NALCOR ENERGY

LABRADOR-ISLAND TRANSMISSION LINK

ENVIRONMENTAL IMPACT STATEMENT

Chapter 3

Project Description

April 2012

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LIST OF ACRONYMS

Acronym	**Description**
µT	micro Tesla
%	percent
Cl	Chlorine ion
H_2O	water (molecule)
OH	Hydroxide ion
ac	alternating current
ATV	all-terrain vehicle
CCA	chromate copper arsenate
CIV	cable installation vessel
Cl_2	Chlorine (molecule)
cm	centimetre
CSA	Canadian Standards Association
dB	decibel
dB(A)	A-weighted decibel
dc	direct current
DFO	Fisheries and Oceans Canada
EMF	electromagnetic field
EMS	Environmental Management System
EPP	Environmental Protection Plan
EPRI	Electrical Power Research Institute
FACE	Field and Corona Effects
GIS	Geographic Information System
GPR	Ground Potential Rise
GPS	Global Positioning System
$H_{2(g)}$	Hydrogen gas
ha	hectare
HDD	Horizontal Directional Drilling
HDPE	high density polyethylene
HVdc	high voltage direct current
IDC	interest during construction
ISO	International Organization for Standardization
kg/yr	kilograms per year
km	kilometre
kPa	kilopascal
kph	kilometres per hour
kV	kilovolt
kV/m^2	kilovolts per square metre

Acronym	Description
L	litre
LiDAR	Light Detection and Ranging
m	metre
MI	Mass Impregnated
mm	millimetre
MW	megaWatt
nA/m^2	nano Amperes per square metre (where nano is 10^{-9})
NLH	Newfoundland and Labrador Hydro
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
NLDEC-WRM	Newfoundland and Labrador Department of Environment and Conservation, Water Resources Management Division
NLEPA	Newfoundland and Labrador *Environmental Protection Act*
º	degrees
O_2	Oxygen
OPGW	Optical overhead groundwire
pH	potential hydrogen
Project	Labrador-Island Transmission Link
PVC	polyvinyl chloride
QMI	Quality Management Institute
ROV	remotely operated vehicle
ROW	right-of-way
SCADA	Supervisory Control and Data Acquisition
SHERP	Safety, Health and Environmental Emergency Response Plan
TCH	Trans-Canada Highway
TL	Transmission Line (when referring to specific line number)
TLH	Trans-Labrador Highway
TLH2	Trans-Labrador Highway Phase 2
TLH3	Trans-Labrador Highway Phase 3
USEPA	United States Environmental Protection Agency
VHF	very high frequency
W/m	Watts per metre

3 PROJECT DESCRIPTION

This chapter describes the Labrador-Island Transmission Link (Project), including converter stations, overhead transmission line, submarine cables, land cables, electrodes and associated infrastructure. It also describes the Construction, and Operations and Maintenance of the Project. As the Project enters the detailed design phase, the Project Description may undergo further definition to refine and optimize technical, economic and environmental features; consequently, specific descriptions of these features are approximate. Such refinements are consistent with the normal planning and design process and with EA as a planning tool and based on the best information available at the time of this submission; these refinements and optimizations will not affect the overall Project footprint or the predicted environmental effects presented in subsequent chapters.

Section 3.1 provides a general overview of the Project, and Section 3.2 describes the Project location. Section 3.3 describes the Project components from north-west to south-east along the transmission line, from the Muskrat Falls converter station to Forteau Point, across the Strait of Belle Isle to Shoal Cove, then across Newfoundland to Soldiers Pond. The Construction schedule, infrastructure and activities are then described in Section 3.4. Schedule and activities associated with Project Operations and Maintenance, including maintenance and repairs, vegetation management and Project inspections, are described in Section 3.5. Section 3.5 also describes emissions during Project Operations and Maintenance. Section 3.6 describes environmental protection and emergency response planning. Workforce requirements for both Project Construction and Project Operations and Maintenance are described in Section 3.7, and estimated Project expenditures are provided in Section 3.8.

3.1 Project Overview

The Project consists of the Construction and Operations of a ± 350 kilovolt (kV) High Voltage direct current (HVdc) electricity transmission system from Central Labrador to the Avalon Peninsula on the Island of Newfoundland (the Island). A two kilometre (km) wide study corridor has been identified within which a transmission line right-of-way (ROW) with an average width of 60 metres (m) will be selected.

The proposed transmission system will include the following key components:

- an alternating current (ac) to direct current (dc) converter station at Muskrat Falls;
- approximately 400 kilometre (km) overhead HVdc transmission line from Muskrat Falls to Forteau Point;
- three, approximately 35 km long, submarine cables across the Strait of Belle Isle (i.e., between Forteau Point and Shoal Cove), with associated onshore infrastructure (transition compounds and land cables at both cable landings);
- approximately 700 km of overhead HVdc transmission line from Shoal Cove to the Avalon Peninsula;
- a dc to ac converter station at Soldiers Pond; and
- shoreline electrodes at L'Anse au Diable and Dowden's Point, and overhead, wood pole electrode lines between the shoreline electrode sites and their respective converter stations.

These components and their Construction, Operations and Maintenance are described in the following sections. A general overview of the main Project components is presented in Figure 3.1-1.

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FIGURE 3.1-1

Labrador - Island Transmission Link: Project Overview

3.2 Project Location

The Project and all of its components will be located wholly within the Province of Newfoundland and Labrador, including the Strait of Belle Isle.

A converter station will be constructed at Muskrat Falls near the ac switchyard for the Lower Churchill Hydroelectric Generation Project in Labrador. From there, the transmission line will travel to the south-east to meet the Trans-Labrador Highway (TLH) corridor, then generally parallels the TLH for approximately 135 km before continuing to extend south-east to Forteau Point (Figure 3.2-1). From Forteau Point, three submarine cables will extend under and across the Strait of Belle Isle and make landfall on the north-western side of the Island, at Shoal Cove (Figure 3.2-2). The transmission line will then head from the landing site, southward along the western portion of the Northern Peninsula, as far as Portland Creek, then in a south-easterly direction across the Island to the Soldiers Pond converter station (Figure 3.2-3 and Figure 3.2-4). Shoreline electrodes will be constructed at L'Anse au Diable in the Strait of Belle Isle (Figure 3.2-5) and at Dowden's Point, Conception Bay (Figure 3.2-6), with electrode lines suspended on wood poles connecting them to their respective converter stations.

At this stage of Project planning, and prior to ROW selection, the various forms of land tenure (e.g., leases, grants) required for the Project are unknown. Once a ROW has been finalized, Nalcor Energy (Nalcor) will obtain all required forms of land tenure and will comply with the *Lands Act*.

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FIGURE 3.2-1

Transmission Corridor: Muskrat Falls to Forteau Point

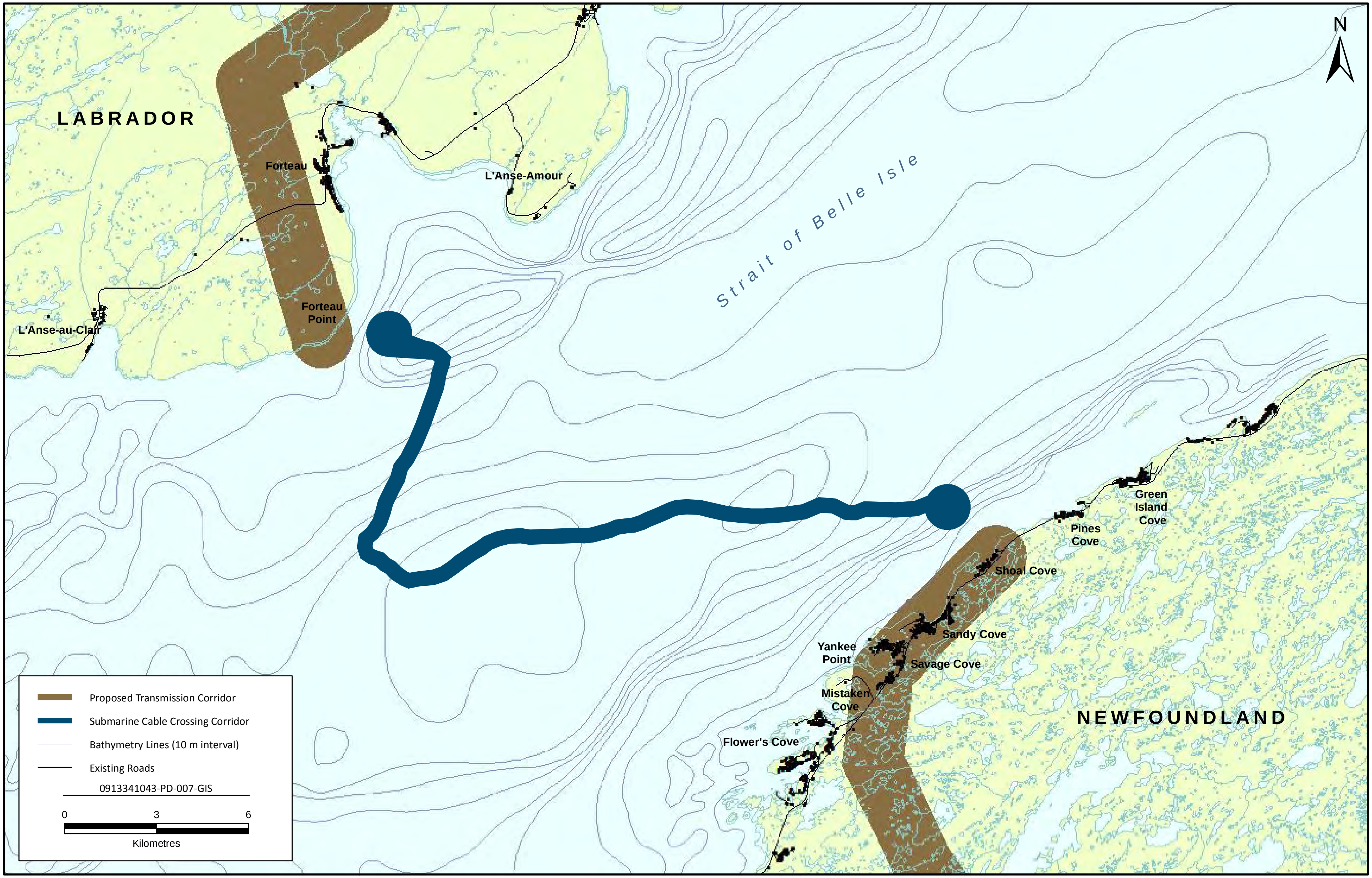

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FIGURE 3.2-2

Strait of Belle Isle Submarine Cable Crossing Corridor

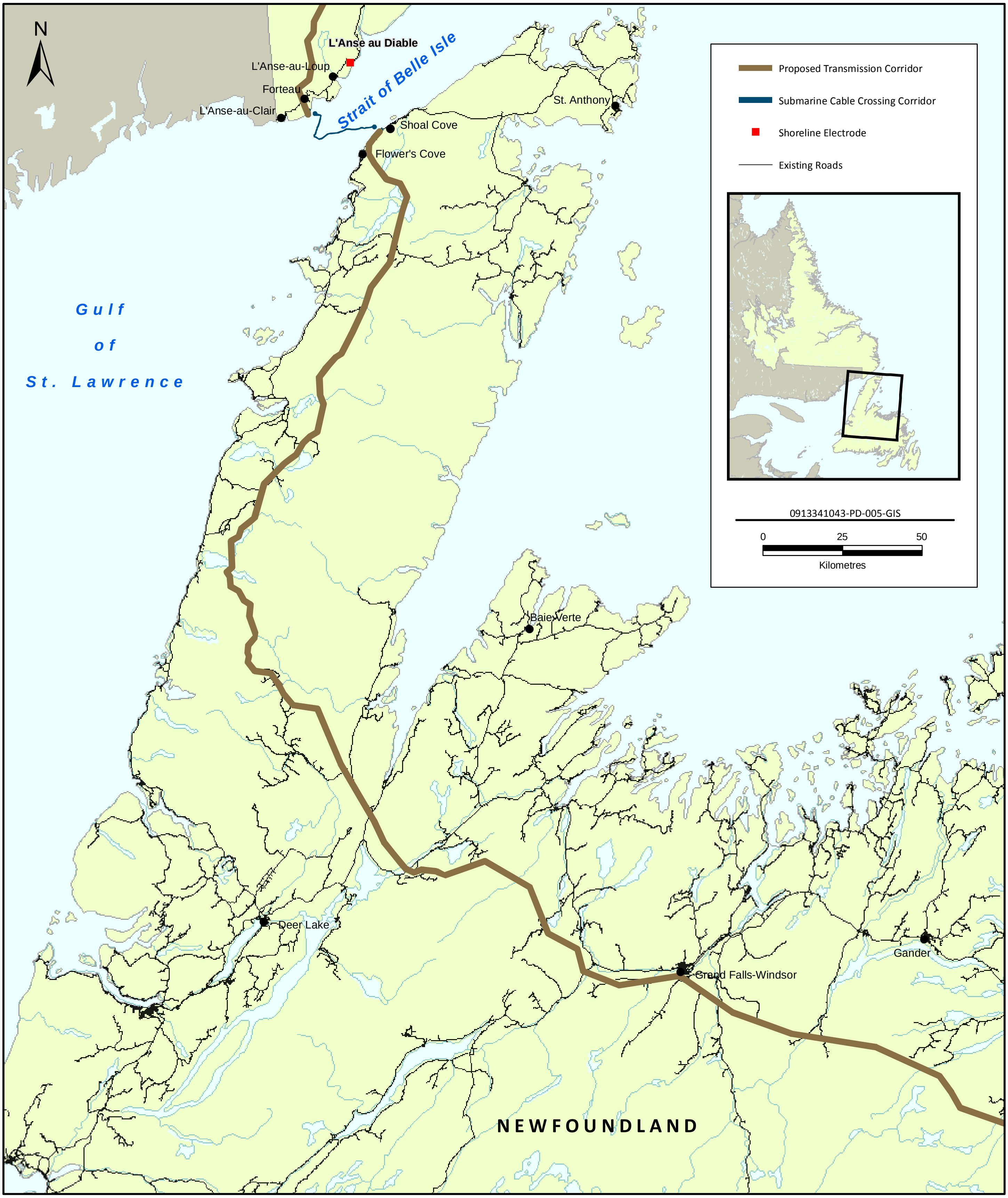

FIGURE 3.2-3

Transmission Corridor:
Strait of Belle Isle to Central Newfoundland

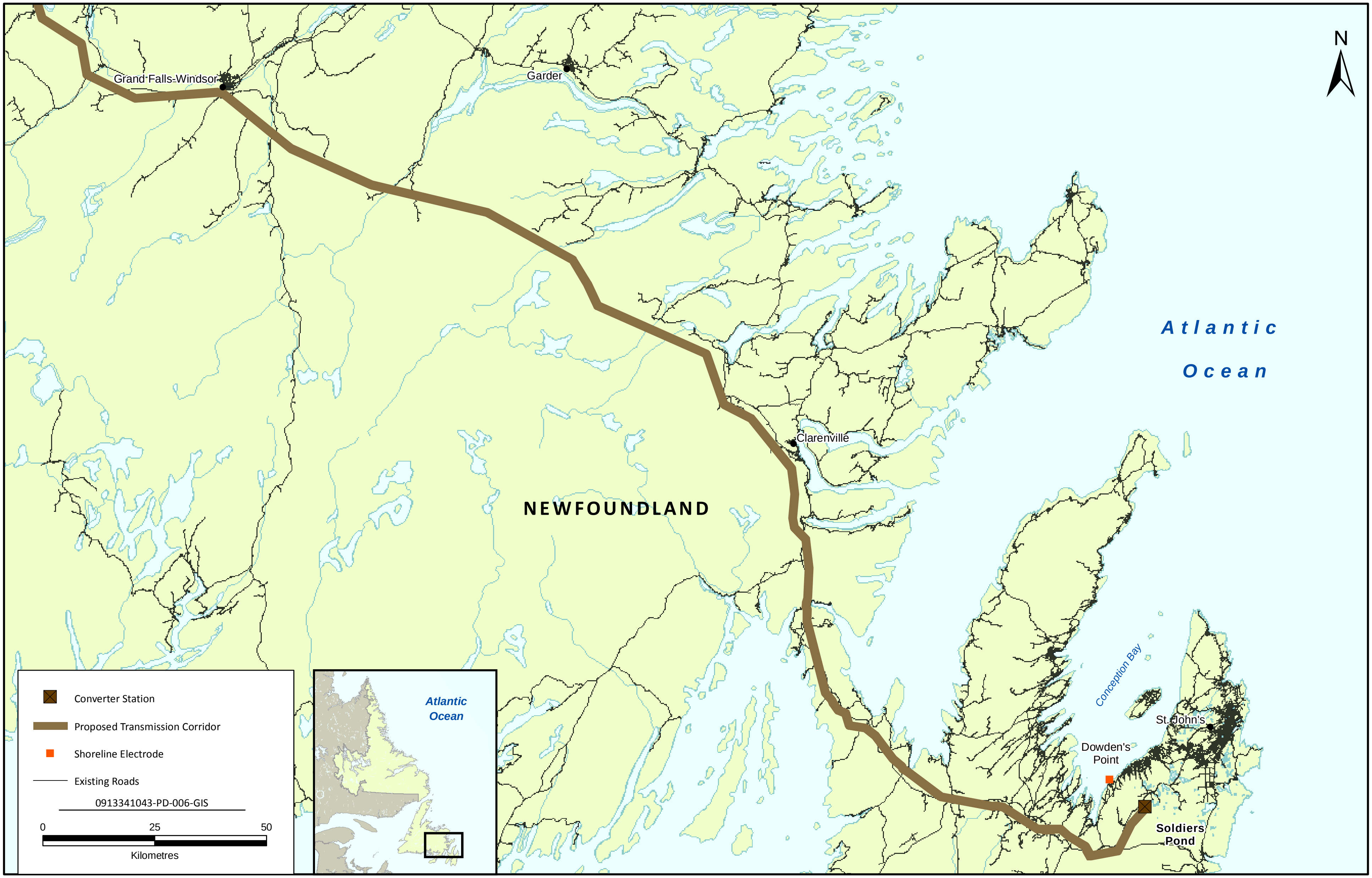

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FIGURE 3.2-4

Transmission Corridor: Central Newfoundland to Soldiers Pond

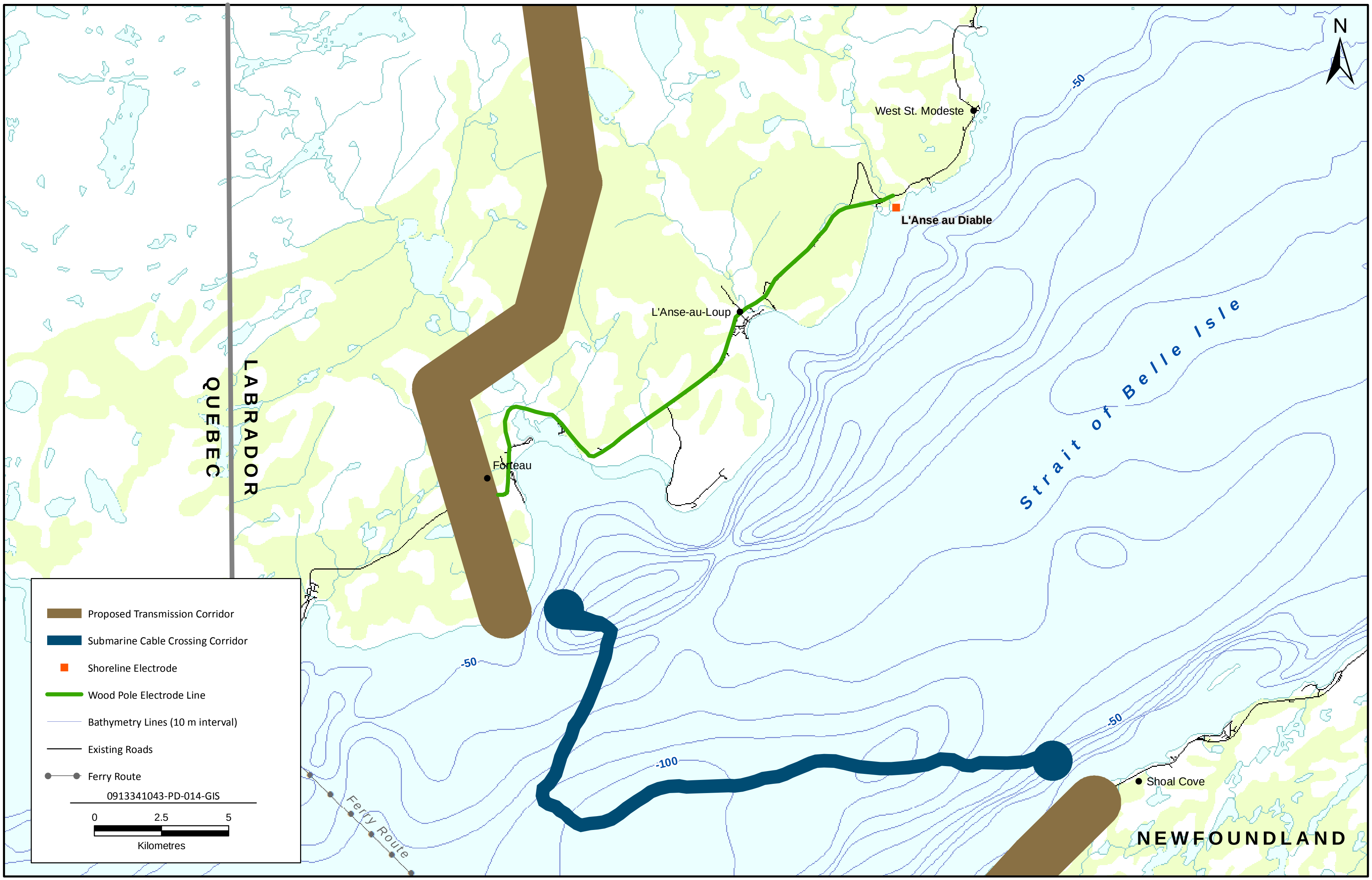

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FIGURE 3.2-5

Shoreline Electrode and Wood Pole Electrode Line - L'Anse au Diable

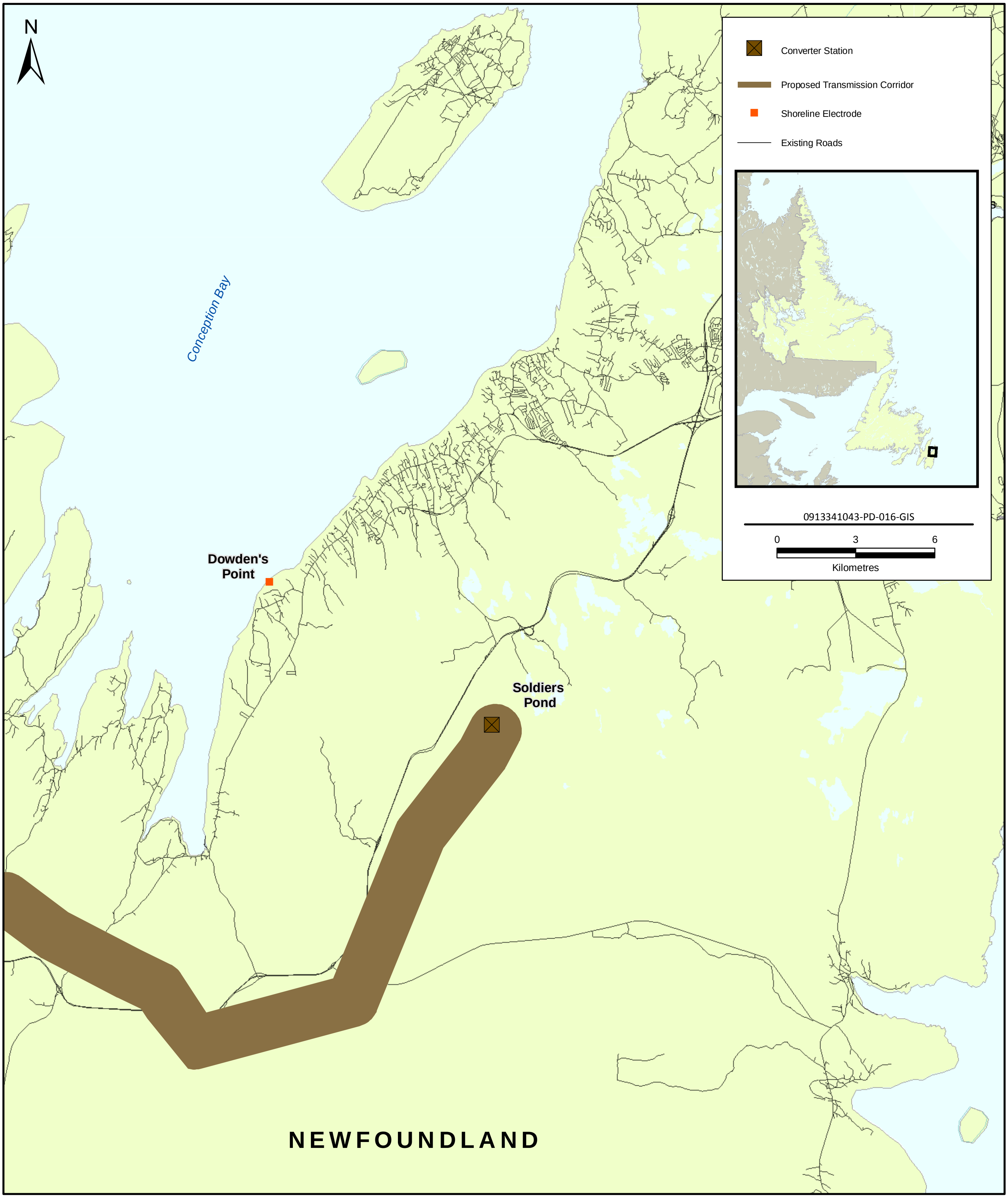

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FIGURE 3.2-6

Shoreline Electrode - Dowden's Point

3.3 Project Components and Layout

This section provides a general overview of the Project's key components, including the converter stations, the HVdc transmission line, the Strait of Belle Isle cable crossing, and the shoreline electrodes and connecting wood pole electrode lines. This section also describes some potential upgrades to the Island's existing electricity transmission system that may be required to accommodate the 900 Megawatts (MW) of additional power transmission.

3.3.1 Muskrat Falls Converter Station

A portion of the electricity generated by the Lower Churchill Hydroelectric Generation Project will be converted to dc for transmission. This will be accomplished by converters using semiconductor valves that allow current to flow in only one direction, thus converting the current from ac to dc or from dc to ac. The proposed converter station locations are Muskrat Falls and Soldiers Pond.

The Muskrat Falls converter station will be located near the ac switchyard for the Lower Churchill Hydroelectric Generation Project, at the approximate coordinates 53° 14' 18" N, 60° 45' 30" W, as shown in Figure 3.2-1. The Muskrat Falls converter station will consist of a converter yard that contains HVdc equipment, including converter transformers, converter valves, a valve cooling system, and possibly a standby or emergency diesel generator and fuel storage facilities. This equipment is described in Table 3.3.1-1, and the conceptual layout of the converter yard is provided in Figure 3.3.1-1. The Muskrat Falls converter station will have a dc voltage rating of ± 350 kV and an ac voltage rating of 315 kV.

Table 3.3.1-1 Muskrat Falls Converter Station Equipment

Equipment	Description / Function
Converter transformers	– Establish and maintain system voltages at specified levels – Provide an electrical connection between the ac and dc systems – Provide an impedance to limit fault currents
Converter valves	– Consist of large groups of power electronic switches that allow for the conversion of electricity from dc to ac at the inverter and from ac to dc at the rectifier – Valves are housed in an enclosure known as the valve hall
Valve cooling systems	– Designed to prevent the overheating of electronic equipment – Consist of a closed loop water system that is cooled by forced air – Water in the closed loop system is de-ionized and supplemented with glycol to prevent freezing
Power supply	– Specified to ensure that the HVdc system meets reliability, availability and maintainability requirements – May include a diesel generator (as standby for emergency) and fuel storage facilities
ac filter	– Provide the required reactive power for converter operation – Filter the harmonic currents into the ac system that are generated by the converters
dc yard	– Accommodate dc side bus work, dc filters, arresters, smoothing, reactors, dc side disconnect and grounding switches, and measuring instruments

FIGURE 3.3.1-1

Conceptual Layout of Muskrat Falls Converter Station

The Muskrat Falls converter station will occupy an area of approximately 450 m by 600 m. The converter station will have a gravel surface, and a vegetation control program will restrict vegetation growth. Some parking areas or specific roadways within the converter station may be paved. A series of concrete foundations and galvanized steel structures will support the electrical equipment and switchgear. A grounding grid will be installed beneath the foundations. Two types of foundation may be used to support the structures within the converter yard: rectangular strip footings and square pier footings. Equipment that requires shelter from the elements will be enclosed in the valve halls. Unauthorized access to the converter station will be restricted by a galvanized steel security fence and a locked gate. As appropriate, "high voltage" signage will be posted at the converter station.

Four single circuit 315 kV lines, each supported by two to three transmission towers, will link the Muskrat Falls converter station to the Lower Churchill Hydroelectric Generation Project. As the Muskrat Falls converter station is near the Lower Churchill Hydroelectric Generation Project, the converter station will be accessed using existing roads and new access roads that will be established for the Lower Churchill Hydroelectric Generation Project. No new access roads or water supply systems are planned for the Muskrat Falls converter station as part of this Project. New washroom facilities and an associated sewage treatment system are planned which will comply with provincial guidelines and regulations.

3.3.2 Transmission Line

A 2 km wide on-land transmission corridor and a 500 m wide submarine cable crossing corridor were selected for the transmission line, as described in Section 2.11.2. The on-land transmission line will consist of three wires, also referred to as poles, (i.e., two conductors and an optical groundwire (OPGW)) suspended on galvanized steel lattice towers, connecting the Muskrat Falls converter station with Forteau Point and Shoal Cove with Soldiers Pond. The submarine cable crossing will include three cables (i.e., two for electricity transmission, and one spare cable) connecting the Forteau Point on-land transmission line with the Shoal Cove on-land transmission line.

The transmission corridor will be approximately 1,100 km long, with approximately 1,065 km of the corridor being land-based and 35 km being submarine. The transmission corridor selection process considered the following:

- minimizing the length of the transmission line to the extent possible and practical;
- avoiding unfavourable meteorological conditions (such as heavy icing and / or strong winds);
- avoiding difficult terrain where possible;
- minimizing the requirement for new access roads and trails;
- minimizing watercourse and wetland crossings;
- avoiding interactions with communities, protected areas and other known environmentally and socially important areas where possible and practical;
- avoiding areas of known archaeological and historical significance; and
- for the submarine cable crossing, finding the shortest access to deep water and making use of natural seabed features to shelter the cables in deep valleys and trenches, thus minimizing the possibility of interaction with fishing areas and activity, and sea ice and ice bergs.

The specific routing of the transmission line within the selected corridor will be conducted as part of the detailed Project design. This will involve consideration of information on the existing natural and human environments within the transmission corridor to identify and evaluate key environmental and socioeconomic factors and issues for consideration in the final ROW route selection process. Inputs to this analysis and planning process will include information on the biophysical and socioeconomic environments, any additional baseline information collected, issues identified as part of the environmental assessment process, and the results of the public and stakeholder consultations.

Within the land-based corridor segments, a ROW will be cleared for the transmission line, as appropriate. The width of the ROW will vary between less than 60 m in some areas to approximately 80 m in others, with an average width of 60 m. This width is determined primarily through consideration of the span between towers and the sag of the conductor. The amount that the transmission line can swing in the wind and the resulting ROW width required for obstacle clearance is directly related to the tower span and conductor sag. Although there may be a different ROW width in the different meteorological loading regions (as described in Section 3.3.2.1), the ROW width will not change from span to span within the same region.

3.3.2.1 Muskrat Falls to Forteau Point

Transmission Corridor

The Labrador portion of the transmission corridor connects the Muskrats Falls converter station to Forteau Point (Figure 3.3.2-1 and Figure 3.3.2-2). The corridor begins at the Muskrat Falls converter station then heads south-east to meet the Trans-Labrador Highway (Phase 3) (TLH3). It then follows the TLH3, diverging from the highway at points where the highway makes turns that cannot be negotiated with a transmission line. Approximately 135 km from Muskrat Falls, the transmission corridor diverts away from the TLH3 and heads in a south-easterly direction, crossing a landscape of bogs and unnamed lakes. Approximately 310 km from the Muskrat Falls converter station, the transmission corridor turns south, avoiding several large ponds (e.g., Island Pond, Silver Pond, Stag Pond, Big Pond and Little Pond), then terminates at the Forteau Point transition compound.

Transmission Infrastructure

The HVdc transmission line will consist of two poles and a shield wire suspended on galvanized steel lattice towers. Two poles will carry power, and an OPGW will provide shielding from lightning strikes. The OPGW includes a fibre optic cable for communication between the converter stations. The Project conductors and transmission towers will be designed to meet Canadian Standards Association (CSA) standards, and they will be of similar design throughout the length of the transmission line, with some variation to address topographic, meteorological and environmental conditions, and technical requirements.

Transmission Towers

Galvanized steel lattice transmission towers approximately 35 to 45 m high will be used for the Project. Tower heights are generally governed by clearance requirements and depend on the local conditions such as meteorological loadings and topography crossed by the ROW. Conductor clearance (i.e., the distance between the ground and the closest point of the transmission line span) will meet CSA C22.3 Standard No. 1-10 for road crossings. The conductor clearance will meet CSA C22.3 Standard No. 1-10 for road crossings. The conductor clearance will be a minimum of 7.4 m, increasing to 9.2 m at highway crossings.

The configuration of the steel lattice transmission towers may be altered due to changes in line angle, design capacity or environmental loading. There are two basic tower configurations: suspension and dead end. Suspension towers hold the conductor in the air, whereas dead end towers support the conductor tension. Figure 3.3.2-3 shows the two basic transmission tower configurations. Nalcor will meet the CSA conductor clearance standard applicable to the type and size of the watercourse and will comply with the *Navigable Waters Protection Act*.

