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CONNECTION ASSESSMENT & APPROVAL PROCESS

PRELIMINARY ASSESSMENT REPORT

For the Proposed 115kV Supply to the North Caribou Lake First Nation Community

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Long Term Forecasts & Assessments Department

FINAL Version (Revised)

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Preliminary Assessment Report

For the Proposed 115kV Supply to the North Caribou Lake First Nation Community

Acknowledgement

The IMO wishes to acknowledge the assistance of Hydro One in completing some of the studies for this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IMO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, Section 6 of the Market Rules.

Approval of the proposed connection is based on information provided to the IMO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IMO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by the transmitter(s) at the request of the IMO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. Approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IMO-controlled grid. However, connection approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IMO in accordance with Chapter 4, Section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use, which it makes of this report. Any liability that the IMO may have to the connection applicant in respect of this report is governed by Chapter 1, Section 13 of the Market Rules. The IMO reserves the right to revise this report at any time, at its sole discretion, without notice to the connection applicant. Although the IMO will use its best efforts to advise the connection applicant of such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

Hydro One

Special Notes and Limitations of Study Results

The results reported in this preliminary assessment are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades, which are required to incorporate the proposed connection, have been identified to the extent permitted by a preliminary assessment. Additional facility studies may be necessary to confirm constructability and the time required for construction. System impact or further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

PRELIMINARY ASSESSMENT REPORT

For the Proposed 115kV Supply to the North Caribou Lake First Nation Community

Preamble

The North Caribou Lake First Nation community is proposing to replace their existing supply, which is provided by local diesel generating units, with a new supply that is to be established via an 85km 115kV transmission line connected to the existing 115kV circuit M1M.

Circuit, M1M, between Crow River DS and the Musselwhite Mine, is a privately-owned facility belonging to Placer Dome (Canada) Ltd.

Since Placer Dome (Canada) Ltd. is not a Licensed Transmitter and since the IMO presently has no operating agreement with Placer Dome giving it authority to direct the operation of circuit M1M, circuit M1M is therefore not currently part of the IMO-controlled grid.

The IMO has therefore undertaken this assessment on the assumption that, should agreement be reached between North Caribou Lake First Nation and Placer Dome (Canada) Ltd. for the connection of the NCLFN line on to circuit M1M, that circuit M1M would be classified as a part of the IMO-controlled grid.

1. Introduction

The existing 185km 115kV circuit, M1M, provides a dedicated, radial supply to the Placer Dome Musselwhite Mine from the 260km 115kV circuit, E1C, between Ear Falls GS and Crow River DS.

Diagram 1 shows the existing transmission facilities between Ear Falls SS and the Musselwhite Mine.

Voltage support in the Ear Falls area is provided by the hydroelectric generating stations of Ear Falls GS (20MVA) and Manitou Falls GS (80MVA), with the latter station being connected into Ear Falls SS by an 18.8km radial circuit, M3E.

Diagram 2 shows the facilities that it is proposed to install to establish the new connection to the North Caribou Lake First Nation (NCLFN) community.

It is also proposed to retain one of the existing 1MW diesel generating units at the NCLFN community for use as an emergency supply in the event of an outage involving the 115kV system. This diesel generating unit is not to be operated in parallel with the 115kV system and suitable interlocks are to be installed to ensure that inadvertent parallelling cannot occur.

The projected peak load at the NCLFN community is 2MW, and this load was used in the assessment.

Existing & Approved Loads

The following Table summarises the peak loads in the area that are supplied from circuit E1C and which have been used in the subsequent analysis:

Location	*Peak Load*
Slate Falls DS	0.4MW
Cat Lake TS	1.0MW
Crow River DS	2.4MW

Approval has also been given for Placer Dome (Canada) to increase their peak load at the Musselwhite Mine to 16MW at a power factor of 0.90.

2. Connection Arrangement

It is proposed to connect the new 115kV NCLFN transmission line to the Placer Dome circuit, M1M, at a point approximately 1km from the circuit's termination at the Musselwhite Mine. This junction point has been designated 'NCLFN Junction' in this Report.

The new line is to be terminated via a series-connected 115kV circuit breaker and circuit-switcher combination. In the event of a contingency involving the new 115kV NCLFN line, trip signals are to be sent to both switching devices simultaneously. Normally the circuit breaker, as a result of its faster operating time, would be expected to clear the fault, and the subsequent operation of the circuit-switcher would provide physical isolation. However should the circuit breaker malfunction and fail to clear the fault, then the circuit-switcher would provide back-up clearance. By providing local back-up switching, this arrangement would avoid the need to install transfer-trip facilities to initiate tripping of circuit M1M at Crow River DS for a breaker-failure condition.

The remote terminal of the new line is to be connected on to a three-phase 115/25kV 7.5/10MVA step-down transformer via a 115kV circuit-switcher. This transformer is to be equipped with an under-load tap-changer with a range of ±15% on a nominal voltage of 120kV. The impedance of the transformer has been quoted as 10% on a rating of 7.5MVA. It is proposed to have an identical transformer available locally for installation should the main transformer be subjected to a permanent fault.

Two -1.22MVAr (rated at 118kV) shunt reactors would be connected on the line side of the circuit breaker/circuit switcher combination at the Musselwhite terminal (NCLFN Junction). A further -1.22MVAr shunt reactor would be connected at the NCLFN remote terminal. Each shunt reactor would be switched via an individual 115kV circuit-switcher. This arrangement, with the three shunt reactors directly connected to the line, has been selected to ensure that the reactors and the line would be switched as a single entity, either into- or out-of-service.

The reactors have been sized to provide reactive compensation approximately equivalent to the reactive power generated by the line (approximately +4.5MVAr at a voltage of 124kV) less the reactive power losses of the 115kV line and the associated step-down transformer for a nominal load at the NCLFN community of 1MW. The intent is that the line should appear to be approximately 'reactive power neutral'.

The circuit breaker, circuit-switchers and disconnect switches are all to be rated for a maximum voltage of 145kV and a continuous current of 600A.

3. Reactive Compensation at the Musselwhite Mine

Two SVCs are presently installed at the Musselwhite Mine connected directly to the 4.16kV busbar.

These SVCs are used to limit the terminal voltage at the mine during line energisation and also to compensate for the reactive power losses on the system as the load at the mine is increased.

Configuration of the Existing SVCs at the Musselwhite Mine

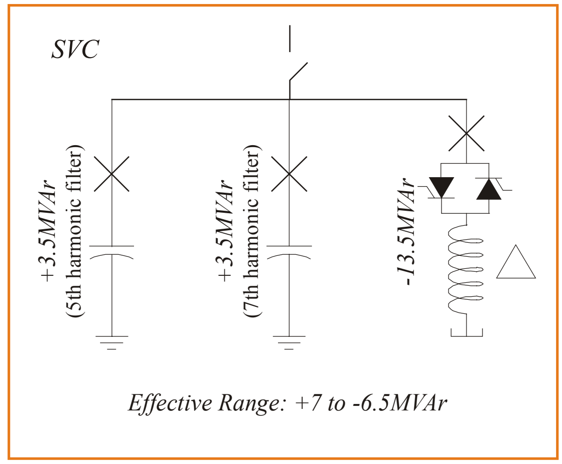
The two static VAr compensators at the Musselwhite Mine are configured as shown in the Diagram to the right.

