A REPORT TO

THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

	Electrical
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28-AUG-2009 DATE PROVINCE OF NEWFOUNDLAND	Transmission & Distribution
	Telecontrol
	System Planning

LABRADOR CITY VOLTAGE CONVERSION DISTRIBUTION LINE UPGRADE

August 2009

newfoundland labrador hydro

a nalcor energy company

Table of Contents

1 INTRODUCTION 1
2 PROJECT DESCRIPTION 3
3 EXISTING SYSTEM 4
3.1 Age of Equipment or System 7
3.2 Major Work and/or Upgrades 7
3.3 Anticipated Useful life 8
3.4 Maintenance History 8
3.5 Outage Statistics 9
3.6 Industry Experience 11
3.7 Maintenance or Support Arrangements 11
3.8 Vendor Recommendations 11
3.9 Availability of Replacement Parts 11
3.10 Safety Performance 12
3.11 Environmental Performance 13
3.12 Operating Regime 13
4 JUSTIFICATION 14
4.1 Net Present Value 14
4.2 Levelized Cost of Energy 14
4.3 Cost Benefit Analysis 15
4.4 Legislative or Regulatory Requirements 15
4.5 Historical Information 15
4.6 Forecast Customer Growth 15
4.7 Energy Efficiency Benefits 16
4.8 Losses during Construction 17
4.9 Status Quo 17
4.10 Alternatives 17
5 CONCLUSION 19
5.1 Budget Estimate 19
5.2 Project Schedule 19

Appendix A Existing System Single Line Diagram
Appendix B Labrador City Distribution System Upgrading Study

1 INTRODUCTION

As part of its 2009 Capital Budget Application (CBA), Newfoundland and Labrador Hydro (Hydro) included two projects related to upgrading the Labrador City Distribution System (LBC). These projects were "Upgrade Voltage Conversion Phase I - Labrador City" (see Section D, p. D-26, 2009 CBA) and "Labrador City Voltage Conversion Terminals and Transmission Reconfiguration" (see report at Tab 3, Volume 2, 2009 CBA). The current proposal is Phase II of the Voltage Conversion Upgrade. Phase I consists of the preliminary engineering to confirm the scope of the work and the costs for Phase II. Phase I is approximately 90 percent completed.

LBC consists of a high-voltage 46 kV subtransmission system and five medium-voltage 4.16 kV distribution systems. The subtransmission system consists of five 46 kV subtransmission feeders, L32, L33, L9, L10 and L11, and a 46 kV switching station (Townsite Switching Station). The function of this system is to supply bulk power to the 4.16 kV distribution systems. The medium voltage distribution systems supply power directly to customers and include five 46/4.16 kV step-down substations, (Bartlett Substation, Hudson Substation, Vanier Substation, Quartzite Substation, and Harrie Lake Substation), and twenty 4.16 kV distribution feeders, (L1 to L8 and L12 to L23). In addition to the above, two customer owned distribution feeders are supplied from the Harrie Lake and Hudson Distribution systems. One line extends westward from the Harrie Lake Substation to the Tamarack Lake Golf Course (Tamarack Line), and the second line extends from the Hudson Substation and supplies facilities along the Québec North Shore and Labrador Railway (QNS&L Line). A simplified single line diagram of the existing system is shown in Appendix A.

LBC is supplied from the Churchill Falls Generating Station via two 230 kV transmission lines. The transmission lines run from the 230 kV Switchyard at Churchill Falls to the 230/46 kV Wabush Terminal Station (WBH), which is owned by Twin Falls Power Company Ltd. (TWINCo) and operated by Churchill Falls (Labrador) Corporation Ltd. (CF(L)Co). This station also feeds the Wabush Townsite Substation (WAB), as well as the mining facilities at Iron Ore Company of Canada (IOCC), and Wabush Mines (WM).

Voltage regulation for the system is provided by two synchronous condensers located at WBH. The synchronous condensers regulate the voltage on the 46 kV bus to 46.6 kV (1.013 p.u.). There are no other voltage regulation devices located in this system. A single 46 kV subtransmission line, L32, carries power to the Townsite Switching Station where power is then transmitted to the substations where the voltage is stepped-down to 4.16 kV for distribution to customers in Labrador City.

Hydro's Labrador City Upgrading Project has been developed to ensure that continued, least-cost, reliable service is provided to customers in Labrador City, and to provide the capacity to meet load growth. The present system was designed to supply approximately 52 MW of load. A study of the distribution system was conducted in the fall of 2007. It found that beyond 52 MW, the existing system would be subject to poor voltage regulation, low voltages, and more frequent component failures due to excessive heating. More detail on the results of the study can be found in the Engineering Report entitled Labrador City Distribution System Upgrading Study found in Appendix B attached to "Labrador City Voltage Conversion Terminals and Transmission Reconfiguration" (see report at Tab 3, Volume 2, 2009 CBA). The study is also attached to this proposal as Appendix B. The study determined that in order to serve additional load growth, it would be necessary to convert the system to a higher distribution voltage. Converting the distribution system to 25 kV will increase the power transfer capability, improve voltage regulation, and should improve the reliability of the system.

2 PROJECT DESCRIPTION

This project, Phase II will include the work to complete the voltage conversion on the existing Labrador City distribution system from 4.16 kV to 25 kV. The existing distribution line components, currently rated for a nominal voltage of 4.16 kV cannot operate at 25 kV. Work tasks will include the following activities:

- Pole Installation – The installation of poles will be required to replace deteriorated poles and extend existing lines.

- Insulator Replacement – The replacement of all insulators is required to provide adequate insulation levels for the 25 kV operation.

- Structure Framing – Existing structures will need to be reframed to provide adequate clearance between conductors and with ground.

- Conductor Replacement – Sections of existing conductor will be replaced to meet the requirements of the voltage conversion. New conductor will also be strung on any new extensions that may be required. Any existing conductor identified as weak and deteriorated will be replaced with new conductor.

- Porcelain Cutouts Replacement - The existing cutouts will be replaced with new polymer cutouts because porcelain cutouts no longer meet current Hydro standards with respect to safety performance. Refer to Section 3.10 “Safety Performance” for more information.

3 EXISTING SYSTEM

The existing distribution system consists of five substations supplied radially by a 46 kV subtransmission system. The substations step the voltage down from 46 kV to 4.16 kV nominal. Power is distributed to customers on twenty 4.16 kV distribution feeders. LCB was acquired by Hydro from IOCC in 1992. At that time economic conditions were poor, since the mining operations were in decline. To meet the system requirements at the time, the distribution was upgraded to meet minimum standards (i.e. minimum acceptable voltage) and supply a peak load of 52 MW. The upgrades completed in 1992 are outlined in Section 3.2 of this report. However, inadequacies in the current system are illustrated in Figures 1 and 2 below.

Figure 1: Existing poles are congested and overloaded.

Figure 2: Inadequate structure clearance for increased voltage levels.

The 2007 study and 2009 proposals were completed at a time when high demand for iron ore on the world market had driven prices for this commodity to all time highs. Compelled by the high value of their product, IOCC and Wabush Mines ramped up production. IOCC announced a $500 million expansion plan to increase production capacity by 50 percent by 2011, which has now been deferred. However, it is anticipated the expansion will occur in the future. The region's economy is driven mainly by the mining operations at IOCC and Wabush Mines and, as such, the local economy had been benefiting from the spin-offs.

Following a similar trend in the rest of the country, the demographics of the area is changing. A large number of retirements are expected at the mining operations in the next few years as the baby boom generation starts to retire. It is expected that 50 to 65 percent of retirees will remain in the region. IOCC had planned to hire an additional 200 employees to backfill positions vacated by retirement. The combination of retirees choosing to stay in the region along with the additional new employees that come to Labrador West will result in a need for additional housing. An additional 250 construction workers for the expansion project, if and when it occurs, will also drive an increased need for accommodations. This led to a small boom in the region's real estate market with housing prices comparable to those in the St. John's metro region. Projections for housing requirements indicate that between 140 to 180 new homes may be required. Residential developments have been proposed for the area west of Labrador City and a number of new additions have gone into the Harrie Lake Trailer Park. In response to the increased demand for services, a number of new businesses have set up in the region, while others that were already present have expanded their operations. Table 1 below shows the number of new services connected in Labrador City from January 2003 to August 2009.

Table 1: New Services Connected in Labrador City 2003 – 2009

Year	New Service Connections		
	Domestic Service	General Service	Total
2003	7	4	11
2004	9	7	16
2005	18	10	28
2006	12	12	24
2007	56	16	72
2008	92	31	123
2009	10	4	14
Total	204	84	288

Since July 2008, there have been 84 new domestic and 19 new general services connected to the system for a total of 204 new domestic and 84 new general services connected since 2003. The general trend (except 2009) shows a steady increase in the number of services connected each year and it is expected that this trend will continue for the foreseeable future. Most of the commercial/industrial development has been in the town's industrial park in the form of mine service industries. In addition to these developments, the Government of Newfoundland and Labrador plans to construct a new regional hospital and college in the town. The location of these facilities is currently under review, but is being proposed at a site just north of the town. Finally, if the new mining developments proposed for the Bloom Lake and LabMag Iron Ore deposits go ahead, they are expected to have a positive impact on the region in the form of direct and indirect employment opportunities.

The existing 4.16 kV distribution system was designed to serve a load of up to 52 MW. It has been operating near the limits of its capacity for several years, but the peak load has not increased in this time. The forecasted peak load for Labrador City is 52.2 MW in 2009, and 52.8 MW in 2010 and the peak load is expected to continue to grow. At loads above 52 MW, the existing system will start to experience low voltage during peak conditions. During peak conditions the existing 4.16 kV distribution system will be subject to a number of problems, including poor voltage regulation, high feeder currents, and difficulty in protecting against faults. Additional Information on the existing system can be found in the engineering report included with the 2009 CBA and attached here as Appendix B.

3.1 Age of Equipment or System

LCB was constructed and installed by the IOCC in the early 1960's. Hydro acquired the distribution system from IOCC in 1992.

3.2 Major Work and/or Upgrades

At the time of Hydro's takeover, the distribution system was assessed by Hydro and IOCC as being in poor condition. The system required upgrading to bring it to acceptable standards and make it safe to operate. The original upgrades in 1992 were initiated to address safety concerns and power quality issues present at that time. Table 2 below shows the major upgrades that have occurred since the system was taken over in 1992.

Table 2: Major Work or Upgrades Since 1992

Year	Major Work/Upgrade	Cost ($000)
1992	Purchase Spare Transformer	211.8
1992	Switching Center Upgrade/Gang Switch Installations	131.6
1992	Harrie Lake Upgrading	61.8
1992	Bartlett Feeder #1 and #2 Conversion	593.6
1993	Hudson Substation Reclosers	114.2
1993	Vanier Substation	790.0
1993	System Protection Improvements	130.1
1993	Transformer Purchases and Replacements	298.1
1994	Labrador City - Distribution Upgrading	1,562.2
1995	Labrador City - Distribution Upgrading	1,007.9
1996	Labrador City - Distribution Upgrading	51.3
1997	Bartlett Substation Upgrade	782.6
1998	Harrie Lake (Labrador City) - Upgrade Distribution System	407.3
1998	Cable Replacements - Quartzite and Harrie Lake Substations	97.4

The above upgrades were completed by Hydro over a six-year period, 1992 to 1998. The cost of this work was shared between Hydro and IOCC. The upgrading project, of which the table above is a subset, had a total cost of approximately $7.9 million, and IOCC contributed $2.5 million of this amount. The last major upgrades were completed in 1998.

3.3 Anticipated Useful life

The service life of a subtransmission line and distribution line is 30 years.

3.4 Maintenance History

The five-year maintenance history for the Labrador City Distribution System is shown in the Table 3 below.

Table 3: Maintenance History for the Labrador City Distribution System

Year	Preventive Maintenance ($000)	Corrective Maintenance ($000)	Total Maintenance ($000)
2008	218.8	73.1	291.9
2007	24.4	74.4	98.8
2006	8.0	69.7	77.7
2005	15.2	84.7	99.9
2004	12.0	80.5	92.5

Corrective maintenance costs are those associated with the repair of system components that have failed. Preventive maintenance costs are those that can be contributed to tasks such as line inspection, trouble calls and routine minor maintenance.

The total amount spent on corrective maintenance exceeds the amount spent on preventative maintenance, which may be an indicator of a system operating near its maximum capability and prone to higher than normal component failure rates. Besides preventive and corrective maintenance, other items comprising consumables (e.g. gloves, and coverall suits), technical assessments and studies, and emergency repairs, cost $462,500 over the five-year period.

3.5 Outage Statistics

Hydro tracks all distribution system outages using industry standard indexes, SAIFI and SAIDI which are explained as follows:

SAIDI - System Average Interruption Duration Index for customers served per year, or the average length of time a customer is without power in the respective distribution system per year.

SAIFI - System Average Interruption Frequency Index per year which indicates the average of sustained interruptions per customer served per year or the average number of power outages a customer has experienced in the respective distribution system per year.

Table 4 lists the 2004 to 2008 average SAIFI and SAIDI data for Labrador City, and compares all outage causes to defective equipment outages. The table also lists the 2004 to 2008 corporate value and the latest CEA five-year averages (2003 to 2007) for comparison. These statistics are not justification for this project.

Table 4: Outage Statistics - SAIFI SAIDI Data

Five-year Averages (2004 to 2008)				
Location	**All Causes**		**Defective Equipment**	
	SAIFI	**SAIDI**	**SAIFI**	**SAIDI**
Labrador City	5.91	9.24	0.18	0.22
Hydro Corporate	5.92	9.50	0.74	1.30
CEA (2003 – 2007)	2.67	8.33	0.48	1.13

Defective Equipment is defined by the CEA as:
Customer interruptions resulting from equipment failures due to deterioration from age, incorrect maintenance, or imminent failures detected by maintenance. It does not include planned outages to repair defective equipment.

Although the outage statistics for this system are not close to Hydro's average statistics and the historical reliability performance of the distribution system has been relatively acceptable, recent outages experienced by the system have prompted further investigation. A series of 14 outages that occurred in 2007 and 15 outages that occurred in 2008 raised public concerns about the reliability of the distribution systems in Labrador West. As a result, Hydro conducted a review of the system to determine the cause of the decrease in reliability of the system. Analysis of historical reliability data shows a substantial increase in outage rates over the past three years, and it shows a general trend of decreasing reliability. The project will replace aging distribution system equipment with new equipment and should improve the reliability of the distribution system. The work will be conducted proactively to avoid a major failure of the line resulting in an extended outage for the customers.

3.6 Industry Experience

In general, larger distribution systems (in terms of maximum demand) transfer power at distribution voltages in the range of 12.5 kV to 25 kV. Typically, these voltages offer superior performance over 4.16 kV systems in terms of power transfer capability and voltage regulation. For comparison purposes, the distribution system in Labrador City, which has a 2009 forecast peak of 52.2 MW, is supplied at 4.16 kV. Other distribution systems in Newfoundland and Labrador with similar annual peaks to Labrador City are supplied with 12.5 kV or 25 kV service. This is mainly because operating the distribution system voltage at 12.5 kV or 25 kV provides greater power carrying capacity per feeder and results in better voltage regulation.

3.7 Maintenance or Support Arrangements

Since the distribution system was acquired from IOCC in 1992, Hydro personnel have operated and maintained it. It is expected that Hydro will continue to operate and maintain the system in this manner.

3.8 Vendor Recommendations

There are no specific vendor recommendations for this project.

3.9 Availability of Replacement Parts

Replacement parts are readily available for these assets.

3.10 Safety Performance

Although the justification for this project is based on the requirement for increased power supply there are some safety issues with respect to existing line components in the distribution system.

The following safety issues have been identified:

- Deteriorated poles pose a risk to the safety of operations personnel while performing climbing activities to conduct regular inspections or maintenance work. The majority of the poles identified as deteriorated are blackjack poles that are no longer commonly used in the utility industry. Industry experience shows that it is common for blackjack poles to deteriorate from the inside out as a result of the thick layer of tar/creosote on the surface of the pole. The deterioration on the inside of the pole causes a reduction in strength of the structure. This may give a false sense of security in that they may appear acceptable by visual inspection but the actual strength of the structure may be reduced increasing the risk of failure.

- The porcelain cutouts have experienced failures during opening and closing operations. Damaged cutouts can result in equipment becoming energized while indicating they are in an open position. This poses an electrical contact threat for operation crews. Due to these safety concerns, the porcelain cutouts no longer comply with Hydro standards and are being replaced with new polymer cutouts.

- Copper Conductor becomes brittle and susceptible to breakage overtime. A conductor failure would result in an outage and may cause injury or damage to persons and property.

3.11 Environmental Performance

There are no major environmental issues surrounding this project.

3.12 Operating Regime

LBC is in continuous operation.

4 JUSTIFICATION

This project is necessary to meet the electricity needs of customers in Labrador City and to ensure that a quality, safe, least-cost and reliable electrical service is delivered to Hydro's customers. The existing system was designed to supply a peak load of 52 MW and has now reached its operational limit. Continuing with the status quo will result in low voltages to customers, lower system reliability, and could compromise the ability to protect people and equipment when faults on the system occur. The study (Appendix B) of the existing distribution system completed by Hydro in 2007 identified that a voltage conversion is the only practical method of meeting the forecasted load growth and correcting problems on the existing system.

4.1 Net Present Value

A net present value calculation was not performed at this time since this is Phase II of a project to upgrade the voltage conversion at Labrador City. In Board Order No. P.U. 36(2008), Hydro received approval for the proposal "Labrador City Voltage Conversion Terminals and Transmission Reconfiguration". That proposal showed that the 25 kV conversion was more economical than the 12.5 kV conversion by $3,525,886 over the 30-year period to 2040. This current proposal is a continuation of the 25 kV conversion to complete the distribution lines portion of the project.

4.2 Levelized Cost of Energy

The levelized cost of energy is a high level means to compare costs of developing two or more alternative generating sources. Therefore, the levelized cost of energy is not applicable in this case.

4.3 Cost Benefit Analysis

A cost benefit analysis was not necessary for this project since the alternatives were technically equivalent and offered the same benefits to the system.

4.4 Legislative or Regulatory Requirements

This project is required to ensure that the service Hydro provides to customers served by this system complies with Section 37 of the Public Utilities Act in that it is "reasonably safe and adequate and just and reasonable".

4.5 Historical Information

This is not a recurring project, and Hydro has not performed any system voltage conversions in the past five years.

4.6 Forecast Customer Growth

The load forecast for Labrador City is based on a combination of historical data since 1992, the effects of increased mining activities, the impacts of a new college and hospital, a modest amount of new residential construction and electric heat conversions. The load forecast for the Labrador West Interconnected System is shown in Table 5 below.

Table 5: Labrador West Load Forecast

Labrador West Interconnected Forecast Spring 2009						
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Labrador City						
Gross Peak (kW)	52,218	52,777	53,316	53,799	53,495	53,617
Gross Energy (MWh)	210,875	213,069	215,244	218,201	217,439	216,461
Total Sales (MWh)	201,417	203,513	205,591	208,415	209,076	208,135
Company Use (MWh)	0	0	0	0	0	0
Wabush						
Gross Peak (kW)	17,428	17,705	17,852	18,028	18,189	18,275
Gross Energy (MWh)	70,077	71,137	71,727	72,435	73,079	73,425
Total Sales (MWh)	66,019	67,018	67,577	68,248	68,858	69,186
Company Use (MWh)	375	380	380	380	380	380
Labrador West Sub-Total						
Gross Peak (kW)	69,646	70,482	71,168	71,827	71,684	71,892
Gross Energy (MWh)	280,952	284,205	286,972	290,636	290,518	289,886
Total Sales (MWh)	267,436	270,531	273,169	276,663	277,934	277,321
Company Use (MWh)	375	380	380	380	380	380
Gross peak or energy equates to bulk deliveries on interconnected systems						

While the load forecast represents the expected energy and demand growth on the Labrador City System, the risk of higher load growth exists due to several factors. A fully utilized housing stock along with the changing demographic in the region from retiree retention and new employees for the mining operations, along with the impacts of the IOCC expansion and the Bloom Lake Development, could potentially generate new residential developments. In combination with approximately 2 MW of electric heat conversion potential in the region, the load could approach 60 MW over the next 20 years.

4.7 Energy Efficiency Benefits

Operating the system at a higher distribution voltage should result in approximately 1.1 MW of savings in line losses during peak load.

4.8 Losses during Construction

There are very few anticipated energy losses during construction. The distribution system is interconnected in such a way that it is possible to isolate small sections of the system during off peak periods while still maintaining service to the remaining customers on the feeder. This will allow outages to customers to be minimized while the work is conducted.

4.9 Status Quo

The status quo is not an option. The 4.16 kV distribution system that currently supplies the customers in Labrador City was designed to supply a peak load of 52 MW. The system load is forecasted to exceed 52 MW in 2009 and to continue to grow to 60 MW within 20 years. The distribution system is now at its operational limit. Continuing with the status quo will result in low voltages to customers, lower system reliability, and could compromise the ability to protect people and equipment when faults on the system occur. Failure to upgrade the existing feeders could increase the number of outages of varying durations to the customers they serve. In addition, deteriorated/outdated equipment poses considerable safety risks to Hydro operations personnel who maintain the lines, as well as to individuals residing in and occupying the area.

4.10 Alternatives

A voltage conversion was identified as the most efficient means to meet the growing electrical needs of customers and to correct the problems on this system. Two alternatives were considered in the design. Alternative 1 is to upgrade the distribution to 25 kV; Alternative 2 is to upgrade the distribution to 12.5 kV. The 25 kV and 12.5 kV alternatives are both based on Hydro's standard design and operating practices. The 25 kV plan consists of a two substation system with nine 25 kV feeders. The 12.5 kV plan would consist of three substations with seventeen 12.5 kV feeders and a 46 kV switching station. Both alternatives would provide acceptable voltage regulation and keep line currents at levels to ensure fault protection is adequate. They provide operational flexibility and improved reliability over the existing system. An analysis of the two alternatives shows that either will increase the system capability to supply a peak load greater than 66 MW which is higher than the current forecast. As stated in Section 4.1, Alternative 1 is the least-cost choice.

5 CONCLUSION

This project is required to continue the voltage conversion begun with the approval of the 2009 capital proposal to reconfigure the Labrador City Terminals Stations and Transmission assets. It will ensure that a reliable energy supply is available for the customers served by these lines. To accomplish this task, the proposed voltage conversion is the most efficient and economical way to obtain these desired results.

5.1 Budget Estimate

The budget estimate for this project is shown in Table 6.

Table 6: Budget Estimate

Project Cost: *($ x1,000)*	**2010**	**2011**	**Beyond**	**Total**
Material Supply	250.0	1,400.0	1,400.0	3,050.0
Labour	270.0	300.0	360.0	930.0
Consultant	0.0	0.0	0.0	0.0
Contract Work	400.0	1,200.0	2,100.0	3,700.0
Other Direct Costs	0.0	0.0	0.0	0.0
O/H, AFUDC & Escln.	76.9	311.2	564.2	952.3
Contingency	92.0	290.0	386.0	768.0
TOTAL	**1,088.9**	**3,501.2**	**4,810.2**	**9,400.3**

5.2 Project Schedule

The anticipated project schedule is shown in Table 7.

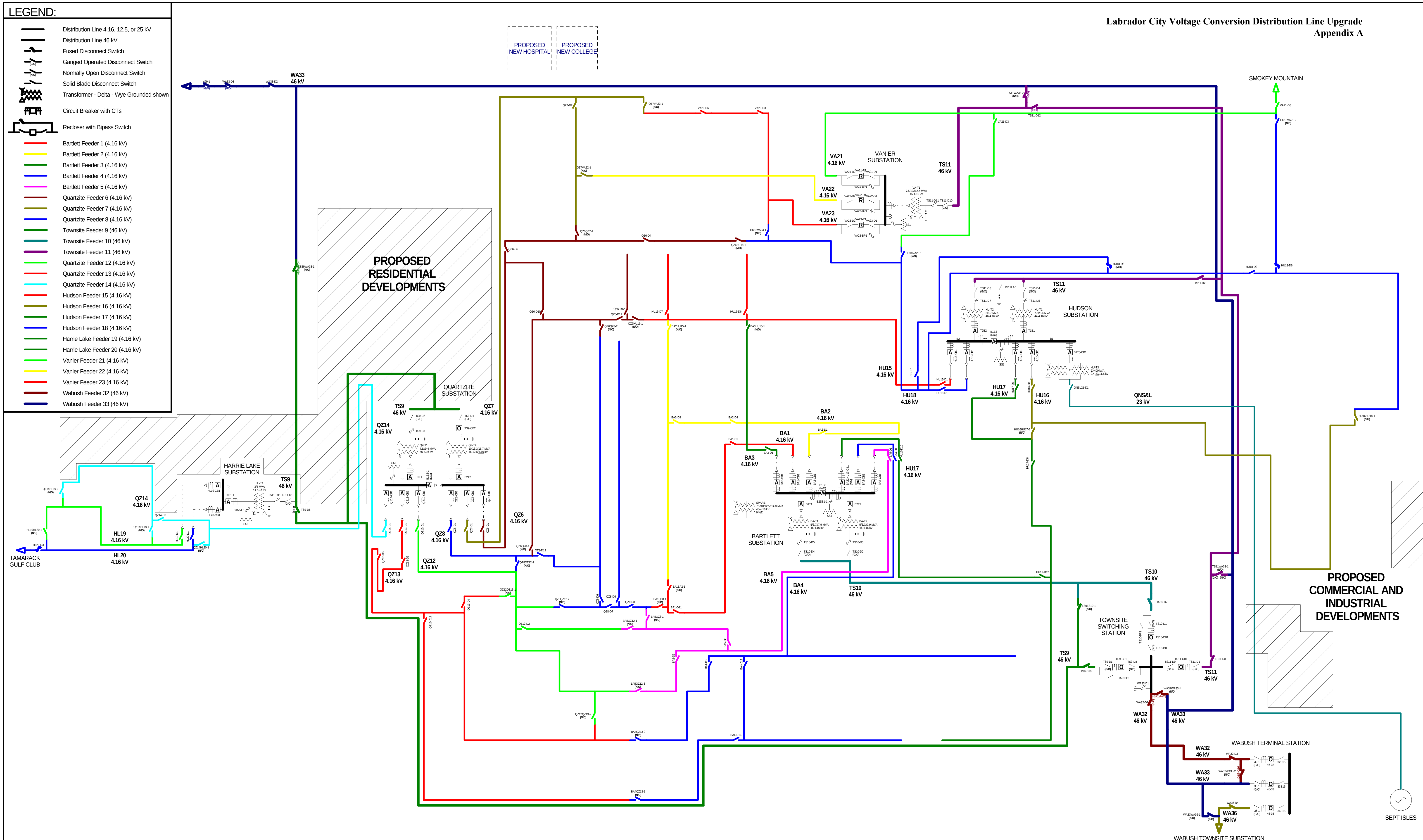
Table 7: Project Schedule

Project Milestone	Completion Date
Initiation	January 2010
Field Assessment	October 2010
Engineering Design	April 2010
Material Procurement	May 2011
Installation Commencement	June 2011
Installation Complete	Oct 2013
Commission	Nov 2013
Project Closeout	Dec 2013

APPENDIX A

Labrador City System Single Line Diagram

Labrador City Voltage Conversion Distribution Line Upgrade
Appendix A



SYS PLANNING: CRW	SHEET 1 OF 1
SYS OPERATIONS: --	DATE: NOV 8, 2007
TERM DESIGN: --	DRAWN BY: CRW
PROTECTION: --	FILE: EXISTING 4.16 KV SYSTEM.SKF

APPENDIX B

Labrador City Distribution Upgrading Study

LABRADOR CITY DISTRIBUTION SYSTEM UPGRADING STUDY

	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Approved for Release

Date

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SUMMARY

This document is a study of the ability of the distribution system in Labrador City to serve load growth.

The study determined that the existing system would not be able to meet future load requirements. In order to ensure that customers on the distribution receive acceptable power quality, will be necessary to upgrade the system.

The voltage conversion plan developed in 1992 was revisited. However, it was determined that this design would not adequately meet current requirements. Two alternative plans were developed to better address load growth and meet present day requirements to well beyond the forecast period.

One alternative is to upgrade the distribution system to 25 kV, and the other, because a considerable amount of infrastructure already exists, is to upgrade the distribution system to 12.5 kV.

The 25 kV alternative proved to be $3.9 million less costly than the 12.5 kV alternative. It also offers some superior performance benefits such as greater power transfer capability, and better motor starting performance over the 12.5 kV Upgrading Plan.

A number of recommendations have been made in the final section, which identify further work required and measures that can be taken to improve the system.

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TABLE OF CONTENTS

INTRODUCTION 1

1.1 TOWNSITE SWITCHING STATION 2
1.2 SUBSTATIONS 3
1.2.1 BARTLETT SUBSTATION 3
1.2.2 HUDSON SUBSTATION 4
1.2.3 VANIER SUBSTATION 4
1.2.4 QUARTZITE SUBSTATION 5
1.2.5 HARRIE LAKE SUBSTATION 5
1.3 RECENT DEVELOPMENTS 7
1.4 LOAD FORECAST 9

2 EXISTING SYSTEM 11

2.1 OUTAGE STATISTICS 13
2.2 LOAD FLOW ANALYSIS 15
2.2.1 LOAD FLOW ANALYSIS 2007 FORECASTED PEAK 15
2.2.2 LOAD FLOW ANALYSIS 2027 FORECASTED PEAK 17
2.3 1992 12.5 KV UPGRADING PLAN 18

3 2007 UPGRADING PLAN 20

3.1 DESIGN CONSTRAINTS 20
3.1.1 VOLTAGE AND LOAD 21
3.1.1.1 Voltage Levels 21
3.1.1.2 Voltage Unbalance 21
3.1.1.3 Current 22
3.1.1.4 Current Unbalance 22
3.1.2 INITIAL FEEDER LOADING 22
3.1.3 COLD LOAD PICKUP 23
3.1.4 FAULT PROTECTION 24
3.1.5 OPERATIONAL FLEXIBILITY AND RELIABILITY 24
3.1.6 POWER TRANSFORMERS 24
3.1.7 FIRM CAPACITY 25

4 2007 LABRADOR CITY 25 KV UPGRADING PLAN 27

4.1 SUBSTATIONS 27
4.2 SUBTRANSMISSION SYSTEM 30
4.3 FINAL 25 KV DISTRIBUTION SYSTEM 31
4.4 LOAD FLOW ANALYSIS - 2027 LOAD FORECAST 32
4.5 CONTINGENCY ANALYSIS 34
4.5.1 LOSS OF A SUBTRANSMISSION LINE 34
4.5.2 LOSS OF A TRANSFORMER 35
4.5.3 LOSS OF A RECLOSER 36

5 2007 LABRADOR CITY 12.5 KV UPGRADING PLAN....................... 38

5.1 SUBSTATIONS.. 38
5.2 SUBTRANSMISSION SYSTEM.. 40
5.3 FINAL 12.5 KV DISTRIBUTION SYSTEM 41
5.4 LOAD FLOW ANALYSIS - 2027 LOAD FORECAST 43
5.5 CONTINGENCY ANALYSIS 45
5.5.1 LOSS OF A SUBTRANSMISSION LINE 45
5.5.2 LOSS OF A TRANSFORMER 47
5.5.3 LOSS OF A FEEDER BREAKER 50

6 CONCLUSIONS AND RECOMMENDATIONS 52

6.1 COMPARISON OF ALTERNATIVES 25 kV VERSUS 12.5 KV 53
6.2 ECONOMIC ANALYSIS.. 54
6.3 RECOMMENDATIONS... 58

REFERENCES... 61

APPENDICIES

APPENDIX A - SINGLE LINE DIAGRAMS
A1 – LABRADOR CITY DISTRIBUTION SINGLE LINE DIAGRAM
A2 – TOWNSITE SWITCHING STATION
A3 – BARTLETT SUBSTATION
A4 – HUDSON SUBSTATION
A5 – VANIER SUBSTATION
A6 – QUARTZITE SUBSTATION
A7 – HARRIE LAKE SUBSTATION

APPENDIX B – MEMO FR. DAVID HARRIS RE. 4.16 KV UPGRADING PLAN

APPENDIX C – RURAL (ISOLATED) DISTRIBUTION SYSTEMS OVERCURRENT PROTECTION UPGRADE

APPENDIX D 25 KV DISTRIBUTION UPGRADING PLAN SINGLE LINE DIAGRAMS
D1 – LABRADOR CITY 25 KV CAPITAL PLAN 2007
D2 – PROPOSED 46 KV SUB-TRANSMISSION UPGRADES
D3 – PROPOSED QUARTZITE 25 KV SUBSTATION
D4 – PROPOSED VANIER 25 KV SUBSTATION

APPENDIX E – SCOPE OF WORK FOR THE 25 KV UPGRADING PLAN

APPENDIX F – 12.5 KV DISTRIBUTION UPGRADING PLAN SINGLE LINE DIAGRAMS
F1 – LABRADOR CITY 12.5 KV CAPITAL PLAN 2007

F2 – PROPOSED TOWNSITE SWITCHING SUBSTATION
F3 – PROPOSED 46 KV SUB-TRANSMISSION UPGRADES
F4 – PROPOSED BARTLETT 12.5 KV SUBSTATION
F5 – PROPOSED QUARTZITE 12.5 KV SUBSTATION
F6 – PROPOSED VANIER 12.5 KV SUBSTATION

APPENDIX G – SCOPE OF WORK FOR THE 12.5 KV UPGRADING PLAN

APPENDIX H – TRANSFORMER SURVEY

LIST OF TABLES

Table 1: Load Breakout at Townsite Switching Station ... 2
Table 2: Substation Breakout and 2007 Undiversified Forecasted Peak ... 3
Table 3: Bartlett Substation Feeder Breakout ... 4
Table 4: Hudson Substation Feeder Breakout ... 4
Table 5: Vanier Substation Feeder Breakout ... 5
Table 6: Quartzite Substation Feeder Breakout ... 5
Table 7: Harrie Lake Substation Feeder Breakout ... 6
Table 8: Labrador City Long-term Load Forecast ... 9
Table 9: NL Hydro Distribution SAIDI and SAIFI ... 14
Table 10: Labrador City Outage Statistics Summary ... 14
Table 11: Anticipated Feeder Current - 2007 Forecasted Peak Load ... 16
Table 12: Anticipated Worst Case Feeder Voltage - 2007 Forecasted Peak Load ... 16
Table 13: Anticipated Feeder Current - 2027 Forecasted Peak Load ... 17
Table 14: Anticipated Worst Case Feeder Voltage - 2027 Forecasted Peak Load ... 18
Table 15: Voltage limits at Customer Service Entrance and on the Primary as per CSA C235-83. ... 21
Table 16: 25 kV Plan - Feeder Current - 2027 Forecasted Peak Load ... 32
Table 17: 25 kV Plan - Worst Case Feeder Voltage - 2027 Forecasted Peak Load ... 33
Table 18: 25 kV Plan - Transformer Load - 2027 Forecasted Peak Load ... 33
Table 19: Contingency - 25 kV Plan - Feeder Current - L33 Out of Service ... 34
Table 20: Contingency - 25 kV Plan - Feeder Voltage - L33 Out of Service ... 35
Table 21: Contingency - 25 kV Plan - Transformer Load - L33 Out of Service ... 35
Table 22: Contingency - 25 kV Plan - Feeder Current –VA-T1 Out of Service ... 36
Table 23: Contingency - 25 kV Plan - Feeder Voltage – VA-T1 Out of Service ... 36
Table 24: Contingency - 25 kV Plan - Transformer Load – VA-T1 Out of Service ... 36
Table 25: Contingency - 25 kV Plan - Feeder Current – VA21-R1 Out of Service ... 37
Table 26: Contingency - 25 kV Plan - Feeder Voltage - VA21-R1 Out of Service ... 37
Table 27: Contingency - 25 kV Plan - Transformer Load - VA21-R1 Out of Service ... 37
Table 28: 12.5 kV Plan - Feeder Current - 2027 Forecasted Peak Load ... 43
Table 29: 12.5 kV Plan - Feeder Voltage - 2027 Forecasted Peak Load ... 44

Table 30: 12.5 kV Plan - Transformer Load - 2027 Forecasted Peak Load 44
Table 31: Contingency - 12.5 kV Plan - Feeder Current – L9 Out of Service 46
Table 32: Contingency - 12.5 kV Plan - Feeder Voltage - L9 Out of Service................ 46
Table 33: Contingency - 12.5 kV Plan - Transformer Load - L9 Out of Service............ 47
Table 34: Contingency - 12.5 kV Plan - Feeder Current – QZ-T1 Out of Service......... 48
Table 35: Contingency - 12.5 kV Plan - Feeder Voltage - QZ-T1 Out of Service 49
Table 36: Contingency - 12.5 kV Plan - Transformer Load - QZ-T1 Out of Service 49
Table 37: Contingency - 12.5 kV Plan - Feeder Current - QZ7-CB1 Out of Service..... 50
Table 38: Contingency - 12.5 kV Plan - Feeder Voltage - QZ7-CB1 Out of Service 51
Table 39: Contingency - 12.5 kV Plan - Transformer Load - QZ7-CB1 Out of Service. 51
Table 40: Project Estimate - Station Work for 25 kV Alternative 55
Table 41: Project Estimate - Line Work for 25 kV Alternative....................................... 55
Table 42: Project Estimate - Station Work for 12.5 kV Alternative 56
Table 43: Project Estimate - Line Work for 12.5 kV Alternative.................................... 56
Table 44: Net Present Value of Alternatives (2008 Dollars) 57

LIST OF FIGURES

Figure 1: Peak Load History and Load Forecast Plot 10
Figure 2: Line Length versus Nominal Voltage to give EOL Voltage of 116 V for a starting voltage of 120 V on a 120 V base and 376 A line current. 11
Figure 3: Net Present Value Comparison 58

LIST OF ABBREVIATIONS

LBC – Labrador City Distribution System
WBH – Wabush Terminal Station
WAB – Wabush Townsite Substation
NLH – Newfoundland and Labrador Hydro
IOCC – Iron Ore Company of Canada
QNS&L – Quebec North Shore and Labrador Railway
TWINCo – Twin Falls Power Company Ltd.
CFLCo – Churchill Falls Labrador Corporation Ltd.
A - Amperes
V - Volts
W - Watts
VA – Volt-Amperes
VAR – Volt-Amperes Reactive
kA - Kiloamperes
kV – Kilovolts – 1000 V
kW – Kilowatts – 1000 W
kVA – Kilovolt-Amperes – 1000 VA
kVAR – Kilovolt-Amperes Reactive 1000 VAR
MW – Megawatts – 1000000 W
MVA – Megavolt-Amperes – 1000000 VA
MVAR – Megavolt-Amperes Reactive 1000000 VAR
ASC – Aluminum Stranded Conductor
AASC – Aluminum Alloy Stranded Conductor
ACSR – Aluminum Conductor steel Reinforced
AAC – All Aluminum Conductor
AAAC – All Aluminum Alloy Conductor
OLTC – On Load Tap Changer
SCADA – Supervisory Control and Data Acquisition

INTRODUCTION

The Labrador City Distribution System (LBC) consists of five 46 kV subtransmission feeders, L32, L33, L9, L10, L11, a 46 kV switching station, Townsite Switching Station, five 46/4.16 kV step-down substations, Bartlett Substation, Hudson Substation, Vanier Substation, Quartzite Substation, and Harrie Lake Substation, and twenty 4.16 kV distribution feeders, L1 to L8 and L12 to L23. In addition to the above, two customer owned distribution feeders are supplied from the system, one line extends westward to the Tamarack Lake Golf Course (Tamarack Line), a second line supplies facilities along the Quebec North Shore and Labrador Railway (QNS&L Line). A simplified single line diagram of the present day distribution system can be found in Appendix A1.

The Labrador City System is supplied from Churchill Falls via two 230 kV transmission lines. The transmission lines run from the Switchyard at Churchill Falls to the 230/46 kV Wabush Terminal Station. The Wabush Terminal Station is owned by Twin Falls Power Company Ltd. (TWINCo) and operated by Churchill Falls Labrador Corporation Ltd. (CFLCo). This station also feeds the Wabush Townsite Substation (WAB), as well as the mining facilities at Iron Ore Company of Canada (IOCC), and Wabush Mines.

Voltage regulation for the system is provided by On Load Tap Changers (OLTCs) and two synchronous condensers at Wabush Terminal Station. The synchronous condensers regulate the voltage on the 46 kV bus to 46.6 kV (1.013 p.u.).

A 46 kV subtransmission line, L32, runs 1.74 km from Wabush Terminal Station to Townsite Switching Station. The line construction consists of 477 ASC Cosmos conductor, and has a rated capacity of 66.4 MVA at an ambient temperature of -30 °C.

A second 46 kV subtransmission line, L33, also runs by the Townsite Switching Station and from there another 24 km to Fermont Quebec. L33 is connected to the Townsite Switching Station by a normally open tie switch, WA32WA33-1. The line can serve as an alternate supply to Townsite Switching Station when L32 is unavailable. The line conductor is 477 ACSR Pelican, and similar to L32 it has a capacity of 66.4 MVA based on a -30 °C ambient temperature and a 50 °C conductor temperature. The line was built as an emergency tie line between Fermont, Quebec and Labrador West.

In the event of an outage to either system, power can be supplied on an emergency basis in either direction. Fermont is normally supplied power by the Hydro Quebec Grid via the Mont Wright Terminal Station. In the event that supply to Fermont is lost from Mont Wright, up to 15 MW of power can be transferred to Fermont from Wabush Terminal Station over L33. In a similar way, up to 5 MW of power can be supplied from Fermont to Labrador West. There is a 30° phase difference between the Hydro Quebec and Labrador West electrical systems. Therefore, the two system cannot be operated in parallel, and L33 is not tied to Fermont on a regular basis. When the line must be utilized, then either Fermont of the Labrador West Distribution must be completely isolated from its normal source of supply before the interconnection can be made. This line is considered an emergency line and is not normally kept energized. In regards to the supply contract between NLH and Hydro Quebec, there are no stipulations regarding the amount of power that must be supplied over the Fermont Line.

L32 (or L33 during unusual circumstances) supply power to the Townsite Switching Station where power is distributed to the other substations.

1.1 TOWNSITE SWITCHING STATION

The Townsite Switching Station serves as a distribution and sectionalizing center for the 46 kV subtransmission system. The station consists of a 46 kV bus structure, three 46 kV oil circuit breakers, and a control cabinet. Its role in the system is to provide switching and protection to the substations within the system. Appendix A2 shows the single line diagram of the Townsite Switching Station.

The Townsite Switching Station connects three 46 kV subtransmission lines, L9, L10, and L11, which supply the distribution substations located throughout the town. L9 runs westward from Townsite along the southern part of town to the Quartzite and Harrie Lake Substations. The line is 3.85 km to Quartzite Substation and 3.75 km to the Harrie Lake Substation, this line uses 266.8 ACSR Partridge conductor and has a capacity of 47.9 MVA at -30 °C ambient temperature. L10 also runs in a generally westward direction to the Bartlett Substation in the center of town. This line is approximately 0.75 km long and is constructed of 266.8 ACSR Partridge conductor. L11 runs in a generally northern direction to the Hudson and Vanier Substations. The Hudson Substation is tapped off of L11 approximately 0.85 km down the line from the Townsite Switching Station. The line then extends from Hudson Substation 1.3 km to the Vanier Substation. The section of L11 running from Townsite to Hudson is constructed using 266.8 ACSR Partridge conductor, the section from Hudson to Vanier was constructed more recently and is built using 477 ASC Cosmos conductor. Based on historical breaker readings the load at Townsite Switching Station is distributed as shown in Table 1 below.

Table 1: Load Breakout at Townsite Switching Station

	INCOMING FEEDERS		OUTGOING FEEDERS		
	L32	L33	L9	L10	L11
TOTAL	100.0%	0%	35.9%	24.7%	39.3%
Φ_A	100.0%	0%	34.9%	24.6%	40.4%
Φ_B	100.0%	0%	35.6%	23.9%	40.5%
Φ_C	100.0%	0%	37.4%	25.6%	37.0%

As Table 1 above shows loads are relatively evenly distributed between the outgoing feeders that supply the 46/4.16 kV substations (L9 and L11 each feed two substations, a large one and a small one). Note however that L32 carries 100 % of the system load, rather than sharing the load with L33. As was stated above L33 is only considered an emergency feeder. The line is not normally energized; however, it may prove beneficial to operate this line in parallel with L32 both from the point of view of a backup supply as well as in terms of reliability.

From the Townsite Switching Station power is distributed to the Bartlett, Hudson, Vanier, Quartzite, and Harrie Lake Substations.

1.2 SUBSTATIONS

There are five 46/4.16 kV substations located in Labrador City which distribute power to customers at 4.16 kV. The system total installed nameplate capacity is 65668 kVA, plus another 12500 kVA of uninstalled capacity. Table 2 below shows the expected undiversified substation peaks for the current year.

