff".
Proven Technology	This is the state of technology used in the design, construction and operation of any system including each piece of equipment, component or structure that has a proven record of performance. (First technology applications will only be considered after review by the LCP Design Integrity group and then only after approval by Executive Management).
Rehabilitation	Measures taken to remedy environmental damage to the environment.
Reliability Level Return Period	A statistical measurement denoting the average recurrence interval over an extended period of time. Used to estimate loads to design transmission lines.
Rotor	The multi-poled rotating component of the *generator*.

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Split Yard	Switchyard divided physically into two2 independent sections with an electrical connection so as to limit the loss of generation in order to meet reliability criteria.
Stoplog	Steel sections used to isolate water passages for inspection or maintenance and are installed and removed under balanced pressures.
Tailrace	A watercourse that carries water away from a turbine or powerhouse.
Trash Boom	An anchored, floating barrier spanning the approach channel of the intake. It is used to limit floating objects from reaching the intake and blocking the *Trash Racks*.
Trash Racks	Equally spaced rectangular bars installed at the entrance to the intake to protect the turbine from impinging objects.
Waste Management	The management of waste generation in order to reduce the volume of solid waste deposited in landfills through recycling and the reuse of materials where practical.
Wicket Gates	Adjustable guide vanes used to regulate the flow of water into a turbine.

4.0 Abbreviations and Acronyms

ac	alternating current
ADSS	All Dielectric Self-Supporting
BCC	Backup Control Center
BMS	Building Management Systems
BOD	Basis of Design
CCTV	Closed Circuit Television
CF	Churchill Falls Hydroelectric Facility
CFRD	Concrete Faced Rockfill Dam
CPU	Central Processing Unit
CTS	Cellular Telephone System
dc	direct current

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DFO	Department of Fisheries and Oceans
EPP	Environmental Protection Plan
ECC	Energy Control Centre
FSL	Full Supply Level (Reservoir)
GI	Gull Island Hydroelectric Development
HADD	Harmful Alteration Damage or Disruption (Fish Habitat)
HDD	Horizontal Directional Drilling
HVac	High Voltage alternating current
HVAC	Heating, Ventilation and Air Conditioning
HVdc	High Voltage direct current
HVGB	Happy Valley – Goose Bay
kV	kilovolts (Thousand Volts)
kWs	Kilo Watt Seconds
kVA	Kilo Volt Amp
LCC	Line Commutated Converter
~~**LEED**~~	~~Leadership in Energy and Environmental Design~~
LCP	Lower Churchill Project
LEED	Leadership in Energy and Environmental Design
LITL	Labrador – Island Transmission Link Project
LMRS	Land Mobile Radio System
LSL	Low Supply Level (Reservoir)
LTA	Labrador Transmission Asset Project
MF	Muskrat Falls Hydroelectric Development
MFL	Maximum Flood Level (Reservoir)
MI	Mass Impregnated
MIS	Mobile Internet System
MVA	Mega Volt Ampere
MVAR	Mega Volt Ampere Reactive (Million VARs)
MW	MegaWatt (Million Watts)
NE	Nalcor Energy
NMS	Network Management Systems

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OHGW	Over-Head Ground Wire
OLTC	On-load Tap Changer
OPGW	Optical Ground Wire
OTN	Optical Transport Network
pf	power factor
PMF	Probable Maximum Flood
RCC	Roller Compacted Concrete
ROW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SACS	Security and Access Control System
SLD	Single Line Diagram
SOBI	Strait of Belle Isle
SONET	Synchronous Optical Network
TBD	To Be Determined
TL	Transmission Line
TLH	Trans Labrador Highway
Vac	Voltage Alternating Current
Vdc	Voltage Direct Current
VSC	Voltage Source Converter

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5.0 Reference Documents and/or Associated Forms

Engineering Studies comprising the 2007/2008/2009/2010 Engineering Program

Gull Island Hydroelectric Development

GI1010	Gull Island 2007 Site Investigation
GI1013	Gull Island 2008 Site Investigation
GI1015	Inspection and Structural Analysis Goose Bay Dock
GI1017	Update Report - Reassessment of Gull Island Diversion
GI1020	Study of Concrete Face Rockfill Dam (CFRD) Alternative
GI1030	Powerhouse Configuration
GI1050	Tailrace Channel Improvements Phase 1 – Preliminary Assessment
GI1060	Review of Structure Layouts and Interfaces
GI1061	Review of Structure Layouts and Interfaces, 5x450 MW
GI1070	Ice Study (Gull Island and Muskrat Falls) (by Hatch)
GI1071	Ice Studies (Gull Island) (by SNCL)
GI1076	Ice Observation Program (2010-2011)
GI1090	Review of Construction Camp and Other Infrastructure

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GI1100 Review of Access Roads and Bridges
GI1110 Hydraulic Modeling of River
GI1130 River Operation Duringduring Construction & Impounding
GI1140 PMF and Construction Design Flood Study
GI1141 Upper Churchill PMF and Flood Handling Procedures Update
GI1170 Seismicity Analysis
GI1180 Review of Site Access, Goose Bay and Off-Site Infrastructure
GI1190 Dam Break Study
GI1200 Gull Island Constructability Review
GI1230 Gull Island Site Information for Tenderers
GI1280 Gull Island – Diversion Facilities Numerical Modeling
GI1281 Gull Island – Power Intake and Spillway Facilities – Numerical Modeling
GI1282 Gull Island – Diversion Facilities Physical Modeling Technical Specifications
GI1290 Hydraulic Production Model
GI1300 Gull Island 2008 Report Plates (drawings)
GI1310 Workshop Report on Design and Operational Problems Resulting from Reservoir Preparation
GI1602 Bank Stability and Fish Habitat Deltas

Muskrat Falls Hydroelectric Development

MF1010 Review of Variants
MF1020 Muskrat Falls Site Investigations
MF1050 Spillway Design Review
MF1080 Review of Construction Camp and Other Infrastructure
MF1090 Review of Access Roads and T&W Bridge
MF1091 Desktop Study – Implications/Consequences of Constructing Muskrat Falls Prior to Gull Island
MF1120 Potential Impact of Reservoir Flooding on the TLH
MF1130 River Operation during Construction and Impounding
MF1250 Numerical Modeling of Muskrat Falls Structures
MF1260 Condition Assessment of Existing Pumpwell System (2007)
MF1271 Condition Evaluation of Wells and Pumps in the Muskrat Falls Pumpwell System (2009)
MF1272 Installation of New Piezometers in the Muskrat Falls Pumpwell System
MF1281 Pumpwell System Telecommunication Upgrades
MF1300 2010 Field Investigation Program
MF1310 Site Access Review
MF1320 Power and Energy Study
MF1330 Report #1: Hydraulic Model of the River - 2010 Update
MF1330 Report #2: PMF and Construction Design Study
MF1330 Report #3: Dam Break Study
MF1330 Report #4: Ice Study
MF1330 Report #5: Review of Gull Island 1:60 year Construction Design Flood
MF1330 Report #6: Regulation Study

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MF1340 Review and Confirmation of Structure Layout Interfaces
MF1360 Review of Numerical Modeling
MF1380 Site Information for Tenderers
MF1390 Review Impacts of Earlier Construction of MF on GI and Later Construction of GI on MF

HVac Transmission Systems

AC1020 Tower type selection, 735 kV
AC1030 Field Investigations and Construction Requirements - 735 kV TL - GI to CF
AC1050 Tower type selection, 230 kV
AC1060 Field Investigations and Construction Requirements - 230 kV TL - GI to MF
AC1080 Load Control and Failure Containment
AC1090 Assess Cable De-icing
AC1100 Conductor Selection
AC1130 Corridor Selection & Construction Infrastructure - 735 kV Transmission Line - Gull Island to Quebec Border

HVdc Transmission Systems

DC1010 Voltage and Conductor Optimization
DC1020 HVdc System Integration Study
DC1050 Corridor Selection & Construction Infrastructure-Gull Island to Soldiers Pond
DC1051 Field Investigations – HVdc TL – Gull Island to Soldiers Pond
DC1060 Corridor Selection & Construction Infrastructure-Taylor's Brook to Cape Ray
DC1070 Preliminary Meteorological Load Review
DC1080 Tower Type Selection and Preliminary Optimization
DC1090 Site Investigation - Converter Stations Gull Island and Soldiers Pond
DC1110 Electrode Review - Gull Island and Soldiers Pond
DC1130 Submarine Cable - Strait of Belle Isle
DC1131 Submarine Cable Corridor Survey - Strait of Belle Isle
DC1132 Strait of Belle Isle - Existing Data Compilation
DC1133 Regional Multi-Beam Survey - Strait of Belle Isle
DC1140 Submarine Cable - Cabot Strait
DC1141 Submarine Cable Corridor Survey - Cabot Strait
DC1142 Cabot Strait - Existing Data Compilation
DC1180 Fixed Link Tunnel Cost, Strait of Belle Isle
DC1200 HVdc Overland Transmission Re-estimate
DC1210 HVdc System Sensitivity Analysis
DC1240 HVdc and HVac Proximity Analysis
DC1250 Electrode Review – Type and Location
DC1300 Ice Loadings on HVdc Line Crossing Long Range Mountains
DC1301 Section by Section Analysis of Extreme Rime Ice on the Long Range Mountains using WRF Modeling
DC1500 Electrode Review – Confirmation of Type and site Selection

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DC1600 VSC Technology Review for LCP
DC1700 Review of Holyrood Units 1 & 2 Conversion to Synchronous Condensers

Other Documents

- LCP-PT-ED-0000-EN-PH-0032-01 Synopsis of Engineering Studies
- LCP-PT-ED-0000-EN-PL-0002-01 Reservoir Preparation Plan
- LCP-PT-ED-0000-EN-PL-0002-02 Reservoir Preparation Plan – Summaries and Map Sheets – Muskrat Falls
- LCP-PT-ED-0000-EN-PL-0002-03 Reservoir Preparation Plan – Summaries and Map Sheets – Gull Island
- LCP-HE-CD-0000-EA-RP-0001-01 Muskrat Falls – Review of Saltwater Intrusion
- LCP-HE-CD-0000-EA-RP-0007-01 Muskrat Falls – Review of Sediment Plume
- LC-EN-011 2010 Transmission Corridor LiDAR and Orthographic Data Collection Program
- LC-EN-006 Coordinate System Evaluation, Survey Engineering Services – Transmission
- MFA-PT-ED-6200-TL-DC-0001-01 Meteorological Loading 315 kV transmission lines Muskrat Falls to Churchill Falls
- MFA-PT-ED-6200-TL-DC-0002-01 Overhead Transmission – Meteorological Loading for the Labrador-Island Transmission Link
- LCP-PT-MD-0000-PM-PL-0002-01 Project Change Management Plan
- Development of Extra High Voltage Transmission Lines in Labrador – EDM/RSW - 1999
- Gull Island Power Development SNC-Lavalin Power Division - October 1997
- Gull Island Hydro Electric Development – SNC-AGRA Joint Venture - December 2000
- Gull Island to Soldiers Pond Interconnection – Teshmont Consultant Inc. - June 1998
- Muskrat Falls Hydroelectric Development – SNC-AGRA - January 1999
- Lower Churchill Hydroelectric Generation Project Baseline Report, Application of HADD Determination Methodology – AMEC – December 2007
- Evaluate Extreme Ice Loads From Freezing Rain For Nalcor Energy – Kathy Jones – May 2009
- Assessment of Rime Ice Loading on the Long Range Mountains, Landsvirkjun Power, December 2010.
- Newfoundland and Labrador Hydro Environmental and Guiding Principles

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6.0 Responsibilities

Project Director – The Project Director is responsible for approval of the BOD. The Project Director ultimately is responsible for the allocation and expenditure of the project budget to support the BOD.

