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hydro
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January 24, 2017

Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL A1A 5B2

Attention: Ms. Cheryl Blundon
Director of Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: An Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the Act for the approval to construct a fourth distribution feeder at the Bottom Waters Terminal Station

Please find enclosed the original and nine (9) copies of the above-noted Application, plus supporting affidavit, project proposal, and draft order.

Hydro has received two customer requests for service which will add approximately 2 MW to Bottom Waters distribution system. System analysis indicates that the current system is unable to support the planned additional load as voltage conditions will violate Hydro's distribution planning criteria. The proposed project involves the construction of a fourth distribution feeder at the Bottom Waters Terminal Station to ensure that Hydro can continue to provide safe and adequate and just and reasonable service to its customers.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Tracey L. Pennell
Legal Counsel

TLP/lb

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Sheryl Nisenbaum – Praxair Canada Inc.
Dennis Browne, Q.C. – Consumer Advocate
Thomas J. O'Reilly, Q.C. – Cox & Palmer

ecc : Larry Bartlett – Teck Resources Limited

IN THE MATTER OF the *Electrical Power Control Act,* RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for approval to construct a fourth distribution feeder at the Bottom Waters Terminal Station.

TO: The Board of Commissioners of Public Utilities (the Board)

THE APPLICATION OF NEWFOUNDLAND AND LABRADOR HYDRO (HYDRO) STATES THAT:

1. Hydro is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the Act, and is subject to the provisions of the *Electrical Power Control Act, 1994*.

2. Hydro owns and operates the Bottom Water Terminal Station, which serves customers in a number of communities located on the Baie Verte Peninsula. In May 2016, Hydro received two service requests from large commercial customers. Both of these customers are located in the Ming's Bight area and are supplied by feeder BW1 from the Bottom Waters Terminal Station. These requests, one for a new service, and one for a service expansion, will add over 2 MW of additional load at the end of BW1 on the Bottom Waters distribution system.

3. System analysis indicates that the current distribution system is unable to support the proposed additional load as voltage conditions would violate Hydro's distribution planning criteria. If the system is not upgraded and Hydro permits the additional load to be connected to the system, the system will, at times, operate outside of Hydro's

System Planning criteria and some customers on the distribution system will experience voltage conditions that could damage customer owned equipment.

4. Hydro is recommending the construction of a new 25 km distribution feeder out of the Bottom Waters Terminal Station along Route 414 and 418 on the Baie Verte Peninsula, to allow the load in the area to be shared between the existing feeder BW1 and the proposed new feeder. This will allow for the proposed load to be connected to the system without causing any equipment damaging voltage conditions on the distribution system and keep the distribution system within Hydro's distribution planning criteria. This project will take approximately 6 months to complete. Details regarding Hydro's proposal to construct the fourth distribution feeder are contained in the attached project proposal document.

5. The estimated cost of this project is $3,045,000.

6. Hydro submits that the construction of a fourth distribution feeder from the Bottom Waters terminal station is necessary to ensure that Hydro can continue to provide service which is safe and adequate and just and reasonable as required by Section 37 of the *Act.* An Engineering Report supporting this supplemental capital application is attached.

7. Hydro therefore makes Application for an Order pursuant to section 41(3) of the *Act* approving the construction of a fourth distribution feeder from the Bottom Waters Terminal Station, at an estimated capital cost of $3,045,000, all as set out in this Application and in the attached project description and justification document.

DATED at St. John's in the Province of Newfoundland and Labrador this 24th day of January 2017.

Tracey Pennell

Tracey L. Pennell
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A REPORT TO
THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

REGISTERED PROFESSIONAL ENGINEER R.J.H. MOULTON SIGNATURE Jan 24, 2017 PROVINCE OF NEWFOUNDLAND	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Additions for Load Growth – New Distribution Feeder

Bottom Waters

January 24, 2017

newfoundland labrador hydro
a nalcor energy company

Executive Summary

This report details a proposal to upgrade the Bottom Waters distribution system to accommodate proposed load growth on feeder BW1.