Table 2: Substation Breakout and 2007 Undiversified Forecasted Peak

	%TOTAL	Forecasted Peak (kW)
Bartlett Substation	23%	11708
Hudson Substation	26%	13395
Vanier Substation	14%	7402
Quartzite Substation	29%	14564
Harrie Lake Substation	8%	4020

As is shown in Table 2, the Bartlett, Hudson, and Quartzite Substations carry 78 % of the system load. A general description of the substations is provided below.

1.2.1 BARTLETT SUBSTATION

Bartlett Substation (BA) consists of two 46/4.16 kV step-down power transformers, T1 (5000/6667 kVA) and T2 (5000/6667 kVA), a 46/4.16 kV system spare transformer, SPARE (7500/10000/12500 kVA), switchgear building. The switchgear building contains 15 kV metal-clad type switchgear, there are three 2000 A breakers, B1T1 connects T1 to bus B1, B2T2 connects T2 to bus B2, and B1B2 is normally open and ties B1 to B2, connected off of B1 and B2 are six 1200 A feeder breakers. The breakers are designed to interrupt up to 25000 A of symmetrical fault current. The substation currently operates at 4.16 kV and is capable of operating at voltages up to 14.4 kV. Appendix A3 shows the single line diagram of the Bartlett Substation.

The Bartlett Substation connects six 4.16 kV distribution feeders, L1, L2, L3, L4, and L5. The feeders supply distribution customers in the southern and central part of the town. A sixth feeder L17 also connects to the Bartlett Substation by a normally open breaker, however, normally this line is fed from the Hudson Substation. L2, L4, and L5 supply mainly residential type loads. L1 supplies a combination of residential and apartment loads as wells as two schools. The feeder load breakout based on historical breaker readings at Bartlett Substation is shown below in Table 3.

Table 3: Bartlett Substation Feeder Breakout

FEEDER	%-OF-TOTAL	%-PH-A	%-PH-B	%-PH-C
L1	17%	25%	35%	40%
L2	22%	39%	34%	27%
L3	19%	32%	30%	37%
L4	23%	34%	28%	38%
L5	20%	31%	35%	33%

1.2.2 HUDSON SUBSTATION

Hudson Substation (HU) consists of a 44/4.16 kV step-down power transformer, T1 (7500 kVA), a 46/4.16 kV step-down power transformer, T2 (5000/6667 kVA), two 2.4/23-11.5 kV single-phase step-up power transformers, T3A (400 kVA) and T3B (400 kVA), and a switchgear building. The switchgear building contains 5 kV metal-clad type switchgear, there are three 2000 A breakers, T1B1 connects T1 to bus B1, T2B2 connects T2 to bus B2, and B1B2 is normally open and ties B1 to B2, connected off of B1 and B2 are five 1200 A feeder breakers. The breakers are designed to interrupt up to 25000 A of symmetrical fault current. Appendix A4 shows the single line diagram of the Hudson Substation.

The Hudson Substation connects four 4.16 kV distribution feeders and a customer owned line, L15, L16, L17, L18. The feeders supply distribution customers in the eastern part of town and the industrial park, a 23 kV customer owned feeder (QNS&L Line) is connected off of T3. L17 can be fed from either Bartlett or Hudson Substations however, it is normally fed from Hudson Substation, and the tie breaker BA22HU17-CB1 is left normally open. Over peak, Bartlett Substation does not have sufficient capacity to supply L17. Thus, its use is restricted to off peak periods. L15 supplies mainly residential customers in the central part of the town. L16, L17, L18 supply mainly commercial and industrial type loads. The feeder load breakout based on historical breaker readings at Hudson Substation is shown below in Table 4.

Table 4: Hudson Substation Feeder Breakout

FEEDER	%-OF-TOTAL	%-PH-A	%-PH-B	%-PH-C
L15	22%	31%	34%	35%
L16	23%	33%	33%	33%
L17	32%	32%	37%	31%
L18	16%	23%	45%	33%
QNS&L	6%	-	100%	-

1.2.3 VANIER SUBSTATION

Vanier Substation (VA) consists of a 46/4.16 kV step-down power transformer, T1 (7500/10000 kVA), a control building, and three 15 kV, 1120 A outdoor type reclosers, the reclosers are designed to interrupt up to 20000 A of symmetrical fault current. The substation buswork has an insulation rating of 25 kV and operates at 4.16 kV. Appendix A5 shows the single line diagram of the Vanier Substation.

The Vanier Substation connects three 4.16 kV distribution feeders, L21, L22, and L23. L21 supplies the Captain William Jackman Memorial Hospital and the Ski Hill at Smokey Mountain. L22 supplies residential customers in the northern part of town. L23 supplies power to the Labrador Mall. The feeder load breakout based on historical breaker readings at Vanier Substation is shown below in Table 5.

Table 5: Vanier Substation Feeder Breakout

FEEDER	%-OF-TOTAL	%-PH-A	%-PH-B	%-PH-C
L21	34%	33%	35%	33%
L22	31%	38%	25%	37%
L23	35%	33%	29%	38%

1.2.4 QUARTZITE SUBSTATION

Quartzite Substation (QZ) consists of two 46/4.16 kV step-down power transformers, T1 (7500 kVA) and T2 (10000/13333/16667 kVA), and two switchgear buildings. The switchgear buildings contain 4.8 kV metal-clad type switchgear, there are three 2000 A breakers, B1T1 connects T1 to bus B1, B2T2 connects T2 to bus B2, and B1B2 is normally open and ties B1 to B2, connected off of B1 and B2 are six 1200 A feeder breakers. The breakers are designed to interrupt up to 29000 A of symmetrical fault current. Appendix A6 shows the single line diagram of the Quartzite Substation.

The Quartzite Substation connects six 4.16 kV distribution feeders, L6, L7, L8, L12, L13, and L14. L6, L7, L8, L12, and L13 supply residential customers in the western part of the town. L14 supplies residential customers in the Harrie Lake Trailer Court, as well as a small business district at Harrie Lake. The feeder load breakout based on historical breaker readings at Quartzite Substation is shown below in Table 6.

Table 6: Quartzite Substation Feeder Breakout

FEEDER	%-OF-TOTAL	%-PH-A	%-PH-B	%-PH-C
L6	16%	31%	35%	34%
L7	13%	39%	33%	27%
L8	20%	35%	31%	34%
L12	20%	23%	38%	40%
L13	22%	37%	33%	30%
L14	9%	30%	29%	41%

1.2.5 HARRIE LAKE SUBSTATION

Harrie Lake Substation (HL) consists of a 44/4.16 kV step-down power transformer, T1 (3000/4000 kVA), and a switchgear building. The switchgear building contains 4.8 kV metal-clad type switchgear, there is a 2000 A breaker, T1B1-1 that connects T1 to bus B1, connected off of B1 and B2 are two 1200 A feeder breakers. The breakers are the same as those installed at Quartzite Substation and are designed to interrupt up to 29000 A of symmetrical fault current. Appendix A7 shows the single line diagram of the Harrie Lake Substation.

The Harrie Lake Substation connects two 4.16 kV distribution feeders, L19, and L20. The feeders supply mainly residential customers at the Harrie Lake Trailer Court to the west of the main part of the town. A customer owned line to the Tamarack Golf Course is connected off of L20. The feeder load breakout based on historical breaker readings at Harrie Lake Substation is shown below in Table 7.

Table 7: Harrie Lake Substation Feeder Breakout

FEEDER	%-OF-TOTAL	%-PH-A	%-PH-B	%-PH-C
L19	51%	23%	41%	36%
L20	49%	34%	30%	36%

1.3 RECENT DEVELOPMENTS

The Labrador City Distribution System was taken over by NLH from IOCC in 1992. At that time, the system received extensive upgrades to bring it to standard: Bartlett and Hudson Substations were rebuilt, the Vanier Substation was constructed, a number of feeders were upgraded, and the distribution was reconfigured to better share the load between the stations. The original upgrades were initiated to address safety concerns and power quality issues. The last major upgrades the system received were completed in the mid to late nineteen-nineties. During this time, a voltage conversion to 12.5 kV to part of the system was contemplated. However, the load was not forecasted to change much.

In the early 1990s, the mining companies were essentially wrapping up their operations. The economy of the region depends heavily on iron ore mining, and it was expected that the shutdown of the mines would lead to a decline in load. As a result, the plans for a voltage conversion were deferred, and the 4.16 kV distribution systems were retained. When the decision was made not to carry out the voltage conversion, it was noted that because the existing system is operating so near its capacity limits should any load growth occur, a voltage conversion would become necessary in order to accommodate the growth. See Appendix B for further details.

Today, the economic outlook for Labrador West is much different than it was in the early 1990s. The economy in the area has experienced revitalization, and there are present signs of load growth appearing in the region. People are moving to the area, the real-estate market is booming, enrolment is up in the schools, and service industries are expanding and setting up new operations. This growth is attributable to a number of factors as noted below. High demand for iron ore on the world market has subsequently driven prices for this commodity to all time highs. Compelled by the high value of their product, these companies have maximized production to capitalize on their profits, and are planning further expansions. The regions economy is driven mainly by the mining operations at IOCC, and Wabush Mines, and as such the local economy is benefiting from the spin-offs. A larger number of retirements are expected at these operations in the next few years as the baby boom generation starts to retire on mass. A number of the retirees are deciding to remain in the region after retirement. As new people hired to replace the retirees come to Labrador West the demand for housing increases. In addition to new hires coming into the region, it seems that some of the population from Fermont, PQ have moved to the area apparently drawn by the low cost of electricity relative to that in Quebec. This has lead to a small boom in the regions real estate market. New residential developments have been proposed for the area west of Labrador City and a number of new additions have gone into the Harrie Lake Trailer Park. In response to the increased demand for services, a number of new businesses have setup in the region, while others that were already present have expanded their operations. Most of this commercial/industrial development has been in the town’s industrial park. In addition to these developments the Government of Newfoundland and Labrador plans to construct a new hospital and college for the region in the town. The location for these developments is not yet finalized, but they are being proposed at a site just north of the town.

The peak load for Labrador City now exceeds 51 MW. The operations at Wabush Mines and IOCC are at full production, and IOCC is planning an expansion. The region now has potential for considerable growth. The town itself has experienced a considerable amount of growth in the past year. New trailers and mini-homes are constructed in the Harrie Lake trailer court area, a residential development has been proposed to start off of Hudson Drive near the Quartzite Substation. New commercial/industrial lots have been released in the industrial park, this area would be served by L18 out of Hudson Substation. The new college and hospital for Labrador West have been announced, the proposed location for the hospital is off the Fermont Highway behind the Labrador Mall. While the location of the college has not been officially announced, it is being proposed to go adjacent to the new hospital with a shared facilities concept. These loads would be supplied either by a new substation or from the Vanier Substation.

1.4 LOAD FORECAST

Table 8 below shows the long term load forecast for Labrador City as provided by the Market Analysis Section of Newfoundland and Labrador Hydro's System Planning Department.

Table 8: Labrador City Long-term Load Forecast

Labrador City Load Forecast 2007-2027							
Labrador City	2007	2008	2009	2010	2011	2012	2013
Gross Peak (kW)[1]	51,089	51,345	52,367	52,349	52,446	52,783	52,922
Gross Energy (MWh)[1]	204,974	208,674	212,825	215,072	213,147	214,516	215,082
Total Sales (MWh)	197,489	201,054	205,054	207,219	205,364	206,683	207,228
Company Use (MWh)	0	0	0	0	0	0	0
	2014	2015	2016	2017	2018	2019	2020
Gross Peak (kW)[1]	53,105	53,229	53,353	53,478	53,602	53,726	53,850
Gross Energy (MWh)[1]	215,827	216,331	216,836	217,340	217,844	218,348	218,853
Total Sales (MWh)	207,953	208,440	208,926	209,412	209,899	210,385	210,871
Company Use (MWh)	0	0	0	0	0	0	0
	2021	2022	2023	2024	2025	2026	2027
Gross Peak (kW)[1]	53,974	54,098	54,222	54,346	54,470	54,594	54,718
Gross Energy (MWh)[1]	219,357	219,861	220,366	220,870	221,374	221,879	222,383
Total Sales (MWh)	211,357	211,844	212,330	212,816	213,303	213,789	214,275
Company Use (MWh)	0	0	0	0	0	0	0
1. Gross peak or energy equates to bulk deliveries on interconnected systems. Source: Spring 2007 HROPLF with Summer 2007 Long Term Extension System Planing Department August 2007							

The load forecast was plotted with the historic annual peaks from 1994 to the present. The results are shown below.

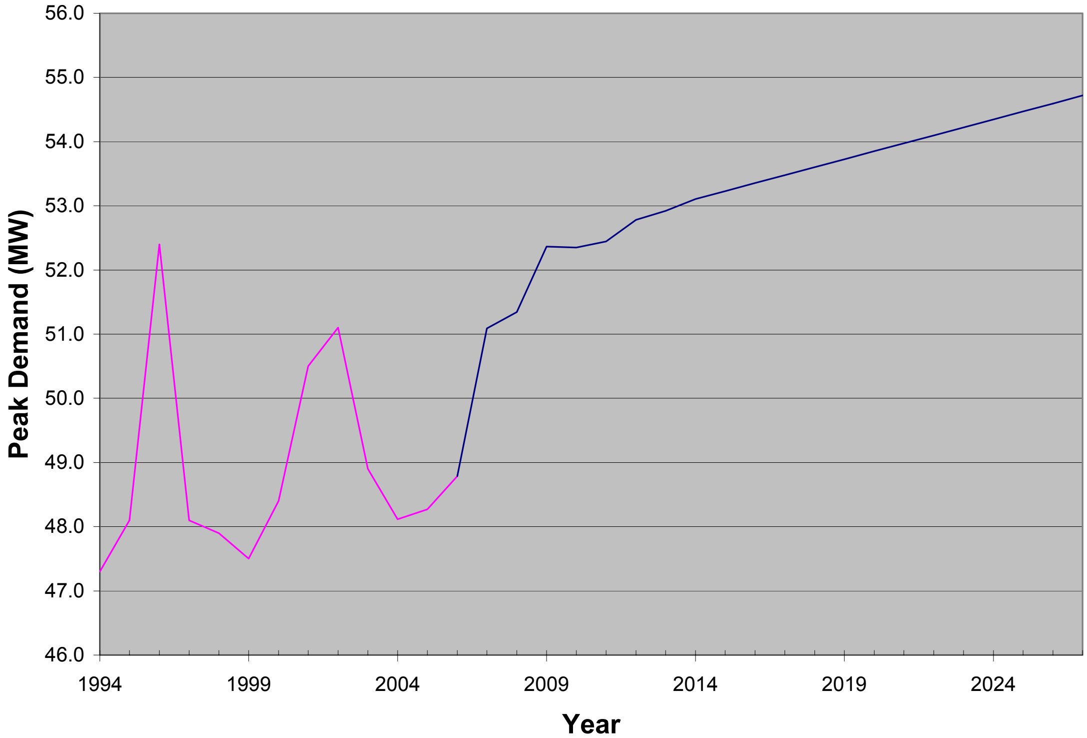


Figure 1: Peak Load History and Load Forecast Plot

Figure 1 above shows the system peak load history from 1994 to 2006, and the forecasted load out to 2027. The forecast shows the system load should go to approximately 55 MW by 2027. The existing system has several limitations which limit of the amount of additional power that can be supplied above present peak conditions. A brief discussion of these limitations on the existing system is given in the next section.

2 EXISTING SYSTEM

The existing 4.16 kV distribution system was designed to serve a load of up to 52 MW. It has been operating near the limits of its capacity for several years, but the peak load has not increased in this time. The 4.16 kV distribution system has a number of limitations that prevent it from supplying much load beyond 52 MW. These limitations are discussed briefly in this section.

The first limitation is voltage regulation. As a distribution voltage, 4.16 kV has capability to carry only a small amount of power over any distance because the voltage drop per unit length is larger in comparison to higher distribution voltages. For the same amount of power, more current is required at 4.16 kV than for say 12.5 kV or 25 kV. Since line current is higher, then the voltage drop through the line will also be greater. Therefore, the feeder length must be kept short to avoid having low voltages occur to customers on the distribution. Figure 2 below provides a comparison of the available reach over which power can be transmitted for a given operating voltage and constant line current. The chart shows the feeder length versus nominal system voltage that results in an end-of-line voltage of 96.7 % for a 100 % sending end voltage at 376 A line current. To model a distributed load, half the load is placed at the end of the line, and half was place halfway down the line. A line current of 376 A was chosen because this is representative of typical peak feeder currents that would be seen in Labrador City.

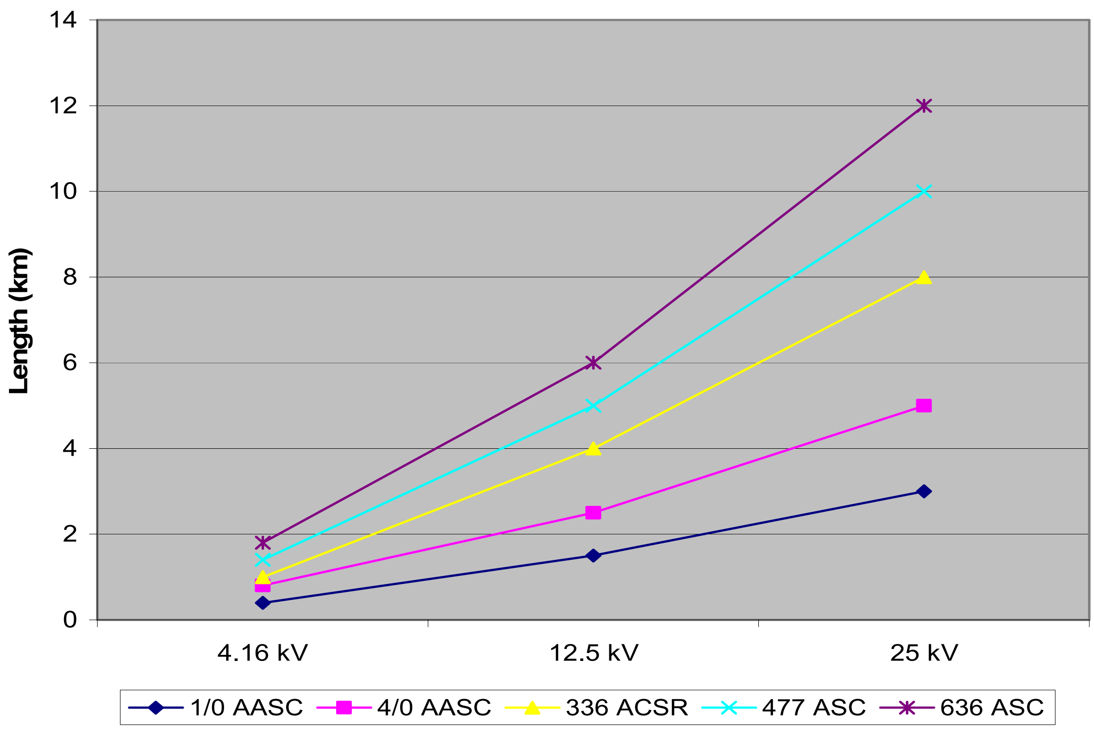


Figure 2: Line Length versus Nominal Voltage to give EOL Voltage of 116 V for a starting voltage of 120 V on a 120 V base and 376 A line current.

As Figure 2 shows, at higher nominal operating voltages a larger amount of power can be transmitted over a much larger distance than at a lower voltage. 336 ACSR is a very common size conductor in Labrador City, for a line current of 376 A, at 4.16 kV, about 2700 kVA of power can be transported a distance up to 1.8 km, in comparison at 25 kV, about 16200 kVA can be transported over a distance of 8 km. Therefore for the same size conductor up to six times the power can be transmitted over four times the distance at 25 kV as opposed to 4.16 kV. Not only does a higher system voltage allow more power to be transmitted over a longer distance, it also allows for use of smaller sized conductors and therefore cost savings when it comes to line construction.

The next is the limitation on operating a system at 4.16 kV is due to heat losses. This condition is associated with the relatively high currents that flow through the lines. Since the operating voltage is fixed within the range of regulation, in order to supply more power, more current must flow through the line. The high currents do not only cause larger voltage drops, it also causes more heating of components due to I^2R losses. If heating is excessive, it can stress and damage electrical equipment, and cause it to age prematurely. In general, 4.16 kV systems that supply large loads like that in Labrador City are less forgiving than similar size systems at higher operating voltages. The extra heating on the equipment will lead to failure more quickly and more often than a system operating at higher voltage for the same load. Preventing failures from becoming a regular occurrence requires a persistent and aggressive preventative maintenance program, and can require a considerable amount of the resources from the operations crew.

Another challenging aspect of supplying 50+ MW of load at 4.16 kV is adequately protecting the system from faults. Fault levels in Labrador City are very high (500 MVA at the substation high voltage bushings). Since the system operating voltage is rather low in comparison to more commonly used distribution voltages, very high fault currents are available at the substation low voltage bus. This is even with the choking effect of the substation power transformers. Due to the extremely high short circuit currents, operating restrictions prevent paralleling of transformers to keep fault levels below the interrupting rating of the breakers. As the distance from the substation increases the fault levels drop off quickly because the per unit system impedance is high. Therefore, as the distance increases the short circuit currents decrease, subsequently it can be more difficult to detect faults farther away from the substation. The problem can be compounded even further because the ground resistivity is very high in Labrador West (approximately 2000 Ωm). Impedance type faults can occur when a conductor (or conductors) contacts the ground, trees, or other objects and there is resistance to the flow of fault current. The most common type of fault is line-to-ground (i.e. when a single phase falls and contacts with the ground), and in general most of these faults are of the impedance type. When an impedance fault occurs on a 4.16 kV system, the current flowing into the fault can be very low. For example, a fault impedance of 40 Ω will only result in about fifty to sixty amperes of fault current. Such fault currents look no different than load current to a protective relay, and will not cause the devices to trip and clear the fault.

Typically, the protective relay phase-trip setting is twice the load current, up to a reasonable level of detection. The average undiversified feeder loads in Labrador City are approximately 2500 kW or about 350 A of line current. Basing the protection setting on the line current, the corresponding phase trip setting would be 700 A. The ground trip setting is typically set to be 50 % of the load current. Therefore, the corresponding ground trip setting is 175 A. For this protection setting, only faults with an impedance of less than 14 Ω would be detectable. For an impedance fault of 40 Ω, the fault current would be too low to trip the protective relay. Further details on distribution system overcurrent protection can be found in Appendix C.

Considering the above it seems the feeder loads in this system are at the point where increasing the protection settings any further to accommodate more load could compromise the ability to detect faults. Line to ground faults can become difficult to detect because the current flowing into the fault is low enough to be indistinguishable from normal load current. In such a case, breakers will not trip, and in the worst case, the fault may not burn clear and an energized line would be left on the ground. This can pose a considerable risk to the public. In Labrador City, the problem is further compounded by high load currents, which tend to mask more impedance faults.

The available fault current at the end of the line both limits the line length and the loading because the protection settings must be kept sufficiently low to ensure that most faults can be detected. This means that despite having additional thermal capacity on the system, very little additional load can be added to the system and still operate it safely. Ultimately, if any new loads are to be supplied at 4.16 kV in Labrador City, then this will require expansion of the existing substations, and construction of new feeders.

Operating the system is more difficult than with other systems. The system is complex because of the required number of substations and feeders. Therefore, maintenance requirements are demanding. Ensuring feeder loads are balanced to within 10 % is difficult due to small load variations having a large effect on line current.

The cost of the system is higher because equipment of higher ratings is required, larger conductors and circuit breakers must be used. Limiting feeder capacity to prevent low voltages and protection issues from arising will require more and more feeders. In many cases, this is impractical because the real estate is already built up or simply not available or the substation has already been expanded to its maximum capacity. All the additional work because of the switchgear requirement make the cost and timelines for such work very prohibitive when new loads come on stream.

2.1 OUTAGE STATISTICS

Reliability of NLHs distributions systems is tracked by industry standard indexes, SAIFI, and SAIDI. Service Continuity Indices for distribution are defined as shown below:

Table 9: NL Hydro Distribution SAIDI and SAIFI

Index	Description	Detail
SAIDI	Indicates System Average interruption duration for customers served per year.	TOTAL CUSTOMER - HOURS OF INTERRUPTIONS / TOTAL CUSTOMERS SERVED
SAIFI-S	Indicates the average of sustained interruptions per customer served per year.	TOTAL CUSTOMER - INTERRUPTIONS / TOTAL CUSTOMERS SERVED

Outages are tracked and stored in the Distribution Outage Reporting System (DORS).

Table 10: Labrador City Outage Statistics Summary

YEAR	NO OF CUSTOMERS	TOTAL		LOSS OF SUPPLY OUTAGES	
		SAIFI	SAIDI	SAIFI	SAIDI
2002	3650	4.499	1.711	1.786	0.217
2003	3650	3.596	0.757	0.000	0.000
2004	3658	3.220	1.992	2.659	1.580
2005	3670	4.669	9.181	3.593	8.542
2006	3661	5.965	11.490	0.908	0.298
2007	3675*	10.881	14.652	2.810	4.814
LBC 5 YR AVG**		4.390	5.026	1.789	2.127
NLH 5 YR AVG**		6.888	10.707		

YEAR	NO OF CUSTOMERS	PLANNED OUTAGES		UNPLANNED OUTAGES Exclusive of Loss of Supply	
		SAIFI	SAIDI	SAIFI	SAIDI
2002	3650	0.117	0.175	2.597	1.319
2003	3650	0.003	0.004	3.593	0.753
2004	3658	0.000	0.003	0.561	0.410
2005	3670	0.003	0.017	1.073	0.622
2006	3661	2.373	8.208	2.684	2.984
2007	3675*	1.406	2.789	6.665	7.048
LBC 5 YR AVG**		0.499	1.681	2.102	1.217
NLH 5 YR AVG**		1.555	3.399	5.333	7.308

*Number of customer forecasted at year end, exclusive of street lights. Provided by Market Analysis Section of Systems Planning Department.
**Five year average is for years ending 2002 to 2006.

In general the distribution system in Labrador City has performed well in the past from a reliability point of view. Although within the last three years, the outage rates have gone up substantially. Year-to-date SAIFI and SAIDI are more than twice the system five year average. The 2005 and 2006 statistics are up over previous years as well. If the outage reports for the year 2007 are indicative of the true reliability of the system, then customers in Labrador City can expect to experience almost eleven outages per year, and each outage could be up to fifteen hours in duration. The System Operations and Customers Services Department has received several complaints about the outages that have occurred in recent months. Given the relatively poor performance of the system in recent years, and the general dissatisfaction of the customers, the system may require upgrading to improve the system reliability.

The are a number of possible causes for the increased outage rates. Until 2005, the outage rates were as good as or better than any other NLH distribution system. The last major upgrades to the distribution were completed in 1997, typically, new equipment is very reliable, and it will take approximately five years for the equipment to start to exhibit the true reliability of that component over its lifetime. Now that most of the components on this system have reached more than five years in service, it is possible that the statistics are reflecting the true reliability of the system. Second, the system operates with relatively high line currents for a distribution system. This in turn causes higher I^2R losses, and therefore, more heating. Heat stress tends to be hard on equipment, and can cause it to age prematurely. The result can be an increase in failure rates, and thus lower reliability.

2.2 LOAD FLOW ANALYSIS

Load Flow Analysis was conducted to determine present and future peak load conditions. The study assumes substation power transformer taps provide 2.5 % boost at the 4.16 kV bus. The distribution system model was updated using the information currently available, and should be representative of actual system conditions. The results described below will be confirmed when Load and Voltage Studies are conducted on the distribution system in the winters of 2008 and 2009.

2.2.1 LOAD FLOW ANALYSIS 2007 FORECASTED PEAK

The model was scaled to the 2007 peak load forecast of 51089 kW to project current conditions on the distribution system. The results of the load flows are shown in Table 11 and Table 12 below.

Table 11: Anticipated Feeder Current - 2007 Forecasted Peak Load

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
BA1	202	280	322	268	24.6%
BA2	410	358	286	351	18.7%
BA3	293	272	339	302	12.6%
BA4	375	303	419	366	17.1%
BA5	310	349	331	330	5.9%
QZ6	305	339	328	324	5.9%
QZ7	309	259	214	261	18.6%
QZ8	429	370	422	407	9.0%
QZ12	266	449	470	395	32.7%
QZ13	492	437	388	439	12.1%
QZ14	165	165	238	189	25.6%
HU15	377	429	440	415	9.3%
HU16	428	428	431	429	0.4%
HU17	565	667	553	595	12.2%
HU18	201	401	290	297	34.9%
B1T3	-	343	-	-	-
HL19	193	350	303	282	31.6%
HL20	274	249	300	274	9.4%
VA21	341	359	339	346	3.7%
VA22	362	234	357	318	26.4%
VA23	351	312	407	357	14.1%

Based on the results in Table 11, present day loads are considerably high. Most feeders carry in excess of 300 A, feeder HU17 is the most heavily loaded. The line carries more than 600 A on B-phase over peak. The feeders are also considerably unbalanced. More than half the lines are unbalanced by more than 10 %. The high load current and unbalance can be expected to cause poor voltage regulation and voltage unbalance on the feeders.

Table 12: Anticipated Worst Case Feeder Voltage - 2007 Forecasted Peak Load

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$	Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	98.4%	118.1	HU15	96.3%	115.6
BA2	97.8%	117.4	HU16	98.1%	117.7
BA3	98.8%	118.5	HU17	93.9%	112.7
BA4	96.9%	116.3	HU18	96.9%	116.3
BA5	97.5%	117.0	HL19	96.8%	116.2
QZ6	97.3%	116.8	HL20	95.2%	114.3
QZ7	95.1%	114.1	VA21	94.8%	113.8
QZ8	96.8%	116.2	VA22	98.5%	118.1
QZ12	96.0%	115.2	VA23	96.4%	115.7
QZ13	94.4%	113.2	-	-	-
QZ14	93.7%	112.4	-	-	-

Table 12 above shows the expected minimum voltage at the end of the 4.16 kV distribution feeders in Labrador City. The load flow analysis confirms that voltage regulation on this system is very poor. A number of feeders are at the lower limit of acceptable primary voltage according to NLH planning criteria. The worst case voltage may be on feeder QZ14. The voltage at the end of this feeder may be as low as 93.7 % of nominal. It is expected that these problems will worsen as the system load grows.

2.2.2 LOAD FLOW ANALYSIS 2027 FORECASTED PEAK

The model was scaled to the 2027 peak load forecast of 54718 kW to project future conditions on the distribution system if nothing is done with the existing system. Again, it is expected that conditions on the 4.16 kV distribution systems will only worsen as time progresses. The results of the load flows are shown in Table 13 and Table 14 below.

Table 13: Anticipated Feeder Current - 2027 Forecasted Peak Load

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
BA1	217	300	345	287	24.7%
BA2	440	384	306	377	18.7%
BA3	314	292	364	323	12.6%
BA4	402	325	450	392	17.1%
BA5	333	374	356	354	6.0%
QZ6	327	364	352	348	5.9%
QZ7	333	278	229	280	18.8%
QZ8	460	397	453	437	9.1%
QZ12	285	483	505	424	32.8%
QZ13	530	469	417	472	12.3%
QZ14	177	177	256	203	25.9%
HU15	404	461	472	446	9.4%
HU16	459	460	462	460	0.4%
HU17	607	719	593	639	12.4%
HU18	216	431	310	319	35.1%
B1T3		368			
HL19	207	376	326	303	31.7%
HL20	294	267	323	294	9.5%
VA21	366	385	363	371	3.7%
VA22	389	250	383	341	26.5%
VA23	377	334	437	383	14.3%

Table 13 above shows that by 2027 most line currents could be in excess of 400 A per phase. This could have a negative impact on fault detection. High currents such as those shown in Table 13 indicate possible problems with cold load pick up. During a cold load pick up scenario line current could be double that seen above. Finally the higher currents will worsen voltage regulation even further and likely cause low voltages throughout the system.

Table 14: Anticipated Worst Case Feeder Voltage - 2027 Forecasted Peak Load

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$	Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	97.9%	117.5	**HU15**	95.7%	114.9
BA2	97.3%	116.8	**HU16**	97.5%	117.0
BA3	98.3%	118.0	**HU17**	93.5%	112.2
BA4	96.4%	115.7	**HU18**	96.4%	115.6
BA5	97.0%	116.4	**HL19**	96.3%	115.6
QZ6	96.8%	116.1	**HL20**	94.6%	113.5
QZ7	94.6%	113.5	**VA21**	94.1%	112.9
QZ8	96.2%	115.5	**VA22**	98.0%	117.6
QZ12	95.3%	114.4	**VA23**	95.7%	114.9
QZ13	93.6%	112.3	**-**	-	-
QZ14	92.8%	111.3	**-**	-	-

Table 14 above shows many feeders will have voltages which dip below 96.7 %. The worst case end of line voltage will be on QZ14 where the voltage could dip as low as 92.8 % during the system peak.

Given that the above analysis is for undiversified peaks, it is possible that the end of line voltages may be lower still on the 4.16 kV distribution system.

For a peak demand of 54718 kW the system losses are 1813 kW.

It is clear from the load flow analysis that the existing 4.16 kV distribution system does not have the ability to support future load growth without a significant amount of upgrading. Even if the existing system were expanded i.e. additional feeders and expanded substations, such upgrades may not be possible in all areas, and would not provide enough capacity to support load growth in the long term. Therefore, to address load growth in the long term, it is recommended that a voltage conversion be done on this system. The subsequent sections describe the options that were taken into consideration.

2.3 1992 12.5 KV UPGRADING PLAN

When the distribution system in Labrador City was taken over from IOCC a plan was developed to convert a portion of the system to 12.5 kV. This plan consisted of the conversion of the Bartlett System to 12.5 kV and picking up the bulk of the system load from the Bartlett substation. This would essentially have the distribution consisting of the core of the town at 12.5 kV, and the outer peripheral regions at 4.16 kV. The plan would significantly reduce feeder load currents allowing for improved system protection, and better ability to detect faults. It also should have improved the system reliability somewhat because the lower line currents would put less stress on the system components.

However, this plan does have some deficiencies when present planning criteria and design requirements are taken into account. The existing load in the developed areas of the town is fairly saturated, and not much growth would be expected here. The expected regions of growth are focused on the undeveloped lands to the west and north of the town, and in the undeveloped lands around the Labrador City industrial park. Since the original upgrading plan proposed to leave the peripheral areas of the town at 4.16 kV, it would be a relatively short time until feeders in these areas became loaded to capacity. As more load is connected to the system, additional feeders and eventually substations would be required. This would lead to a short-term requirement to upgrade the system again in the near future. It should be noted that as a distribution operating voltage 4.16 kV is best suited to small compact loads. In places where the ground resistivity is high as it is in Labrador the line currents must be limited so as not to compromise the ability to detect faults, and because the voltage drop is higher due to the higher line current the feeder length must be kept short to prevent low voltages to customers.

In light of the above issues, an alternate upgrading plan would be necessary to better address load growth on this system and provide a higher level of operability and reliability for this system.

The previous upgrading plan was not intended to address growth in these areas as these parts of the town were to continue to operate at 4.16 kV, therefore an alternate plan was developed which takes into account the expected regions of growth, improve and ease the operability of the system for operations personnel, and to improve the system reliability.

3 2007 UPGRADING PLAN

Due to current deficiencies in the 1992 Upgrading Plan (requirements have changed since that time), two alternate plans are proposed which would better address expected load growth in the town. The first plan would upgrade the system to 25 kV, which is Hydro's current standard construction for distribution. The other plan builds on the previous 12.5 kV upgrading plan and makes use of some of the existing infrastructure that is capable of operating at 12.5 kV. Both plans have their own respective merits.

The 4.16 kV systems that currently supply the distribution have been pushed to its limits. In order to supply any significant additional load, it would be necessary to expand the substations and construct new feeders. In most cases, due to the location of the substation, and their construction, this is impractical. The load in Labrador West has started to grow, it is now necessary to develop a long-term upgrading plan for the distribution system.

Considering NLH Standards and the infrastructure that presently exists, there are two options for the Capital Plan; a 25 kV upgrading plan, and a 12.5 kV upgrading plan. The 25 kV Plan is based on Hydro standard design and operating practices, and consists of a two substation system with nine 25 kV feeders. A 12.5 kV option is also being examined because some of the existing infrastructure in the system is capable of operating at 12.5 kV. This plan would consist of three substations with seventeen 12.5 kV feeders and a 46 kV switching station.

Both plans are designed to provide good voltage regulation, and to keep line currents at acceptable levels, the plans also should provide operational flexibility, and improved reliability. Either option will take the system out beyond 66 MW which is higher than the current forecast. The following is a brief overview of the two options and the reasoning behind them.

3.1 DESIGN CONSTRAINTS

A number of issues must be accounted for in the design of the new distribution system in Labrador City.

System Planning carries out Load and Voltage Studies to determine the state of the system. The load and voltage study obtains a snapshot of the power flow on the system by recording the voltage and current on the feeders at different locations. This information is gathered using digital recording ammeters (DRAs) and digital recording voltmeters (DRVs). By placing the devices at strategic points along the feeder, the voltage levels and currents under peak loading conditions can be viewed. From the study the peak load, feeder voltage, currents, and load breakout is determined. This information is then entered into a model of the system, and then the model is used to determine future loads, the effect of new loads, upgrades, etc. The upgraded system must meet the technical constraints outlined in the following sections.

3.1.1 VOLTAGE AND LOAD

3.1.1.1 Voltage Levels

Voltage levels on the system must stay within a specified range to ensure proper operation of devices connected to the system. Hydro uses the standard defined by CAN3-C235-83 (R2006) *Preferred Voltage Levels for AC Systems, 0 to 50 000 V*. The utility is responsible for voltages up to the customer service entrance. To ensure proper voltages at the service entrance, the voltages on the primary feeder must be high enough to account for the drops in the distribution transformer, secondary wire, and the service drop wire. Table 15 below shows the acceptable range of voltages at the service entrance under heavy and light load conditions.

Table 15: Voltage limits at Customer Service Entrance and on the Primary as per CSA C235-83.[1]

		Voltage (120 V Base)	
		Heavy Load	Light Load
Service Entrance Voltage		110	125
Voltage Drop at	Service Drop Wire	1	0.375
	Secondary Conductor	2	-
	Distribution Transformer	3	1.125
Total Voltage Drop from Primary to Service Entrance		6	1.5
Voltage at Primary		116	126.5

As Table 15 shows, the voltage on the primary should not go below 116 V on a 120 V nominal delivery voltage or 96.67 % of nominal. In some cases, it is known that the distribution transformer/secondary/service conductor voltage drop is less than 6 V. In such a case, a primary voltage of less than 116 V is acceptable. For light load conditions, the maximum allowable voltage on the primary is 126.5 V (105.4 %). For light load conditions the secondary conductor voltage drop not included since there are cases were secondary runs are not used (express drops).

3.1.1.2 Voltage Unbalance

Hydro calculates voltage unbalance as the maximum deviation of the phase voltage from the average voltage for all phases expressed as a percentage of the average voltage.

[1] Voltage drops are typical values for the equipment listed (1). Actual field measurements may in fact be lower depending on the impedance of the item in question. In cases where express service drops are used, the maximum allowable primary voltage during light load conditions is 126.5 V.

$$\%UV = \frac{MAX(\left|V_A - V_{avg}\right|, \left|V_B - V_{avg}\right|, \left|V_C - V_{avg}\right|)}{V_{avg}} \times 100\%$$

Voltage unbalance has the greatest effect on motors because circulating currents in the machine cause excessive heating. Subsequently motors supplied by unbalanced voltages must be derated. To minimize potential for damage to customers, Hydro limits the maximum allowable voltage unbalance to 2 %.

3.1.1.3 Current

Currents on the feeder must not exceed the maximum allowable ampacity for the conductors, transformers, and associated equipment. Exceeding allowable ampacities can cause damage to equipment, as well as unplanned outages.

3.1.1.4 Current Unbalance

Current unbalance is determined in a way similar to voltage unbalance as the maximum deviation from the average current as a percentage of the average current.

$$\%UI = \frac{MAX(\left|I_A - I_{avg}\right|, \left|I_B - I_{avg}\right|, \left|I_C - I_{avg}\right|)}{I_{avg}} \times 100\%$$

Unbalanced currents cause different voltage drops between the phase conductors and therefore, induce voltage unbalance. The unbalanced currents will flow in the system neutral. When neutral current is significant, corresponding protection settings will be higher to prevent nuisance tripping. Where line-to-ground fault levels are low, a high trip setting may compromise protection. For these reasons, NLH tends to limit the maximum permissible current unbalance to 10 %. However, there are situations where it is more feasible to correct for voltage unbalance with voltage regulators rather than by load balancing i.e. three-phase power may not be available in some areas. To improve protection it may necessary to install additional protective devices if load balancing is not possible.

3.1.2 INITIAL FEEDER LOADING

The system will be reconfigured to ensure that block loading on two adjacent feeders can be carried completely on one individual feeder.

The new system will be designed around NLHydro Distribution Standards for distribution lines and protection equipment. As a standard stock item, Hydro purchases distribution circuit reclosers with 560 A continuous current rating. A typical recloser stocked by Hydro is the Cooper Power Systems VWVE27, this recloser has a rated operating voltage of 24.9 kV a rated maximum voltage of 27 kV, a continuous current rating of 560 A, and a typical symmetrical rms interrupting rating of 12000 A.

Typically, recloser trip settings are determined based on a setting of twice the peak load current. This is done to prevent nuisance tripping on the system. Give this information, and knowing that the maximum recloser trip setting is 560 A, and then the maximum acceptable recloser load (based on a 560 A trip setting) is 280 A which is 50 % of the recloser rating.

Unlike most other NLH distribution systems, the distribution system in Labrador City is heavily meshed with multiple tie points. Transferring load and sectionalizing the feeders to minimize outages is presently available on this system however, the low operating voltage coupled with high line currents restricts the ability to switch load over peak. Generally, switching operations on the current system are restricted to off-peak periods. It is desirable to retain this functionality because of the operational flexibility and reliability it offers.

The system will be redesigned such that any single feeder will be able to carry the load of any adjacent feeder at any time in a contingency or maintenance situation. Thus the design feeder load will be one-half the maximum desirable recloser load 140 A per phase.

Note: The recloser can be loaded to 350 A (approximately 60 % of recloser rating) on a continuous basis without causing nuisance tripping for a maximum trip setting of 560 A. Designing for an initial feeder load of 140 A per phase allows for an additional 25 % load growth on the feeders before additional feeders are required.

3.1.3 COLD LOAD PICKUP

Cold load pickup is a condition that occurs following a prolonged outage during cold temperatures. Immediately following restoration of service, loads will be highly coincident. This results in extremely high demand for a period following the outage. The duration and magnitude of cold load pickup is influenced by a number of factors. These include the weather and ambient temperature at the time of the outage, the duration of the outage, the amount of insulation in the buildings, and the penetration of electric heat and electric water heaters in the region. Where penetration of electric heat is high, and very low ambient temperatures are common, cold load pickup can be extremely high. When the condition occurs, equipment ratings and protection settings can be exceeded potentially causing damages, and false tripping of reclosers and breakers. This can cause difficulties to restore service to customers. Such is the case for interconnected systems in Labrador. According to conversations with T&D staff in Labrador, cold load pickup has been experienced for an outage as short as 30 minutes. Typically cold load pickup is assumed to be 200 % of the normal peak load current.

Where the system has insufficient capacity to handle cold load pickup, sectionalized switching is applied to reduce its magnitude. Therefore, to prevent possible damages and nuisance tripping, sufficient additional capacity must be retained to account for cold load pickup.

3.1.4 FAULT PROTECTION

Protection settings will be determined by standard techniques (2X peak load current). Full zone coverage will be provided. Settings will be sufficiently high to allow for cold load pickup, and to prevent nuisance tripping. To ensure sensitivity to faults is adequately maintained, feeder loads will be such that a line-to-ground fault with 40 Ω of impedance should be detectable.

3.1.5 OPERATIONAL FLEXIBILITY AND RELIABILITY

The upgraded distribution system will maintain equivalent or superior operational flexibility to the present system.

To provide further reliability, and reduce the requirement for planned outages for breaker and transformer maintenance, the 46 kV Subtransmission System will be upgraded to a looped system. Two lines will be available to supply each substation. This will allow for quick restoration of service in the event of a subtransmission line failure, and provide flexibility for line maintenance without the need for an outage.

3.1.6 POWER TRANSFORMERS

Transformers will be built to CSA standard CAN/CSA-C88-M90 (R2004) *Power Transformers and Reactors*.

If a transformer is to be equipped with an on load tap changer, it shall be installed on the high voltage windings. The on load tap changer should be designed to provide 15 % boost and 5 % buck in thirty-three tap positions. Having 20 % tap range in thirty-three positions gives 0.625 % per tap position. The 0.625 % resolution on the tap changer provides the same resolution for voltage adjustment as a distribution class voltage regulator. Voltage control at the 46 kV bus in Wabush Terminal Station is provided by synchronous condensers. The synchronous condensers regulate the voltage on the 46 kV bus to 46.6 kV (1.013 p.u.), the voltage is maintained at this level at the request of IOCC to maintain the voltage at the desired level within their 4.16 kV system. Under normal circumstances the voltage does not rise above 47.4 kV (1.030 p.u.) the only time the voltage is likely to get significantly higher would be during restoration of the power to Labrador West following an outage to the 230 kV transmission system. Under such circumstances, the distribution systems are isolated from the supply until the voltage on the 46 kV bus has been stabilized. Therefore, a 5

% buck capability on the tap changer is suitable for this application. For fixed tap changers the standard ±5 % taps in five tap positions should suffice.