Project Manager, Generation and Island Link – The Project Manager, Generation and Island Link is responsible to ensure that all related project estimates and schedules respect the BOD.

Project Manager, Marine Crossings – The Project Manager, Marine Crossings is responsible to ensure that all related project estimates and schedules respect the BOD.

Engineering Manager and Leads – The Engineering Manager is responsible to prepare the BOD. The Engineering Leads are to support this process and prepare individual sections of the BOD for coordination and final preparation by the Engineering Manager.

Deputy Project Manager, Generation and Island Link **Project Services Manager** - The Project Services Manager Deputy Project Manager for the Generation and Island Link is is to ensure that all sections of the BOD are prepared as per the applicable LCP Procedures to establish and maintain PCM process. and In addition, the Project Services Manager is to ensure that all project estimates and schedules respect the BOD.

Engineering Manager – The Engineering Manager is responsible to prepare the BOD. The Engineering Leads are to support this process and prepare individual sections of the BOD for coordination and final preparation by the Engineering Manager.

Commercial Services Manager – The Commercial Services Manager is to ensure that all contracts and commercial issues respect the BOD.

Environmental Assessment Manager - The Environmental Assessment Manager is to ensure that the Environmental Impact Statements and subsequent documentation related to the Environmental Assessment reflect the BOD and that the BOD reflects good environmental practices.

7.0 Descriptions

7.1 General

This BOD includes the Gull Island hydroelectric facility, the Muskrat Falls hydroelectric facility, all related high voltage alternating current transmission lines, all high voltage direct current transmission lines associated with the Labrador to Island transmission link, including Cconverter Sstations, submarine cables and landing sites, and all related facilities including switchyards, terminal stations, infrastructure upgrades, communications and project specific transportation networks.

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The BOD also includes the Maritime Link which currently reflects the level of technical and economic work carried out to-date. It must be emphasized that the Maritime Link is at a lesser degree of technical maturity.

All design assumptions used to establish the BOD respect the following overarching principles:

- Only proven technologies will be considered, unless it can be clearly demonstrated to the satisfaction of the Engineering Manager, Project Director and VP of the LCP that emerging technologies can be as reliable and provide significant cost and/or schedule savings.
- Local climatic/service conditions such as ambient temperature, elevation, humidity, sea temperature, sea currents and wind will be respected throughout the Project.
- All hydroelectric plants and transmission systems will be remotely operated and monitored from NE-NLH's Energy Control Centre.
- Environmental *mitigation* and *rehabilitation* will be designed by LCP prior to issuing construction contracts for tender.
- The designs will assume the use of existing transportation infrastructure to the maximum extent possible. In particular, existing roads, bridges, railways and wharfs.
- *Good Utility Practice* will be observed.
- *Fail Safe Design* principles will be employed.
- Principles of *Life Cycle Cost Analysis* will be employed.
- The designs will be consistent with the NE Safety and Health Program.
- The designs will be consistent with NE Environmental Policy and Guiding Principles.
- The designs will be consistent with NE Asset Management Policy and Guiding Principles.
- The designs will be consistent with all applicable governing Standards, Codes, Acts and Regulations.
- All assets and systems will be designed to ensure safety, reliability, efficiency and minimal impact to the environment.

7.2 Gull Island ~~Hydroelectric Development~~Generating Facility Project On Hold

~~1100 Access General~~

- ~~Site roads to be gravel surfaced, unless conditions dictate otherwise e.g. to limit dust and flying stones in areas such as accommodations complex and other site facilities.~~
- ~~Site access to north side from TLH.~~
- ~~Site access to south side initially by ferry and barge, thence by a temporary one lane construction bridge to be located upstream of the site. This temporary construction bridge will be removed prior to reservoir impounding; however concrete piers/abutments may be left in place if determined prudent to do so.~~

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1200 Permanent Accommodations

- Constructed in place on a concrete foundation.
- To be located on north side of the river approximately 0.5 km downstream of dam.
- 40- person capacity.
- Self- contained facility.
- Energy Star qualified building systems (Nalcor Energy's LEED program).

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13001310 Construction Power

- Construction power will be from NE-NLH whenever practicable.

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1400 1410 Construction Telecommunications – General

- Construction communication system required.

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1500 Temporary Site Facilities and Accommodations Complexes

- Staged, modular construction to accommodate up to 2,500 persons with appropriate offices, cooking, dining, sleeping, washing, medical, fire fighting, entertainment, recreational, power, water, sewage, and other life support facilities both at site , within the project area and at other locations, yet to be determined.
- Includes substation and distribution system with construction power supplied from NE-NLH and backup diesel generation at the site.
- Main site location and facilities to be on North side of river approximately 6 km downstream from dam on existing cleared site.
- Voice and data communication systems.
- Designed for removal following construction.

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2100 Reservoir

- FSL = 125 m; LSL = 122 m; MFL = 127 m.
- Remove all trees that grow in, or extend into, the area between 3 m above FSL and 3 m below LSL, except where the reservoir preparation strategy dictates otherwise.
- Trash management system required for the reservoir.
- Fish habitat will be based on compensation strategy agreed with DFO.

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2200 Diversion

- 2 tunnels in rock located on south side of river.
- Capacity = 4,800 m^3/s.
- Concrete portals at inlet of both tunnels.
- Operable gates at inlet portals.
- *Fish Compensation Flow* will be approximately 30% of mean annual flow.

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2300 Dams & Cofferdams

- Main dam is to be CFRD.
- Main dam crest is to be El. 129 m.
- Deep concrete cut-off wall connecting base of dam to bedrock.
- *Cofferdams* are to be earth/rockfill dams.

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- Downstream *cofferdam* designed to carry collector lines from powerhouse to switchyard.

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2400 Spillway

- Concrete structure in rock excavation.
- Capacity = PMF @ 20,800 m^3/s.
- Vertical lift gates with individual wire rope hoists in heated enclosures designed for severe cold climate operation.
- 2 gates to be heated.
- All gate gains to be heated.
- 1 set of interchangeable steel *Stoplogs* with a permanent hoist system.
- Downstream chute with *Flip Bucket* and *Plunge Pool* for energy dissipation.

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3100 Tailrace

- Channel to river in open cut earth/rock excavation.

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3220 Intakes

- Approach channel in open cut earth/rock excavation; designed to eliminate frazil ice.
- Concrete structure in rock excavation.
- 5 intakes (one per *Penstock*).
- 5 sets of vertical lift operating gates with individual wire rope hoists in heated enclosures.
- 1 set of steel *Bulkhead Gates* with a permanent hoist system.
- 5 sets of removable steel *Trash Racks*.
- 1 permanent trash management system.

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3250 Penstocks

- 5 individual *Penstock* tunnels in rock.
- All tunnels are concrete/steel lined.
- Separate venting (exterior to intake) of each *Penstock*.

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3300 Powerhouse Civil Works

- Concrete structure in rock excavation.
- Structural steel super-structure with metal cladding.
- Energy Star qualified building systems (Nalcor Energy's LEED program).
- 5 unit powerhouse with maintenance bay large enough to assemble 1 complete turbine/*Generator* unit, plus assembly and transfer of 1 extra *rotor*. Provision for an unloading area.
- Area for offices, maintenance shops and warehouse. After completion of turbine/*generator* installation, the maintenance bay may be reduced in size to accommodate the dismantling of 1 entire turbine/*generator* unit only. Offices, maintenance shops, and warehouse may occupy the remaining area of the maintenance bay.
- 2 sets of draft tube *Stoplogs* with a permanent hoist system in a heated enclosure.

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3400 – Turbines and Generators

- 5 – 450 MW, approximately, @ 0.9 pf vertical axis *Generators*.
- 5 *Francis Turbines* with *Cavitation Resistant Design*.
- Unitized approach from intake to Generator step-up transformer.
- Failure of any equipment/system of one unit not to affect the operation of the remaining units.

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3440 – Electrical Ancillary Equipment

- Dual dc battery system.
- A minimum of 2 sources of station service.
- Dual digital protection systems.
- A distributed digital control and monitoring system.
- Dual CPU for control system functions.
- 2 standby emergency diesel *Generators*, in separate locations, complete with fuel storage systems.

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3450 – Mechanical Ancillary Equipment

- Separate high &and low pressure compressed air systems.
- Separate service, domestic, and fire water systems.
- HVAC systems. *Generators* are to be a source of powerhouse heating.
- 2 overhead2 overhead powerhouse cranes, with the capability to operate in tandem having a combined design capacity, when operated in tandem, to lift a fully assembled *Rotor*.
- Elevator access to all levels of powerhouse, including transformer gallery.
- Dewatering and drainage systems c/womplete with oil interception system.
- Permanent waste hydraulic and & lubricating oil storage and handling system complete with a permanent centrifuge filtration system.
- Permanent hoist system required for each turbine pit.