In May 2016, Newfoundland and Labrador Hydro (Hydro) received two service requests from customers in the area of Ming's Bight on the Baie Verte Peninsula. These requests, one for a new service, and one for a service expansion, will add over 2 MW of additional load at the end of a 25 km distribution line on the Bottom Waters distribution system. System analysis indicates that the current distribution system is unable to support the proposed additional load as voltage conditions would violate Hydro's distribution planning criteria.[1] If the system is not upgraded and Hydro permits the additional load to be connected to the system, the system will, at times, operate outside of Hydro's System Planning criteria and some customers on the distribution system will experience voltage conditions which could damage customer owned equipment.

A number of upgrade alternatives were considered to address the new load growth. A detailed analysis identified which ones were technically feasible and then an economic analysis was carried out to determine the least cost alternative. The least cost alterative is the construction of a new feeder from the Bottom Waters Terminal Station to the area of the new load.

The scope of this project includes constructing a new 25 km distribution feeder along Route 414 and 418 on the Baie Verte Peninsula to allow the load in the area to be shared between the existing feeder BW1 and the proposed new feeder. This will allow for the proposed load to be connected to the system without causing any equipment damaging voltage conditions on the distribution system and keep the distribution system within Hydro's distribution

[1] Hydro's Distribution Planning Criteria are a set of criterion that ensures an adequate supply of power to customers served on Hydro's distribution systems. These criteria are described and explained in Appendix A to this report. Criteria relevant to this project are presented in Section 3.2. Hydro's Distribution Planning Assumptions are attached in Appendix B.

planning criteria.

The total projected capital cost for this project is $3,045,000 and will be completed by August 2017.

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1.0 INTRODUCTION

On May 2, 2016, Newfoundland and Labrador Hydro (Hydro) received a new service request for a new customer with a forecast peak demand of 1319 kW. On May 27, 2016, Hydro received a service expansion request for an existing customer of 701 kW, indicating that it expected to grow its peak demand to 1614 kW over 5 years. Both of these customers are located in the Ming's Bight area of the Baie Verte Peninsula and are supplied from the Bottom Waters Terminal Station. This additional load cannot be accommodated by the existing distribution system as it would cause voltage conditions that would violate Hydro's distribution planning criteria.[2] In order to accommodate the additional load, upgrades to the existing system are required. Otherwise, the system will, at times, operate outside of Hydro's System Planning criteria and some customers on the distribution system will experience voltage conditions which could damage customer-owned equipment.

Hydro is recommending the construction a fourth distribution feeder (BW4) out of the Bottom Waters Terminal Station. The new line would be 25 km long and run parallel to feeder BW1 for 600 m after the turn off to Highway 418. At this point, the load currently on BW1 would be transferred to BW4. This project would also involve installing a 200 A regulator bank at the end of the new feeder to maintain proper voltage levels near existing customers. This project will take approximately 6 months to complete.

Due to the timing of the new customer requests, it was too late for Hydro to include a proposal for this project in Hydro's 2017 Capital Budget Application. However, if Hydro waited to include this project in its 2018 Capital Budget Application, it would likely not be approved until December 2017, meaning that the work would not be completed until approximately August 2018. As the customers requesting additional power require the power as soon as possible, Hydro has determined that the needs of Hydro's customers, and

[2] Hydro's Distribution Planning Criteria are a set of criterion that ensures an adequate supply of power to customers served on Hydro's distribution systems. These criteria are described and explained in Appendix A to this report. Criteria relevant to this project are presented in Section 3.2. Hydro's Distribution Planning Assumptions are attached in Appendix B.

the resulting severity of the criteria violations on the existing system if the system is not upgraded, are enough to warrant a supplementary Capital Budget Application.

To aid in the understanding of the services requested and the selection process behind the chosen alternative, this report contains the following information:

- Projected load forecast;
- Outline of the operating deficiencies that are expected to occur as a result of the customer requests;
- Alternatives to address those deficiencies; and
- Recommendations associated with system expansion required to accommodate requests.