3.1.7 FIRM CAPACITY

To provide an acceptable level of substation reliability and operability it is proposed that each substation have at least two power transformers. The transformers are to be sized such that for the loss of the largest unit in the system there will be sufficient capacity in the remaining units to carry the load of the entire system without the need for rotating outages.

Newfoundland and Labrador Hydro (NLH) has a back-up policy in place for transformer stations within its system (2). The policy groups transformer stations into three categories: Major Stations, Single Unit Stations, and Generation Stations. Generation station transformers go beyond the scope of this report, so they are not discussed here. Major Stations are those with multiple transformer installations and they handle large quantities of power. They often serve as points of supply to other smaller substations i.e. Hardwoods, Deer Lake, Oxen Pond, etc. Where the stations are linked with other major stations via transmission lines the group of stations are treated as looped systems where firm capacity is applied to the entire system. This type of station, because of the vital role it serves, is designed to withstand the loss of the largest unit. That is, the stations are planned based on firm capacity, the available capacity with the largest unit out of service. If the load reaches the firm capacity of the station then additional capacity is added to meet firm criteria. Single Unit Substations as the name implies have only one transformer unit. These stations typically serve small loads in the range of 50 kW to 10 MW. In the event that the transformer is lost from such a station NLH relies on a portable transformer unit to restore power to customers on a short-term basis, in the long-term a spare transformer unit would be mobilized and installed to supply customers.

For the distribution system in Labrador City, the same design criteria for major stations on the island will be applied as opposed to single unit stations. Most of NLHs substations on the island system are single unit stations. This is primarily because they only supply relatively small loads, and should a transformer failure occur, a portable transformer can be quickly mobilized and transported to the site to restore power. Typically, power can be restored to the systems on the island in less than two days. In Labrador, the situation is a little different. The extreme cold temperatures and severe winter weather further limit the time available to get power restored because things start to freeze very quickly. There is high dependence on electric heat in the region because of the low cost of energy. A major outage to the power system in winter would endanger property and maybe even lives. NLH does not stock a portable transformer with a 46 kV high voltage winding. The vast geographic distances and terrain of Labrador coupled with the lack of road infrastructure and severe weather would hamper the ability to mobilize a portable unit. This in turn would lengthen restoration time as well as costs. Finally, the required size of transformer (minimum 10 MVA) would be difficult to retain as a portable unit. Such factors make implementing the island back-up policy for single unit stations nonviable for systems in interconnected Labrador. One other factor worth noting here is the relative size of the system in question. Labrador City has a peak load of approximately 50 MW at present and the load is growing. The summertime minimum load is approximately 7 MW (this is larger than the peaks for most of NLHs island systems). Given the relative size of the load in Labrador City the system can be treated as a major load and thus warrants major substation backup capability.

Applying firm capacity criteria (N-1) for major substations to the Labrador City System for each substation two transformers will be installed to provide reliability and flexibility for switching operations and substation maintenance.

For a two substation system with two units per substation and a long term forecasted load of 54.7 MW in 2027 the minimum required transformer size based on a 0.99 lagging power factor will be 54.7 MW / 0.99 / (4 -1) = 18.4 MVA. Adding 20 % additional capacity for a safety factor, the required transformer nameplate capacity is 22.1 MVA, thus a 15/20/25 MVA transformer size should be suitable for a two-substation system.

For a three substation system the minimum required transformer size would be 54.7 MW / 0.99 / (6 – 1) = 11.1 MVA. Again, adding 20 % additional capacity for a safety factor, the required transformer nameplate capacity is 13.3 MVA. Therefore, a 10/13.3/16.7 MVA power transformer should be suitable to serve a three-substation system.

4 2007 LABRADOR CITY 25 KV UPGRADING PLAN

The 2007 25 kV upgrading plan for Labrador City will upgrade the system to NLH Standards for distribution such that load growth is addressed to well beyond the planning horizon. Recognizing that a 25 kV feeder can safely carry much more power than a 4.16 kV feeder, the number of feeders, and subsequently the number of substations in the system can be reduced. The result will be a simpler system with lower annual operation and maintenance costs.

Using the criteria noted in Section 3.1.2, the initial feeder current will be 140 A. Therefore the average 25 kV feeder load will be, 25 kV * 140 A * √3 ≈ 6000 kVA under normal operating conditions. Under abnormal operating conditions (recloser failure for instance) the expected feeder load will be approximately 12000 kVA or twice the normal feeder load. Designing for this initial feeder load will leave sufficient capacity to accommodate cold load pickup and handle contingencies (i.e. carry 100 % of the load of an adjacent feeder). An additional 25 % to 30 % capacity will remain for load growth if the maximum continuous ampacity is based on use of a standard recloser with 560 A continuous current rating.

The forecasted peak load for 2007 is 51089 kW, assuming a system power factor of 0.99 lagging over peak, the required number of feeders are:

$$N = \frac{51089\,\text{kW}}{0.99 \times 6000\,\text{kVA}} \cong 9$$

Therefore, at least nine 25 kV feeders are required to supply the system.

4.1 SUBSTATIONS

Allowing for up to six feeders per substation, then two substations will be required for a 25 kV Labrador City Distribution System.

As a minimum the distribution system can be supplied with two substations at 25 kV (nine feeders at 5.7 MW each) for a 51 MW peak load.

Given there are six substations in the present system there is an opportunity to select the optimal sites to convert to 25 kV. The optimal sites have the following characteristics:

- The substation must have sufficient space to contain at least two 46 kV circuit breakers, two power transformers, a control building, three 25 kV circuit breakers, up to six feeder breakers or reclosers, and room for future expansions.

- The substation should be located in close proximity to the existing distribution feeders to allow easy connection to them, and it should be in close proximity to the areas where most load growth is expected to occur.
- The age of the existing equipment and the presence of any infrastructure that could be reused. This could reduce the cost of the upgrades.

Hudson Substation is located at the Eastern side of town near the Labrador City Industrial Park. It is a smaller substation, and the yard is relatively congested. There is no additional room for expansion. Some growth is expected in this area, mainly in the industrial park. The substation connects four 4.16 kV distribution feeders (L15, L16, L17, and L18) and a 23 kV customer owned line (QNSL21). It was rebuilt in the mid 1990s however, the buswork is insulated for 4.16 kV. Hudson Substation was ruled out due to the lack of available expansion space in the yard, and the fact that the existing equipment will require replacement for a voltage conversion.

Harrie Lake Substation is located at the western edge of town just before the entry to the Harrie Lake Trailer Court. The lands surrounding the substation are vacant and acquiring the necessary lands to expand the substation should be possible. The expansion would require a significant amount of civil work due to the small size of the existing substation. This substation currently connects two feeders 4.16 kV distribution feeders (L19 and L20). A third feeder L14 from the Quartzite Substation passes nearby. It would be necessary to construct two additional feeders approximately 1.3 km long to connect to the remaining Labrador City Feeders connected to the Quartzite Substation. Due to the amount of work needed, the Harrie Lake Substation was ruled out since its location would require construction of a number of feeders to pickup the existing distribution feeders around Quartzite Substation.

Vanier Substation is located in the northern end of the town. Sufficient vacant land surrounds the substation, and the required amount of line construction to connect the feeders is minimal. is strategically located in relatively close proximity to where the new hospital and college are being proposed, and the substation is situated relatively close to several of the system feeders (L6, L15, and L18). In order to pick up these lines the substation will have to be expanded. The substation was constructed in the mid 1990s, and the low voltage buswork is insulated for 25 kV (to be confirmed in the field), the reclosers in the substation have a maximum rated voltage of 15 kV and are capable of operating at 12.5 kV. A conversion to 25 kV would require installation of new switchgear and power transformers as well as expanding this substation. The existing 15 kV switchgear could possibly be reused at another location.

The Quartzite Substation is located in an area just to the west of town. The substation yard was recently expanded and is surrounded by a large tract of undeveloped lands. If necessary, more lands can be acquired to expand the substation. Quartzite Substation is also situated close to areas of expected growth. The undeveloped land in this area is zoned for residential development, and subdivision developments have been proposed on this land. In the Harrie Lake Trailer Park, a mini-home subdivision development is underway, and IOCC has proposed to construct a 300-person bunkhouse there as well.

This part of Harrie Lake is fed from Quartzite feeder L14. The substation connects six distribution feeders (L6, L7, L8, L12, L13, and L14) and is located in a good area to serve new loads arising from residential developments. Most of the equipment in this substation was originally installed by IOCC. There are two metal clad 4.16 kV switchgear buildings. These are filled to capacity, and due to the lack of available breaker space, a considerable amount of work would be required to bring additional 4.16 kV feeders out of the substation. A conversion to 25 kV would require a complete rebuild of this substation and replacement of the 4.16 kV switchgear. However, given the existing 4.16 kV equipment is in excess of 30 years old, and it will soon be reaching the age of obsolescence. The operations personnel have had trouble racking the breakers into the switchgear bays. A rebuild of this substation was likely to have occurred in the near future. Based on the location, the existing feeder infrastructure already around the substation, and the fact that it would likely have required major work in the near future anyway, the Quartzite Substation was selected as one of the stations to retain in the 25 kV upgrading plan.

The Bartlett Substation is located centrally in the town; therefore, it is located suitably to supply a large portion of the central part of town. Bartlett Substation was rebuilt in the mid 1990s and at that time the yard was expanded as part of the original 1992 12.5 kV Upgrading Plan. Also installed at the time was metal clad switchgear rated for operation at 12.5 kV. This substation connects five distribution feeders (L1, L2, L3, L4, and L5) and there are already a number of tie points available, which allow picking up most of the town distribution feeders. A conversion to 25 kV would require a complete rebuild or the removal of this substation. Its location in a built up area of the town however does not allow much space for bringing feeders into new areas of development. Any additions to the system near the Bartlett Substation would have to be accommodated on the existing feeders.

The Townsite Switching Station is located on the southeastern edge of the town. This station is a switching center that provides sectionalizing of each the of the 46 kV subtransmission lines supplying the substations. There are sufficient lands surrounding this station to allow its expansion. The station does not connect any 4.16 kV distribution feeders, however much of the remaining lands around the Labrador City Industrial Park are situated around, or close to the Townsite Switching Center. Some load growth is expected to occur in the industrial park. There should be right-of-ways to allow for connection into the existing nearby feeders. This station is one of the older stations in the system and like the Quartzite Substation; it will soon be due for a major overhaul. A considerable amount of civil work and feeder construction would be required to upgrade the station to accommodate the power transformers and switchgear.

Based on the above information the Vanier and Quartzite Substations were selected as the optimal locations to retain for conversion to 25 kV. These locations will provide the greatest flexibility for system operation, and for future system expansion.

As was discussed previously in Section 3.1.7, 15/20/25 MVA 46/25 kV power transformers would be of suitable size for a two-substation system. This should leave sufficient capacity to supply the system with the largest transformer out of service. With the system load carried between two substations, voltage regulation on the high voltage (46kV) distribution system may be of concern during contingency. Therefore, the substation power transformers should be equipped with on load tap changers (OLTCs) on the high voltage winding. The on load tap changer should be designed to regulate from a minimum voltage of 39.1 kV (15 % boost) to a maximum voltage of 48.3 kV (5 % buck) in thirty-three tap positions.

4.2 SUBTRANSMISSION SYSTEM

At present the 46 kV Subtransmission System is radial. In the present configuration the loss of a line results in the loss of at least an entire substation.

For the loss of a single substation in Labrador City based on the 2007 forecasted system peak of 51089 kW and a two substation system, the maximum acceptable downtime based on the unsupplied energy criteria would be 1.4 days.

As a side note, for the current system, for the loss of supply from the Townsite Switching Center or feeder L32 then the maximum acceptable downtime based on the unsupplied energy criteria is 16 hours.

In such a case the duration of the outage depends on the nature of the problem and the time it will take operations crews to make the necessary repairs. For a major component failure, the acceptable downtimes based on the unsupplied energy criteria will be violated. Therefore other measures are necessary to ensure that power can be restored to customers within an acceptable timeframe.

A 46 kV tie line will be connected between the substations so that an alternate supply is available to each substation. If the main supply to a particular substation is unavailable, then the substation can be fed from the alternate line. This will prevent or minimize outages to customers and allow operations crews to prioritize repairs.

The layout of the current system provides opportunities for low cost construction of a looped subtransmission system. Specifically 46 kV feeders L33 and L9 form a quasi-loop that surrounds Labrador City. The Vanier Substation and the Quartzite Substation are located less than 500 m from this loop. Therefore the time to restore substation power at the Vanier and Quartzite substations can be improved by construction of new 46 kV taps off of L33, and L9. A tap from L33 to Vanier Substation would be approximately 450 m long. The same can be accomplished at Quartzite Substation with construction of a 300 m tap from L9. L9 would be opened between the new tap and the existing tap to the station and the original tap would be connected to L33. Breakers will be installed at the line terminations in each substation to provide sectionalizing and protection from faults. This would turn the section of L33 between Vanier and Quartzite Substations into a 46 kV tie line.

Due to high ground impedance and low line-to-ground fault levels, the subtransmission system will be operated as an open loop. This is to ensure that line to ground faults can be properly detected and cleared. The section of L33 which runs from Vanier Substation to Fermont will be energized from Vanier Substation via a normally-closed breaker. A normally-open breaker installed at the line termination in Quartzite Substation will provide means for an alternate supply from L33.

Since two 46 kV feeders are available (L32, and L33) from Wabush Terminal Station, it would no longer be necessary to retain the Townsite Switching Station.

Under normal conditions each substation will be fed by a separate line. When either L32 or L33 is unavailable the tie line will be used to supply both substations through the remaining line.

4.3 FINAL 25 KV DISTRIBUTION SYSTEM

Based on the above information, the new 25 kV distribution system will consist of two 46 kV subtransmission lines, two 46/25 kV substations, and nine 25 kV distribution feeders. A simplified single line diagram of the proposed distribution system is shown in Appendix D1.

Subtransmission lines L32, and L33 from Wabush Terminal Station will be the primary supply to the 25 kV distribution system. L32 will run to the Quartzite Substation, L33 will run to the Vanier Substation. A 46 kV subtransmission tie line will be connected between the two substations. The tie line will also be available for supply to Fermont in an emergency. For improved fault protection and reliability, a 46 kV breaker will be installed at the termination of each subtransmission line. A simplified single line diagram of the proposed subtransmission system is shown in Appendix D2.

The Vanier Substation and the Quartzite Substation will step the voltage down from 46 kV the 25 kV. Each substation is to consist of a 46 kV load transfer bus, two 15/20/25 MVA 46/25 kV power transformers with on load tap changers, and two 25 kV load transfer buses. Each 25 kV bus will have space for up to three 25 kV breakers. A total of nine 25 kV distribution feeders are required. It is expected that more load growth would occur near the Quartzite Substation then the Vanier Substation. Therefore, four 25 kV distribution feeders will be connected to the Quartzite Substation, and the remaining five will be connected to the Vanier Substation. As a provision for future expansion, two 25 kV breaker bays will be available at Quartzite Substation, and one additional 25 kV breaker bay for will be available at Vanier Substation. A simplified single line diagram of the proposed 25 kV Quartzite Substation is shown in Appendix D3. A simplified single line diagram of the proposed 25 kV Vanier Substation is shown in Appendix D4.

All 4.16 kV feeders (with the exception of the Smokey Mountain Line) will be upgraded to 25 kV nominal system voltage. It is recommended that existing 4.16 kV primary services, underground services, and pad-mounted transformers be supplied by overhead step-down transformers. This should be less costly than replacing these services with overhead services.

A general scope of work for this project is defined in Appendix E. The work involves upgrades at the Vanier Substation and the Quartzite Substation, the conversion of the 4.16 kV distribution feeders to 25 kV, and the upgrading of the 46 kV subtransmission system to an open looped system for improved reliability and operational flexibility.

4.4 LOAD FLOW ANALYSIS - 2027 LOAD FORECAST

Load Flow Analysis was ran to determine the ability of the proposed 25 kV system to accommodate future load growth. The study assumes that substation power transformer OLTCs are set to regulate the voltage at the 25 kV bus to 102.5 % within a 2.5 % bandwidth. Complete model proofing has yet to be completed since Load and Voltage Study data must first be collected. Load and Voltage data will be acquired in the winter of 2008. Model data is currently based on studies more than ten years old, along with (incomplete) pole line drawings, and semi-monthly breaker readings. Caution must be used when drawing conclusions from the load flow results. However the results should provide a reasonable picture of how the proposed system should behave.

Table 16: 25 kV Plan - Feeder Current - 2027 Forecasted Peak Load

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
QZ8	119	109	134	121	10.8%
QZ12	127	156	149	144	11.7%
QZ13	149	131	142	140	7.0%
QZ14	110	130	142	128	13.7%
VA15	125	143	129	132	8.2%
VA18	147	160	119	142	16.3%
VA21	130	153	132	138	10.4%
VA22	146	122	150	139	12.1%
VA23	129	139	142	137	5.6%
WA32	306	295	312	304	3.1%
WA33	379	401	389	390	2.9%
VA33	2	2	2	2	0.0%

Table 17: 25 kV Plan - Worst Case Feeder Voltage - 2027 Forecasted Peak Load

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
WBH-B15	101.2%	121.5
QZ-B3	100.1%	120.1
QZ12	101.6%	121.9
QZ13	101.0%	121.2
QZ14	101.1%	121.3
VA-B3	100.1%	120.1
VA15	100.2%	120.2
VA18	100.8%	121.0
VA21	101.2%	121.4
VA22	101.6%	121.9
VA23	100.1%	120.2

Table 18: 25 kV Plan - Transformer Load - 2027 Forecasted Peak Load

Unit	P (MW)	S (MVA)
QZ-T1	12.4	12.7
QZ-T2	18.1	18.5
VA-T1	12.0	12.2
VA-T2	11.8	12.1

With the distribution system upgraded to 25 kV, the system losses at 54718 kW are 695 kW. This represents a savings of approximately 1100 kW over the 4.16 kV distribution system. The saved losses on the distribution system will in turn result in loss savings on the transmission system. While cost of losses are low in interconnected Labrador, they power can generate revenues in the form of recall sales.

4.5 CONTINGENCY ANALYSIS

A contingency analysis was performed to verify the system meets all required criteria under contingency. The main contingencies considered for analysis are for the loss of a subtransmission line, loss of the largest power transformer, and the loss of a feeder recloser. While there are many different possible cases for each contingency, a single case was modeled that is representative of worst case conditions. All the analysis below were conducted with the system load scaled to the 2027 forecasted peak of 54718 kW and the bus voltage at Wabush Terminal Station set to 1.013 per unit. The transformer OLTCs are set to regulate the voltage to 1.025 per unit with a 2.5 per unit bandwidth.

4.5.1 LOSS OF A SUBTRANSMISSION LINE

Load flow analysis was conducted to verify the behavior of the system with a subtransmission line out of service. For the loss of the main subtransmission line to either substation, the substation that is out of service can be alternately fed from the remaining substation via the tie line. The worst case for loss of a subtransmission line would be loss of L33 from Wabush Terminal Station. For this case the Vanier Substation would be alternately supplied via the tie line from Quartzite Substation. For this case the Vanier Substation is approximately 11 km (electrically) from Wabush Terminal Station. Since Vanier Substation will have five feeders and Quartzite Substation will have four feeders, it is expected that more of the load will be towards the end of the line. The results of the load flows are shown in Table 19, Table 20, and Table 21 below.

Table 19: Contingency - 25 kV Plan - Feeder Current - L33 Out of Service

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
QZ8	122	112	137	124	10.8%
QZ12	130	160	153	148	11.8%
QZ13	153	134	145	144	6.9%
QZ14	113	134	146	131	13.8%
VA15	124	142	126	130	8.8%
VA18	151	164	122	146	16.2%
VA21	134	158	137	143	10.4%
VA22	150	126	155	144	12.0%
VA23	132	143	146	140	5.7%
WA32	705	717	721	714	1.3%
WA33	0	0	0	0	-
VA33	394	417	404	405	3.0%

Table 20: Contingency - 25 kV Plan - Feeder Voltage - L33 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
WBH-B15	101.2%	121.5
QZ-B3	98.2%	117.8
QZ8	101.3%	121.5
QZ12	101.6%	121.9
QZ13	101.0%	121.2
QZ14	101.1%	121.3
VA-B3	96.3%	115.5
VA15	100.2%	120.2
VA18	100.8%	121.0
VA21	101.2%	121.4
VA22	101.6%	121.9
VA23	100.1%	120.2

Table 21: Contingency - 25 kV Plan - Transformer Load - L33 Out of Service

Unit	P (MW)	S (MVA)
QZ-T1	12.0	12.2
QZ-T2	11.8	12.1
VA-T1	18.1	18.5
VA-T2	12.4	12.7

As the results in Table 19, Table 20, and Table 21 above show, there are no expected adverse impacts if a main subtransmission line were the go out of service.

During peak, the load will exceed the capacity of the 266.8 ACSR conductor section of L32 (formerly L9). Therefore, approximately 4.5 km of L32 will have to be reconductored to 477 ASC Cosmos.

4.5.2 LOSS OF A TRANSFORMER

This case models the system behavior with the largest transformer out of service. Load flows were run to determine the effect of feeder switching operations on line loading and voltage. Since all transformers for the proposed system are to be the same size, the contingency analysis was conducted with the most heavily loaded unit out of service. For the case of the loss of the largest transformer in the system the following procedure is to apply. The damaged transformer is isolated from the rest of the system. Transfer one feeder from the failed unit to another substation via a tie switch. Close the bus tie breaker to restore power to the remaining feeders. If cold load pickup is believed to be of concern, then sectionalized switching is to be applied. For this case VA-T1 has failed. Feeder VA23 has been transferred to feeder QZ8 via tie switch QZ6-D4, and bus tie breaker VA-B1B2 has been closed. The results of the load flows are shown in Table 22, Table 23 and Table 24 below.

Table 22: Contingency - 25 kV Plan - Feeder Current –VA-T1 Out of Service

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
QZ8	256	255	285	265	7.3%
QZ12	131	161	154	149	11.8%
QZ13	153	134	145	144	7.0%
QZ14	113	134	146	131	13.7%
VA15	122	140	124	129	8.7%
VA18	149	162	120	144	16.3%
VA21	132	156	134	141	10.9%
VA22	148	125	152	142	11.6%
VA23	0	0	0	0	-
WA32	386	374	396	385	2.9%
WA33	158	156	157	157	0.7%
VA33	2	2	2	2	0.1%

Table 23: Contingency - 25 kV Plan - Feeder Voltage – VA-T1 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
WBH-B15	101.2%	121.5
QZ-B3	99.7%	119.6
QZ8	100.5%	120.6
QZ12	101.2%	121.4
QZ13	101.1%	121.4
QZ14	101.3%	121.6
VA-B3	100.2%	120.3
VA15	101.6%	121.9
VA18	102.3%	122.7
VA21	101.4%	121.7
VA22	102.7%	123.2
VA23	100.3%	120.3

Table 24: Contingency - 25 kV Plan - Transformer Load – VA-T1 Out of Service

Unit	P (MW)	S (MVA)
QZ-T1	12.0	12.2
QZ-T2	18.0	18.4
VA-T1	0.0	0.0
VA-T2	12.4	12.7

4.5.3 LOSS OF A RECLOSER

A recloser failure will result in a feeder being transferred to another line. This effectively doubles the load on that line as well as increases its length. Load flows were run to determine the effect of feeder switching operations on line loading and voltage. As a typical case the load and voltages are shown for feeder VA21 transferred to feeder VA18. The results of the load flows are shown in Table 25, Table 26, and Table 27 below.

Table 25: Contingency - 25 kV Plan - Feeder Current – VA21-R1 Out of Service

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
QZ8	121	111	136	123	10.8%
QZ12	130	159	152	147	11.7%
QZ13	152	133	145	143	7.0%
QZ14	112	133	145	130	13.7%
VA15	123	142	125	130	8.9%
VA18	285	323	258	289	12.0%
VA21	0	0	0	0	-
VA22	149	125	153	142	12.1%
VA23	132	143	145	140	5.7%
WA32	306	295	312	304	3.1%
WA33	382	406	392	393	3.2%
VA33	2	2	2	2	0.1%

Table 26: Contingency - 25 kV Plan - Feeder Voltage - VA21-R1 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
WBH-B15	101.2%	121.5
QZ-B3	100.1%	120.1
QZ8	101.9%	122.2
QZ12	102.2%	122.7
QZ13	101.6%	121.9
QZ14	101.7%	122.1
VA-B3	100.0%	120.0
VA15	100.4%	120.5
VA18	101.2%	121.4
VA21	99.8%	119.7
VA22	102.1%	122.5
VA23	100.4%	120.5

Table 27: Contingency - 25 kV Plan - Transformer Load - VA21-R1 Out of Service

Unit	P (MW)	S (MVA)
QZ-T1	12.0	12.2
QZ-T2	11.8	12.1
VA-T1	24.3	25.1
VA-T2	6.2	6.3

5 2007 LABRADOR CITY 12.5 KV UPGRADING PLAN

The presence of infrastructure within the current system warrants the consideration of a 12.5 kV upgrading plan. The existing system infrastructure includes 15 kV switchgear located at Bartlett and Vanier Substations, a 46/12.5-4.16 kV power transformer is located at Quartzite Substation, and there are a number of dual-voltage (7200-2400 V primary) distribution transformers installed throughout the distribution system. The 2007 12.5 kV upgrading plan for Labrador City will upgrade the system utilizing some of the existing infrastructure such that load growth is addressed to well beyond the planning horizon.

Recognizing that a 12.5 kV feeder can safely carry much more power than a 4.16 kV feeder the number of substations in the system can be reduced.

Using the criteria noted in Section 3.1.2, the initial feeder current will be 140 A. Therefore the average 12.5 kV feeder capacity will be, 12.5 kV * 140 A * √3 ≈ 3000 kVA under normal operating conditions. Under abnormal operating conditions (recloser failure for instance) the expected feeder load will be approximately 6000 kVA or twice the normal feeder load.

The forecasted peak load for 2007 is 51089 kW, assuming a system power factor of 0.99 lagging over peak, the required number of feeders are:

$$N = \frac{51089\,\text{kW}}{0.99 \times 3000\,\text{kVA}} = 17$$

Therefore, at least seventeen feeders are required operating at 12.5 kV to supply the system.

5.1 SUBSTATIONS

Allowing for six feeders per substation, then in total three substations will be required for a 12.5 kV Labrador City Distribution System.

The switchgear installations at the Bartlett and Vanier Substations are rated at 15 kV. Therefore, they could easily be converted to operate at 12.5 kV.

In terms of strategic location, the Vanier Substation is located in relatively close proximity to where new hospital and college infrastructure are being planned. In addition to the feeders connected to the substation (L21, L22, and L23), it is situated relatively close to several of the system feeders (L6, L15, and L18). The substation will have to be expanded to pick up these feeders; however, only about 500 m of line construction is necessary to tie into these feeders. This substation would be converted to a 12.5 kV substation because of its existing infrastructure, space for expansion, and strategic location.

The Bartlett Substation connects six distribution feeders (L1, L2, L3, L4, L5, and L17. The substation is located in the center of town and there are already a considerable number of tie points available, which allow picking up most of the town distribution from the substation. The Bartlett Substation would also be converted to 12.5 kV since upgrading costs would be reduced because of the existing infrastructure located at this substation, and its central location.

Of the remaining stations, the Quartzite Substation is best suited for a conversion to 12.5 kV. The substation is located on the Western Side of town and connects six distribution feeders (L6, L7, L8, L12, L13, and L14). The location is situated in close proximity to expected areas of residential development. One of the power transformers at this substation is a dual voltage unit capable of operating at 12.5 kV. There is no other equipment in this substation capable of operating at 12.5 kV, however the existing 4.16 kV equipment is rather old and will soon be reaching the age of obsolescence. Therefore given that the substation is in a strategic location and will be due for an upgrade soon, it is proposed that this be the third substation for the 12.5 kV upgrade.

As was discussed previously in the Section 3.1.6, a 10/13.3/16.7 MVA power transformer would be of suitable size for a three-substation system. This should leave sufficient capacity to supply the system with the largest transformer out of service. With the load shared relatively evenly between three substations, voltage regulation on the high voltage (46kV) distribution system is not expected to be of concern. Therefore, standard fixed taps (±5 % in 2.5 % per step) will be suitable for these units. Since the plan proposes to upgrade the system to what not an NLH standard distribution voltage the transformers should have dual low voltage windings to allow operation at both 12.5 kV and 25 kV. This will provide the provision for a future conversion to 25 kV should there be higher than expected load growth.

The time to restore substation power at the Vanier and Quartzite substations can be improved by construction of new 46 kV taps off of L33, and L9. A tap from L33 to Vanier Substation would be approximately 450 m long creating a 46 kV loop to that substation. The same can be accomplished at Quartzite with construction of a 300 m tap from L9 to the substation. L9 would be opened between the new tap and the existing tap to the substation and the old tap would be supplied from L33. The difficult part comes with getting a second 46 kV tap between Bartlett Substation and one of the other substations as this region of the system is already built up.

Retaining three stations in this system will require retention of the Townsite Switching Substation since only two lines come from Wabush Terminal Station and three circuits are required. The present load-transfer-bus configuration with a single primary feeder and an emergency feeder that must be tied in manually is unsuitable by today's standards from both a voltage regulation, security of supply, and operability point of view. In order to address these issues to a reasonable degree, the Townsite Switching

Station will be reconstructed as a ring bus. A ring bus will provide the required level of reliability for a looped system of this size and improve voltage regulation between Wabush Terminal Station and Townsite Switching Station. The ring bus arrangement may however prove to be costly due to the breaker requirement. A less costly alternative to rebuilding the Townsite Switching Station is to construct a third 46 kV feeder (assuming sufficient space is available) from Wabush Terminal Station to Townsite Switching Station. The line would be approximately 1.75 km long and constructed of 477 ASC Cosmos conductor. If this option is a viable one, the switching station could then be removed, and the three substations would be supplied by three 46 kV subtransmission lines from Wabush Terminal Station.

5.2 SUBTRANSMISSION SYSTEM

At present the 46 kV Subtransmission System is radial. In the present configuration the loss of a line results in the loss of at least an entire substation.

For the loss of a single substation in Labrador City based on the 2007 forecasted system peak of 51089 kW and a three substation system, then for the loss of a single substation the maximum acceptable downtime based on the unsupplied energy criteria would be two days.

As a side note, for the current system, for the loss of supply from the Townsite Switching Center or feeder L32 then the maximum acceptable downtime based on the unsupplied energy criteria is 16 hours.

In such a case the duration of the outage depends on the nature of the problem and the time it will take operations crews to make the necessary repairs. For a major component failure, the acceptable downtimes based on the unsupplied energy criteria will likely be violated. Therefore other measures are necessary to ensure that power can be restored to customers within an acceptable timeframe.

A 46 kV tie line will be connected between the substations to bring an alternate supply to each substation. If the main supply to a particular substation is unavailable, then the substation can be fed through the alternate line. This will prevent or minimize outages to customers and allow operations crews to prioritize repairs.

The layout of the current system provides opportunities for construction of a looped subtransmission system. Specifically 46 kV feeders L33 and L9 form a quasi-loop around the system. The Vanier and Quartzite substations are located less than 500 m from this loop. Therefore the time to restore substation power at the Vanier and Quartzite substations can be improved by construction of new 46 kV taps off of L33, and L9. A tap from L33 to Vanier Substation would be approximately 450 m long and create a 46 kV tie line to that substation. The same can be accomplished at Quartzite with construction of a 300 m tap from L9 to the substation. L9 would be opened between the new tap and the existing tap to the substation and the old tap would be supplied from

L33. The final tie line will be constructed between Bartlett and Vanier Substations. The exact routing of the line is yet to be determined; however the distance is estimated to be 1.25 km. Breakers will be installed at the line terminations in each substation to provide sectionalizing and protection from faults. Due to high ground impedance and low line-to-ground fault levels, the subtransmission system will be operated as an open loop. The Vanier-Quartzite tie line will be energized from Vanier Substation via a normally-closed breaker. A normally-open breaker installed at Quartzite Substation will provide means for an alternate supply from L33. The Bartlett-Vanier tie line will be energized from Bartlett Substation and connected to Vanier Substation via a normally-open breaker.

Three 46 kV feeders are required to supply the three 46/12.5 kV substations. Since two 46 kV feeders are available (L32, and L33) from WBH, it will be necessary to retain the Townsite Switching Station. 46 kV feeders L32 and L33 will operate in parallel to supply the Townsite Switching Station. The Townsite Switching Station will serve as the primary point of supply for the Bartlett, Vanier, and Quartzite Substations. Note it may be possible to eliminate the need for a switching station if a third circuit can be constructed from Wabush Terminal Station to the Townsite Switching Station. The viability of this option will require field verification to determine that sufficient right-of-way is available for a third line.

Under normal conditions each substation will be fed by a separate line. When either of the main lines is unavailable, the tie line will be used to supply two substations through the remaining line.

5.3 FINAL 12.5 KV DISTRIBUTION SYSTEM

Based on the above information, the new 12.5 kV distribution system will consist of five 46 kV subtransmission lines, a 46 kV ring bus, three 46/12.5 kV substations, and seventeen 12.5 kV distribution feeders. All construction and equipment for the 12.5 kV plan is to be compatible with 25 kV standards. A simplified single line diagram of the proposed distribution system is shown in Appendix F1.

Subtransmission lines WA32, and WA33 from Wabush Terminal Station will be the primary supply to the 46 kV ring bus at the Townsite Switching Station. A single line diagram of the proposed new Townsite Switching Station is shown in Appendix F2. The ring bus will supply three 46 kV subtransmission lines TS9, TS10, and TS33. TS9 supplies the Quartzite Substation, TS10 supplies the Bartlett Substation, and TS33 supplies the Vanier Substation. A 46 kV subtransmission tie line will be connected between the Vanier Substation and the Quartzite Substation. This tie line will also be available for emergency supply to Fermont. A second 46 kV tie line will be connected between the Bartlett Substation and the Vanier Substation. For improved fault protection and reliability, a 46 kV breaker will be installed at the termination of each subtransmission line. A simplified single line diagram of the proposed subtransmission system is shown in Appendix F3.

If a 3rd circuit can be constructed from Wabush Terminal Station and the Townsite Switching Station, then the ring bus will not be necessary. Then, the Townsite Switching Station can be removed. This would be a considerable cost savings for the 12.5 kV upgrading plan. It will be necessary to verify that enough space is in the existing corridor for an additional circuit.

The Bartlett Substation, the Vanier Substation, and the Quartzite Substation will step the subtransmission voltage down from 46 kV the 12.5 kV. Each substation is to consist of a 46 kV load transfer bus, two 10/13/16 MVA 46/25-12.5 kV power transformers with on load tap changers, and two 12.5 kV load transfer buses. Each 12.5 kV bus will have space for up to three 12.5 kV breakers.

A total of seventeen 12.5 kV distribution feeders are required. Therefore, six distribution feeders will be connected to each of the Bartlett Substation, and the Quartzite Substation, and the remaining five distribution feeders will be connected to the Vanier Substation. Simplified single line diagrams of the proposed 12.5 kV Bartlett Substation, the proposed 12.5 kV Quartzite Substation, and the proposed 12.5 kV Vanier Substation is shown in Appendices F4, F5, and F6 respectively.

All 4.16 kV feeders (with the exception of the Smokey Mountain Line) will be upgraded to 12.5 kV nominal system voltage. It is recommended that existing 4.16 kV primary services, underground services, and pad-mounted transformers be supplied by overhead step-down transformers. This should be less costly than replacing these services with overhead services.

A general scope of work for this project is defined in Appendix G. The work involves upgrades at the Bartlett Substation, the Vanier Substation, and the Quartzite Substation, the conversion of the 4.16 kV distribution feeders to 12.5 kV, and the upgrading of the 46 kV subtransmission system to an open looped system for improved reliability and operational flexibility.

5.4 LOAD FLOW ANALYSIS - 2027 LOAD FORECAST

Load Flow Analysis was ran to determine the ability of the proposed 12.5 kV system to accommodate future load growth. The study assumes that substation power transformers are set nominal taps. Complete model proofing has yet to be completed since Load and Voltage Study data must first be collected. Load and Voltage data will be acquired in the winter of 2008. Model data is currently based on studies more than ten years old, along with (incomplete) pole line drawings, and semi-monthly breaker readings. Caution must be used when drawing conclusions from the load flow results. However the results in Table 28, Table 29, and Table 30 should provide a reasonable picture of the expected behavior of the proposed system.

Table 28: 12.5 kV Plan - Feeder Current - 2027 Forecasted Peak Load

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
WA32	343	349	352	348	1.4%
WA33	341	347	350	346	1.4%
TS9	248	242	259	250	3.6%
TS10	231	251	241	241	4.1%
TS33	206	203	204	204	0.9%
BA1	108	165	183	152	28.9%
BA2	170	144	129	148	15.1%
BA3	118	134	138	130	9.4%
BA4	189	196	117	167	29.9%
BA5	155	129	162	149	13.5%
BA17	127	174	130	144	21.2%
QZ6	136	157	173	155	12.4%
QZ7	131	164	147	147	11.2%
QZ8	156	136	153	148	8.2%
QZ12	98	161	172	144	31.9%
QZ13	175	160	142	159	10.9%
QZ14	162	150	192	168	14.4%
VA15	163	148	151	154	5.9%
VA18	138	170	154	154	10.5%
VA21	148	165	145	153	7.9%
VA22	180	144	170	165	12.6%
VA23	128	113	145	129	12.6%

As shown in Table 28 there are no expected overloads on any system feeders. The analysis does indicate load unbalance on some distribution feeders. Therefore, it may be necessary to initiate load rebalancing as part of the feeder reconfigurations.

Table 29: 12.5 kV Plan - Feeder Voltage - 2027 Forecasted Peak Load

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	98.5%	118.2
BA2	98.8%	118.5
BA3	98.9%	118.7
BA4	97.3%	116.7
BA5	98.1%	117.7
BA17	98.1%	117.7
QZ6	97.7%	117.2
QZ7	97.4%	116.9
QZ8	97.7%	117.3
QZ12	97.8%	117.4
QZ13	97.7%	117.3
QZ14	96.6%	115.9
VA15	98.3%	118.0
VA18	98.8%	118.6
VA21	97.3%	116.7
VA22	99.1%	118.9
VA23	98.5%	118.2

Table 29 show voltages are within tolerance, although at the lower end of the acceptable range. By 2027 voltages at the end of feeder QZ14 could be just below 96.7 %. This will probably be improved by a program of load rebalancing. However, given that most voltages are in the lower range, it is recommended that the substation power transformers be operated in 2.5 % boost; this will ensure voltages remain within standard to well beyond the planning horizon.

Table 30: 12.5 kV Plan - Transformer Load - 2027 Forecasted Peak Load

Unit	P (MW)	S (MVA)
BA-T1	9.2	9.4
BA-T2	9.7	9.9
QZ-T1	9.9	10.2
QZ-T2	9.5	9.7
VA-T1	6.8	6.9
VA-T2	9.3	9.5

Table 30 shows the substation power transformers will be loaded to base ratings. No problems are expected.

With the distribution system upgraded to 12.5 kV, the system losses at 54718 kW are 733 kW. This represents a savings of approximately 1100 kW over the 4.16 kV distribution system. The saved losses on the distribution system will in turn result in loss savings on the transmission system. While cost of losses are low in interconnected Labrador, they power can generate revenues in the form of recall sales.

5.5 CONTINGENCY ANALYSIS

A contingency analysis was performed to verify the system meets all required criteria under contingency. The main contingencies considered for analysis are for the loss of a subtransmission line, loss of the largest power transformer, and the loss of a feeder breaker. While there are many different possible cases for each contingency, a single case was modeled that is representative of worst case conditions. All the analysis below were conducted with the system load scaled to the 2027 forecasted peak of 54718 kW and the bus voltage at Wabush Terminal Station set to 1.013 per unit. The substation power transformer fixed taps were set to boost the voltage by 2.5 %.

5.5.1 LOSS OF A SUBTRANSMISSION LINE

Load flow analysis was conducted to verify the behavior of the system with a subtransmission line out of service. For the loss of the main subtransmission line to either substation, the substation that is out of service can be alternately fed from the remaining substation via the tie line. The worst case for loss of a subtransmission line would be loss of TS9 from Townsite Switching Station. For this case the Quartzite Substation would be alternately supplied via the tie line from Vanier Substation VA33. For this case the Quartzite Substation is approximately 10 km (electrically) from Wabush Terminal Station. Since Vanier Substation will have five feeders and Quartzite Substation will have six feeders, it is expected that more of the load will be towards the end of the line. The results of the load flows are shown in Table 31, Table 32, and Table 33 below.

Table 31: Contingency - 12.5 kV Plan - Feeder Current – L9 Out of Service

Name	I(a)	I(b)	I(c)	|Iavg|	%IU
WA32	345	350	354	350	1.4%
WA33	343	348	352	348	1.4%
TS9	0	0	0	0	-
TS10	231	250	241	241	4.0%
TS33	457	448	465	457	1.9%
BA10	0	0	0	0	0.1%
VA33	250	244	261	252	3.6%
BA1	105	161	178	148	28.9%
BA2	166	140	126	144	15.1%
BA3	115	131	135	127	9.4%
BA4	184	191	114	163	29.9%
BA5	151	125	158	145	13.5%
BA17	124	170	126	140	21.2%
QZ6	134	154	170	153	12.4%
QZ7	129	161	145	145	11.2%
QZ8	153	134	150	146	8.3%
QZ12	96	159	169	141	31.9%
QZ13	173	157	139	156	10.8%
QZ14	159	148	189	165	14.4%
VA15	160	145	147	151	5.9%
VA18	135	166	151	151	10.5%
VA21	145	161	142	149	7.8%
VA22	176	141	166	161	12.6%
VA23	125	111	142	126	12.6%

As shown in Table 31, there are no expected overloads on any system feeders or subtransmission lines with a subtransmission line out of service.

Table 32: Contingency - 12.5 kV Plan - Feeder Voltage - L9 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	101.1%	121.4
BA2	101.4%	121.7
BA3	101.5%	121.8
BA4	100.0%	120.0
BA5	100.8%	120.9
BA17	100.8%	120.9
QZ6	99.2%	119.0
QZ7	99.0%	118.9
QZ8	99.2%	119.1
QZ12	99.3%	119.2
QZ13	99.2%	119.1
QZ14	98.1%	117.7
VA15	100.5%	120.6
VA18	101.0%	121.2
VA21	96.8%	116.2
VA22	101.3%	121.5
VA23	100.7%	120.8

Table 32 shows that with a subtransmission line out of service, and the transformers in 2.5 % boost; voltages should remain within tolerance for the foreseeable future.

Table 33: Contingency - 12.5 kV Plan - Transformer Load - L9 Out of Service

Unit	P (MW)	S (MVA)
BA-T1	9.2	9.3
BA-T2	9.7	9.9
QZ-T1	9.9	10.1
QZ-T2	9.5	9.7
VA-T1	6.8	6.9
VA-T2	9.3	9.5

Table 33 shows the substation power transformers will be loaded to base ratings. No problems are expected.

As the results in Table 31, Table 32, and Table 33 above show, there are no expected adverse impacts if a main subtransmission line were to go out of service.

5.5.2 LOSS OF A TRANSFORMER

This case models the system behavior with the largest transformer out of service. Load flows were run to determine the effect of feeder switching operations on line loading and voltage. Since all transformers for the proposed system are to be the same size, the contingency analysis was conducted with the most heavily loaded unit out of service. For the case of the loss of the largest transformer in the system the following procedure is to apply. The damaged transformer is isolated from the rest of the system. Transfer one feeder from the failed unit to another substation via a tie switch. Close the bus tie breaker to restore power to the remaining feeders. If cold load pickup is believed to be of concern, then sectionalized switching is to be applied. For this case QZ-T1 has failed. Feeder QZ6 has been transferred to feeder VA15 via tie switch QZ6HU18-1, and bus tie breaker QZ-B1B2 has been closed. The results of the load flows are shown in Table 34, Table 35 and Table 36 below.

Table 34: Contingency - 12.5 kV Plan - Feeder Current – QZ-T1 Out of Service

Name	I(a)	I(b)	I(c)	|Iavg|	%IU
WA32	344	350	354	349	1.5%
WA33	342	348	352	347	1.5%
TS9	208	205	216	210	3.1%
TS10	231	250	241	241	4.0%
TS33	248	243	249	247	1.5%
BA10	0	0	0	0	0.1%
VA33	2	2	2	2	0.1%
BA1	105	161	178	148	28.9%
BA2	166	140	126	144	15.1%
BA3	115	131	135	127	9.4%
BA4	184	191	114	163	29.8%
BA5	151	125	158	145	13.5%
BA17	124	170	126	140	21.2%
QZ6	0	0	0	0	-
QZ7	129	161	145	145	11.3%
QZ8	153	134	151	146	8.2%
QZ12	96	159	169	142	31.9%
QZ13	173	157	139	156	10.9%
QZ14	159	148	189	165	14.4%
VA15	293	299	317	303	4.6%
VA18	135	167	151	151	10.5%
VA21	145	161	141	149	7.9%
VA22	175	140	166	160	12.6%
VA23	126	111	143	127	12.7%

As shown in Table 34, there are no expected overloads on any system feeders or subtransmission lines with a power transformer out of service.