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3460 – Generator Transformers & Switching

- 5 step5 step- up transformers located upstream of the powerhouse.
- Each unit will have a Ggenerator breaker.

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4200 – Gull Island Switchyard – General

- Situated on the north side of the Churchill River on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Details ON HOLD – final design is dependent on the market access route and the export transmission connection point which is currently subject of ongoing transmission access applications and an appeal of the Regie de l'energie ruling of May 2010.

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9210 – Operations Telecommunication Systems

- All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.

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7.3 Muskrat Falls ~~Hydroelectric Development~~Generating Facility Project

1100 Access - General

- Site roads to be gravel surfaced unless conditions dictate otherwise e.g. to limit dust and flying stones in areas such as accommodations complex and other site facilities.
- Permanent site access from south, along south side of river via TLH.
- Temporary site access to north side from TLH.

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1200 Permanent Accommodations

- No permanent accommodations required.

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~~1300~~1320 Construction Power

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- ~~Construction power will be from NE-NLH whenever practicable.~~Construction power will be supplied from the existing 138 kV transmission line between CF and HVGB by means of a tap station at MF, to be located on the ~~N~~north side of the Churchill River. It will comprise~~-~~ 1 – 50 MVA, 138 – 25 kV transformer with an on-load tap changer (OLTC), 138 kV circuit breakers for the transformer and the line feeder to HVGB and capacitor banks to provide voltage regulation. The installation will be capable of providing 12 MW peak load and will be remotely controlled and supervised from the Nalcor ECC in St. John's.
- Construction power will be supplied to the North side of the Churchill River with a 25 kV distribution feeder that will take off from this substation and cross the river to provide power to the construction sites and the campsite located approximately 10.5 km east of Muskrat Falls.
- A new 125 MVA, 230 – 138 kV transformer with OLTC will be installed in CF as a replacement for the ~~two~~2 existing 42 MVA transformers without OLTC to accommodate the increase of power transfer to provide 12 MW of power at MF.
- Once the 315 kV HVac network is energized during construction, power will be supplied from the 315-138 kV substation transformer tertiary winding until all construction facilities are demobilized.

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142~~0~~0 Construction Telecommunications – ~~General~~Muskrat Falls

- ~~Construction communication system required.~~Communications during early works of access road, camp start-up and start of site excavations will be by land mobile radio system and cellular phones.
- Communications during the main construction phase will be linked to a new high speed fibre-optic network being constructed in Labrador and will include~~:~~
  - Data (business and personal)~~;~~
  - Telephone (business and personal)~~;~~
  - Video C~~c~~onferencing~~;~~
  - Television~~;~~
  - Land ~~m~~Mobile ~~r~~Radio ~~s~~System (LMRS)~~;~~
  - Cellular ~~t~~Telephone ~~s~~System (CTS)~~;~~
  - Mobile ~~i~~Internet ~~s~~System (MIS)~~;~~

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- Building ~~m~~Management ~~s~~Systems (BMS)~~;~~
- Network ~~m~~Management S~~s~~ystems (NMS)~~;~~
- Closed ~~c~~Circuit ~~t~~Television (CCTV)~~;~~
- Security and Access Control System (SACS)~~;~~
- Supervisory Control and Data Acquisition (SCADA) and Protection~~.~~

1500 ~~Temporary Site Facilities and Accommodations Complexes~~Accommodations Complex

- Staged, modular construction to accommodate up to 1,500 persons with appropriate offices, cooking, dining, sleeping, washing, medical, fire fighting, entertainment, recreational, power, water, sewage, and other life support facilities both at site , within the project area and at other locations, yet to be determined.
- Main site facilities to be located on south side of river approximately 10.5 km southeast of Muskrat Falls.
- Includes substation and distribution system for construction power supplied from ~~NE-NLH~~the 25 kV feeder and backup diesel generation at the site.
- Voice and data communication systems.
- Designed for removal following construction.

1800 Offsite Logistics, Infrastructure and Support – General
[Dave – please provide bullets on offsite marshalling and warehousing, off site port facilities and upgrades and offsite road and bridge construction or upgrades included in DG-3]

2100 Reservoir

- FSL = 39 m; LSL = 38.5 m; MFL = ~~44 m~~45.1 m without GI and 44.3 m with GI.
- Remove all trees that grow in, or extend into the area between 3 m above FSL and 3 m below LSL, except where determined otherwise by the reservoir preparation strategy.
- Trash management system ~~required for the reservoir~~to include [Bob Besaw – please provide some words, including comment on log booms as appropriate].
- Fish habitat will be based on compensation strategy agreed with DFO.

2200 Diversion

- Through spillway structure.
- Capacity = 5,~~930~~ 990 m^3/s based on a 1:20 year return period.~~.~~
- *Fish Compensation Flow* will be approximately 550 m^3/s equivalent to 30% of mean annual flow.
- *Fish Compensation Flow* will be through spillway structure.

2300 Dams & Cofferdams - General

~~Main dams are to be RCC.~~

- Development flood capacity is based on the PMF, equal to 25,060 m^3/s at 45.1 m without GI and 44.3 m with GI.

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- South RCC Dam to be an earth/rockfill dam with a central core crest elevation to be El. 45.5 m.
- North RCC Dam to be an overflowRCC overflow dam, acting as a secondary spillway with a crest elevation of El. 39.5 3 m over a 430 m long overflow section.
- Transition dams to be conventional concrete.
- All dams are to be founded directly on bedrock.
- *Cofferdams* are to be earth/rockfill damsof the most economical and proven material and technology.

2400 Spillway (Gated Section) - General

- Primary spillway structure.
- Concrete structure in rock excavation.
- Capacity = PMF in conjunction with North RCC Dam. at MFL elevation of 44 m.
- 2 – Low level outlet vertical lift gates 10.5 m high by 10.5 m wide withSpillway sill at El. 5.0 m.
- 3 – Surface vertical lift gates on parabolic rollways, 10.5 m wide with top of gate at El. 40.0 m and sill at El. 15.7 m.
- Gates with heating and hoisting mechanisms designed for severe cold climate operation.
- 1 set (of upstream and downstream) interchangeable steel *Stoplogs* with a permanent hoist system.
- 1 set of downstream *Stoplogs* operated by a mobile crane.
- *Stoplog* storage on site.
- 1 emergency diesel generator set, complete with fuel storage system, for emergency load requirements sufficient for heating and operation of 2 surface gates only.

2800 North Spur - General

- Significant infrastructure will be required for long term stabilization of the North Spur.[Dave – can you add some bullets for here based on DG-3]

3100 TailracePowerhouse Channels

- Approach channels excavated in bedrock with minimum rock reinforcement required.
- Draft tubes discharge directly into river in rock excavation.
- Tailrace channel excavated in bedrock with minimum rock reinforcement required..

32203200 Intake & Penstocks - Generals

- Approach channel in open cut earth/rock excavation and designed to eliminate frazil ice.
- Concrete structure in rock excavation.
- 4 intakes (one per unit).
- 4 sets of vertical lift operating gates with individual wire rope hoists in heated enclosures.

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- 1 ~~set~~ suite of Bulkhead ~~Gates~~ *Stoplogs* able to close any single intake passage opening~~with a permanent hoist system~~.
- 4 sets of removable steel *Trash Racks*.
- 1 permanent trash management system complete with permanent hoist capable of removing the intake Bulkhead *Stoplogs*.
- No penstocks; 4 individual water passages in concrete (close-coupled intake/powerhouse).

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~~3250 Penstocks~~

- ~~No *penstocks*; 4 individual water passages in concrete (close-coupled intake/powerhouse).~~

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3300 Powerhouse ~~Civil Works~~

- Concrete structure in rock excavation.
- Structural steel super-structure with metal cladding.
- Energy Star qualified building systems (Nalcor Energy's / Government of NL Sustainable Building Policy ~~LEED program~~).
- 4 unit powerhouse with maintenance bay large enough to assemble 1 complete turbine/~~G~~generator unit, plus assembly and transfer of 1 extra *rotor*. Provision for an unloading area.
- Area for offices, maintenance shops and warehouse. After completion of turbine/generator installation, the maintenance bay ~~may~~ will be reduced in size to accommodate the dismantling of 1 entire turbine/generator unit only. Offices, maintenance shops, and warehouse ~~may~~ will occupy the ~~remaining area~~south of the maintenance bay.
- 2 sets of draft tube *Stoplogs* with a permanent hoist system in a heated enclosure.

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34~~0~~10/3420 ~~Turbines and Generators~~Turbines and Generators

- 4 – 206 MW, approximately, -@ 0.90 pf vertical axis *Generators*.
- Inertia constant H not less than 4.1 kWs/kVA.
- 4 *Kaplan turbines* with *Cavitation Resistant Design*.
- Unitized approach from intake to ~~G~~generator step-up transformer.
- Failure of any equipment/system of ~~one~~1 unit not to affect the operation of the remaining units.

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~~3440~~ 3430 Electrical Ancillary Equipment

- Dual ~~dc 125 Vdc battery system~~125 Vdc battery systems with dual chargers per battery system for control and protection.
- Independent 125 Vdc battery system with dual chargers for field flashing and other dc power.
- Dual 48 Vdc battery ~~system~~systems with dual chargers per battery system for telecommunication system.
- A minimum of 2 sources of station service.

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- Arc flash category 2 for all electrical panels of 600 Vac or greater.
- Dual digital protection systems.
- A distributed digital control and monitoring system.
- Dual CPU for control system functions.
- 1 - ~~2~~ standby emergency diesel ~~G~~generator~~s~~ for the powerhouse essential load auxiliaries, ~~in separate locations,~~ complete with fuel storage systems.

~~3450~~3440 Mechanical Ancillary Equipment

- Raw water supply system, with raw strainers, for supply of turbine and generator cooling water, fire water and surface water systems.
- Separate high ~~&~~and low pressure compressed air systems.
- Separate service, domestic, and fire water systems.
- Domestic waste water to septic tank and field [Dave Brown?????]
- HVAC systems. *Generators* are to be a source of powerhouse heating.
- 2 overhead powerhouse cranes, with the capability to operate in tandem having a combined design capacity, when operated in tandem, to lift a fully assembled *Rotor*.
- Elevator access to all levels of powerhouse.
- Dewatering and drainage systems ~~c/w~~complete with oil interception system.
- Permanent waste hydraulic ~~&~~ and lubricating oil storage and handling system complete with a permanent centrifuge filtration system.
- Permanent hoist system required for each turbine pit.