Two, individually-switched +3.5MVAr shunt capacitor banks, that act as filters for the 5th and 7th harmonic currents respectively, are connected in parallel with a -13.5MVAr thyristor-controlled shunt reactor.

The effective reactance of the shunt reactor portion of each SVC is varied by controlling the current through the reactor using thyristor switching to provide a variable reactance of 0MVAr to -13.5MVAr.

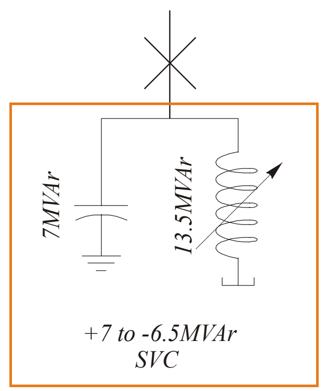
This results in an effective operating range for each SVC from +7MVAr (with 0MVAr from the reactor) to -6.5MVAr (with -13.5MVAr from the reactor).

The thyristor-controlled reactor portion of the SVC is connected in delta to minimise third harmonic currents.



Upon initial connection, the inductive portion of the SVC is energised first, followed by the switching of the 5th harmonic & 7th harmonic capacitor banks, in succession.

The Diagram to the right shows the simplified representation that has been used in the Diagrams accompanying this Report.



Assumptions Regarding the Status of the SVCs at the Musselwhite Mine

During discussions with representatives of the Mine, the IMO has been informed that the SVCs may not always be available, possibly because of outages and/or maintenance activities at the Mine, and that operation of the NCLFN line should therefore be independent of the status of the SVCs.

Furthermore, should the mine cease operations then it is a requirement for the site to be reclaimed. This would entail removing all of the electrical facilities, including both step-down transformers along with the two SVCs.

This assessment has therefore examined the potential effect that the unavailability of both SVCs at the Mine would have on the supply to the NCLFN community.

4. *Rating of existing transmission facilities*

The following Table summarises the ratings that were used in the assessment:

Circuit	*Conductor*	*Maximum Conductor Operating Temperature*	*Thermal Rating at 30^{o}C ambient & 4km/hr wind*	
E1C	167.8kcmil	60^{o}C	220A	47MVA at 124kV
M1M	336.4kcmil	93^{o}C	500A	107MVA at 124kV
NCLFN Line	336.4kcmil	93^{o}C	500A	107MVA at 124kV

Since circuit E1C is equipped with very small, 167.8kcmil conductors that have a low maximum conductor operating temperature, its continuous rating is only 47MVA. Furthermore, because of its considerable length (~260km), achieving any marked increase in its thermal rating would be extremely difficult. It therefore represents the critical transmission element in the supply to the Musselwhite Mine.

The surge impedance for the 167.8kcmil conductors that are installed on circuit E1C, has been calculated as approximately 423Ω, which would give a surge impedance loading of approximately 36MW at 124kV. For transfers of less than 36MW circuit E1C would be expected to be a net generator of MVAr, while for transfers greater than 36MW, the line would become a net absorber of reactive power.

5. *Power System Analysis*

The power system analysis that was performed for this assessment consisted of the following two components:

- an examination of the effect of energising the proposed NCLFN line, and
- an assessment of the load supply capability of both the existing and the proposed transmission facilities.

5.1 Line Energisation Studies for the new NCLFN line

Table 1 summarises the results for energising the proposed NCLFN line.

With no SVCs in-service at the Musselwhite Mine, the voltage at the remote terminal would be unacceptably high at 147.8kV. However, it is worth noting that the increase in voltage over the entire length of the line from the NCLFN Junction to the remote terminal at the NCLFN community would be only 0.4kV. This demonstrates that the shunt reactors that have been proposed would meet the requirement to make the line approximately 'reactive-neutral'.

Energising the NCLFN line with both SVCs at the Musselwhite Mine in-service at their full inductive output (for a net output of -6.5MVAr per SVC) would limit the terminal voltage at the NCLFN community to just 119.6kV. This could be increased by reducing the inductive component of the two SVCs at the Musselwhite Mine. As before, it is worth noting that the voltage increase over the length of the NCLFN line is just 0.2kV.

The final study is with an assumed -10MVAr of additional shunt reactors connected at the NCLFN Junction, and with both SVCs at the Musselwhite Mine out-of-service. The resulting voltage profile, under no-load conditions, is very good. This study therefore indicates that if the NCLFN line is to be successfully energised whenever the LV facilities (including both SVCs) at the Musselwhite Mine are out-of-service, that additional shunt reactors totalling approximately -10MVAr would need to be installed at the NCLFN Junction.

Alternatively, additional shunt reactors could be installed at Crow River DS to reduce the shunt reactor capacity required at the NCLFN Junction. The combined capacity at the two locations would however still need to total approximately -10MVAr.

Installing an SVC at Crow River DS

Should it be decided to install additional shunt reactors at the NCLFN Junction to ensure that circuit M1M can be successfully energised whenever both SVCs at the Musselwhite Mine are unavailable, then the rating of each reactor would need to be limited to approximately -3MVAr in order to ensure that the voltage change upon switching is less than 4%.

To provide approximately -10MVAr of shunt reactor capacity, it would therefore be necessary to install three, or possibly four, separately-switched units. Together with the two -1.22MVAr shunt reactors that are to be connected directly to the NCLFN line at NCLFN Junction, this is considered to be an excessive number of reactors and circuit-switches at a single location.

Consideration was therefore given to the installation of a new SVC at Crow River DS to try and reduce the amount of shunt reactance that would be required at the NCLFN Junction in order to limit voltage increases during line energisation.

Furthermore, by substituting a single SVC for a number of shunt reactors, it would be expected to simplify the switching scheme required for controlling the reactors.

The existing arrangement at Crow River DS consists of two pairs of series-connected step-down transformers. Each pair is comprised an 8MVA 115/28kV step-down transformer connected to a 7.5MVA 28/25kV step-down transformer. However, because of the relative phase configurations and the different impedances of the respective transformer-pairs, it is understood that the transformers cannot be operated in parallel.

The rating of any SVC that is to be installed at Crow River DS would therefore be restricted by the 7.5MVA rating of the 28/25kV transformers.

It was therefore decided to limit the *maximum* output of the SVC to +/-6MVAr. With the SVC comprised a fixed shunt capacitor bank and a variable shunt reactor this would limit the maximum size of the variable reactor to -12MVAr i.e. +6MVAr capacitive & -12MVAr inductive, thereby providing an effective output range of +6MVAr to -6MVAr.

[While a single +6MVAr capacitor bank was assumed in the analysis, it is expected that two capacitor banks rated at +3MVAr will need to be installed to provide filters for the 5th and 7th harmonic currents.]

A series of line energisation studies was therefore conducted with no SVCs in-service at the Musselwhite Mine, and with the following amounts of additional reactive compensation installed at Crow River DS and at the NCLFN Junction:

Energisation of the 115kV circuit M1M & the NCLFN Line with no SVCs at the Musselwhite Mine					
	Rating of SVC at Crow River DS	*Rating of additional shunt reactors at NCLFN Junction*	*Voltages*		
			Crow River DS	Musselwhite Mine	NCLFN Community
1.	+6MVAr/-10MVAr: -4MVAr	-	136.8kV	141.1kV	141.5kV
2.	+6MVAr/-10MVAr: -4MVAr	-1.2MVAr	134.9kV	138.1kV	138.4kV
3.	+6MVAr/-11MVAr: -5MVAr	-2.0MVAr	131.8kV	134.5kV	134.7kV

The results, which are given in Table 2, have also been summarised in the Table above. These show that in order to achieve acceptable, though high, voltages at Crow River DS and at the Musselwhite Mine it would only be necessary to install a single shunt reactor rated at between -2.0MVAr & -2.5MVAr at the NCLFN Junction. This shunt reactor would be in addition to the +6MVAr/-11MVAr SVC that it is proposed to install at Crow River DS and the three shunt reactors that are to be connected directly to the NCLFN line.