Table 35: Contingency - 12.5 kV Plan - Feeder Voltage - QZ-T1 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	101.1%	121.4
BA2	101.4%	121.7
BA3	101.5%	121.8
BA4	100.0%	119.9
BA5	100.8%	120.9
BA17	100.8%	120.9
QZ6	100.1%	120.1
QZ7	98.9%	118.7
QZ8	99.1%	118.9
QZ12	99.3%	119.2
QZ13	99.2%	119.1
QZ14	98.1%	117.7
VA15	100.1%	120.1
VA18	100.7%	120.8
VA21	97.2%	116.6
VA22	101.6%	121.9
VA23	100.3%	120.4

Table 35 shows that with a power transformer out of service; voltages should remain within tolerance for the foreseeable future.

Table 36: Contingency - 12.5 kV Plan - Transformer Load - QZ-T1 Out of Service

Unit	P (MW)	S (MVA)
BA-T1	9.2	9.3
BA-T2	9.7	9.9
QZ-T1	0.0	0.0
QZ-T2	16.2	16.7
VA-T1	6.8	6.9
VA-T2	12.6	12.9

Table 36 shows that with transformer QZ-T1 out of service, transformer QZ-T2 will be loaded to 100 % of its nameplate rating over peak. The remaining units will be loaded to approximately base ratings. No problems are expected. There is sufficient capacity to carry the system through peak periods.

As the results in Table 34, Table 35, and Table 36 above show, there are no expected adverse impacts if a main power transformer were to go out of service.

5.5.3 LOSS OF A FEEDER BREAKER

A feeder breaker failure will result in a feeder being transferred to another line. This effectively doubles the load on that line as well as increases its length. Load flows were run to determine the effect of feeder switching operations on line loading and voltage. As a typical case, the load and voltages for a failure of feeder breaker QZ7-CB1 have been computed. For this case, feeder QZ7 is transferred to feeder VA22 by closing the disconnect QZ7-D2. The results of the load flows are shown in Table 37, Table 38, and Table 39 below.

Table 37: Contingency - 12.5 kV Plan - Feeder Current - QZ7-CB1 Out of Service

Name	|Ia|	|Ib|	|Ic|	|Iavg|	%IU
WA32	343	349	352	348	1.4%
WA33	341	347	350	346	1.4%
TS9	210	201	215	209	3.6%
TS10	231	250	241	241	4.0%
TS33	244	244	246	245	0.7%
BA10	0	0	0	0	0.1%
VA33	2	2	2	2	0.1%
BA1	105	161	178	148	28.9%
BA2	166	140	126	144	15.1%
BA3	115	131	135	127	9.4%
BA4	184	191	114	163	29.9%
BA5	151	125	158	145	13.5%
BA17	124	170	126	140	21.2%
QZ6	132	152	167	150	12.3%
QZ7	0	0	0	0	-
QZ8	151	131	148	143	8.3%
QZ12	95	157	167	140	31.9%
QZ13	171	155	138	155	10.9%
QZ14	157	146	187	163	14.3%
VA15	157	141	158	152	7.2%
VA18	134	166	150	150	10.5%
VA21	145	162	142	150	8.0%
VA22	304	303	310	306	1.4%
VA23	128	114	131	124	7.8%

As shown in Table 37, there are no expected overloads on any system feeders or subtransmission lines with a feeder breaker out of service.

Table 38: Contingency - 12.5 kV Plan - Feeder Voltage - QZ7-CB1 Out of Service

Feeder	V_{MIN}	$V_{MIN\ (120\ Vbase)}$
BA1	101.2%	121.4
BA17	100.8%	120.9
BA2	101.4%	121.7
BA3	101.5%	121.9
BA4	100.0%	120.0
BA5	100.8%	120.9
QZ12	100.6%	120.8
QZ13	100.5%	120.6
QZ14	99.4%	119.3
QZ6	101.0%	121.2
QZ7	98.7%	118.4
QZ8	101.1%	121.3
VA15	100.9%	121.1
VA18	101.4%	121.7
VA21	96.4%	115.7
VA22	100.8%	121.0
VA23	101.1%	121.3

Table 35 shows that with a feeder breaker out of service, and two feeders tied together; voltages should remain within tolerance for the foreseeable future.

Table 39: Contingency - 12.5 kV Plan - Transformer Load - QZ7-CB1 Out of Service

Unit	P (MW)	S (MVA)
BA-T1	9.2	9.3
BA-T2	9.7	9.9
QZ-T1	9.9	10.1
QZ-T2	6.4	6.5
VA-T1	9.9	10.1
VA-T2	9.3	9.5

Table 39 shows the substation power transformers will be loaded to base ratings. No problems are expected.

As the results in Table 37, Table 38, and Table 39 above show, there are no expected adverse impacts if a feeder breaker were to go out of service.

6 CONCLUSIONS AND RECOMMENDATIONS

The Labrador City Distribution System has generally performed well since it was taken over from IOCC in 1992. Initially, a voltage conversion to 12.5 kV for part of the system was being planned. However, lack load growth resulted in deferral of this plan. The 4.16 kV distribution systems were then redesigned to support a peak load of up to 52 MW.

Recent developments in Labrador West and a strengthening in world markets for iron ore have changed this outlook. Now there is potential for a considerable amount of growth on this system.

Generally, in the past, the reliability of this system has been good. However, in the past three years there has been a considerable decline in the system reliability. The reliability indices have steadily increased in the past three years. The exact cause of many of these outages is not entirely clear, however a large number of outages are attributed to loss of supply, and the causes behind the remaining outages is now under investigation. It is apparent from the events experienced in 2007 that the problems be identified and necessary work done to improve the system reliability.

As was previously identified in the past, load flow analysis indicates the present day system is not capable supporting additional load growth in the long term.

It is now necessary to initiate an upgrading plan for this distribution system, so that load growth can be addressed for the foreseeable future.

The past upgrading plan was reviewed, but it was determined that it would not sufficiently meet present day needs.

Out of the system review, two alternative plans were developed: A 25 kV Upgrading Plan, and a modified 12.5 kV Upgrading Plan. The 25 kV option only requires nine feeders in two substations to serve the system. For the 12.5 kV option the system will require seventeen feeders, three substations, and a switching station. In both cases, the upgrades will address the problems encountered on the existing system, as well as bring a higher level of reliability and operational flexibility to the system.

In Labrador, extreme weather and temperatures are common, and when coupled with the difficulty to mobilize any portable or spare equipment such as power transformers, this has the potential for high risk to customers and equipment when major component failures occur. This means the distribution system in Labrador City will require a more robust design than typical distribution systems found on the island. Therefore, the substations will be dual unit substations, and the system will have firm capacity installed. To ensure quick restoration of service in the event of a line failure, at least two subtransmission lines will be available to each substation, and full switching capabilities will be available on the distribution feeders. The two options developed in this study meet these requirements.

Comparisons of system losses for the two options show the difference to be negligible. Over the present system approximately 1100 kW of loses can be saved. While the loss savings are negligible because the cost of energy from Churchill Falls is very low, this will also result loss savings on the transmission system. The savings in losses could generate additional revenues in the form of recall sales.

Ultimately, the selected option will come down to a matter of economics. However, should there be little difference between the costs of these two plans, and then the option offering the most benefits to Hydro and its customers should be selected. The following section provides a comparison of the two options.

6.1 COMPARISON OF ALTERNATIVES 25 KV VERSUS 12.5 KV

Functionally the two plans will meet the requirements of the system, and either option will carry the system to well beyond the forecast period. Each has its own respective merits.

The 25 kV plan will be a simpler system, and therefore it will be easier to operate. However, since the system design will have only nine feeders and two substations, it will have less switching capabilities than the 12.5 kV option, and therefore, is operationally less flexible.

This system should perform at a higher level of reliability because it would contain less equipment; therefore a lower failure rate can be expected. Additionally, since the system is simpler, there will be less potential for human error. Again, this will result in fewer outages. In general, outages should be less frequent than they are now. However, there will be more customers per feeder and substation. So even though outages will be less frequent, when they do occur more customers will be affected.

25 kV distribution feeders will provide the best line voltage regulation over the lower distribution voltages. Superior line voltage regulation also means better motor starting performance.

Voltage regulation in the form of OLTCs will be installed on the substation power transformers. This will make the distribution system independent of regulation at Wabush Terminal Station, and it will mitigate the effects of voltage regulation on the subtransmission system. Having voltage regulation available in the substations also means that if the Hydro Quebec System can deliver it, then it would be possible to get more than 5 MW over L33 from Fermont.

The firm capacity for the 25 kV plan is 75 MVA installed. This allows for a 36 % margin over the 2027 load forecast.

The system will consist of two substations. Since there are fewer components in this system, the annual maintenance costs should be lower.

The 12.5 kV distribution system would be more complex than a 25 kV distribution system. In comparison to the present system, the 12.5 kV design will be much simpler, and given the experience operations crew, the complexity of a three-substation system should not be of concern. Since the system has more feeders and substations, it will have more options for switching load.

Similar to the 25 kV plan, the 12.5 kV plan should provide a higher level of reliability. Fewer customers should be affected by an outage because there will be less customers on a feeder, and restoring customers will be easier since there are more switching options. The system will have more equipment, and therefore failure rates could be higher. The additional complexity of this option means the potential for human error is greater. In general, outages may be more frequent on the 12.5 kV system then the 25 kV system. However, there will be fewer customers affected, and they are more likely to be restored quickly. So even though outages may be more frequent, when they do occur fewer customers are affected.

Line voltage regulation will not be as good on the 12.5 kV system as on 25 kV system. No voltage regulation will be available in the substations, so this option depends on voltage regulation at Wabush Terminal Station.

The firm capacity for the 12.5 kV plan is 83 MVA installed. This allows for a 51 % margin over the 2027 load forecast.

The 25 kV plan may be superior to the 12.5 kV plan in that it offers better voltage regulation, greater line capacity, and better motor starting capabilities. It may also provide a system where fewer outages occur, but because the system does not possess the switching flexibility of the 12.5 kV plan, it may take longer to restore customers following an outage.

6.2 ECONOMIC ANALYSIS

The project has been broken down into the following major components: Terminal Station and Line Construction. Distribution feeder upgrades and conversions.

The distribution feeder upgrades and conversions is a common item to both alternatives, and as such, the costs associated with this work should be the same. As was already stated in Section 5 there are some dual-voltage 7200-2400 V distribution transformers installed on the distribution system. However, after conducting a survey of the distribution transformers it was found that dual-voltage units account only for approximately 12 % of the total. Details of the Transformer Survey can be found in

Appendix H. Therefore, the associated cost difference between the two alternatives will be negligible.

The major difference in cost for the two alternatives is for the station and line construction.

As was discussed in Section 4 above the 25 kV alternative will consist of two 46/25 kV substations. Each station is to consist of two 15/20/25 MVA 46/25 kV power transformers and associated switchgear.

The estimate for the terminal station construction portion of the 25 kV alternative is shown in Table 40 below. The cost estimate for 25 kV alternative is $ 10.0 million.

Table 40: Project Estimate - Station Work for 25 kV Alternative

Project Cost: ($ x1,000)	2009	2010	2011	TOTAL
Material Supply	50.0	1,919.0	3,409.0	5,378.0
Labour	83.0	231.2	200.5	514.7
Consultant	0.0	0.0	0.0	0.0
Contract Work	83.0	890.0	800.0	1,773.0
Other Direct Costs	15.0	67.5	89.2	171.7
O/H, AFUDC & Escln.	29.1	476.3	864.0	1,369.4
Contingency	23.1	310.8	449.9	783.8
TOTAL	283.2	3,894.8	5,812.6	9,990.6

The bulk of the above costs are associated with power transformer purchases. Recent experience has shown that these costs vary considerably when tenders are issued, and is highly dependant on the timeline for delivery and the manufacturer backlog at the time the quote is issued. The above estimate could change once the tender is awarded.

The estimate for the line work portion of this alternative (exclusive of the distribution upgrades and conversions) is shown in Table 41 below. This work is estimated to cost $ 207.4 thousand.

Table 41: Project Estimate - Line Work for 25 kV Alternative

Description	Quantity	Unit Cost	Total ($ x1,000)
25 kV distribution line construction	0.500 km	$ 100,000/km	$50.0
46 kV subtransmission line construction	0.750 km	$ 119,850/km	$89.9
46 kV subtransmission line reconductoring	4.500 km	$ 15,000/km	$67.5
		TOTAL ($ x1,000)	$207.4

The total cost of station and line work for the 25 kV alternative is $ 10.2 million. This estimate does not include the cost of feeder conversions as stated earlier; it also does not include environmental cleanup costs associated with removal of the existing substations.

As was discussed in Section 5 above the 12.5 kV alternative will consist of three 46/12.5 kV substations and a 46 kV switching station. Each substation is to consist of two 10/13.3/16.7 MVA 46/25 kV power transformers and associated switchgear. The switching station will consist of five 46 kV breakers arranged in a ring bus configuration.

The estimate for the terminal station construction portion of the 12.5 kV alternative is shown in Table 42 below. The cost estimate for 12.5 kV alternative is $ 13.8 million.

Table 42: Project Estimate - Station Work for 12.5 kV Alternative

Project Cost: ($ x1,000)	2009	2010	2011	TOTAL
Material Supply	450.0	2,319.0	4,975.0	7,744.0
Labour	113.0	287.2	203.5	603.7
Consultant	0.0	0.0	0.0	0.0
Contract Work	383.0	1,100.0	800.0	2,283.0
Other Direct Costs	15.0	74.5	89.2	178.7
O/H, AFUDC & Escln.	124.2	593.9	1,163.2	1,881.3
Contingency	96.1	378.1	606.8	1,081.0
TOTAL	1,181.3	4,752.7	7,837.7	13,771.7

Again, the bulk of the above costs are associated with power transformer purchases. Recent experience has shown that these costs vary considerably when tenders are issued, and is highly dependant on the timeline for delivery and the manufacturer backlog at the time the quote is issued. The above estimate could change once the tender is awarded.

The estimate for the line work portion of this alternative (exclusive of the distribution upgrades and conversions) is shown in Table 43 below. This work is estimated to cost $ 459.7 thousand.

Table 43: Project Estimate - Line Work for 12.5 kV Alternative

Description	Quantity	Unit Cost	Total ($ x1,000)
25 kV distribution line construction	2.200 km	$ 100,000/km	$220.0
46 kV subtransmission line construction	2.000 km	$ 119,850/km	$239.7
		TOTAL ($ x1,000)	$459.7

The total cost of station and line work for the 12.5 kV alternative is $ 14.2 million. This estimate does not include the cost of feeder conversions as stated earlier; it also does not include environmental cleanup costs associated with removal of the existing substations.

As stated above, distribution upgrading and conversions is common to both alternatives and are expected to have the same cost. Detailed cost estimates for this component of the project is not included in report. This work requires a formal system survey and assessment to perform an accurate estimate. Due to time and budgetary constraints, the survey cannot be completed until 2009. A capital budget proposal will be submitted in 2008 to complete the distribution survey and assessment in 2009. The study is to be completed in time for the 2009 capital budget process so that detailed estimates for the distribution-upgrading portion of the project can be submitted for the 2010 budget year.

The cost estimates for the two alternatives considered in this study are summarized below:

Alternative 1: Upgrade Distribution System to 25 kV - $10,200,000
Alternative 2: Upgrade Distribution System to 12.5 kV - $14,200,000

From a technical point of view, either alternative will suffice; however, the capital cost of upgrading the distribution system to 25 kV is $4,000,000 lower than upgrading the distribution system to 12.5 kV. Therefore, Alternative #1 – *Upgrade Distribution to 25 kV- $10,200,000* is the most cost-effective alternative.

6.2.1 Net Present Value

The Net Present Value of the alternatives to the year 2040 for a terminal station in-service date of 2011 in 2008 dollars is shown in Table 44 below:

Table 44: Net Present Value of Alternatives (2008 Dollars)

Alternative	Net Present Value (NPV)	NPV Difference from Least Cost Alternative
Alternative #1 Upgrade Distribution to 25 kV	$9,312,403	$0
Alternative #2 Upgrade Distribution to 12.5 kV	$12,838,289	$3,525,886

A comparison of the Net Present Value of each alternative shows that the chosen alternative, Alternative #1 is $3,774,712 less costly than Alternative #2. Figure 3 below shows a plot of the Alternative #1 versus Alternative #2. Again, this plot shows that there is no crossover point, and that Alternative #1 is the most cost effective solution.

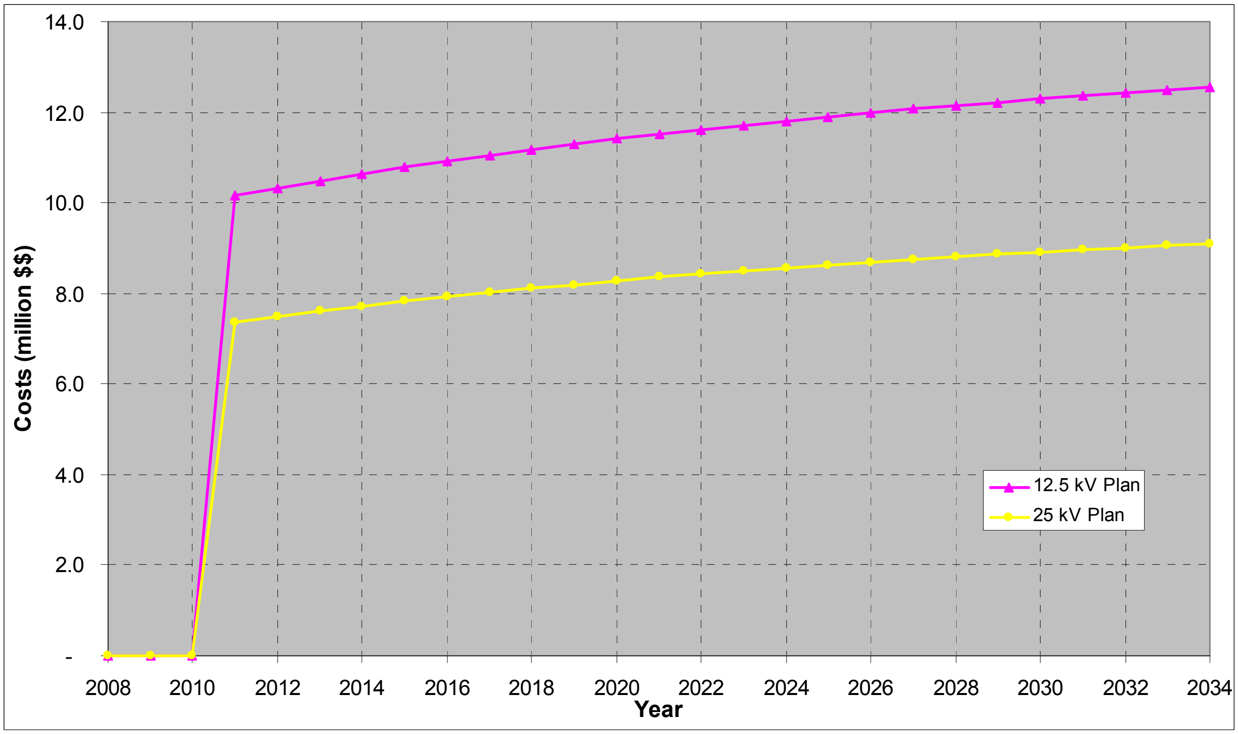


Figure 3: Net Present Value Comparison

A cost benefit analysis was not necessary for this project since the alternatives were technically equivalent and offered the same benefits to the system.

6.3 RECOMMENDATIONS

This study has found that the distribution system that exists in Labrador City is incapable of serving load growth in the long-term. Continued operation with the status-quo will result in customers receiving voltages outside those recommended in CSA Standard CAN3-C235-83 (R2006) *Preferred Voltage Levels for AC Systems, 0 to 50 000 V*.

In order to address this issue two alternatives were examined, converting the distribution voltage to 25 kV, and converting the distribution voltage to 12.5 kV. An analysis of the cost of each project showed that the 25 kV alternative is $3,774,712 less costly than the 12.5 kV alternative. Therefore, the 25 kV upgrading plan is selected as the favoured alternative.

The following recommendations are intended to assist in completion of the work involving this study, and to aid in selecting and implementing the favored option.

To date, load and voltage studies have been carried out on the Quartzite and Vanier distribution systems. The remaining systems, Bartlett, Hudson, Harrie Lake, and the 46 kV subtransmission system have not had studies conducted in several years.

Therefore, it is recommended that studies be conducted on these systems in the winter of 2009. The data from these studies will provide information on load profiles, diversity, and will be necessary in proofing the recently developed model of the distribution system.

When the system was taken over in the 1992, as a cost saving measure, easements were not acquired on the 4.16 kV distribution lines. In some cases easements have been acquired when a property is sold, for the remaining land prescriptive rights are all that exist on these lines. The Wabush staff has expressed concerns of customers constructing buildings very close to or directly underneath the power lines. In such cases the customers have had to sign waivers to protect Hydro from potential liabilities. The presence of structures in the line right-of-ways may cause difficulties in gaining access for the upgrades. Therefore, it is recommended that easements be acquired on all the distribution system.

A number of underground, padmount distribution transformers, and 4.16 kV primary services in Labrador City. The cost of upgrading these services to a higher primary voltage could be significant. Therefore, it is necessary to determine the exact number of these services that are in the system. This is so that the number of 25/4.16 kV or 12.5/4.16 kV step-down transformers can be found.

All the substation equipment associated with the 12.5 kV upgrading plan is intended to be upwards compatible to 25 kV. This is to provide a provision for conversion to 25 kV in the future if load growth were higher than expected. Therefore, long-term distribution transformer replacements on the 12.5 kV distribution system should be dual voltage type with a 14.4 kV - 7.2 kV primary winding.

There is the possibility that at some point in the future, a second 230 kV terminal station will be constructed in Labrador West. The location of this facility will depend on the nature of the load initiating the upgrade. If the new station is initiated primarily due to town load, then a suitable location would to the west of the system in the general area of the intersection of the Fermont Highway and Circular Road. A property of suitable size could be secured in that area.

Most of the switchgear in the substations is indoor metal clad type. Generally the operations staff has expressed a preference for this type of switchgear because the buildings provide a warm and comfortable space for carrying out maintenance work, and the rack mounted configuration allows easy access the feeder breakers. Given the favourable experience that TRO Labrador has had with this type of switchgear, and considering the working conditions with the severe winter climate in Labrador West, it is recommended that the continued use of metal clad type switchgear versus outdoor type switchgear be taken into consideration.

Problems have been experienced with carrying out investigations into the causes of a number of outages on the distribution system. The most common issue has been the general lack of information about system conditions at the time of the incidents due to a lack of metering. The only metering currently available are MW, and kV readings at Wabush Terminal Station. The System Operations Department has expressed an interest in having SCADA installed at each of these substations. It is recommended that this be done with the new distribution system. Telemetry can be provided by optical fiber or most economical available means.

The Fermont Line, L33, can serve as an emergency supply to Labrador West or Fermont in Quebec. It can also be used as a backup subtransmission line when there is trouble with L32. However, utilizing this line is cumbersome. Prior to energizing the line, notice must be sent to Hydro Quebec informing of this. Until an acknowledgement is received from Hydro Quebec, the line can't be energized. As well the protection settings on L33 are lower than the settings on L32. In order to supply Labrador City from L33, the protection settings would have to be changed. Both the above items make utilizing L33 a time consuming and cumbersome process. It is recommended that a different operating arrangement be made on this line. There is a disconnect switch, WA33-D3 at the Quebec/Labrador border. If this switch were opened the line could remain energized at all times. For emergency supply, the switch would be closed. Doing this would allow the line to be utilized for the distribution system, and the protection settings could be adjusted appropriately. This will have the benefits of improved voltage regulation on the 46 kV subtransmission system, and better reliability for Hydro's customers.

REFERENCES

1. CEA 29, CEA Distribution Planner's Manual, Sept. 1983
2. INT 31, Newfoundland & Labrador Hydro's Transformer Back-up Policy, July 1991

APPENDICIES

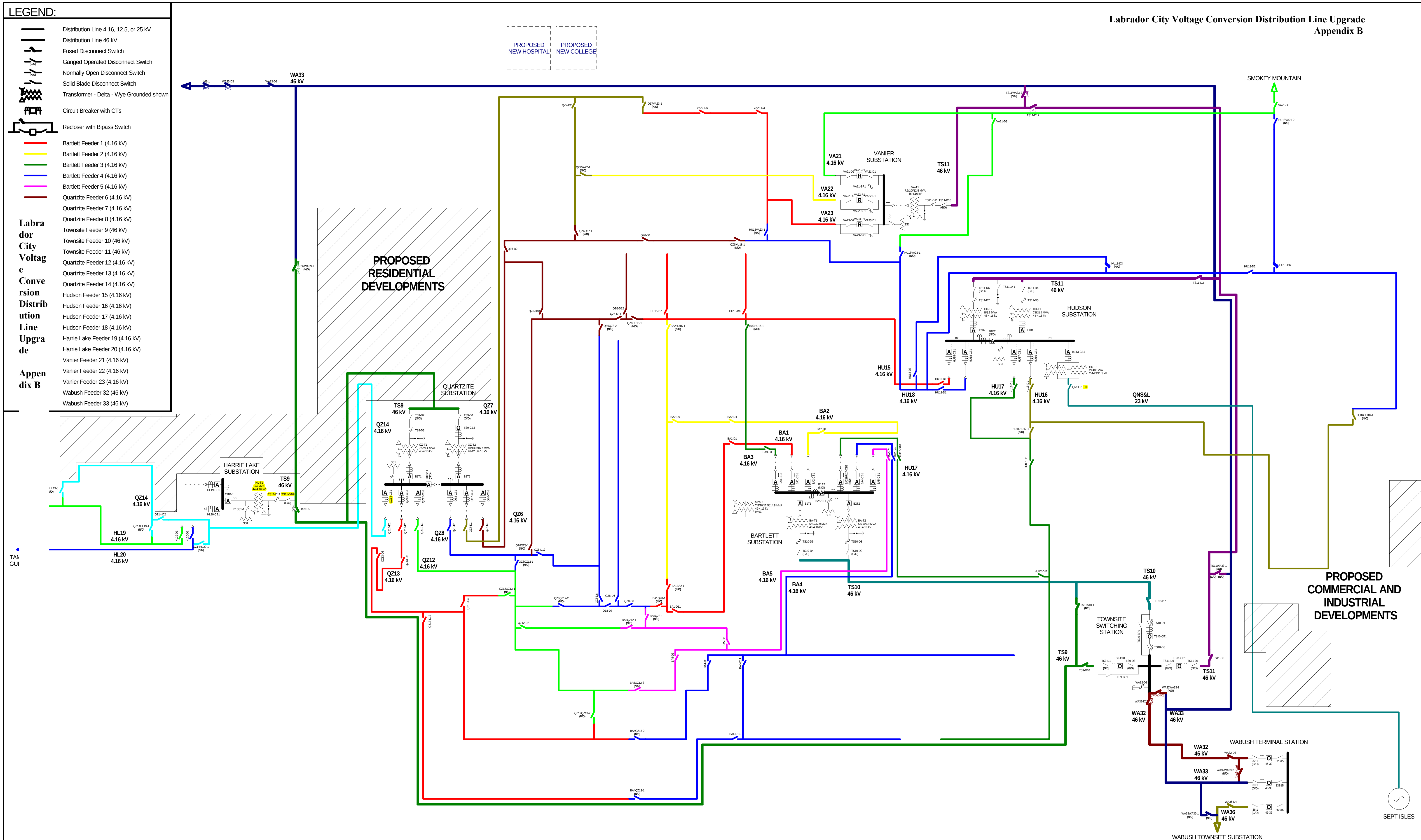
APPENDIX A

SINGLE LINE DIAGRAMS

A1

LABRADOR CITY DISTRIBUTION SINGLE LINE DIAGRAM

Labrador City Voltage Conversion Distribution Line Upgrade
Appendix B



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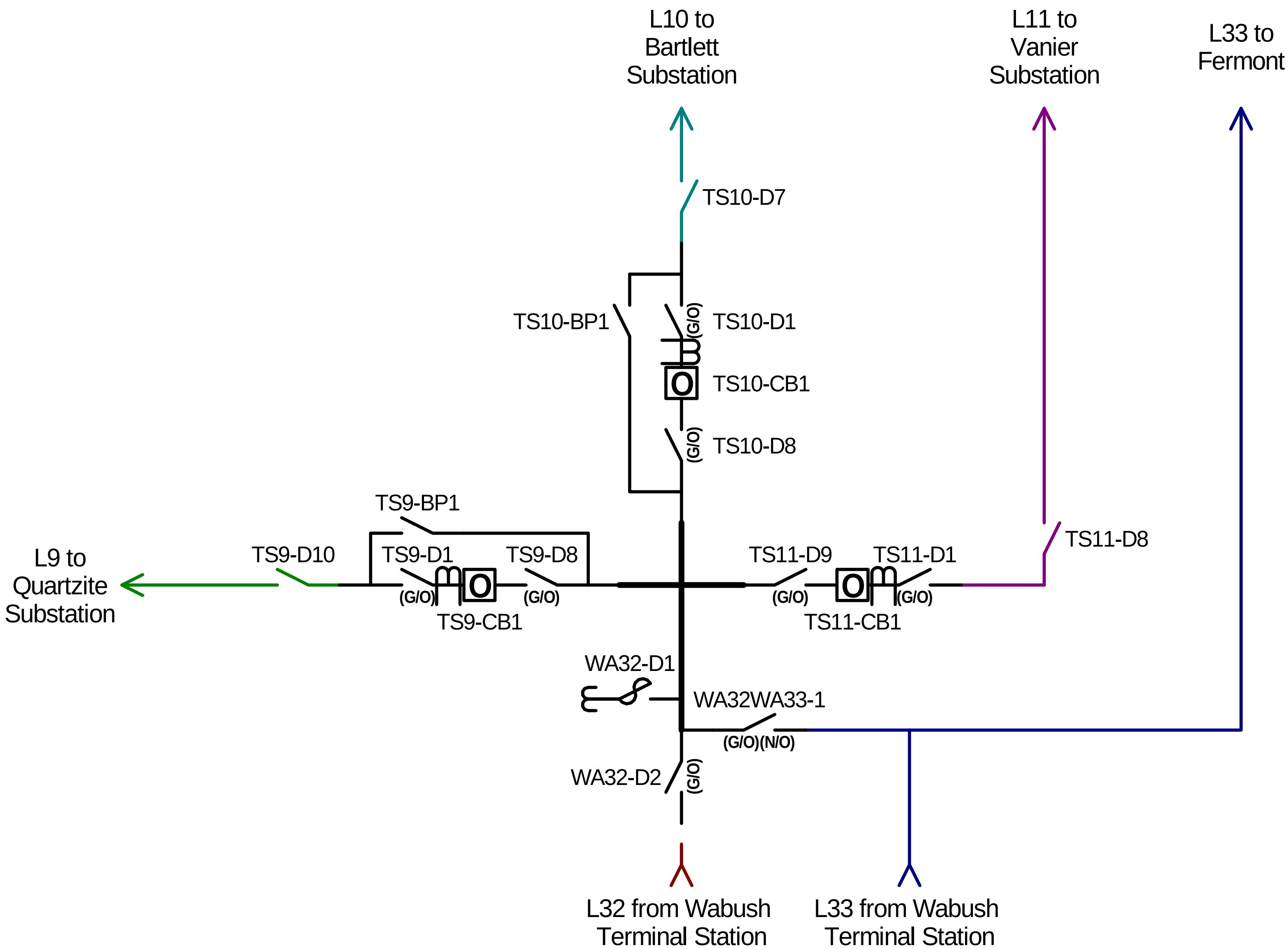
A2

TOWNSITE SWITCHING STATION

EXISTING
TOWNSITE SWITCHING STATION



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A3

BARTLETT SUBSTATION

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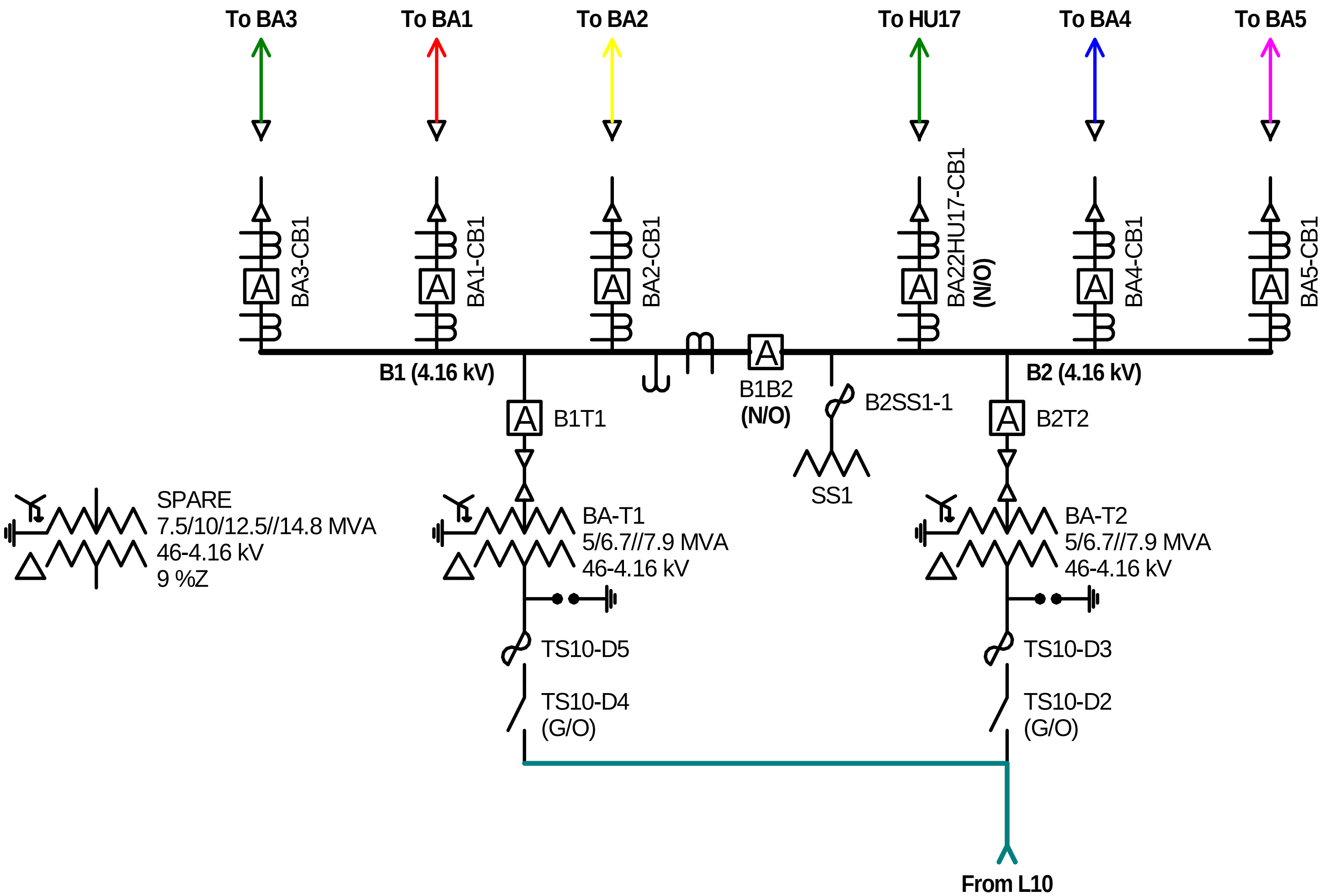

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A4

HUDSON SUBSTATION

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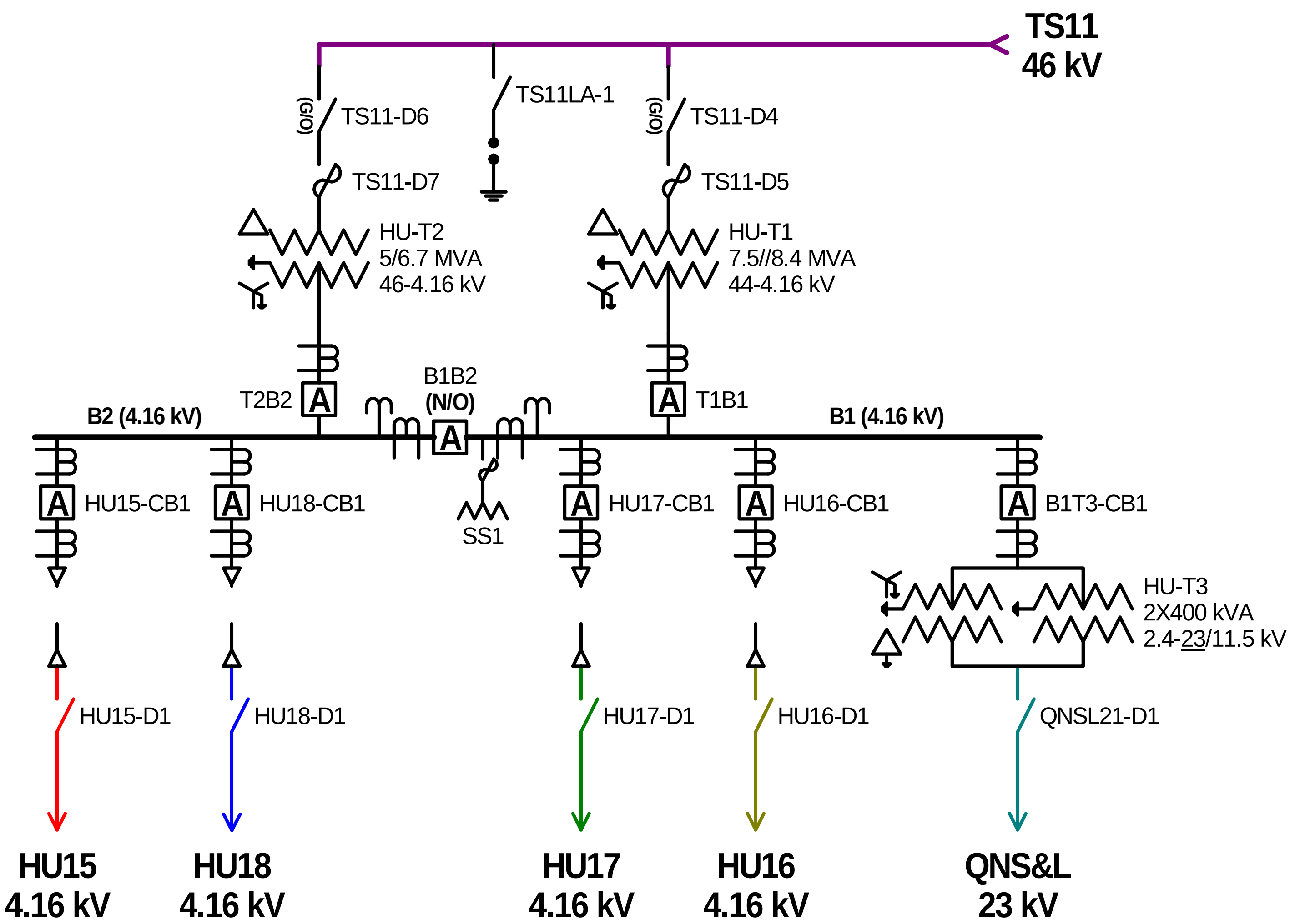

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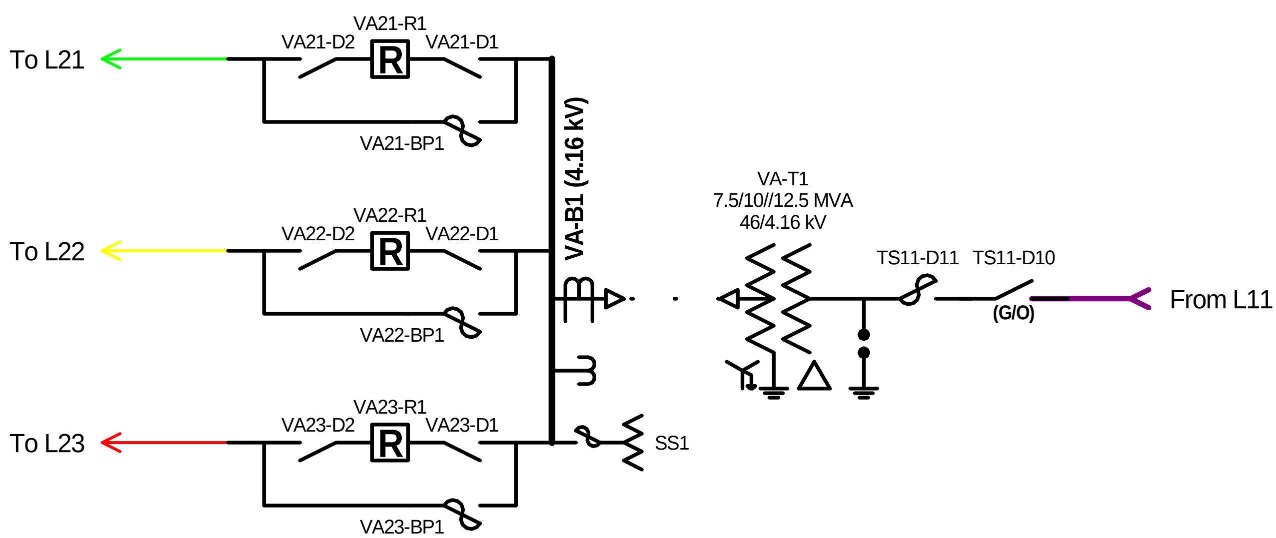
A5

VANIER SUBSTATION

EXISTING VANIER SUBSTATION



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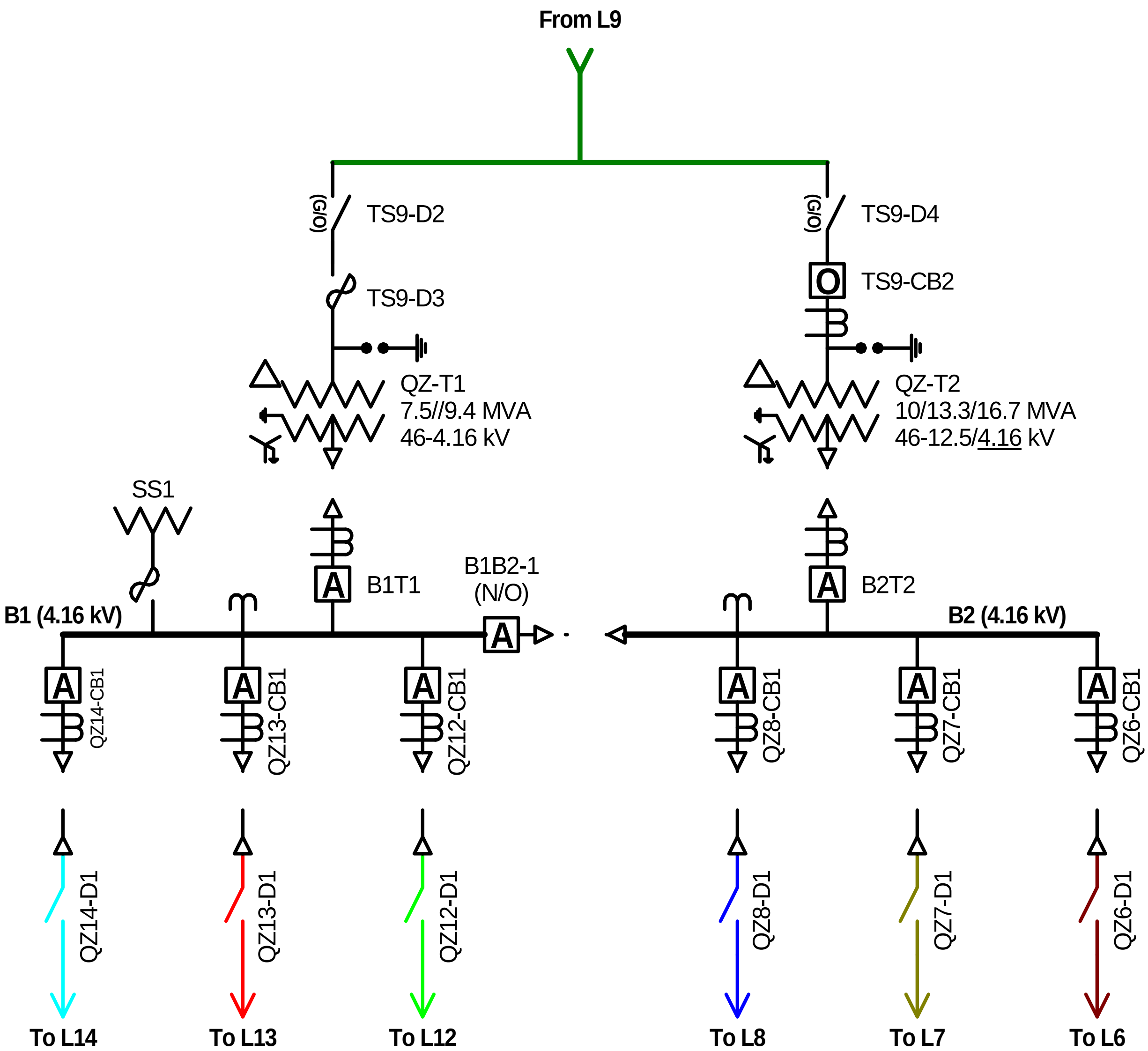
A6

QUARTZITE SUBSTATION

EXISTING QUARTZITE SUBSTATION



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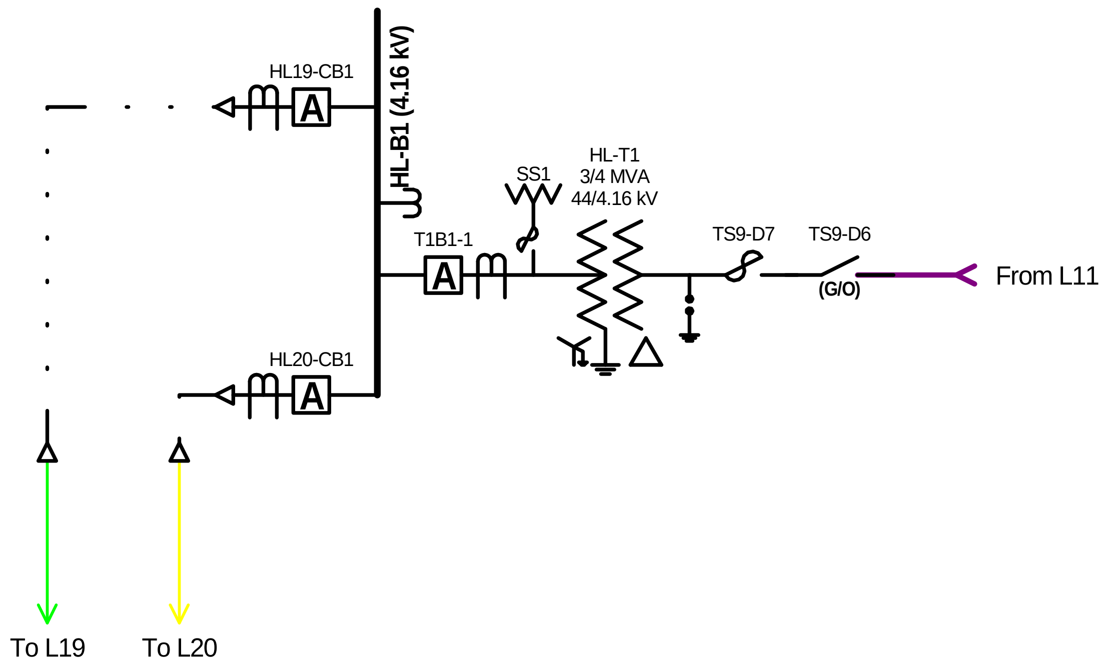
A7

HARRIE LAKE SUBSTATION

EXISTING HARRIE LAKE SUBSTATION



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APPENDIX B

MEMO FR. DAVID HARRIS RE. 4.16 KV UPGRADING PLAN

752.63.10/04
David

INTEROFFICE MEMORANDUM

DATE: January 29, 1992

MEMO TO: Harvey Young

FROM: David Harris

SUBJECT: CAPITAL COST ESTIMATES - 4.16 KV CAPITAL PLAN

Concerns have been expressed regarding the requirement of 12.5 kV conversion in Labrador City, particularly in light of the less than forecast peak for this year. In response to these concerns, the capital plan for the community has been again examined. In particular, the system was examined for operation at a 48 MW peak as opposed to 52.5 MW. After considerable time and effort, a plan has been developed allowing the system to remain at 4.16 kV while providing marginally acceptable voltages. By marginally acceptable, it is meant that all feeder minimum voltages may not necessarily meet Hydro's voltage standards, but come close enough to be within the accuracy of our models. Let me state at the outset, however, that while the 4.16 kV plan can meet the technical requirements of the system, it provides absolute bare minimum feeder voltages and limited reliability. The 4.16 kV plan does not offer near the same flexibility as the 12.5 kV plan.