2.0 Existing System

The Bottom Waters Terminal Station is located near the intersection of Baie Verte Highway (Route 414) and Nipper's Harbour Road (Route 415) as shown in Figure 1 and Figure 2. Both requests are from mining customers located in an area currently supplied from feeder BW1 (Figure 2), which is supplied from the Bottom Waters Terminal Station (Figure 2). BW1 is a 25 kV feeder serving approximately 1800 customers, including two large mining customers.

Figure 1: Layout of Bottom Waters Distribution System

BW1 runs from Bottom Waters Terminal Station for 30 km along Route 414 (La Scie Highway) to Route 418 (Ming's Bight Road) as a three phase feeder with 2/0 AASC conductor. It then proceeds 10.5 km along Route 418 as a three phase feeder with 1/0 AASC conductor supplying two mining customers and customers in the community of Ming's Bight.[3 & 4] The location of the Bottom Waters distribution system is shown in Figure 2.

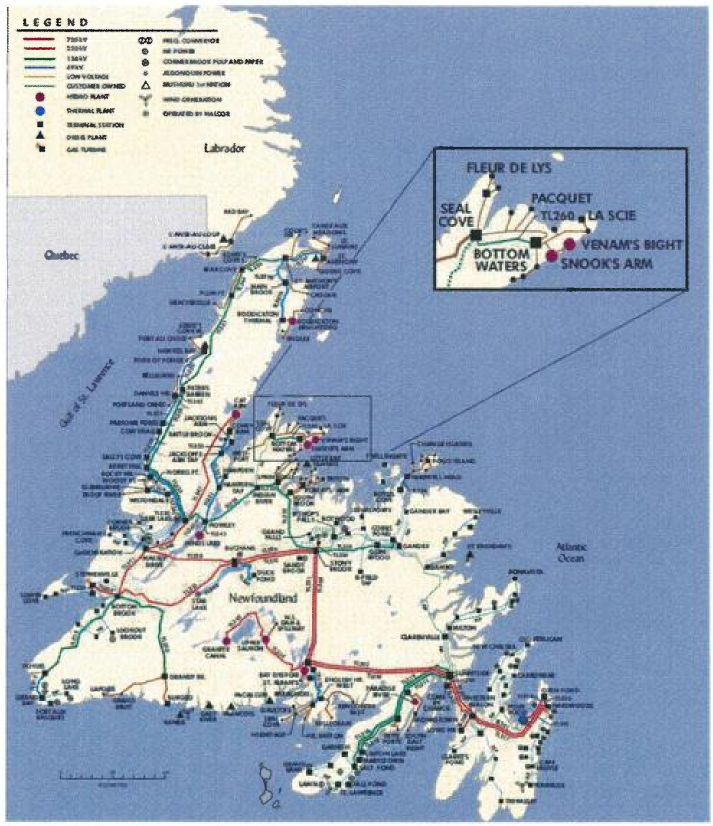


Figure 2: Location of Bottom Waters Distribution System

2.2 Historical Load Information

The Bottom Waters Terminal Station has experienced steady growth in peak load and electricity sales for the past five years mainly due to a growth in the area's mining industry. The annual energy consumption and historic peak load of the Bottom Waters distribution system as a whole and for feeder BW1 from 2011 to 2015 is shown in Figure 3.

[3] For more information on the conductor size of this distribution system, please see Figure 6 in section 4.3.
[4] A Single Line Diagram of BW1 is provided in Appendix C.