This also assumes that all of the new equipment associated with the proposed NCLFN connection will be capable of continuous operation at 138kV.

It should also be noted that these voltages would only occur if both SVCs at the Musselwhite Mine were to be out-of-service. If either of the SVCs at the Musselwhite Mine were also available, they would be able to control the voltages to lower values.

Summary of the Line Energisation Studies

The results of the line energisation studies can be summarised as follows:

For the existing system configuration -

- In order to maintain acceptable voltages at the stations supplied from circuit E1C, at least one of the SVCs at the Musselwhite Mine must be in-service when circuit M1M is energised. Furthermore, the SVC must be at its full inductive value of -13.5MVAr so as to provide a net value of -6.5MVAr once both shunt capacitor banks are in-service.

For the arrangement with the NCLFN line connected to circuit M1M

- If both SVCs at the Musselwhite Mine were to be out-of-service, energisation of circuit M1M and the proposed NCLFN line would only be possible if the facilities identified in either of the following options were to be available:

  i. With shunt reactance of approximately -10MVAr capacity installed at the NCLFN Junction and Crow River DS (in individually switched banks that are rated at -3MVAr or less)

  OR

  ii. With a +6MVAr/-11MVAr SVC at Crow River DS *AND* with a shunt reactor rated at between -2MVAr and -2.5MVAr at the NCLFN Junction.

The transmission facilities associated with the new NCLFN connection would need to be suitable for continuous operation at 138kV.

Diagram 3 shows the proposed arrangement with a new SVC installed at Crow River DS, together with a -2MVAr shunt reactor at the NCLFN Junction.

5.2 Load Supply Capability

Existing Transmission Facilities

Table 3 shows the results of the studies to determine the maximum load, at a power factor of 0.94, that could be supplied at the Musselwhite Mine from the existing transmission facilities.

These studies show that at a load level of 16MW, the inductive portions of the two SVCs at the mine have not 'bottomed-out' and are still absorbing -1.7MVAr.

At a load level of 17MW, the inductive portions of the SVCs is at 0MVAr, so that the SVC is behaving purely as a shunt capacitor to support the voltage.

At a load level of 18MW, since the SVCs are unable to provide any additional support, the voltages begin to decline, and at Crow River DS and the Musselwhite Mine they would be below the minimum voltage of 113kV specified in the Market Rules.

Consequently, the maximum load, at a power factor of 0.94, that could be supplied from the existing facilities would be limited to 17MW.

With an SVC at Crow River DS

The line energisation studies have shown that, if the existing SVCs at the Musselwhite Mine were unavailable, it would only be possible to operate the proposed NCLFN line if shunt reactors having a combined capacity of approximately -10MVAr were to be installed at the NCLFN Junction and Crow River DS. Since the size of each individual reactor would need to be limited to respect the maximum voltage change that is permitted upon switching, a total of three or four separately-switched shunt reactors that would need to be installed. Consequently, the installation of an SVC at Crow River DS has been recommended. This would reduce the amount of shunt reactance required at the NCLFN Junction to between -2MVAr and -2.5MVAr and this could be installed as a single switchable reactor.

Furthermore, the capacitive component of the new SVC would provide voltage support at Crow River DS and this should therefore allow additional load beyond the 16MW (17MW at a power factor 0f 0.94) that could be supplied via the existing transmission facilities.

Studies were therefore performed for the arrangement shown in Diagram 3 with the load at the Musselwhite Mine at assumed power factors of 0.90 and 0.94, respectively.

Table 4 summarises the results with the load at the Musselwhite Mine at a power factor of 0.90.

It should be noted that no attempt was made in the studies to optimise the tap position on the transformers at Crow River DS and at the Musselwhite Mine to achieve the optimal LV voltage at these locations.

These results show that, with a 2MW load at the NCLFN community, the SVCs at the Musselwhite Mine become limiting for a load at the Mine of approximately 15MW, while the SVC at Crow River DS would become limiting for a load of approximately 17MW at the Musselwhite Mine. At 15MW, the SVCs at the Musselwhite Mine are still able to maintain voltages of 119.5kV & 4.2kV at the HV and LV busbars, respectively. At 16MW, because there is no additional support available from the shunt capacitor portions of the SVCs, the voltages begin to decline. However, at Crow River DS, the output of the inductive portion of the SVC is not reduced to 0.0MVAr until the load at the Musselwhite Mine is increased to 17MW.

It should also be noted that for loads of 14MW and higher, the -2.0MVAr shunt reactor that it is proposed should be installed at the NCLFN Junction, has been switched out-of-service.

The results in Table 4 for the condition with a 14MW load at the Mine and with a 2MW supply to the NCLFN community, with the -2MVAr shunt reactor at the NCLFN Junction out-of-service, effectively correspond to the maximum load supply capability of the ***existing*** *transmission facilities. At this combined load level of 16MW, the SVC that has been assumed at Crow River DS is contributing only -0.2MVAr and therefore, is essentially out-of-service, while the two SVCs at the Mine are at their maximum capacitive output (+16.0MVAr). [If the LV voltage at the Musselwhite Mine were to be controlled to around 4.16kV, the output from the capacitor banks would decline and this would adversely affect the voltage profile on the 115kV system.]*

Consequently, the ***existing*** *transmission facilities are* ***only*** *capable of supplying a load of just 16MW (at a power factor of 0.90) at the Musselwhite Mine.*

Table 4A shows the results for a repeat study for loads of 16MW at the Musselwhite Mine and 2MW at the NCLFN community, with the tap-changers on the step-down transformers at the Musselwhite Mine and at Crow River DS adjusted to maintain a better HV profile, while allowing the SVCs to maintain their respective LV voltages.

These results confirm that with the load at the Musselwhite Mine at a power factor of 0.90, and *with a 2MW load at the NCLFN community*, the maximum load that could be supplied at the Mine, assuming a new +6MVAr/-11MVAr SVC is installed at Crow River DS, would be between 16MW & 17MW.

Table 5 summarises the results with the load at the Musselwhite Mine at a power factor of 0.94.

As before, no attempt was made in the studies to optimise the tap position on the transformers at Crow River DS and at the Musselwhite Mine to achieve the optimal LV voltage at these locations.

These studies show that the SVCs at the Musselwhite Mine would become limiting before the SVC at Crow River DS. At 16MW the output from the inductive portion of the SVCs at the Musselwhite Mine would be 0.0MVAr, although the LV voltage is still high at 4.41kV, indicating that additional load could be supplied before the voltage would decline below the nominal value of 4.16kV. At Crow River DS, the SVC would still have approximately +4MVAr of capacitive support available for a mine load of 16MW.

It has therefore been concluded that with the Mine load at a power factor of 0.94 and with the new SVC installed at Crow River DS, that a load of 17MW could be supplied at the Mine, in addition to a 2MW load at the NCLFN community.