Attached is a list of work required for the 4.16 kV plan. Please provide rough cost estimates for this work. When the estimates have been prepared, please contact or have someone contact either myself or Keith Boone to discuss possible scheduling of the work in order to provide guidance in preparing the cash flows. For comparison purposes, please provide the cost estimates using the same assumptions as were made for the 12.5 kV program. As well, please provide the cost for the work assuming Hydro stands to the cost of pole replacement, and the scenario in which Newfoundland Telephone stands to the cost of pole replacement.

As you are well aware, the date for the hearing on Labrador City is soon approaching. If the rough estimates could be prepared by February 6, 1992, it would be greatly appreciated.

If you have any comments or questions regarding the plan, please contact me at extension 1964. Thanks.

David Harris, Planning Engineer
Generation and Rural

DH:cfh

cc Keith Boone
Peter Nell
Bob Whitehorne
File 752.63.10/04

Attachment

LABRADOR CITY 4.16 KV CAPITAL PLAN

46 KV TRANSMISSION:

- Reconductor existing 266.8 MCM conductor with 477 MCM ASC.
- Reconductor 266.8 MCM, 46 kV buswork in the Townsite Switching Centre with 477 MCM ASC.
- Provide 46 kV switching capability between the existing Townsite line and the 477 MCM Fermont emergency line. See attached single line diagram SK-1.
- Construct a 1.5 km, 3 Phase, 46 kV, 266.8 MCM ACSR line from the Hudson Substation to the location of the new Vanier Substation.

SUBSTATIONS:

- Construct a new 46:4.16 kV substation near the Labrador Mall (Vanier Substation). See attached single line diagram SK-2.
- Replace the 3/4 MVA transformer in the Bartlett Substation with a 5/6.67 MVA unit.
- Extend the Quartzite Substation, buswork, etc., to allow addition of a 7.5/10/12.5 MVA unit. See attached single line diagram SK-3.
- Move feeders Quartzite 1 and Quartzite 2 onto transformer QZ-TH-1.
- Move feeders Quartzite 3 and Quartzite 4 onto transformer QZ-TH-2.
- Move feeders Quartzite 5 and Quartzite 6 onto transformer QZ-TH-3.
- Improve buswork in Bartlett Substation to Hydro standards.
- Improve buswork in Hudson Substation to Hydro standards.
- Install three 1-Phase, 400 Amp, 4.16 kV voltage regulators in the Quartzite Substation for use with feeder Quartzite 6.
- Install a circuit switcher on the incoming 46 kV line to Hudson Substation.
- Install a circuit switcher on the incoming 46 kV line to Quartzite Substation.
- Install a circuit switcher on the incoming 46 kV line to Harrie Lake Substation.

PRIMARY DISTRIBUTION LINES:

- Reconductor approximately 500 m of feeder Bartlett 2 (from the substation to 601 Bartlett Drive) with 266.8 MCM ACSR.

- Reconductor approximately 200 m of feeder Bartlett 3 (from the substation to 424 Grenfell Crescent) with 266.8 MCM ACSR.

- Reconductor approximately 1 km of feeder Bartlett 5 (from the substation to 703 Tamarack Drive) with 477 MCM ASC.

- Reconductor approximately 750 m of feeder Bartlett 5 (from 703 Tamarack Drive to 733 Willow Drive, and from 709 Tamarack Drive to 751 Tamarack Drive) with 266.8 MCM ACSR.

- Reconductor approximately 600 m of feeder Bartlett 5 (from 703 Tamarack Drive to 722 Bartlett Drive) with 266.8 MCM ACSR.

- Install a 3-Phase, 266.8 MCM, 200 m line connecting Quartzite feeder 5 to Vanier feeder 1.

- Install 3-Phase, 600 Amp cutouts on Quartzite feeder 6 at 805 Churchill Street.

- Construct a 3-Phase, 500 m, 477 MCM line connecting feeder Quartzite 6 at 604 McPharland Street to Vanier feeder 2. Reconductor the branch between 401 and 419 Montagais Avenue with 3-Phase, 477 MCM conductor (approximately 250 m).

- Construct a 3-Phase, 1.1 km, 477 MCM line on existing structures from Vanier feeder 3 to 802 Carol Drive. See attached diagram SK-4. Reconductor the branch between 833 and 819 Cook Street with 3-Phase, 477 MCM conductor (approximately 250 m).

- Construct a 3-Phase, 100 m, 477 MCM line connecting Quartzite feeder 4 to 823 Hamilton Street. See attached diagram SK-4. Reconductor the branch between 823 and 801 Hamilton Street with 3-Phase, 477 MCM conductor (approximately 300 m).

- Add 266.8 MCM conductor to branch running from 413 Centennial Drive to 420 Massey Crescent in order to make the branch 3-Phase (approximately 500 m).

- Reconductor the branch between Quartzite feeder 6 at the substation and 829 Carol Drive using 3-Phase, 477 MCM ASC (approximately 700 m).

- Construct a 3-Phase, 477 MCM ASC, 1.1 km line from Hudson feeder 2 at the substation to the industrial area, terminating near City Motors.

- Install a 3-Phase, 300 kVAR, 2.4 kV L-N capacitor bank at the relay station in the Hudson feeder 2 industrial area.

- Install a 3-Phase, 300 kVAR, 2.4 kV L-N capacitor bank on Hudson feeder 2 near the Lumber Mart.

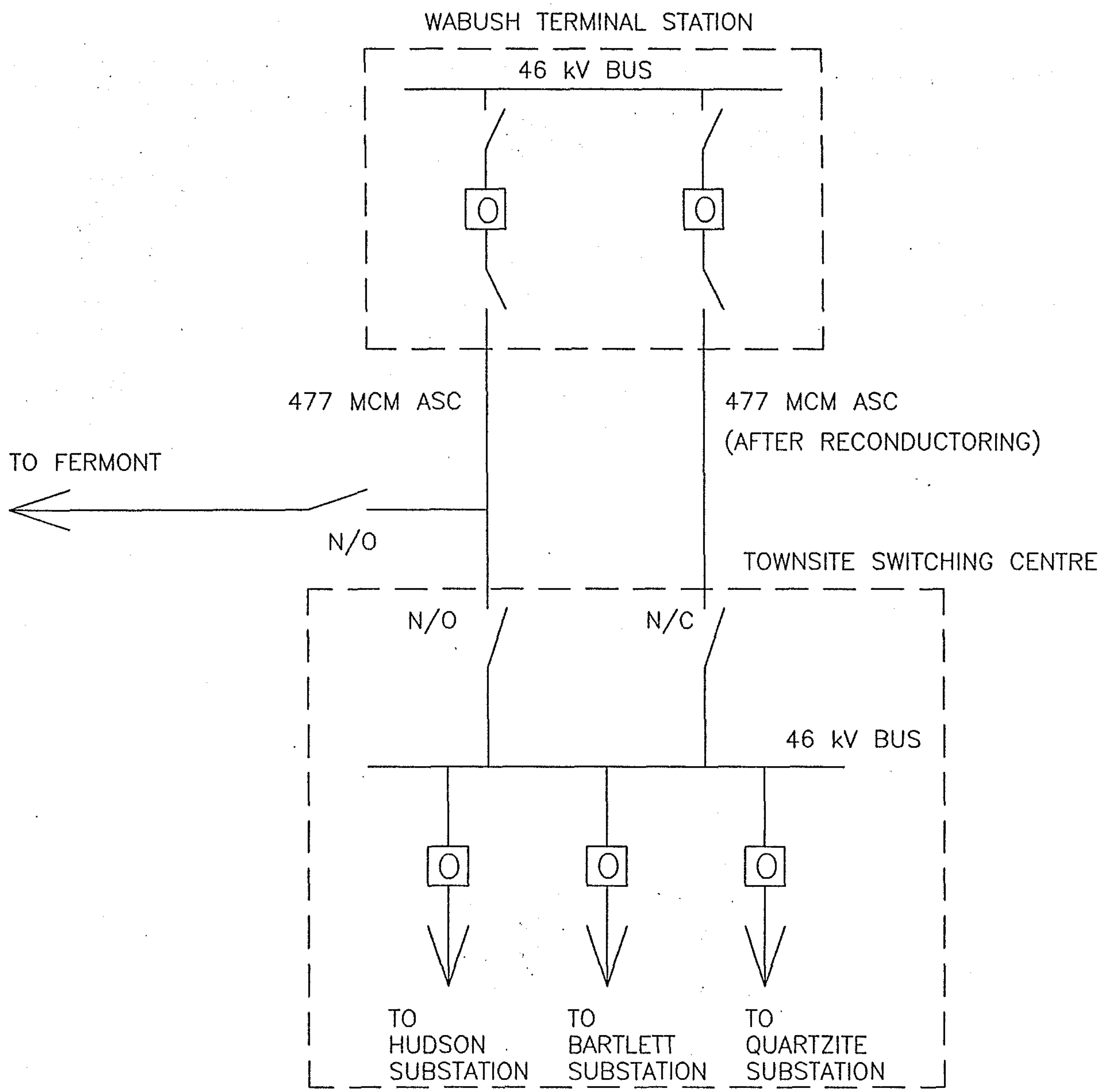
- Install a 3-Phase, 300 kVAR, 2.4 kV L-N capacitor bank on Bartlett feeder 5 near 714 Bartlett Drive.

- Install a 3-Phase, 300 kVAR, 2.4 kV L-N capacitor bank on Quartzite feeder 2 near 764 Tamarack Drive.

- Install a 3-Phase, 600 kVAR, 2.4 kV L-N capacitor bank on Quartzite feeder 3 near 816 Lakeside Drive.

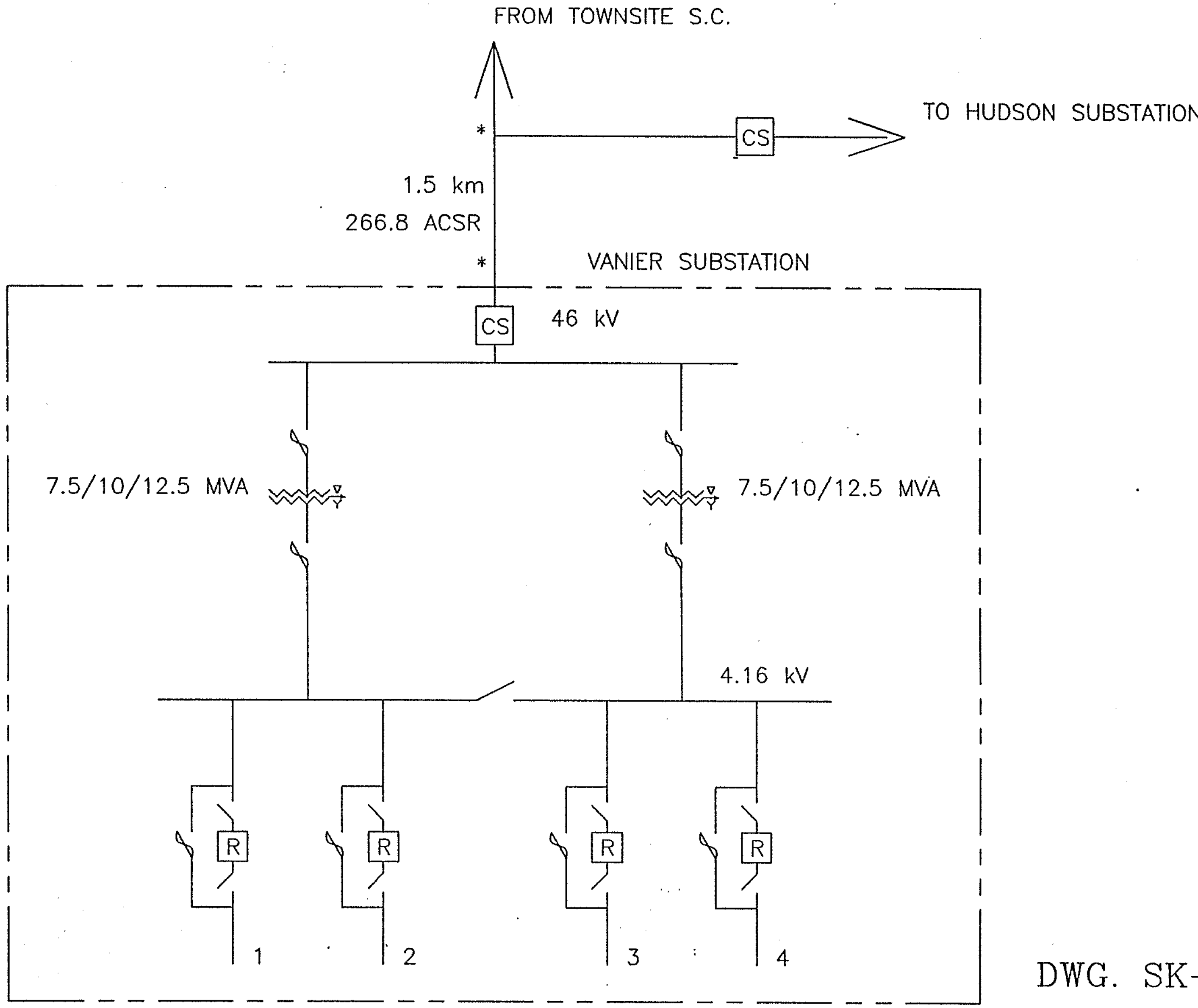
- Install a 3-Phase, 300 kVAR, 2.4 kV L-N capacitor bank on Quartzite feeder 4 near 727 Bartlett Drive.

- Install a 3-Phase, 150 kVAR, 2.4 kV L-N capacitor bank on Quartzite feeder 4 near 768 Stirling Crescent.



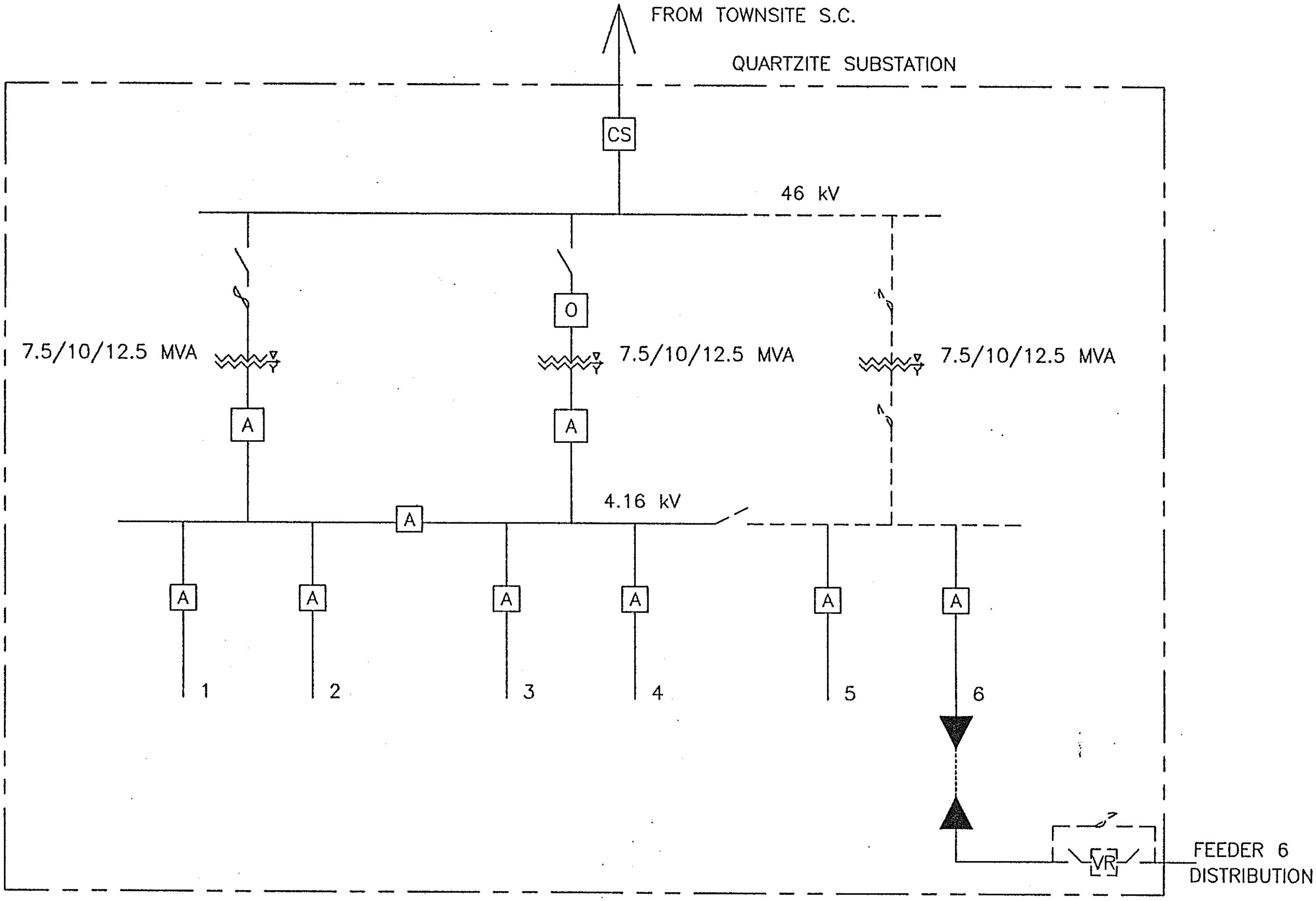
DWG. SK-1

HYDRO	TITLE: LABRADOR CITY 4.16 kV CAPITAL PLAN PROPOSED SWITCHING ARRANGEMENT – T.S.C.	SHEET 1 OF 1 DRAWN: D. HARRIS DATE: JANUARY 28, 1992



DWG. SK-2

HYDRO	TITLE: LABRADOR CITY 4.16 kV CAPITAL PLAN PROPOSED VANIER SUBSTATION SINGLE LINE DIAGRAM	SHEET 1 OF 1 DRAWN: D. HARRIS DATE: JANUARY 28, 1992



DWG. SK-3

HYDRO

TITLE: LABRADOR CITY 4.16 kV CAPITAL PLAN
PROPOSED QUARTZITE SUBSTATION SINGLE LINE

SHEET 1 OF 1

DRAWN: D. HARRIS

DATE: JANUARY 28, 1992

APPENDIX C

RURAL (ISOLATED) DISTRIBUTION SYSTEMS

OVERCURRENT PROTECTION UPGRADE

Rural (Isolated) Distribution Systems
Overcurrent Protection Upgrade

Introduction

The distribution system is a vital contributor to the overall power system function of providing quality electrical service to its customers. To fulfill this role, the design and operation of the distribution system must take into account the basis fundamentals of system fault overcurrent protection. The questions that arise from this type of analysis are as follows:

(1) What are the distribution system fault overcurrent problems?
(2) What protective equipment is available to deal with these problems?
(3) How is the protective equipment applied to the distribution system?

Distribution System Faults

The operator of any distribution system must anticipate a variety of operating conditions which may interfere with normal operation. One of the predominant abnormal conditions on distribution systems are overhead line faults. These line faults are normally caused by adverse weather conditions such as strong winds which can whip phase conductors together or which blow tree branches onto the overhead primary line(s). As well, freezing rain can produce a gradual buildup of ice on an overhead line and eventually one or more conductors may break and fall to the ground. Most of these fault conditions are considered as line to ground faults with significant levels of fault impedance, such as the ice on the conductor or the tree branch that is in contact with one of the overhead conductors. In fact, on a 3-phase wye grounded distribution system some 80% of the overhead line faults are line-to-ground in nature. These types of faults are well know for the distribution systems within Newfoundland and Labrador, both for grid interconnected and isolated diesel distribution systems.

The fault overcurrent protection design for all distribution systems must therefore minimize the severe effects that a hostile environment can have on owner's as well as customer's electrical equipment.

Types of Faults

The types of system faults that can occur on any 3-phase, multi-grounded distribution line are as follows:

(1) Three-Phase
(2) Line-to-Line
(3) Line-to-Ground
(4) Double Line-to-Ground

For the two types of ground faults listed above if one or more of the line conductors does not contact the system neutral wire (ie. bolted fault) the level of fault current that results is much dependant on the magnitude of the fault impedance involved, as well as the integrity of the system grounding for the soil resistivity involved. A fault impedance

Rural (Isolated) Distribution Systems
Overcurrent Protection Upgrade

value of 20 to 80 ohms would be typical for the line-to-ground fault calculations in order to determine expected line-to-ground fault current level(s) for the distribution system involved, and based on minimum generation source. This fault impedance is a more significant factor for lower voltage distribution systems such as 4.16 kV, than those operating at 12.5 or 25 kV. At this point the emphasis for system fault overcurrent protection will concentrate on the single line-to-ground fault, and in particular those involving a fault impedance.

Isolated Distribution Systems

For an isolated 3-phase, 4-wire wye grounded distribution system with diesel generation, the magnitude of the line-to-ground fault current will not only depend on the ohmic value of the fault impedance, but also the number and size of diesel generating units operating at the time of the system fault. It is very common for one diesel unit to be operating under system off peak conditions, which would be considered as a worst case scenario should a system line-to-ground fault occur at that time. Calculated values for these distribution systems using a fault impedance show line-to-ground fault levels as low as 80 amps. Many of these isolated distribution systems have only phase overcurrent protection which would be the step-up transformer's high voltage fuses, thus no type of sensitive line-to-ground protection exists. Typically the line-to-ground overcurrent protection for any distribution system would be in the range of 10% to 50% of the phase overcurrent value depending on feeder load unbalance. Existing high voltage fuses on the 4.16 kV side of the step-up transformer bank are designed to melt at 200% of their rating thus a 50 amp fuse will melt at 100 amps, which is well above this line-to-ground fault level. The step-up transformer bank's delta/wye grounded connection configuration is a block to zero sequence current, thus any phase overcurrent protection on the 600V generation side is not sensitive enough to detect these lower fault levels.

Protection Upgrade Program

The grid interconnected distribution systems have protective devices such as three phase and single phase electronic reclosers which are designed with line-to-ground fault sensing capability. These same protective devices do exist on many of the isolated diesel distribution systems as well, with the remainder having only high voltage fused cutouts. Thus of the twenty-six (26) prime power diesel plants that Hydro operates, there are twelve(12) that require line-to-ground protection upgrading, as listed in the table that follows. This would involve the installation of sensing transformers on the high side of the step-up power transformer bank and a solid state protective relay, which would trip the plant's main breaker. For those plants that do not have a main breaker which is compatible for the protective relay application, then an electronic recloser installation is proposed. For example, the main breaker at both the Little Bay Islands and St. Brendan's diesel plants has no shunt trip and the cost to upgrade these breakers for the protection upgrade using the solid state protective relay option is higher in cost than the electronic recloser option. The system outage time involved in upgrading these main breakers is also prohibitive. Please note as well for the electronic recloser installation that its control panel will be brought inside the diesel plant for ease of access by the operator.

Rural (Isolated) Distribution Systems
Overcurrent Protection Upgrade

The schedule proposed for the overcurrent protection upgrade project(s) is based on work commencing immediately in 2002 for two (2) of the rural distribution systems involved and completing the remaining ten (10) in the budget year 2003.

Diesel Plant Location	Protective Relay Installation	Electronic Recloser Installation	Budget Year	Budget Estimate *($ x1000)*
Central Region:				
Little Bay Islands		*	2002	79.0
St. Brendan's		*	2002	79.0
Grey River	*		2003	52.7
Francois	*		2003	52.7
Petites	*		2003	52.7
McCallum	*		2003	52.7
Northern Region:				
St. Lewis		*	2003	84.2
William's Hbr.	*		2003	52.7
Norman Bay	*		2003	52.7
Labrador Region:				
Black Tickle		*	2003	105.1
Postville		*	2003	84.2
Paradise River	*		2003	52.7

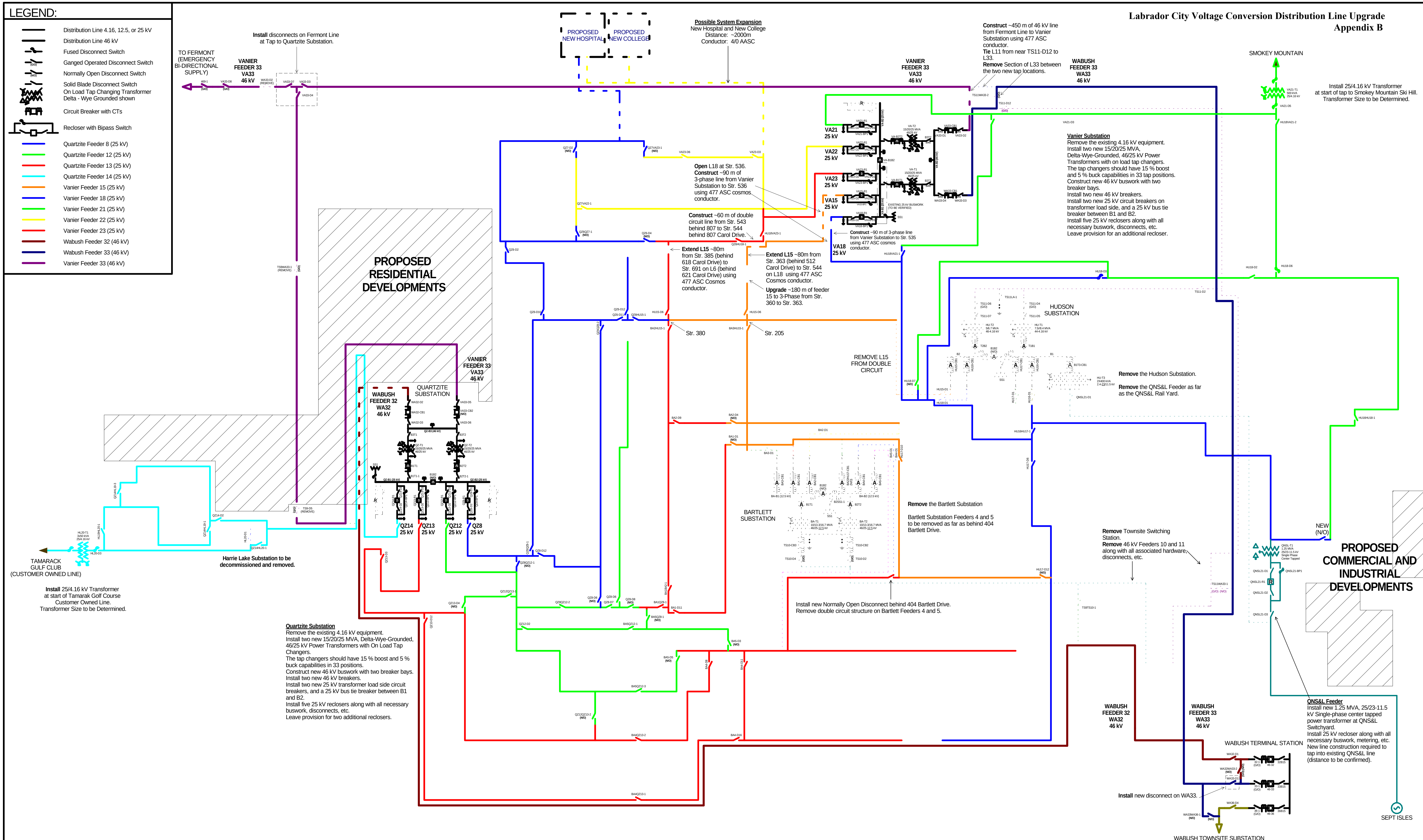
APPENDIX D

25 KV DISTRIBUTION UPGRADING PLAN

SINGLE LINE DIAGRAMS

D1

LABRADOR CITY 25 KV CAPITAL PLAN 2007



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SYS OPERATIONS:	--	DATE: NOV 2, 2007
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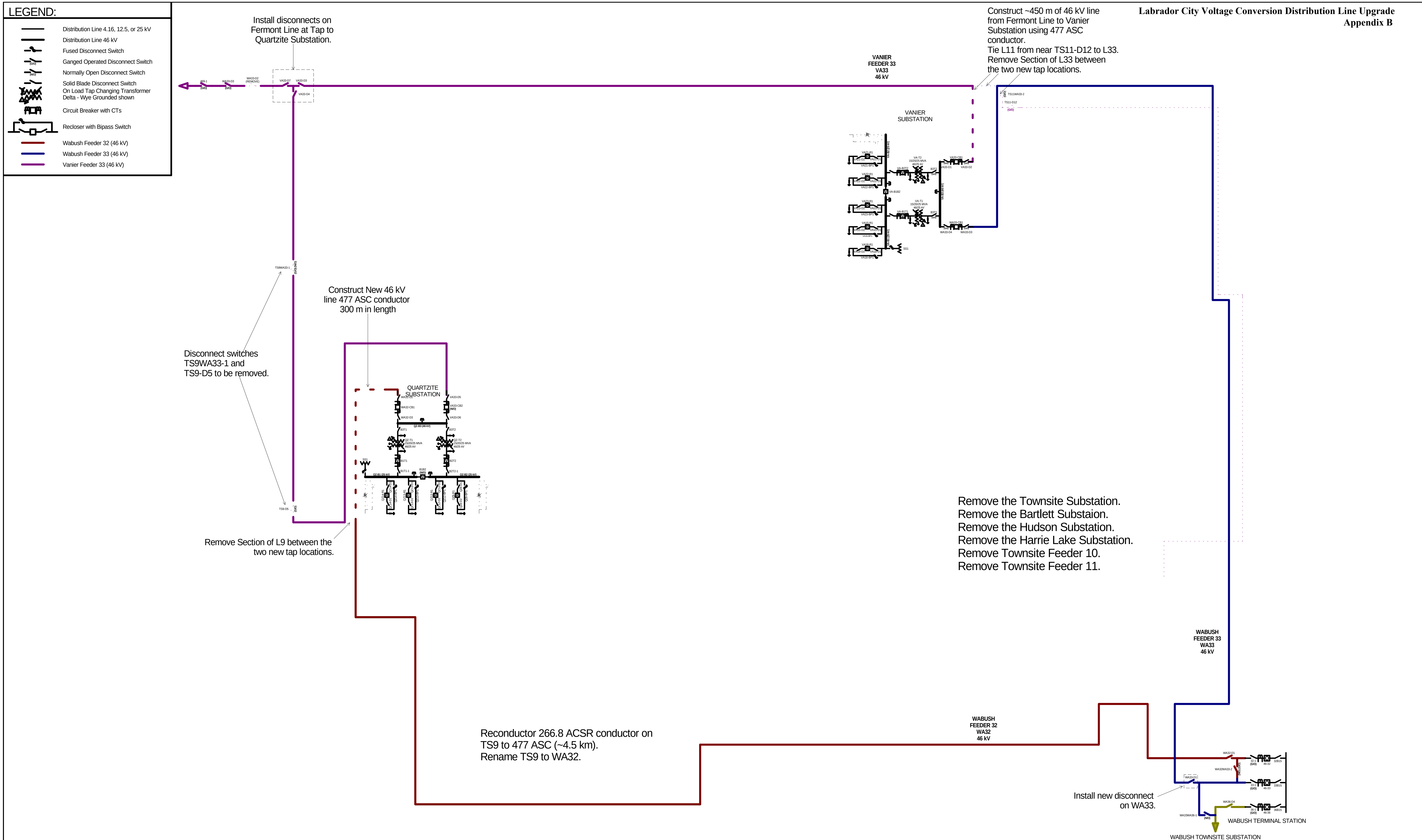
D2

PROPOSED 46 KV SUB-TRANSMISSION UPGRADES



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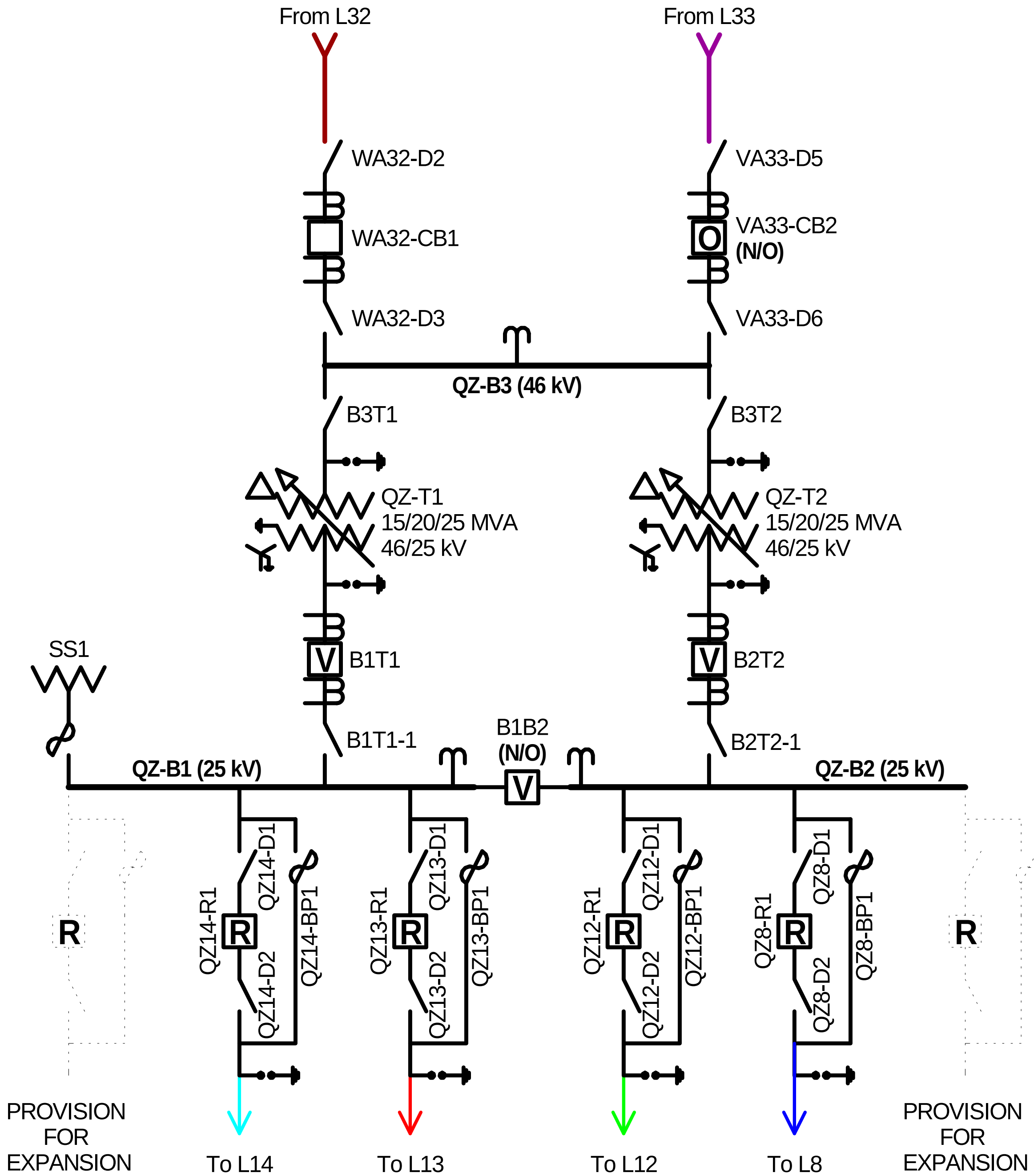
D3

PROPOSED QUARTZITE 25 KV SUBSTATION

PROPOSED QUARTZITE 25 kV SUBSTATION



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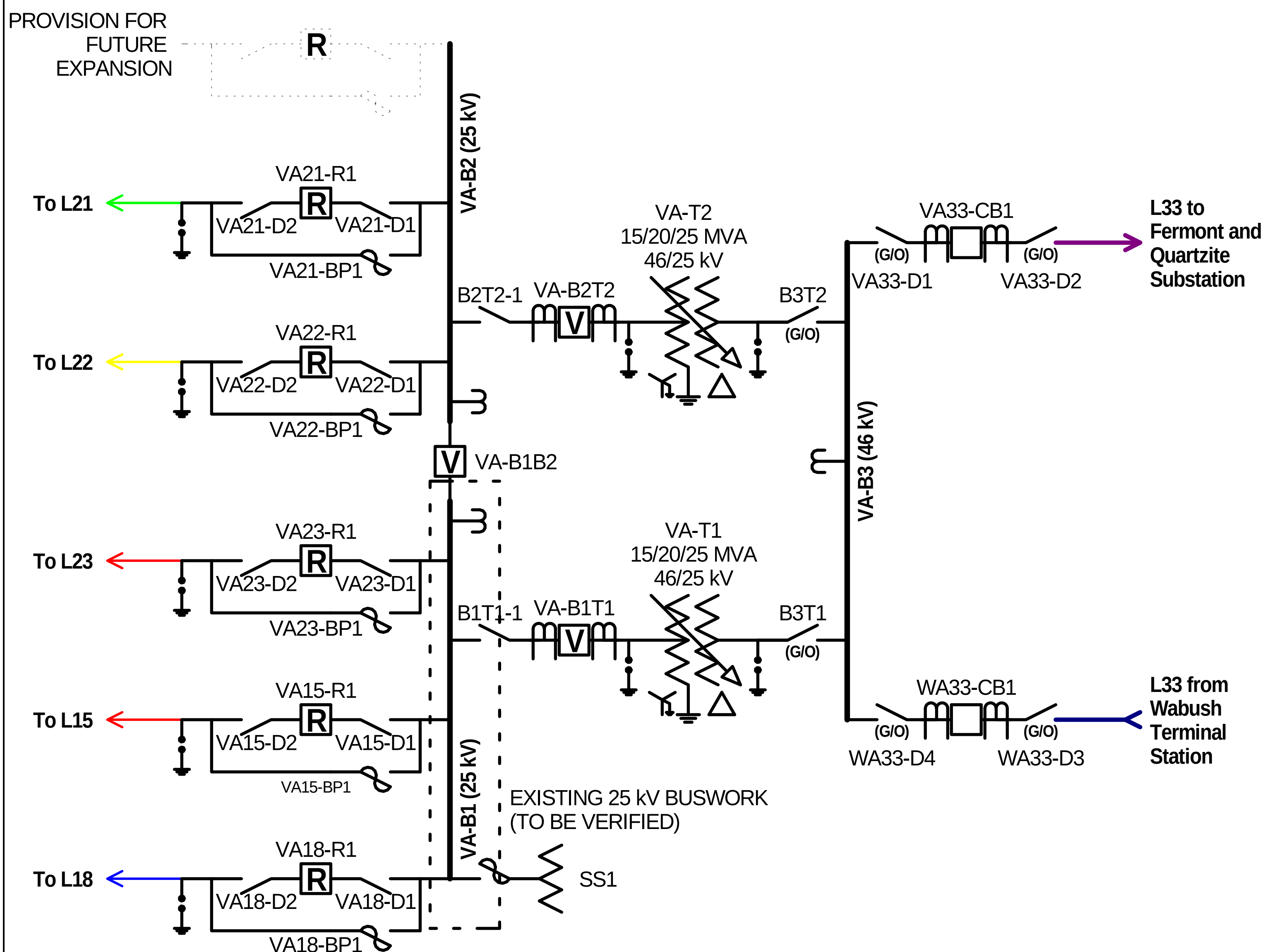
D4

PROPOSED VANIER 25 KV SUBSTATION

PROPOSED VANIER 25 kV SUBSTATION



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APPENDIX E

SCOPE OF WORK FOR THE 25 KV UPGRADING PLAN

SCOPE OF WORK FOR THE 25 KV UPGRADING PLAN

Due to the complexity of this plan and the amount of work required to implement it, it is recommended the upgrades be performed over a number of years. The first phase of the plan will be the upgrading of the Vanier Substation and the portion of Quartzite Substation associated with T2 to 25 kV, the conversion of feeders L6, L7, L8, L21, L22, and L23, the construction of a tie line between Vanier and Quartzite Substation, and reconnecting the Vanier Substation to L33. The second phase would include upgrading the remaining half of the Quartzite Substation to 25 kV, converting feeders L12, L13, L14, L19, and L20 to 25 kV, and the removal of the Harrie Lake Substation from service. The third phase of the upgrades would include converting feeders L1, L2, L3, L4, L5, L15, L16, L17, and L18 to 25 kV, and removing the Bartlett Substation and the Hudson Substation. The final phase of the upgrades will involve removing of the Townsite Switching Station. Once completed the Vanier substation and Quartzite Substation would remain and the Bartlett, Harrie Lake, Hudson, and Townsite Switching Substations would be removed.

Note max foreseeable fault levels for breaker sizing are provided. This takes the following upgrades and conditions into consideration. Maximum foreseeable fault levels include the installation of the third synchronous condenser at Wabush Terminal Station, a third 230 kV circuit into Labrador West, all 46 kV tie switches/breakers closed, and the 25 kV bus tie breaker in the substations closed. Transformer impedances were assumed to be approximately 6 %, similar to Quartzite Transformer No. 2.