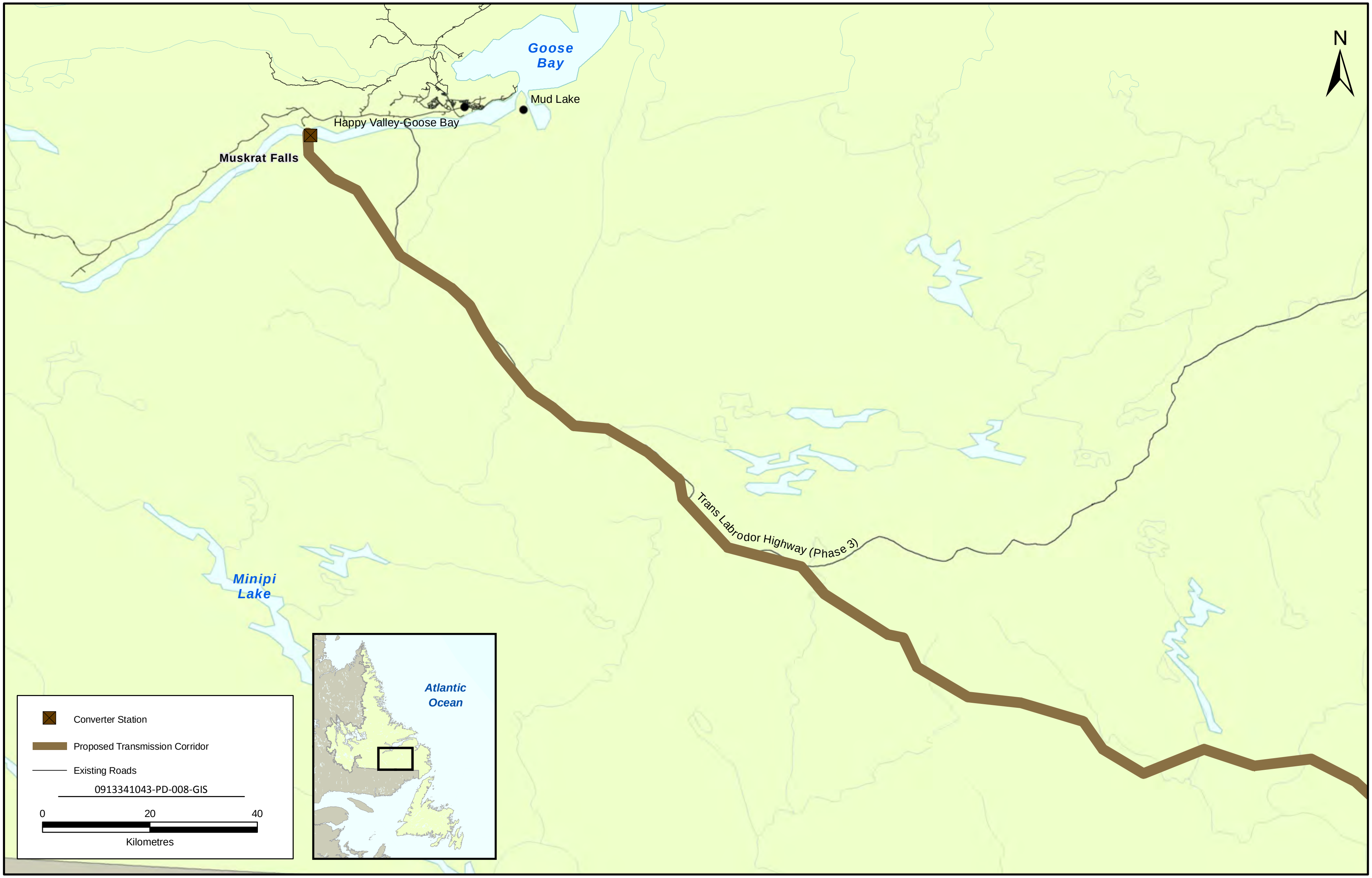

FIGURE 3.3.2-1

Transmission Corridor: Muskrat Falls Converter Station to Forteau Point (kilometre 0 to kilometre 200)

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FIGURE 3.3.2-2

Transmission Corridor: Muskrat Falls to Forteau Point (kilometre 200 to kilometre 385)

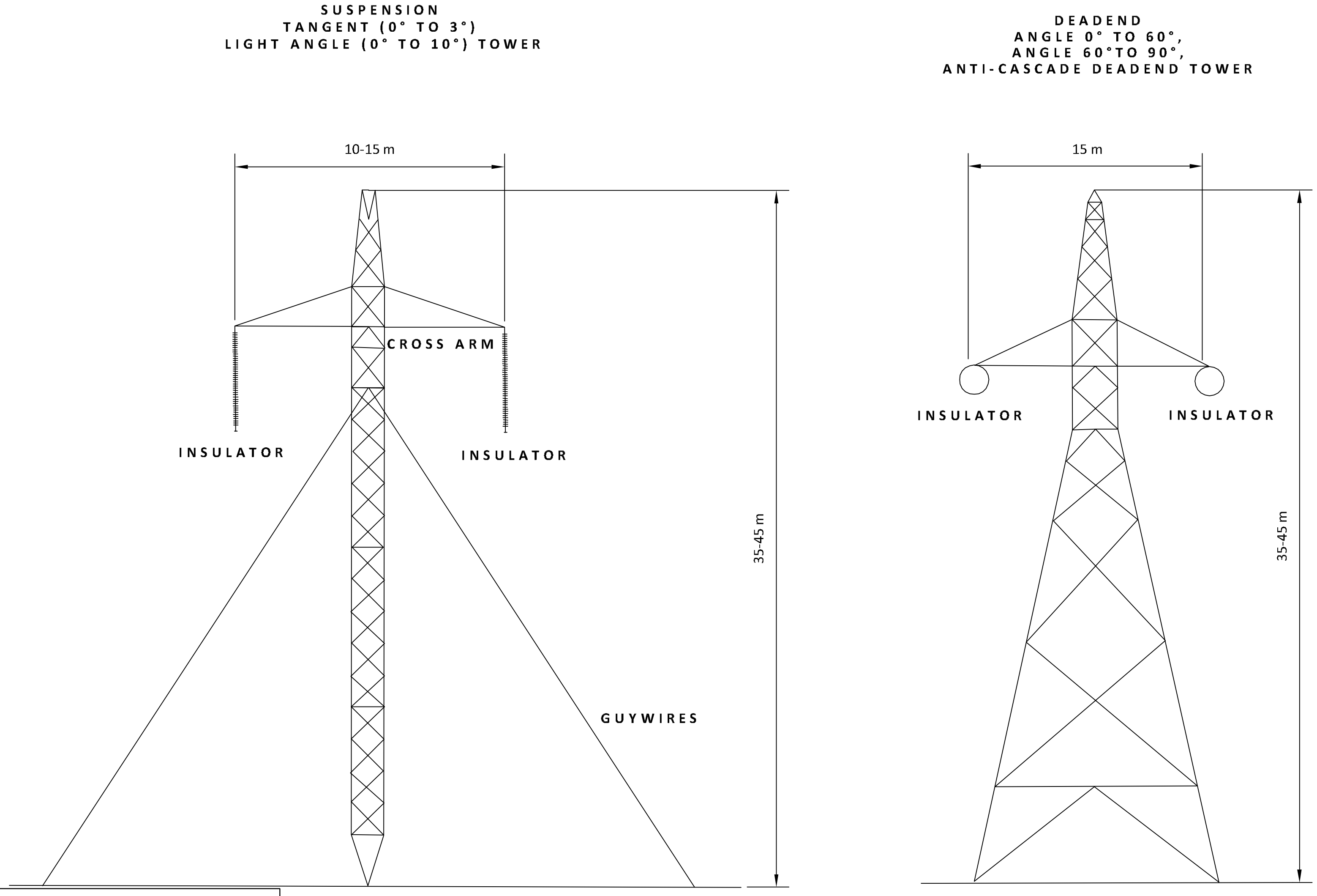

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FIGURE 3.3.2-3

Transmission Towers

Where the transmission line changes direction, the towers at the turning points are designed to withstand higher forces. Dead-end towers capable of withstanding large forces are placed at large angle turns. Anti-cascade towers, also capable of withstanding large forces, are placed throughout the line to limit the potential for cascade failure of sequential towers. Anti-cascade towers will be installed at optimal locations such that no more than 15 to 20 towers would fail in a single cascade failure situation.

Preliminary foundation design was completed using the forces resulting from the transmission tower analysis and data available from similar existing developments. Based on the soil conditions along the transmission corridor, three basic categories of foundations were selected:

- overburden type footing for a soil with bearing capacity of 300 kilopascals (kPa) (i.e., strong soil);
- overburden type footing for soil with a bearing capacity of 100 kPa (i.e., weak soil); and
- rock type foundation.

Steel grillage type foundations (Figure 3.3.2-4) will generally be used for all soil applications. There is a possibility that other types such as driven piles will be used as required. Weaker soils will require larger and deeper steel grillage structures. Rock foundations (Figure 3.3.2-5) will be used where bedrock is encountered. Suspension transmission towers will have a single tower mast foundation and four guy wire supports connected to foundations in the ground. Larger dead end towers will require four foundations and will be self-supporting, without the use of guy wires. Table 3.3.2-1 summarizes the principal design features of each basic tower type, including foundation design.

The transmission towers are designed to withstand loadings associated with a 50-year return period meteorological event (i.e., a wind or icing event that is statistically expected to occur every 50 years). As part of the design process, three general meteorological loading regions were defined for the corridor between Muskrat Falls and Soldiers Pond:

- normal region, where ice and wind loading are representative of average loading for the province;
- alpine region, where the corridor is subjected to very severe wind and ice loads; and
- eastern region, where high levels of ice are known to occur.

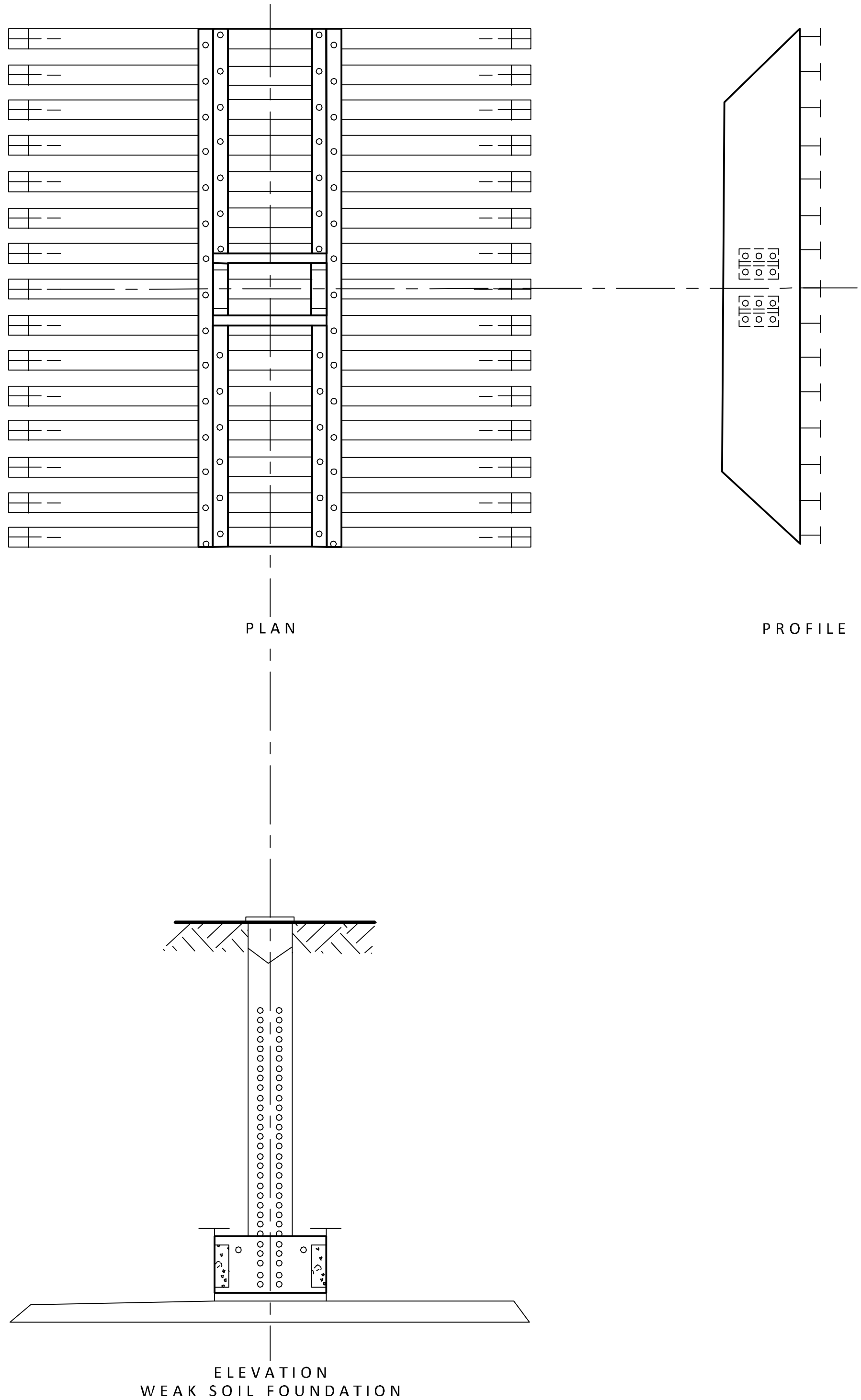

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FIGURE 3.3.2-4

Overburden Steel Grillage Foundation

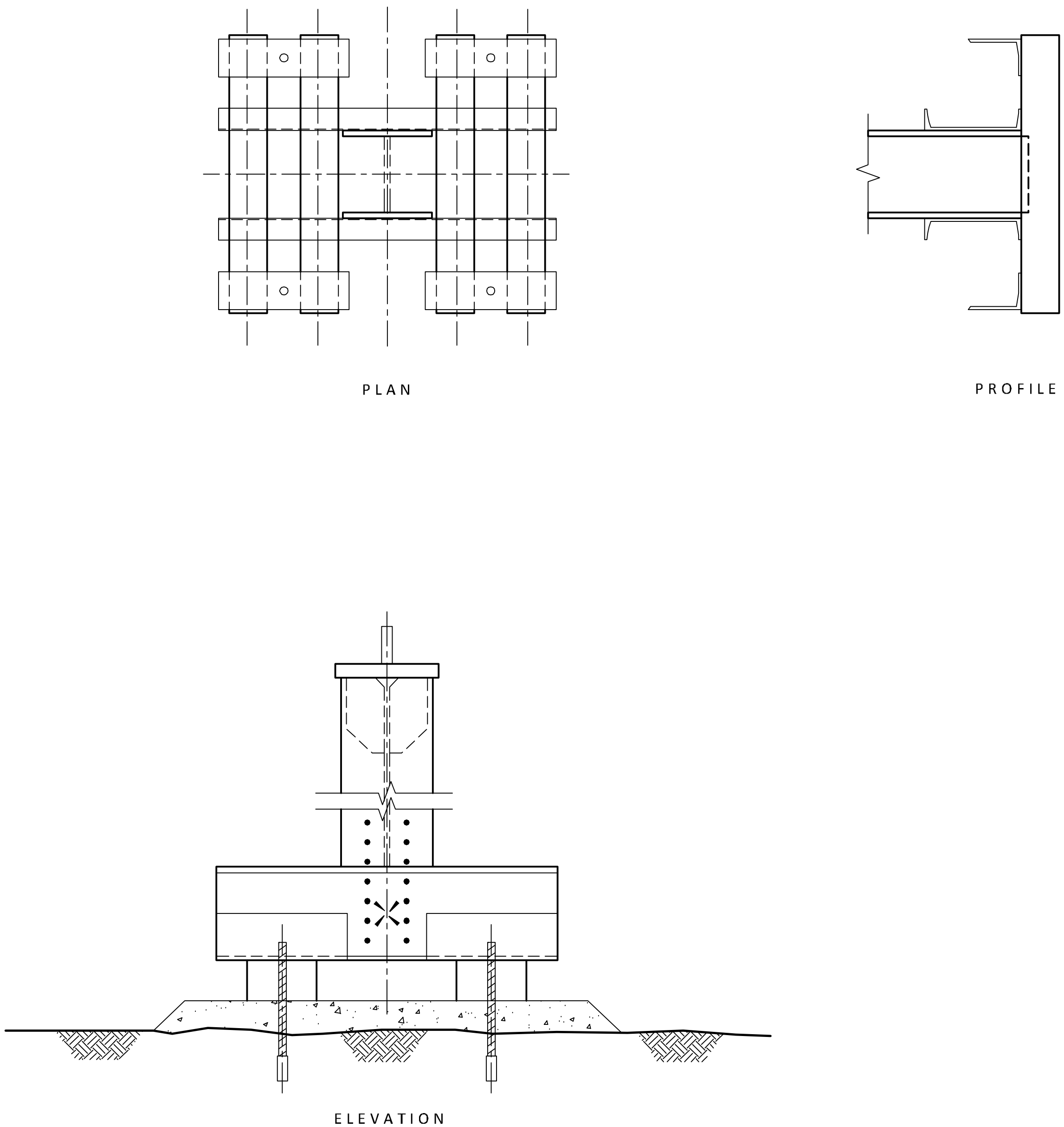

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FIGURE 3.3.2-5

Rock Type Foundation

Table 3.3.2-1 Transmission Tower Types

Tower Type	Use	Description	Foundation
Suspension – Tangent (0 to 3 degrees (°))	Used on straight line sections of the transmission line	– Approximate height of 45 metres (m) – Cross arm length of 10 to 15 m – Supported by four high strength guy wires	– Guy anchors will be 1 m by 2.5 m, buried 3.5 m deep, with anchor rods to the surface – Mast foundation will be 2.5 m by 2.5 m, buried 2.5 m deep – Rock foundation for guy anchor and tower mast will be 1 m by 1 m, attached to rock surface using rock bolts
Suspension – Light Angle (0 to 10°)	Used for up to 10° angles or heavier loads	– Approximate height of 45 m – Cross arm length of 10 to 15 m – Supported by four high strength guy wires	– Guy anchors will be 1.5 m by 3 m, buried 3.5 m deep, with anchor rods to the surface – Mast foundation will be 2.5 m by 2.5 m, buried 2.5 m deep – Rock foundation for guy anchor and tower mast will be 1 m by 1 m, attached to the rock surface using rock bolts
Dead end (Angle 0 to 60°)	Used at turning angles between 0° and 60°	– Self-supporting towers that stand on four legs. These are heavier and stronger than guyed towers – Self-supporting towers are typically shorter (approximately 40 m) than the light angle structures and have 10 to 15 m long cross arms	– Each foundation will be 4 m by 4 m, buried 3.5 m deep – Rock foundations will be 1.5 m by 1.5 m, attached to the rock surface using rock bolts
Dead end (Angle 60 to 90°)	Used at turning angles between 60° and 90°	– Self-supporting towers that stand on four legs – Approximate height of 40 m – Cross arm length of 15 m	– Each foundation will be 5 m by 5 m, buried 4.5 m deep – Rock foundations will be 2 m by 2 m, attached to the rock surface using rock bolts
Dead end (Anti-cascade)	Installed at optimum locations to limit a cascade failure event to 15 to 20 towers	– Heavier than the other tower types – Self-supporting towers that stand on four legs – Approximate height of 40 m – Cross arm length of 10 to 15 m	– Each foundation will be 5 m by 5 m, buried 4.5 m deep – Rock foundations will be 2 m by 2 m, attached to rock surface using rock bolts

These meteorological loading regions were further classified into 16 zones (Figure 3.3.2-6). The criteria for each of these 16 zones is presented in Table 3.3.2-2.

Table 3.3.2-2 Detailed Meteorological Zones Between Muskrat Falls and Soldiers Pond including Zone Criteria

Meteorological Loading Zone	Zone	Region	Maximum Ice	Maximum Wind	Combined Ice and Wind
Normal	1	Inner Labrador	50 mm (Glaze)	105 km/h	25 mm (Glaze) and 60 km/h
	3	Labrador Coast	50 mm (Glaze)	120 km/h	25 mm (Glaze) and 60 km/h
	4	Northern Peninsula Coast	50 mm (Glaze)	120 km/h	25 mm (Glaze) and 60 km/h
	6	Northern Peninsula	50 mm (Glaze)	120 km/h	25 mm (Glaze) and 60 km/h
	8a	Central-West Newfoundland	50 mm (Glaze)	120 km/h	25 mm (Glaze) and 60 km/h
	8b	Central-West Newfoundland	50 mm (Glaze)	105 km/h	25 mm (Glaze) and 60 km/h
	10	Central-East Newfoundland	50 mm (Glaze)	105 km/h	25 mm (Glace) and 60 km/h
Alpine	2a	Alpine Labrador	115 mm (Rime)	135 km/h	60 mm (Rime) and 95 km/h
	2b	Alpine Labrador	135 mm (Rime)	135 km/h	70 mm (Rime) and 95 km/h
	2c	Alpine Labrador	115 mm (Rime)	135 km/h	60 mm (Rime) and 95 km/h
	5	Highlands of St. John	115 mm (Rime)	150 km/h	60 mm (Rime) and 105 km/h
	7a	Long Range Mountains Crossing	115 mm (Rime)	180 km/h	60 mm (Rime) and 125 km/h
	7b	Long Range Mountains Crossing	135 mm (Rime)	180 km/h	70 mm (Rime) and 125 km/h
	7c	Long Range Mountains Crossing	115 mm (Rime)	180 km/h	60 mm (Rime) and 125 km/h
	9	The Birchy Narrows	75 mm (Glaze)	130 km/h	45 mm (Glaze) and 60 km/h
Eastern	11	Eastern Newfoundland	75 mm (Glaze)	130 km/h	45 mm (Glaze) and 60 km/h

Meteorological loading for the transmission system for the Project was determined using:

- historical assessment and transmission line modelling using data and information collected over a 50-year time frame;
- design maximum ice loads that are realistic for the Newfoundland and Labrador environment, yet exceed the CSA Standard C22.3 (No. 1 Overhead Systems and No. 60826 Design Criteria of Overhead Transmission Lines) (CSA Standard), usually equating to CSA Standard 500-year loads or more; and
- design maximum wind loads that meet CSA Standard 50-year wind speeds, and are higher than historical transmission line design levels (even though Nalcor transmission lines have never failed due to extreme wind events).

FIGURE 3.3.2-6

Meteorological Loading Regions

Wind Loading

Newfoundland and Labrador Hydro (NLH) has historically designed most of its transmission lines to a maximum wind load case of 175 kilometres per hour (kph) gust wind speed which corresponds to a sustained wind speed of approximately 100 kph. To date, NLH has not had a structural failure of a transmission line due to the maximum wind load case. Based on NLH's operating experience over the past 50 years, and the fact that there have been no failures of the transmission system related to the maximum wind load, NLH considers the 1:50 year wind loads as per the CSA Standard to be appropriate, and that no amplification of these wind loads is required. Therefore, Nalcor has adopted the 50-year CSA Standard wind loads for the design of the Project for all but the alpine region.

Analysis of wind speeds on the Long Range Mountains (LRM) is based on a correlation study between the Environment Canada Meteorological Weather Station at Daniel's Harbour on the Northern Peninsula and a wind speed monitor installed in the LRM. This analysis resulted in a reference wind speed of 180 kph, much higher than any wind load in the province but considered realistic for this area. Considering that topographical features amplify the wind speed profile in the LRM, this reference wind speed of 180 kph as the 1:50 year design wind speed was selected as compared to the 120 kph wind speed specified in the CSA Standard. Nalcor also applied the 180 kph reference wind speed to the other alpine regions (i.e., Highlands of St. John and Labrador coast) along the transmission corridor. The selection of this elevated reference wind speed is considered appropriate for those areas.

Ice Loading

Through decades of experience operating transmission equipment in harsh environments, NLH has gained extensive knowledge of the necessary design criteria for its electricity infrastructure. NLH has designed transmission lines to ice loads higher than the CSA Standard in recent years. Icing amounts for a 50-year return period range from 15 mm of radial glaze ice (ice thickness measured from the conductor surface) in central Labrador up to a maximum of 40 mm on the Avalon Peninsula. CSA Standard recommends a factor of 1.5 times the reference amount to account for the spatial nature of transmission systems, and the elevation correction for conductors which are assumed to be 20 m higher than the reference level of 10 m above ground. This would equate to 50-year design loads from 23 mm to 60 mm across the transmission system. CSA Standard also recommends that spatial factors less than 1.5 may be substantiated by local data and experience.

In the case of Newfoundland and Labrador, Nalcor has determined that the design ice loads should be higher than the CSA Standard based on a significant amount of historical data. Studies completed by Meteorology Research Inc., Teshmont, and RSW for the Project produced loads of up to 100 mm of radial glaze ice. These loads are significantly higher than the CSA Standard loads and there is very little evidence of loads coming close to this level in the history of transmission lines in the province. A study completed by NLH, also for the Project, produced loads that were significantly lower than the CSA Standard loads, loads which have been experienced relatively frequently in the province. The discrepancy in findings between the studies were considered in determining what loads should be used in the design criteria. While the ice loading studies that cover the entire Project area produced up to 100 mm of radial glaze ice, recent meteorological load studies performed by NLH which were focused on more localized loading in the NLH electricity system have produced load cases of 75 mm of radial glaze ice on the Avalon and 50 mm of radial glaze ice for the Granite Canal transmission line in 2001. Both locations are based on an extreme value analysis using 40 years of data and the analyses resulted in what was calculated statistically to be 1:50 year return period load cases. These local studies, the previous Project wide studies, as well as operating experience were all used to determine the final ice load cases.

The alpine regions are areas above 350 m elevation that experience significant levels of rime (in-cloud) ice. Although rime ice can occur at any level, rime ice load cases exceed the glaze ice load cases in alpine areas. Because of this, rime ice load cases are used for transmission line design in alpine regions. Because the CSA Standard does not cover this type of ice, an intense meteorological study including atmospheric modelling and correlation with test spans on the LRM was performed using international experts in rime ice formation on transmission lines. As a result of this study, Nalcor selected a maximum ice load case of up to 135 mm of radial rime ice for design in all alpine regions.

Tower Numbers and Span

The number of towers required between Muskrat Falls and Forteau Point will depend on tower span distances, as determined by topographic, meteorological and associated technical requirements. Based on an average span of 300 to 430 m in a normal loading region and 165 to 210 m in an alpine loading region, there will be approximately 910 to 1,305 towers between the Muskrat Falls converter station and the Forteau Point transition compound, of which approximately 90 percent (%) will be suspension type structures (Table 3.3.2-3).

Table 3.3.2-3 Preliminary Estimate of Number and Types of Towers to be Constructed Between Muskrat Falls and Forteau Point

Tower Type	Number of Towers in Each Meteorological Region (Span)			Total
	Normal (300 to 430 m)	Alpine (165 to 210 m)	Eastern (255 to 420 m)	
Suspension	790 to 1,170	35 to 45	0	**825 to 1,215**
Dead end	75 to 80	10	0	**85 to 90**
Total	**865 to 1,250**	**45 to 55**	**0**	**910 to 1,305**

Insulators

Insulators made from glass or porcelain will be used to prevent electricity from travelling from the conductor to the tower, thus electrifying the tower and causing a fault in the system (flashover). In most locations, the transmission line will have 30 to 40 insulators per string, depending on contamination level. Contamination such as salt spray and icing can reduce the ability of an insulator to resist flashover, so the transmission corridor avoids coastal areas and areas prone to icing, where possible and practical. In locations where salt spray or icing are expected to occur, the number of insulators may be increased to limit the potential for flashover. Increasing the number of insulators may require increasing tower height and cross-arm length.

Conductors

Two poles will be connected to the two lattice steel cross arms on the transmission towers. Each pole will consist of a single conductor or a bundle of conductors. Conductors are wires (or bundles of wire) that carry the electricity. Transmission lines operating at 350 kV generally include a "bundle" of two or more relatively small conductors. The conductors will be either all aluminum or aluminum with a steel core, and it will have a diameter of approximately 55 to 60 millimetres (mm). As part of detailed design, the type of pole to be used (bundle or single; including material) will be determined.

Optical Ground Wire

An OPGW is a type of cable that combines the functions of grounding and communications, which will be suspended from the tops of the transmission towers. It contains a tubular structure with one or more optical fibres, surrounded by layers of steel and aluminum wire. The OPGW cable is expected to have a diameter of 12 to 22 mm and it will be suspended along the tops of the transmission towers. The conductive part of the cable bonds adjacent towers to the earth ground (i.e., the counterpoise) and shields the conductors from lightning strikes. The optical fibres are used for the high-speed transmission of data between the two converter stations.

Counterpoise

To reduce the electrical resistance between the transmission towers and the ground, counterpoise will be installed along the ROW. It will be attached to the base of each tower to further protect the transmission line against damage from lightning surges. The counterpoise will be a No. 1 galvanized steel wire, ploughed approximately 30 centimetres (cm) beneath the ground and buried. The counterpoise will generally follow the approximate centre line of the ROW throughout the length of the transmission line. Where required and appropriate, the counterpoise will be terminated using grounding rods (i.e., where the transmission line crosses large waterbodies or watercourses). The grounding rods will be made of either copper clad steel or galvanized steel and will typically be 19 mm in diameter and 2,500 mm in length.

Transition Compound

Up to 1,000 m from the shoreline at Forteau Point, the overhead transmission line will enter a transition compound. The location of the transition compound will be determined during the detailed Project design and will depend on the topography near the submarine cable crossing point. The transition compound will be approximately 100 m x 100 m, and will consist of an enclosed shelter approximately 50 m long by 50 m wide and up to 16 m high, and will house the end terminations (i.e., the stand, insulator and ancillary equipment). Control equipment will be housed in a climate controlled building. From the transition compound, the cables will be buried underground, in a backfilled trench approximately 4 m wide and 2 m deep to the cable landfall entry site.

3.3.2.2 Strait of Belle Isle Submarine Cable Crossing

From Forteau Point, cables will extend under and across the Strait of Belle Isle and make landfall on the north-west side of the Island’s Northern Peninsula, at Shoal Cove. The proposed Strait of Belle Isle submarine cable crossing is described below.

The evaluation of the submarine cable corridor and landing points included detailed submarine surveys of the crossing area using side-scan and multi-beam sonar, sub-bottom profile surveys and underwater video. It also involved the compilation and analysis of existing environmental information including geology, bathymetry, oceanography, environmental sensitivities, fishing activity, and known historic sites.

As a result of this process, Forteau Point was identified as the landing point on the Labrador side, and Shoal Cove was identified as the landing point on the Island side. A 500 m wide corridor approximately 35 km in length has been indentified for the submarine cables. The landing points and the submarine cable corridor are shown in Figure 3.2-2.

Horizontal Directional Drilling

Near the landing points, the cables will be protected through the use of horizontal directional drilling (HDD) technology. The HDD solution will provide three lined (steel or high-density polyethylene (HDPE)) conduits for each shore approach. These will begin between 15 m and 100 m from the high water mark on the land side and extend 1.5 km to 2.5 km underground and exit into the Strait of Belle Isle. The HDD boreholes will be spaced appropriately apart at the on shore entry point and will diverge toward target exit locations on the sea floor. The borehole locations are shown in Figures 3.3.2-7 and Figure 3.3.2-8.