Improving the power factor of the Mine load from 0.90 to 0.94 would therefore increase the maximum load that could be supplied at the Mine by between 1MW and 2MW

Tables 6 & 7 shows the results for a contingency involving the loss of the NCLFN line, with maximum loads at the Musselwhite Mine of 17MW (at a power factor of 0.90) & 18MW (at a power factor of 0.94), respectively.

In Table 6, tripping of the NCLFN line, without automatic post-contingency reinsertion of the -2.0MVAr reactor at the NCLFN Junction, is shown to result in an immediate voltage increase at the Mine of 10% at the HV busbar & 11% at LV busbar, respectively.

However, in Table 7, with the -2.0MVAr reactor automatically switched into service following a contingency involving the NCLFN line, the voltage increase at the Mine is limited to only 3.8% at both the HV and the LV busbars.

It has therefore been concluded that in order to limit the post-contingency voltage rise at the Musselwhite Mine for a contingency involving the NCLFN line, facilities will need to be installed to initiate automatic reinsertion (into service) of the -2.0MVAr shunt reactor at the NCLFN Junction.

System Losses

As a result of the very small conductor on circuit E1C, the losses at the higher load levels would become a significant factor, affecting the load-meeting capability of the existing transmission facilities. These have been tabulated in Table 8 for load levels of 16MW & 18MW at the Musselwhite Mine.

In addition to the actual load at the Musselwhite Mine and the 2MW supply to the NCLFN community, circuit E1C is required to supply approximately 4MW of load that is tapped off circuit E1C at Slate Falls DS, Cat Lake TS and Crow River DS.

Consequently, for a 18MW load at the Musselwhite Mine, the flow on circuit E1C at Ear Falls SS would total ***36MW*** (18MW + 6MW + 12MW losses). Since this flow would be equivalent to the surge impedance loading of approximately 36MW for circuit E1C, increasing amounts of reactive compensation would need to be installed to maintain an acceptable voltage profile at higher load levels.

Furthermore, since the reactive power flow recorded on circuit E1C for an 18MW load at the Musselwhite Mine was 20MVAr, the effective flow on this circuit would be approximately 41MVA. This is approaching the continuous rating of 47MVA for this circuit under summertime conditions at an ambient temperature of 30°C.

Since the losses would increase disproportionately at higher load levels, and since increasing amounts of reactive compensation would be required along the entire length of the radial system in order to maintain an acceptable voltage profile, it has therefore been concluded that the maximum load that it would be possible to supply at the Musselwhite Mine would be limited to around 20MW (in addition to the 4MW of existing load supplied directly from circuit E1C and the proposed 2MW at the NCLFN community - for a combined total of 26MW).

Any further increases in load beyond the 26MW identified above would therefore be expected to require the construction of additional transmission capacity.

6. *Conclusions from the Analysis*

For the connection of the North Caribou Lake First Nation Line

The following conclusions have been drawn from the preceding analysis:

- Energisation of the 85km NCLFN line whenever the two SVCs at the Musselwhite Mine are unavailable would only be possible if additional shunt reactors totalling approximately -10MVAr were to be installed at the NCLFN Junction. Alternatively, if an additional +6MVAr/-11MVAr SVC were to be installed at Crow River DS, then only a single shunt reactor rated between -2MVAr & -2.5MVAr would need to be installed at the NCLFN Junction.
- The latter option, involving the installation of an SVC at Crow River DS, is preferred since it would allow a supply of 2MW to be provided to the NCLFN community (all loads at 0.90 power factor) in *addition to* supplying the approved load of 16MW at the Musselwhite Mine.

  Without the SVC at Crow River DS, the transmission facilities would only be adequate to supply the load of 16MW at the Musselwhite Mine.
- With an SVC at Crow River DS, and with the power factor of the load at the Musselwhite Mine maintained above 0.94, the maximum combined load that could be supplied at the Mine and the NCLFN community would increase to approximately 19MW.

Summary of the Load Supply Capability

The following Table summarises the load meeting capability of both the existing system, and following the installation of the new facilities associated with the NCLFN line, with the mine load at power factors of 0.90 and 0.94:

Load Supply Capability					
System Conditions		Power Factor of Mine Load	*Max. Load that could be supplied*		
			At the Musselwhite Mine	*At the NCLFN community*	*Additional Load*
1.	Existing System	0.90	16MW	-	-
2.		0.94	16MW	-	*+1MW*
3.	With the NCLFN line & a new +6/-11MVAr SVC at Crow River DS	0.90	16MW	2MW	-
4.		0.94	16MW	2MW	*+1MW*

It is worth noting, by comparing the results in the following rows of above Table, that while the installation of the proposed SVC at Crow River DS associated with the connection of the NCLFN line to circuit M1M, would increase the supply capability of the *existing* transmission facilities, the increase would only be sufficient to provide a 2MW supply to the NCLFN community. It would have no net effect on the supply capability to the Musselwhite Mine that is presently available from the existing facilities:

- compare Row 1 (total load: 16MW) with Row 3 (total load: 18MW) - for a mine load power factor of 0.90,

and

- compare Row 2 (total load: 17MW) with Row 4 (total load: 19MW) - for a mine load power factor of 0.94.

7. IMO Requirements for the Connection of the NCLFN Line to Circuit M1M

Subject to agreement being reached between Placer Dome (Canada) Ltd. and North Caribou Lake First Nation for the connection of the NCLFN line on to circuit M1M, and circuit M1M becoming part of the IMO-controlled grid, the IMO's requirements for connecting the North Caribou Lake First Nation Line to 115kV circuit M1M are as follows:

- Install a 115kV shunt reactor, rated at between -2MVAr & -2.5MVAr (at 118kV), connected directly to circuit M1M via a 115kV circuit-switcher, at the connection point on to circuit M1M (NCLFN Junction).
- Install a +6MVAr/-11MVAr SVC at Crow River DS.

  [It is expected that two shunt capacitor banks, each rated at approximately +3MVAr, will need to be installed to provide filters for 5th & 7th harmonic currents.]
- Install a scheme for the automatic post-contingency reinsertion (into service) of the -2MVAr shunt reactor at the NCLFN Junction for a contingency involving the NCLFN line. This scheme is to include the capability to remotely select (pre-arm) this auto-switching operation.

All facilities associated with the NCLFN line must be suitable for continuous operation at 138kV.

Diagram 4 shows the facilities required for the connection of the NCLFN line.

It is also recommended that the 115kV circuit breaker be equipped with heated blankets.

Consideration should also be given to installing a fibre-optic skywire on the new 115kV transmission line for protective relaying; control of the switching of the shunt reactors associated with the new line; and for normal communications.

Facilities may also need to be installed to meet the requirements of the Market Rules for automatic Under-Frequency Load Shedding (Market Rules: Appendix 4.3 - Reference 2 and Chapter 5 - Clause 10.4.6)

Provision should be included in the design of the distribution facilities at the North Caribou Lake First Nation substation for the installation of shunt capacitor banks to ensure that the power factor of the load, measured on the HV side of the transformer is maintained between 0.9 lagging and 0.9 leading (Market Rules: Appendix 4.3 - Reference 1)

Installation of the facilities identified above would allow a supply of 2MW, at a power factor of 0.90, to be provided to the NCLFN community, while a peak load of 16MW (at a power factor of 0.90) is being at the Musselwhite Mine.

8. Approximate Cost Estimates

An attempt has been made to provide approximate cost estimates for the work that would not be a direct part of the installation of the new 115kV NCLFN line.