1.1 VANIER SUBSTATION

Extend and upgrade the Vanier Substation:

- Extend the Vanier Substation Northward.
- Remove the existing 4.16 kV equipment.
- Install a new control building of suitable size.
- Construct a new transformer pad.
- Construct a 46 kV box structure complete with 46 kV bus and two breakers bays. The structure should be laid out such that and additional breaker can be accommodated in the future.
- Purchase and install two 46 kV breakers.
    - As a minimum the breakers should have the following capabilities:
        - Symmetrical Interrupting Rating: 10631 A, 847 MVA
        - Continuous Current Rating: 941 A.
- Purchase and install two 46/25 kV, 15/20/25 MVA power transformers.
    - Transformers are to be fitted with On Load Tap Changers having 33 positions at 0.625 % per tap. The taps are to have a range from 39.1 kV (0.85) to 48.3 kV (1.05).
- Construct a 25 kV box structure, adjacent to the existing structure.

  - The structure is to contain a 25 kV bus, and three 25 kV breaker bays.
  - The structure is to be laid out such that sufficient space is available for a bus tie breaker, and the transformer load side breakers.
- Purchase three new 25 kV circuit breakers,
  - Two of the breakers will be installed between the transformer load side bushings and the 25 kV bus.
  - The third breaker will be installed as a bus-tie breaker between B1 and B2.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 7066 A, 306 MVA
    - Continuous Current Rating: 686 A.
- Purchase and install five reclosers, along with all necessary buswork, etc.
  - As a minimum the reclosers should have the following capabilities:
    - Symmetrical Interrupting Rating: 7066 AIC, 306 MVA,
    - Continuous Current Rating: 560 A.
- Leave the provision for an additional recloser.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.
- A total of six 941 A 46 kV disconnect switches will be required.
- A total of two 686 A 25 kV class disconnects will required for isolation of the power transformer and low voltage circuit breaker.
- A total of fifteen 560 A 25 kV class disconnects will required for isolation and the recloser bypass switches.

1.2 QUARTZITE SUBSTATION

Rebuild and upgrade the Quartzite Substation:

- Remove the existing 4.16 kV equipment.
- Install a new control building of suitable size.
- Construct a 46 kV box structure complete with 46 kV bus and two breakers bays. The structure should be laid out such that and additional breaker can be accommodated in the future.
- Purchase and install two 46 kV breakers.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 9765 A, 778 MVA.
    - Continuous Current Rating: 941 A.
- Purchase and install two 46/25 kV, 15/20/25 MVA power transformers.
  - Transformers are to be fitted with On Load Tap Changers having 32 tap positions at 0.625 % per tap. The taps are to have a range from 39.1 kV (0.85) to 48.3 kV (1.05).
- Construct two 25 kV box structures.
  - Each structure is to contain a 25 kV bus, and three 25 kV breaker bays.
  - The structures are to be laid out such that sufficient space is available for a bus tie breaker, and for transformer load side breakers.

- Purchase three new 25 kV circuit breakers, two of the breakers will be installed between the transformer load side bushings and each 25 kV bus, the third breaker will be installed as a bus-tie breaker between B1 and B2.
    - As a minimum the breakers should have the following capabilities:
        - Symmetrical Interrupting Rating: 6851 A, 297 MVA.
        - Continuous Current Rating: 686 A.
- Purchase and install four new reclosers, along with all necessary buswork, disconnects, etc.
    - As a minimum the reclosers should have the following capabilities:
        - Symmetrical Interrupting Rating: 6851 A, 297 MVA.
        - Continuous Current Rating: 560 A.
- Leave the provision for two additional reclosers.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.
- A total of six 941 A 46 kV disconnect switches will be required.
- A total of two 686 A 25 kV class disconnects will required for isolation of the power transformer and low voltage circuit breaker.
- A total of eighteen 560 A 25 kV class disconnects will required for isolation and the recloser bypass switches.

1.3 DISTRIBUTION FEEDER UPGRADES

1.3.1 Line Extensions/Upgrades

- Construct ~60 m of double circuit line from structure 543 behind 807 Carol Drive to structure 544 behind 807 Carol Drive.
- Extend L15 ~80m from structure 363 (behind 512 Carol Drive) to structure 544 on L18 using 477 ASC Cosmos conductor.
- Upgrade ~180 m of feeder 15 from structure 360 to structure 363 to 3-Phase.
- Extend L15 ~80m from structure 385 (behind 618 Carol Drive) to structure 691 on L6 (behind 621 Carol Drive) using 477 ASC Cosmos conductor.
- Open L18 between structure 535 and structure 536 near the Vanier Substation.
- Construct ~90 m of 3-Phase line from the Vanier Substation to structure 536.
- Construct ~90 m of 3-Phase line from the Vanier Substation to structure 535.

The total required line extensions and upgrades to the low voltage distribution system is approximately 580 m. Since the system will be designed for contingency switching ability, and to remain consistent with the existing infrastructure, the type of conductor to be used for the above noted upgrades should be 477 ASC Cosmos.

1.3.2 Feeder Reconfigurations

Since the number of feeders will be reduced, some of the existing lines will have to be reconfigured. Most of this work will involve transferring existing feeders or sections of feeders to new 25 kV lines. The majority of the reconfigurations can be done using existing disconnects and tie switches. Load and Voltage Study results are required before feeder configurations can be finalized. The following describes a proposed reconfiguration based on the information currently available to provide roughly equal loading on each line. This work assumes that the line construction and upgrades described in the preceding section have already been completed, and that the voltage conversions on the respective line sections will be completed at the time they are transferred.

- Open feeder VA23 at structure 546. Reconnect the section of VA23 that feeds the Labrador City Mall to feeder VA22.
- Open disconnect QZ7-D2. Reconnect the section of QZ7 from Centennial Drive to Churchill Street to feeder VA22 by closing tie switch QZ7VA22-1.
- Open disconnect QZ6-D4, and close tie switches HU18VA23-1 and QZ6HU18-1 to transfer a section of feeder HU18 and feeder QZ6 to feeder VA23.
- Open L15 at structure 380 on both the source and load sides. Close tie switch BA2HU15-1 and open disconnect BA2-D4 to transfer the bulk of feeder BA2 to the new feeder VA23.
- Open disconnect BA1-D1, and close tie switch BA1BA2-1 to transfer the whole of feeder BA1 to the new feeder VA23.
- Open disconnect QZ8-D8, and close the tie switch BA1QZ8-1 to transfer the respective section of feeder QZ8 to the new feeder VA23.
- Open L15 at structure 338. Transfer the whole of feeder HU15 to the new feeder VA15 by closing the disconnect HU15-D6.
- Transfer feeder BA3 to the new feeder VA15 by closing the tie switch BA3HU15-1.
- Transfer the remainder of feeder BA2 to the new feeder VA15 by jumpering the lines together at structure 183.
- Open the disconnect HU17-D10. Jumper the lines sections of BA1, BA2, BA3, and HU17 just outside the Bartlett Substation together to transfer the respective section of feeder HU17 to the new feeder VA15.
- Open disconnect HU17-D12 and transfer the section of feeder HU17 bounded by HU17-D10 and HU17-D12 to the new feeder VA15.
- Transfer the sections of feeder HU18 bounded by HU18VA21-2, HU18-D2, HU18-D7 and the industrial park to feeder VA21.
- Open feeder HU16 and install a normally open disconnect at structure 1439. Reconnect the section of L16 bounded by Airport Road and Humphrey Avenue to the new feeder VA21 by closing tie switch HU16HU18-1.
- Transfer the remainder of feeder HU18 from Vanier Substation to Hudson Substation to the new feeder VA18.
- Transfer the remainder of feeder HU17 to the new feeder VA18 by jumpering the lines near the Hudson Substation.

- Transfer the remainder of feeder HU16 to the new feeder VA18 by closing the tie switch HU16HU17-1.
- Transfer feeder QZ6 to the new feeder QZ8 by closing the tie switch QZ6QZ8-1.
- Transfer the remainder of feeder QZ7 to the new feeder QZ8 by jumpering the lines together at structure 580.
- Transfer the remaining of section feeder HU15 bounded by tie switch QZ6HU15-1 and structure 380.
- Transfer a section of feeder QZ13 to feeder QZ12 by opening the disconnect QZ13-D4 and closing the tie switch QZ12QZ13-1.
- Transfer a section of feeder QZ8 to feeder QZ12 by opening the disconnect QZ8-D6 and closing the tie switch QZ8QZ12-2.
- Transfer a section of feeder BA5 to feeder QZ12 by opening the disconnect BA5-D3 and closing the tie switch BA5QZ12-1.
- Transfer a section of feeder BA5 to feeder QZ12 by opening the disconnect BA5-D5 and closing the tie switch BA5QZ12-3.
- Transfer a section of feeder BA4 to feeder QZ13 by opening the disconnect BA4-D8 and closing the tie switch BA4QZ13-2.
- Transfer the remainder of feeders BA4 and BA5 to feeder QZ13 by opening disconnects BA4-D1 and BA5-D1, closing the tie switch BA4QZ13-1 and jumpering BA4 and BA5 together at structure 246.
- Install a normally open disconnect between the new feeders QZ13 and VA15 at the structure behind 404 Bartlett Drive.
- Transfer feeder HL19 to feeder QZ14 by opening the disconnect HL19-D1 and closing the tie switch QZ14HL19-1.
- Transfer feeder HL20 to feeder QZ14 by opening the disconnect HL20-D1 and closing the tie switch QZ14HL20-1.

The above work will complete the conversion and reconfiguration of the 4.16 kV distribution feeders to the new 25 kV distribution system. The reconfiguration will off load the Bartlett, Hudson, and Harrie Lake Substations and will allow them to be removed from service.

1.3.3 Primary and Underground Services

There are a number of primary, underground, and customer owned services in Labrador City. The system will have to be surveyed to determine the exact number. The previous plan determined that most of the customers are willing to be switched to overhead services. However, as this would involve replacement of underground cables, removal of padmount and indoor transformers, and replacement of service entrances, completely converting the services to overhead may prove to be costly. An alternate solution to serve these customers is to install pole mounted 25/4.16 kV step-down transformers and continue to supply these customers at 4.16 kV, therefore the underground services could remain intact.

The Smokey Mountain line is a section of feeder Vanier 21, it runs from the Beverly Lake Water Supply to the Smokey Mountain Ski Hill. Much of this line is not constructed to NL Hydro Standards and to convert it would require significant upgrading of approximately 5.7 km of distribution line. To lower the cost of conversions a step down transformer should be installed so that the line can continue to be operated at 4.16 kV.

The Labrador City Mall is fed by five underground primary services which run under the mall parking lot to indoor transformers (1 MVA) inside the building. Pole/platform mounted transformers should be installed to avoid complete replacement of the existing customer owned equipment.

1.3.4 QNS&L Railway Feeder

The Quebec North Shore and Labrador Railway (QNS&L) line is a 23/11.5 kV single-phase center-tapped customer owned line. The line runs from Labrador City, NL to Sept Isles, PQ, and is constructed with two hot conductors and uses a ground return path for phase to neutral connected loads. Currently this line is fed from the Hudson Substation via a pair of 2.4/23-11.5 kV single-phase power transformers (400 kVA each). The center-tap connection on the transformers is grounded to provide the neutral return path for the line.

The line is metered at the substation and demand readings show this line has exceeded the capacity of the transformers by 19 % of the rated nameplate capacity. The load on this customer owned line will require a capacity increase. It is recommended to replace the existing transformers with two 25/23-11.5 kV, 1 MVA units once the conversion of L16 to 25 kV is completed. The transformers will no longer be located at Hudson Substation as it is slated for removal. Instead the transformers will be located within QNSLs railway yard in the Labrador City Industrial Park. The supply will come off of two phases of L16 (i.e. line-to-line), and will be connected to the line section of L16 that is operated by the QNS&L Railway. The section of the QNS&L line that is located between the Hudson and the new QNS&L substation is to be removed.

1.4 46 KV SUBTRANSMISSION FEEDER UPGRADES

The present 46 kV system in Labrador City consists of a single 46 kV line (L32) from Wabush Terminal Station to the Townsite Switching Station, and three radial feeders (L9, L10, and L11) which serve the 46/4.16 kV substations. A second feeder from Wabush Terminal Station (L33) runs to Fermont, Quebec. There are tie points on this line near the Townsite, Hudson, Vanier, and Harrie Lake Substations. This forms a quasi-looped system. However utilizing this loop requires manual switching operations by the regions line crews, and since only a single feed runs into the individual substations the effectiveness of this configuration is somewhat limited.

To improve the operability of this system, the 46 kV subtransmission system will be upgraded to a looped system similar to the electrical systems in Corner Brook, and Stephenville. At least two feeds will be brought into each substation, with control provided by the high voltage breakers in the substations.

The line to ground fault levels on the 46 kV system in Labrador West are limited to approximately 24 MVA (300 A). This is for purposes of protecting the machinery at the mine sites. Additionally the ground resistivity in the region is rather high; therefore to adequately protect the system from line-to-ground faults it will be necessary to operate the system as an open loop.

Since two substations will remain in the 25 kV system, a single tie line will be constructed between Vanier Substation and Quartzite Substation.

The work to upgrade the 46 kV subtransmission system to an open loop will involve the following:

- Construct approximately 300 m of 46 kV (3ART Structure Type, 477 ASC – Cosmos) line from the Quartzite Substation to the nearest point on L9 (near the intersection of Cavendish Crescent and Bartlett Drive).
- Remove the section of L9 between the new tap to the substation and the existing tap to the substation (two to three spans).
- Under contingency the 266.8 ACSR Partridge conductor on L9 does not have sufficient capacity to supply the Labrador City Distribution and Fermont. Therefore this line (~4.5 km) will be reconductored to 477 ASC Cosmos.
- Construct approximately 450 m of 46 kV (3ART Structure Type, 477 ASC – Cosmos) line from the Vanier Substation to the nearest point on L33 (near the Beverley Lake Pumping Station where L11 and L33 separate).
- Open and remove switch TS11-D12. Jumper over switch TS11WA33-2 and remove the tie switch. The Vanier Substation will be fed via L33.
- Remove the section of L33 between the two taps to the Vanier Substation (approximately one span).
- Purchase and install three disconnect switches on L33 at the Fermont-Harrie Lake tap. The switches may be gang operated and capable of carrying up to 81 MW of power.
- Purchase and install a 46 kV disconnect on L33 just after the tie switch WA33WA36-1.

To enable energizing of L33 while still remaining isolated from Fermont. The border switch WA33-D3 will be kept normally open. The health of this line will be monitored as far as the border switch by the breaker at Vanier Substation, VA33-CB1. It will be necessary to inform Hydro Quebec of the proposed new operating arrangement, so they can arrange for monitoring the health of the line at their end.

Upon completion of the above noted work on the 46 kV System the following equipment is to be removed:

- Remove 46 kV disconnects and tie switches TS11WA33-1, TS9TS10-1, TS11-D2, TS11-D12, TS11WA33-2, TS9-D5, TS9WA33-1, WA33-D2.
- Remove L11 and all associated hardware.
- Remove L10 and all associated hardware.

1.5 ASSET RETIREMENTS

Upon completion of this work the following assets are to be retired:

- Remove 46 kV disconnects and tie switches TS11WA33-1, TS9TS10-1, TS11-D2, TS11-D12, TS11WA33-2, TS9-D5, TS9WA33-1, WA33-D2.
- Remove L10 and all associated hardware.
- Remove L11 and all associated hardware.
- Feeder L9 is to be retired, this asset will be transferred to L32.
- Remove the Bartlett Substation and all associated hardware.
- Remove the Hudson Substation and all associated hardware.
- Remove the Harrie Lake Substation and all associated hardware.
- Remove the double circuit on BA4 and BA5.

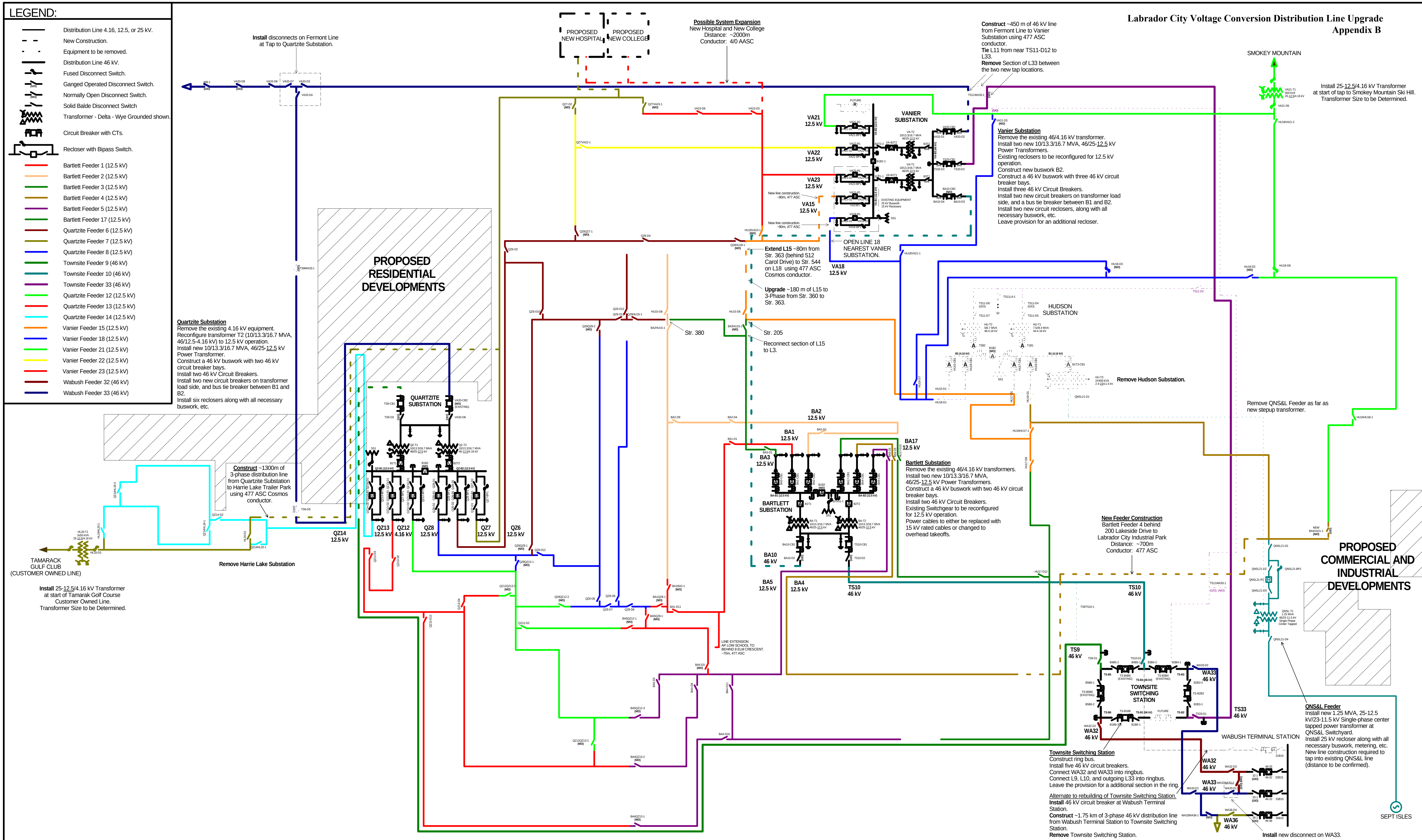
APPENDIX F

12.5 KV DISTRIBUTION UPGRADING PLAN

SINGLE LINE DIAGRAMS

F1

LABRADOR CITY 12.5 KV CAPITAL PLAN 2007



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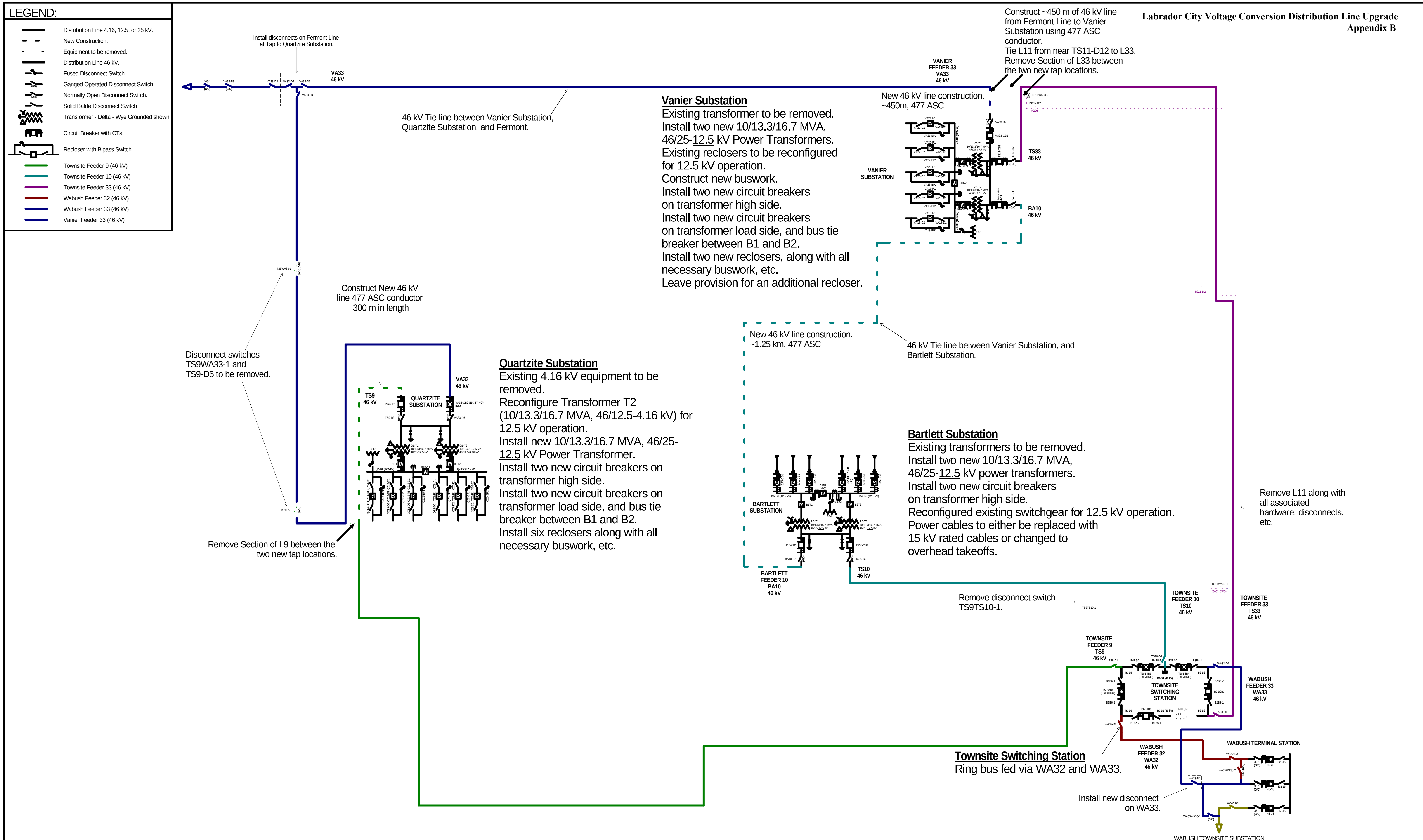
F2

PROPOSED 46 KV SUB-TRANSMISSION UPGRADES

Labrador City Voltage Conversion Distribution Line Upgrade
Appendix B



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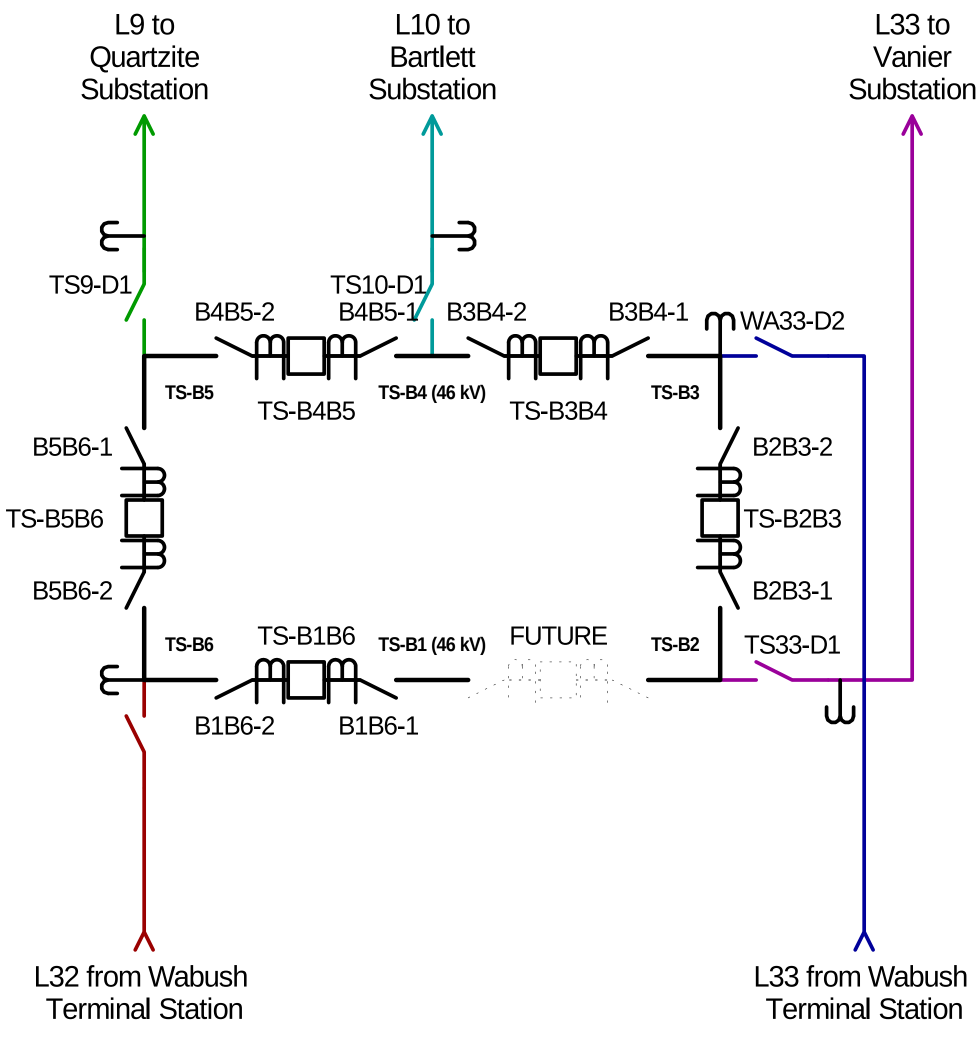
F3

PROPOSED TOWNSITE SWITCHING SUBSTATION

PROPOSED
TOWNSITE SWITCHING SUBSTATION



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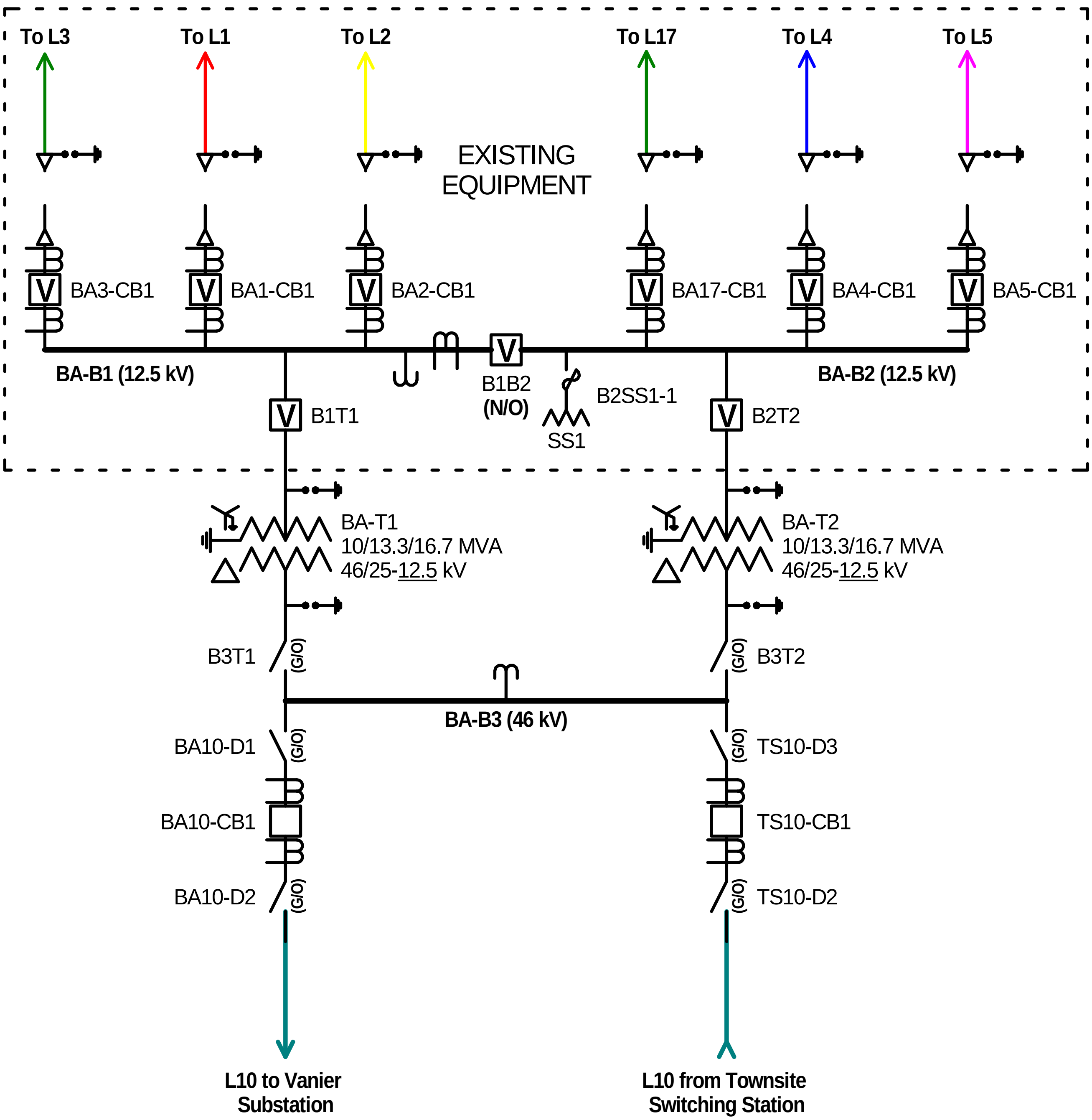
		PROTECTION:	--	FILE: PROPOSED TOWNSITE SWITCHING STATION.SKF

F4

PROPOSED BARTLETT 12.5 KV SUBSTATION

PROPOSED BARTLETT 12.5 kV SUBSTATION



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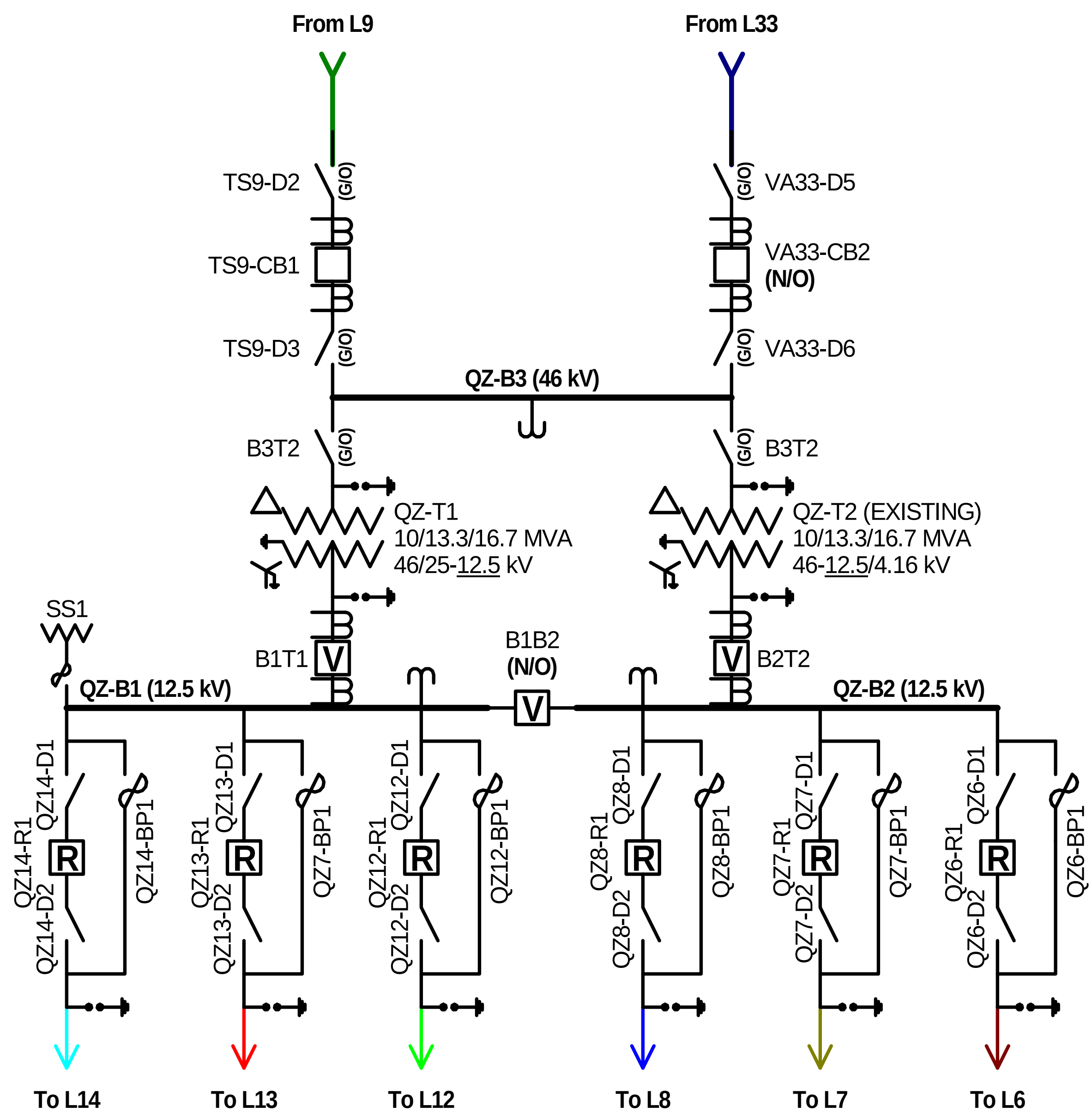
F5

PROPOSED QUARTZITE 12.5 KV SUBSTATION

PROPOSED QUARTZITE 12.5 kV SUBSTATION



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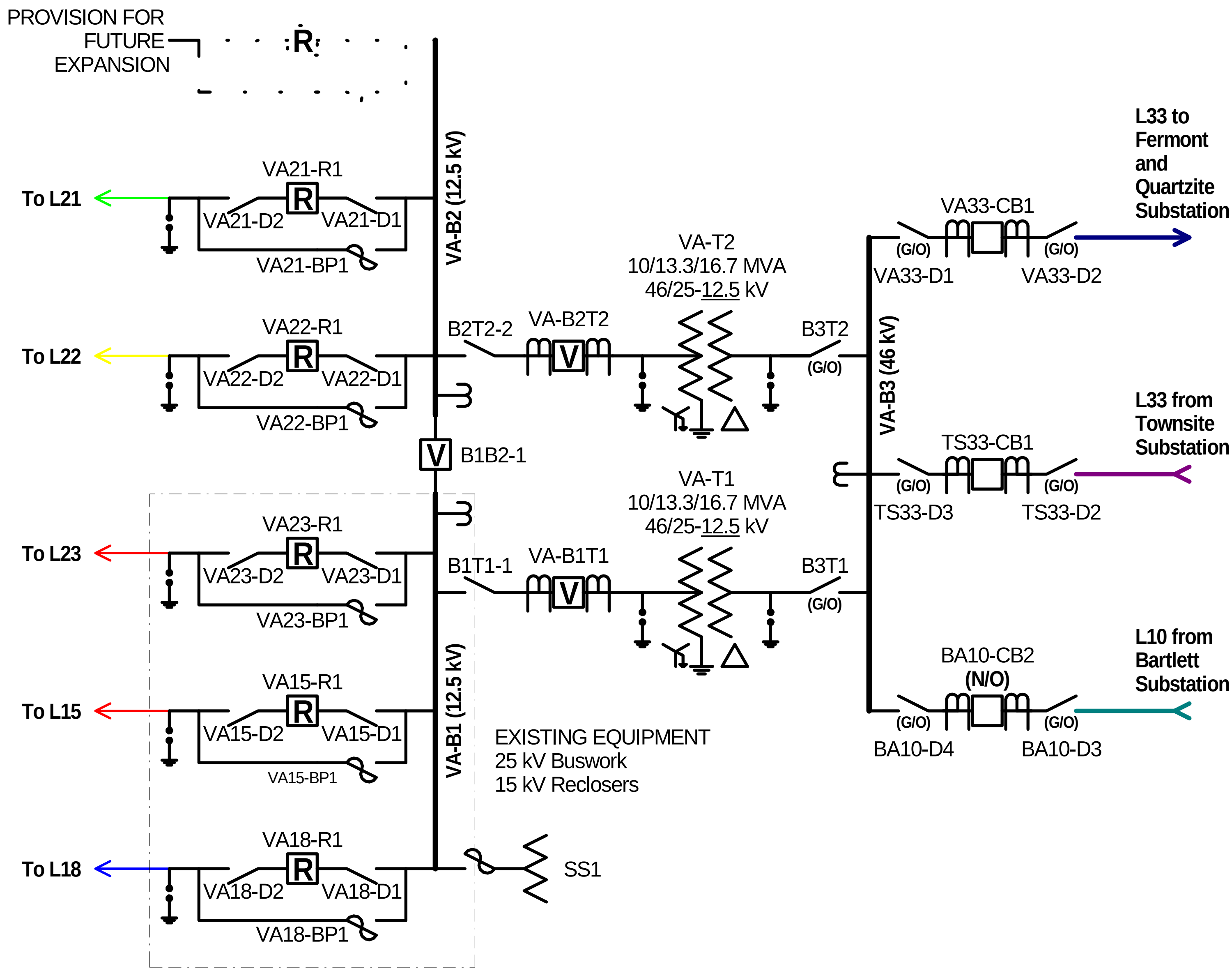
F6

PROPOSED VANIER 12.5 KV SUBSTATION

PROPOSED VANIER 12.5 kV SUBSTATION



SYS PLANNING:	CRW	SHEET 1 OF 1
SYS OPERATIONS:	--	DATE: NOV 6, 2007
TERM DESIGN:	--	DRAWN BY: CRW
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APPENDIX G

SCOPE OF WORK FOR THE 12.5 KV UPGRADING PLAN

SCOPE OF WORK FOR THE 12.5 KV UPGRADING PLAN

Due to the complexity of this plan and the amount of work required to implement it, it is recommended the upgrades be performed over a number of years. The first phase of the plan will be the upgrading of the Vanier Substation and the portion of Quartzite Substation associated with T2 to 12.5 kV, the conversion of feeders L6, L7, L8, L21, L22, and L23 to 12.5 kV, the construction of a 46 kV tie line between Vanier and Quartzite Substation, and reconnecting the Vanier Substation to L33. The second phase would include upgrading the remaining half of the Quartzite Substation to 12.5 kV, construction of a distribution line from Quartzite Substation to Harrie Lake Substation, converting feeders L12, L13, L14, L19, and L20 to 12.5 kV, and the removal of the Harrie Lake Substation from service. The third phase of upgrading will include the following work: Constructing a 46 kV tie line between the Bartlett Substation and the Vanier Substation. Converting feeders L1, L2, L3, L4, and L5 to 12.5 kV, and upgrading the Bartlett Substation to 12.5 kV, upon conversion of Bartlett Substation, feeders L15, L16, L17, and L18 will be converted to 12.5 kV and the Hudson Substation could then be removed from service. The final phase of the upgrades will involve reconstruction of the Townsite Switching Station to a ring bus. Once completed the Bartlett Substation, Vanier Substation, and Quartzite Substation would remain in service, and the Harrie Lake Substation and Hudson Substation would be removed.

All construction associated with the 12.5 kV upgrading plan is to be built to 25 kV standards. This will allow the provision for a future conversion of the 12.5 kV system to 25 kV should phenomenal load growth occur.

Note max foreseeable fault levels for breaker sizing are provided. This takes the following upgrades and conditions into consideration. Maximum foreseeable fault levels include the installation of the third synchronous condenser at Wabush Terminal Station, a third 230 kV circuit into Labrador West, all 46 kV tie switches/breakers closed, and the 25 kV bus tie breaker in the substations closed. Transformer impedances were assumed to be approximately 6 %, similar to Quartzite Transformer No. 2.

1.1 VANIER SUBSTATION

Extend and Upgrade the Vanier Substation:

- Extend the Vanier Substation Northward.
- Remove the existing 4.16 kV equipment.
- Install a new control building of suitable size.
- Install new transformer pad.
- Construct a 46 kV box structure complete with 46 kV bus and three breakers bays.

- Purchase and install 3x46 kV breakers.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 12502 A, 996 MVA.
    - Continuous Current Rating: 838 A.
- Purchase and install two 46/25-12.5 kV, 10/13.3/16.7 MVA power transformers.
  - Transformers are to be fitted with fixed taps having 2 raise and 2 lower at 2.5 % per tap.
- Reconfigure the existing reclosers for 12.5 kV operation.
- Construct a 25 kV box structure, adjacent to the existing structure.
  - The structure is to contain a 12.5 kV bus, and three 25 kV class breaker bays.
  - The structure is to be laid out such that sufficient space is available for a bus tie breaker, and the transformer load side breakers.
- Purchase three new 12.5 kV circuit breakers.
  - Two of the breakers will be installed between the transformer load side bushings and the 12.5 kV bus.
  - The third breaker will be installed as a bus-tie breaker between B1 and B2.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 11155 A, 483 MVA.
    - Continuous Current Rating: 916 A.
- Purchase and install two new feeder breakers, along with all necessary buswork, disconnects, etc.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 11155 A, 483 MVA.
  - Continuous Current Rating: 560 A.
- Leave the provision for an additional breaker.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.
- A total of eight 838 A 46 kV disconnect switches will be required.
- A total of two 916 A 25 kV class disconnects will required for isolation of the power transformer and low voltage circuit breaker.
- A total of fifteen 560 A 25 kV class disconnects will required for isolation and the recloser bypass switches.

1.2 QUARTZITE SUBSTATION

Rebuild and upgrade the Quartzite Substation:

- Remove the existing 4.16 kV equipment.
- Install a new control building of suitable size.
- Construct a 46 kV box structure complete with 46 kV bus and two breakers bays.
- Purchase and install two 46 kV breakers.

- As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 9739 A, 776 MVA.
    - Continuous Current Rating: 838 A.
- Purchase and install one 46/25-12.5 kV, 10/13.3/16.7 MVA power transformer along with all associated buswork, isolation, etc.
  - Transformer is to be fitted with fixed taps having 2 raise and 2 lower at 2.5 % per tap.
- Reconfigure the windings on Transformer T2 (10/13.3/16.7 MVA, 46/12.5-4.16 kV) to 12.5 kV operation.
- Construct two 25 kV box structures.
  - The structure is to contain a 12.5 kV bus, and three 25 kV class breaker bays.
  - The structure is to be laid out such that sufficient space is available for a bus tie breaker, and the transformer load side breakers.
- Purchase three new 12.5 kV circuit breakers.
  - Two of the breakers will be installed between the transformer load side bushings and the 12.5 kV bus.
  - The third breaker will be installed as a bus-tie breaker between B1 and B2.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 10459 A, 453 MVA.
    - Continuous Current Rating: 916 A.
- Purchase and install six new feeder breakers, along with all necessary buswork, disconnects, etc.
  - As a minimum the breakers should have the following capabilities:
    - Symmetrical Interrupting Rating: 10459 A, 453 MVA.
    - Continuous Current Rating: 560 A.
- Leave the provision for an additional breaker.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.
- A total of six 838 A 46 kV disconnect switches will be required.
- A total of two 916 A 25 kV class disconnects will required for isolation of the power transformer and low voltage circuit breaker.
- A total of eighteen 560 A 25 kV class disconnects will required for isolation and the recloser bypass switches.

1.3 BARTLETT SUBSTATION

Upgrade the Bartlett Substation:

- Remove the existing 46/4.16 kV power transformers and associated equipment.
- Install a new control building of suitable size if there is insufficient space in the existing switchgear building to accommodate the necessary controls associated with the 46 kV breakers.

- Construct a 46 kV box structure complete with 46 kV bus and two breaker bays.
- Purchase and install two 46 kV breakers.
    - As a minimum the breakers should have the following capabilities:
        - Symmetrical Interrupting Rating: 13353 A, 1064 MVA.
        - Continuous Current Rating: 838 A.
- Purchase and install two 46/25-12.5 kV, 10/13.3/16.7 MVA power transformers.
    - Transformers are to be fitted with fixed taps having 2 raise and 2 lower at 2.5 % per tap.
- Reconfigure the existing switchgear to operate at 12.5 kV.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.
- A total of six 838 A 46 kV disconnect switches will be required.
- Replace the existing 5 kV power cables 25 kV rated power cables.