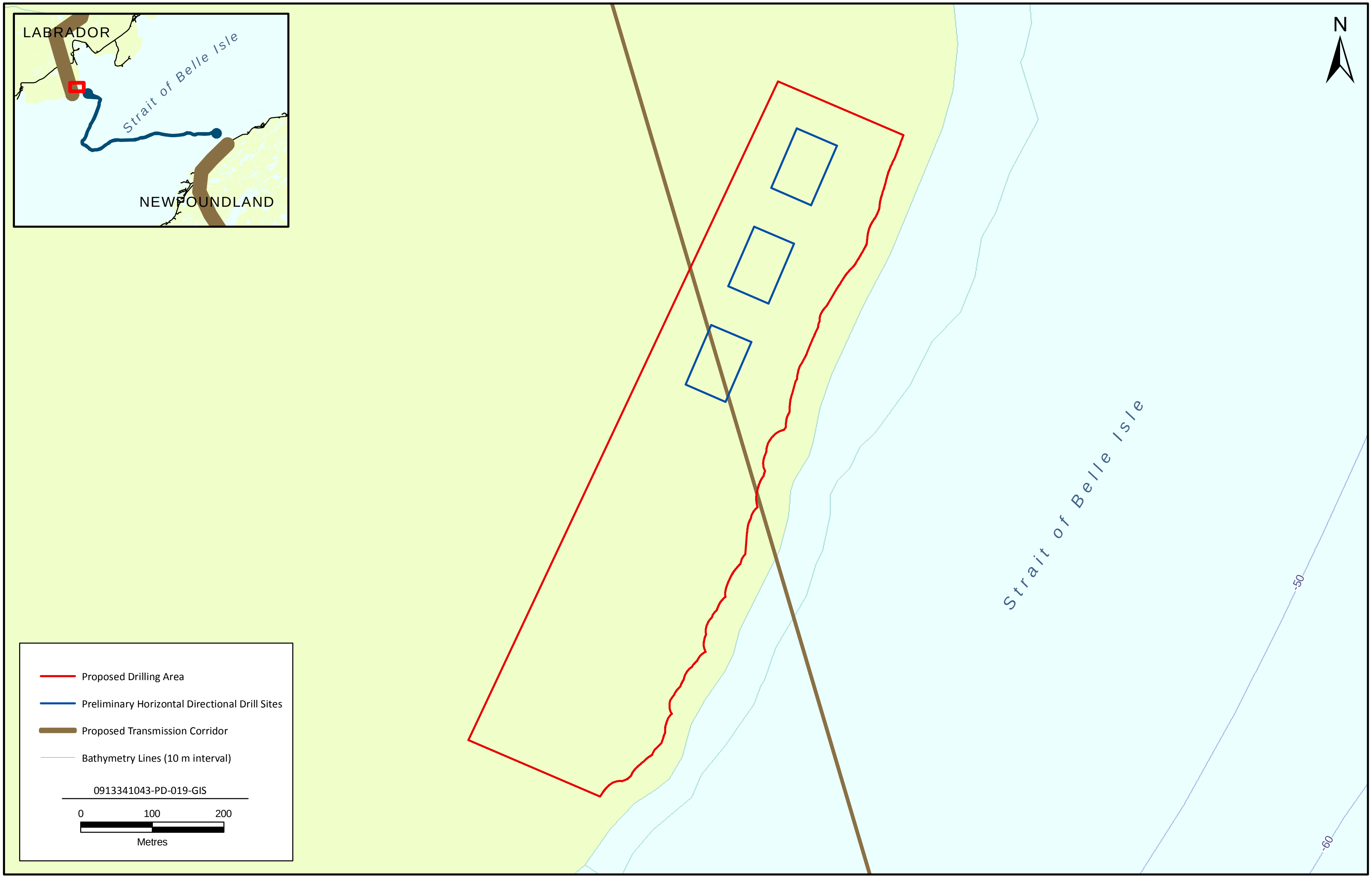

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FIGURE 3.3.2-7

Strait of Belle Isle Submarine Cable Crossing - Forteau Point
Preliminary Horizontal Directional Drill Sites

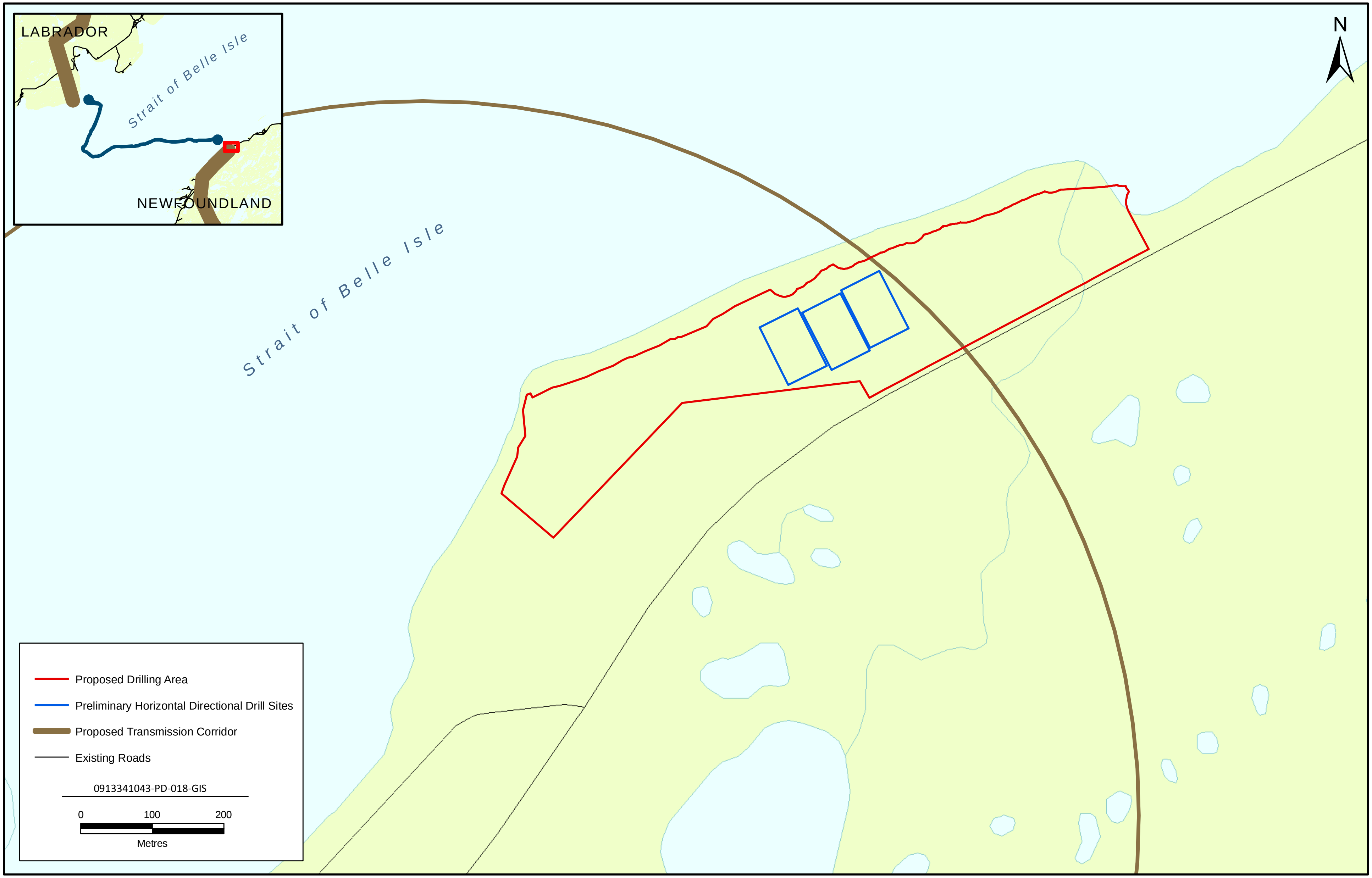

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FIGURE 3.3.2-8

Strait of Belle Isle Submarine Cable Crossing - Shoal Cove
Preliminary Horizontal Directional Drill Sites

Submarine Cable Crossing

The proposed corridor along the sea floor uses natural seabed features to protect the cables and minimize the possibility of interaction with external influences (e.g., fishing activity, icebergs). The Strait of Belle Isle submarine cable crossing will include three cables placed within the 500 m wide corridor approximately 150 m apart. Two cables will be used for electricity transmission and one will be used as a spare. Up to 900 MW can be readily transmitted over two working cables, while the spare cable will improve the overall reliability of the cable crossing in the unlikely event of a cable failure. Within the corridor, the cables will run parallel to each other across the Strait of Belle Isle. While the cables will be installed independently within the corridor, flexibility in the final cable route is required for path optimization, cable protection and reliability.

Each cable will be protected by a rock berm of approximately 8 to 12 m in width and between 0.8 m and 1.5 m high along the entire length of the cables. The berms will have a normal side slope ratio of 1:4 (rise:run). Figure 3.3.2-9 (inset a) shows a typical rock berm cross section.

The cables will be of mass impregnated (MI) design with copper or aluminum conductors, and will have armour layers and a highly abrasion resistant external sheathing. A typical cable cross section is shown in Figure 3.3.2-9 (inset b). Each cable will be approximately 35 km in length and will have an outer diameter between 100 mm and 130 mm. A fibre optic cable may be embedded with the submarine cable to provide a distributed temperature sensing along the cable length. The spare fibre optic may be used for communication as well.

3.3.2.3 Shoal Cove to Soldiers Pond

Transition Compound

At the on shore landfall entry location, the submarine cables will be spliced with land cables that will travel underground, in backfilled trenches approximately 1 m wide and 1 to 5 m deep, to a transition compound (Figure 3.3.2-9 (inset c)). The location of the transition compound will be determined during the detailed Project design and will depend on local topography, and environmental and geological conditions. It is expected to be sited within 1,000 m of the shoreline. The transition compound will be similar to the one located at Forteau Point, as described in Section 3.3.2. A microwave system may also be established at the Shoal Cove transition compound.

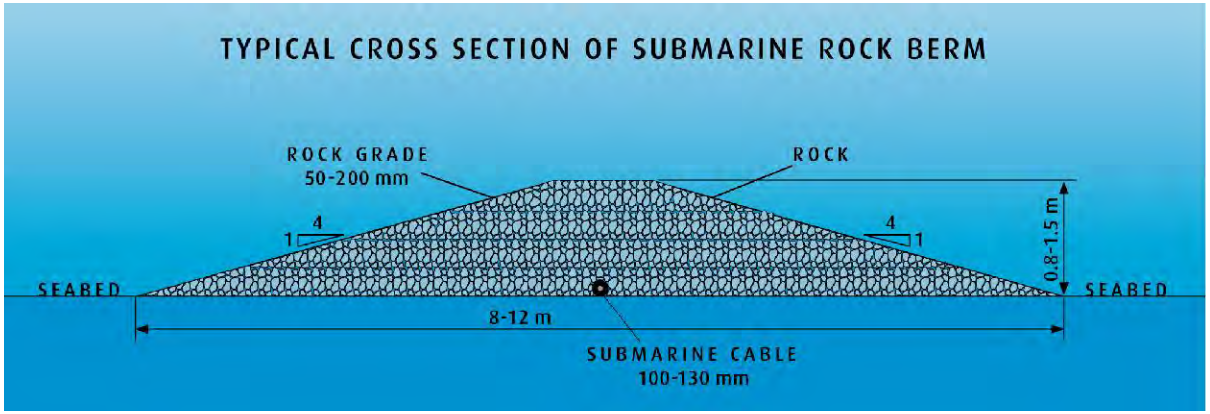
Transmission Corridor

The Newfoundland portion of the transmission corridor connects Shoal Cove to the Soldiers Pond converter station. The corridor between Shoal Cove and Soldiers Pond is shown in Figure 3.3.2-10, Figure 3.3.2-11, Figure 3.3.2-12 and Figure 3.3.2-13.

From Shoal Cove, the transmission corridor generally heads south, winding between several large waterbodies, and crossing Highway 432. The transmission corridor passes along the east side of Western Brook / Middle Pond, heads south and west to avoid elevated terrain, then passes the west side of Eastern Blue Pond. From there, the corridor generally heads south-west, past Brians Pond, Portland Creek Pond and Inner Pond. It then climbs the elevated terrain south of Inner Pond. The transmission corridor continues in a southerly direction, avoiding areas of extreme elevation change and taking advantage of topographic shielding as available.

The transmission corridor turns south-west to avoid the Main River Special Management Area then heads in a south-easterly direction. The transmission corridor along the Long Range Mountains are within a high icing region. From this area, the transmission corridor heads south-east, paralleling the ROW for Transmission Line (TL) 246 and TL 252 until Hampden. It then crosses the ROW for TL 247 and TL 251 near the intersection of Highway 420 and Highway 421. The transmission corridor heads south-east, crossing Birchy Lake at a narrows, turns east to follow a valley, then emerges near a region of high wind and snow known as the Gaff Topsails and descends into Sheffield Brook Basin. The transmission corridor then heads north-east then south-east, avoiding the Gaff Topsails.

a) TYPICAL CROSS SECTION OF SUBMARINE ROCK BERM



b) CROSS SECTION OF A TYPICAL SUBMARINE CABLE

c) SIDE VIEW OF SUBMARINE CABLE CROSSING

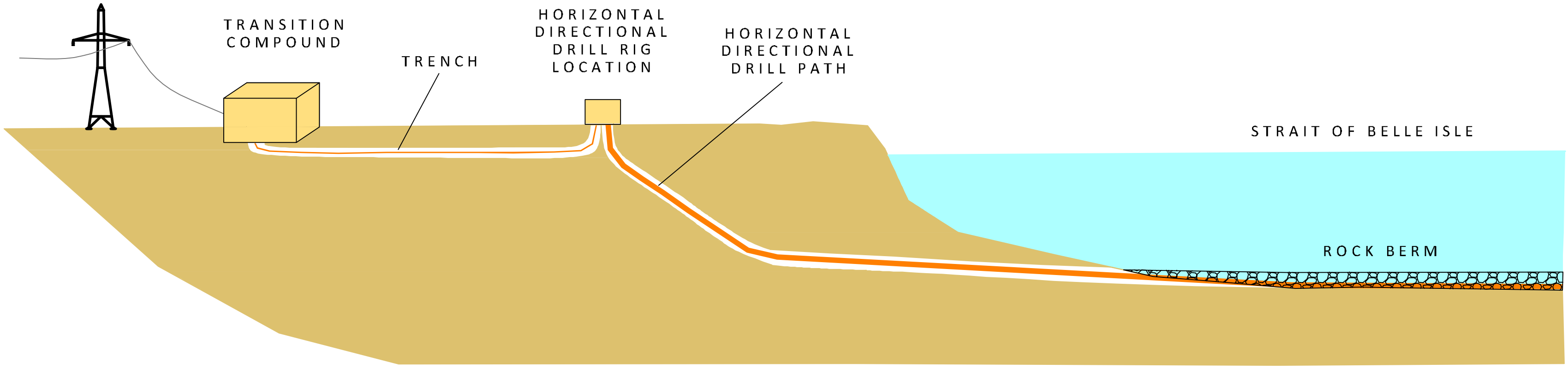


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FIGURE 3.3.2-9

Side View of the Submarine Cable Crossing, Cross Section of Submarine Cable, and Cross Section of Rock Berm

FIGURE 3.3.2-10

Transmission Corridor:
Shoal Cove to Soldiers Pond (kilometre 0 to kilometre 140)

FIGURE 3.3.2-11

Transmission Corridor:
Shoal Cove to Soldiers Pond (kilometre 140 to kilometre 320)

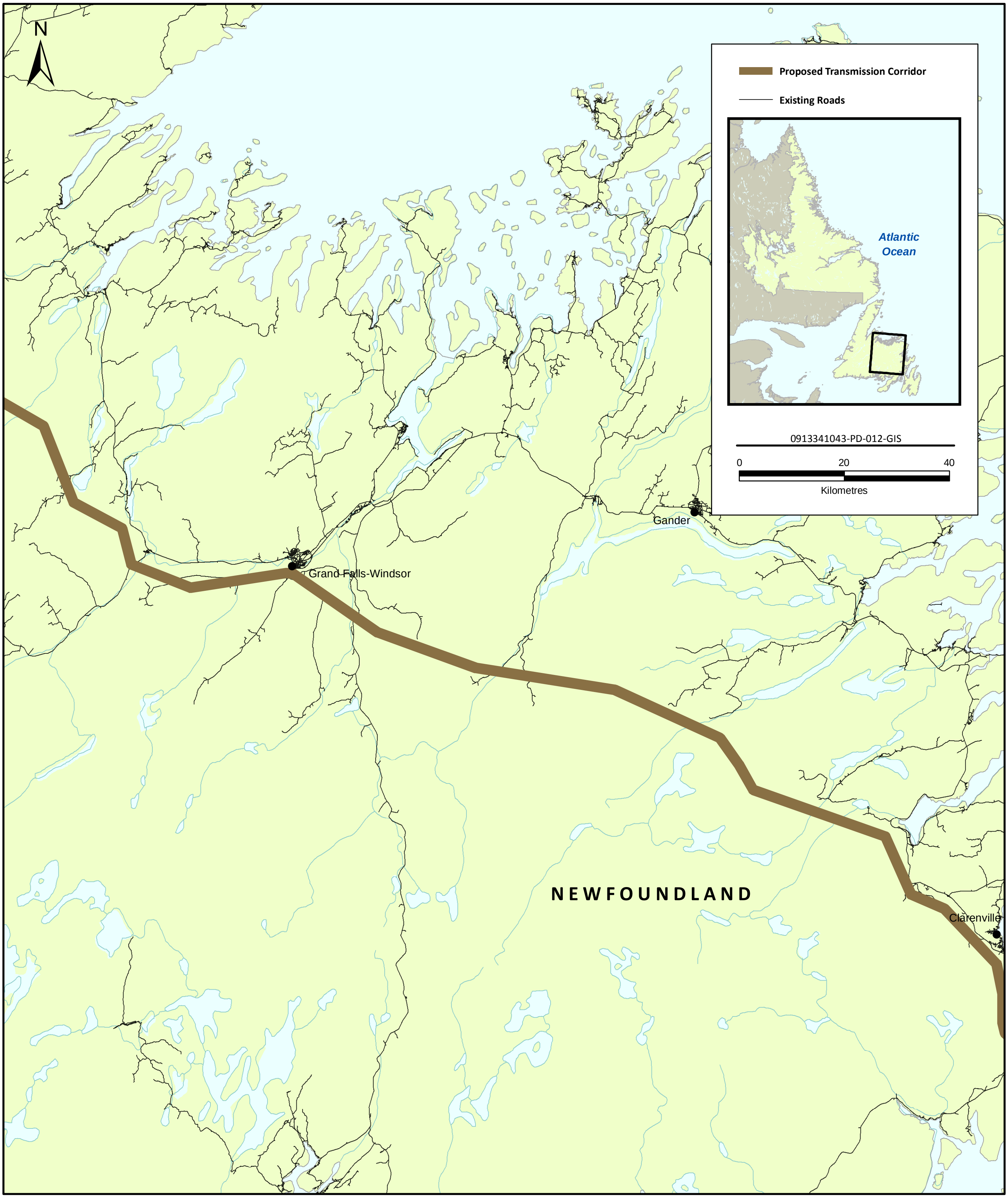

FIGURE 3.3.2-12

Transmission Corridor:
Shoal Cove to Soldiers Pond (kilometre 320 to kilometre 530)

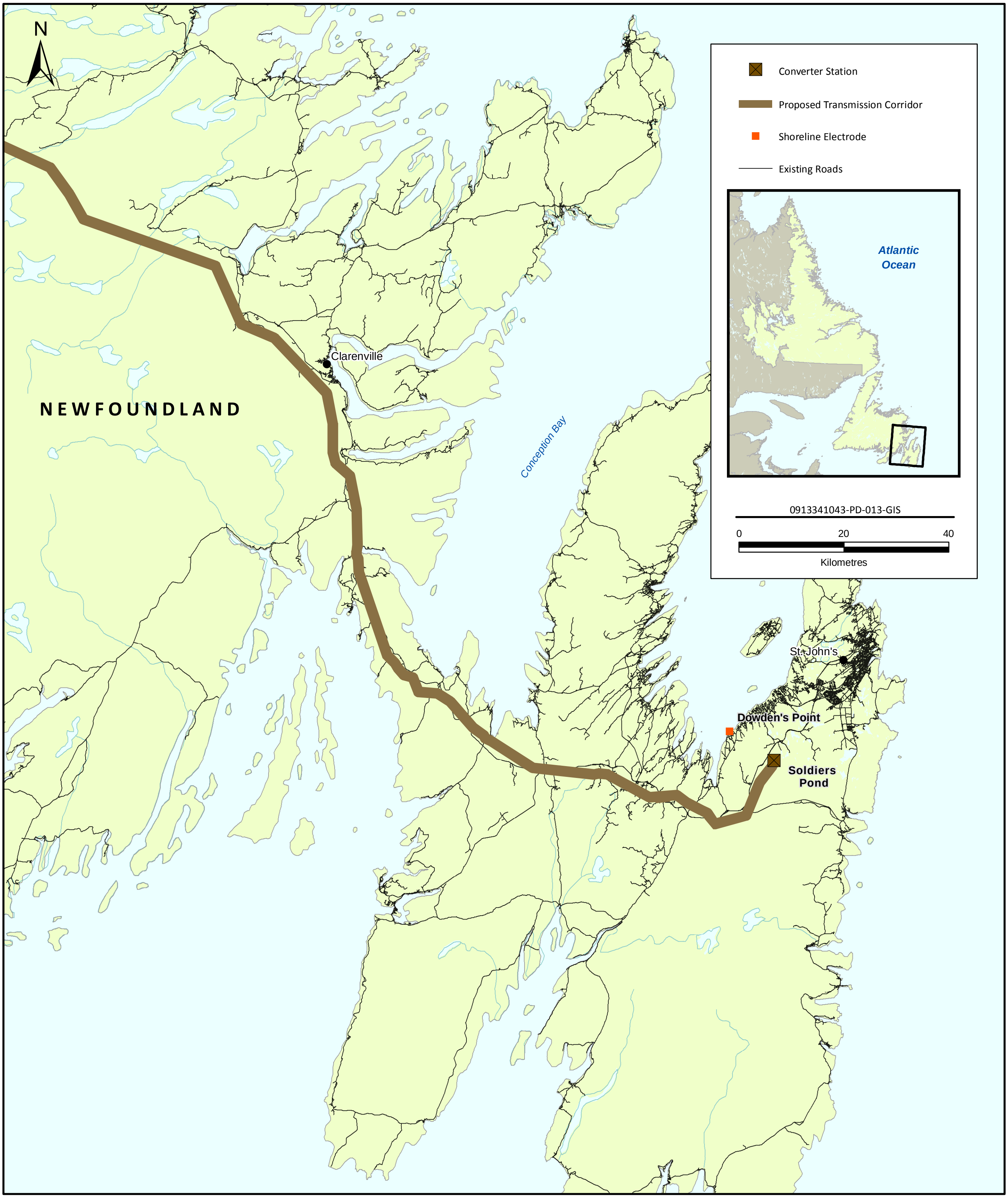

FIGURE 3.3.2-13

Transmission Corridor:
Shoal Cove to Soldiers Pond (kilometre 530 to kilometre 690)

The transmission corridor then heads east, following the ROW for TL 205 and TL 232, and crosses a 69 kV line from Newfoundland Power's Sandy Brook Generating Station. From Grand Falls-Windsor, the transmission corridor heads south-east toward Port Blandford. Between Port Blandford and Sunnyside, the transmission corridor heads south along a Newfoundland Power ROW which contains a single 138 kV line between Port Blandford and Clarenville. A second 138 kV line joins the ROW at Clarenville, and both continue to the Sunnyside substation. The transmission corridor skirts the Sunnyside substation before returning to follow the ROW for TL 203 and continuing across the Avalon Peninsula.

The transmission corridor then follows the ROW of TL 207, then parallels the ROW for TL 203 and TL 237, passing Nalcor's Western Avalon substation at Chapel Arm. The transmission corridor follows the ROW for TL 201 and TL 217, which contain two of Newfoundland Power's 138 kV transmission lines. The transmission corridor crosses several roads, electrical lines and developed areas before turning south-east and crossing Harbour Main Pond at a narrow section at its south end. The transmission corridor then follows the existing ROW for TL 201 and TL 217 until it reaches the Soldiers Pond converter station.

Transmission Towers

Galvanized steel lattice towers will be built along the final ROW within the transmission corridor between Shoal Cove and Soldiers Pond. The transmission towers and associated equipment (i.e., insulators, conductors, OPGW and counterpoise) will be similar in design to that described for the Muskrat Falls to Forteau Point portion of the corridor.

The number of towers required between the transition compound at Shoal Cove and converter station at Soldiers Pond will depend on tower span distances, as determined by topographic, meteorological and associated technical requirements. Based on an average span of 300 to 430 m in a normal region, 165 to 210 m in an alpine region and 255 to 420 m in an eastern region, there will be approximately 2,150 towers included in the transmission line between Shoal Cove and Soldiers Pond (Table 3.3.2-4). Approximately 90% of these will be suspension structures.

Table 3.3.2-4 Number and Types of Towers to be Constructed Between the Shoal Cove and Soldiers Pond

Tower Type	Number of Towers in each Region (Span)			Total
	Normal (300 m to 430 m)	Alpine (165 m to 210 m)	Eastern (255 m to 420 m)	
Suspension	920 to 1,340	350 to 450	440 to 630	1,710 to 2,420
Dead end	85 to 100	30 to 50	55 to 60	170 to 210
Total	**1,005 to 1,440**	**380 to 500**	**495 to 690**	**1,880 to 2,630**

3.3.3 Soldiers Pond Converter Station, ac Switchyard, and Synchronous Condenser Yard

The Soldiers Pond converter station, ac switchyard, and synchronous condenser yard will be located north-east of Soldiers Pond, near existing Nalcor transmission system infrastructure (TL 201, TL 217, TL 218 and TL 242) (Figure 3.2-6). The approximate coordinates of the Soldiers Pond converter station are 47° 25' 00" N and 52° 58' 31" W. The conceptual layout of the Soldiers Pond converter station, including the converter yard, the ac switchyard and the synchronous condenser yard is provided in Figure 3.3.3-1.

The converter station will consist of a converter yard that measures approximately 450 m by 600 m and will contain HVdc equipment, including converter transformers, converter valves, a valve cooling system, diesel generator and fuel storage facilities. The converter yard equipment is described in Table 3.3.3-1, and the layout of the converter yard is provided in Figure 3.3.1-2.

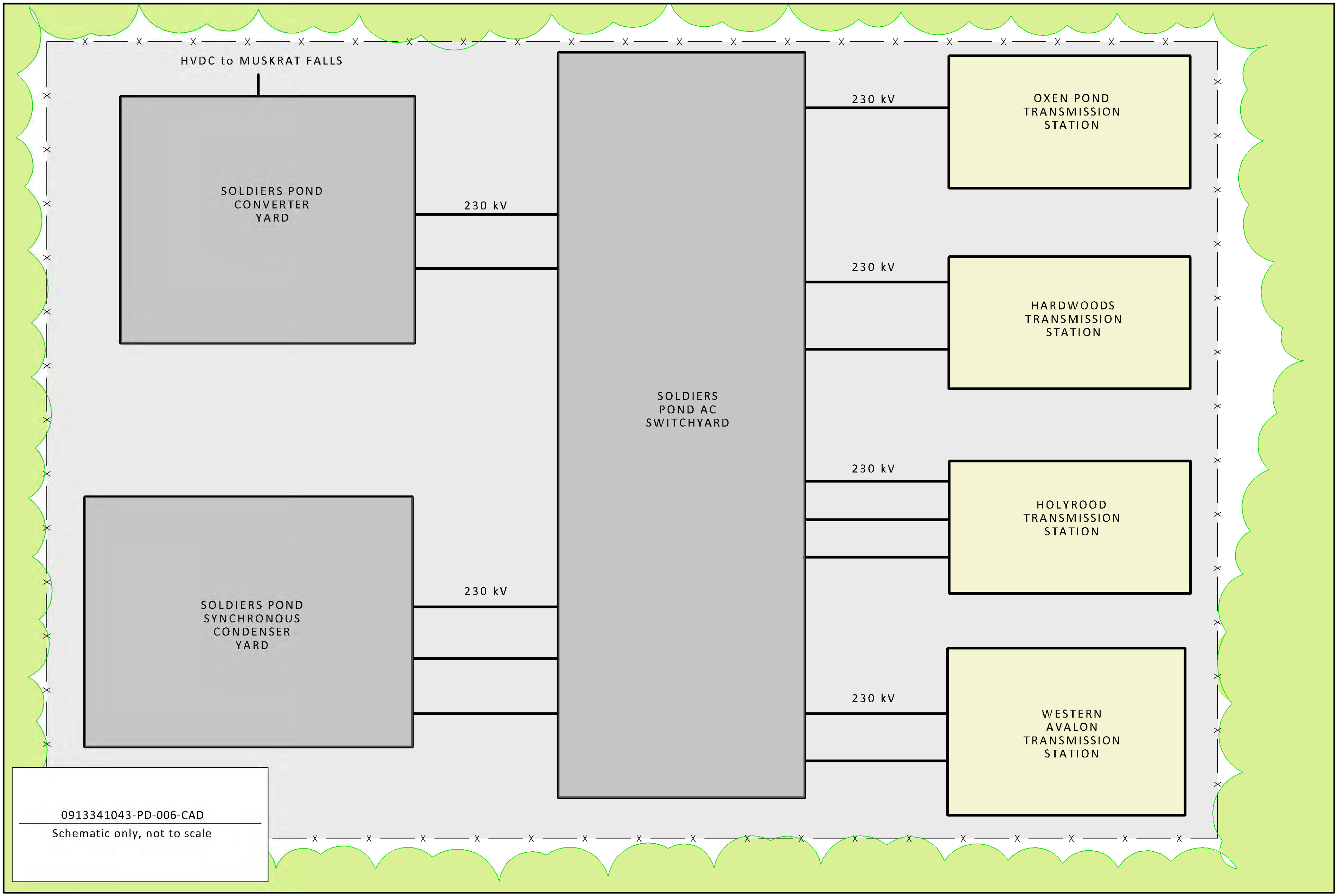

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FIGURE 3.3.3-1

Conceptual Layout of the Soldiers Pond Converter Station, Including Converter Yard, Alternating Current Switchyard and Synchronous Condenser Yard

Adjacent to the converter station, a synchronous condenser yard will be constructed at Soldiers Pond. The synchronous condenser yard will measure 150 m by 100 m and will contain three synchronous condensers, used to provide reactive power and system inertia. The Soldiers Pond converter station will have a dc voltage rating of ± 350 kV and an ac voltage rating of 230 kV.

An ac switchyard will be constructed adjacent to the Soldiers Pond converter station. It will be approximately 250 m by 350 m. The ac switchyard is required to provide interconnection to the 230 kV transmission lines. The existing four lines (TL 201, TL 217, TL 218, and TL 242) in this area will be redirected into this switch yard.

The Soldiers Pond converter station, synchronous condenser yard and ac switchyard will all have a gravel surface, and a vegetation control program to restrict vegetation growth. Some parking areas or specific roadways may be paved. A series of concrete foundations and galvanized steel structures will support the electrical equipment and switchgear. A grounding grid will be installed beneath the foundations. Two types of foundations may be used to support the structures within the converter yard: rectangular strip footings and square pier footings. Equipment that requires shelter from the elements will be enclosed in the valve hall. Unauthorized access to the converter station will be restricted by a galvanized steel security fence and a locked gate. Appropriate signage will be posted in high voltage areas.

A new access road approximately 1.3 km long will be required for the Soldiers Pond converter station. This access road will connect with the eastbound lane of the Trans-Canada Highway (TCH). The gravel access road will have a 9.5 m wide top with 1.5:1 side slopes, as shown in Figure 3.3.3-2. The road will be constructed with open drainage ditches or swales along the sides. Galvanized steel culverts will be installed where required at stream and river crossings and other areas, as appropriate, to maintain natural drainage patterns.

3.3.4 Shoreline Electrodes

The Project has been designed as a bipolar system with a converter station at each end of the HVdc transmission line, and a shoreline saltwater pond electrode connected to each converter station via an electrode line, providing a ground return path. The shoreline electrodes will be constructed and installed at two locations: L'Anse au Diable North, Labrador (connected to the Muskrat Falls converter station) and Dowden's Point, Newfoundland (connected to the Soldiers Pond converter station).

During normal balanced bipolar operation, the two poles (one positive and one negative with respect to ground) provide a path for the dc current, and small amounts of electrical current due to voltage imbalances will flow through the electrode (i.e., less than 1% of the system's total capacity). The electrode provides a return path for the small amount of current due to voltage imbalances.

If both poles are in service, the system can operate at its full rated capacity. If a transmission conductor failure or a pole fault were to occur, the electrodes can provide a temporary ground return path for the current for the duration of the fault. The electrodes may be used during a pole outage if metallic return is not available. This is expected to occur for a duration of less than 40 hours per year and the ground return duration will be shorter than 40 hours if metallic return is used for some of the outages. The use of the electrodes to provide a long-term return path for the full current is expected to occur only under specific circumstances, such as two of the three submarine cables or the overhead conductor. The likelihood of a conductor failure is reduced through corridor and final ROW selection of the overhead line, cable protection planning, use of a spare cable across the Strait of Belle Isle, and reliable design of the transmission towers and conductors.

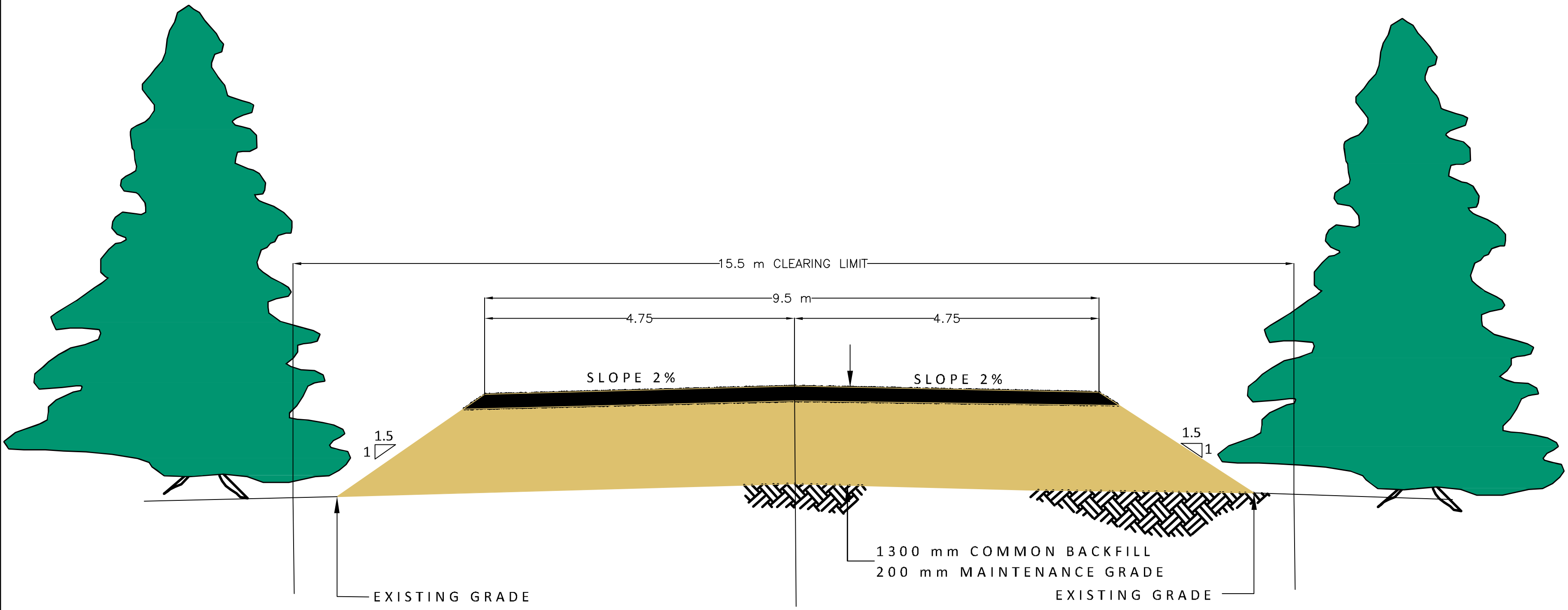

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FIGURE 3.3.3-2

Typical Access Road Cross Section

To provide an acceptable return path, the electrodes must provide adequate grounding. Ground Potential Rise (GPR) occurs when large electrical currents enter the ground and the earth becomes charged with electricity. The GPR of the ground decreases with distance from the point where the current entered the ground. In general, rock and soil are relatively poor conductors of electricity. Therefore, adequate grounding often requires the installation of electrodes in highly conductive material, such as salt water. For this reason, Nalcor has selected the use of shoreline saltwater pond electrodes for the Project.