3450 Protection, Control & Monitoring

[Raj – please supply suitable bullets for this section]

3460 Generator Transformers ~~& Switching~~

- 4 ~~-~~ – step-~~-~~up transformers (unit voltage to ~~345~~ 315 kV) located on powerhouse draft tube deck, plus 1 spare step-~~-~~up transformer~~.~~.
- Each unit will have a ~~G~~generator circuit breaker~~.~~.
- Each transformer set up will include drainage to an oil water separator~~.~~.
- Transformers will be separated from each other by a concrete firewall.~~.~~

4100 Churchill Falls Switchyard Extension ~~– General~~

- Extension of the existing 735 kV main bus with bus coupling circuit breakers.
- Provision for 3 future 735 kV transmission line feeders.
- 2 – 833 MVA, 735-315 kV auto-transformers, with tertiary windings rated at 13.8 kV to supply the substation service loads.
- ~~To accommodate~~Accommodation -of 2 X ~~345~~ 315 kV HVac transmission lines from M~~uskrat~~ Falls.
- ~~To be an extension within the existing CF Switchyard.~~CF switchyard extension is to be located approximately 500 m east of the existing yard.
- 2 – 735 kV transmission lines, each approximately 500 m in length, to join the existing CF switchyard to the CF switchyard extension.
- Construction and operation not to adversely impact the existing CF operation.

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- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Provision for future 315 kV transmission line feeders.
- Provision of a warehouse for spare parts and repair shop. [Raj to confirm]
- Temporary facilities and accommodations complex of modular construction to accommodate up to 150 persons with appropriate offices, cooking, dining, sleeping, washing, medical, fire fighting, entertainment, recreational, power, water, sewage, and other life support facilities.

4300 Muskrat Falls Plant Switchyard - General

- Situated on the south side of the river on a level, fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).
- Substation to interconnect the Plant to the 315 kV HVac transmission lines to CF and the HVdc Converter Station.

9112 Fish Habitat Compensation
[Marion/Dave to provide appropriate bullets here]

9122 Terrestrial Habitat Compensation
[Marion /Dave to provide appropriate bullets here]

9220 Operations Telecommunications System – Muskrat Falls

- Telecommunication System shall be comprised of three 3 separate layers: Optical Transport Network (OTN), Convergence, and Access Layers.
- OTN Layer shall be the telecommunications backbone and utilize the OPGW, All Dielectric Self Supporting (ADSS) or equivalent fibre optic infrastructure. The OTN Layer equipment nodes shall be designed based upon the least total cost of ownership alternative.
- Convergence Layer shall be based on the Synchronous Optical Network (SONET) international standard. It shall be used to create logical point-to-point telecommunication links between the all MF locations. It will multiplex and de-multiplex the Access Layer subsystems for transmission on the OTN.
- Access Layer shall be based on the Ethernet (IEEE 802.3) standard. It shall be comprised of a minimum of three3 separate telecommunication systems: Protection and Control, SCADA, and Administrative systems. The Administrative system may include the following subsystems: telephony, corporate data, security access control system, and video surveillance.
- The Muskrat Falls Telecommunication Assets specifically include the following:

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- Convergence and Access Layers telecommunication systems at the MF Hydroelectric Plant, Converter Station and Switchyards.
- NLH ECC and BCC SCADA system upgrades.
- Network Management System to monitor, notify, and provision the OTN, Convergence and Access Layers telecommunication systems.

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~~9220 Operations Telecommunication Systems~~
~~All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.~~

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7.4 ~~HVac Transmission Systems~~Labrador Transmission Asset Project

~~4500 Soldiers Pond Switchyard~~
~~Situated on the north-east side of Soldiers Pond on a level, fenced site.~~
~~Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.~~
~~Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).~~
~~Switchyard to interconnect 8 – 230 kV transmission lines (4 existing transmission lines looped in), the synchronous condensers and the Converter Station.~~

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6110 HVac Overland Transmission - Gull Island to Churchill Falls

- ON HOLD ~~- final design, including suitability of 345 kV transmission lines between Gull Island and Churchill Falls, is dependent on the market access route and the export transmission connection point which is currently subject of ongoing transmission access applications and an appeal of the Regie de l'energie ruling of May 2010.~~

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6130 Muskrat Falls Switchyard to HVdc Converter Station

- 2 - ~~345~~ 315 kV HVac transmission lines to connect the Muskrat Falls switchyard to the ~~±320~~350 kV HVdc Converter Station.
- Each of the ~~345~~ 315 kV HVac ~~line~~transmission lines to have a designed power capacity of 900 MW.

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6140 HVac Overland Transmission - Muskrat Falls to Churchill Falls

- 2 - ~~345~~ 315 kV HVac overhead transmission lines to connect the Muskrat Falls switchyard to Gull Island and the Churchill Falls switchyard extension.
- ~~Line~~Transmission lines are to be carried on galvanized lattice steel towers, with self supported angles and deadends, and guyed suspension towers.
- ~~Line~~Transmission line power capacity is to be 900 MW for each ~~line~~transmission line, allowing for all load to be carried on a single circuit.
- ~~Line~~Transmission line corridor as per Key Plan. (See Drawings).
- 50-year *Reliability Level Return Period* of loads.
- ~~All~~ Both ~~line~~transmission lines to have overhead lightning protection (OHGW). ~~with~~ ~~O~~One transmission line to have ~~being~~ OPGW on one side for the Operations Telecommunications System.
- *Counterpoise* installed from station-to-station.

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6160 HVac Overland Transmission - Collector LinesCollector Lines – Powerhouse to Switchyard

Gull Island

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Muskrat Falls

- 4 – 345 315 kV HVac cable setsoverhead conductor lines to connect the high side of the step up transformers to the switchyard.

4600 Lingan Switchyard Extension - General

- To be an extension within the existing Lingan Switchyard.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard TBD.

4700 Bottom Brook Switchyard Extension - General

- To be an extension within the existing Bottom Brook Switchyard.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard extension is TDB.

4800 Granite Canal Switchyard Extension - General

- To be an extension within the existing Granite Canal Switchyard.
- To accommodate 1 X 230 kV HVac transmission lines to Bottom Brook.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.

6170 HVac Overland Transmission – Granite Canal to Bottom Brook

- 1 X 230 kV HVac overhead transmission line to connect the Granite Canal switchyard to the Bottom Brook switchyard.
- Line is to be carried on galvanized lattice steel towers, with self supported angles and deadends, and guyed suspension towers.
- Line power capacity is to be sized to ensure the NE 230 kV transmission system feeding the Bottom Brook Terminal Station has sufficient capacity to supply the Maritime Link with 500 MW while one of the incoming 230 kV lines is out of service.
- Line corridor is TBD.
- 50 year Reliability Level Return Period of loads.
- Line to have overhead lightning protection (OHGW) with one being OPGW for the Operations Telecommunications System.
- Counterpoise installed from station to station.

7520 315/138 kV Muskrat Falls Tap Station Switchyard

- Located on the north side of the Churchill River on a level, fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).

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- Substation interposed between CF and MF Plant Switchyard and includes 2 – 125 MVA transformers, 315 - 138 kV, 4 – 315 kV transmission line feeders and 2 – 138 kV transmission line feeders (plus 2 additional for future expansion) interconnecting HVGB.
- The 2 – 125 MVA transformers also include tertiary windings rated at 25 kV to supply power for substation services, converter station, construction loads and distribution loads in the region of the MF Tap Station.

9250 Operations Telecommunications System – Labrador Transmission

- Telecommunication System shall be comprised of ~~three~~3 separate layers: Optical Transport Network (OTN), Convergence, and Access Layers.
- OTN Layer shall be the telecommunications backbone and utilize the OPGW, All Dielectric Self Supporting (ADSS) or equivalent fibre optic infrastructure. The OTN Layer equipment nodes shall be designed based upon the least total cost of ownership alternative.
- Convergence Layer shall be based on the Synchronous Optical Network (SONET) international standard. It shall be used to create logical point-to-point telecommunication links between ~~the~~ all MF locations. It will multiplex and de-multiplex the Access Layer subsystems for transmission on the OTN.
- Access Layer shall be based on the Ethernet (IEEE 802.3) standard. It shall be comprised of a minimum of ~~three~~3 separate telecommunication systems: Protection and Control, SCADA, and Administrative systems. The Administrative system may include the following subsystems: telephony, corporate data, security access control system, and video surveillance.
- The Labrador Transmission Link Telecommunication Assets specifically include the following:
  - HVac OPGW fibre optics connecting
    - MF 315kV Switchyard to CF 735-315kV Switchyard.
  - TLH ADSS fibre optics connecting
    - Labrador West to CF to MF to HVGB.
  - OTN Layer optical-electronics associated with the above referenced fibre optic interconnections.
  - Convergence and Access Layer telecommunication systems associated with the above referenced OTN Layer optical-electronics, except these telecommunication layers at MF.
  - CF SCADA system upgrades.

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7.5 HVdc Transmission SystemsLabrador – Island Transmission Link Project (LITL)

Overall HVdc system consists of a 900 MW HVdc Island Link between Labrador and Newfoundland. [I have removed any reference to the Maritime Link] and assumes a 500 MW HVdc Maritime Link between NS and NL as described further in this BOD. Without this HVdc Maritime Link, overload capacity may be required at the Labrador and Soldiers Pond converter stations.

1330 Construction Power

[Raj – Please provide items for this section]

1430 Construction Telecommunication Systems – Island Link

- Provision of telecommunications services and infrastructure during the construction phase to the end of the Project along the 315 kV HVac and the ±350 kV HVdc transmission lines and associated construction camps, including the CF Extension Switchyard construction camp.:
  - Services along the Transmission Line rights-of-way:
    - Land Mobile Radio System (LMRS).
  - Services available at the various remote campsites:
    - Data (Corporate and personal);
    - Telephony (corporate and personal);
    - LMRS;
    - Network Management System (NMS);
    - Closed Circuit Television (CCTV) ;-and
    - Security and Access Control System (SACS).