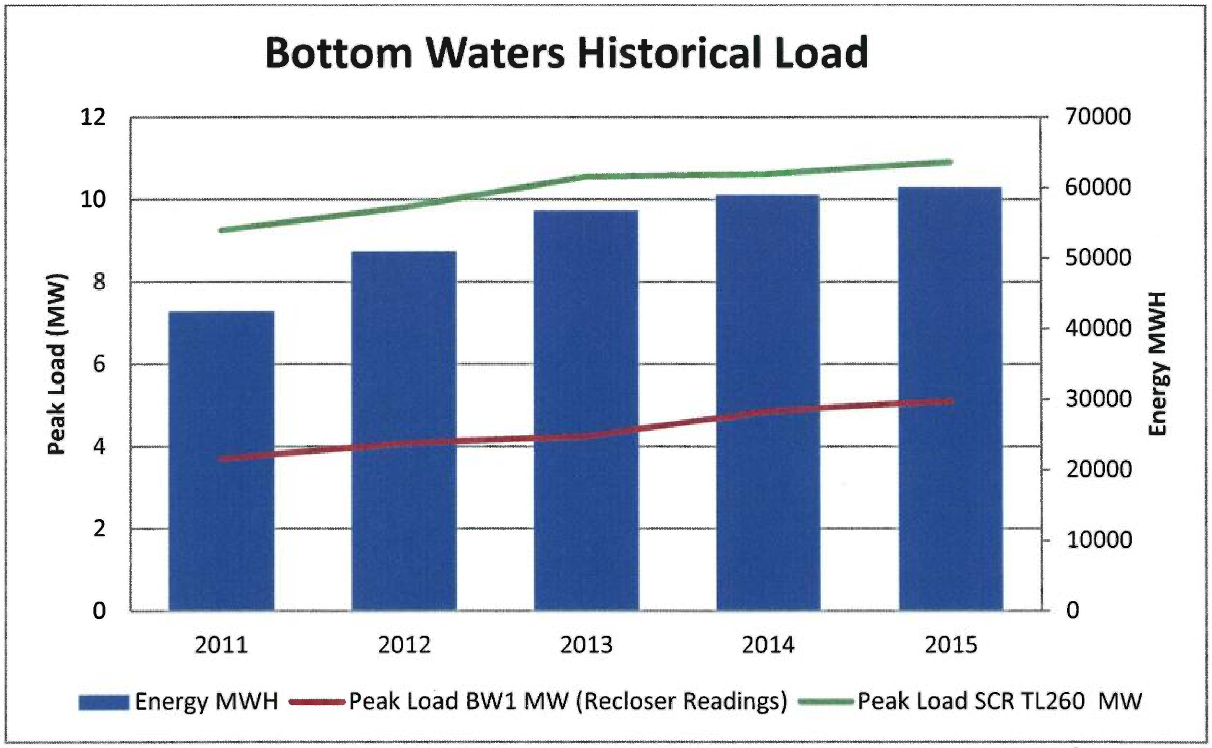


Figure 3: Historical Load Information

It should be noted that there is no communications system installed in the Bottom Waters Terminal Station.[5] As a result, system load readings are obtained from transmission line TL260 leaving the Seal Cove Road (SCR) Terminal Station and the recloser readrs from feeder BW1. The peak system load readings from TL260 include the electrical losses of the transmission line and transformer into the Bottom Waters Terminal Station. The feeder BW1 load readings come from recloser readings captured during monthly field visits. The recloser readings capture the individual peak of each phase on the distribution line. As each phase will typically not peak at the same time, recloser readings tend to be higher than the actual peak load on the system.

[5] A communications system is approved to be installed in Bottom Waters Terminal Station as part of Hydro's 2017 Capital Budget Application.

3.0 Justification

This project is justified on the requirement to meet the growing electricity needs of Hydro's customers on the Bottom Water distribution system. According to load flow analysis and recent load studies, it has been determined that the addition of the new load resulting from the customers' requests results in a violation of Hydro's distribution planning criteria on the Bottom Waters distribution system if the system is not upgraded.

3.1 Forecasted Load Growth

Hydro's Market Analysis division generated a base case peak load forecast for BW1 to account for the two service requests. The base case forecast is the expected forecast and was used to determine the required amount of capacity that the distribution system, or a piece of equipment within the system, must have in order to meet the expected demand. This forecast includes the existing load on the system plus the expected load growth over a twenty-year period. The forecast includes new and existing Domestic Service Customers (i.e., new homes) and General Service Customers (i.e., new businesses and institutional facilities), and also projects the peak demand for the distribution system over a twenty-year period.