Electrode operation is described further in Section 3.5.1.

3.3.4.1 L'Anse au Diable Shoreline Electrode

Preliminary studies have identified L'Anse au Diable in the Strait of Belle Isle as the preferred site for the Labrador shoreline electrode (Figure 3.2-5). The shoreline electrode will be submerged in a natural cove. The cove will be connected to the Strait of Belle Isle by an engineered, permeable berm that extends beyond the mouth of the cove into the Strait of Belle Isle, as shown in Figure 3.3.4-1.

The electrode design consists of between 40 and 60 silicon cast iron electrode elements installed vertically in the water on the pond side of the permeable berm. Figure 3.3.4-2 shows a conceptual drawing of the electrode. Each electrode will be encased in rigid polyvinyl chloride (PVC) conduit piping and will be attached to an electrode junction box at the top of the permeable berm. The junction boxes will be connected by a distribution cable running the length of the permeable berm. A road will be constructed along the crest of the permeable berm for access during maintenance activities.

The permeable berm will be designed to withstand the expected worst case site conditions, including wave action, tidal effects, pack ice and freezing inside the shoreline electrode pond. The depth of the shoreline electrode pond at the land side toe line will be sufficient to submerge the vertical electrode elements, and to accommodate changes in the water level due to tides and ice formation within the shoreline electrode pond. The depth will be such that the electrode elements are fully immersed in water, below the ice, under various tide conditions. At the land side toe of the permeable berm, where the electrode elements are installed, there will be a natural low-tide sea depth of 4 m. The electrode elements will be connected by a distribution cable to the land-based electrode line termination structure. The termination structure will contain switches that allow a series of electrode elements to be turned off for maintenance or repairs.

It is expected that the permeable berm will be a rubble mound structure consisting of embankment materials obtained from nearby quarries. The majority of the structure will be random quarry material, with larger quarry rocks used as armour stone on the sea side slope to protect the permeable berm from storm waves. A further selection of suitably sized rocks will be made to form the embankment, which must be permeable to allow the natural flushing and transfer of seawater through the embankment.

The size of the permeable berm, its composition and its location relative to the shoreline will depend on electrical performance requirements, structural integrity and operational and maintenance needs. The length of the permeable berm along the centre line will be approximately 205 m. It is expected that the permeable berm centre line will be approximately 15 m above the sea floor. The side slope ratio will be approximately 1:1.5 (rise:run), and the permeable berm will have a crest width of approximately 9.5 m. Figure 3.3.4-2 shows a typical permeable berm cross section.

A layer of uniformly sized rock with an increased void ratio is required to conduct the electrode current through the permeable berm and into the sea, as maintaining the salinity of the water in the shoreline electrode pond is critical to the performance of the electrode. The contact area between the permeable berm and the sea is driven by safety considerations. A minimum contact area must be achieved between the shoreline electrode pond and the permeable berm to ensure a safe voltage gradient on the sea side of the permeable berm. The design uses a conservative void ratio of approximately 20%, and the average size of rock in the permeable zone is anticipated to be 0.5 to 1 m in diameter.

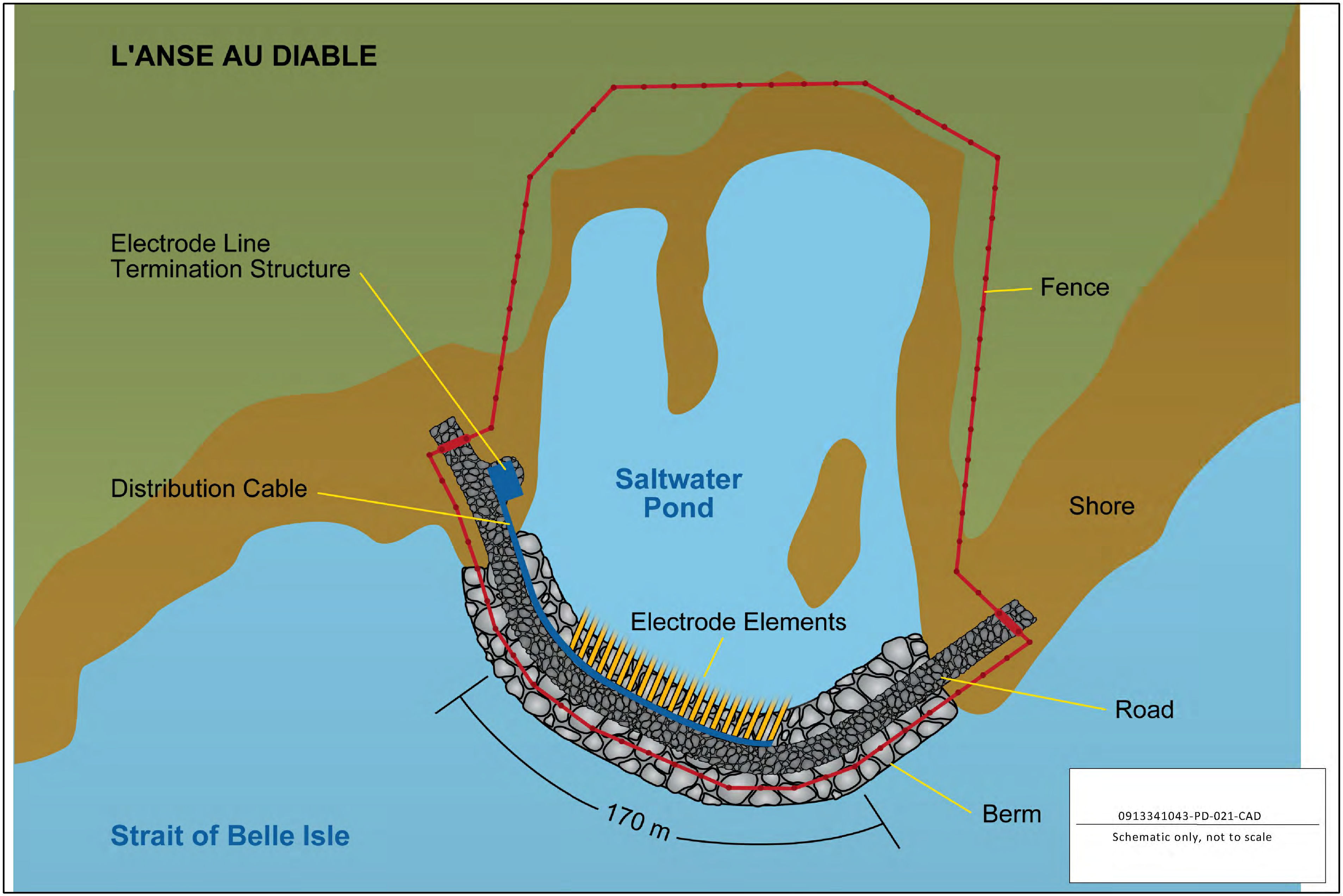

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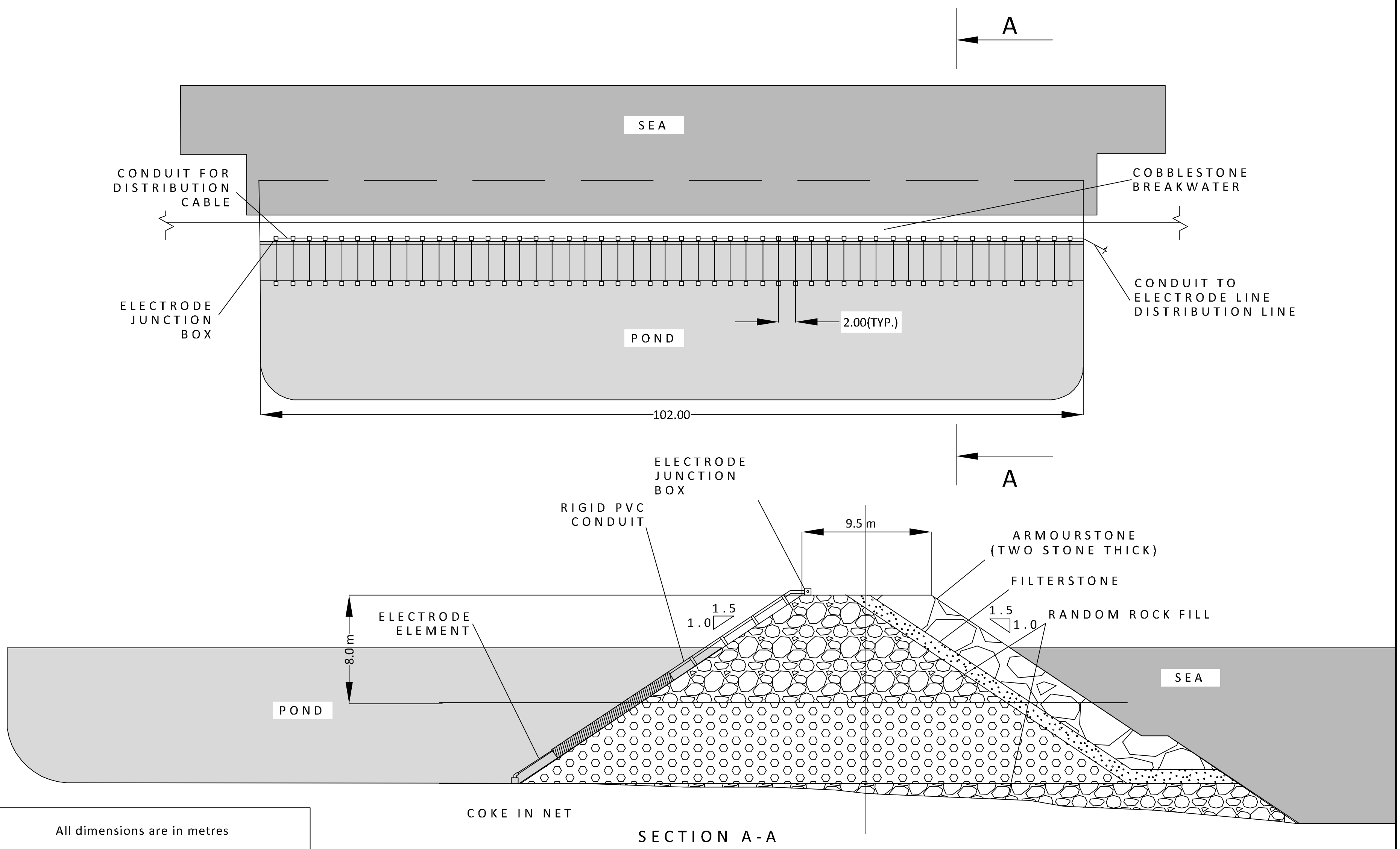
FIGURE 3.3.4-1

L'Anse au Diable Shoreline Electrode



All dimensions are in metres

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FIGURE 3.3.4-2

Schematic of Shoreline Electrode and Cross Section of Permeable Berm

The electrode site will be enclosed by a locked, chain-link fence to prevent public access from the land and sea sides. Sea side fencing will be installed on the permeable berm crest.

The electrode will be connected to the Muskrat Falls converter station by two low voltage, 43 mm, metallic conductors suspended on standard single wood poles. The treated wood poles (i.e., Penta or chromate copper arsenate (CCA)) will be approximately 10 to 12 m high and spaced approximately 70 to 90 m apart. Where required, the wood poles will be guyed with standard anchor configurations. The wood pole electrode line from the Muskrat Falls converter station will be located within the HVdc ROW, as described in Section 3.3.1, for approximately 350 to 400 km, until it reaches the general area of the Labrador Straits Highway (Route 510). Then, it will generally follow the Labrador Straits Highway and / or an existing distribution line ROW for 25 km to the L'Anse au Diable electrode line termination structure. The approximate location of the electrode wood pole line is shown in Figure 3.2-5.

3.3.4.2 Dowden's Point Shoreline Electrode

The shoreline electrode for the Soldiers Pond converter station will be located at Dowden's Point, on the south-east shore of Conception Bay, approximately 3 km north-east of the Holyrood Thermal Generating Station (Figure 3.2-6). Two permeable berm design options are under consideration for the Dowden's Point electrode site. The first option is to extend the permeable berm into Conception Bay such that, at the pond side of toe of the permeable berm, where the electrode elements are installed, a natural low-tide depth of 4 m is achieved (i.e., no excavation of the seabed is required), as shown in Figure 3.3.4-3. The permeable berm length for this option, measured along the centre line, would be approximately 385 m.

The second option has the crest of the permeable berm aligned with the top of the existing bank and the sea side toe line coincident with the existing low tide shoreline. A channel would be excavated to a depth of 4 m from the inside of the shoreline electrode pond outward to a natural depth of 4 m in Conception Bay, as shown in Figure 3.3.4-4. The depth of the soil above the bedrock at Dowden's Point is anticipated to be approximately 30 m, which would permit excavation without the need for blasting. The permeable berm length measured along the centre line for this option would be approximately 90 m. A regular excavation program may be required during Operations and Maintenance for this option to maintain the seabed depth requirement of 4 m.

The electrode and permeable berm design will be similar to that described for the L'Anse au Diable shoreline pond electrode (Section 3.3.4-1). The electrode design consists of between 40 and 60 silicon cast iron electrode elements installed vertically in the water on the pond side of the permeable berm. The permeable berm will be a rubble mound structure consisting of embankment materials obtained from nearby quarries, and it is expected that the permeable berm centre line will be approximately 15 m high, the side slope ratio will be approximately 1:1.5 (rise:run), and the permeable berm will have a crest width of approximately 9.5 m.

The electrode will be connected to the Soldiers Pond converter station by two low voltage, 43 mm, metallic conductors suspended on standard single wood poles. The treated wood poles will be approximately 10 to 12 m high and spaced approximately 70 to 90 m apart. The wood pole electrode line from the Soldiers Pond converter station will follow an existing transmission corridor to a point near Conception Bay then follow an existing ROW (i.e., existing road or distribution line, or both) to Dowden's Point, a total distance of approximately 15 km (Figure 3.2-6 – note, specific location not shown as it is yet to be confirmed).

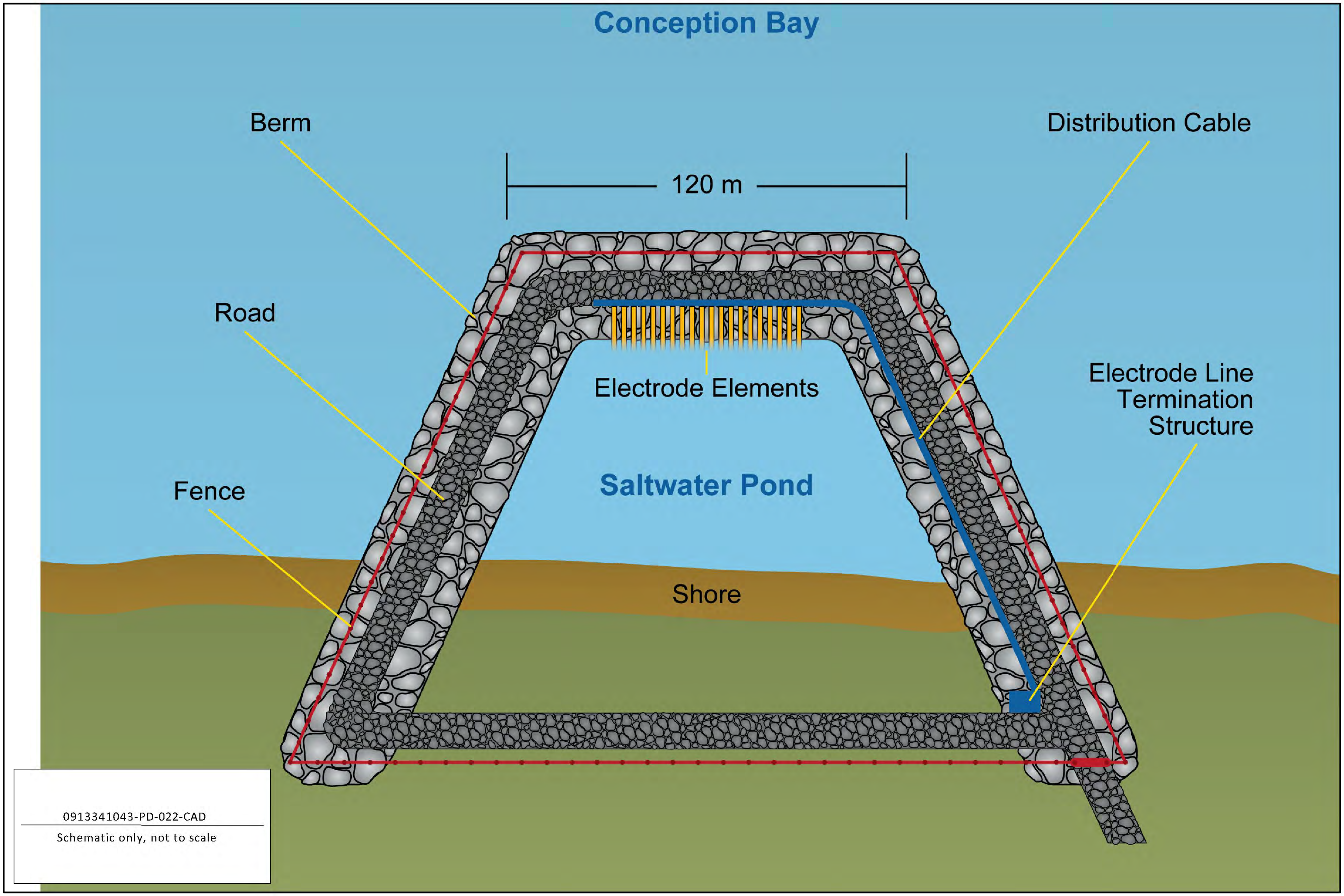

FIGURE 3.3.4-3

Dowden's Point Shoreline Pond Electrode - Design Option 1

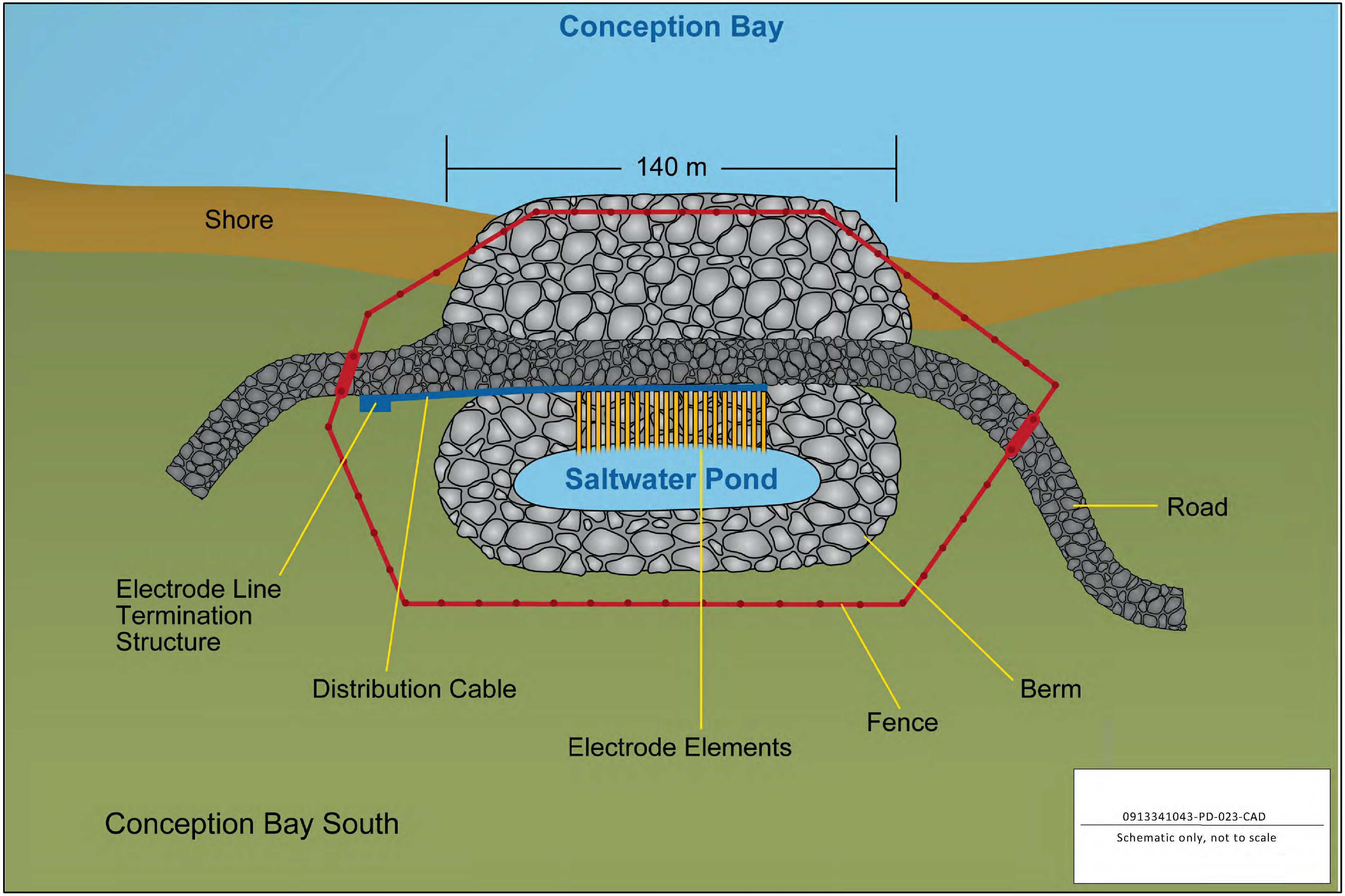

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FIGURE 3.3.4-4

Dowden's Point Shoreline Pond Electrode - Design Option 2

3.3.5 Island System Upgrades

Existing transmission lines will be connected to the Soldiers Pond switchyard thus enabling electricity from the Project to be transmitted into the Island grid. Some modifications and additions to the NLH existing Island transmission system may be required to successfully integrate the HVdc system, and to accept the power it transmits into the Island grid. The need for, and nature of, any such modifications will be determined through the completion of power system studies conducted during detailed Project engineering. These will primarily involve standard and routine upgrades to existing infrastructure, occur within and adjacent to existing facilities, and will likely be addressed through the NLH standard and ongoing system maintenance programs. Any additional required components and activities which are specific to the integration of the HVdc system, and which are not part of the NLH ongoing or planned system maintenance program and existing capital plans, will be defined during the next phase of engineering for the Project.

System upgrades include the conversion of two of the Holyrood generating units to synchronous condensers. These upgrades would help maintain system stability and keep voltages at specified levels. Also, the 230 kV and 138 kV circuit breakers at the Holyrood Thermal Generating Station (nine in total), Sunnyside Terminal Station (11 in total) and Bay d'Espoir Hydroelectric Generating Station (four in total) may be upgraded to allow for the isolation of power system components in response to system events (e.g., lightning strike, insulator failure, dropped conductor).

Power will be delivered from the Soldiers Pond converter station to the Island grid via the following eight existing transmission lines:

- TL 217;
- TL 201;
- TL 218; and
- TL 242.

New towers will be built in existing ROWs, within 1.6 km of the converter station for each of these existing transmission lines, and lightning protection (i.e., an overhead ground wire) will be installed. The new towers will be spaced approximately 250 m apart, they will be self-supporting and will carry two overhead groundwires and three conductors. The transmission lines will be re-built within three existing ROWs ranging from 70 m wide (two lines) to 110 m wide (three lines).

3.3.6 Telecommunications Systems

The Project will include a telecommunication system that provides voice, video and data communication. Telecommunications will be established through a combination of the OPGW and either fibre optic submarine cable and / or microwave link across the Strait of Belle Isle. The Project telecommunication system will include:

- a Supervisory Control and Data Acquisition (SCADA) / Operational Data System, which provides remote monitoring and control of electrical equipment and facility systems;
- a teleprotection system to provide reliable communication channels for the operation and control of protection equipment; and
- very high frequency (VHF) radio systems for communication during Construction, Operations and Maintenance of the Project.

The preferred option of communications facilities across the Strait of Belle Isle is optical fibres either embedded in the power cables, or separate submarine optical cables laid adjacent to the power cables. The alternative option is a digital microwave radio facility. The final decision will be made during detailed engineering.

If a microwave radio system is required to be established, it will be established at or near the transition compound. This system would link the on-land fibre optic cable system installed on the transmission structures in Labrador to those on the Island transmission structures. The interconnected telecommunications system would be used for the transmission of control signals for the HVdc system and other operational data and voice traffic. The microwave radio system would consist of a fenced microwave site (approximately 15 m by 30 m) near each transition compound, within the transmission corridor. Each microwave site would include a telecommunications building to house the systems required for the operation of the microwave radios (e.g., communications electronics and battery bank power supply), a structure to house a back-up generator and fuel tank, and a guyed microwave tower structure approximately 35 m to 50 m in height. Nalcor will also consider the potential for coordination with other existing microwave facilities in the area. All aspects of the proposed microwave radio system, including transmission power and frequencies, will be registered with Industry Canada in accordance with applicable legislation.

3.4 Construction

The Project includes the construction of two converter stations, two shoreline electrodes, an on-land HVdc transmission line, and a submarine cable crossing with associated onshore infrastructure (i.e., transition compounds). A general overview of construction schedule, activities and infrastructure requirements are provided in the following sections.

3.4.1 Construction Schedule

The engineering design and construction phase will begin in Year 0 with detailed engineering and the procurement and manufacture of key long-lead components. Construction activity is scheduled to begin in the middle of Year 1 and finish in early Year 5. Project commissioning and the start of operation is expected to occur in Year 5.

Appendix 3-1 provides a list of permits required for the Project. All construction activities will be conducted in accordance with permits and regulations.

Construction of the Labrador components, the Island components and the Strait of Belle Isle submarine cable crossings will be initiated and conducted separately. A general overview of the Project schedule is provided in Figure 3.4.1-1. This figure includes the estimated timing and duration of construction for each Project component.

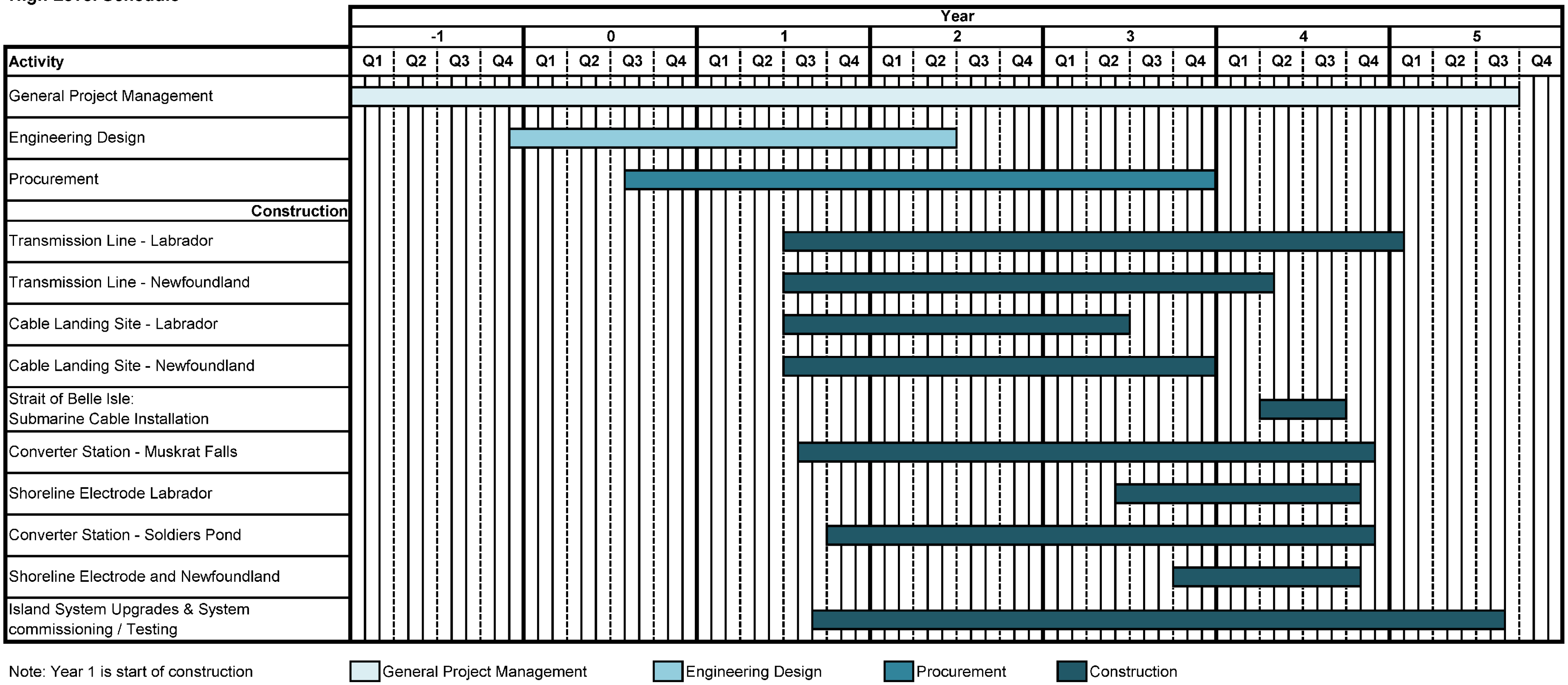
Construction of the on-land transmission infrastructure in both Labrador and on the Island is scheduled to begin in the middle of Year 1, and will be initiated from multiple locations along the ROW. Construction will begin with the establishment of temporary camps, access infrastructure and marshalling yards, followed by ROW clearing, materials distribution and the installation of tower foundations and anchors. The transmission towers will be assembled and erected during Year 2 and Year 3, followed by conductor installation. Construction of the Labrador and Island onshore transition compounds will also occur in Year 2 and Year 3. The Island transmission line is scheduled for completion in early to mid Year 4 and the Labrador line in early Year 5.

Construction activities associated with the submarine cable protection (e.g., HDD) will begin in the middle of Year 1 and will continue until the end of Year 3. Cable installation will be conducted during the ice-free season of Year 4 and will likely be completed by late Year 4.

3.4.1.1 Public Notification of Construction Activities

Nalcor will contact land owners along the transmission corridor during detailed design and route selection. Nalcor will begin one-on-one contact with land owners who are directly affected by construction many months in advance of construction. Communication will continue until after the project construction has been completed.

High Level Schedule



Note: Year 1 is start of construction

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FIGURE 3.4.1-1

High Level Schedule for Project Construction

Nalcor will also notify the public and land users of ongoing construction activities. Affected municipalities will be notified and Nalcor will work with municipalities and other relevant stakeholders to disseminate construction activity information throughout communities. Nalcor will use various communication initiatives to inform land users of ongoing work, including advertising, Nalcor's website, social media, newsletters, information sheets and Nalcor / Hydro's customer service information line.

Nalcor will also consult with the Department of National Defence during the detailed design phase of the Project and will develop a communications plan to address potential restrictions to low-level flying activities and communication with aircraft Construction Infrastructure.

3.4.2 Construction Infrastructure

3.4.2.1 Access

Access to the ROW is required for the transportation and distribution of personnel, equipment and materials to the work sites. Existing roads and winter trails will be used where practical to limit disturbance resulting from construction of new access. All vehicle movement on Project access roads will be in accordance with applicable regulations and guidelines. Ground access for materials distribution may also be supplemented by helicopter transport, in some areas.

In Labrador, access for the construction of the Muskrat Falls converter station, the western sections of the transmission line and the shoreline electrode site will be via the existing transportation network to and within Central Labrador, including the TLH and the highway between Happy Valley-Goose Bay and North West River (Route 520), and existing resource roads in the area. The existing paved Labrador Straits Highway (Route 510) will provide access to the eastern end of the Labrador transmission line. Along the remainder of the transmission line, one or more additional access trails will be established from select points on the TLH3 and from the southern part of the TLH (Phase 2) (TLH2).

In Newfoundland, considerable access is already available through the existing provincial highway systems and resource road networks, including existing facilities and associated roads and trails (Appendix 3-2). These existing access networks will be of particular use in those areas where sections of the Project follow along, or near, existing transmission lines on the Island. Any modifications or upgrades required to existing access infrastructure will comply with applicable regulations and guidelines.

The specific number, location and characteristics of all new access for the Project will be finalized as part of ongoing Project engineering and design, and will be planned and developed in compliance with applicable legislation, regulations and authorizations. Dust control and de-icing activities are not likely to be required for the access roads or trails. Upon completion of project construction, a select number of access roads and trails will remain in place to provide an appropriate level of access for transmission line maintenance activities.

Access Roads

In Central and Southeastern Labrador, it is expected that an approximately 20 km long access road will be required from the Labrador Straits Highway (Route 510) to the transmission corridor. It is also expected that one new access road, approximately 12 km in length, will be required at the base of the Northern Peninsula. These access roads will be built to a Class C standard; they will be 5.0 m wide and require a ROW width of 20 m. Figure 3.3.3-2 shows the cross section of typical access roads. Nalcor is not planning to build ice roads, including ice bridges and ice crossings, for the Project.

Access Trails

In Central Labrador, short access trails will extend off the western half of the TLH3 to the ROW. An access trail will also be established within the transmission line ROW for use during Construction, and Operations and Maintenance. This access trail will be located, for the most part, within the cleared ROW, however, in some places (e.g., where the ROW spans a waterbody or crosses difficult terrain) the trail may lie outside the cleared ROW. The access trails will be approximately 4 m wide, with this width reduced at watercourse crossings to

3 m for a distance of 20 m. The trails will use local material to create a stable surface for travel (e.g., cleared wood may be used as corduroy for travel across wetlands, bogs and / or low areas). Crushed rock will not be placed on the trail surface.