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7.5.1 HVdc Island Link

8210 Muskrat FallsLabrador Converter Station

- 900 MW, ±320 350 kV bi-pole, LCC Converter Station capable of operating in mono-polar mode.
- Each pole rated at 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.
- Situated on the south side of the Churchill River on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an *Electrode*.

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6310 *Electrode Line* - Muskrat Falls to SOBIL'Anse au DiableLabrador

- An *Electrode Line* carrying 2 conductors – route to be selected within the same ROW of the HVdc transmission line.with the first 380 km to be supported on the HVdc lattice steel towers from Muskrat Falls to Forteau Point and the remaining section from Forteau Point to L'Anse au Diable to be supported on a wood pole line.

Wood pole construction.

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- 50-year Reliability Level Return Period of loads.
- *Electrode line* will have provision for lightning protectionarcing horns.

8610 *Electrode* – Labrador Labrador

- A shoreline pond *electrode* to be located at L'Anse au Diable on the Labrador side of the SOBI.
- Nominal rating of 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.

6270 Labrador HVdc Overland HVdc Transmission – Muskrat Falls to Strait of Belle Isle

- An HVdc overhead transmission line, ±320 350 kV bi-pole, to connect the Muskrat Falls Converter Station to the Labrador Transition Compound at the Strait of Belle Isle.
- LineTransmission line to carry both poles (single conductor per pole), 2 *electrode conductors* and one1 OPGW.
- LineTransmission line corridor as per Key Plan. (See Drawings).
- This section of the HVdc overhead transmission line is approximately 380 km.
- This segment of the HVdc linetransmission line is to have a designed nominal power capacity of 900 MW; however, given the mono-polar operation criteria, each pole is to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- *Counterpoise* installed from station-to-station.
- Towers are to be galvanized lattice steel, with self supported angles and deadends, and guyed suspension towers.
- 50-year Reliability Level Return Period of loads.

8510 Transition Compound - Labrador

- Situated on a level fenced site at Forteau Point.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Overhead line to cable transition equipment.
- Switching, control, protection, monitoring and communication equipment.

8110 Marine Crossing – SOBI - General

- [Greg to provide bullets, change, add, delete – as necessary]
- 3 - ±320 350 kV MI sub-sea cables transmit power across the SOBI. One of these cables will be a spare.
- Cable(s) for each pole to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- The route for the sub-sea cable(s) crossing shall be designed to meet the transmission, protection, reliability, and design life requirements, and give consideration to technical and economic optimization.
- Cable corridor as per Key Plan. (See Drawings).

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- Cables shall be adequately protected along the entire length of the crossing as required. However, installation methodologies may be employed to mitigate damage from external environmental and man-made risks.
- Where discrete protection application is required, protection measures shall be designed to meet the transmission and reliability requirements.
- Cable protection methodology will employ proven technologies only, and may include tunnelling, rock placement, trenching, horizontal directional drilling (HDD) and concrete mattresses.

8520 Transition Compound – Northern Peninsula

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- Situated on a level fenced site at Shoal Cove.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Cable to overhead line transition equipment.
- Switching, control, protection, monitoring and communication equipment.

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6220 Island~~HVdc~~ Overland HVdc Transmission~~ – Strait of Belle Isle to Soldiers Pond~~

- An HVdc overhead transmission line, ±~~320~~ 350 kV bi-pole, to connect the Northern Peninsula Transition Compound at the Strait of Belle Isle to the Soldiers Pond Converter Station.
- ~~Line~~Transmission line to carry both poles (single conductor per pole) and ~~one~~1 OPGW.
- ~~Line~~Transmission line corridor as per Key Plan. (See Drawings).
- This segment of the HVdc ~~line~~transmission line is to have a designed nominal power capacity of 900 MW; however, given the mono-polar operation criteria, each pole is to have a nominal rating of 450 MW with 100% overload capacity for 10 minutes and 50% overload capacity for continuous operation.
- *Counterpoise* installed from station-~~-~~to-~~-~~station.
- Towers are to be galvanized lattice steel, with self supported angles and deadends, and guyed suspension towers.
- 50-~~-~~year Reliability Level Return Period of loads.

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8220 Soldiers Pond Converter Station

- 900 MW, ±~~320~~ 350 kV bi-pole, LCC Converter Station capable of operating in mono-polar mode.
- Each pole rated at 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.
- Situated on the north side of the Soldiers Pond Tap on the Avalon Peninsula on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an *Electrode*.

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6320 *Electrode Line* – Soldiers Pond to Conception BayNewfoundland East

- An *Electrode Line* carrying 2 conductors generally follows the existing transmission ROW from Soldiers Pond to Conception Bay.
- Wood pole construction.
- 50-year Reliability Level Return Period of loads.
- *Electrode line* will have provision for lightning protection.

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8620 *Electrode* - Soldiers PondNewfoundland East

- A shoreline pond *electrode* to be located at Dowden's Point on the east side of Conception Bay.
- Nominal rating of 450 MW with 100% overload protection for 10 minutes and 50% overload protection for continuous operation.

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4500 Soldiers Pond Switchyard

- Situated on the north-east side of Soldiers Pond on a level, fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Electrical layout of the switchyard is to be in accordance with the proposed SLD. (See Drawings).
- Switchyard to interconnect 8 – 230 kV HVac transmission lines (4 existing transmission lines looped in), the synchronous condensers and the Converter Station.

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7100 System Upgrades for Island LinkIsland System Upgrades East

- Conversion of existing Holyrood Units 1 &and 2 to synchronous condensers.
- 230 kV and 138 kV circuit breaker replacements.
- 1 - 230 kV HVac transmission line – TBD.Bay d'Espoir to Western Avalon.
- Replacement of conductors, 230 kV transmission line – Bay d'Espoir to Sunnyside
- 23 - 300 MVAR high inertia synchronous condensers at Soldiers Pond (including I spare) to maintain system performance. Alternatively, 3 – 150 MVAR units can be installed based on value engineering. [RAJ WHAT DOES THIS LAST STATEMENT MEAN???????]
- Additional upgrades to be determined by NE-NLH's System Planning following further studies and analysis. Looping in-out of the 4 existing 230 kV transmission lines into the new Soldier's Pond Switchyard. This requires reconstruction of approximately 1.6 km of the resulting 8 transmission lines entering and leaving the switchyard.
- Upgrade of the protection and control systems at Hardwoods, Oxen Pond, Holyrood and Western Avalon Switchyards.

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92301430 Operations Construction Telecommunication Systems – Island Link

- All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.Provision of telecommunications services and infrastructure during the construction phase to the end of the Project along the 315 kV HVac and the ±350 kV HVdc transmission lines and associated construction camps, including the CF Extension Switchyard construction camp:
  - Services along the Transmission Line rights-of-way:
    - Land Mobile Radio System (LMRS).
  - Services available at the various remote campsites:
    - Data (Corporate and personal);
    - Telephony (corporate and personal);
    - LMRS;
    - Network Management System (NMS);
    - Closed Circuit Television (CCTV); and
    - Security and Access Control System (SACS).

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9230 Operations Telecommunications System – Island Link

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- Telecommunication System shall be comprised of three3 separate layers: Optical Transport Network (OTN), Convergence, and Access Layers.

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- OTN Layer shall be the telecommunications backbone and utilize the OPGW, All Dielectric Self Supporting (ADSS) or equivalent fibre optic infrastructure. The OTN Layer equipment nodes shall be designed based upon the least total cost of ownership alternative.

- Convergence Layer shall be based on the Synchronous Optical Network (SONET) international standard. It shall be used to create logical point-to-point telecommunication links between the all MF locations. It will multiplex and de-multiplex the Access Layer subsystems for transmission on the OTN.

- Access Layer shall be based on the Ethernet (IEEE 802.3) standard. It shall be comprised of a minimum of three3 separate telecommunication systems: Protection and Control, SCADA, and Administrative systems. The Administrative system may include the following subsystems: telephony, corporate data, security access control system, and video surveillance.

- The Island Transmission Link Telecommunication Assets specifically includes the following.:

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  - HVdc OPGW fibre optics connecting:
    - Muskrat Falls Converter Station to Forteau Point Transition Compound.
    - Shoal Cove Transition Compound to Soldiers Pond Converter Station.
  - ADSS fibre optics connecting:

- Forteau Point Transition Compound to the L'Anse au Diable *Electrode*.
- Soldiers Pond Converter Station to Dowden's Point *Electrode*.

- Fibre optic infrastructure shall also be used to connect:
  - Forteau Point Transition Compound to Shoal Cove Transition Compound.
  - Soldiers Pond Converter Station to the NLH Energy Control Centre (ECC) in St. John's.
  - Soldiers Pond Converter Station to the NLH Backup Control Centre (BCC) in Holyrood.
- OTN Layer optical-electronics associated with the above referenced HVdc OPGW fibre optic interconnections.
- Convergence and Access Layers telecommunication systems associated with all of the above referenced fibre optic interconnections, except these telecommunication layers at MF.

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7.5.2 HVdc Maritime Link

8240 – Bottom Brook Converter Station

- 500 MW, ±200 kV bi-pole, VSC Converter Station capable of operating in mono-polar mode at 250 MW continuous operation.
- Situated near Bottom Brook Terminal Station on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an Electrode.

6340 – Electrode Line – Bottom Brook

- An Electrode Line carrying 2 conductors joining the Bottom Brook HVdc converter station to the Bottom Brook shoreline pond electrode.
- Wood pole construction.
- 50 year Reliability Level Return Period of loads.
- Electrode line will have provision for lightning protection.

8640 – Electrode – Bottom Brook

- A shoreline pond electrode to be located on the west coast of Newfoundland near Bottom Brook.
- Capable of operating at 250 MW continuous operation.

6260 – HVdc Overland Transmission – Bottom Brook to Cape Ray

- An HVdc overhead transmission line, ±200 kV bi-pole, to connect the Bottom Brook Converter Station to the Cape Ray Transition Compound.
- Line to carry both poles (single conductor per pole) and one OPGW.
- Line corridor as per Key Plan. (See Drawings).
- This segment of the HVdc line is to have a designed power capacity of 500 MW; however, given the mono-polar operation criteria, each pole can sustain 250 MW continuously.
- Counterpoise installed from station to station.
- Towers are to be galvanized lattice steel, with self supported angles and deadends, and guyed suspension towers.
- 50 year Reliability Level Return Period of loads.