These costs are based on available unit costs and do not make any allowance for site conditions. Neither do they take account of outage or construction constraints; associated work that may be triggered by the work identified; or other unforeseen difficulties.

It should also be noted that, for those situations that involve modifications to existing facilities the extent of any associated upgrades to station buswork is unlikely to be known until a detailed review of the existing station facilities has been undertaken.

8.1 Installation of a +6MVAr/-11MVAr SVC at Crow River DS

Estimated Cost ≈ $3 to $5 million

8.2 Installation of a 115kV shunt reactor rated at -2MVAr to -2.5MVAr (at 118kV), including a circuit-switcher

Estimated Cost ≈ $2 to $3 million

8.3 Installation of a scheme for the automatic post-contingency reinsertion (into service) of the -2MVAr shunt reactor at the NCLFN Junction

Estimated Cost ≈ $½ to $¾ million

9. Identification of 'Sole Beneficiary'

Section 9.2.5 of the Transmission System Code states:

> *Modifications and upgrades to specific network facilities or installation of new network facilities that are triggered by a load customer and are for its sole benefit shall be borne by that customer.*

Since the installation of the shunt reactor at NCLFN Junction and the SVC at Crow River DS are required to allow circuit M1M to be energised to provide a supply to the NCLFN community whenever both SVCs at the Musselwhite Mine are unavailable, the IMO considers that they would be for the 'sole benefit' of the North Caribou Lake First Nation.

Furthermore, since it would not be possible to provide a 2MW supply to the NCLFN community without the proposed SVC at Crow River DS, this would also support the argument that these facilities would be for the 'sole benefit' of the North Caribou Lake First Nation.

10. Customer Impact Assessment

The results of the Customer Impact Assessment carried out by Hydro One Networks Inc. concluded that:

- Subject to the installation of the SVC at Crow River DS and the shunt reactor at NCLFN Junction, the addition of a 2MW load at the North Caribou Lake First Nation community would have minimal impact on other customers in the area.
- There would be no impact on the existing fault levels in the area.
- The connection of the new line through a series-connected circuit breaker/circuit-switcher combination would not materially reduce the supply reliability of the existing transmission system.

11. System Impact Assessment

All of the analysis required to determine the potential impact that this Project would be expected to have on the IMO-controlled grid has been completed in this assessment.

A separate System Impact Assessment will therefore not be required for this Project.

12. Notification of Approval of the Connection Proposal

Subject to the following, it is therefore recommended that a Notification of Approval for the proposed connection be issued:

- That agreement be reached between Placer Dome (Canada) Ltd. and North Caribou Lake First Nation for the connection of the NCLFN line on to circuit M1M, and that circuit M1M be classified as a part of the IMO-controlled grid.
- That NCLFN implement all of the IMO's requirements for connection.

TABLES

Line Energisation Studies

TABLE 1	*Conditions:*	*Energisation of the proposed 115kV North Caribou Lake First Nations Line: Circuit M1M assumed to be in-service*						
System Condition	*Voltages*							
	Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine 115kV*	*Musselwhite Mine 4.16kV*	*NCLFN Community*	
1. With no SVCs at the Musselwhite Mine	124.9kV	135.3kV	139.0kV	142.9kV	147.4kV	5.05kV	147.8kV	
2. With both SVCs (net -13.0MVAr) at the Musselwhite Mine	124.0kV	126.0kV	126.1kV	124.6kV	119.3kV	3.90kV	119.6kV	
3. With no SVCs at Musselwhite Mine & with an additional -10.0MVAr of shunt reactors at NCLFN Junction	124.0kV	127.3kV	127.6kV	127.0kV	123.0kV	4.02kV	123.3kV	

TABLE 2	*Conditions:*	*Energisation of the proposed 115kV North Caribou Lake First Nations Line: Circuit M1M assumed to be in-service With an SVC at Crow River DS*						
System Condition	*Voltages*							
	Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine 115kV*	*Musselwhite Mine 4.16kV*	*NCLFN Community*	
1. With no SVCs at the Musselwhite Mine & with an additional +6MVAr/-10MVAr (net -4MVAr) SVC at Crow River DS	124.6kV	132.2kV	134.7kV	136.8kV	141.1kV	4.84kV	141.5kV	
2. With no SVCs at the Musselwhite Mine & with an additional +6/-10MVAr SVC at Crow River DS & an additional -1.2MVAr reactor at NCLFN Junction	124.4kV	131.3kV	133.3kV	134.9kV	138.1kV	4.73kV	138.4kV	
3. With no SVCs at the Musselwhite Mine & with an additional +6/-11MVAr SVC at Crow River DS & an additional -2.0MVAr reactor at NCLFN Junction (-2.4 & -2.0MVAr)	124.3kV	129.7kV	131.1kV	131.8kV	134.5kV	4.50kV	134.7kV	

Load Supply Capability ***Power Factor of the Musselwhite Mine Load: 0.94***

TABLE 3	***Conditions:***	***Existing System, without the NCLFN line, and with loads at the Musselwhite Mine at 0.94 power factor***						
System Condition			***Voltages***					
			Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine*	
							115kV	*4.16kV*
1.	Load at the Musselwhite Mine (at 0.94 pf)	16MW	124.3kV *SVC Output*	123.1kV	122.8kV	122.3kV	125.5kV	4.43kV *+15.9/-1.7:= +14.2*
2.		17MW	124.2kV *SVC Output*	122.0kV	121.1kV	120.5kV	123.8kV	4.39kV *+15.6/-0:= +15.6*
3.		18MW	123.7kV *SVC Output*	116.4kV	113.2kV	109.2kV	107.6kV	3.76kV *+11.5/-0:= +11.5*

Voltages below the Market Rule minimum of 113kV for the 115kV system.

Load Supply Capability (Continued) **Power Factor of the Musselwhite Mine Load: 0.90**

TABLE 4	**Conditions:**	**With the NCLFN line & 2MW of load; With two SVCs at Musselwhite Mine (+7/-13.5MVAr) & one SVC at Crow River (+6/-11MVAr); With an additional -2MVAr reactor at Musselwhite Junction; and with loads at the Musselwhite Mine at 0.90 power factor**							
System Condition			***Voltages***						
			Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine*		*NCLFN Community*
							115kV	*4.16kV*	
1.	Load at the Musselwhite Mine (at 0.90 pf) & with 2MW at NCLFN (at 0.90 pf)	5MW	124.3kV *SVC Output*	126.2kV	126.3kV	125.6kV *+6.7/-9.5:= -2.8*	125.9kV	4.34kV *+15.3/-11.4:= +3.9*	125.6kV
2.		10MW	124.3kV *SVC Output*	124.3kV	124.1kV	123.1kV *+6.6/-8.1:= -1.5*	124.2kV	4.34kV *+15.3/-4.9:= +10.4*	123.9kV
3.		14MW	124.2kV *SVC Output*	122.0kV	121.1kV	119.9kV *+6.7/-5.4:= +1.3*	120.6kV	4.26kV *+14.7/-0:= +14.7*	120.3kV
4.		14MW**	124.3kV *SVC Output*	123.1kV	122.8kV	122.3kV *+6.7/-6.9:= -0.2*	125.8kV	4.45kV *+16.0/-0:= +16.0*	125.3kV
5.		15MW**	124.1kV *SVC Output*	121.1kV	119.9kV	118.4kV *+6.7/-5.4:= +1.3*	119.5kV	4.2kV *+14.3/-0:= +14.3*	119.2kV
6.		16MW**	124.1kV *SVC Output*	120.0kV	118.5kV	116.9kV *+6.6/-2.7:= +3.9*	116.3kV	4.07kV *+13.4/-0:= +13.4*	116.0kV
7.		17MW**	123.9kV *SVC Output*	117.8kV	115.6kV	113.2kV *+6.7/-0:= +6.7*	110.1kV	3.82kV *+11.9/-0:= +11.9*	109.6kV
TABLE 4A	**Conditions:**	***With Voltage at Crow River DS Optimised***							
6A.	Load at the Musselwhite Mine (at 0.90 pf) & with 2MW at NCLFN (at 0.90 pf)	16MW**	124.3kV *SVC Output*	123.4kV	123.8kV	124.6kV *+6.0/-0:= +6.0*	127.3kV	4.61kV *+17.2/-0:= +17.2*	127.1kV

Note: ** Indicates that the 2MVAr shunt reactor at NCLFN Junction was switched out-of-service.