3.4.2.2 Water Crossings

The construction of access infrastructure for the Project will involve water crossings. These will include fording, culvert installation or bridge installation, depending on local site conditions, environmental characteristics and sensitivities, and other technical, regulatory and economic considerations. In some cases, it will not be possible or practical to cross a waterbody using any method, in which case access to the area will be gained through access trails approaching the watercourse from both sides. In all cases, access trails and any associated watercourse crossings will be selected, designed, constructed and maintained in accordance with industry practices and in compliance with all applicable legislation and regulations. In keeping with Nalcor's corporate policy and practice, and regulatory requirements, each watercourse crossing will be evaluated and applicable permits acquired prior to construction. Nalcor will meet the CSA conductor clearance standard applicable to the type and size of the watercourse and will comply with the *Navigable Waters Protection Act*.

Fording

Fording will be subject to stipulations contained in Certificates of Approval obtained from the Newfoundland and Labrador Department of Environment and Conservation (NLDEC) and authorizations obtained from Fisheries and Oceans Canada (DFO). Crossings will be restricted to a single location and will be conducted at right angles to the waterbody, where possible. All equipment will be inspected for leaks of oil, fuel and hydraulic fluids prior to crossing, and the number of crossings will be kept to a minimum. Where possible, fording locations will be chosen where the banks and substrate are not sensitive to erosion.

If fording must occur where the banks of the waterbody are sensitive to erosion, the bank will be modified to minimize the potential for erosion. This may be accomplished through the placement of a vegetation mat or by sloping and diverting drainage flow. Where bank material is highly erodible, riprap may be required. If banks are sloped for stabilization, no material will be deposited in the waterbody. Sloping will be accomplished by back-blading above the high water mark. If fording must occur where the substrate of the waterbody is sensitive to erosion, the substrate will be modified to minimize the potential for erosion. A temporary timber bridge may also be installed to minimize the siltation of the waterbody.

Fording activities will be conducted such that the depth of the waterbody is not decreased to less than 20 cm. Where the existing depth is less than 20 cm, that depth will be maintained. Temporary silt traps will be installed in highly sensitive areas near waterbodies, as required, and approaches to ford sites will be stabilized to avoid rutting, thereby avoiding the potential for water build-up that is pushed into the watercourse by the equipment.

Permanent Bridges

Permanent bridges may be constructed in areas where regular travel is required across a ford site or where bank stabilization may not adequately prevent watercourse sedimentation. The approach to the permanent bridges will be designed and constructed perpendicular to the watercourse. The bridges will be built entirely above the high water mark and will not be located on meander beds, braided streams, alluvial fans, active flood plains or other unstable terrain. The bridges will be no greater than two lanes in width and will not encroach on the natural channel width by the placement of abutments, footings or rock armouring below the high water mark.

Sediment and erosion control measures will be installed prior to commencing work. These will include measures to prevent the introduction of cement, grout, paint, ditch sediment, preservatives and other deleterious substances from entering the watercourse. Upon completion of bridge construction, banks will be returned to their original profile and stabilized.

Temporary Bridges

Temporary bridges may be constructed where stream banks are stable and have low slope. Temporary bridges will be no greater than one lane in width, and no part of the structure will be placed within the wetted portion of the watercourse. The bridges will be built entirely above the high water mark and will not be located on meander beds, braided streams, alluvial fans, active flood plains, or other unstable terrain. Crossing materials will be removed immediately following the completion of work.

Sediment and erosion control measures, as described for permanent bridges, will be installed prior to commencing work. Upon removal of the crossing materials, the watercourse banks will be returned to their original profile and disturbed areas will be stabilized, as necessary, to prevent soil erosion.

Culverts

Culvert selection will consider site-specific conditions such as the width of the watercourse crossing, fish habitat characteristics, substrate type, and hydrologic characteristics of the watercourse. Culverts will be sized to handle peak flow, and aligned parallel to the watercourse channel on a straight section of uniform gradient. Culverts will extend a minimum of 300 mm beyond the fill, and a minimum water depth of 200 mm will be provided throughout the culvert length. Baffles may be required where site-specific conditions result in high water velocities.

3.4.2.3 Construction Accommodations

Lodging for the construction work force will be provided through small, temporary construction camps established at strategic points along the ROW. As particular construction activities are phased and completed, workers and crews will move between camps. It is anticipated that eleven temporary construction camps will be established along but outside the ROW. Four will be located between Muskrat Falls and Forteau Point, three will be located between Shoal Cove and Taylors Brook, and four will be located between Taylors Brook and Soldiers Pond. The approximate preliminary locations of the camps are provided in Figure 3.4.2-1. Final locations will be based on detail design, contractor preference and field conditions.

Each camp will occupy an area of approximately 135 m by 135 m (1.82 ha) and will accommodate a bunkhouse for 150 workers, a kitchen, a dining hall and a recreation area. Each camp will be equipped with a first aid station, communications system, helicopter pad, water treatment facility, waste water treatment system, water supply and a fuel supply. The typical layout of the camps is provided in Figure 3.4.2-2. Specific features and / or layout may vary due to local topography and site conditions.

The construction of the camps will include clearing, as necessary, and levelling. If bedrock is exposed, some excavation may be required during grading. Vegetation will generally be cleared using mechanical harvesters to remove the timber and bulldozers to remove the remaining woody vegetation. Camps may be designed to be mobile; as construction activities progress away from each camp location, trailers may be transported along the ROW to the next camp location, thus reducing the need for total Project camp site space.

Potable water for most camps will be obtained from nearby artesian wells. A pumphouse, a water treatment system and a water distribution system will be constructed, as required. Camps B and C will draw water from the St. Augustine River and St. Paul River, respectively, and Camp E and Camp G will draw water from adjacent lakes. The camps will use an intake pumping system which will send the water to a wet well. Camp D may obtain water from the community of L'Anse au Loup. All water taken from natural sources will be treated and chlorinated as required to comply with the *Guidelines for Canadian Drinking Water Quality – Summary Table* (Health Canada 2010, internet site). All permits and authorizations required for the development of potable water supplies, as identified in Appendix 3-1, will be obtained prior to camp construction.

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FIGURE 3.4.2-1

Approximate Temporary Construction Camp Locations

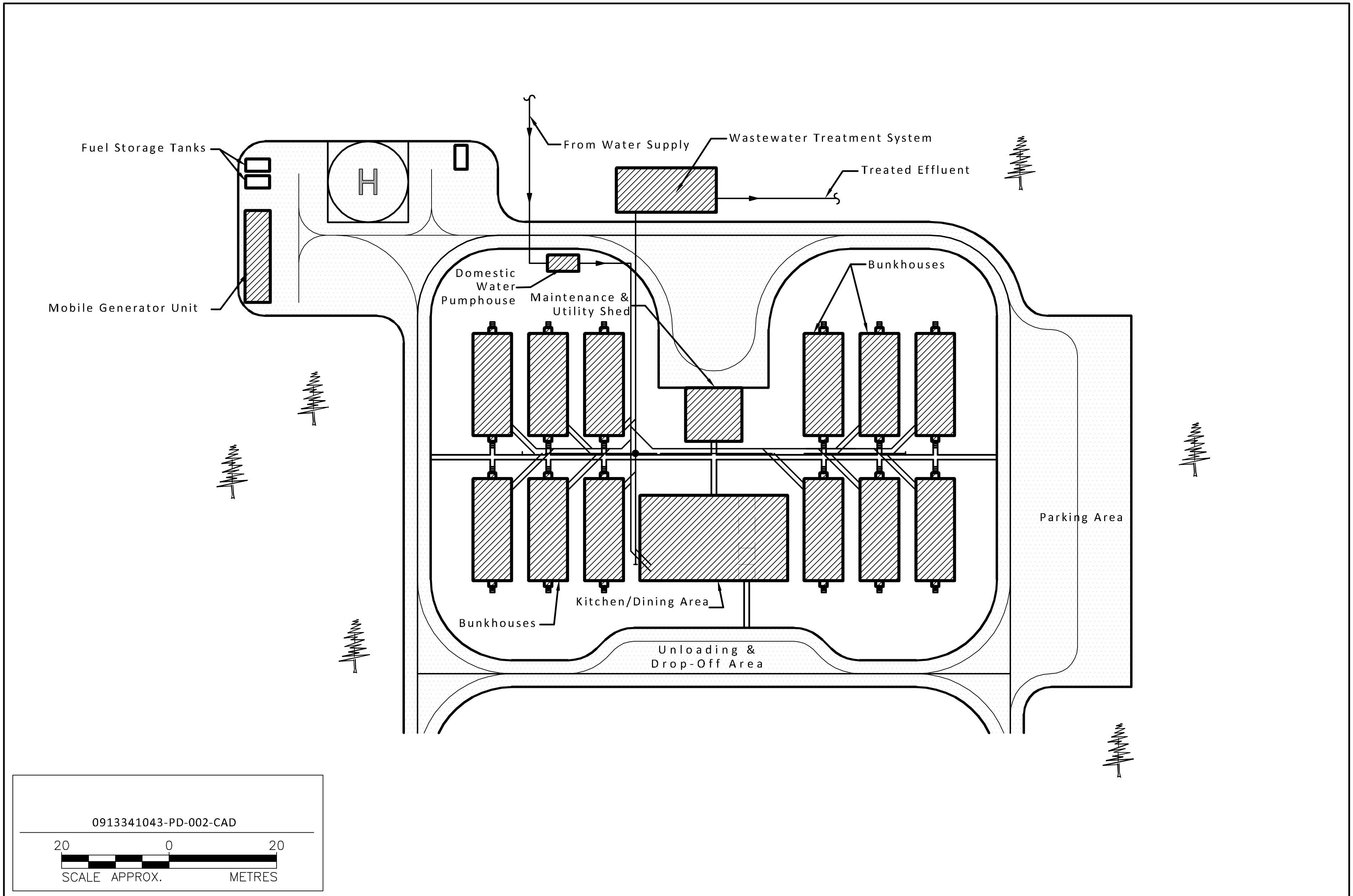

FIGURE 3.4.2-2

Typical Temporary Construction Camp Layout

A sewage treatment system, designed in accordance with guidelines and regulations of applicable regulatory departments will provide sewage effluent acceptable for discharge. Ground percolation tests will be conducted at the camp locations prior to construction to ensure that they are acceptable for the disposal of wastewater in accordance with the *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* (Newfoundland and Labrador Department of Environment and Conservation, Water Resources Management Division (NLDEC-WRM) 2010). Camp D may use existing wastewater treatment infrastructure at L'Anse au Loup.

Solid waste disposal at the camps will be in compliance with the Project Environmental Protection Plan (EPP). Solid waste will be temporarily stored in bear-proof containers before being transported to an approved waste disposal site. A recycling program will be implemented at all camps to reduce the amount of solid waste generated.

Electricity will be supplied to the camps using temporary diesel generators. The diesel generators will be operated in compliance with applicable regulations and guidelines. In some locations, power may be drawn from the existing Newfoundland and Labrador power grid.

3.4.2.4 Marshalling Yards and Lay Down Areas

Marshalling yards will be established at strategic points to receive and temporarily store materials and equipment during Project construction. Five marshalling yards (5 ha each) are proposed, two in Labrador and three on the Island. The approximate locations of these marshalling yards are shown in Figure 3.4.2-3. The marshalling yards will be cleared of vegetation, grubbed and levelled. Vegetation will generally be cleared using mechanical harvesters to remove the merchantable timber and bulldozers to remove the remaining woody vegetation. The yards will be equipped with perimeter lighting and fencing for safety and security. A typical marshalling yard layout is provided in Figure 3.4.2-4.

Materials stored at the marshalling yards will typically include foundation steel, anchoring and guy wire material, tower steel, conductor and groundwire reels, insulators and conductor fittings, and miscellaneous hardware. A site office and a workshop will also be constructed within each marshalling yard perimeter. Table 3.4.2-1 describes the approximate location of each marshalling yard and the proposed route of material and equipment delivery to the marshalling yard.

Lay down (staging) areas will also be established for temporary storage. Bulk material will be transported from the marshalling yards to the lay down areas by transport truck. At the lay down areas, smaller loads may be collected by off-road tracked equipment for transportation to the ROW. These sites require no infrastructure (i.e., no fencing or buildings) and, where practical, contractors will use existing disturbance areas such as pits or other clearings for this purpose.

Assembly yards may also be required for the Labrador portion of the transmission line due to isolation. Approximately 10 assembly yards will be required and the location of each is yet to be identified. These yards will contain approximately 20,000 litres of fuel storage. Handling and fuelling procedures will comply with the Storage and Handling of Gasoline and Associated Products regulations.

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FIGURE 3.4.2-3

Approximate Marshalling Yard Locations

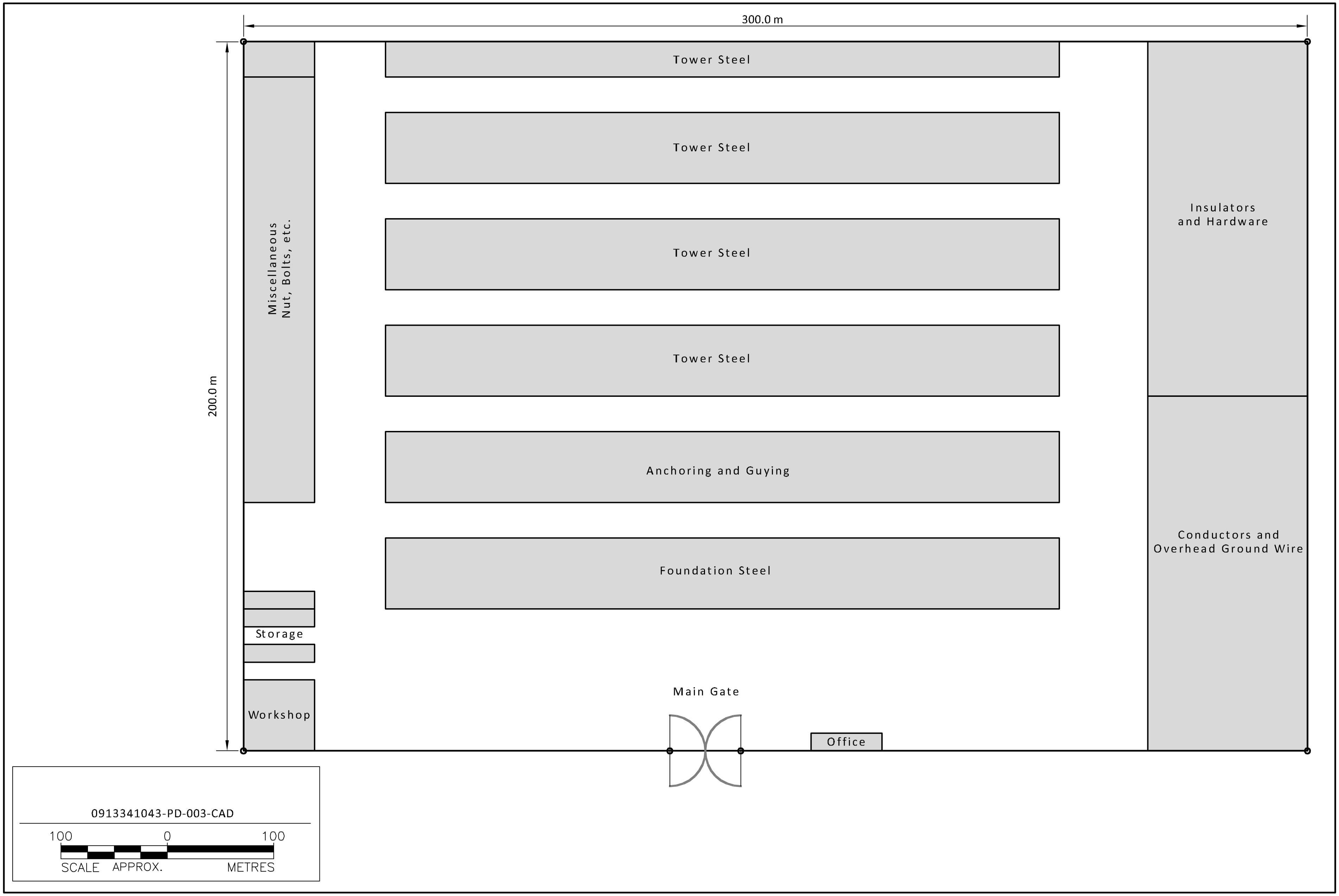

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FIGURE 3.4.2-4

Typical Marshalling Yard Layout

Table 3.4.2-1 Approximate Marshalling Yard Locations and Propose Route of Material and Equipment Delivery

Marshalling Yard	Location	Material and Equipment Delivery
A	Located approximately 150 km SE of Happy Valley-Goose Bay near the southern most point of the TLH3.	Material can be transported by road, either from Goose Bay or through Québec, to the marshalling yard.
B	Located on the Labrador side of the Strait of Belle Isle, near the intersection of Route 510 (Labrador Straits Highway) and the secondary road that leads to Point Amour.	Transmission line materials can be transported by ship or barge or the TLH3.
C	Located near the community of Plum Point on the Northern Peninsula. This is considered an auxiliary yard as it will be used for relatively short-term storage only.	Materials can be transported to the marshalling yard via Route 432. Materials and equipment that are brought in from off-Island will either be sent via boat to Corner Brook or via the TCH via the Marine Atlantic Ferry at Port aux Basques.
D	Located near Deer Lake. This will be the main marshalling yard for the Island portion of the Project and will include an administration building and security office.	Materials can be transported to the marshalling yard via the TCH. Materials and equipment that are brought in from off-Island will either be sent via boat to Corner Brook or on the TCH via the Marine Atlantic Ferry at Port aux Basques.
E	Located at the eastern end of the transmission corridor, on the Witless Bay Line (Route 13), near the existing transmission line.	Materials can be transported to the marshalling yard by road. Materials and equipment that are brought in from off-Island will be either sent via boat to Corner Brook or St. John's or on road (TCH and Route 13) via the Marine Atlantic Ferry at Port aux Basques. Alternate docking locations may be available.

3.4.2.5 Quarries and Borrow Material

Project construction will require aggregate and borrow material. Processed aggregate will be required for the construction of the converter stations, marshalling yards and access roads, and for concrete mixing. The total quantity of aggregate required will be determined during detailed Project design. Borrow material may be required for backfilling during the construction of the converter stations, access roads and transmission tower foundations (e.g., when transmission tower foundation is located in bog material). The development of new quarries is not likely, as it is expected that the volume of material required can be obtained from existing quarries and / or purchased from local suppliers. A map showing the location of existing quarries is included in Appendix 3-2. Borrow material will be obtained from the sources listed below, in the order of preference:

- borrow material obtained from the cleared ROW, from within a 25 m radius of the centre point of the excavation for a tower foundation or anchor;
- borrow material obtained from the cleared ROW but outside a 25 m radius of the centre point of the excavation; and
- borrow material obtained from approved areas outside the ROW.

Borrow pits will be developed in the following manner:

- organic layer and topsoil will be removed and kept separate from mineral soil to limit admixing;
- a pit will be excavated;
- unused excavated material will be replaced;
- the area will be graded to a stable contour; and
- topsoil and organic layer will be replaced.

All borrow pits will be identified, established and decommissioned in accordance with applicable regulatory requirements. The excavation of acid generating material is not anticipated for the Project and metal leaching is not expected to occur.

3.4.2.6 Concrete Production

Concrete for the Muskrat Falls converter station will be sourced from the Lower Churchill Hydroelectric Generation Project construction site. Concrete for the Soldiers Pond converter station will be purchased from local suppliers. Along the transmission line, minimal concrete is required for levelling rock foundations. This concrete is typically mixed on-site, but can be sourced from local suppliers, if available. No concrete batch plants will be developed for the Project, and water use will be minimal. Construction water sources and methods of accessing water and delivering water to construction sites for purposes such as mixing cement and the volume required is not known at this stage of Project Planning but will be conducted in accordance with all applicable regulatory requirements. Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will flow into closed system aggregate rinsing settling basins. In the event that water from the closed settling system is intended for release, it will be tested first for parameters related to concrete additives, pH, and total suspended solids.

3.4.3 Construction Activities and Sequence

3.4.3.1 Converter Stations

Detailed converter station design, and the procurement and manufacture of specialized equipment is expected to take two years. Construction will take place simultaneously at each of the two converter stations during Year 3 and Year 4 of Project construction. The work will include site preparation, delivery of materials and equipment, installation of supporting infrastructure, and testing and commissioning. For planning purposes, converter construction has been divided into four phases, as described below.

Phase One

Phase one of converter station construction will take place in Year 3 of the Project and will include site preparation activities and installation of foundations and infrastructure. The following will be completed during phase one:

- construct access roads;
- site clearing, grubbing and grading, and rock compaction;
- excavate building foundations;
- install station roads and lay down areas;
- prepare valve hall foundation, including footings, formwork and reinforcements;
- install station ground grid;

- install water supply and sewer systems;
- erect security fence; and
- begin installation of valve hall and switchyard concrete foundations.

Potable water for the converter station will be supplied by nearby artesian wells. A pumphouse, a water treatment system and a water distribution system will be constructed as required. All water taken from natural sources will be treated and chlorinated to comply with the *Guidelines for Canadian Drinking Water Quality – Summary Table* (Health Canada 2010, internet site). All permits and authorizations required from the development of potable water supplies, as identified in Appendix 3-1, will be obtained prior to converter station construction.

A sewage treatment system, designed in accordance with guidelines and regulations of applicable regulatory departments, will provide sewage effluent acceptable for discharge.

Phase Two

Phase two of the converter station construction will take place in Year 3 and will include the completion of building construction and the initial stages of valve hall equipment installation. The following activities will be completed during phase two:

- complete the valve hall and switchyard foundations;
- erect the steel building superstructure;
- install roof and cladding;
- begin installation of ac switchgear and filters in the switchyard;
- install transformers, structural components and cable trays inside the valve hall; and
- begin installation of buswork and installation and termination of electrical cables.

Phase Three

Phase three of the converter station construction will take place in Year 4 and will include the interior outfitting of the facility, finalizing the installation of several exterior components, and the installation of interior equipment. Testing and commissioning will be initiated during this phase. The following activities will be completed during phase three:

- complete exterior switchgear and filters;
- install interior, electrical, heating, ventilation and air conditioning systems;
- install converter transformers, transformers, valve hall switchgear, electronics used to protect (i.e., monitor conditions) and control (e.g., open breakers), auxiliary supplies and battery banks;
- install piping for the thyristor (i.e., a solid-state semiconductor switching device) cooling modules;
- begin installation of valve modules and electrical and instrumentation connections;
- complete buswork installation and the installation and termination of electrical cables; and
- install thyristor cooling plant.

Phase Four

Phase four of the converter station construction will take place in Year 4 and will include the completion of installation of interior equipment and final testing and commissioning. The following activities will be completed during phase four:

- complete installation of valve modules and instrumentation connections;
- complete installation of the cooling plant;
- functional testing and partial system testing; and
- initiate start-up and complete system testing.

3.4.3.2 Transmission Line

Transmission line construction will begin after a two-year design and fabrication phase. This two-year period will allow the construction of necessary infrastructure and the clearing of the ROW before the first materials have been fabricated and delivered for system installation.

Land-based transmission line construction activities will be staged in segments: Muskrat Falls to Forteau Point; Shoal Cove to Taylors Brook (km 248); and Taylors Brook to Soldiers Pond. Each transmission line segment will have multiple work fronts that will allow the concurrent execution of construction activities along the transmission ROW. The pattern of work will be different for each section but, overall, it will take about three years to complete construction within each segment.

Transmission line construction will typically include the following activities:

- surveying;
- construction of infrastructure (i.e., access roads, bridges, marshalling yards and temporary construction camps);
- clearing of the transmission ROW and construction of ROW access trail;
- staking of towers and guy locations;
- material distribution;
- installation of tower foundations;
- assembly and erection of transmission towers;
- installation of conductors;
- counterpoise installation;
- cleanup and reclamation; and
- inspection and commissioning.

An overview of each transmission line construction activity is provided below.

Surveying

The first phase of transmission line construction includes surveying the centre line. The transmission corridor was surveyed in 2010 using aircraft equipped with Light Detection and Ranging (LiDAR) equipment. This technology provides accurate and precise geo-referenced survey data from the air with no cutting of survey lines.

Global Positioning System (GPS) technology will guide equipment used to clear the ROW. The location of all transmission towers will be staked using information exported to the GPS equipment from the Project design software.

Construction of Infrastructure and Associated Clearing

Construction of the temporary camp sites, access roads and marshalling yards will begin during the transmission line design and fabrication phase. Section 3.4.1 describes the activities associated with the development of construction infrastructure. Exact timing of camp construction will depend on contract award and contractor schedule.

Clearing of Transmission ROW and Construction of ROW Access Trail

Clearing will be required for the construction of camps, marshalling yards, and transition compounds. The associated clearing will require site clearing, grubbing, and grading.

ROW preparation will be carried out in accordance with standard utility practices and procedures, and will involve the clearing of all vegetation that exceeds 2 m at maturity. Chapter 12.2, the Vegetation Effects Analysis, describes the vegetation types and clearing requirements along the ROW. Clearing will consist of cutting tree trunks parallel to, and within 15 cm of the ground or lower, as well as the removal of all shrubs, debris and other such materials. Grubbing will only occur at tower foundation locations, and may be required to construct the access trail. Clearing of the ROW will consider:

- the location and identification of watercourse crossings along the ROW;
- widths of watercourses;
- location of wetlands;
- areas of commercial timber and the method of cutting and storing commercial timber;
- required buffer zones (e.g., for watercourses); and
- locations of access trails required to bypass zones of difficult access in the ROW.

Vegetation will generally be cleared using mechanical harvesters to remove the timber. Chainsaws may be used for small scale clearings (e.g., tree removal adjacent to a watercourse), as required. All vegetation will be cut within 15 cm of the ground surface. Salvaged timber will be limbed and stacked within the ROW, at right angles to and approximately 6 m from the ROW centre line, in neat piles with a maximum height of 3 m. Slash and debris will be piled in long narrow rows, separate from the merchantable timber, approximately 6 m from the centre line on both sides of the ROW, as appropriate. A 6.5 m wide break in slash windrows will be made at least every 200 m, or as required to address site-specific issues, to allow surface water flow and wildlife passage.

At watercourse and road crossings, the width of the cleared ROW will be reduced to 3 m for a distance of 20 m on either side of the crossing. Selective cutting may be completed in these areas. All woody debris generated at these crossings will be removed from the stream banks and placed in a location within the ROW where it will not enter the watercourse or impede natural drainage.

An access trail will be established within the cleared ROW for use during construction, Operations and Maintenance. The trail will be approximately 4 m wide, with this width reduced at watercourse and road crossings to 3 m for a distance of 20 m. The ROW access trail will use local material to create a safe, surface for travel. Crushed stone will not be placed on the trail surface, however, cleared wood may be used as corduroy for travel across wetlands, bogs or low areas.

Staking of Tower and Guy Locations

Following ROW clearing, field survey crews will physically mark (i.e., stake) the specific locations of the towers, foundations and anchors using GPS technology and data from the LiDAR survey.

Material Distribution

Five marshalling yards will be established at strategic points along the ROW to receive and temporarily store materials and equipment during project construction. Material will be delivered to the marshalling yards primarily by truck, as described in Table 3.4-1. Construction materials will be distributed from the marshalling yards along the ROW using tracked vehicles, such as Nodwells, or other appropriate equipment as dictated by the terrain or other environmental considerations. Distributed materials will include steel foundations, tower sections, guy wire, conductor and hardware. Helicopters may also be used for material distribution, as appropriate and required. Where possible and practical, distribution will be carried out during the winter months, which provides easier access and less ground disturbance (i.e., frozen ground and snow cover).

Installation of Tower Foundations

Foundations are required for both the self-supporting towers and the guyed towers. Foundation installation will require excavation at each tower location, and the installation of a steel grillage structure. If existing material is unsuitable for foundation support, borrow material may be required. Figure 3.3-6 shows the overburden type steel grillage foundation that will be used for the Project. The size of each steel grillage foundation and associated depth will vary with tower size and soil strength.

When constructing in wetlands, cribs made of untreated lumber and backfilled with borrow material will be installed to provide stability to foundations.

Tower foundations may also be on bedrock, which will typically require rock anchors. Figure 3.3-7 shows a rock type foundation. If the bedrock does not provide the stability required (i.e., it contains fractures or it is of inadequate size), blasting may be required. All blasters will have a Blasters Safety Certificate from the Newfoundland and Labrador Department of Human Resources, Labour and Employment. The handling, transportation, storage and use of explosives will comply with all applicable federal and provincial laws, regulations and orders of the Newfoundland and Labrador Department of Human Resources, Labour and Employment and the Mining and Energy branches of the Newfoundland and Labrador Department of Natural Resources and the *Dangerous Good Transportation Act* (RSN, Chapter D-1, plus amendments).

If blasting is required, it will occur as small, localized events. The number of blasts is dependent on the site conditions. Blasting within 200 m of a fish bearing waterbody will be carried out in accordance with DFO guidelines (DFO 2010, internet site). No blasting will occur within 15 m of a fish bearing watercourse.

Assembly and Erection of Transmission Towers

Once the materials are distributed to a foundation location and the foundation is in place, tower assembly and erection will be completed in stages. The steel components will be bolted together on the ground adjacent to the tower location to form the lattice structure. Off-road (tracked) equipment and cranes will be used to attach the tower sections and lift the tower into place. The tower will then be bolted to the foundations. As required, guy wires will be attached to the tower, anchored to the ground using steel grillage foundations, and tensioned to keep the tower in place. Hardware such as insulators will then be attached to the towers in preparation for the installation of the conductor. Typically, it will take a six to eight member crew one to three days to assemble and erect a tower.

Generally, tower assembly will occur at the site where the tower is to be erected. Where helicopter slinging is required, the towers may be assembled in marshalling yards or lay down areas.

Installation of Conductors

Next, the conductor will be installed on the tower structures. The conductor will be rolled onto the line using stringing blocks (i.e., pulleys used to string the conductor from structure to structure) and attached by specialized crews. The conductor is then tensioned and sagged to ensure that the correct design tension is applied and the necessary ground clearance is maintained. A tensioner holds the wire to set the sag, and the wire is then marked, cut, equipped with hardware, and installed. Figure 3.4.3-1 shows the typical conductor installation activities.

Project infrastructure will be inspected prior to commissioning the system. This will include a tower by tower inspection of the transmission line conductors and insulators and testing of converter station equipment.

Counterpoise Installation

The counterpoise will be installed at a depth of 0.3 m along the approximate centre line of the corridor. Counterpoise will be buried along the majority of the length of the ROW. A less than 1 m wide counterpoise trench will be excavated using a small plough, which will feed the counterpoise directly into the trench. The trench will then be backfilled with the removed material using an excavator. The counterpoise will be terminated and a grounding rod will be installed where required and appropriate (i.e., where the transmission line crosses waterbodies or watercourses and authorization to lay the counterpoise on the bed of the watercourse or waterbody cannot be obtained). The grounding rod will be driven below the counterpoise and a bolted connection fixes the counterpoise to the grounding rod.

3.4.3.3 Strait of Belle Isle Cable Crossing

Between the transition compound and the submarine cable landfall onshore entry point, the land cables will be buried in trenches approximately 1 m wide and 1 to 5 m deep. The location of the transition compound will be determined during the detailed Project design, but the length of the trenches is expected to be between 50 and 1,500 m. There will be a maximum of three trenches per landing point, i.e., one or more cables per trench. The trench will be excavated, chaseways installed, and the cable laid. To close the trench an engineered backfilled material may be used to partially or fully fill the trench. Appropriate measures (e.g., signage) will be taken to ensure that there is no excavation or development in the cable areas. There currently is no requirement for surface infrastructure between the landing points and the transition compounds.

To complete the Strait of Belle Isle submarine cable crossing, the Project will employ a combination of HDD technology and a cable installation vessel (CIV). The HDD will provide three lined (steel or HDPE) conduits for each landfall (i.e., Forteau Point and Shoal Cove). The cable will be laid on the sea floor and hauled through the conduit to the onshore landing point. The same connection methods will be used for both landing sites. The construction methods planned for the Strait of Belle Isle cable crossing do not require ocean disposal.

Horizontal Directional Drilling

Each HDD construction site will measure approximately 90 m by 60 m (0.54 ha). The drill sites will contain a drill rig, mud pumps and a drilling mud return pit, and storage facilities for the drill pipes, drill mud and bentonite. Figure 3.4.3-2 shows the typical layout of an HDD site.

Three boreholes will be drilled for the landfalls at Forteau Point and Shoal Cove. The drill path for each borehole will be downward then out under the sea floor, for a distance of approximately 1.5 to 2.5 km. Figure 3.4.3-3 shows a side view of the HDD process.

It is expected that the HDD process will take place 24 hours a day, seven days a week and it is expected to take approximately 2.5 years to complete the three conduits on each side of the Strait of Belle Isle. Two drill rigs will operate concurrently, one at Forteau Point and the other at Shoal Cove. There will be three separate boreholes at each shore approach (i.e., one per cable) and these will be drilled in sequence. A pilot borehole will be drilled at each location, then one or two additional reaming passes will be completed to achieve the desired borehole diameter. Once the borehole is completed, a liner pipe will be installed in the hole, then the drill rig will move on to start the next pilot hole.