8530 – Transition Compound – Cape Ray

- Situated on a level fenced site.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Cable to overhead line transition equipment.
- Switching, control, protection, monitoring and communication equipment.

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8120 Marine Crossing – Cabot Strait

- 2 - ±200 kV MI sub sea cables transmit power across the Cabot Strait.
- Cable(s) for each pole to be rated to carry the 250 MW continuously.
- Cables shall be designed for exposure to a marine environment, criteria specific to the Cabot Strait region.
- The route for the sub-sea cable(s) crossing shall be designed to meet the transmission, protection, reliability, and design life requirements, and give consideration to technical and economic optimization.
- Cables shall be adequately protected along the entire length of the marine crossing and may include, as an alternative to discrete protection, installation methodologies employed to mitigate damage from external environmental and man-made risks.
- Where discrete protection application is required, protection measures shall be designed to meet the transmission and reliability requirements.
- Cable protection methodology will employ proven technologies only, and may include rock placement, trenching, horizontal directional drilling (HDD) and concrete mattresses.
- Cable corridor as per NL-NS HVdc Proposed Link. (See Drawings).

8540 Transition Compound – Lingan

- Situated on a level fenced site.
- Provision for cables and associated switching requirements.
- Concrete pads and steel structures to support the electrical equipment and switchgear.
- Cable to overhead line transition equipment.
- Switching, control, protection, monitoring and communication equipment.

8230 Lingan Converter Station

- 500 MW, ±200 kV bi-pole, VSC Converter Station capable of operating in mono-polar mode at 250 MW continuous operation.
- Situated in Lingan, Nova Scotia on a level fenced site.
- Concrete foundations and galvanized steel structures to support the electrical equipment and switchgear.
- Mono-polar operation shall be supported by an Electrode.

6330 Electrode Line – Lingan

- An Electrode Line carrying 2 conductors joining the Lingan HVdc converter station to the Lingan shoreline pond electrode.
- Wood pole construction.
- 50 year Reliability Level Return Period of loads.
- Electrode line will be protected by lightning arrestors located at each end of the line.

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8630 – Electrode - Maritimes
A shoreline pond electrode to be located on the north coast of Cape Breton Island near Lingan.
Capable of operating at 250 MW continuous operation.

7200 – Island System Upgrades for Maritime Link
Island system upgrades to be determined by NE-NLH's System Planning following further studies and analysis.

9240 – Operations Telecommunication Systems – Maritime Link
All permanent control, teleprotection, SCADA and voice circuits to have communication redundancy.