Load Supply Capability (Continued) ***Power Factor of the Musselwhite Mine Load: 0.94***

TABLE 5	***Conditions:***		***Two SVCs at Musselwhite (+7/-13.5MVAr) & one SVC at Crow River (+6/-11MVAr); Additional -2MVAr reactor at Musselwhite Junction; and with loads at the Musselwhite Mine at 0.94 power factor***						
System Condition			***Voltages***						
			Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine*		*NCLFN Community*
							115kV	*4.16kV*	
1.	Load at the Musselwhite Mine (at 0.94 pf) & with 2MW at NCLFN (at 0.90 pf)	14MW	124.4kV *SVC Output*	123.9kV	123.9kV	123.8kV *+6.9/-4.2:= +2.7*	125.9kV	4.46kV *+16.0/-1.7:= +14.3*	125.6kV
2.		14MW**	124.4kV *SVC Output*	124.9kV	125.4kV	125.9kV *+6.9/-5.6:= +1.3*	130.0kV	4.62kV *+17.3/-1.9:= +15.4*	130.0kV
3.		16MW	124.2kV *SVC Output*	120.9kV	119.8kV	118.7kV *+6.7/-2.7:= +4.0*	119.0kV	4.22kV *+14.4/-0:= +14.4*	118.8kV
4.		16MW **	124.3kV *SVC Output*	122.1kV	121.6kV	121.3kV *+6.7/-4.1:= +2.6*	124.3kV	4.41kV *+15.7/-0:= +15.7*	124.0kV
5.		18MW**	124.0kV *SVC Output*	118.1kV	116.1kV	114.1kV *+6.8/-0:= +6.8*	112.6kV	3.96kV *+12.7/-0:= +12.7*	112.2kV

Note: ** Indicates that the 2MVAr shunt reactor at NCLFN Junction was switched out-of-service

Contingency Response ***Power Factor of the Musselwhite Mine Load: 0.90***

TABLE 6	***Conditions:***	***Two SVCs at Musselwhite (+7/-13.5MVAr) & one SVC at Crow River (+6/-11MVAr); Additional -2MVAr reactor at Musselwhite Junction; and with loads at the Musselwhite Mine at 0.90 power factor***							
Contingency Condition		***Voltages***							
		Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine*		*NCLFN Community*
						115kV	*4.16kV*	
Load Supply with two SVCs at Musselwhite & one SVC at Crow River and with loads at 0.90 power factor & 2MW at NCLFN Community: With -2MVAr reactor								
0. ***Reference: Pre-contingency***	17MW **	123.9kV *SVC Output*	117.8kV	115.6kV	113.2kV *+6.7/-0:= +6.7*	110.1kV	3.82kV *+11.9/-0:= +11.9*	109.6kV
1. ***Loss of NCLFN Line No auto-switching of -2MVAr reactor at Junction***		124.2kV *SVC Output*	121.9kV	121.1kV	120.2kV *+6.8/-4.1:= +2.7*	121.2kV (+10.1%)	4.24kV (+11.0%) *+14.6/-0:= +14.6*	*Out-of-Service*

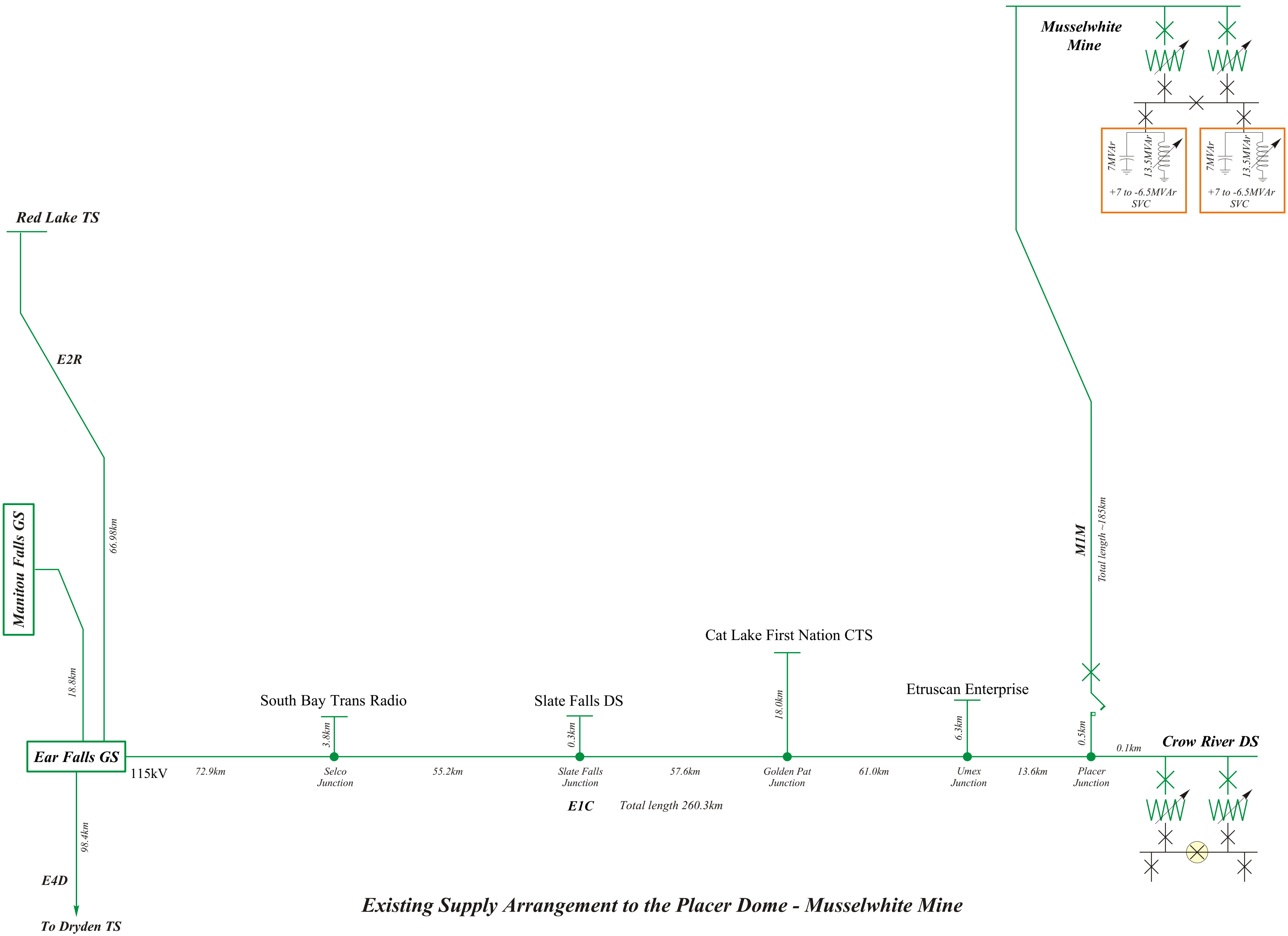
Contingency Response ***Power factor of the Musselwhite Mine Load: 0.94***