The 2016 base case load forecast for the Bottom Waters distribution system, as a whole, and for feeder BW1, is presented in Table 1.

Table 1: Bottom Waters Distribution System Forecasts

Year[6]	Base Case Forecast		High Growth Forecast	
	Gross System Peak (MW)	Gross Feeder BW1 Peak (MVA)	Gross System Peak (MW)	Gross Feeder BW1 Peak (MVA)
2016	11.3	5.5	11.3	5.5
2017	13.4	7.6	14.9	9.0
2018	13.9	7.8	15.6	9.4
2019	14.2	8.0	16.4	9.9
2020	14.3	8.1	18.0	11.8
2021-2036	14.3	8.1	18.0	11.8

3.2 Analysis

The voltage unbalance and temporary overvoltage limits of a distribution system are based on Hydro's distribution planning criteria and are used to determine when capital work must be carried out to avoid criteria violations.[7]

According to load flow analysis and recent load studies, feeder BW1 is at its full operating capacity. Using the load forecasts in Table 1, it has been determined that this increased load will result in a voltage unbalance with high temporary overvoltages exceeding system planning criteria on BW1 if the proposed load growth proceeds using available infrastructure. Exceeding these particular distribution planning criteria may cause damage to customer-owned equipment.

As is shown in Table 2, load flow analysis indicates that if the proposed new load is added to the feeder and no upgrades are carried out, voltage unbalance above Hydro's distribution planning criteria of 2% begins to occur in 2017 (2.5% unbalance). By 2020, voltage unbalance increases to 3.6%.

[6] For a winter peaking system like Bottom Waters, the forecasted peak for a particular year includes the winter season starting in the year referenced, which ranges between November and March of the following year. For example, the 2018 forecasted peak includes the winter of 2018/2019, which ranges between November 2018 and March 2019.

[7] Please refer to Appendix A and B for Hydro's Distribution Planning Criteria Standard and Hydro's Distribution Planning Assumptions, respectively.

Table 2: Voltage Unbalance – BW1

Year	Voltage Unbalance (%)
2016	1.9%
2017	2.5%
2018	3.1%
2019	3.8%
2020	3.6%

3.3 Operating Experience

3.2.1 Reliability Performance

This project is justified based on proposed load growth resulting from customer requests and not to improve reliability on the distribution system.

3.3.2 Legislative or Regulatory Requirements

There are no legislative or regulatory requirements associated with this project.

3.3.3 Safety Performance

This project is not required to enhance safety performance.

3.3.4 Environmental Performance

This project does not impact Hydro's environmental performance.

3.3.5 Industry Experience

All work and justification associated with this project is based on good utility practice. Industry Experience is not applicable.

3.3.6 Vendor Recommendations

All work and justification associated with this project is based on good utility practice. No vendor recommendations are required for this project.

3.3.7 Maintenance or Support Arrangements

Distribution lines and terminal stations are inspected and maintained by Hydro.

3.3.8 Maintenance History

The maintenance history of this system is not relevant to this project.

4.0 Development of Alternatives

When criteria violations are forecasted to occur on a distribution system, Hydro investigates various options to prevent the violations from occurring. As such, each alternative investigated includes a combination of applicable technical options that address predicted abnormal conditions. The common technical options studied by Hydro are:

- Transfer Load;
- Single-phase to Three-phase Line Conversion;
- Installation of Voltage Regulators;
- Replace Existing Equipment with Equipment with Higher Ratings;
- Increase Conductor Size (Reconductor);
- Voltage Conversion;
- Relocate Equipment; and
- Construct New Distribution Feeder.

As a result of Hydro's analysis, four technically viable solutions were considered:

1. Transfer of load from feeder BW1 to feeder SCR-01, which is owned by Newfoundland Power Inc.;
2. Construction of a fourth distribution feeder out of the Bottom Waters Terminal Station to the area of the load growth;
3. Replace feeder BW1 with a larger conductor; and
4. Construct a new 138 kV terminal station in Mings Bight to supply power to feeder BW1.