1.4 TOWNSITE SWITCHING STATION

Rebuild the Townsite Switching Station:

- Construct a ring bus at Townsite Switching Station.
- Install a new control building of suitable size.
- Purchase and install five 46 kV breakers.
    - As a minimum the breakers should have the following capabilities:
        - Symmetrical Interrupting Rating: 15581 A, 1241 MVA.
        - Continuous Current Rating: 1048 A.
- Each breaker will require two disconnect switches having a minimum continuous current rating of 1027 A. In total, ten disconnects will be required for purposes of isolating breakers for maintenance.
- Leave the provision for a sixth breaker and feeder takeoff in the ring bus.
- For the purposes of isolation, install a disconnect switch at the terminations of each feeder at the Townsite Switching Station. Five disconnects in total will be required, each is to have capacity to carry up to 1048 A of current.
- Purchase and install all necessary metering and RTUs to provide full SCADA capabilities to EMS control.

1.5 DISTRIBUTION FEEDER UPGRADES

1.5.1 Line Extensions/Upgrades

- Construct an approximately 80 m 3Φ line extension from structure 544 on L18 to structure 383 on L15 (behind 512 Carol Drive).
- Upgrade the section of line between structure 205 and structure 383 on L15 to 3Φ (approximately 60 m).

- Construct an approximately 70 m 3Φ line extension from the end of L1 near the A.P. Low School to behind 8 Elm Crescent.
- Construct an approximately 700 m 3Φ line extension from behind 200 Lakeside Drive to L16 in the Labrador City Industrial Park.
- Construct an approximately 1300 m 3Φ line extension from the Quartzite Substation to the four-pole structure at the Harrie Lake Substation.

The total required line extensions and upgrades to the low voltage distribution system is approximately 2.2 km. Since the system will be designed for contingency switching ability, and to remain consistent with the existing infrastructure, the type of conductor to be used for the above noted upgrades should be 477 kcmil ASC Cosmos.

1.5.2 Feeder Reconfigurations

Since the number of feeders will be reduced, some of the existing lines will have to be reconfigured. Most of this work will involve transferring existing feeders or sections of feeders to new 12.5 kV lines. The majority of the reconfigurations can be done using existing disconnects and tie switches. Load and Voltage Study results are required before feeder configurations can be finalized. The following describes a proposed reconfiguration based on the information currently available to provide roughly equal loading on each line. This work assumes that the line construction and upgrades described in the preceding section have already been completed, and that the voltage conversions on the respective line sections will be completed at the time they are transferred.

- Transfer the section of feeder BA5 bounded by BA5-D3 and BA5QZ12-1 to feeder BA1 via a new line section between AP Low School and behind 8 Elm Crescent.
- Open L15 at structure 380 on both the source and load sides. Close tie switch BA2HU15-1 to transfer the section of feeder HU15 connected through disconnect HU15-D6 to feeder BA2.
- Transfer the section of feeder HU15 between structure 205 and structure 380 to feeder BA3. The tie switch BA3HU15-1 is to remain in its current state.
- Transfer feeder HU16 (as far as structure 1439) to feeder BA4 via the new line section from structure 235 to structure 1446 behind UAP.
- Open feeder HU16 and install a normally open disconnect at structure 1439.
- Transfer the section of feeder BA4 west of structure 223 to feeder BA5 by jumpering the double circuit together beyond that point.
- Transfer feeder HU17 to Bartlett Substation by closing breaker BA22HU17-CB1.
- Transfer the section of feeder HU15 bounded by tie switch QZ6HU15-1 and structure 380 to feeder QZ6 by closing tie switch QZ6HU15-1.
- Transfer feeder HL20 to feeder QZ7 by the new line from QZ7 near Quartzite Substation to the Harrie Lake Trailer Park.

- Transfer feeder HL19 to feeder QZ14 by opening the disconnect HL19-D1 and closing the tie switch QZ14HL19-1.
-
- Transfer feeder HU15 to the new feeder VA15 by closing the disconnect HU15-D6.
- Transfer the section of feeder HU17 as far as HU17-D10 to the new feeder VA15 by opening disconnect HU17-D10 and jumpering the lines near the Hudson Substation.
- Transfer the feeder HU18 to the new feeder VA18 from Vanier Substation to Hudson Substation.
- Transfer a section of feeder VA21 to feeder VA18 by opening the disconnect VA21-D3 and closing the tie switch HU18VA21-1.
- Transfer the section of feeder HU18 (the industrial park) to feeder VA21 by opening the disconnect HU18-D2, and closing the tie switch HU18VA21-2.
- Transfer the remainder of feeder HU16 to the new feeder VA21 by closing the tie switch HU16HU18-1 and opening the newly installed disconnect at structure 1439.
- Open disconnect QZ7-D2. Reconnect the section of QZ7 from Centennial Drive to Churchill Street to feeder VA22 by closing tie switch QZ7VA22-1.

The above work will complete the conversion and reconfiguration of the 4.16 kV distribution feeders to the new 12.5 kV distribution system. The reconfiguration will off load the Hudson and Harrie Lake Substations and will allow them to be removed from service.

1.5.3 Primary and Underground Services

There are a number of primary, underground, and customer owned services in Labrador City. The system will have to be surveyed to determine the exact number. The previous plan determined that most of the customers are willing to be switched to overhead services. However, as this would involve replacement of underground cables, removal of padmount and indoor transformers, and replace ment of service entrances, completely converting the services to overhead may prove to be costly. An alternate solution to serve these customers is to install pole mounted 25/4.16 kV step-down transformers and continue to supply these customers at 4.16 kV, therefore the underground services could remain intact.

The Smokey Mountain line is a section of feeder Vanier 21, it runs from the Beverly Lake Water Supply to the Smokey Mountain Ski Hill. Much of this line is not constructed to NL Hydro Standards and to convert it would require significant upgrading of approximately 5.7 km of distribution line. To lower the cost of conversions a step down transformer should be installed so that the line can continue to be operated at 4.16 kV.

The Labrador City Mall is fed by five underground primary services which run under the mall parking lot to indoor transformers (1 MVA) inside the building. Pole/platform mounted transformers should be installed to avoid complete replacement of the existing customer owned equipment.

1.5.4 QNS&L Railway Feeder

The Quebec North Shore and Labrador Railway (QNS&L) line is a 23/11.5 kV single-phase center-tapped customer owned line. The line runs from Labrador City, NL to Sept Isles, PQ, and is constructed with two hot conductors and uses a ground return path for phase to neutral connected loads. Currently this line is fed from the Hudson Substation via a pair of 2.4/23-11.5 kV single-phase power transformers (400 kVA each). The center-tap connection on the transformers is grounded to provide the neutral return path for the line.

The line is metered at the substation and demand readings show this line has exceeded the capacity of the transformers by 19 % of the rated nameplate capacity. The load on this customer owned line will require a capacity increase. It is recommended to replace the existing transformers with two 25-12.5 / 23-11.5 kV, 1 MVA units once the conversion of L16 to 12.5 kV is completed. The transformers will no longer be located at Hudson Substation as this substation is slated for removal. Instead the transformers will be located within QNSLs own yard in the Labrador City Industrial Park. The supply will come off of two phases of L16 (i.e. line-to-line), and will be connected to the line section of L16 that is operated by the QNS&L Railway. The section of the QNS&L line that is located between the Hudson and the new substation is to be removed.

1.6 46 KV SUBTRANSMISSION FEEDER UPGRADES

The present 46 kV system in Labrador City consists of a single 46 kV line (L32) from Wabush Terminal Station to the Townsite Switching Station, and three radial feeders (L9, L10, and L11) which serve the 46/4.16 kV substations. A second feeder from Wabush Terminal Station (L33) runs to Fermont, Quebec. There are tie points on this line near the Townsite, Hudson, Vanier, and Harrie Lake Substations. This forms a quasi-looped system. However utilizing this loop requires manual switching operations by line crews, and since only a single feed runs into the individual substations the effectiveness of this configuration is somewhat limited.

To improve the operability of this system, the 46 kV subtransmission system will be upgraded to a looped system similar to the electrical systems in Corner Brook, and Stephenville. At least two feeds will be brought into each substation, with control provided by the high voltage breakers in the substations.

The line to ground fault levels on the 46 kV system in Labrador West are limited to approximately 24 MVA (300 A). This is for purposes of protecting the machinery at the mine sites. Additionally the ground resistivity in the region is rather high; therefore to adequately protect the system from line-to-ground faults it will be necessary to operate the system as an open loop.

Since three substations will be retained tie lines will be constructed between Bartlett substation and Vanier Substation, and between Vanier Substation and Quartzite Substation.

The work to upgrade the 46 kV subtransmission system to an open loop will involve the following:

- Construct approximately 300 m of 46 kV (3ART Structure Type, 477 ASC – Cosmos) line from the Quartzite Substation to the nearest point on L9 (near the intersection of Cavendish Crescent and Bartlett Drive).
- Remove the section of L9 between the new tap to the substation and the existing tap to the substation (two to three spans).
- Construct approximately 450 m of 46 kV (3ART Structure Type, 477 ASC – Cosmos) line from the Vanier Substation to the nearest point on L33 (near the Beverley Lake Pumping Station where L11 and L33 separate).
- Open and remove switch TS11-D12. Jumper over switch TS11WA33-2 and remove the tie switch. The Vanier Substation will be fed via L33.
- Remove the section of L11 between the two taps to the Vanier Substation (approximately one span).
- Construct approximately 1.25 km of 46 kV line (3ART Structure Type, 477 ASC – Cosmos) between the Bartlett and Vanier Substations. The area between Bartlett and Vanier Substation has already built up, therefore it may necessary to over-build this line on the existing low voltage feeders L3, and L15 in order to obtain a route between the two.
- Purchase and install three disconnect switches on L33 at the Fermont-Harrie Lake tap. The switches may be gang operated and capable of carrying up to 59 MW of power.
- Purchase and install a 46 kV disconnect on L33 just after the tie switch WA33WA36-1.

To enable energizing of L33 while still remaining isolated from Fermont. The border switch WA33-D3 will be kept normally open. The health of this line will be monitored as the border by the breaker at Vanier Substation, VA33-CB1. It will be necessary to inform Hydro Quebec of the proposed new operating arrangement, so that they can arrange for monitoring the health of the line at their end.

Upon completion of the above noted work on the 46 kV System the following equipment is to be removed:

- Remove 46 kV disconnects and tie switches TS11WA33-1, TS9TS10-1, TS11-D2, TS11-D12, TS11WA33-2, TS9-D5, TS9WA33-1, WA33-D2.

- Remove L11 and all associated hardware.

1.7 ASSET RETIREMENTS

Upon completion of this work on the 46 kV System the following assets are to be retired:

- Remove 46 kV disconnects and tie switches TS11WA33-1, TS9TS10-1, TS11-D2, TS11-D12, TS11WA33-2, TS9-D5, TS9WA33-1, WA33-D2.
- Remove L11 and all associated hardware.
- Remove the Hudson Substation and all associated hardware.
- Remove the Harrie Lake Substation and all associated hardware.
- Remove the double circuit on BA4 and BA5.

APPENDIX H

TRANSFORMER SURVEY

Parent Number	SUBSTATION	FEEDER	Item #	T-NUMBER	Serial #	Description	LOCATION	Remarks Line 2	M Class	M Year	HIGH VOLTAGE	LOW VOLTAGE
270704	BARTLETT	1	258966	T-12220	435745	TRANSFORMER,25kVA	MCMANUS PK LOT - BRISTOL	UNIQUE POLE #: 13593691	WES		2400	120/240
270704	BARTLETT	1	252248	T-12222	LL13769	TRANSFORMER,100kVA	503 BARTLETT	UNIQUE POLE : 13522060	WES	84	2400	120/240
270704	BARTLETT	1	248892	T-09864	ATL1307-9	TRANSFORMER,100kVA	527 BARTLETT	UNIQUE POLE #: 13521723	MAE	92	2400	120/240
270704	BARTLETT	1	252220	T-11303	A1866-25	TRANSFORMER,25kVA	MENIHEK/LAKESIDE	UNIQUE POLE #:	MEC	95	2400	120/240
270704	BARTLETT	1	252225	T-12221	LC25241	TRANSFORMER,100kVA	516- 518 BRISTOL	UNIQUE POLE #: 13521817	WES	77	2400	
270704	BARTLETT	1	252246	T-11050	LG25001	TRANSFORMER,50kVA	500 BARTLETT	UNIQUE POLE #: 13554890	WES	81	2400	120/240
270704	BARTLETT	1	252236	T-12219	LD53587	TRANSFORMER,15kVA	600 DINEEN PARKING LOT	UNIQUE POLE #: 13554796	WES	78	2400	120/240
270704	BARTLETT	1	263626	T-12201	2-179772	TRANSFORMER,75kVA	600 DINEEN	UNIQUE POLE #: 13558112	FPT	80	2400	347/600
270704	BARTLETT	1	263627	T-12202	2-179774	TRANSFORMER,75kVA	600 DINEEN	UNIQUE POLE#: 13558112	FPT	80	2400	347/600
270704	BARTLETT	1	263628	T-12200	2-179773	TRANSFORMER,75kVA	600 DINEEN	UNIQUE POLE #: 13558112	FPT	80	2400	347/600
270704	BARTLETT	1	252258	T-11010	541956	TRANSFORMER,50kVA	DINEEN EMBASSY PLG	UNIQUE NO: 13555979	WES		2400	120/240
270706	BARTLETT	2	248921	T-10944	LFI7698	TRANSFORMER,100kVA	APT 420 AVALON	UNIQUE POLE #: 13575877	WES	80	2400	
270706	BARTLETT	2	248921	T-10944	LFI7698	TRANSFORMER,100kVA	APT 420 AVALON	UNIQUE POLE #: 13575877	WES	80	2400	120/240
270706	BARTLETT	2	248902	T-10938	LL11101	TRANSFORMER,75kVA	707 FIELD	UNIQUE POLE #: 13508796	WES	84	2400	120/240
270706	BARTLETT	2	248908	T-10942	LJ33018	TRANSFORMER,75kVA	208 HOWLEY	UNIQUE POLE #: 13505617	WES	82	2400	120/240
270706	BARTLETT	2	248924	T-12204	937344	TRANSFORMER,75kVA	427 GRENFELL	UNIQUE POLE #: 13576020	WES	75	2400	120/240
270706	BARTLETT	2	248906	T-10941	L0107-2	TRANSFORMER,100kVA	714 STIRLING	UNIQUEPOLE #: 13505429	CAR	83	2400	120/240
270706	BARTLETT	2	248909	T-10947	LC25242	TRANSFORMER,100kVA	F110 CARTIER	UNIQUE POLE: 13593597	WES	77	2400	120/240
270706	BARTLETT	2	248910	T-10952	L0107-1	TRANSFORMER,100kVA	709 ROCHE (BEHIND)	UNIQUE POLE #: 13505241	CAR	83	2400	120/240
270706	BARTLETT	2	248922	T-10943	LC25243	TRANSFORMER,100kVA	APT 440 AVALON	UNIQUE POLE #: 13575783	WES	77	2400	120/240
270706	BARTLETT	2	248934	T-12208	LC25247	TRANSFORMER,100kVA	130 MATTHEW	UNIQUE POLE #:: 13506518	WES	77	2400	120/240
270706	BARTLETT	2	248923	T-12203	467556	TRANSFORMER,50kVA	APT BLDG 400 AVALON	UNIQUE POLE #: 13575689	WES		2400	120/240
270706	BARTLETT	2	272405	T-14044	A2401-59	TRANSFORMER,50kVA	717 FIELD	UNIQUE POLE #: 13508890	MAE	02	2400	
270706	BARTLETT	2	252583	T-09852	A1298-6	TRANSFORMER,100kVA	BALLARD BLDG		MAE	92	2400	347/600
270706	BARTLETT	2	252584	T-09854	A1298-7	TRANSFORMER,100kVA	350 AVALON	UNIQUE POLE #:	MAE	92	2400	347/600
270706	BARTLETT	2	252585	T-09858	A1298-3	TRANSFORMER,100kVA	350 AVALON	UNIQUE POLE #:	MAE	92	2400	347/600
270706	BARTLETT	2	258965	T-11704	A1932-11	TRANSFORMER,25kVA	YOUTH CENTER	UNIQUE POLE #: 13572892	MEC	96	2400	120/240
270706	BARTLETT	2	248894	T-7997	ATL1306-10	TRANSFORMER,50kVA	222 MATTHEW	UNIQUE POLE #: 13506048	MEC	92	2400	120/240
270706	BARTLETT	2	253153	T-12206	760436	TRANSFORMER,167kVA	MCMANUS	UNIQUE NO: 13522154	WES	72	2400	120/240
270706	BARTLETT	2	248903	T-10940	937560	TRANSFORMER,100kVA	718 ROCHE	UNIQUE POLE #: 13509409	WES	75	2400	120/240
270706	BARTLETT	2	248938	T-12209	LC25246	TRANSFORMER,100kVA	112 MATTHEW	UNIQUE POLE #: 13506706	WES	77	2400	120/240
270706	BARTLETT	2	248919	T-10958	LJ33019	TRANSFORMER,75kVA	407 GRENFELL	UNIQUE POLE #: 13576302	WES	82	2400	120/240
270706	BARTLETT	2	248933	T-12207	937341	TRANSFORMER,75kVA	132 MATTTHEW	UNIQUE POLE #: 13506424	WES	75	2400	120/240
270710	BARTLETT	3	253211	T-10992	LF26215	TRANSFORMER,50kVA	BEHIND CLSC	UNIQUE POLE #: 13591795	WES	80	2400	120/240
270710	BARTLETT	3	253211	T-10992	LF26215	TRANSFORMER,50kVA	BEHIND CLSC	UNIQUE POLE #: 13591795	WES	80	2400	120/240
270710	BARTLETT	3	258967	T-12216	LC38198	TRANSFORMER,50kVA	ROYAL THEATRE (BANK)	UNIQUE POLE #: 13592126	WES		2400	600
270710	BARTLETT	3	253196	T-12215	LB24711	TRANSFORMER,167kVA	PENTECOSTAL CHURCH, HUDSON	UNIQUE POLE #: 13590606	WES	76	2400	120/208
270710	BARTLETT	3	253201	T-12214	LB24710	TRANSFORMER,167kVA	610 HUDSON	UNIQUE NO: 13590606	WES	76	2400	120/240
270710	BARTLETT	3	253202	T-12213	LB24712	TRANSFORMER,167kVA	610 HUDSON	UNIQUE NO: 13590606	WES	76	2400	120/208
270710	BARTLETT	3	257862	T-12674	T3060-10	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-CENTRAL	UNIQUE POLE #: 20613343	MEC	01	2400	347
270710	BARTLETT	3	262515	T-12670	T3060-13	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-WESTERN	UNIQUE POLE # 20613249	MAE	01	2400	347/600
270710	BARTLETT	3	262516	T-12671	T3060-14	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-WESTERN	UNIQUE POLE #: 20613249	MEC	01	2400	347/600
270710	BARTLETT	3	262517	T-12678	T3060-11	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-WESTERN	UNIQUE POLE#: 20613249	MEC	01	2400	347/600
270710	BARTLETT	3	253221	T-10754	951038437	TRANSFORMER,100kVA	308 HUDSON	UNIQUE NO: 13592032	CME	95	2400	120/240
270710	BARTLETT	3	258968			TRANSFORMER,50kVA	SCHOOL LANE/GRENFELL	UNIQUE NO: 13592126	WES		2400	600
270710	BARTLETT	3	253224	T-10945	2-34797	TRANSFORMER,25kVA	REAR OF CATHOLIC CHURCH	UNIQUE POLE #: 13579857	WES		2400	120/240
270710	BARTLETT	3	253213	T-10946	LJ31902	TRANSFORMER,100kVA	PENTECOSTAL CHURCH HOUSE	UNIQUE POLE #: 13590700	WES	82	2400	120/240
270710	BARTLETT	3	253249	T-10964	704640	TRANSFORMER,50kVA	BEHIND CLSC	UNIQUE POLE #: 13591319	WES	79	2400	120/240
270710	BARTLETT	3	254793	T-10931	839835	TRANSFORMER,50kVA	UNITED CHURCH 703 HUDSON	UNIQUE POLE #: 13590894	WES	73	2400	120/240
270710	BARTLETT	3	258970	T-12844	LC38200	TRANSFORMER,50kVA	ROYAL THEATRE	UNIQUE POLE #: 13592126	WES		2400	600
270713	BARTLETT	4	249030	T-12217	LC25239	TRANSFORMER,100kVA	202 LAKESIDE	UNIQUE POLE #: 13557023	WES	77	2400	120/240
270713	BARTLETT	4	249049	T-12234	C886-12	TRANSFORMER,100kVA	710 TAMARACK	UNIQUE POLE #: 11629972	CAR	75	2400	120/240
270713	BARTLETT	4	249058	T-12238	C886-7	TRANSFORMER,100kVA	800 TAMARACK	UNIQUE POLE #:: 11629784	CAR	75	2400	120/240
270713	BARTLETT	4	249060	T-12239	C886-3	TRANSFORMER,100kVA	790 TAMARACK	UNIQUE POLE #: 11629690	CAR	75	2400	120/240
270713	BARTLETT	4	249080	T-12241	C886-16	TRANSFORMER,100kVA	756 TAMARACK	UNIQUE POLE #: 11623056	CAR	75	2400	120/240
270713	BARTLETT	4	249085	T-12243	C886-14	TRANSFORMER,100kVA	750 TAMARACK	UNIQUE POLE #: 11629596	CAR	75	2400	120/240
270713	BARTLETT	4	249044	T-12230	934116	TRANSFORMER,167kVA	526 TAMARACK	UNIQUE POLE #: 11625898	WES	75	2400	120/240
270713	BARTLETT	4	249088	T-12262	LA18905	TRANSFORMER,167kVA	307 TAMARACK	UNIQUE POLE #:	WES	70	2400	120/240
270713	BARTLETT	4	249023	T-10980	L130931	TRANSFORMER,50kVA	713 TAMARACK	UNIQUE POLE #: 13546220	WES	80	2400	120/240
270713	BARTLETT	4	249023	T-10980	L130931	TRANSFORMER,50kVA	713 TAMARACK	UNIQUE POLE #: 13546220	WES	80	2400	120/240
270713	BARTLETT	4	249046	T-12231	937335	TRANSFORMER,167kVA	602 TAMARACK	UNIQUE POLE #: 11626041	WES	75	2400	120/240
270713	BARTLETT	4	249089	T-12263	LA18898	TRANSFORMER,167kVA	325 TAMARACK	UNIQUE POLE #:	WES	76	2400	120/240
270713	BARTLETT	4	249090	T-12264	LA18904	TRANSFORMER,167kVA	411 TAMARACK	UNIQUE POLE #:	WES	76	2400	120/240
270713	BARTLETT	4	249092	T-12265	934109	TRANSFORMER,167kVA	429 TAMARACK	UNIQUE POLE #:	WES	76	2400	120/240
270713	BARTLETT	4	249093	T-12276	934111	TRANSFORMER,167kVA	511 TAMARACK	UNIQUE POLE #:	WES	76	2400	120/240
270713	BARTLETT	4	249026	T-10983	LE30945	TRANSFORMER,50kVA	739 TAMARACK	UNIQUE POLE #: 13546032	WES	80	2400	120/240
270713	BARTLETT	4	249038	T-12226	LG25028	TRANSFORMER,100kVA	405 BARTLETT	UNIQUE POLE #: 13557687	WES	81	2400	120/240
270713	BARTLETT	4	248982	T-7981	LG29850	TRANSFORMER,75kVA	311 BARTLETT	UNIQUE POLE #: 13557305	WES	81	2400	120/240
270713	BARTLETT	4	274980	T-00974	61850.10	TRANSFORMER,75kVA	519 TAMARACK	UNIQUE POLE #: 13557969	ONA	94	2400	120/240
270713	BARTLETT	4	248984	T-10752	951039201	TRANSFORMER,100kVA	727 TAMARACK (BEHIND)	UNIQUEPOLE #: 13545795	CME	95	2400	120/240
270713	BARTLETT	4	248985	T-10755	951039200	TRANSFORMER,100kVA	433 TAMARACK	UNIQUE POLE #: 13557875	CME	95	2400	120/240
270713	BARTLETT	4	249029	T-10986	ATL1307-24	TRANSFORMER,100kVA	751 TAMARACK	UNIQUE POLE #: 13544894	MEC	92	2400	120/240
270713	BARTLETT	4	249035	T-12225	ATL1307-11	TRANSFORMER,100kVA	303 LAKESIDE	UNIQUE POLE #: 13558870	MEC	92	2400	120/240

270713	BARTLETT	4	262981	T-13149	A2401-40	TRANSFORMER,50kVA	735 TAMARACK	W/O# 583164	MEC	01	2400	120/240	
270713	BARTLETT	4	250363	T-12859	LJ31903	TRANSFORMER,100kVA	531 TAMARACK	UNIQUE POLE #: 13543423		82	2400	120/240	
270713	BARTLETT	4	249057	T-12237	C886-13	TRANSFORMER,100kVA	734 TAMARACK	UNIQUE POLE #: 11625516	CAR	75	2400	120/240	
270713	BARTLETT	4	249050	T-12235	C886-15	TRANSFORMER,100kVA	720 TAMARACK	UNIQUE POLE #: 11625328	CAR	75	2400	120/240	
270713	BARTLETT	4	249084	T-12242	C886-22	TRANSFORMER,100kVA	746 TAMARACK	UNIQUE POLE #: 11625610	CAR	75	2400	120/240	
270713	BARTLETT	4	249087	T-12244	C886-6	TRANSFORMER,100kVA	780 TAMARACK	UNIQUE POLE #: 11626605	CAR	75	2400	120/240	
270713	BARTLETT	4	249048	T-12233	C886-23	TRANSFORMER,100kVA	706 TAMARACK	UNIQUE POLE #: 11629878	CAR	75	2400	120/240	
270713	BARTLETT	4	249032	T-12218	718903	TRANSFORMER,50kVA	208LAKESIDE	UNIQUE POLE #: 13556880	WES		2400	120/240	
270713	BARTLETT	4	249041	T-12229	934110	TRANSFORMER,167kVA	430 TAMARACK	UNIQUE POLE #: 11627130	WES	75	2400	120/240	
270716	BARTLETT	5	249063	T-10972	LF35166	TRANSFORMER,100kVA	6 MAPLE	UNIQUE POLE #: 13553325	WES	81	2400	120/240	
270716	BARTLETT	5	249174	T-12257	73TH168001	TRANSFORMER,100kVA	669 TAMARACK	UNIQUE POLE #: 13543705	MEP		2400	120/208	
270716	BARTLETT	5	249178	T-12258	73TH168006	TRANSFORMER,100kVA	669 TAMARACK	UNIQUE POLE #: 13543705	MEP		2400	120/208	
270716	BARTLETT	5	249172	T-12256	73TH168004	TRANSFORMER,100kVA	669 TAMARACK	UNIQUE POLE #: 13543705	MEP		2400	120/208	
270716	BARTLETT	5	249152	T-12246	LF17694	TRANSFORMER,100kVA	409 DINEEN	UNIQUE POLE #: 13570708	WES	80	2400	120/240	
270716	BARTLETT	5	249187	T-12259	ATL1307-21	TRANSFORMER,100kVA	715 WILLOW	UNIQUE POLE #: 13542616	MEP		2400		
270716	BARTLETT	5	249149	T-10978	LE30949	TRANSFORMER,50kVA	731 WILLOW	UNIQUE POLE #: 13542146	WES	80	2400	120/240	
270716	BARTLETT	5	249150	T-10979	758297	TRANSFORMER,50kVA	706 BALSAM	UNIQUE POLE #: 13542052	WES	72	2400	120/240	
270716	BARTLETT	5	249153	T-12248	LC27711	TRANSFORMER,50kVA	6 ELM	UNIQUE POLE #: 13553513	WES	77	2400	120/208	
270716	BARTLETT	5	249154	T-12249	LC27717	TRANSFORMER,50kVA	6 ELM	UNIQUE POLE #: 13553513	WES	77	2400	120/208	
270716	BARTLETT	5	249155	T-12250	LC27659	TRANSFORMER,50kVA	6 ELM	UNIQUE POLE #: 13553513	WES	77	2400	120/208	
270716	BARTLETT	5	249016	T-10912	951037697	TRANSFORMER,75kVA	708/710 LAKESIDE	UNIQUE POLE #: 13543047	CME	95	2400	120/240	
270716	BARTLETT	5	249064	T-10973	951037701	TRANSFORMER,75kVA	17 JUNIPER	UNIQUEPOLE #: 13553043	CME	95	2400	120/240	
270716	BARTLETT	5	248986	T-09872	ATL1307-39	TRANSFORMER,100kVA	10 JUNIPER	UNIQUE POLE #: 13552706	MEC	92	2400	120/240	
270716	BARTLETT	5	248986	T-09872	ATL1307-39	TRANSFORMER,100kVA	10 JUNIPER	UNIQUE POLE #: 13552706	MEC	92	2400	120/240	
270716	BARTLETT	5	248987	T-09873	ATL1307-43	TRANSFORMER,100kVA	4 JUNIPER	UNIQUE POLE #: 13552330	MEC	92	2400	120/240	
270716	BARTLETT	5	248995	T-10768	951039206	TRANSFORMER,100kVA	7 EMBASSY /406 DINEEN	UNIQUE POLE #: 13558206	CME	95	2400	120/240	
270716	BARTLETT	5	249001	T-10772	951038429	TRANSFORMER,100kVA	721 WILLOW	UNIQUE POLE # 13542240	CME	95	2400	120/240	
270716	BARTLETT	5	249007	T-10779	951037256	TRANSFORMER,100kVA	700 LAKESIDE	UNIQUE POLE #: 13543141	CME	95	2400	120/240	
270716	BARTLETT	5	249019	T-10921	951037252	TRANSFORMER,100kVA	731 BIRCH/728 BARTLETT	UNIQUE POLE #: 13547785	CME	95	2400	120/240	
270716	BARTLETT	5	249164	T-12252	ATL1307-15	TRANSFORMER,100kVA	10-12 ELM	UNIQUE POLE #: 13553701	MEC	92	2400	120/240	
270716	BARTLETT	5	249166	T-12253	ATL1307-7	TRANSFORMER,100kVA	704 BARTLETT	UNIQUE POLE #: 13548686	MEC	92	2400	120/240	
270716	BARTLETT	5	249171	T-12255	ATL1307-18	TRANSFORMER,100kVA	9-11 POPLAR	UNIQUE POLE #: 13551805	MEC	92	2400	120/240	
270716	BARTLETT	5	249190	T-12260	ATL1307-27	TRANSFORMER,100kVA	701 BALSAM	UNIQUE POLE #: 13546696	MEP	92	2400	120/240	
270716	BARTLETT	5	249192	T-12261	ATL1307-22	TRANSFORMER,100kVA	802 LAKESIDE	UNIQUE POLE #: 13547027	MEP	92	2400	120/240	
270716	BARTLETT	5	300479	T-16286	A3818-10	TRANSFORMER25kVA	698 LAKESIDE		MEC	06	2400	347	
270716	BARTLETT	5	301203	T-16287	A3818-11	TRANSFORMER,25kVA	698 LAKESIDE	UNIQUE POLE #:	MEC	06	2400	347	
270716	BARTLETT	5	301204	T-16285	A3818-9	TRANSFORMER,25kVA	698 LAKESIDE		MEC	06	2400	347	
270716	BARTLETT	5	249161	T-12251	ATL1306-7	TRANSFORMER,50kVA	8 ELM	UNIQUE POLE #: 13553607	MEC	92	2400	120/240	
45974	HARRIE LAKE	19	269561	T-12682	741095958	TRANSFORMER,100kVA	3047 WALSH	UNIQUE POLE #: 02318	RTE		2400	120/240	
45974	HARRIE LAKE	19	274357	T-12868	741097040	TRANSFORMER,100kVA	3061 WALSH RIVER RD	UNIQUE POLE #: 14771507	RTE		2400	120/240	
45974	HARRIE LAKE	19	274359	T-12891	876022	TRANSFORMER,50kVA	3012 BARTLETT	UNIQUE POLE #: 11629214	WES	74	2400	120/240	
45974	HARRIE LAKE	19	274362	T-12861	876025	TRANSFORMER,50kVA	3002 BARTLETT (BEHIND)	UNIQUE POEL #: 14778002	WES		2400	120/240	
45974	HARRIE LAKE	19	274361	T-12271	874210	TRANSFORMER,50kVA	3027 BARTLETT	UNIQUE POLE #: 14159969	WES	74	2400	120/240	
45974	HARRIE LAKE	19	274686	T-12890	876470	TRANSFORMER,50kVA	3000 FLORA	UNIQUE POLE #: 14155607	WES	74	2400	120/240	
45974	HARRIE LAKE	19	274358	T-12680	276008	TRANSFORMER,50kVA	3016 FLORA	UNIQUE POLE #: 14160158	WES	74	2400	120/240	
45974	HARRIE LAKE	19	251590	T-12658	876013	TRANSFORMER,50kVA	3020 WALSH	UNIQUE POLE #: 14778196	WES	74	2400	120/240	
45974	HARRIE LAKE	19	251588	T-12648	875979	TRANSFORMER,50kVA	3044 HARRIE LAKE	UNIQUE POEL #: 14771131	WES	74	2400	120/240	
45974	HARRIE LAKE	19	251596	T-12649	741096673	TRANSFORMER,100kVA	3019 WALSH	UNIQUE POLE #: 14154424			2400	120/240	
45974	HARRIE LAKE	19	251594	T-12639	902184	TRANSFORMER,50kVA	4007 CANNING	UNIQUE POLE #: 14776676	WES		2400	120/240	
270724	HUDSON	15	285768	T-3-1825	427367	TRANSFORMER,50kVA	303 CAROL	UNIQUE POLE#: 13580140	WES		2400		
270724	HUDSON	15	275349	T-10022	484629	TRANSFORMER,50kVA	333 VIKING	UNIQUE POLE # 13584120	WES		2400		
270724	HUDSON	15	285842	T-14210	427362	TRANSFORMER,50kVA	305 GILBERT	UNIQUE POLE #: 13581135	WES		2400		
270724	HUDSON	15	285769	T-3-1857	937551	TRANSFORMER,100kVA	; 337 VIKING	UNIQUE POLE #; 13584214	WES	75	2400		
270724	HUDSON	15	257176	T-13519	A2404-2	TRANSFORMER,75kVA	TOWN HALL, LAB CITY	UNIQUE POLE #: 14774210	MEC	00	2400	347	
270724	HUDSON	15	257177	T-13520	A2404-5	TRANSFORMER,75kVA	TOWN HALL, LAB CITY	UNIQUE POLE #: 14774210	MEC	00	2400	347	
270724	HUDSON	15	257178	T-13518	A2404-6	TRANSFORMER,75kVA	TOWN HALL, LAB CITY	UNIQUE POLE #: 14774210	MEC	00	2400	347	
270724	HUDSON	15	275347	T-09867	ALT-1307-38	TRANSFORMER,100kVA	320 ELIZABETH	UNIQUE POLE #: 13583407	MAE	92	2400		
270724	HUDSON	15	272403	T-14043	A2401-58	TRANSFORMER,50kVA	TOWN HALL LBC		MAE	02	2400		
270724	HUDSON	15	285845	T-3-1826	937552	TRANSFORMER,100kVA	312 ELIZABETH	UNIQUE POLE #: 13583313	WES	75	2400		
270724	HUDSON	15	285843	T-14209	839870	TRANSFORMER,50kVA	307 GILBERT	UNIQUE POLE # 13581605	WES	75	2400		
270724	HUDSON	15	285841	T-14295	937561	TRANSFORMER,100kVA	308 GILBERT	UNIQUE POLE #: 13582130	WES	75	2400		
270728	HUDSON	16	265008	T-13515	A2404-4	TRANSFORMER,75kVA	106 AIRPORT RD	UNIQUE POLE #:	MEC	00	2400	347	
270728	HUDSON	16	265009	T-13517	A2404-3	TRANSFORMER,75kVA	J&B BUSSING	UNIQUE POLE #:	MEC	00	2400	347	
270728	HUDSON	16	265010	T-13665	A2404-8	TRANSFORMER,75kVA	102 AIRPORT RD	UNIQUE POLE #:	MEC	01	2400	347	
270728	HUDSON	16	254585	T-11908	A1953-4	TRANSFORMER,50kVA	HEDDY'S RESTAURANT	UNIQUE POLE #: 13595111	MEC	97	2400	120/208	
270728	HUDSON	16	255193	T-11550	A1906-12	TRANSFORMER,50kVA	211 DRAKE	UNIQUE NO: 13595111	MEC	96	2400	120/208	
270728	HUDSON	16	255197	T-11892	A1953-22	TRANSFORMER,50kVA	HEDDYS RESTAURANT	UNIQUE POLE #: 13595111	MEC	97	2400	120/208	
270728	HUDSON	16	263624	T-12272	701106	TRANSFORMER,75kVA	NORTHERN AUTO BODY	UNIQUE POLE #: 14242529	WES	70	2400	600	
270728	HUDSON	16	263623	T-12900	722360	TRANSFORMER,75kVA	NORTHERN AUTO BODY	UNIQUE POLE #: 14242529	WES	71	2400	600	
270728	HUDSON	16	263625	T-12633	712105	TRANSFORMER,75kVA	NORTHERN AUTO BODY	UNIQUE POLE #: 14242529	WES	71	2400	600	
270733	HUDSON	17	248350	T-12897	718911	TRANSFORMER,50kVA	205 LAKESIDE	UNIQUE POLE #: 13559107	WES	71	2400	120/240	
270733	HUDSON	17	285945	T-14438	A 2401-82	TRANSFORMER,50kVA	123 CABOT, LAB CITY	UNIQUE POLE #:	MAE	03	2400		
270733	HUDSON	17	285967	T-3-1827	ALT 1293-2	TRANSFORMER,25kVA	DEPOT, 390 TAMARACK	UNIQUE POLE NO::	MAE	92	2400		
270733	HUDSON	17	255189	T-11893	A1953-21	TRANSFORMER,50kVA	203 AMHERST	UNIQUE POLE #: 13576684	MEC	97	2400	120/240	

270733	HUDSON	17	262983	T-13148	A2401-41	TRANSFORMER,50kVA	89 Tamarack		MEC	01	2400	120/240	
270733	HUDSON	17	275408	T-10675	951034756	TRANSFORMER,50kVA	BRACE'S BLDG, 211 AMHERST	UNIQUE POLE #: 13577679	CME	95	2400		
270733	HUDSON	17	275423	T-10837	951037583	TRANSFORMER,50kVA	SUPERETTE, 119 AVALON	UNIQUE POLE #: 13576872	CME	98	2400		
270733	HUDSON	17	275424	T-10839	951037585	TRANSFORMER,50kVA	JUBBERS BLDG	UNIQUE POLE #: 13576872	CME	98	2400		
270733	HUDSON	17	286333	T-14208	LG29849	TRANSFORMER,75kVA	TOWN GARAGE MAIN LINE TAMARACK	UNIQUE NO:13594116/13594780	WES	81	2400		
270733	HUDSON	17	248963	T-12266	LL16175	TRANSFORMER,100kVA	109 MARCONI	UNIQUE POLE #: 13571139	WES	84	2400		
270733	HUDSON	17	285965	T-14203	422974	TRANSFORMER,50kVA	ASHUANIPI AVIATION	UNIQUE NO:13593973	WES		2400		
270733	HUDSON	17	286334	T-14207	LJ33004	TRANSFORMER,75kVA	TOWN GARAGE, TAMARACK	UNIQUE NO:13594116/13594780	WES	82	2400		
270733	HUDSON	17	255191	T-7976	681573	TRANSFORMER,50kVA	CRAFTER'S ATTIC	UNIQUE POLE #: 14770512	WES	70	2400	120/240	
270733	HUDSON	17	285952	T-14259	519105	TRANSFORMER,50kVA	122 DRAKE	UNIQUE POLE #: 13571897	WES		2400		
270733	HUDSON	17	285953	T-14279	423493	TRANSFORMER,50kVA	112 DRAKE	UNIQUE POLE #: 13572040	WES		2400		
270733	HUDSON	17	248876	T-10127	661252	TRANSFORMER,50kVA	CHN ENTERPRISES, 300 AVALON	UNIQUE POLE #: 13575119	WES	79	2400	120/240	
270733	HUDSON	17	269492	T-10038	432500	TRANSFORMER,50kVA	CRRS	UNIQUE POLE #: 13578956	WES		2400	120/240	
270733	HUDSON	17	263619	T-11011	LB24661	TRANSFORMER,75kVA	221 BARTLETT	UNIQUE POLE #: 13571609	WES	76	2400	120/240	
270733	HUDSON	17	263621	T-11013	LC23274	TRANSFORMER,37.5kVA	221 BARTLETT	UNIQUE POLE #: 13571609	WES	77	2400	120/240	
270733	HUDSON	17	263622	T-11012	LC23270	TRANSFORMER,37.5kVA	221 BARTLETT	UNIQUE POLE #: 13571609	WES	77	2400	120/240	
270738	HUDSON	18	250480	T-11813	A1939-6	TRANSFORMER,100kVA	321BEVERLY	UNIQUE POLE #: 13517985	MEC	93	2400	120/240	
270738	HUDSON	18	260076	T-13146	A2402-9	TRANSFORMER,50kVA	RSM, LUCE ST	UNIQUE POLE #: 20612630	MEC	01	2400		
270738	HUDSON	18	265006	T-13327	A2402-10	TRANSFORMER,50kVA	RSM, LUCE ST	UNIQUE POLE #: 20611353	MEC	02	2400	347	
270738	HUDSON	18	265007	T-13328	A2402-11	TRANSFORMER,50kVA	RSM, LUCE ST	UNIQUE POLE #: 20611353	MEC	01	2400	347	
270738	HUDSON	18	271889	T-13667	A2404-7	TRANSFORMER,75kVA	BOWRINGER, LUCE ST	UNIQUE POLE #: 20610452	MEC	01	2400	347	
270738	HUDSON	18	271890	T-13669	A2404-9	TRANSFORMER,75kVA	BOWRINGER, LUCE ST	UNIQUE POLE #: 20610152	MEC	01	2400	347	
270738	HUDSON	18	271891	T-13516	A2404-1	TRANSFORMER,75kVA	BOWRINGER, LUCE ST	UNIQUE POLE #: 20610452	MEC	01	2400	347	
270738	HUDSON	18	285946	T-14283	LD5359	TRANSFORMER,50kVA	IOCC GATE	UNIQUE POLE #: 14244237	WES	78	2400		
270738	HUDSON	18	285874	T-14211	839846	TRANSFORMER,50kVA	322 BEVERLY	UNIQUE NO: 13519311	WES	73	2400		
270738	HUDSON	18	285876	T-14272	LG24948	TRANSFORMER,100kVA	? 307 BEVERLY	UNIQUE NO: 13516990	WES	81	2400		
270738	HUDSON	18	256360	T-10908	937347	TRANSFORMER,75kVA	309 CAROL	UNIQUE POLE #: 12582318	WES	75	2400	120/240	
270756	QUARTZITE	6	254453	T-10117	575452	TRANSFORMER,50kVA	804 CHURCHILL	UNIQUE POLE #: 13533421	WES		2400	120/240	
270756	QUARTZITE	6	254447	T-10136	436137	TRANSFORMER,50kVA	811 COOK	UNIQUE POLE #: 13537031	WES	70	2400	120/240	
270756	QUARTZITE	6	254439	T-10110	LJ20537	TRANSFORMER,100kVA	814 CAROL	UNIQUE POLE #: 13534704	WES	82	2400	120/240	
270756	QUARTZITE	6	254433	T-10111	937327	TRANSFORMER,75kVA	814 CORMACK	UNIQUE POLE #: 13535041	WES	75	2400	120/240	
270756	QUARTZITE	6	254452	T-10137	484630	TRANSFORMER,50kVA	835 CAROL	UNIQUE POLE #: 13531249	WES	78	2400	120/240	
270756	QUARTZITE	6	254456	T-10112	895942	TRANSFORMER,50kVA	841 HUDSON	UNIQUE POLE #: 13531907	WES	76	2400	120/240	
270756	QUARTZITE	6	254442	T-10113	424672	TRANSFORMER,50kVA	843 CAROL	UNIQUE POLE #: 13531531	WES		2400	120/240	
270756	QUARTZITE	6	254454	T-10104	700936	TRANSFORMER,50kVA	801 COOK	UNIQUE POLE #: 13537125	WES	70	2400	120/240	
270756	QUARTZITE	6	254435	T-10036	LC25240	TRANSFORMER,100kVA	715 CAROL	UNIQUE POLE #: 13533615	WES	77	2400	120/240	
270756	QUARTZITE	6	254436	T-10037	LE30947	TRANSFORMER,50kVA	603 CAROL	UNIQUE POLE #: 13585685	WES	80	2400	120/240	
270760	QUARTZITE	7	275027	T-10000	A1294-27	TRANSFORMER,75kVA	411 PROWSE	UNIQUE POLE #: 13569297	MEC	92	2400	120/240	
270760	QUARTZITE	7	275030	T-10014	A1294-21	TRANSFORMER,75kVA	424 MASSEY	UNIQUE POLE #: 13563985		92	2400	120/240	
270760	QUARTZITE	7	250808	T-12451	A2401-2	TRANSFORMER,50kVA	828 RETTY	UNIQUE POLE #: 13530724	MEC	99	2400	120/240	
270760	QUARTZITE	7	254469	T-11902	A1953-6	TRANSFORMER,50kVA	SCOUT LODGE	UNIQUE POLE #:	MEC	97	2400	120/240	
270760	QUARTZITE	7	275024	T-10007	ATL1306-17	TRANSFORMER,50kVA	841 D'AIGLE	UNIQUE POLE #: 13569861	MEC	92	2400	120/240	
270760	QUARTZITE	7	275029	T-10009	ATL1306-16	TRANSFORMER,50kVA	425 CENTENNIAL	UNIQUE POLE #: 13563603	MAE	92	2400	120/240	
270760	QUARTZITE	7	264358	T-10120	637671	TRANSFORMER,50kVA	834 D'AIGLE	UNIQUE POLE #: 13569391	WES		2400	120/240	
270760	QUARTZITE	7	269542	T-10123	484669	TRANSFORMER,50kVA	443 CENTENNIAL	UNIQUE POLE #: 13564410	WES		2400	120/240	
270760	QUARTZITE	7	275026	T-10030	839855	TRANSFORMER,50kVA	402 PROWSE	UNIQUE POLE #: 13568960	WES	73	2400	120/240	
270760	QUARTZITE	7	269683	T-10021	937334	TRANSFORMER,75kVA	408 PROWSE	UNIQUE POLE #: 13568866	WES	75	2400	120/240	
270760	QUARTZITE	7	269543	T-10034	575451	TRANSFORMER,50kVA	403 PROWSE	UNIQUE POLE #: 13569579	WES		2400	120/240	
270760	QUARTZITE	7	269491	T-10139	3P0287-08	TRANSFORMER,100kVA	412 CENTENNIAL	UNIQUE POLE #: 13569009	WES	82	2400	120/240	
270760	QUARTZITE	7	269502	T-10140	475920	TRANSFORMER,50kVA	432 MASSEY	UNIQUE POLE #: 13564316	WES		2400	120/240	
270760	QUARTZITE	7	269501	T-10141	467594	TRANSFORMER,50kVA	409 CENTENNIAL	UNIQUE POLE #: 13562990	WES		2400	120/240	
270764	QUARTZITE	8	264829	T-10029	LF26196	TRANSFORMER,50kVA	727 STIRLING	UNIQUE POLE #:	WES	80	2400	120/240	
270764	QUARTZITE	8	248353	T-10108	43160	TRANSFORMER,50kVA	832 HUDSON	UNIQUE POLE #: 13502914	WES		2400	120/240	
270764	QUARTZITE	8	263732	T-10906	LC25248	TRANSFORMER,100kVA	716 FIELD	UNIQUE POLE #: 13507895	WES	77	2400	120/240	
270764	QUARTZITE	8	269769	T-12688	937349	TRANSFORMER,75kVA	709 BARTLETT	UNIQUE POLE #:	WES	75	2400	120/240	
270768	QUARTZITE	12	255783	T-10955	575237	TRANSFORMER,50kVA	6 CEDAR	UNIQUE POLE #: 13550904	WES		2400	120/240	
270768	QUARTZITE	12	255795	T-10784	758-290	TRANSFORMER,50kVA	818 LAKESIDE	UNIQUE POLE #: 13529689			2400	120/240	
270768	QUARTZITE	12	248344	T-10067	LJ20541	TRANSFORMER,100kVA	809 WILLOW	UNIQUE POLE #: 13541527	WES	82	2400	120/240	
270772	QUARTZITE	13	248868	T-12274	LB24474	TRANSFORMER,75kVA	1027 CAVENDISH	UNIQUE POLE #NO: 13526228	WES	76	2400	120/240	
270772	QUARTZITE	13	248875	T-12267	LB24468	TRANSFORMER,75kVA	1063 ARTLETT	UNIQUE POLE #: 13526604	WES	76	2400	120/240	
270772	QUARTZITE	13	254629	T-12296	LB24458	TRANSFORMER,75kVA	1037 BARTLETT	UNIQUE POLE #: 13526134	WES	76	2400	120/240	
270772	QUARTZITE	13	255224	T-12287	LB24472	TRANSFORMER,75kVA	1063 CAVENDISH	UNIQUE POLE #: 13527981	WES	76	2400	120/240	
270772	QUARTZITE	13	255261	T-12283	LB24476	TRANSFORMER,75kVA	1039 CAVENDISH	UNIQUE POLE #: 13527505	WES	76	2400	120/240	
270772	QUARTZITE	13	255272	T-12285	LB24477	TRANSFORMER,75kVA	1057 CAVENDISH	UNIQUE POLE #: 13527877	WES	76	2400	120/240	
270772	QUARTZITE	13	254482	T-12605	C886-5	TRANSFORMER,100kVA	876 TAMARACK	UNIQUE POLE #: 11624051	CAR	75	2400	120/240	
270772	QUARTZITE	13	254525	T-12609	C886-18	TRANSFORMER,100kVA	912 TAMARACK	UNIQUE POLE #: 11623808	CAR	75	2400	120/240	
270772	QUARTZITE	13	255302	T-12610	LJ20519	TRANSFORMER,100kVA	926 TAMARACK	UNIQUE POLE #: 13527035	WES	82	2400	120/240	
270772	QUARTZITE	13	254539	T-12291	LA18912	TRANSFORMER,167kVA	1019 CAVENDISH	UNIQUE POLE #: 13527129	WES	76	2400	120/240	
270772	QUARTZITE	13	254645	T-12297	LB24464	TRANSFORMER,75kVA	1024 CAVENDISH	UNIQUE POLE #: 13525421	WES	76	2400	120/240	
270772	QUARTZITE	13	254646	T-12621	LB24465	TRANSFORMER,75kVA	1075 BARTLETT	UNIQUE POLE #: 13526798	WES	76	2400	120/240	
270772	QUARTZITE	13	254682	T-12618	LB24467	TRANSFORMER,75kVA	1044 CAVENDISH	UNIQUE POLE #: 13525233		76	2400	120/240	
270772	QUARTZITE	13	255222	T-12294	LB24469	TRANSFORMER,75kVA	1053 BARTLETT	UNIQUE POLE #: 13526322	WES	76	2400	120/240	
270772	QUARTZITE	13	255283	T-12288	LB24479	TRANSFORMER,75kVA	1071 CAVENDISH	UNIQUE POLE #: 13528030	WES	76	2400	120/240	
270772	QUARTZITE	13	254581	T-12292	LB17301	TRANSFORMER,100kVA	1021 CAVENDISH	UNIQUE POLE #: 13527223	WES	76	2400	120/240	