TABLE 7	***Conditions:***	***Two SVCs at Musselwhite (+7/-13.5MVAr) & one SVC at Crow River (+6/-11MVAr); Additional -2MVAr reactor at Musselwhite Junction; and with loads at the Musselwhite Mine at 0.94 power factor***						
Contingency Condition		***Voltages***						
		Ear Falls GS	*Slate Falls Junction*	*Cat Lake/ Golden Junction*	*Crow River*	*Musselwhite Mine*		*NCLFN Community*
						115kV	*4.16kV*	
0. ***Reference: Pre-contingency***	18MW **	124.0kV *SVC Output*	118.1kV	116.1kV	114.1kV *+6.8/-0:= +6.8*	112.6kV	3.96kV *+12.7/-0:= +12.7*	112.2kV
1. ***Loss of NCLFN Line With auto-switching of the -2MVAr reactor at Junction***		124.1kV *SVC Output*	120.3kV	118.9kV	117.4kV *+6.7/-0:= +6.7*	116.9kV (+3.8%)	4.11kV (+3.8%) *+13.7/-0:= +13.7*	*Out-of-service*

Line Losses

TABLE 8	***Conditions:***	***Two SVCs at Musselwhite (+9/-13.5MVAr) & one SVC at Crow River (+6/-11MVAr); Additional -2MVAr reactor at Musselwhite Junction; and with loads at the Musselwhite Mine at 0.94 power factor***			
Loads at the Musselwhite Mine	*Line Section*				*Total Losses*
	Circuit E1C: Ear Falls TS to Crow River DS			*Circuit M1M*	
	Ear Falls TS to Slate Falls Jct.	Slate Falls Jct. to Golden Pat Jct.	Golden Pat Jct. to Placer Jct.		
16MW	4.4MW	1.8MW	1.9MW	1.1MW	9.2MW
18MW	5.7MW	2.4MW	2.6MW	1.6MW	12.3MW