4.1 Alternative 1 – Transfer Load to Seal Cove Road SCR-01

This alternative involves connecting the end of feeder BW1 near the intersection of highway 414 and 418 to Seal Cove Road SCR-01 feeder from the Seal Cove Road Terminal Station, which is owned by Newfoundland Power Inc. (Newfoundland Power) and wheeling[8] power through SCR-01 to Hydro's customers in the Ming's Bight area. A map of this alternative is shown in Figure 4.

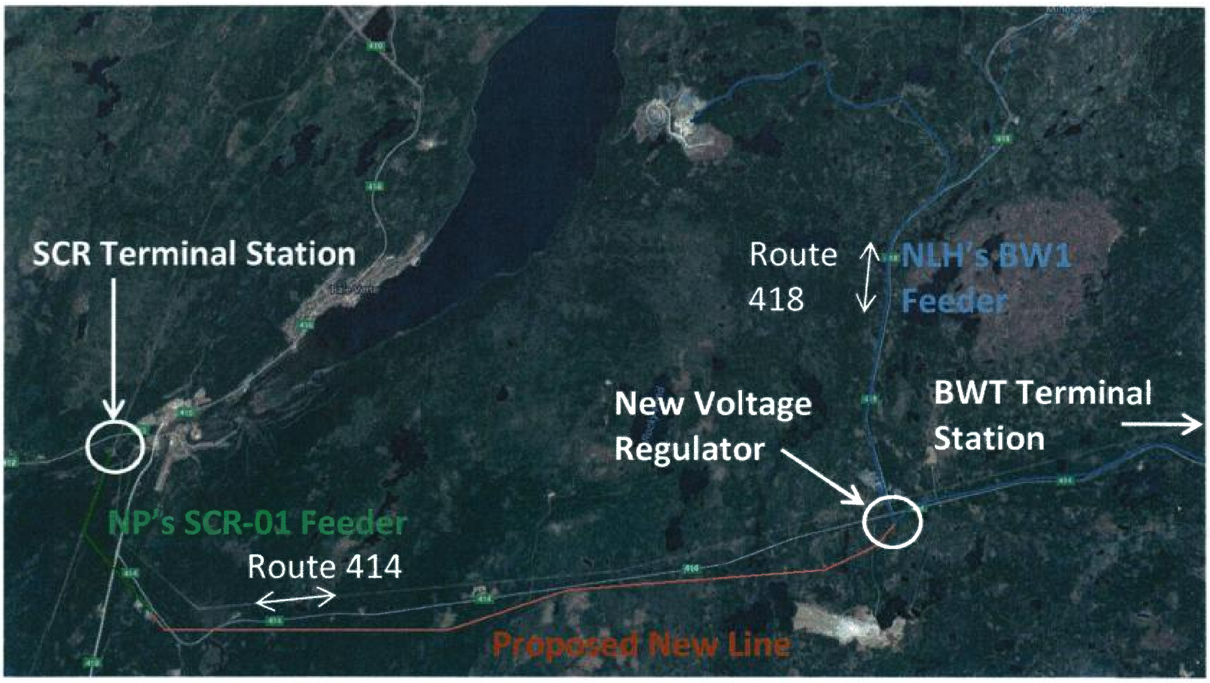


Figure 4: Map of Alternative 1

For this alternative, Newfoundland Power would have to upgrade its existing terminal station equipment, including an existing transformer (SCR-T1), and build new distribution infrastructure. As these upgrades would only be required to support load to Hydro's customers, Hydro would be responsible for Newfoundland Power's costs to upgrade its system. Additionally, Hydro would have to install a new 400 A voltage regulator bank near Highway 418 to prevent voltage drop along the new feeder from violating Hydro's distribution planning criteria. This project would take approximately a year to complete.

[8] Wheeling is the transportation of electrical energy through a transmission or distribution line which is not part of a utilities service area.

Table 3 shows the capital costs estimated for Alternative 1.