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A.0 Activity Flow Chart

N/A

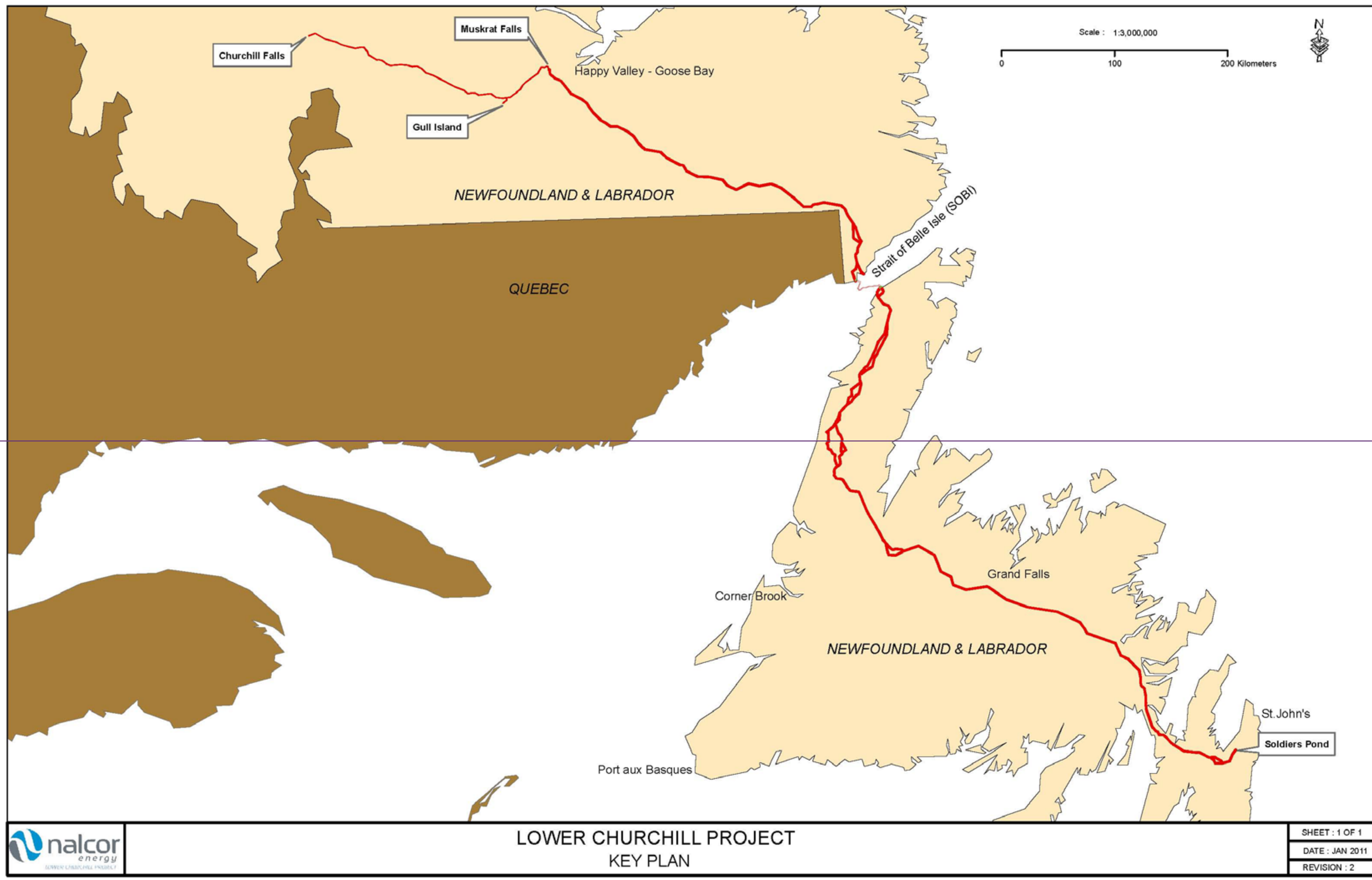
B.0 Attachments/Appendices

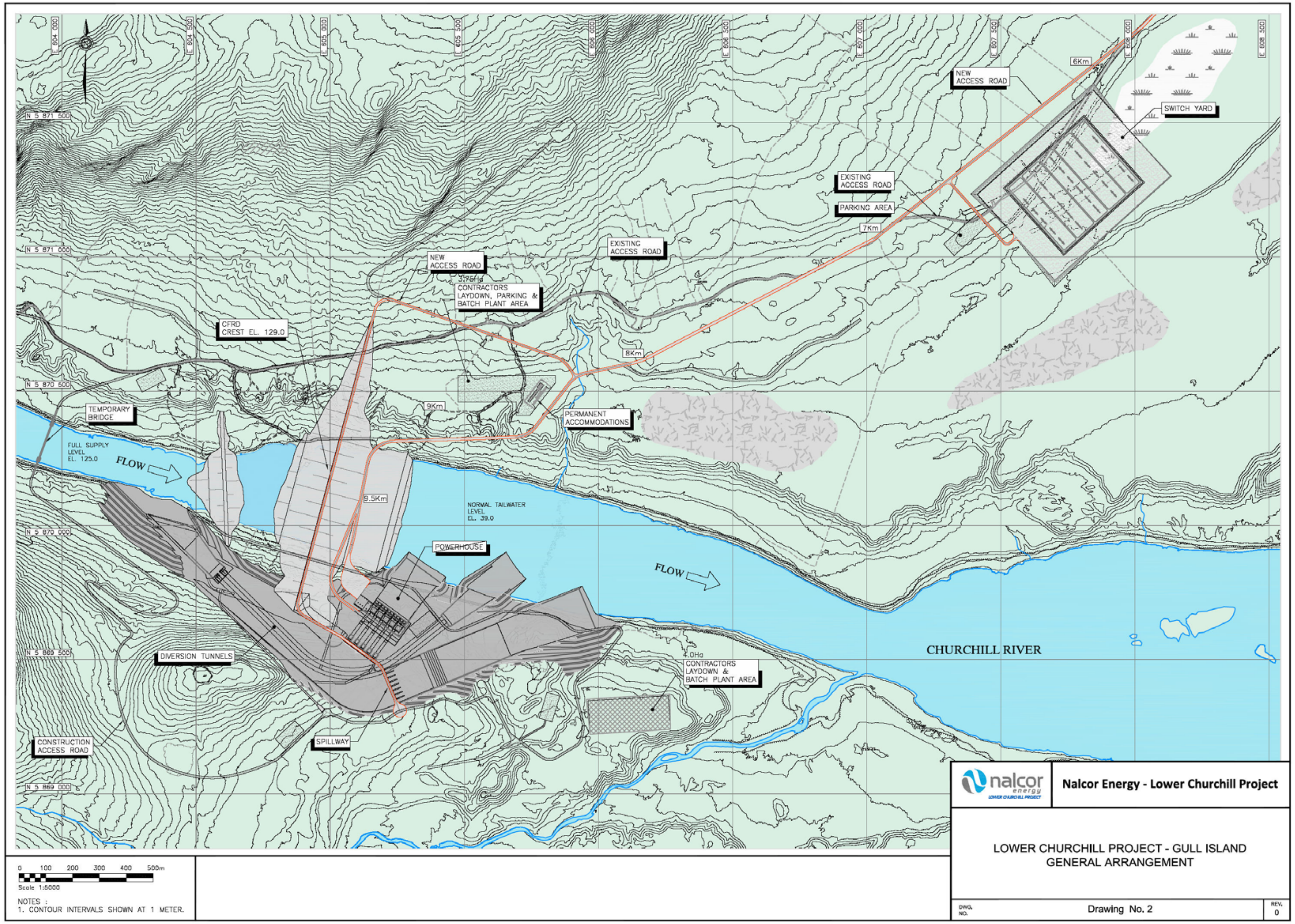
B.1 DRAWINGS

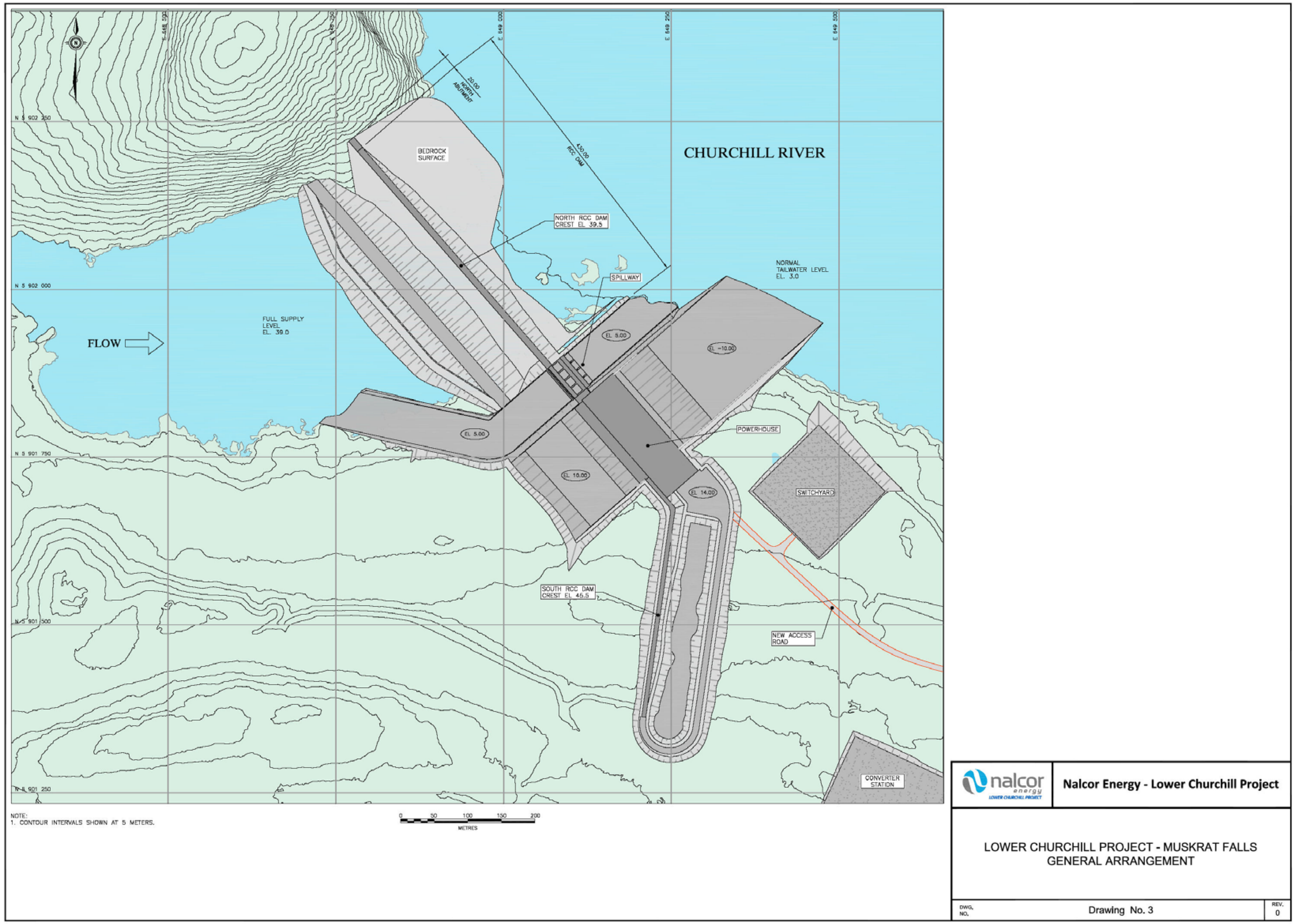
1. Key Plan
2. Gull Island General ArrangementMuskrat Falls General Arrangement
3. Muskrat Falls General ArrangementMuskrat Falls Layout
4. LCP – Asset Schematic
5. Proposed Single Line Diagram – Muskrat Falls [Raj to obtain ASAP]
6. NL-NS HVdc Proposed Link LITL Single Line Diagram [Raj to obtain ASAP]

Proposed Single Line Diagram – Bottom Brook, Granite Canal and Soldiers Pond

Formatted: Numbered + Level: 1 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.5" + Tab after: 0.75" + Indent at: 0.75"


Churchill Falls
Muskrat Falls
Gull Island
Happy Valley - Goose Bay
Scale : 1:3,000,000
0
100
200 Kilometers
N
NEWFOUNDLAND & LABRADOR
QUEBEC
Strait of Belle Isle (SOBI)
Grand Falls
Corner Brook
NEWFOUNDLAND & LABRADOR
St.John's
Soldiers Pond
Port aux Basques
nalcor energy
LOWER CHURCHILL PROJECT
KEY PLAN
SHEET : 1 OF 1
DATE : JAN 2011
REVISION : 2


NEW ACCESS ROAD
SWITCH YARD
6Km
EXISTING ACCESS ROAD
PARKING AREA
7Km
EXISTING ACCESS ROAD
NEW ACCESS ROAD
CONTRACTORS LAYDOWN, PARKING & BATCH PLANT AREA
CFRD CREST EL. 129.0
8Km
9Km
TEMPORARY BRIDGE
PERMANENT ACCOMMODATIONS
FULL SUPPLY LEVEL EL. 125.0
FLOW
9.5Km
NORMAL TAILWATER LEVEL EL. 39.0
POWERHOUSE
FLOW
CHURCHILL RIVER
DIVERSION TUNNELS
CONTRACTORS LAYDOWN & BATCH PLANT AREA
CONSTRUCTION ACCESS ROAD
SPILLWAY
0 100 200 300 400 500m
Scale 1:5000
NOTES :
1. CONTOUR INTERVALS SHOWN AT 1 METER.
nalcor energy
Nalcor Energy - Lower Churchill Project
LOWER CHURCHILL PROJECT - GULL ISLAND
GENERAL ARRANGEMENT
DWG. NO.
Drawing No. 2
REV.
0


CHURCHILL RIVER
FLOW
FULL SUPPLY LEVEL EL. 39.0
BEDROCK SURFACE
20.00 NORTH ABUTMENT
430.00 RCC DAM
NORTH RCC DAM CREST EL 39.5
SPILLWAY
NORMAL TAILWATER LEVEL EL. 3.0
EL 5.00
EL -10.00
EL 5.00
POWERHOUSE
EL 10.00
EL 14.00
SWITCHYARD
SOUTH RCC DAM CREST EL 45.5
NEW ACCESS ROAD
CONVERTER STATION
E 649 000
E 649 250
E 649 500
N 5 902 250
N 5 902 000
N 5 901 750
N 5 901 500
N 5 901 250
NOTE:
1. CONTOUR INTERVALS SHOWN AT 5 METERS.
0 50 100 150 200
METRES
Nalcor Energy - Lower Churchill Project
LOWER CHURCHILL PROJECT - MUSKRAT FALLS
GENERAL ARRANGEMENT
DWG. NO.
Drawing No. 3
REV.
0

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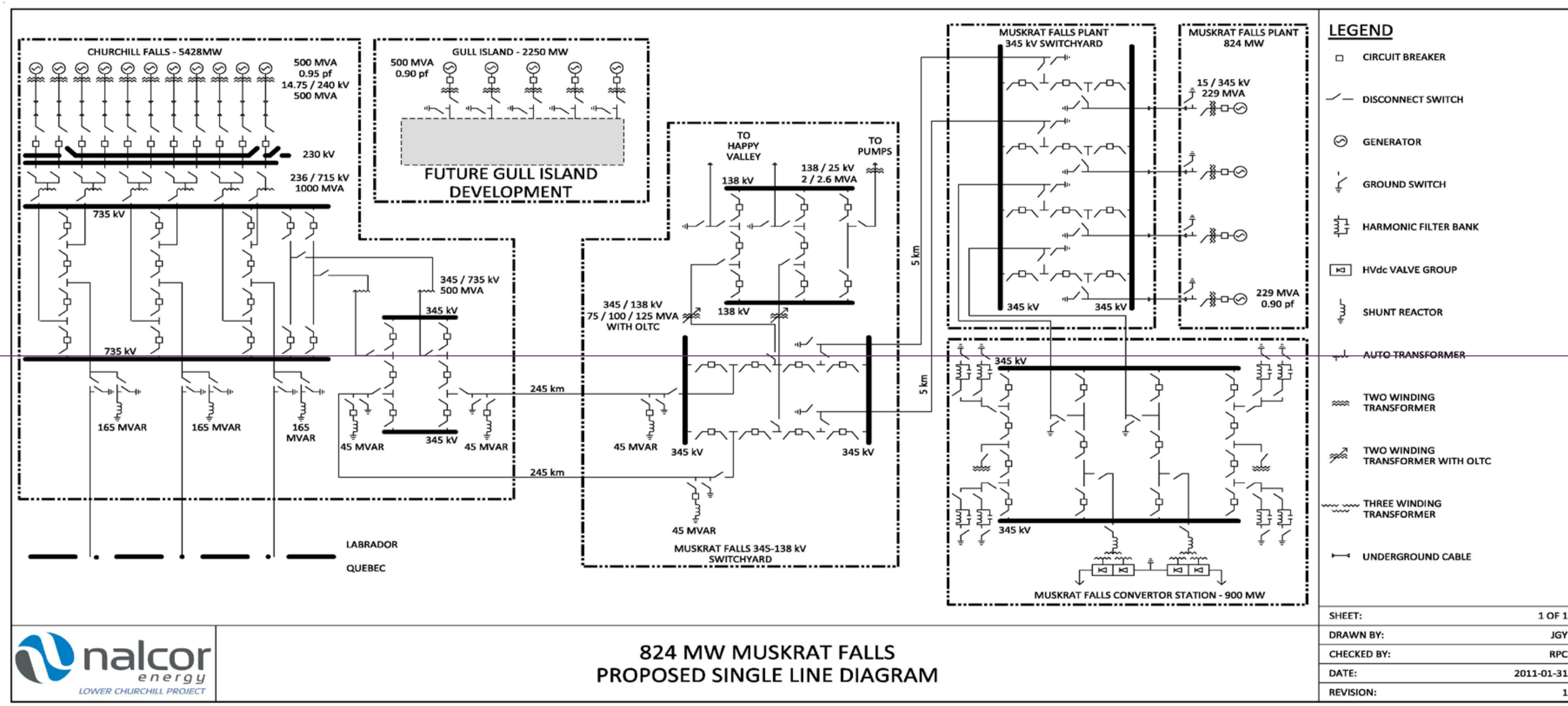