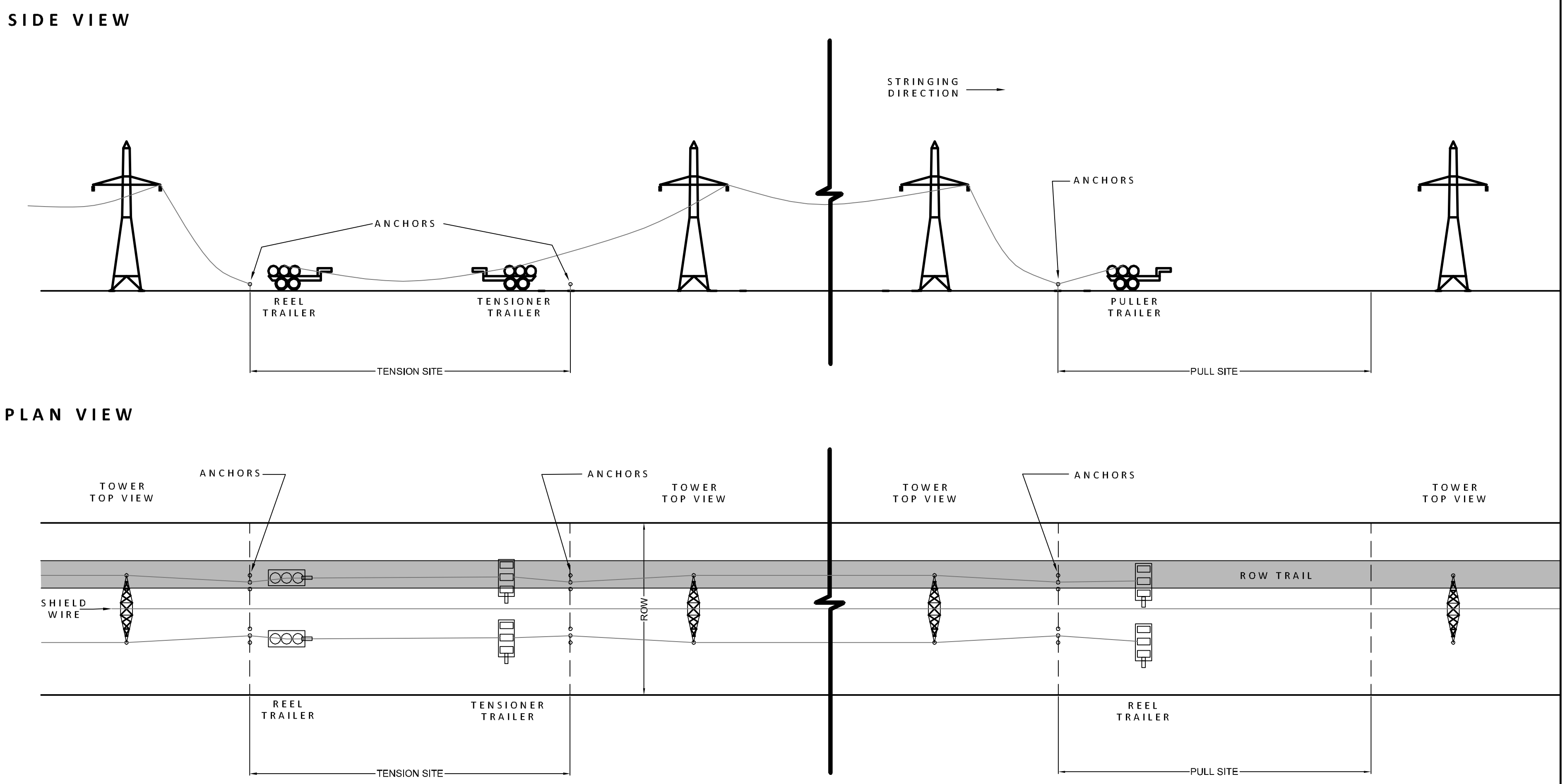

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FIGURE 3.4.3-1

Conductor Installation

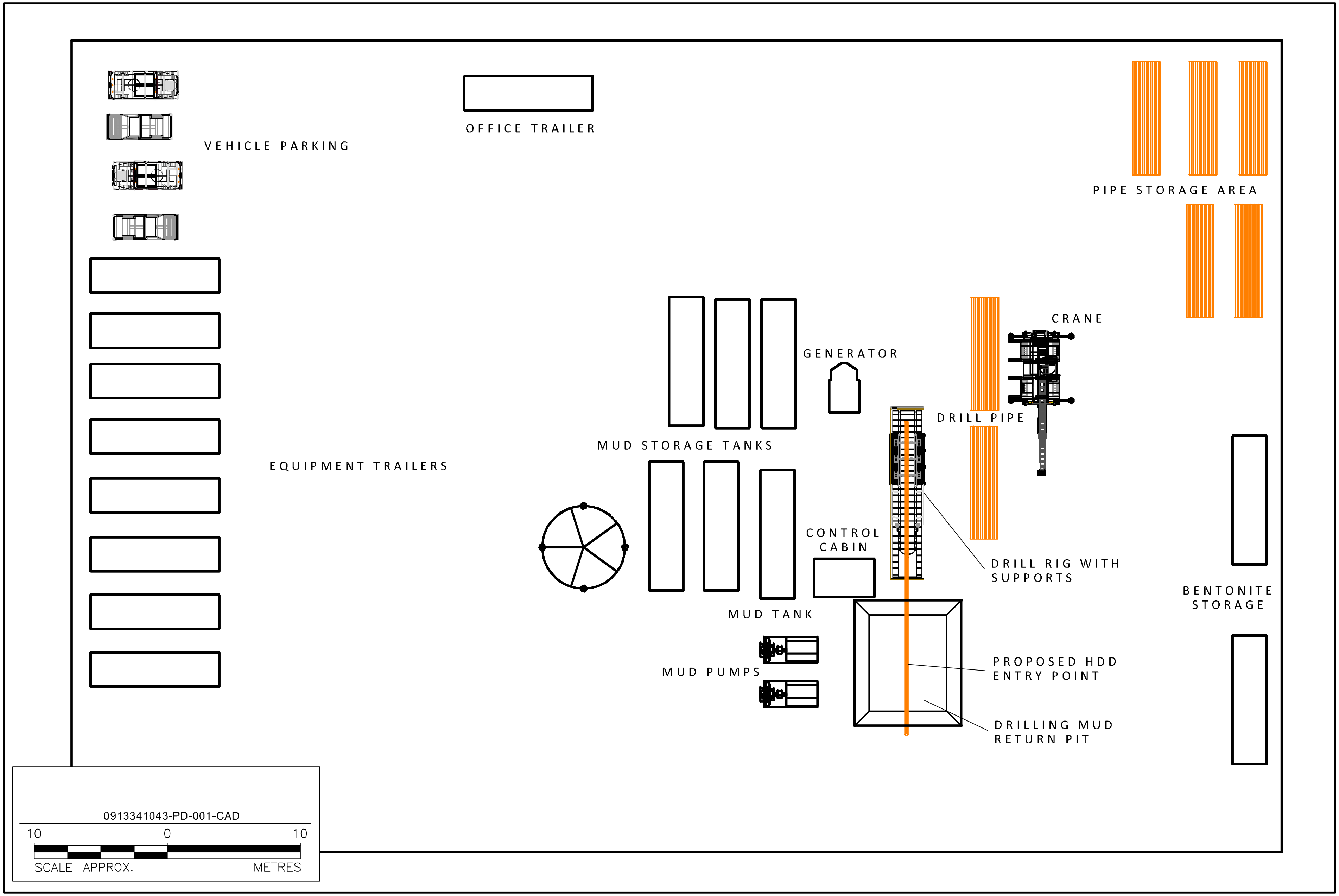

FIGURE 3.4.3-2

Typical Horizontal Directional Drilling (HDD) Site Layout

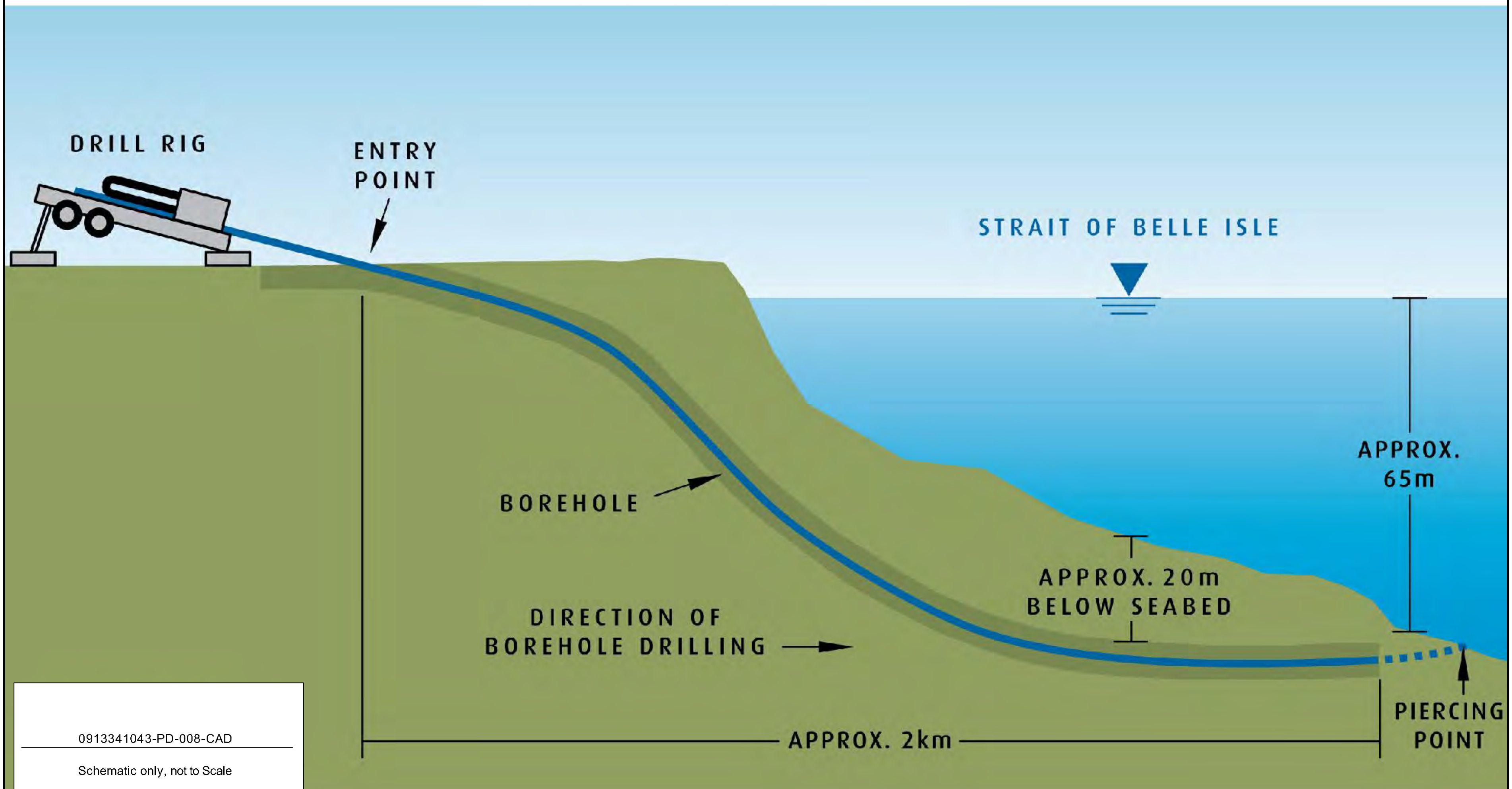

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FIGURE 3.4.3-3

Side View of the Horizontal Directional Drill (HDD) Process

The drill rig pumps drilling fluid which is a waterbased mud (i.e., a mixture of bentonite and water, with other additives as needed) down the centre of the drill pipe during pilot hole drilling and reaming operations. The drilling fluid (also known as drilling mud) flows out of the cutting head or reaming tool and flows back to the drill rig. The drilling mud has three primary purposes. First, it carries soil cuttings out of the borehole so that they may be collected at the drill rig for disposal. Second, the pressure that is exerted by the drilling mud is used to support the borehole walls and prevent the borehole from collapsing. Third, the drilling mud may be used to operate a downhole motor immediately behind the cutting head (i.e., a “mud motor” may be required when drilling through bedrock). The mud will be recovered from the borehole, and will be separated from the cuttings. The cuttings will be disposed of in a landfill, quarry or appropriate facility. The drill muds that cannot be re-used will be disposed of in a landfill quarry or appropriate facility. Any unused muds will be returned to the supplier.

The volume of water required for HDD will be finalized during detailed Project design. The recycling of retrieved drilling muds will reduce the water requirements. A local water source will be indentified during detailed Project design, and all applicable permits will be obtained. Water use for HDD will comply with applicable regulations and guidelines.

Submarine Cable Installation

Prior to cable installation, the bathymetry and geology of the submarine cable corridor will be evaluated. Where the bathymetry exceeds the bending radius (i.e., the radius that the cable can bend before it will potentially sustain damage) of the cable or if there is an indication that the bathymetry will cause free spans (i.e., any time that the cable is suspended between two points) of the installed cable, localized seabed levelling may be required. This would only occur if the free spans caused complications. At this stage of Project design, it is considered unlikely that seabed levelling will occur.

The onshore landfall entry site will be equipped with a combination of mattresses, grout bags and sand bags to ensure a smooth transition for the cable. A bellmouth (i.e., a funnel that will be installed at the end of the HDD conduit to limit the bending radius) will be installed at each landfall seafloor exit location to limit the cable minimum bend radius and provide a smooth surface for the cable during pull-in. If there are large pockets of sediment at the borehole exit locations, localized sediment clearing (i.e., clearing of sediment to ensure there are no free spans) may be required. This would only occur if they (i.e., drilling or bellmouth installation) caused complications. At this stage of Project design, it is considered unlikely that sediment clearing will occur.

A CIV will be used to install the submarine cable. The CIV will be between 80 and 140 m long, 20 to 30 m wide, and will have a draft between approximately 4 and 8 m. The cables will be spooled onto the CIV at the manufacturing facility then transported to the Strait of Belle Isle at the required point in the schedule.

The cable installation process will begin with the release of the first end of the cable, capped by a pulling head or prepared with cable grips, near the first landfall seafloor exit on one side of the Strait of Belle Isle. A line will extend from an onshore winch at the mouth of the borehole, through the borehole, to the borehole exit on the seafloor. An ROV will be used to secure the pulling head to the winch line, and the vessel will pay out the cable as the winch hauls it through the borehole. Once the cable is secured onshore, the CIV will lay the cable to a joint location that will be determined during detailed Project design, and the cable will be abandoned. Additional cable length will be provided at the joint location (i.e., approximately three times the water depth) to allow for the jointing operation. This process will then be repeated from the opposite side of the Strait of Belle Isle until the opposite cable is positioned at the joint location.

The procedure used to join the two cable lengths will depend on the sea depth and jointing location. The CIV will position itself over the two cable ends. The CIV will then recover the cable ends, position them in the jointing house, and complete the jointing process. This process will be repeated for the two remaining cables.

Rock Berm Construction

Each of the three submarine cables will be protected by its own rock berm (Figure 3.3.2-9) constructed using a fallpipe vessel. The fallpipe vessel will be approximately 140 to 160 m long, 30 to 40 m wide, and will have a draft of approximately 6.5 m. The fallpipe vessel will be equipped with an ROV on the end of the fallpipe for accurate placement of the rocks over each of the cable(s).

The fallpipe vessel will make multiple passes to build the berm mass. Rock will be loaded onto the fallpipe vessel at a port, the vessel will then travel to the submarine cable corridor, verify the location for rock placement, then place the rock. The rock will be placed in the appropriate location using a fallpipe whose location is controlled both horizontally and vertically by an ROV to achieve the desired distribution of rock on the seafloor. Rock placement will then be checked by ROV survey, and the fallpipe vessel will return to port, re-load, and repeat the rock placement process.

Successive passes will involve the adjustment of rock volume required for achieving the desired berm profile. It is expected that approximately one million tonnes of rock graded from 50 to 200 mm will be used for the berm. Rock berm construction is expected to take the fallpipe vessel approximately 55 trips. Two fallpipe vessels may be used to improve the schedule for the rock berm construction, however, the total number of trips is not expected to change. There are currently operational quarries and port sites in the province. The quarry(s) and port(s) to be used for the rock berm will be determined by the rock supply and installation contractor.

3.4.3.4 Electrodes

The construction and installation of the shoreline electrodes will include site clearing, excavation and building construction. At both Dowden’s Point and L’Anse au Diable, a permeable berm will be used to create a saltwater electrode pond. At Dowden’s Point the embankment is tied back to the shoreline as required, to create a pond. The natural cove at L’Anse au Diable does not require the embankment to be tied back to the shoreline, but rather will be tied into the outer portions of the cove.

Each permeable berm will be a rubble mound structure consisting of embankment materials obtained from nearby quarries in bedrock. Larger quarry material will be used as armour stone, placed on the sea side slope to protect the permeable berm from storm waves. Larger quarry material will also form the embankment, which needs to be permeable so that saltwater can pass naturally through the embankment, allowing natural flushing.

To construct the permeable berm, trucks will haul appropriately sized material from nearby quarries to the electrode sites. The rock core material will be placed up to the high tide water level, using an excavator or front end loader, from the shore out onto the permeable berm. The armour stone will be placed on the face of the permeable berm, as the core is completed, to protect the core from damage. The permeable berm top core (and armour rock) will then be placed by an excavator as it works back toward the shoreline. A gravel road will cap the crest of the permeable berm, which will facilitate access to the electrodes for Nalcor inspection and maintenance crews.

Construction of the overhead lines connecting the electrodes to the converter stations will be similar to that described for the HVdc transmission line. The erection of single wood poles, however, requires less equipment and smaller excavations than the steel towers proposed for the project. The average pole height for the wood pole electrode line will be between 10 m and 12 m. At each wood pole site, a single hole approximately 2 m deep will be excavated, the pole will be raised and placed into the hole using a crane or backhoe, and the hole will be backfilled with material that came out of the hole to secure the pole in place. If required, guy wires are attached to the pole and connected to buried anchor logs. In bog or wet areas, a crib made of untreated lumber may be placed in the excavation for additional stability. The pole will then be raised and the excavation will be backfilled with borrowed material from a nearby location within the ROW.

3.4.3.5 Island System Upgrades

Upgrades to the Island system will occur within existing infrastructure sites and ROWs. The upgrades include:

- conversion of Holyrood Unit #1 and Unit #2 into synchronous condensers;
- construction of three synchronous condensers at Soldiers Pond;
- replacement of 138 kV and 230 kV breakers at the Holyrood Thermal Generating Station, the Sunnyside Terminal Station and the Bay d'Espoir Hydroelectric Generating Station; and
- rebuilding of eight transmission line sections (i.e., tower and conductor replacement) within 1.6 km of the ac switchyard at Soldiers Pond and removal of the existing lines.

The conversion of Holyrood Unit #1 and Unit #2 from steam powered generators to synchronous condensers will require the modification of electrical and mechanical components within Unit #1 and Unit #2. The modifications will allow Unit #1 and Unit #2 to operate as a generator when connected to a steam turbine or as a synchronous condenser when not connected to a steam turbine. When the Project is in service, the Holyrood plant will be converted to a synchronous condenser to provide system voltage support as well as to provide a backup supply for a short period after the Project comes into service. When operating the generating units as synchronous condensers, the plant is not burning fuel to operate and therefore not releasing emissions into the environment. Following the full commissioning of the infeed, it is intended for the Holyrood plant to remain operable between 2017 and 2020 before all thermal generating aspects of the plant are decommissioned.

The construction of three synchronous condensers at Soldiers Pond is discussed in Section 3.3.3. The construction of these are considered Island system upgrades. However, as a result of the footprint required, and adjacency to the Soldiers Pond converter Station it is discussed in that section.

Breaker replacement at the Holyrood Thermal Generating Station, the Sunnyside Terminal Station and the Bay d'Espoir Hydroelectric Generating Station will include the following activities:

- disconnect all breakers that need replacing;
- remove breakers from their foundations;
- inspect concrete foundations for cracks and deterioration;
- if necessary, replace the foundation with a similar reinforced concrete foundation; and
- install new breakers.

Rebuilding the eight transmission lines within 1.6 km of Soldiers Pond will follow the procedures described in Section 3.4.3 for the construction of the new transmission line. The existing lines will be decommissioned as follows:

- removal of the conductor and insulators from the transmission towers;
- disassembly of the transmission towers using heavy equipment (e.g., cranes);
- decommissioning of in-ground infrastructure as per applicable provincial construction regulations and permits (a list of the permits required for the decommissioning of construction infrastructure is included in Appendix 3-1);
- removal of material (material from the transmission towers, conductor and insulators, will be recycled, where possible, and solid waste disposal will be in compliance with the Project EPP); and
- reclamation and clean-up (i.e., grading disturbed areas, contouring disturbed slopes to a stable profile, removal of refuse, revegetation).

3.4.3.6 Clean-up and Reclamation

Clean-up and reclamation will be conducted as each construction phase is completed. Reclamation and clean-up will include activities such as grading disturbed areas, contouring disturbed slopes to a stable profile and removal of refuse.

At this stage of Project design, the location, capacity and operating conditions of solid waste disposal and recycling sites is not known. All waste disposal / recycling, including hazardous materials, will comply with applicable regulations, and information on solid waste disposal and recycling sites will be provided in the Waste Management Plan.

The disposal of any excavated material will comply with applicable regulations and guidelines.

Reclamation would include site-specific measures to promote natural revegetation of a disturbed area. Disturbed areas will be stabilized, as necessary, to prevent soil erosion.

3.4.4 Construction Equipment

The types and estimated use of vehicles and heavy equipment required for the construction of the overhead transmission line and the converter stations are presented in Table 3.4.4-1.

Table 3.4.4-1 Types and Estimated Use of Heavy Equipment Required for the Construction of the Overhead Transmission Line and Converter Stations

Type of Heavy Equipment	Overhead Transmission Line (hours)	Muskrat Falls and Soldiers Pond Converter Stations (hours)
Excavators	42,000	
Bulldozers	170,000	1,300
Concrete Mixer	5,300	
Graders	40,000	4,400
Muskegs	47,000	
Tracked carrier (e.g., Nodwell)	110,000	
Tracked crane	12,000	78,000
All-terrain crane	31,000	
Truck crane	100,000	
Track drill	36,000	
Dump truck	7,100	150
Tensioner	3,000	
Backhoe		3,900
Boom truck		206,000
Loader	900	490
Generator set		67,000
Hydraulic crane		10,000
Tracked loader	25,000	70
Pick-up trucks	300,000	340,000

3.4.5 Material Requirements and Delivery

The exact material quantities required will be confirmed during detail design. The estimated amount of major civil materials required for the construction of the Project include:

- 2,200,000 m of conductor (2,700 reels);
- 450,000 insulators (approximately 6,250 pallets);
- 3,150 steel towers and 12,000 steel lattice foundations (approximately 76,000 metric tonnes of steel);
- 1,100,000 m each of OPGW and counterpoise (2,750 reels);
- 800,000 m of guy wire (1,000 reels);
- 830,000 m of electrode conductor (1,000 reels);
- 120,000 m or submarine cable;
- 1,000,000 tonnes of rock;
- hardware (nuts and bolts); and
- electrical equipment.

The suppliers of this material will be determined during the procurement phase of the Project, and it is anticipated that material not available locally will be imported from out-of-province suppliers. In addition to these materials, equipment and supplies required to construct the Project include heavy equipment (Table 3.4.4-1), approximately 60,000,000 litres (L) of diesel fuel, and a limited amount of propane (i.e., for camp use). Fuel drums will be cached along the ROW for helicopter use. It is expected that approximately 750 L of Jet-A or Jet-B may be stored in each cache location.

The material distribution plan consists of importing large quantities of material and temporarily storing it at marshalling yards. From each of the marshalling yards, material will be distributed to worksites along the corridor, as described in Section 3.4.2.

Equipment maintenance will be conducted in accordance with manufacturer's requirements and will be completed on-site. All maintenance and repair activities will be undertaken in compliance with environmental rules and regulations and as per the Project Environmental Protection Plan (EPP). Any field servicing will be conducted a minimum of 50 m from any watercourse or wetland, unless otherwise approved or in the event of an emergency. Waste oil will be collected and stored in drums (clearly marked as waste oil) inside a dyked area and will be regularly shipped for disposal. Waste oils, lubricants and other used oil will be disposed of at approved disposal sites.

During construction, fuel will be transported by tanker trucks, in drums or other approved containers. Fuelling stations will be established along the ROW, with self-dyked steel storage tanks. The largest fuel storage tank on-site will hold no more than 125,000 L. When the locations of and requirements for fuel storage are, all mobile storage tanks will be registered under, and in compliance with, the *Storage and Handling of Gasoline and Associated Products Regulations* under the *Newfoundland and Labrador Environmental Protection Act* (*NLEPA*). Records will be maintained of all storage tank contents to reconcile inventories as a check against any undetected leakage. All transport vehicles will be licensed and maintained according to safety requirements.

Fuelling stations at marshalling yards and camps will include concrete pads and drainage controls. Drainage will be retained in a sump where hydrocarbons can be captured and separated prior to release of any rainwater run-off, as appropriate. Equipment with reduced mobility, such as heavy lift cranes and excavators, will have fuel delivered by a mobile tank and re-fuelling will take place on-site. All fuel transfers will follow safety procedures to prevent leaks and drips, and spill response kits will be available on all vehicles used to transport fuel. Fuelling of mobile equipment will not be permitted within 50 m of a waterbody. Handling and fuelling procedures will comply with the *Storage and Handling of Gasoline and Associated Products Regulations* and any additional requirements set forth by the NLDEC.

3.4.6 Decommissioning of Construction Infrastructure

Construction infrastructure that is not required for Project Operations and Maintenance will be decommissioned upon completion of construction. This will include the decommissioning of temporary camps, some access roads and bridges, borrow pits, marshalling yards and temporary lay down areas, and clean-up and reclamation of construction infrastructure sites.

3.4.6.1 Temporary Camps

All temporary camps constructed along the ROW will be decommissioned upon completion of Project construction. All buildings will be removed and water and sewer systems decommissioned in accordance with regulatory requirements. All in-ground infrastructure will be decommissioned as per applicable provincial construction regulations and permits. A list of the permits required for the decommissioning of construction infrastructure is included in Appendix 3-1. Temporary camps will be graded, as appropriate, to re-establish natural drainage patterns, and topsoil will be replaced. Clean-up and reclamation will be undertaken as described below.

3.4.6.2 Access Roads and Bridges

Upon completion of Project construction, a limited number of access roads and trails will remain in place to provide an appropriate level of access for transmission line maintenance activities. All others will be decommissioned and rehabilitated using applicable and appropriate methods and standards. The extent of road and trail rehabilitation will vary and will range from disturbing the road surface using an excavator and restricting access to complete rehabilitation. Complete rehabilitation will include removing the road way, re-grading the area and backfilling ditches. Sediment and erosion control measures will be installed prior to decommissioning watercourse crossings. Decommissioning will include the removal of any watercourse crossing material and processed aggregate from the access road surface. Upon removal of the watercourse crossing materials, the watercourse banks will be returned to a stable condition. Access roads will be graded, as appropriate, to re-establish natural drainage patterns, and topsoil will be replaced. Clean-up and reclamation will be undertaken as described below.

3.4.6.3 Borrow Pits

Borrow pits excavated along the ROW will be rehabilitated as work is completed in that area. Rehabilitation will include the replacement of unused excavated material, grading to a stable slope, grading to re-establish natural drainage patterns, replacement of topsoil, and installation of erosion control structures, as appropriate. Clean-up and reclamation will be undertaken as described below.

3.4.6.4 Marshalling Yards and Temporary Lay Down Areas

All surface infrastructure will be removed from the marshalling yards and lay down areas. All in-ground infrastructure will be decommissioned as per applicable provincial construction regulations and permits. A list of the permits required for the decommissioning of construction infrastructure is included in Appendix 3-1.

3.4.6.5 Clean-up and Reclamation

Clean-up and reclamation will be conducted after the construction infrastructure has been decommissioned. Reclamation and clean-up will include activities such as removing refuse, grading disturbed areas and contouring disturbed slopes to a stable profile. Reclamation will include site-specific measures to promote the natural revegetation of disturbed areas. Disturbed areas will be stabilized, as necessary, to prevent soil erosion.

3.5 Operations and Maintenance

Upon commissioning, the Project will operate on a continuous basis. During operation there is limited potential for emissions, including audible noise, electric fields and electromagnetic fields (EMF). Maintenance activities will include regular inspection of the Project, any necessary repairs and vegetation management along the ROW. Activities associated with the Operations and Maintenance of the Project will be integrated into Nalcor's existing transmission system inspection and maintenance program.

Appendix 3-1 provides a list of permits required for the Project. All Operations and Maintenance activities will be conducted in accordance with permits and regulations.

3.5.1 Operations

Operations of the Project involves the transmission of electricity through the conductors between the Muskrat Falls and Soldiers Pond converter stations, respectively, the conversion of ac to dc and dc to ac at the converters stations, and the operation of shoreline electrodes. The electrical equipment and facility systems will be remotely monitored and controlled using a SCADA / Operational Data System, monitored from the Energy Control Centre at Hydro Place in St. John's.

During normal Project operations, small amounts of electrical current will flow through the electrode (i.e., less than 1% of the total current). This occurs to offset imbalances in the transmission system. Under some circumstances (e.g., during converter maintenance) the system can temporarily operate at a reduced capacity, and electrode operation is not required. The electrodes may be used during a normal fault (e.g., one pole is out of service for maintenance). This is expected to occur for less than 40 hours per year. The use of the electrodes to provide a return path for the full current is expected to occur only under specific circumstances, such as a submarine cable or overhead conductor failure. Project design criteria (e.g., final ROW selection, cable protection planning, the use of a spare cable across the Strait of Belle Isle, and conservative design of the transmission towers and conductors) minimize the potential for and duration of these events.

3.5.2 Maintenance

3.5.2.1 Inspection

Each year the line will be 100% inspected through ground and / or aerial patrol. Ground-based inspections will be conducted on all-terrain vehicles (ATVs) during summer and snowmobiles in the winter, and aerial inspection will be conducted by helicopter. A further 10% to 20% of the transmission line will be inspected via climbing inspections on a yearly basis by Nalcor personnel. Inspection crews look for signs of physical damage (e.g., broken or missing insulators), loose or eroded parts (e.g., bolts) and condition of the conductors (e.g., frayed or areas of reduced clearance). Minor adjustments such as bolt tightening may be done during the inspections. The wood pole electrode lines will also be inspected annually using the same methods as the transmission line inspections.

Inspection of the submarine cables and rock berms, and the electrodes and permeable berms will consist of an annual visual inspection campaign using an ROV for two years post-installation. These inspections will focus on rock berm condition (i.e., deterioration and general anomalies). Following the two years of inspection, the results of the inspection campaign will be assessed to determine the frequency of future inspections.

Switches located in the wood pole electrode line termination structure can be used to turn off a series of electrode elements. The electrode elements will then be accessed and inspected from the road along the crest of the permeable berm.

3.5.2.2 Maintenance and Repairs

Nalcor follows the principles of asset management. Asset management is defined as the comprehensive management of asset requirements (i.e., planning, procurement, operations, maintenance, rehabilitation, disposal and replacement) to achieve maximum value based on the required standard of service to current and future generations. Asset Management ensures that there is a comprehensive listing of all assets and that there is single point accountability for the Operations and Maintenance of each asset. There is a clear focus on short- and long-term maintenance planning and execution. Inspection and replacement includes the collection of performance data for reporting and analysis. This analysis ensures that Nalcor applies the most effective level of maintenance and takes the appropriate level of preventative and corrective action when required.

Typical transmission line maintenance activities include minor adjustments and replacements (e.g., replacement of insulators). However, more extensive repairs may be required that could involve the replacement of anchors or guy wires, necessitating the use of heavy equipment such as backhoes or cranes.

The submarine cable has a 50-year design life and is not expected to require repairs during its design life. The rock berms are also designed to be stable and not require repairs. If a fault does occur in a submarine cable, however, repair of the cable would include the following steps:

- locate the fault;
- remove a portion of the rock berm to expose the faulty cable;
- load spare cable and joining kit onto intervention vessel;
- undertake repair using a spare cable and joining kit; and
- apply protection (rock berm) to the repaired section of cable.

The electrode elements can be continuously operated for 3.5 years before they may need to be replaced. Switches located in the electrode line termination structure can be used to turn off a series of electrode elements during maintenance activities. The road constructed along the crest of the permeable berm will allow safe access to the electrodes.

3.5.2.3 Vegetation Management

Vegetation management encourages the growth of plants compatible with utility operations, encouraging natural biological control of vegetation and providing a safe environment. Nalcor will incorporate the Project into its integrated vegetation management program for its transmission and distribution systems. A survey will be undertaken before each vegetation management program is initiated to determine priority vegetation management areas.

Vegetation that exceeds 2 m in height at maturity (e.g., spruce, alders, birch) will be removed because it can encroach on the transmission line clearance and can affect maintenance crew access. Vegetation will be controlled through a combination of herbicide application and manual cutting. The selective use of herbicides after cutting produces a low, dense plant cover that discourages the invasion of nuisance vegetation (i.e., vegetation that exceeds 2 m in height at maturity) while encouraging the growth of compatible vegetation (i.e., vegetation less than 2 m in height at maturity). Approximately 6,600 ha of area will be managed for vegetation, as required, within the ROW. Vegetation maintenance will likely begin during year eight of operations and will be repeated every seven years thereafter, or as required for safety.

Vegetation management program will also be applied to the converter station, and associated ac switchyard, and synchronous condenser yard.

Currently there are two chemical application techniques used on transmission lines by Newfoundland and Labrador Hydro, a subsidiary of Nalcor Energy and an approved operator for the application of herbicides by the Department of Environment and Conservation. The first and most common technique is a directed foliar application. This technique consists of a sprayer system mounted on a tracked machine such as a muskeg (each application vehicle is licensed under the *Environmental Protection Act*, SNL2002-E-14.2 and Pesticide Control Regulations, 2003). The sprayer system is a single nozzle at the end of a long wand controlled with a trigger by the applicator on the back of the machine. As the name suggests the operator directs the chemical mix to the target vegetation (e.g., spruce, fir, birch, poplar, alder, and maple) as the machine moves along the line. Each operator is also licensed and trained to apply herbicide. Treatment of compatible species also found on the right-of-way is avoided or minimized. Compatible species are low growing and do not grow to a sufficient height to reach energized lines or cause significant impediment or safety concerns to maintenance crews traveling in the right-of-way. Compatible species include berries, Labrador Tea, Kalmia species, Trailing Juniper, Dwarf Birch, and grass. This selective application of herbicide maintains the compatible species within the right-of-way giving them increased growing space with the removal of the target species. Once compatible species have established it makes it more difficult for the target species to re-establish and the length of time between treatments is increased.