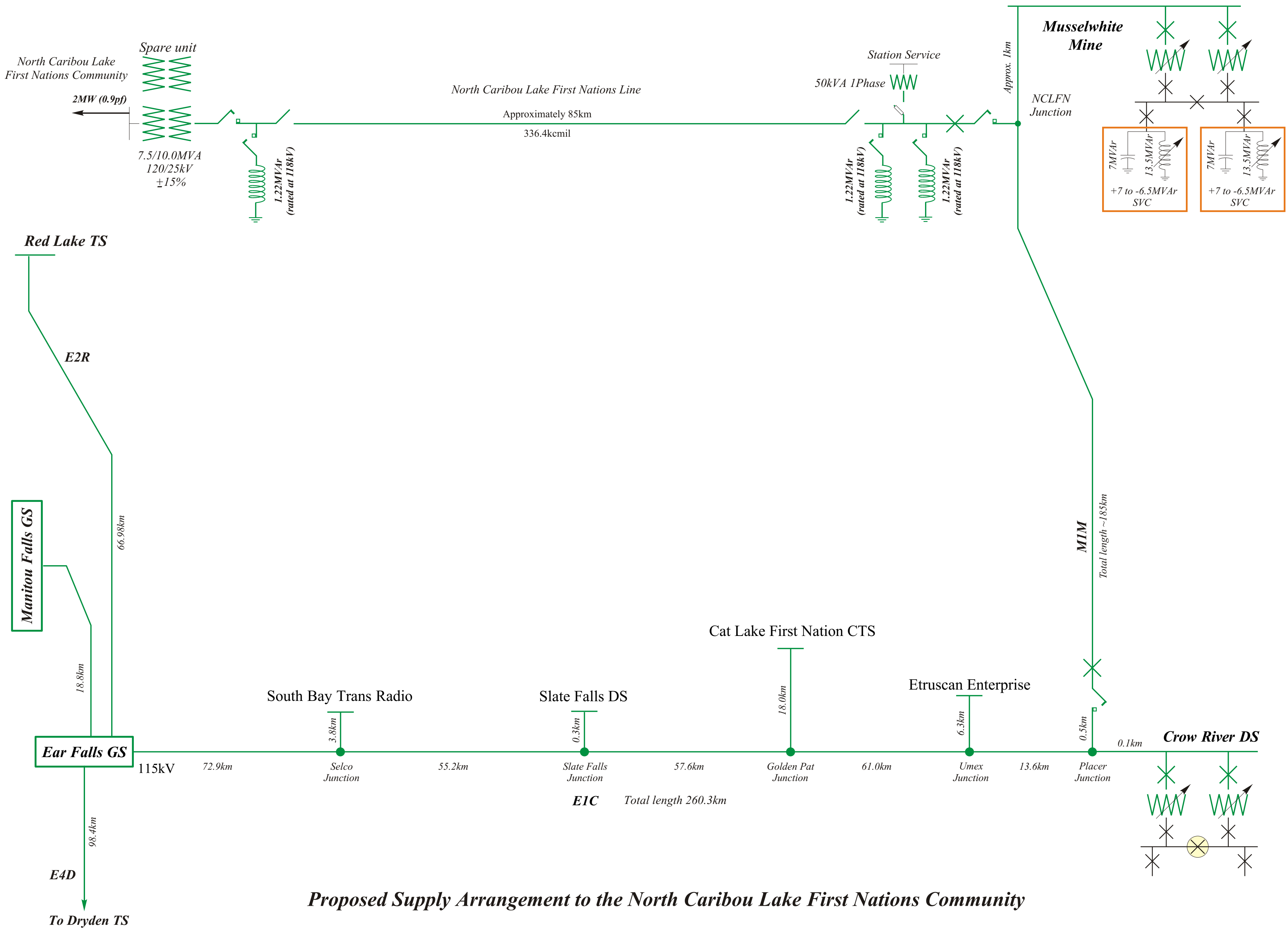
DIAGRAMS



Existing Supply Arrangement to the Placer Dome - Musselwhite Mine

DIAGRAM 1

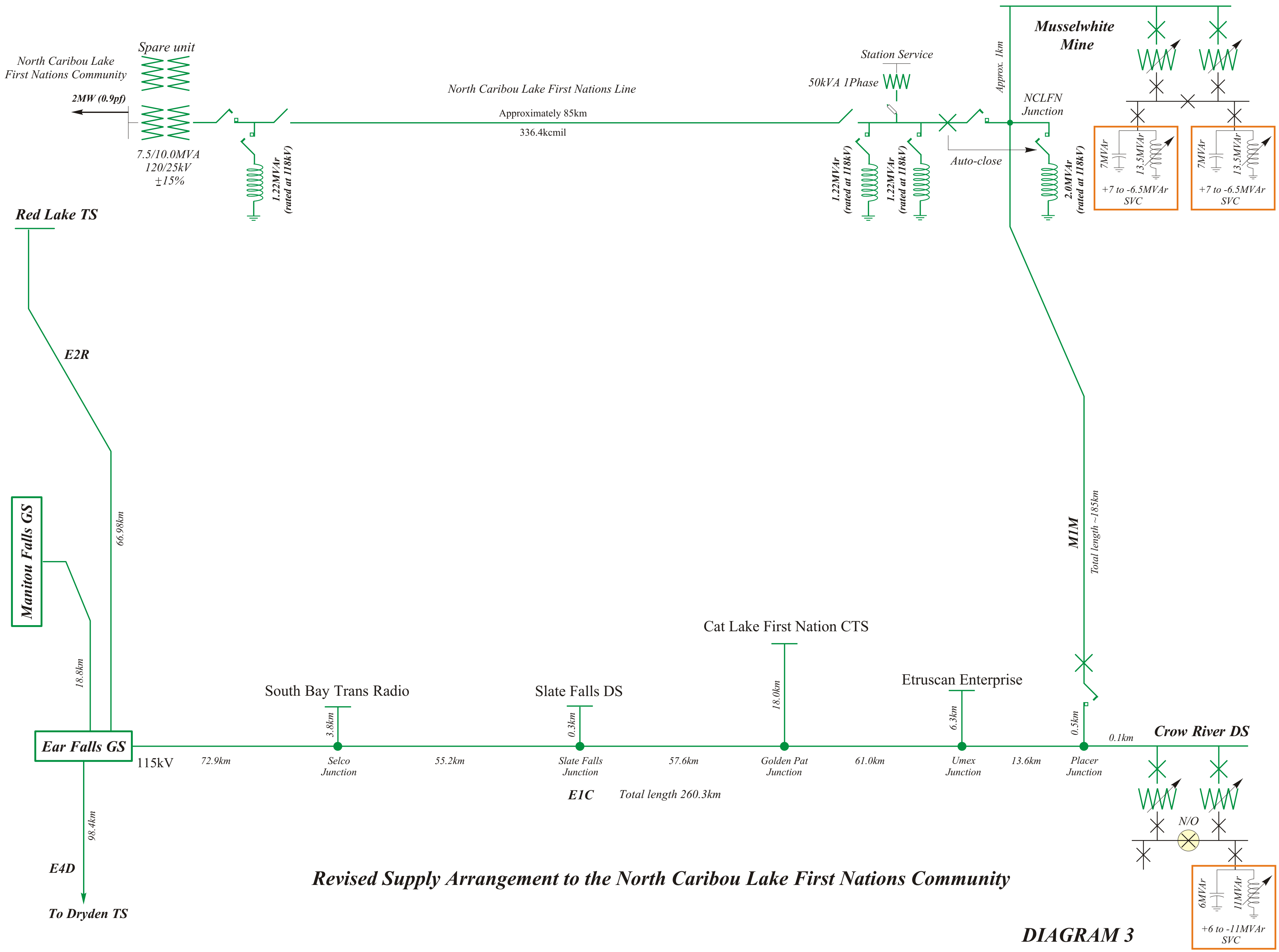
10th May 2003



Proposed Supply Arrangement to the North Caribou Lake First Nations Community

DIAGRAM 2

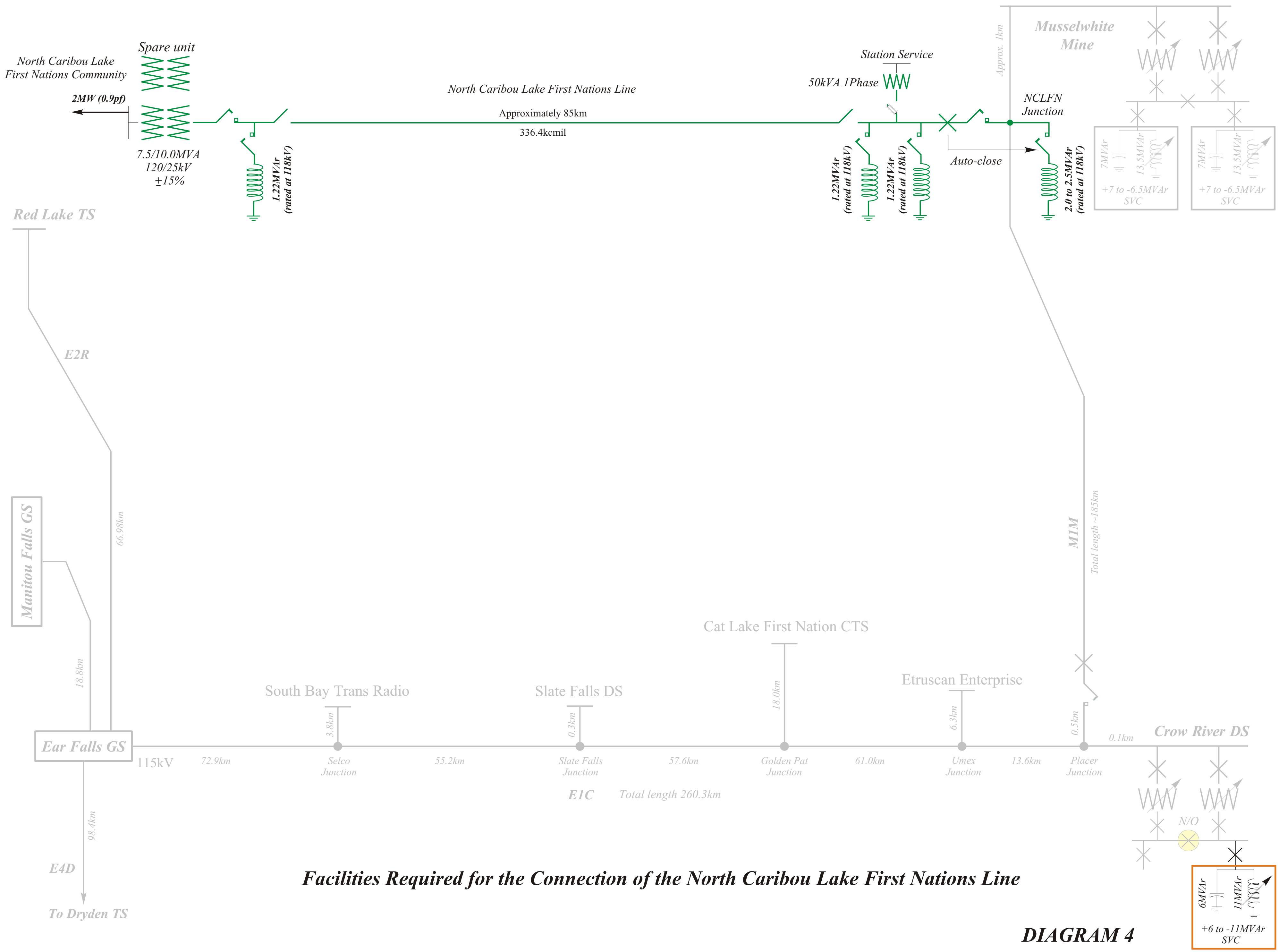
10th May 2003



Revised Supply Arrangement to the North Caribou Lake First Nations Community

DIAGRAM 3

20th May 2003



Facilities Required for the Connection of the North Caribou Lake First Nations Line

DIAGRAM 4

20th July 2003