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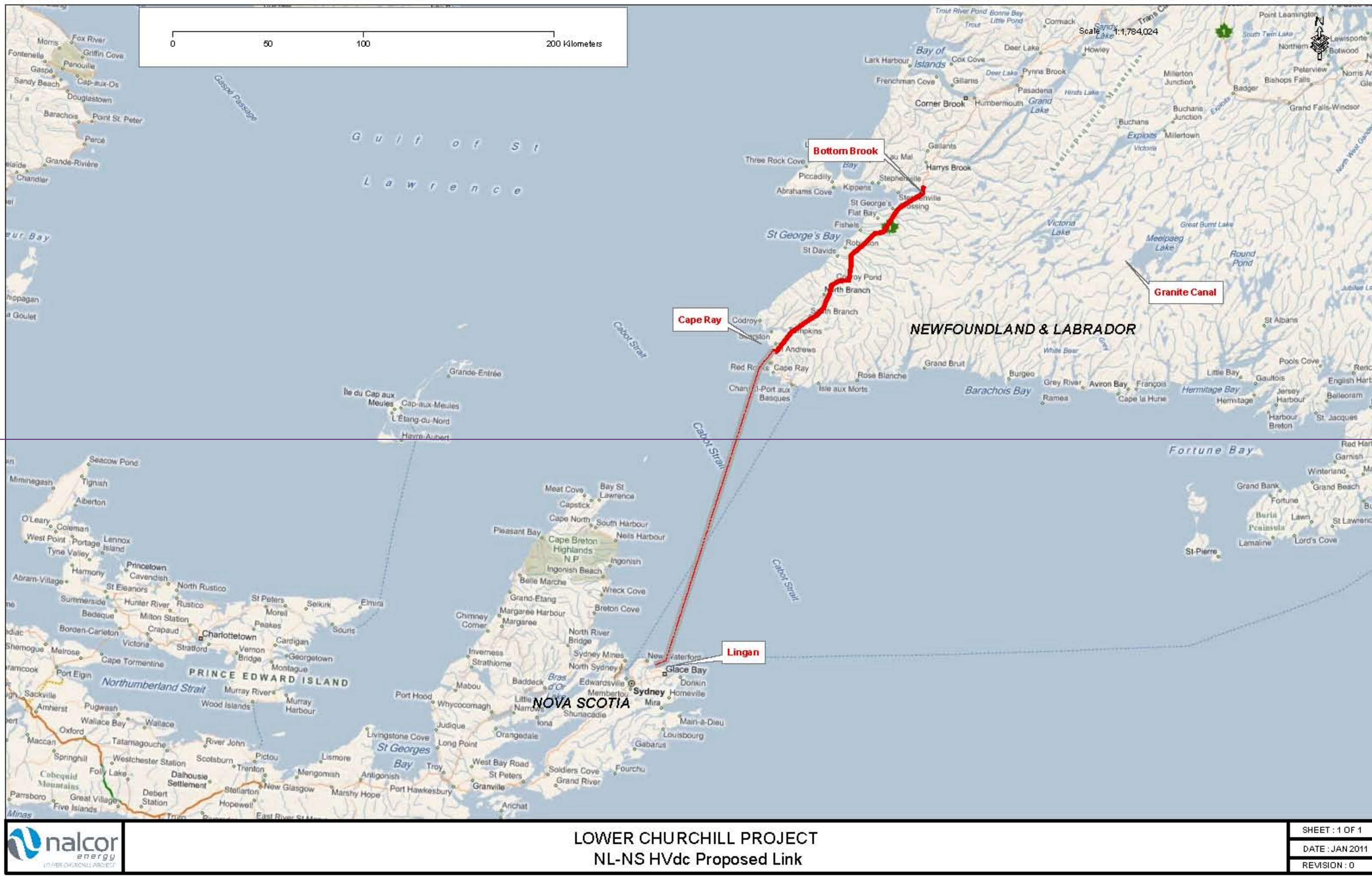

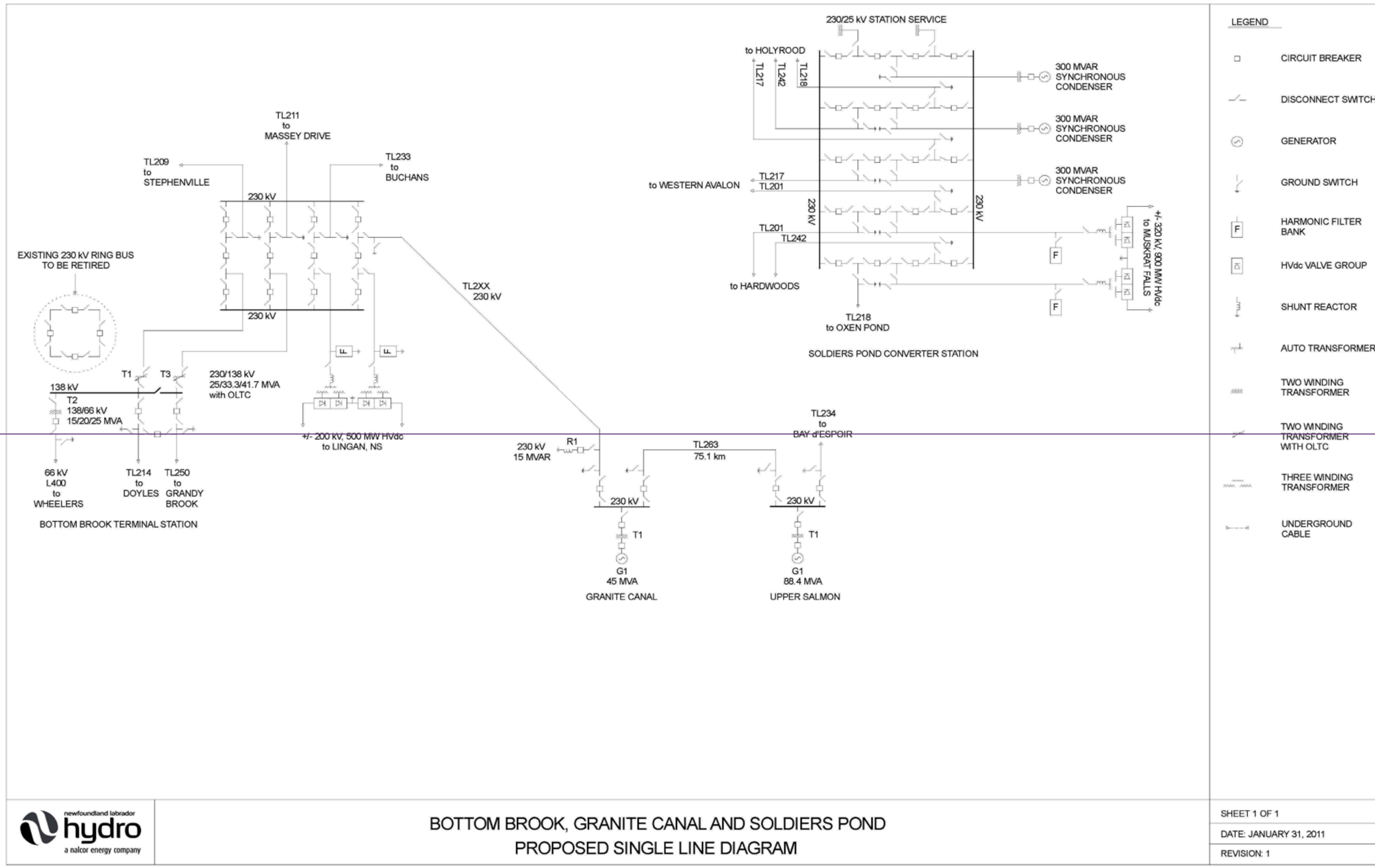
230/25 kV STATION SERVICE
to HOLYROOD
TL217
TL242
TL218
300 MVAR SYNCHRONOUS CONDENSER
300 MVAR SYNCHRONOUS CONDENSER
300 MVAR SYNCHRONOUS CONDENSER
to WESTERN AVALON
TL217
TL201
230 kV
230 kV
TL201
TL242
to HARDWOODS
+/- 320 kV, 900 MW HVdc to MUSKRAT FALLS
TL218 to OXEN POND
SOLDIERS POND CONVERTER STATION
TL211 to MASSEY DRIVE
TL209 to STEPHENVILLE
TL233 to BUCHANS
230 kV
EXISTING 230 kV RING BUS TO BE RETIRED
230 kV
TL2XX 230 kV
T1
T3
138 kV
T2
138/66 kV
15/20/25 MVA
230/138 kV
25/33.3/41.7 MVA
with OLTC
+/- 200 kV, 500 MW HVdc to LINGAN, NS
66 kV L400 to WHEELERS
TL214 to DOYLES
TL250 to GRANDY BROOK
BOTTOM BROOK TERMINAL STATION
230 kV 15 MVAR
R1
TL263 75.1 km
TL234 to BAY d'ESPOIR
230 kV
230 kV
T1
T1
G1 45 MVA
GRANITE CANAL
G1 88.4 MVA
UPPER SALMON
LEGEND
CIRCUIT BREAKER
DISCONNECT SWITCH
GENERATOR
GROUND SWITCH
HARMONIC FILTER BANK
HVdc VALVE GROUP
SHUNT REACTOR
AUTO TRANSFORMER
TWO WINDING TRANSFORMER
TWO WINDING TRANSFORMER WITH OLTC
THREE WINDING TRANSFORMER
UNDERGROUND CABLE
newfoundland labrador hydro a nalcor energy company
BOTTOM BROOK, GRANITE CANAL AND SOLDIERS POND
PROPOSED SINGLE LINE DIAGRAM
SHEET 1 OF 1
DATE: JANUARY 31, 2011
REVISION: 1