The second application technique is a cut and stump treatment. This treatment consists of cutting the target species and applying herbicide to the stump using a back pack sprayer or a sprayer mounted on the brushsaw. This kills the root system and prevents re-sprouting. This system is very expensive and labour intensive. It is typically used in sensitive areas. This vegetation control method will use Tordon 101, Garlon 4, and Glyphosate products.

Buffer zones are applied to all water bodies, private land, wells, and human habitation (temporary or permanent). Buffers on water bodies for foliar treatments are 30 m to 50 m depending on the slope (slopes over 20° get the 50 m buffer). It is possible to cut and stump treat up to 2 m from the water body using glyphosate based products but it is not typically done on a transmission line. Buffer zones for wells, private land, and human habitation are 50 m.

The use of herbicides along the proposed transmission line corridor and other areas requiring vegetation management (e.g., converter yards, ac switchyard) for the Project will be in accordance with the procedures described above and will be applied as appropriate. Approval and appropriate licensing will be obtained from the Department of Environment and Conservation.

Certified crews will use the herbicide Tordon 101 mixed with Sylgard 309, a surfactant that allows easier spreading. The quantities of chemicals used will depend on terrain, and quantity and type of vegetation. The herbicide will be sprayed directly by a person on the vehicle to ensure that only appropriate plants (i.e., tall-growing species) are treated. To the extent practical, short shrubs and bushes will not be sprayed with the herbicide.

All vegetation management activities will be subject to approval from the NLDEC and will be in compliance with the *Pesticides Control Regulations* under the *NLEPA*. Standard practice includes public notification and an evaluation of any environmental sensitivities in areas of herbicide use. Vegetation control personnel will be appropriately trained and qualified, and vegetation management activities will be designed and conducted in accordance with applicable industry and regulatory standards. A list of the permits required for Project Operations and Maintenance is included in Appendix 3-1.

3.5.3 Potential Emissions

HVdc systems and electrodes are commonly used worldwide for the bulk transmission of electrical power over long distances. During the operation of HVdc systems, there are limited emissions and discharges, including audible noise, EMF, electric fields and chemical emissions. This section describes the potential emissions from both the on-land transmission infrastructure and the submarine cable and electrodes during operations. Other emissions (e.g., vehicle exhaust, fugitive dust) are addressed in the appropriate VEC chapters as part of the environmental effects assessment of the Project.

3.5.3.1 Overhead Transmission Line and Converter Stations

Technical analyses have been conducted to estimate the potential audible noise levels, EMF strength and radio interference that may be associated with the on-land Project. These estimates were used for Project planning and design (e.g., conductor design, and voltage and current specifications) to ensure that noise emissions and EMF remain within acceptable standards, as discussed in the following sub-sections.

Audible Noise Due to Overhead Transmission Lines

Audible noise is emitted by a transmission line when a small amount of electrical energy within the conductor interacts with the air surrounding the conductor surface. These ionization reactions, known as corona, depend on ambient conditions such as temperature, humidity, wind speed, and wind direction. The noise emitted typically resembles a crackling or sizzling sound.

Noise level limits for transmission lines are specified at the edge of the ROW and are measured using A-weighted dB (dBA).

There are currently no Canadian noise control regulations applicable to HVdc transmission lines. The United States Environmental Protection Agency's (US EPA 1974) "levels document" proposes a day-night average (Ldn, 50%) noise limit of 55 dBA based on which several regulating bodies have developed regulations for transmission line applications. Since the HVdc lines produce higher noise under fair weather conditions, contrary to ac lines, it is considered prudent to limit Ldn (10%) value to 55 dBA and the corresponding Ldn (50%) value to 50 dBA. Thus the calculated average audible noise, by the application of industry wide accepted empirical methods, should be limited to 42 dBA. This value has been used by Nalcor in its selection of the HVdc voltage level and conductor size.

Audible Noise due to Converter Stations

The converter stations will be designed to limit the audible noise produced at any point immediately outside the fence to 65 dB(A) and at the nearest residential area to 45 dB(A).

Radio Interference Levels Due to Overhead Transmission Lines

Radio Interference (RI) can be caused by corona discharges on pole conductors. The proposed HVdc overhead transmission line will be designed to comply with the Canadian Standards Associated standard CAN-C108.3.1-M84 dated 2009, the same standard that is applied to HVac transmission lines.

The standard limits the fair weather RI level to 63 dB above 1µV/m (as per Table 1 for 600 to 800 kV AC lines) at a distance of 15 m from the outermost conductor. This value is to be calculated at the mid-span and measured at 0.5 MHz. The calculated fair weather RI value, as per the industry wide accepted empirical methods, at ±350 kV is found to be 55 dB, well below the specified limit of 63 dB. The RI value at the edge of the ROW would be approximately 2 dB lower than 55 dB.

Radio Interference Levels due to Converter Stations

The RI Level of electromagnetic radiation generated by the converter station will be limited to 100 µV/m at locations along the perimeter 500 m from any energized component in the converter station.

Electric and Electromagnetic Fields

The dc electric field is the combination of the "electrostatic field" and the enhanced field due to "space charge".

The electrostatic field is the corona-free field that surrounds an energized conductor which results from charges on or near the conductor surface.

On the other hand, "space charge field" is related to the ions produced by corona discharges. In the case of ac lines, these ions remain confined to an area surrounding the conductor due to the fact that the ions are attracted within a half cycle and repelled within the next half cycle. However in HVdc lines, while a small portion of the corona generated ions reach the other polarity conductor and disappear after recombining, most of the generated ions make their way to ground and form a stream of ions that transfer electric charges to human bodies or objects underneath the line.

There are currently no Canadian regulations limiting EMF emissions, nor are there any guidelines for EMF exposure (Canadian Electricity Association 2010, internet site). The practice is to set a limit of the maximum allowable electric field and the current density at ground level under the line. Based on the operating experience of HVdc lines around the world and the CIGRE Technical Brochure 388, "*Impacts of HVDC Lines on the Economics of HVDC Projects*" the fair weather enhanced field values will be limited to the following values:

Variable	Units	Maximum within the ROW
Current density	nA/m^2	100
DC Electric field	kV/m	25

Summary of Project Emission Criteria for On-Land Infrastructure

Table 3.5.3-1 summarizes the expected Project emissions of audible noise, radio interference and EMF.

Table 3.5.3-1 Audible Noise, Radio Interference and Electromagnetic Field Emission Criteria

Audible Noise (dBA)	Radio Interference (dB)		Maximum EMF (kV/m)	Ion Current Density (nA/m^2)
	Wet Conditions	Dry Conditions		
50 (EPRI 2008)	77 (Industry Canada 2001, internet site)	77 (Industry Canada 2001, internet site)	25 (EPRI 2008)	100 (EPRI 2008)

Note: Design criteria and reference are indicated in brackets.
Audible Noise is measured at the edge of the ROW.
Radio interference is measured 15 m away from the positive pole.

3.5.3.2 Submarine Cable and Electrodes

Emission calculations presented in this section for the electrode are based on Hatch Ltd. (2011). Two scenarios, 320 kV and 400 kV, were modelled. The values presented are those for the 320 kV system as these systems were 'worst-case' emission values, and the Project (350 kV) will have lower estimated values.

Electric Fields

The submarine cable will have two sheath armour layers, as described in Section 3.3.3. When two conductive surfaces have an electric potential difference between them, any electric field will be confined within this space. In the submarine cables, the electric field exists between the conductor and the metallic sheath or armour wires, depending on design. There will be no electric field outside the submarine cable.

Electromagnetic Fields

The electromagnetic field for a single submarine cable transmitting current at 1,286 A will be approximately 26 micro Tesla (µT), at a distance of 10 m from the cable. By comparison, day to day battery operated appliances function at 300 to 1,000 µT and, depending on the location on the surface of the earth, the natural field from the Earth's core is between 0 and 50 µT.

Heat Effects

Depending upon detailed design, the heat dissipated by the submarine cable will be approximately 23 Watts per metre (W/m). This is equivalent to one small household light bulb installed every metre along the submarine cable, on the seabed and under the rock berm. In projects where cables are buried just under the surface, the seabed immediately under the cable could experience a 2 to 3 degrees Celsius increase in temperature. For this Project, however, the cables will not be trenched or shallowly buried in the seabed. The cables will be laid on the seafloor and buried under a berm. The cable's influence on the temperature of the water column will be minimal. Where the cables travel beneath the seabed through the conduit, the cables will be tens of metres below the seabed, therefore, heating effects on the seabed are not expected.

The dissipation of energy in the form of heat will be produced by the shoreline electrodes. The energy produced at the electrode is directly proportional to the current flowing into or out of the electrode and to the resistivity of the medium surrounding the electrode. Heat dissipation densities through the permeable electrode berm, the sea, and the pond were calculated for three electrode operating modes for monopolar operations (nominal, maximum continuous and maximum 10 minutes) and during bipolar operations (1% of the current during normal operations accounting for system imbalances).

Also the worst case heat dissipation through the seawater density was calculated at the seaside interface of the berm. The minimum area of berm required to achieve a safe voltage gradient is the only section considered in the analysis; in reality the berm surface area will be larger than the area considered on the sea side and the heat dissipation density will be proportionally lower. Also as a conservative approach, 100% of the current in each case is assumed to flow through the minimum berm section in question and the water in the pond and sea side. In reality, some current will flow through the adjacent sections of the berm and some will flow inland.

Table 3.5.3-2 presents the volumetric heat dissipation through the shoreline electrode berm for both L'Anse au Diable and Dowden's Point.

Table 3.5.3-2 Volumetric Heat Dissipation through Shoreline Electrode Berm

Location	Volumetric Heat Dissipation (Watts per cubic metre (W/m^3))			
	Nominal	Maximum Continuous	Maximum, 10-Minute	1% Imbalance
L'Anse au Diable Electrode	<13.7	<30.8	<54.8	0.001
Dowden's Point Electrode	<14.4	<32.5	<57.7	0.001

Source: Hatch Ltd. (2011).

Table 3.5.3-3 presents the summary of the temperature rise in the shoreline electrode ponds for L'Anse au Diable and Dowden's Point for the monopolar maximum continuous current scenario. The temperature rises are less than 0.5°C, except for the recessed pond option at Dowden's Point which has a smaller pond volume. The actual temperature rise in the ponds will be lower than the temperature presented because as a conservative and precautionary assumption the conductive heat loss to the sea and evaporation are not considered in the analysis. The electrode berm temperature rise will be less than the temperature rise of the pond.

Table 3.5.3-3 Estimated Maximum Temperature Rise in Electrode Pond, Monopolar Maximum Continuous Current

Location	Estimated Maximum Temperature Rise in Pond (°C)
L'Anse au Diable Electrode	<0.47
Dowden's Point Electrode (Design Option 1)	<0.33
Dowden's Point Electrode (Design Option 2)	<3.51

Electric Field

The electric field produced is the result of ground potential rise (GPR) which occurs when an electrical current of large magnitude enters into the ground and the earth becomes charged with electricity. Depending on the electrical resistivity of the ground, the current can travel through the earth, resulting in voltages that decrease with distance from the point where the current entered the ground. For a shoreline pond electrode, GPR is a function of the shoreline electrode berm design, its exposure to the open sea, and seawater resistivity. GPR simulations were performed for both the L'Anse au Diable and the Dowden's Point electrodes using Teshmont's GRELEC program (Hatch Ltd. 2011). The modelling results indicate that the GPR gradients in the sea, on the shoreline and on the berm will be lower than the safe step potential, as shown in Table 3.5.3-4.

Table 3.5.3-4 Modelled Ground Potential Rise Gradient at the Shoreline Electrodes

Description	Calculated Ground Potential Rise Gradient (Volt/metre)	Safe Limit (Volt/metre)	Remarks
At the electrode elements	16.73	N/A	Access to the electrode elements is controlled
On the electrode berm	9.62	95	–
In the water on the sea side of the electrode berm	<1.25	1.25	–

Source: Hatch Ltd. (2011).
Note: N/A = Not applicable.

Electromagnetic Field

The magnetic field from the electrode cables and element will be greatest near the shoreline electrode berm and the contribution of these current dipoles will diminish as distance from the electrode increases. The current through the body of sea water induces a magnetic field at the surface and is normally weak due to the low current density in the body of water.

The calculation of the magnetic field is based on current values deduced from the GPR modelling. The current flow between soil volumes is considered as a dipole to calculate the magnetic field contribution. The magnetic field is calculated at the surface of the water only for anodic operation. In cathodic operation, the dc magnetic field will be equal in magnitude but in the opposite direction as the field produced in anodic operation. The magnitude of the resultant field (earth magnetic intensity plus electrode magnetic intensity) will be different and will be oriented in a different direction. However, the compass deviations will be of the same order as the values reported in the tables below.

The induced magnetic effects are focussed on two aspects: compass deviations (i.e., magnetic field at 1 m above sea level) and marine life (i.e., magnetic field at 0 m above sea level).

For the L'Anse au Diable and Dowden's Point electrode, the zone extending into the sea in which the magnetic compass deviation exceeds 0.5° as a result of maximum continuous electrode operation is limited to 500 m from the electrode. During normal bipolar operation, the compass deviation is estimated to be less than 0.1° at a distance of 100 m from the electrode.

The estimated difference between the resultant absolute value of magnetic field at the surface of the sea and that of the earth's natural magnetic field (53.6 µT near L'Anse au Diable North; 51.4 µT near Dowden's Point) is less than 0.8 µT and 2.2 µT for L'Anse au Diable and Dowden's Point electrode, respectively at a distance of 500 m from the electrode for the continuous maximum current. During normal bipolar operation, the estimated difference is less than 0.2 µT and 0.3 µT at a distance of 50 m from the electrode, for L'Anse au Diable and Dowden's Point electrode respectively.

Chemical Emissions

Emissions as a result of electrolysis are produced during electrode operations, for both monopolar (maximum continuous current) and bipolar operations (system imbalances). These emissions include chlorine and other by-products at the anode, and hydrogen at the cathode.

For L'Anse au Diable electrode, when operating at maximum continuous duty as an anode, the estimated chlorine produced per day is 6.89×10^{-4} g/L, assuming the worst case chlorine selectivity of 30%. For operation as a cathode, the estimated hydrogen produced per day is 2.62×10^{-4} g/L, assuming 100% hydrogen selectivity. It is important to note these values do not consider gas exchange with the air or through the breakwater, which is a conservative, precautionary approach.

For L'Anse au Diable electrode, operating as an anode during normal bipolar operation and assuming a current imbalance of 1% of the nominal electrode duty, the estimated chlorine produced per day is 4.59×10^{-6} g/L, assuming the worst case chlorine selectivity of 30%. For operation as a cathode during normal bipolar operation, the estimated hydrogen produced per day is 1.74×10^{-6} g/L, assuming 100% hydrogen selectivity. These values do not consider gas exchange with the air or through the breakwater.

Tidal flushing continuously reduces the emission concentrations in the electrode pond to an expected maximum chlorine concentration from a day of electrode operation as anode to 3.15×10^{-4} g/L. During the bipolar operation, the expected chlorine concentration is 2.10×10^{-6} g/L. The values do not consider gas exchange with the air or exchange with the sea water due to concentration differential, which is a conservative and precautionary approach.

For Dowden's Point electrode, the estimated chemical emissions are presented for Option 2, as Option 1 modelling results are slightly less than the values estimated for Option 2. When operating at maximum continuous duty as an anode, the estimated chlorine produced per day is 7.44×10^{-3} g/L, assuming the worst case chlorine selectivity of 30%. For operation as a cathode, the estimated hydrogen produced per day is 2.83×10^{-3} g/L, assuming 100% hydrogen selectivity. It is important to note these values do not consider gas exchange with the air or through the breakwater, which is a conservative and precautionary approach.

For Dowden's Point electrode, operating as an anode during normal bipolar operation and assuming a current imbalance of 1% of the nominal electrode duty, the estimated chlorine produced per day is 4.96×10^{-5} g/L, assuming the worst case chlorine selectivity of 30%. For operation as a cathode during normal bipolar operation, the estimated hydrogen produced per day is 1.88×10^{-5} g/L, assuming 100% hydrogen selectivity. These values do not consider gas exchange with the air or through the breakwater, which is a conservative and precautionary approach.

Tidal flushing continuously reduces the emission concentrations in the electrode pond to an expected maximum chlorine concentration from a day of electrode operation as anode to 2.70×10^{-3} g/L. During the bipolar operation, the expected chlorine concentration is 1.80×10^{-5} g/L. The values do not consider gas exchange with the air or exchange with the sea water due to concentration differential, which is a conservative and precautionary approach.

The chlorine gas emitted at the anode will be dissolved in the water and form secondary and tertiary products, a small quantity of which could escape to the environment depending on the conditions. Any gas escaping to the air would be dispersed efficiently by the wind. Chlorine concentrations are predicted to be safe (i.e., below 0.4 ppm) (Canadian Centre for Occupational Health and Safety 2011, internet site), in the air outside of the pond limits.

3.5.4 Decommissioning

The Project will be operated for an indeterminate time period and decommissioning is not anticipated. Should decommissioning activities eventually be considered for some or all Project components, decommissioning will be planned and conducted in accordance with relevant standards and regulatory requirements of the day. This would include the development of a decommissioning plan that considers environmental planning and mitigation measures, socioeconomic mitigation measures, and public health and safety procedures. The decommissioning plan will be submitted to the relevant regulatory authorities for approval.

3.6 Environmental Protection Planning

A construction EPP and an Operations and Maintenance EPP will be prepared for use by all Project personnel, including employees of Nalcor and its contractors. The EPPs will incorporate applicable regulatory requirements and all Construction, Operations and Maintenance related environmental commitments made as part of this EIS. A proposed table of contents for the EPPs is presented in Appendix 3-3. Project construction, Operations and Maintenance will be managed to the standards established by the International Organization for Standardization (ISO) 14001 Environmental Management System (EMS). Existing Nalcor facilities, including Churchill Falls, have been individually registered by an external auditor (Quality Management Institute, QMI) as compliant with the ISO 14001 standard. This Project will be constructed, operated and maintained in accordance with a Project-specific EMS.

3.6.1 Environmental Protection Plan

As a corporation with significant experience in building, operating and maintaining transmission infrastructure in the province, Nalcor has established state-of-the-art procedures related to environmental protection and management. Nalcor's Environmental Policy and Guiding Principles (Appendix 3-4) will be implemented during the Construction, Operations and Maintenance of the Project.

An EPP is an important tool for consolidating environmental information and commitments into procedures and responsibilities for the implementation of environmental protection measures in the field. The main objectives of the EPP are to:

- consolidate information for planning;
- ensure compliance with current environmental standards and regulations;
- ensure Project commitments to environmental protection and planning are met; and
- provide guidelines for field activities and decision-making on environmental issues.

Geographic Information System (GIS)-based mapping has been developed for the Nalcor transmission system to provide environmental information to planning personnel. These maps provide information on:

- ecological reserves, parks and protected areas;
- listed species and their habitat;
- wetlands and other sensitive habitat;
- protected water supply areas;
- existing access trails;
- stream crossing and approved fording sites; and
- terms and conditions of environmental permits and authorizations.

These maps provide Nalcor's personnel with the information relative to environmental considerations that have and will be considered for the Project Construction, Operations and Maintenance.

An EPP has been developed and implemented for the Project's pre-construction environmental and engineering field studies. This EPP addresses issues related to storage and handling of fuel, waste disposal, vessel operation, hunting and fishing, encounters with wildlife, the discovery of historic resources and rehabilitation measures. This EPP will be used as a starting point, but it will be expanded for construction activities.

The Project-specific Construction, and Operations and Maintenance EPPs will be field-useable documents, addressing provisions for the identification of, and avoidance or reduction of environmental effects. The EPPs will include activity-specific protection measures, contingency measures and reporting protocols for unplanned events (e.g., spills), and reclamation procedures.

The table of contents for the Project's EPP will include:

- Introduction;
- Project Description and Construction Schedule;
- Roles and Responsibilities;
- Relevant Legislation;
- General Environmental Protection Procedures;
- Environmental Monitoring and Follow-up;
- Contingency Plans;
- Contact List;
- Forms; and
- Reference Documents.

3.6.2 Safety, Health and Environmental Emergency Response Plan

Nalcor will proactively identify potential safety, health and environmental concerns related to Project Construction, Operations and Maintenance. Prevention measures and response procedures will be described in the Safety, Health and Environmental Emergency Response Plan (SHERP), and all Project personnel will receive SHERP training.

The SHERP will be a field-useable document that addresses the prevention measures and emergency response procedures for unplanned safety, health and environmental events. The objectives of the SHERP include:

- the protection and maintenance of human health and safety;
- the identification of the potential for accidents and emergency situations;
- the planned response to accidents and emergency situations; and
- the prevention and mitigation of potential environmental effects associated with accidents and emergency situations.

The SHERP will include specific instructions for the prevention of and response to spills or leaks of hydrocarbons or other hazardous material. Spill response kits will be maintained at all activity sites, and the contents will be based on the volume of fluids in use, the type of fluid, proximity to water and other relevant factors at the particular site. All personnel involved in hydrocarbon transport and transfer will be trained in spill response, and spill response kits will be available on all vehicles used to transport fuel. A Response Team will be formed, trained and will receive regular practice in "mock" responses for incidents that require co-ordinated action.

In addition to spill prevention and response, the SHERP will describe roles, responsibilities and procedures related to:

- personal protective equipment;

- materials storage;
- vehicle safety;
- working at heights;
- working near or over water;
- working near or on ice;
- vessel operation and safety;
- HDD operation and safety;
- animal encounters;
- emergency response communications;
- personnel injury response;
- search and rescue;
- fire and explosion response; and
- vehicle / vessel accidents.

3.6.3 Environmental Inspection

A key component of environmental protection during Project construction is provided by on-site environmental inspectors. In addition to advising on compliance with environmental regulations, on-site environmental inspectors will provide information and advice to the planning process. This may include recommended travel routes and fording sites, and the design and implementation of mitigation measures. Responsibilities of the environmental inspectors will include:

- inspection of work areas and activities;
- advising on the avoidance of sensitive areas;
- input into the design and implementation of environmental mitigation measures (e.g., sediment and erosion control measures, and site water management); and
- assistance with the development and implementation of reclamation plans.

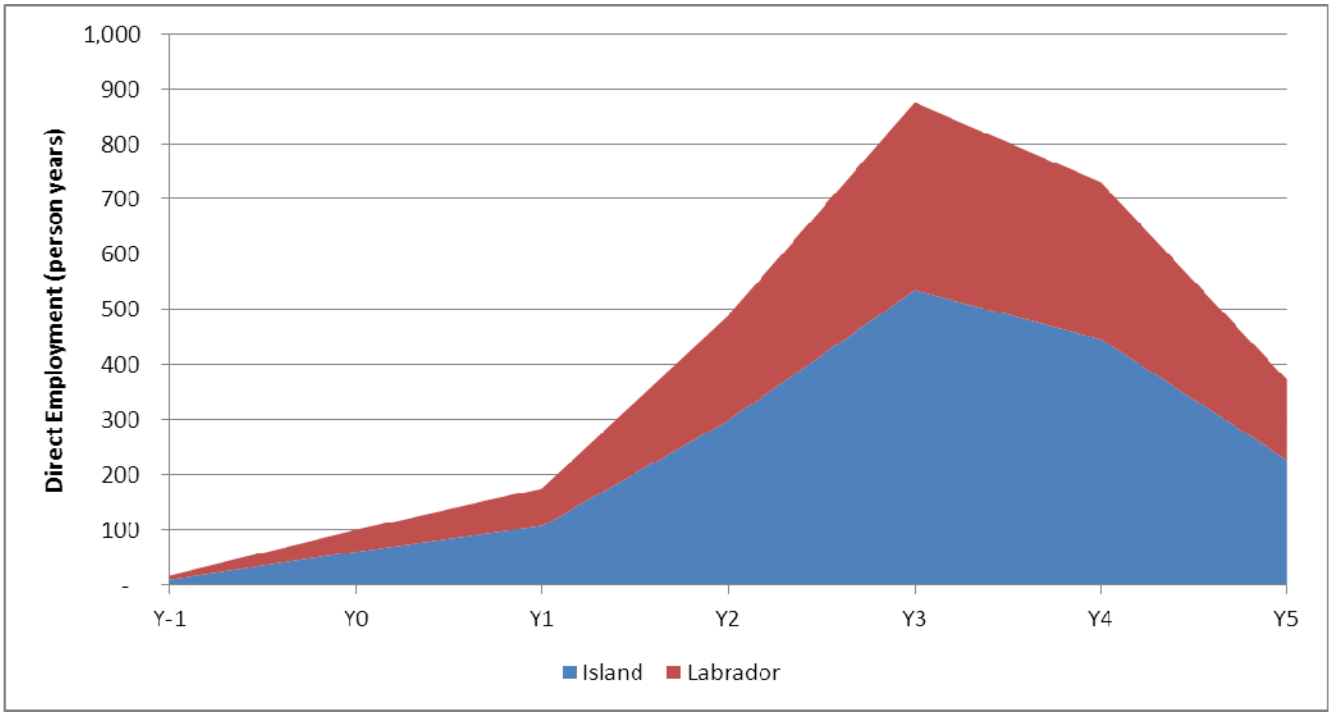
3.7 Project Workforce

Approximately 3,070 person-years are required to construct the Project. Of this total, approximately 1,700 person-years will be located on the Island of Newfoundland and 1,100 person-years will be located in Labrador, with the remainder located elsewhere. The estimated percentage of the workforce required from Newfoundland and / or Labrador is not known at this stage of Project Planning. Peak direct construction employment is expected in Year 3, with 540 person-years of work occurring on the Island and 340 person-years in Labrador. During the Operations and Maintenance phase, approximately 30 additional full-time personnel will be required, in addition to specialized contractors. Working schedules for Construction, and Operations and Maintenance personnel are to be determined during detailed Project Planning.

3.7.1 Construction Workforce

The size of the estimated yearly Project Construction workforce is illustrated in Figure 3.7.1-1. The Project workforce will average approximately 180 direct person-years during Year 1, and is expected to increase in Year 2 to 490 persons, and peak in Year 3 with 880 person-years. The Project workforce for Year 4 is expected to average approximately 730 direct person-years, and will decrease to approximately 370 direct person-years in Year 5.

Figure 3.7.1-1 Required Project Workforce by Year



The two most represented categories of occupations required for the Project will likely be heavy equipment operators and construction trades helpers and labourers. The general occupations expected to be engaged in Project planning, design and construction are listed below:

- heavy equipment operators;
- labourers;
- ironworkers;
- line workers;
- concrete finishers;
- drillers and blasters;
- construction managers;
- carpenters;
- surveyors;
- electricians;
- truck drivers;
- building custodial staff;
- engineers and technologists;
- forestry workers;
- mechanics; and

- building and accommodation staff.

3.7.2 Operations and Maintenance Workforce

The Operations and Maintenance workforce will form part of Nalcor's overall transmission line maintenance program and will consist of Nalcor employees based in Labrador and on the Island. Approximately 30 new managers, technologists and tradespeople will be required (Table 3.7.2-1). It is currently anticipated that 12 of these positions will be located in Labrador and 18 on the Island.

Specialized services will be required on a periodic basis to perform maintenance and technical operations. It is anticipated that these services will be provided by contractors who will supply approximately 6,000 hours of technical support annually.

Table 3.7.2-1 Anticipated Workforce Requirements for Project Operations and Maintenance

Position Description	Quantity
Manager, Labrador – Island Transmission Link	1
Manager, Operations and Work Execution	1
Manager, Long-Term Asset Planning	1
Asset Specialist – Transmission	1
Asset Specialist – HVdc Specialties	1
Supervisor, Short-Term Work Planning and Scheduling	1
Asset Planner	1
Communications / Network Services Technologist	1
Lines Superintendent	2
Line Persons	6
Maintenance Supervisor	2
Electricians / Electrical Maintenance	6
General Maintenance Workers	2
Electrical Engineer	1
Transmission Engineer	1
Administrative	1
Finance and Accounting	1
Total Estimated New Positions	**30**

3.7.3 Workforce Demand Profiles by National Occupation Classification Code

Table 3.7.3-1 presents the total estimated labour demand by National Occupation Classification (NOC) code.

Table 3.7.3-1 Labrador-Island Transmission Link Total Estimated Labour Demand by National Occupation Classification Code

NOC Code	Person-years
A0 - Senior Management Occupations	10
A1 - Specialist Managers	120
A3 - Other Managers, n.e.c.	100
B0 - Professional Occupations in Business and Finance	150
B3 - Administrative and Regulatory Occupations	130
B4 - Clerical Supervisors	20
B5 - Office Equipment Operators	110
C0 - Professional Occupations in Natural and Applied Sciences	580
C1 - Technical Occupations Related to Natural and Applied Sciences	230
D2 - Technical and Related Occupations in Health	10
E0 - Judges, Lawyers, Psychologists, Social Workers, Ministers of Religion and Policy and Program Officers	60
F0 - Professional Occupations in Art and Culture	20
G9 - Sales and Service Occupations n.e.c.	30
H0 - Contractors and Supervisors in Trades and Transportation	120
H1 - Construction Trades	70
H2 - Stationary Engineers, Power Station Operators and Electrical Trades and Telecommunications Occupations	230
H3 - Machinists, Metal Forming, Shaping and Erecting Occupations	110
H4 - Mechanics	80
H5 - Other Trades, n.e.c	10
H6 - Heavy Equipment and Crane Operators, Including Drillers	360
H7 - Transportation Equipment Operators and Related Workers, Excluding Labourers	90
H8 - Trades Helpers, Construction and Transportation Labourers and Related Occupations	390
I1 - Occupations Unique to Forestry Operations, Mining, Oil and Gas Extraction and Fishing, Excluding Labourers	10
J2 - Assemblers in Manufacturing	20
Total	**3,060**

3.7.3.1 Methodological Considerations

The following figures illustrate the demand profile for each occupation listed in Table 3.7.3-1. The totals are quarterly average figures. Therefore monthly peaks could be slightly higher than those illustrated. The estimates were derived through the Decision Gate 2 (DG2) (as discussed in Chapter 2) capital cost estimate where total hours for each activity by each type of occupation were made. The total hours for each occupation were combined and divided by the average hours per month. In the case of trade labour, it was assumed that a 21 and 7 schedule would be used with individuals working an average of 210 hours per month. For non-trade labour, an average of 185 hours per month was used to convert total hours into average person months, which were then converted to person quarters.

Figure 3.7.3-1 Total Labour Demand – Labrador-Island Transmission Link

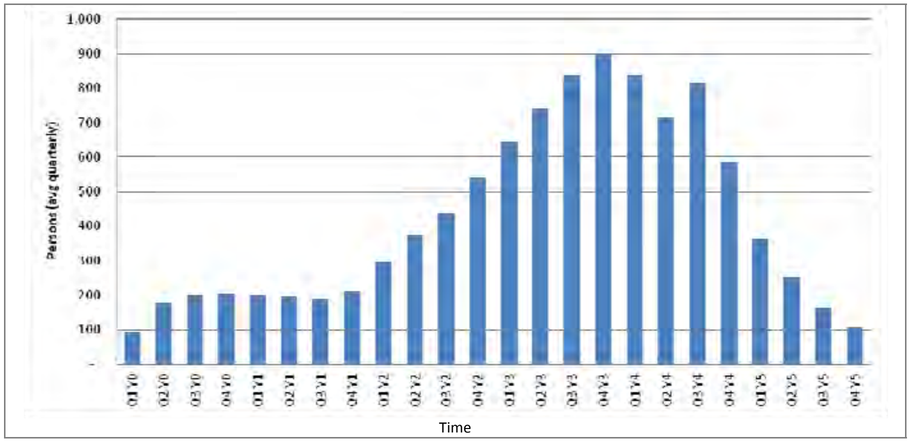


Figure 3.7.3-2 A0 – Senior Management Occupation

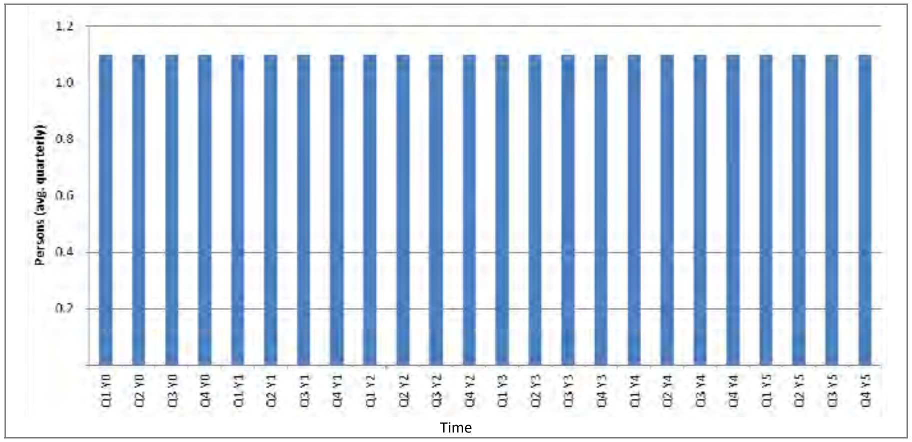


Figure 3.7.3-3 A1 – Specialist Manager

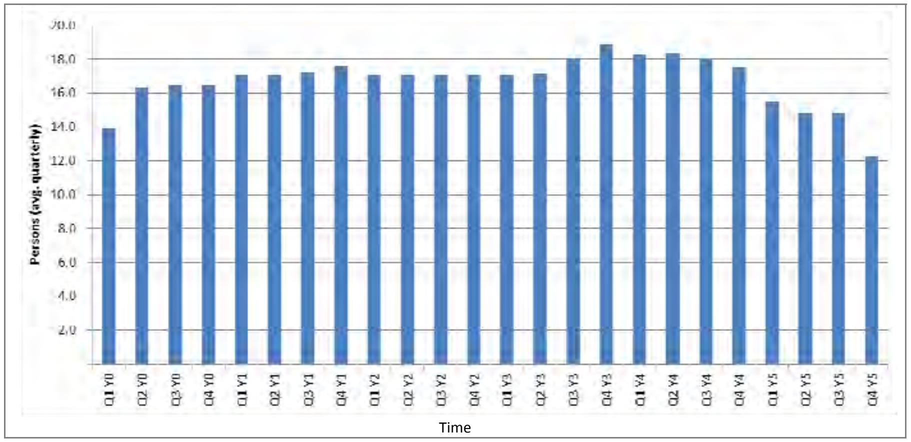


Figure 3.7.3-4 A3 – Other Managers, n.e.c.