270772	QUARTZITE	13	254627	T-12298	LB19105	TRANSFORMER,50kVA	1018 CAVENDISH	UNIQUE POLE #: 13525327	WES	76	2400	120/240	
270772	QUARTZITE	13	254647	T-12284	LB24466	TRANSFORMER,75kVA	1043 CAVENDISH	UNIQUE POLE #: 13537699	WES	76	2400	120/240	
270772	QUARTZITE	13	254533	T-12290	LA18897	TRANSFORMER,167kVA	1001 BARTLETT	UNIQUE POLE #: 13525897	WES	76	2400	120/240	
270772	QUARTZITE	13	255223	T-12281	LB24470	TRANSFORMER,75kVA	1031 CAVENDISH	UNIQUE POLE #: 13527411	WES	76	2400	120/240	
270772	QUARTZITE	13	254644	T-12293	LB24463	TRANSFORMER,75kVA	1069 BARTLETT	UNIQUE NO: 13526510	WES	76	2400	120/240	
270772	QUARTZITE	13	255238	T-12224	LB24475	TRANSFORMER,75kVA	1032 CAVENDISH	UNIQUE NO: 13525515	WES	76	2400	120/240	
270772	QUARTZITE	13	248849	T-12273	951039207	TRANSFORMER,50kVA	821 TAMARACK	UNIQUE NO: 13545131	CME	95	2400	120/240	
270772	QUARTZITE	13	255301	T-12619	LB24481	TRANSFORMER,75kVA	1050 CAVENDISH	UNIQUE POLE: 13525045	WES	76	2400	120/240	
270772	QUARTZITE	13	254527	T-12602	C886-17	TRANSFORMER,100kVA	854 TAMARACK	UNIQUE POLE #: 11624709	CAR	75	2400	120/240	
270772	QUARTZITE	13	254641	T-12299	LB24461	TRANSFORMER,75kVA	1002 CAVENDISH	UNIQUE POLE #: 13525609	WES	76	2400	120/240	
270772	QUARTZITE	13	254522	T-12601	C886-11	TRANSFORMER,100kVA	840 TAMARACK	UNIQUE POLE #: 11624521	CAR	75	2400	120/240	
270772	QUARTZITE	13	254530	T-12600	C886-21	TRANSFORMER,100kVA	814 TAMARACK	UNIQUE POLE#: 11629308	CAR	75	2400	120/240	
270772	QUARTZITE	13	254575	T-12617	LA19104	TRANSFORMER,50kVA	1040 CAVENDISH	UNIQUE NO: 13525139	WES	76	2400	120/240	
270772	QUARTZITE	13	254630	T-12286	LB24459	TRANSFORMER,75kVA	1053 CAVENDISH	UNIQUE POLE #: 13527793	WES	76	2400	120/240	
270772	QUARTZITE	13	254635	T-12620	LB24460	TRANSFORMER,75kVA	1012 CAVENDISH	UNIQUE POLE #: 13525703	WES	76	2400	120/240	
270772	QUARTZITE	13	254479	T-12606	C 886-2	TRANSFORMER,100kVA	882 TAMARACK	UNIQUE POLE #: 11624145	CAR	75	2400	120/240	
270772	QUARTZITE	13	254480	T-12604	C886-1	TRANSFORMER,100kVA	870 TAMARACK	UNIQUE POLE #: 1162206	CAR	75	2400	120/240	
270772	QUARTZITE	13	254481	T-12603	C886-4	TRANSFORMER,100kVA	860 TAMARACK	UNIQUEPOLE #: 11624803	CAR	75	2400	120/240	
270772	QUARTZITE	13	254537	T-12608	C886-10	TRANSFORMER,100kVA	904 TAMARACK	UNIQUE POLE #: 11624333	CAR	75	2400	120/240	
270772	QUARTZITE	13	254559	T-12289	LA19102	TRANSFORMER,50kVA	1103 CAVENDISH	UNIQUE POLE #: 13528124	WES	76	2400	120/240	
270772	QUARTZITE	13	254628	T-12282	LB24457	TRANSFORMER,75kVA	1027 CAVENDISH	UNIQUE POLE #: 13527317	WES	76	2400	120/240	
270772	QUARTZITE	13	255276	T-12295	LB24478	TRANSFORMER,75kVA	1043 BARTLETT	UNIQUE POLE #: 13526416	WES	76	2400	120/240	
270772	QUARTZITE	13	248846	T-12879	LA18903	TRANSFORMER,167kVA	1161 CAVENDISH	UNIQUE POLE #:: 13524426	WES	76	2400	120/240	
270772	QUARTZITE	13	248845	T-10052	LL11098	TRANSFORMER,100kVA	918 ALDERDICEE	UNIQUE POLE # 13528694	WES	84	2400	120/240	
270776	QUARTZITE	14	272402	T-14042	A2401-57	TRANSFORMER,50kVA	FISH MARKET		MAE	02	2400	120/240	
270776	QUARTZITE	14	251563	T-12643	741096677	TRANSFORMER,100kVA	3007 TANYA	UNIQUE NO: 14775963			2400	120/240	
270776	QUARTZITE	14	251593	T-12653	902172	TRANSFORMER,50kVA	4011 HARRIE LAKE	UNIQUE NO: 14778572	WES	74	2400	120/240	
270776	QUARTZITE	14	251553	T-12642	741098020	TRANSFORMER,100kVA	3007 HARRIE LAKE	UNIQUE POLE #: 14774686	RTE		2400	120/240	
270780	VANIER	21	262980	T-13271	A2398-18	TRANSFORMER,10kVA	SMOKEY HEAT TRACE		MAE	02	2400		
270780	VANIER	21	285683	T-14492	A2398-24	TRANSFORMER,10kVA	BEV LAKE STLIGHTS		MAE	00	2400		
270780	VANIER	21	262506	T-13143	A2399-88	TRANSFORMER,25kVA	ROD&GUN CLUB	UNIQUE POLE #: 14772314	MEC	01	2400	120/240	
270780	VANIER	21	262984	T-13165	A2401-46	TRANSFORMER,50kVA	AGTEWAY	UNIQUE POLE #:	MEC	01	2400	120/240	
270784	VANIER	22	256352	T-10988	700972	TRANSFORMER,50kVA	410 NASCOPIE	UNIQUE POLE #:			2400	120/240	
270784	VANIER	22	286427	T-10923	951037704	TRANSFORMER,75kVA	701 CHURCHILL	UNIQUE POLE #: 13590042	CME	95	2400		
270784	VANIER	22	269541	T-10116	484668	TRANSFORMER,50kVA	410 MACDONALD	UNIQUE POLE #: 13561143	WES		2400	120/240	
271168	VANIER	23	255800	T-10966	422955	TRANSFORMER,50kVA	413 VANIER	UNIQUE POLE #:	WES		2400	120	
271168	VANIER	23	255803	T-10967	436126	TRANSFORMER,50kVA	ORANGE LODGE	UNIQUE POLE #:	WES		2400	120/240	
271168	VANIER	23	255801	T-10991	424680	TRANSFORMER,50kVA	619 MCPARLAND	UNIQUE POLE #:	WES		2400	120/240	
271168	VANIER	23	258526	T-4-0121	632976	TRANSFORMER,50kVA	627 MCPARLAND	W/O# 583164	WES		2400	120/240	
271168	VANIER	23	255806	T-10928	637701	TRANSFORMER,50kVA	611 MCPARLAND	UNIQUE POLE #:			2400	120/240	
270716	BARTLETT	5	249169	T-12254	577116	TRANSFORMER,100kVA	7 MAPLE	UNIQUE POLE #: 13554038	WES		4160	120/240	
270716	BARTLETT	5	249151	T-12245	2-178368	TRANSFORMER,225kVA	500 DINEEN	UNIQUE POLE #: 13555409	FPT	80	4160	347/600	
270733	HUDSON	17	286330	T-14200	J1098-3	TRANSFORMER,167kVA	SEWAGE PLANT, TAMARACK	UNIQUE NO: 13594592/13594498	CAR	82	4160		
270733	HUDSON	17	286331	T-14202	J1098-2	TRANSFORMER,167kVA	SEWAGE PLANT, TAMARACK	UNIQUE NO:13594592/13594498	CAR	82	4160		
270772	QUARTZITE	13	248877	T-14239	LA19060	TRANSFORMER,75kVA	LIFT STATION/HERITGE	UNIQUE POLE #: 13525991	WES	76	4160	347/600	3-Phase Transformer
270704	BARTLETT	1	252242	T-12205	LE20054	TRANSFORMER,167kVA	12 EMBASSY (BEHIND)	UNIQUE POLE #:	WES	80	2400/4160	120/240	
270706	BARTLETT	2	255775	T-10901	937539	TRANSFORMER,100kVA	709 STIRLING	UNIQUE POLE #: 13500454			2400/4160	120/240	
270706	BARTLETT	2	255771	T-10902	LD62040	TRANSFORMER,100kVA	714 HUDSON	UNIQUE POLE #: 13500548			2400/4160	120/240	
270710	BARTLETT	3	257863	T-12673	T3060-9	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-CENTRAL	UNIQUE POLE #: 20613343	MEC	01	2400/4160	347/600	
270710	BARTLETT	3	257865	T-12672	T3060-8	TRANSFORMER,333kVA	WESTLAB SHOPPING CTR-CENTRAL	UNIQUE POLE #: 20613343	MEC	01	2400/4160	347/600	
270713	BARTLETT	4	249039	T-12227	876995	TRANSFORMER,75kVA	INDIAN POINT LIFT STATION	UNIQUE POLE #:	WES	74	2400/4160	347/600	
270713	BARTLETT	4	249047	T-12232	2-17120	TRANSFORMER,75kVA	530 TAMARACK	UNIQUE POLE #:	FPT		2400/4160	600	
45974	HARRIE LAKE	19	251591	T-12647	902165	TRANSFORMER,50kVA	3045 BARTLETT	UNIQUE POLE #: 14773215	WES	74	2400/4160	120/240	
45974	HARRIE LAKE	19	251583	T-12656	741098022	TRANSFORMER,100kVA	4014 WALSH	UNIQUE POLE #: 14772126	RTE		2400/4160	120/240	
45974	HARRIE LAKE	19	251551	T-12657	741096288	TRANSFORMER,100kVA	4000 WALSH	UNIQUE POLE #: 14156320	RTE		2400/4160	120/240	
45974	HARRIE LAKE	19	251318	T-12646	741095956	TRANSFORMER,100kVA	3025 WALSH RIVER	UNIQUE POLE #: 14778290	RTE		2400/4160	120/240	
45974	HARRIE LAKE	19	251556	T-12652	741096289	TRANSFORMER,100kVA	3005 WALSH	UNIQUE POELI#: 14775681	RTE		2400/4160	120/240	
45974	HARRIE LAKE	19	251558	T-12640	741096292	TRANSFORMER,100kVA	4036 HARRIE LAKE	UNIQUE POLE #: 14774780	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251585	T-12659	741098023	TRANSFORMER,100kVA	4009 DULEY	UNIQUE POLE #: 14771225	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251586	T-12661	741101458	TRANSFORMER,100kVA	3014 MILLS CRES	UNIQUE POLE #: 14776958			2400/4160	120/240	
270749	HARRIE LAKE	20	251587	T-12660	741101455	TRANSFORMER,100kVA	4002 DULEY	UNIQUE POLE #: 14779661	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251296	T-12662	741097725	TRANSFORMER,100kVA	4016 DULEY	UNIQUE POLE #: 14777483	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251299	T-12663	741098019	TRANSFORMER,100kVA	4056 FULRY	UNIQUE POLE #: 14770606	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251577	T-12664	741097718	TRANSFORMER,100kVA	4028 ASHUANIPI	UNIQUE POLE #: 14773879	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251597	T-12665	741097717	TRANSFORMER,100kVA	3028 BARTLETT	UNIQUE POLE #:	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251598	T-12666	741096675	TRANSFORMER,100kVA	4018 BARTLETT	UNIUE POLE #:	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251576	T-12668	741097715	TRANSFORMER,100kVA	4028 BARTLETT	UNIQUE POLE #: 14772502	RTE		2400/4160	120/240	
270749	HARRIE LAKE	20	251584	T-12667	741098021	TRANSFORMER,100kVA	4008 ASHUANIPI	UNIQUE POLE #: 14779379	RTE		2400/4160	120/240	
270728	HUDSON	16	288633	T-14459	A2404-15	TRANSFORMER,75kVA	CAPITAL CRANE, 1050 LORRAINE	UNIQUE POLE #:	MAE	03	2400/4160		
270738	HUDSON	18	257169	T-09181	G-8113-4	TRANSFORMER,167kVA	ARENA, BOOTH AVE	UNIQUE POLE #: 20530071	FPE	91	2400/4160	347/600	
270738	HUDSON	18	260077	T-13145	A2402-8	TRANSFORMER,50kVA	RSM, LUCE ST	UNIQUE POLE #: 20612630	MEC	01	2400/4160	347	
270738	HUDSON	18	260078	T-13105	A2402-5	TRANSFORMER,50kVA	RSM, LUCE ST	UNIQUE POLE #: 20612630	MEC	01	2400/4160	347	
270738	HUDSON	18	265005	T-13147	A2402-7	TRANSFORMER,50kVA	RSM LUCE ST	UNIQUE POLE #: 20611353	MEC	01	2400/4160	347	
270738	HUDSON	18	257249	T-7983	LL23740	TRANSFORMER,75kVA	334 BEVERLEY	UNIQUE POLE #: 13518886	WES	85	2400/4160	120/240	

270768	QUARTZITE	12	248356	T-12896	LG24982	TRANSFORMER,100kVA	833 WILLOW	UNIQUE POLE #: 13540814	WES	81	2400/4160	120/240	
270768	QUARTZITE	12	255794	T-10787	741096674	TRANSFORMER,100kVA	815 SPRUCE	UNIQUE POLE #: 13529971			2400/4160	120/240	
270768	QUARTZITE	12	248355	T-10064	LJ33013	TRANSFORMER,75kVA	825 WILLOW	UNIQUE POLE #:	WES	82	2400/4160	120/240	
270776	QUARTZITE	14	251541	T-12655	741095959	TRANSFORMER,100kVA	4040 TANYA	UNIQUE NO: 14152434			2400/4160	120/240	
270776	QUARTZITE	14	251566	T-12644	741097714	TRANSFORMER,100kVA	4006 QZ/4007 TANYA	UNIQUE POLE #: 14772978	RTE		2400/4160	120/240	
270776	QUARTZITE	14	251578	T-12645	741097719	TRANSFORMER,100kVA	3010 QUARTZITE	UNIQUE POLE #: 14151627			2400/4160	120/240	
270776	QUARTZITE	14	251546	T-12654	741097722	TRANSFORMER,100kVA	4048 TANYA	UNIQUE NO: 14772032			2400/4160	120/240	
271168	VANIER	23	255799	T-6903	P0614-4	TRANSFORMER,100kVA	419 VANIER	UNIQUE POLE #: 13586674	CAR	86	2400/4160	120/240	
270704	BARTLETT	1	251535	T-10306	61923.1	TRANSFORMER,167kVA	AP LOW SCHOOL	UNIQUE POLE #:	FPT	94	2400/7200	347/600	
270704	BARTLETT	1	251536	T-10305	61923.3	TRANSFORMER,167kVA	AP LOW SCHOOL	UNIQUE POLE #:	FPT	94	2400/7200	347/600	
270704	BARTLETT	1	251537	T-10304	61923.5	TRANSFORMER,167kVA	AP LOW SCHOOL	UNIQUE POLE #::	FPT	94	2400/7200	120/240	
270706	BARTLETT	2	248897	T-10001	A1294-22	TRANSFORMER,75kVA	710 ROCHE	UNIQUE POLE #: 13509503	MEC	92	2400/7200	120/240	
270706	BARTLETT	2	248896	T-7998	ATL1307-13	TRANSFORMER,100kVA	216 MATTHEW	UNIQUE POLE #: 13506142	MEC	92	2400/7200	120/240	
270706	BARTLETT	2	248920	T-10916	951036612	TRANSFORMER,100kVA	725 FIELD	UNIQUE POLE#: 13508984	CME	95	2400/7200	120/240	
270710	BARTLETT	3	248348	T-7996	ATL1307-10	TRANSFORMER,100kVA	420 GRENFELL	UNIQUE POLE #: 13593121	MAE	92	2400/7200	120/240	
270710	BARTLETT	3	257184	T-13030	A2784-1	TRANSFORMER,100kVA	WESTLAB SHOPPING CTR-EASTERN	UNIQUE POLE #: 20613061	MEC	01	2400/7200	347	
270710	BARTLETT	3	257185	T-13029	A2784-2	TRANSFORMER,100kVA	WESTLAB SHOPPING CTR-EASTERN	UNIQUE POLE#: 20613061	MEC	01	2400/7200		
270710	BARTLETT	3	257192	T-13034	A2784-8	TRANSFORMER,100kVA	WESTLAB SHOPPING CTR-EASTERN	UNIQUE POLE #: 20613061	MEC	01	2400/7200	347	
270710	BARTLETT	3	248959	T-12210	ATL1306-2	TRANSFORMER,50kVA	430 GENFELL	UNIQUE POLE #: 13592790	MEC	92	2400/7200	120/240	
270713	BARTLETT	4	249034	T-10981	LL16176	TRANSFORMER,100kVA	717 TAMARACK	UNIQUE POLE #: 13546408	WES	84	2400/7200	120/240	
270713	BARTLETT	4	249021	T-10766	951036131	TRANSFORMER,100kVA	4 BEAVER	UNIQUE POLE #: 13558682	CME	95	2400/7200	120/240	
270713	BARTLETT	4	249029	T-10986	ATL1307-24	TRANSFORMER,100kVA	751 TAMARACK	UNIQUE POLE #: 13544894	MEC	92	2400/7200	120/240	
270713	BARTLETT	4	248983	T-09862	ATL1306-1	TRANSFORMER,50kVA	430 TAMARACK	UNIQUE POLE #: 11627036	MEC	92	2400/7200	120/240	
270716	BARTLETT	5	248993	T-09971	61850:12	TRANSFORMER,75kVA	709 WILLOW	UNIQUE POLE #: 13542428	FPT	94	2400/7200	120/240	
270716	BARTLETT	5	249017	T-10914	951036132	TRANSFORMER,100kVA	712 BARTLETT	UNIQUE POLE #: 13548874	CME	95	2400/7200	120/240	
270716	BARTLETT	5	249018	T-10919	951036610	TRANSFORMER,100kVA	724 BARTLETT /727 BIRCH	UNIQUE POLE #: 13547691	CME	95	2400/7200	120/240	
270724	HUDSON	15	275348	T-09978	61850-2	TRANSFORMER,75kVA	305 VIKING	UNIQUEPOLE #: 13584596	FPT	94	2400/7200		
270724	HUDSON	15	275344	T-10770	951037253	TRANSFORMER,100kVA	318 CARSON	UNIQUE POLE #:: 13582794	COO	95	2400/7200		
270724	HUDSON	15	275345	T-09835	ALT-1307-34	TRANSFORMER,100kVA	513 HUDSON	UNIQUE POLE #: 13582506	MAE	92	2400/7200		
270724	HUDSON	15	275350	T-09818	ALT 1307-33	TRANSFORMER,100kVA	615 CARIBOU	UNIQUE POLE #: 13585497	MAE	92	2400/7200		
270724	HUDSON	15	275351	T-09880	ALT 1307-46	TRANSFORMER,100kVA	615 HUDSON	UNIQUE POLE #: 13584784	MAE	92	2400/7200		
270724	HUDSON	15	275352	T-09834	ALT-1307-32	TRANSFORMER,100kVA	621 HUDSON	UNIQUE POLE #: 13538214	MAE	92	2400/7200		
270724	HUDSON	15	275353	T-10134	ALT 1307-3	TRANSFORMER,100kVA	711 HUDSON	UNIQUE POLE #: 13537789	MAE	92	2400/7200		
270724	HUDSON	15	275354	T-09885	ALT 1307-53	TRANSFORMER,100kVA	703 RICHARDS	UNIQUE POLE #: 13537883	MAE	92	2400/7200		
270728	HUDSON	16	254540	T-10285	61891.3	TRANSFORMER,75kVA	114 AIRPORT RD	UNIQUE NO: 14241816	FPT	94	2400/7200	347	
270728	HUDSON	16	254558	T-11530	62308.3	TRANSFORMER,75kVA	CO-OP BLDG	UNIQUE POLE #: 14241816	FPT	96	2400/7200	120/240	
270728	HUDSON	16	254592	T-11535	62308.4	TRANSFORMER,75kVA	CO-OP BLDG	UNIQUE POLE #: 14241816	FPT	96	2400/7200	120/240	
270728	HUDSON	16	254518	T-6361	310641	TRANSFORMER,100kVA	CAROL WABUSH DISTRIBUTING	UNIQUE POLE #: 1424435	MEP	84	2400/7200	347/600	
270728	HUDSON	16	254519	T-11547	A1900-2	TRANSFORMER,100kVA	L16 LBC	UNIQUE POLE#: 14242435	MEC	96	2400/7200	347/600	
270728	HUDSON	16	254538	T-09989	61851:2	TRANSFORMER,100kVA	CAROL WABUSH DISTRIBUTING	UNIQUE POLE #: 14242435	FPT	94	2400/7200	347/600	
270728	HUDSON	16	254582	T-12843	951034737	TRANSFORMER,50kVA	SHELL CANADA	UNIQUE POLE #:	CME	96	2400/7200	347/600	
270728	HUDSON	16	254584	T-11400	961001028	TRANSFORMER,100kVA	L16 LBC	UNIQUE POLE #: 14245044	CME	96	2400/7200	347/600	
270733	HUDSON	17	262511	T-10568	62068:6	TRANSFORMER,75kVA	ROYAL CARPET	UNIQUE POLE #: 20614620	FPT	95	2400/7200	120/240	
270733	HUDSON	17	257175	T-11801	A1939-11	TRANSFORMER,100kVA	130 MARCONI	UNIQUE POLE #: 13574124	MEC	97	2400/7200	120/240	
270733	HUDSON	17	255217	T-12614	33030-0001	TRANSFORMER,167kVA	90 AVALON	UNIQUE POLE #: 14778854	ABB	99	2400/7200	347	
270733	HUDSON	17	255218	T-12615	33030-0002	TRANSFORMER,167kVA	MCDONALD'S 90 AVALON	UNIQUE POLE #: 14778854	ABB	99	2400/7200	347	
270733	HUDSON	17	255219	T-12616	33030-0003	TRANSFORMER,167kVA	90 AVALON	UNIQUE NO: 14778854	ABB	99	2400/7200	347	
270733	HUDSON	17	254919	T-11680	A1932-23	TRANSFORMER,25kVA	217 DRAKE	UNIQUE POLE #: 14248311	MEC	95	2400/7200	120/240	
270733	HUDSON	17	285966	T-14204	ALT-1293-1	TRANSFORMER,25kVA	TOWN GARAGE, TAMARACK	UNIQUE POLE #: 13594968	MAE	92	2400/7200		
270738	HUDSON	18	262513	T-10571	62068:2	TRANSFORMER,75kVA	HOPE HAVEN		FPT	95	2400/7200	120/240	
270738	HUDSON	18	257179	T-13510	A2438-1	TRANSFORMER,167kVA	ARENA (BANK)	UNIQUE POLE #: 20530071	MEC	00	2400/7200	347	
270738	HUDSON	18	257180	T-13513	A2438-2	TRANSFORMER,167kVA	ARENA, BOOTH AVE	UNIQUE POLE #: 20530071	MEC	00	2400/7200	347	
270738	HUDSON	18	248357	T-12430	A2401-1	TRANSFORMER,50kVA	CAROL AUTO	UNIQUE POLE #: 13596394	MAE		2400/7200	120/240	
270738	HUDSON	18	255220	T-12177	A1954-1	TRANSFORMER,50kVA	CAROL AUTO 55 AVALON	UNIQUE POLE #: 14245420	MEC	97	2400/7200		
270756	QUARTZITE	6	254425	T-10146	A1294-5	TRANSFORMER,75kVA	803 HUDSON	UNIQUE POLE #: 13536600	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254426	T-10132	A1294-11	TRANSFORMER,75kVA	318 CURTIS	UNIQUE POLE #: 13535987	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254427	T-10011	A1294-18	TRANSFORMER,75kVA	819 CAROL	UNIQUE POLE #: 13532808	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254428	T-10133	A1294-25	TRANSFORMER,75kVA	710 CAROL	UNIQUE POLE #: 13535605	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254430	T-10013	A1294-26	TRANSFORMER,75kVA	833 HUDSON	UNIQUE POLE #: 13531719	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254432	T-10131	A1294-23	TRANSFORMER,75kVA	718 CAROL	UNIQUEPOLE #: 13535417	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254431	T-09879	ATL1307-49	TRANSFORMER,100kVA	822 RETTY	UNIQUE POLE #: 13530818	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254441	T-7992	ATL1307-4	TRANSFORMER,100kVA	819 HUDSON	UNIQUE POLE #: 13536318	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254444	T-10145	ATL1307-23	TRANSFORMER,100kVA	805 CORMACK	UNIQUE POLE #: 13538308	MEP	92	2400/7200	120/240	
270756	QUARTZITE	6	254446	T-10144	ATL1307-26	TRANSFORMER,100kVA	815 CORMACK	UNIQUE POLE #: 13538784	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254449	T-09883	ATL1307-35	TRANSFORMER,100kVA	619 CAROL	UNIQUE POLE #: 13534234	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254451	T-09868	ATL1307-37	TRANSFORMER,100kVA	707 CAROL	UNIQUE POLE #: 13533997	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254458	T-09878	ATL1307-44	TRANSFORMER,100kVA	703 CAROL	UNIQUE POLE #: 13534046	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254459	T-09881	ATL1307-42	TRANSFORMER,100kVA	834 CAROL	UNIQUE POLE #: 13534328	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254462	T-09876	ATL1307-40	TRANSFORMER,100kVA	310 CURTIS	UNIQUE POLE #: 13539021	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	257522	T-13039	A2785-1	TRANSFORMER,100kVA	609 CAROL	UNIQUE POLE #:	MEC	01	2400/7200	120/240	
270756	QUARTZITE	6	254434	T-10018	ATL1306-3	TRANSFORMER,50kVA	808 CHURCHILL	UNIQUE POLE #: 13533333	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254437	T-10019	ATL1306-6	TRANSFORMER,50kVA	827 CAROL	UNIQUE POLE #: 13530630	MEC	92	2400/7200	120/240	
270756	QUARTZITE	6	254440	T-10020	ATL1306-19	TRANSFORMER,50kVA	812 CHURCHILL	UNIQUE POLE #: 13533051	MEC	92	2400/7200	120/240	
270760	QUARTZITE	7	254473	T-11225	951102068	TRANSFORMER,100kVA	823 D'AIGLE	UNIQUE POLE #: 13567207	CME	95	2400/7200	120/240	

270764	QUARTZITE	8	262510	T-10567	62068:9	TRANSFORMER,75kVA	840 HUDSON	UNIQUE NO: 13503157	FPT	95	2400/7200	120/240	
270768	QUARTZITE	12	255797	T-10756	951037700	TRANSFORMER,75kVA	867 HUDSON	UNIQUE NO: 13522624	ONA		2400/7200	120/240	
270768	QUARTZITE	12	257174	T-11793	A1939-1	TRANSFORMER,100kVA	816 LAKESIDE	UNIQUE POLE #:	MAE	97	2400/7200	120/240	
270780	VANIER	21	257289	T-6255	3106426	TRANSFORMER,100kVA	RED LIFT SMOKEY	UNIQUE POLE #:	MEP	84	2400/7200	600	
270780	VANIER	21	257272	T-6209	310642-4	TRANSFORMER,100kVA	RED LIFT SMOKEY	UNIQUE POLE #:	MEP	94	2400/7200	600	
270784	VANIER	22	256353	T-10774	951038435	TRANSFORMER,100kVA	412 VANIER	UNIQUE POLE #:	ONA		2400/7200	120/240	
270784	VANIER	22	256354	T-10771	951038438	TRANSFORMER,100kVA	410 MONTAGNAIS	UNIQUE POLE #:	ONA		2400/7200	120/240	
270784	VANIER	22	256355	T-10773	951039204	TRANSFORMER,100kVA	404 MONTAGNAIS	UNIQUE POLE #:	ONA		2400/7200	120/240	
270784	VANIER	22	262512	T-10576	62068:7	TRANSFORMER,75kVA	415 MASSEY	UNIQUE POLE #:	FPT	95	2400/7200	120/240	
270784	VANIER	22	257206	T-3-0111	975586	TRANSFORMER,75kVA	408 MURPHY	UNIQUE POLE #:	GEI	75	2400/7200	120/240	
271168	VANIER	23	255798	T-10016	A1294-24	TRANSFORMER,75kVA	431 VANIER	UNIQUE POLE #: 13587011	MEC	92	2400/7200	120/240	
45974	HARRIE LAKE	19	269556	T-3-1819	741095955	TRANSFORMER,100kVA	3027 HARRIE LAKE	UNIQUE POLE #:	RTE				
270724	HUDSON	15	275349	T-10022	484629	TRANSFORMER,50kVA	333 VIKING	UNIQUE POLE # 13584120	WES				
270724	HUDSON	15	275346	T-09977		TRANSFORMER,75kVA	513 GUY	UNIQUE POLE #: 13583125					
270724	HUDSON	15	275343	T-09871	ATL-1307-47	TRANSFORMER,100kVA	501 HUDSON	UNIQUE POLE #: 13582224	MAE	92			
270724	HUDSON	15	275351	T-09880	ALT 1307-46	TRANSFORMER,100kVA	615 HUDSON	UNIQUE POLE #: 13584784	MAE	92			
270724	HUDSON	15	269377	T-10135	LC25245	TRANSFORMER,100kVA	704 RICHARD	UNIQUE POLE #: 13539497	WES	77			
270724	HUDSON	15	269768	T-10076	937565	TRANSFORMER,100kVA	306 CAROL	UNIQUE POLE #: 13581799	WES	75			
270724	HUDSON	15	269383	T-10077	LG25025	TRANSFORMER,100kVA	321 ELIZABETH	UNIQUE POLE #: 13582982	WES	81			
270724	HUDSON	15	269479	T-10048	LJ20518	TRANSFORMER,100kVA	502 CAROL	UNIQUE POLE #: 13583977	WES	82			
270724	HUDSON	15	269681	T-10138	839860	TRANSFORMER,50kVA	621 HUDSON	UNIQUE POLE #: 13585303	WES	73			
270728	HUDSON	16	275398	T-10103	718904	TRANSFORMER,50kVA	101 STATION RD	UNIQUE POLE #: 14241534	WES	71			
270728	HUDSON	16	275400	T-10834	551034750	TRANSFORMER,50kVA	SHELL BULK PLANT	UNIQUE POLE #: 14245138	CME	95			
270728	HUDSON	16	275404	T-10915	951037301	TRANSFORMER,100kVA	BRUNO PLAZA	UNIQUE NO: 14242811/14242717	CME	95			
270728	HUDSON	16	248981	T-7993	ALT 1306-12	TRANSFORMER,100kVA	HOLLOWAY ENT 105 AIRPORT RD	UNIQUE NO:14243712	CAR	94		120/240	
270728	HUDSON	16	275367	T-11905	A1953-5	TRANSFORMER,50kVA	PEACE PARK/AVALON	UNIQUEPOLE #:	MAE	97			
270728	HUDSON	16	275369	T-09981	61851:1	TRANSFORMER,100kVA	LAB MOTORS AVALON	UNIQUE POLE #:	FPT	94			
270728	HUDSON	16	275370	T-09988	61851:3	TRANSFORMER,100kVA	LAB MOTORS/AVALON	UNIQUE POLE #:	FPT	94			
270728	HUDSON	16	275372	T-10760	951037300	TRANSFORMER,100kVA	CITY TIRE/STAT RD	UNIQUE POE #: 14241348	CME	95			
270728	HUDSON	16	275375	T-10920	951037303	TRANSFORMER,100kVA	CITY TIRE/STAT RD	UNIQUEPOLE #: 14241346	CME	95			
270728	HUDSON	16	275379	T-10758	951037305	TRANSFORMER,100kVA	CITY TIRE/STAT RD	UNIQUE POLE #: 14241348	CME	95			
270728	HUDSON	16	275399	T-10846	951034749	TRANSFORMER,50kVA	SHELL BULK PLANT	UNIQUEPOLE #: 14245138	CME	95			
270728	HUDSON	16	275401	T-10684	951034748	TRANSFORMER,50kVA	SHELL BULK PLANT	UNIQUE POLE #: 14245138	CME	95			
270728	HUDSON	16	275402	T-10751	951037304	TRANSFORMER,100kVA	BRUNO PLAZA	UNIQUE NO: 14242811/14242717	CME	95			
270728	HUDSON	16	275403	T-10922	951037302	TRANSFORMER,100kVA	BRUNO PLAZA	UNIQUE NO: 14242811/14242717	CME	95			
270728	HUDSON	16	269503	T-10960	484647	TRANSFORMER,50kVA	218 HUMPHREY	UNIQUE POLE #: 14241158	WES				
270733	HUDSON	17	275440	T-10099	ATL 1307-2	TRANSFORMER,100kVA	211 LAKESIDE	UNIQUE POLE #: 13559489	MAE	92			
270733	HUDSON	17	275410	T-10005	A1294-17	TRANSFORMER,75kVA	MARY BROWNS, 210 DRAKE	UNIQUE POLE #: 13577203	MAE	92			
270733	HUDSON	17	275412	T-7994	ALT 1307-14	TRANSFORMER,100kVA	MARY BROWNS, 210 DRAKE	UNIQUE POLE #: 13577015	MAE	92			
270733	HUDSON	17	275430	T-10101	ATL1307-12	TRANSFORMER,100kVA	131 CABOT	UNIQUE POLE #: 13575401	MAE	92			
270733	HUDSON	17	275434	T-10130	ALT 1307-1	TRANSFORMER,100kVA	120 AVALON	UNIQUE POLE #: 13571421	MAE	92		120/240	
270733	HUDSON	17	275435	T-10142	ATL1307-29	TRANSFORMER,100kVA	121 MARCONI	UNIQUE POLE: 13571233	MAE	92			
270733	HUDSON	17	275437	T-09969	618 50-5	TRANSFORMER,75kVA	111 DRAKE	UNIQUE POLE #: 13573223	FPT	94			
270733	HUDSON	17	275444	T-10098	ATL1307-30	TRANSFORMER,100kVA	311 BARTLETT	UNIQUE POLE #: 13574500	MAE	92			
270733	HUDSON	17	275406	T-10673	951034752	TRANSFORMER,50kVA	BRACE'S BLDG, 211 AMHERST	UNIQUE POLE #: 13577679	CME	95			
270733	HUDSON	17	275407	T-10682	951034757	TRANSFORMER,50kVA	BRACES BLDG, 211 AMHERST	UNIQUE POLE #: 13577679	CME	95		347	
270733	HUDSON	17	275414	T-10681	951034755	TRANSFORMER,50kVA	CITY AUTO PARTS 207 AMHERST	UNIQUE POLE #: 13577109	CME	95			
270733	HUDSON	17	275422	T-10680	951034742	TRANSFORMER,50kVA	CITY AUTO, AMHERST	UNIQUE POLE #: 13577109	CME	95			
270733	HUDSON	17	275438	T-10097	ATL 1306-4	TRANSFORMER,50kVA	222 BARTLETT	UNIQUE POLE #: 13559771	MAE	92			
270733	HUDSON	17	275439	T-10096	ATL 1306-18	TRANSFORMER,50kVA	230 BARTLETT	UNIQUE POLE #: 13559583	MAE	92			
270733	HUDSON	17	275441	T-10095	ATL 1306-20	TRANSFORMER,50kVA	302 BARTLETT	UNIQUE POLE #: 13570520	MAE	92			
270733	HUDSON	17	269381	T-14274	LF26207	TRANSFORMER,50kVA	GALLERY 201	UNIQUE POLE #: 13577961	WES	80			
270733	HUDSON	17	269540	T-10100	484654	TRANSFORMER,50kVA	120 MARCONI	UNIQUE POLE #: 13574030	WES				
270738	HUDSON	18	275449	T-12689	535228	TRANSFORMER,50kVA	302 BERERLY	UNIQUE POLE #: 13516702	WES				
270738	HUDSON	18	269378	T-10949	LE30946	TRANSFORMER,50kVA	507 CAROL	UNIQUE POLE #: 13586110	WES	80			
270760	QUARTZITE	7	275025	T-11560	A1906-10	TRANSFORMER,50kVA	422 CENTENNIAL	UNIQUE POLE #: 13568490	MAE	96			
270760	QUARTZITE	7	275028	T-11232	951102064	TRANSFORMER,100kVA	417 CENTENNIAL	UNIQUE POLE #: 13563133	COO	95		120/240	
270764	QUARTZITE	8	269682	T-10109	937322	TRANSFORMER,75kVA	816 HUDSON	UNIQUE POLE #: 13502538	WES	75			
270764	QUARTZITE	8	269765	T-10106	937550	TRANSFORMER,100kVA	715 DURRELL	UNIQUE NO: 13503345	WES	75			
270764	QUARTZITE	8	269478	T-10118	LG25026	TRANSFORMER,75kVA	804 BEOTHUCK	UNIQUE POLE #: 13520446	WES	81			
270768	QUARTZITE	12	248410	T-12872	LJ33017	TRANSFORMER,75kVA	841 WILLOW	UNIQUE POLE #:	WES	82			
270768	QUARTZITE	12	255796	T-10783	839882	TRANSFORMER,50kVA	1003 PINE	UNIQUE POLE #: O: 13547403	WES				
270768	QUARTZITE	12	269376	T-10062	L0107-3	TRANSFORMER,100kVA	815 WILLOW	UNIQUE POLE #: 13541715	CAR	83			
270772	QUARTZITE	13	269544	T-10054	700956	TRANSFORMER,50kVA	841 TAMARACK	UNIQUE POLE #: 13541245	WES	70			
270780	VANIER	21	269499	T-10059	432681	TRANSFORMER,25kVA	TAP TO GATEWAY	UNIQUE POLE #:	WES				
270784	VANIER	22	269767	T-10050	937559	TRANSFORMER,100kVA	405 MASSEY	UNIQUE POLE #:	WES	75			
270784	VANIER	22	269766	T-10043	937553	TRANSFORMER,100kVA	405 MURPHY	UNIQUE POLE #: 13561425	WES	75			
271168	VANIER	23	255802	T-10990	427369	TRANSFORMER,50kVA	705 MCPARLAND	UNIQUE POLE #:	WES				