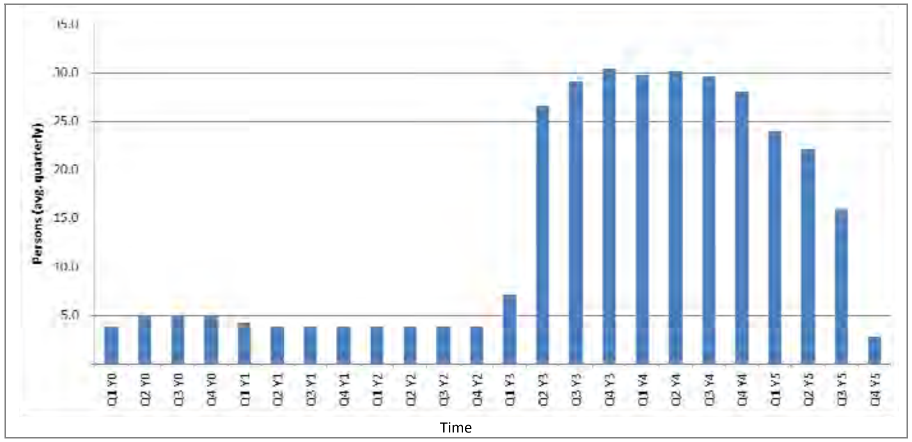


Figure 3.7.3-5 B0 – Professional Occupations in Business and Finance

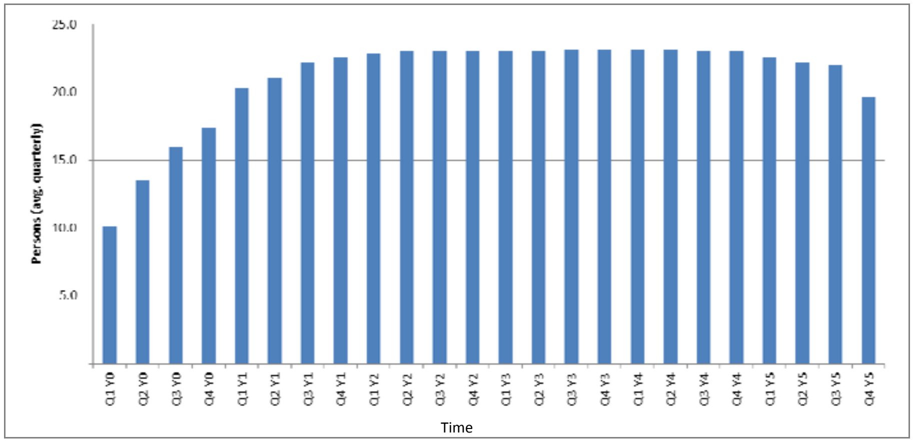


Figure 3.7.3-6 B3 – Administrative and Regulatory Occupations

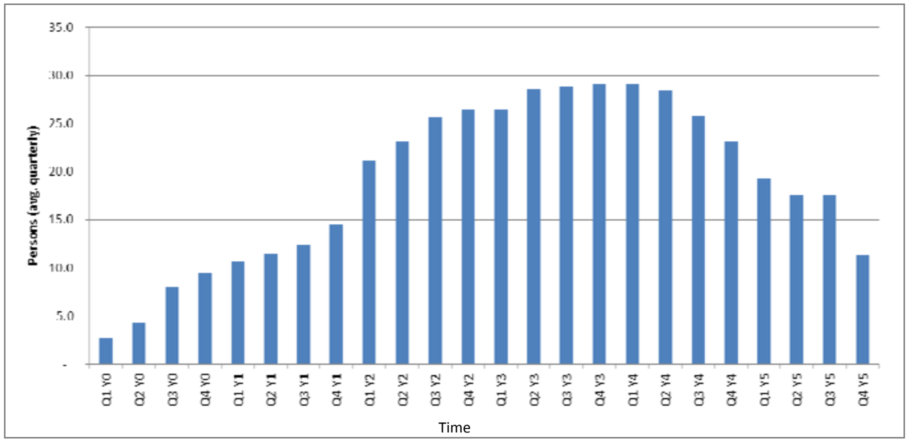


Figure 3.7.3-7 B4 – Clerical Supervisors

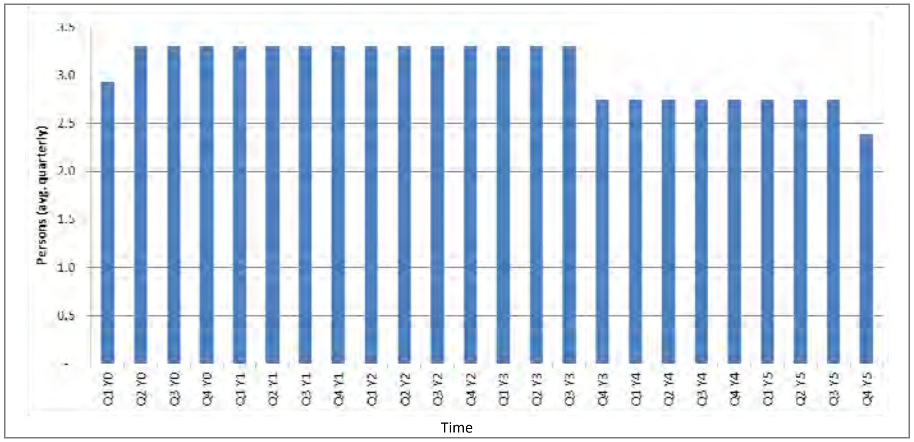


Figure 3.7.3-8 B5 – Office Equipment Operators

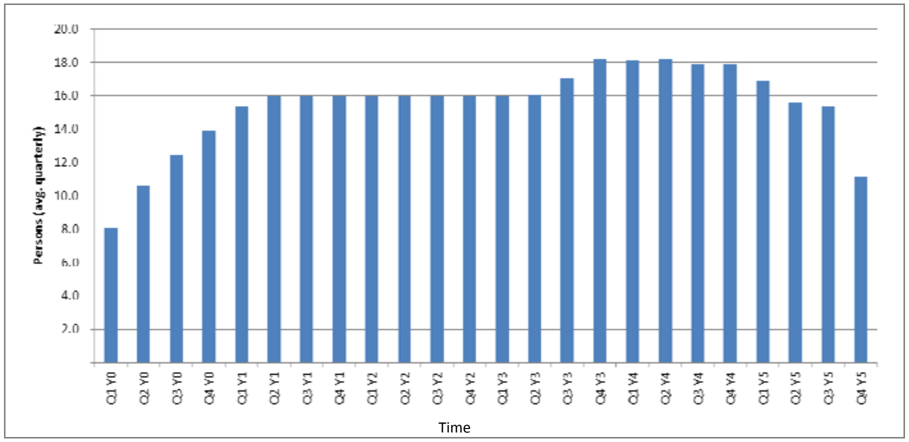


Figure 3.7.3-9 C0 – Professional Occupations in Natural and Applied Sciences

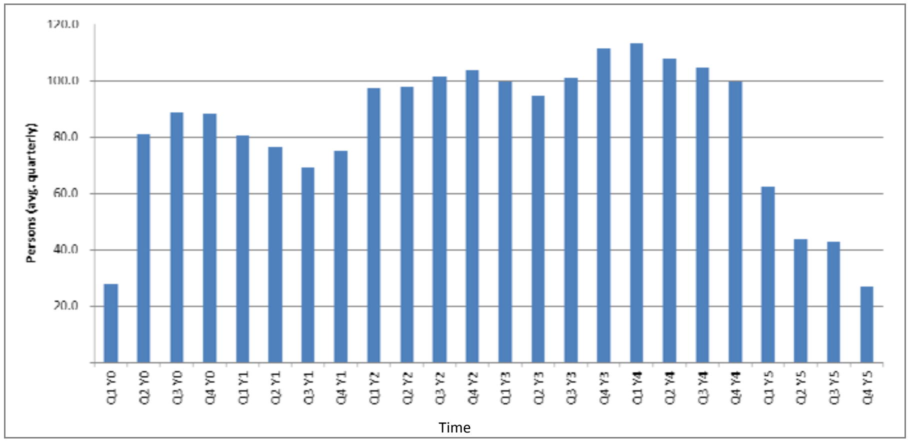


Figure 3.7.3-10 C1 – Technical Occupations Related to Natural and Applied Sciences

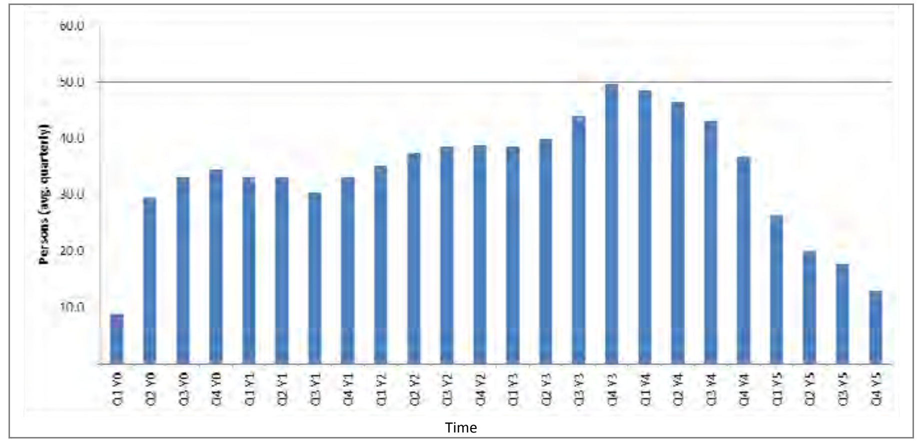


Figure 3.7.3-11 D2 – Technical and Related Occupations in Health

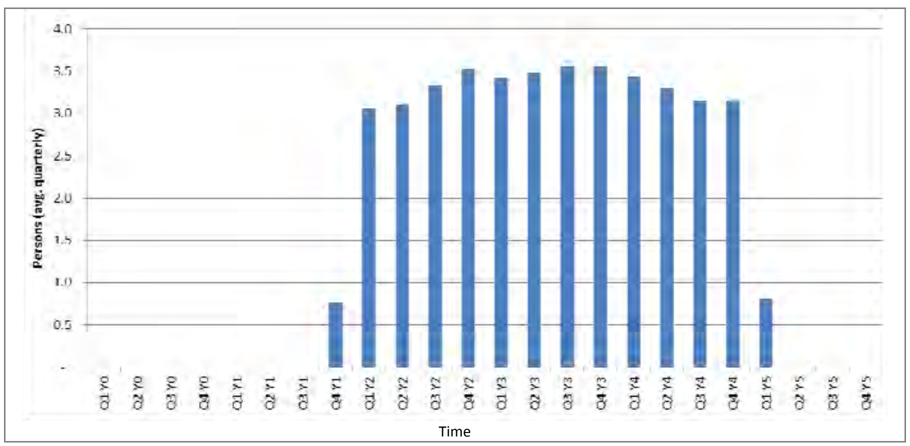


Figure 3.7.3-12 E0 – Judges, Lawyers, Psychologist, Social Workers, Ministers of Religion and Policy and Program Officers

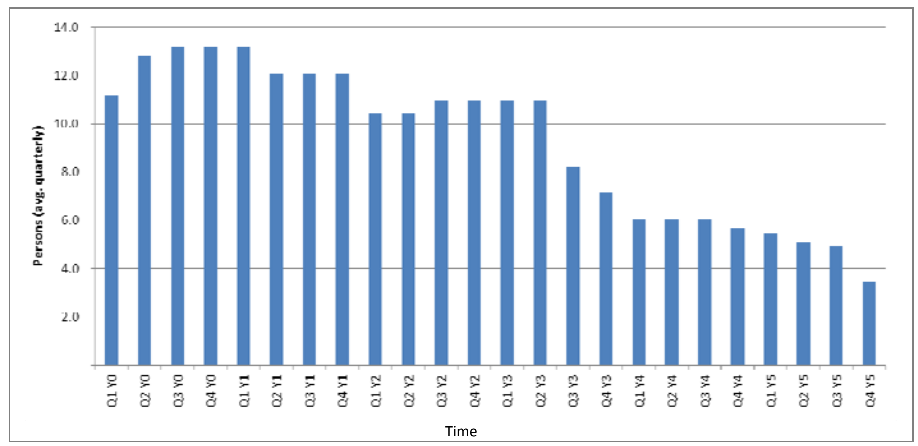


Figure 3.7.3-13 F0 – Professional Occupations in Art and Culture

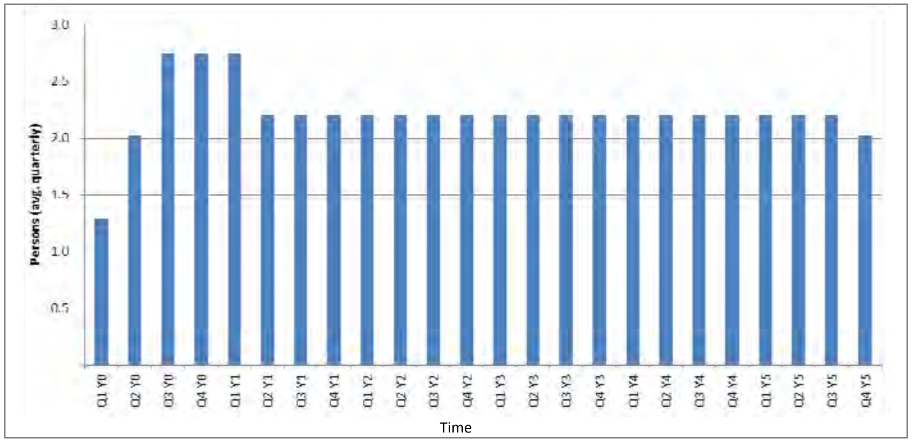


Figure 3.7.3-14 H0 – Contractors and Supervisors in Trades and Transportation

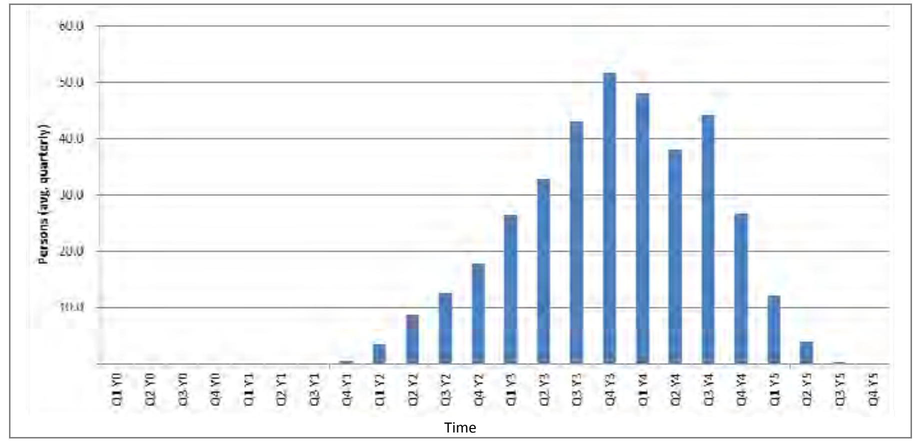


Figure 3.7.3-15 H1 – Construction Trades

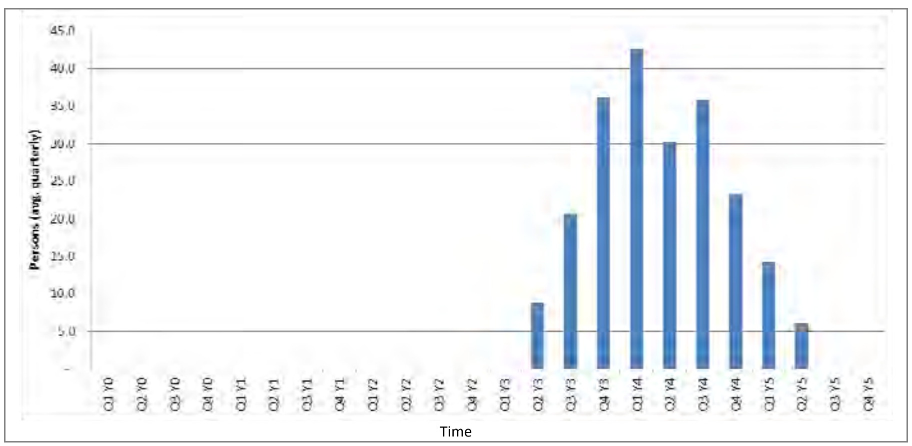


Figure 3.7.3-16 Stationary Engineers, Power Station Operators and Electrical Trades and Telecommunications Occupations

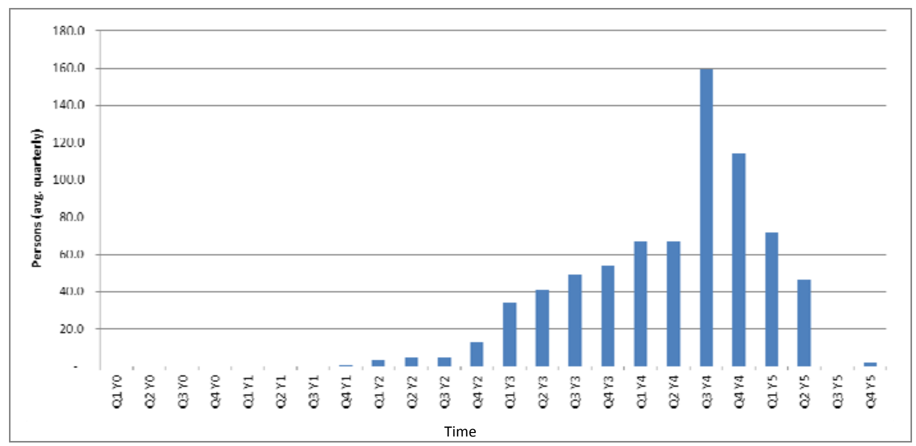


Figure 3.7.3-17 H3 – Machinists, Metal Forming, Shaping and Erecting Occupations

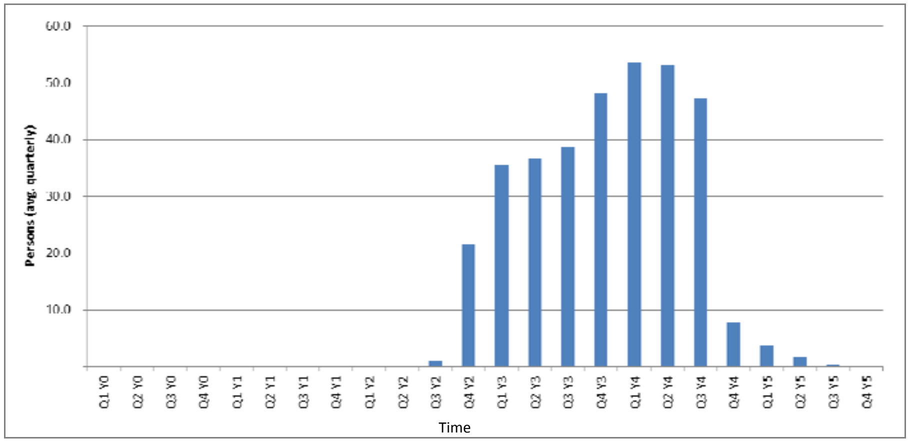


Figure 3.7.3-18 H4 - Mechanics

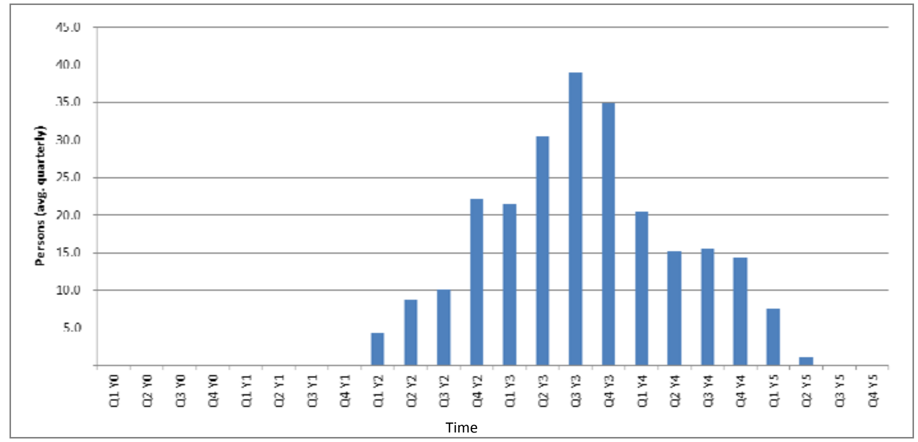


Figure 3.7.3-19 H5 – Other Trades, n.e.c.

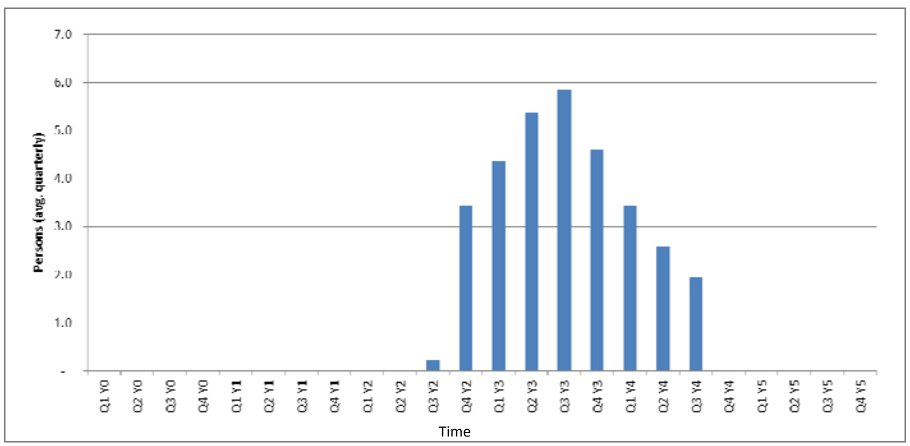


Figure 3.7.3-20 H6 – Heavy Equipment and Crane Operators, Including Drillers

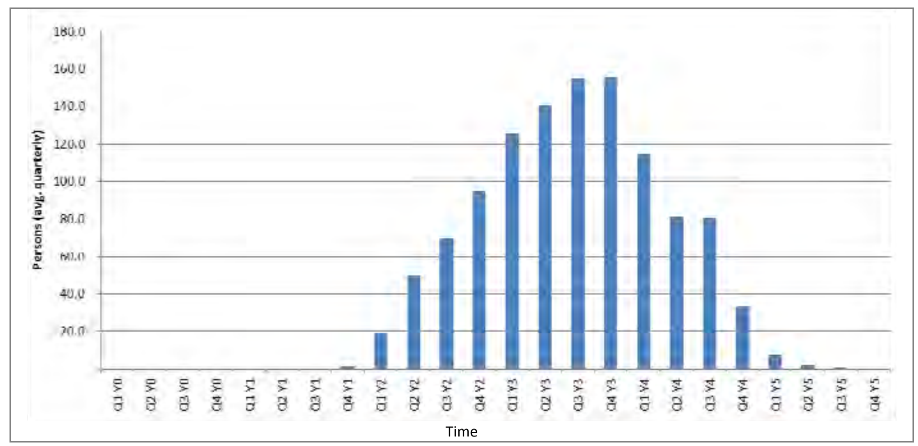


Figure 3.7.3-21 H7 – Transportation Equipment Operators and Related Workers, Excluding Labourers

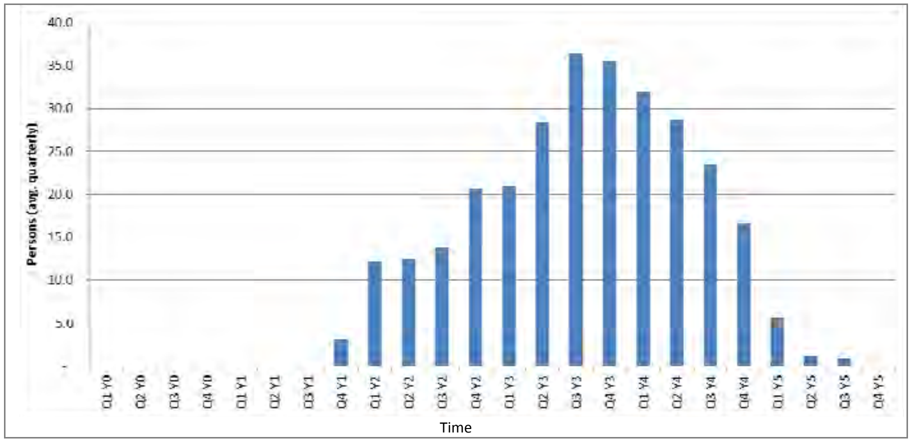


Figure 3.7.3-22 H8 – Trades Helpers, Construction and Transportation Labourers and Related Occupations

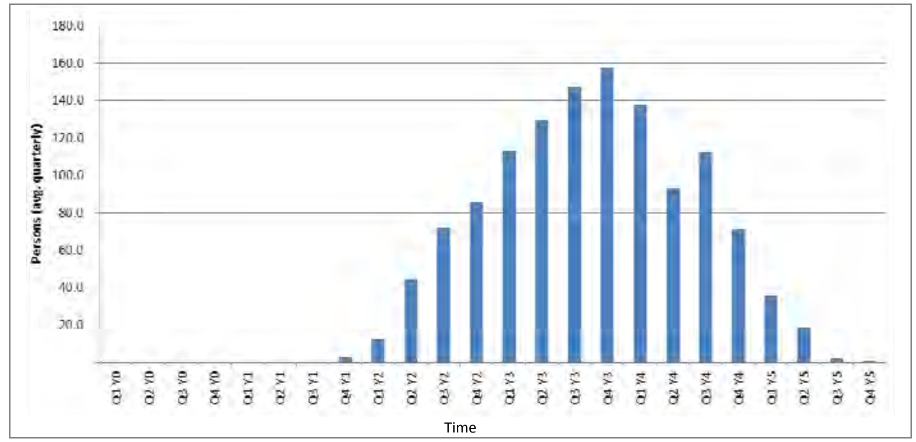


Figure 3.7.3-23 I1 – Occupations Unique to Forestry Operations, Mining, Oil and Gas Extraction and Fishing, Excluding Labourers

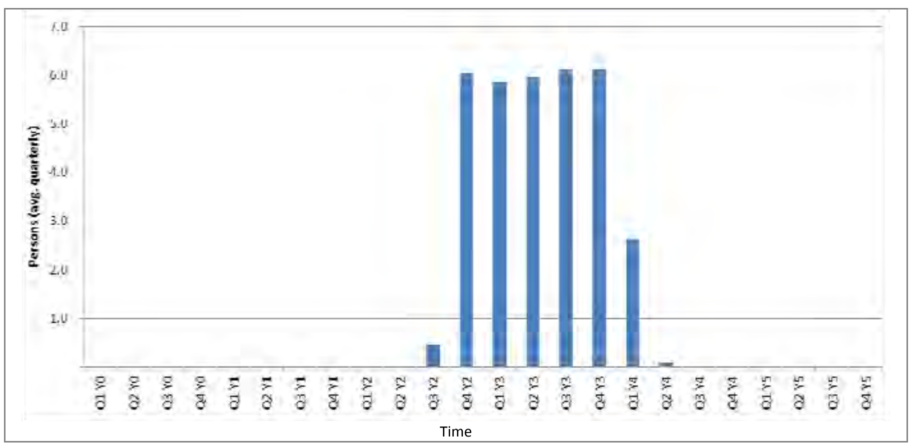
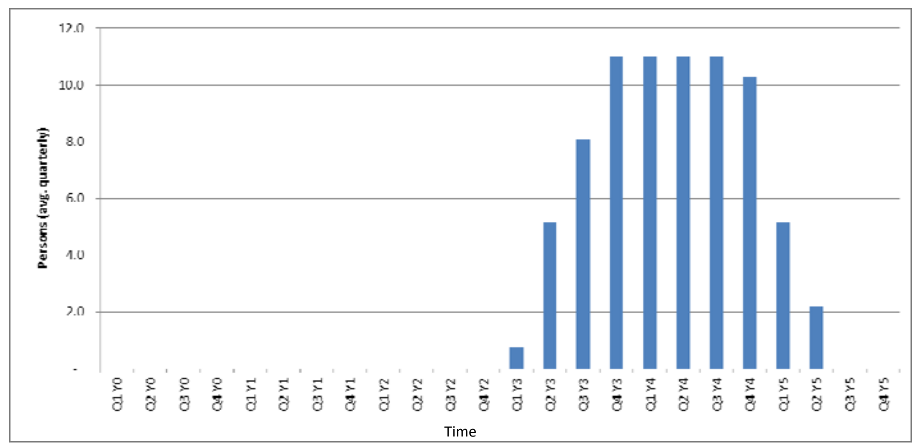


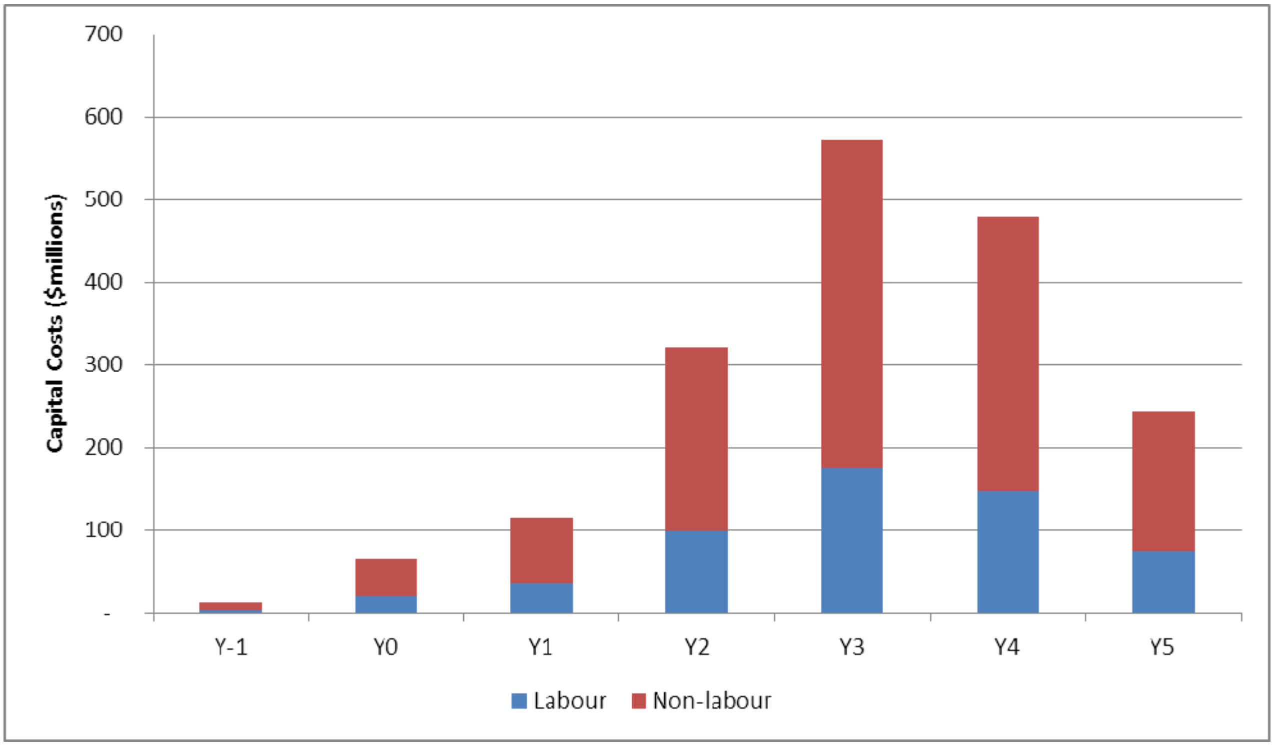
Figure 3.7.3-24 J2 – Assemblers in Manufacturing



3.8 Project Cost and Expenditures

The total estimated capital cost for the Project is $2.1 billion in as-spent dollars (including contingency and escalation). Approximately $1.25 billion will be spent on materials and equipment with labour accounting for approximately $560 million of the total capital costs. An escalation allowance of $230 million and historical costs of $42 million account for the remainder of the costs, bringing the total capital cost to approximately $2.1 billion. Most costs will be incurred during the final three years of construction with the highest single year cost occurring in Year 3 (approximately $570 million) (Figure 3.8-1).

Figure 3.8-1 Capital Cost Estimates for Project Construction



The estimated costs associated with each Project component are presented in Table 3.8-1. The Strait of Belle Isle marine crossing is the highest cost item at $337 million, followed by the overhead transmission line on the Island at $305 million. These estimates include all costs up to commissioning of the Project, excluding interest during construction (IDC).

Table 3.8-1 Total Project Costs by Component

Project Component	Approximate Cost (million dollars)
Project management and engineering	273
HVdc Overland Transmission – Labrador / Island	460
Strait of Belle Isle Submarine Cable Crossing and Cable Landing Sites	359
Converter Stations – Muskrat Falls and Soldiers Pond Electrode and overhead line – Labrador and Island	536
Island system upgrades	223
Escalation	227
Total	**2,080**

Note: All costs exclude IDC.

3.9 References

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