Table 3: Alternative 1 Capital Costs

Item	Cost ($000)
Cost for Newfoundland Power system modifications to allow power to be wheeled to through feeder SCR-01 to feeder BW1	3,791.0
Purchase and install a new set of three 400A, 14.4 kV voltage regulators	357.0
Purchase and install a new three phase recloser at interconnection point	84.0
Total	4,232.0

4.2 Alternative 2 – Construct a new distribution feeder from Bottom Waters Terminal Station

This alternative involves constructing a fourth distribution feeder (BW4) out of the Bottom Waters Terminal Station. The new line would be 25 km long, constructed with 4/0 AASC conductor and run parallel to BW1 for 600 m after the turn off to Highway 418. At this point, the load currently on BW1 would be transferred to BW4. This alternative also involves installing a 200 A regulator bank at the end of the new feeder to maintain proper voltage levels near existing customers. This project would take approximately 6 months to complete. A map of this alternative is shown in Figure 5. A single line diagram is included in Appendix C.

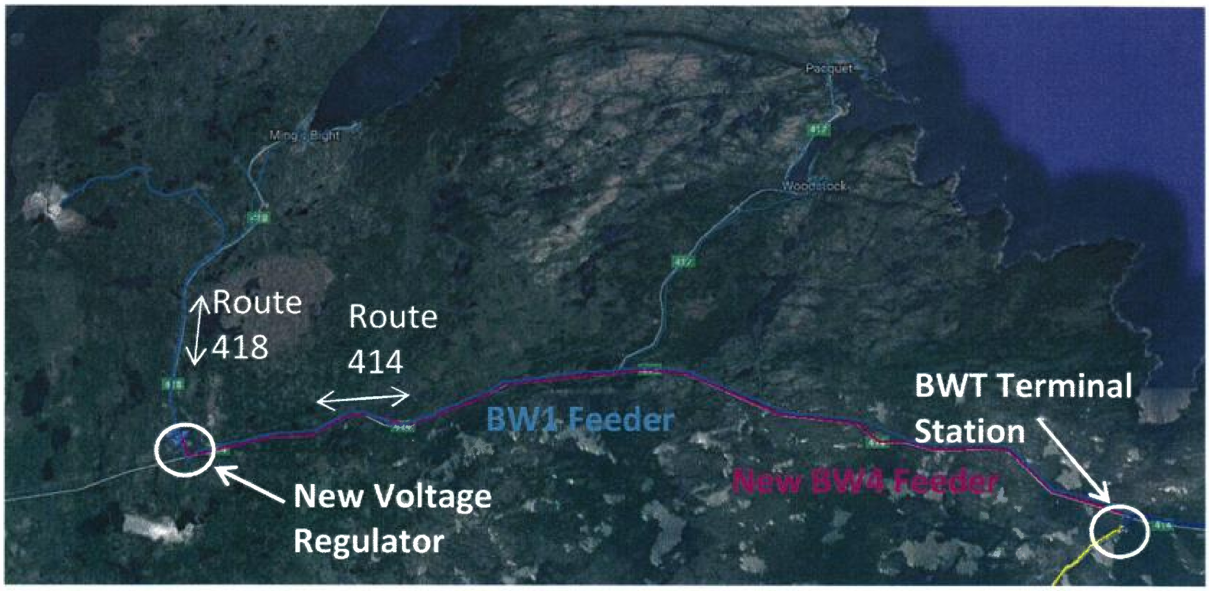


Figure 5: Map of Alternative 2

Table 4 shows the capital costs for Alternative 2.

Table 4: Alternative 2 Capital Costs

Item	Cost ($000)
Supply and install 25 km of three phase 4/0 AASC distribution line	2,464.0
Supply and install 200A, 25 kV Three Phase Voltage Regulator	280.0
Reconfigure BWT terminal station to allow fourth feeder	301.0
Total	**3,045.0**

4.3 Alternative 3 – Replace Existing Feeder BW1

This alternative involves constructing the same distribution feeder as described in Alternative 2, except that the existing feeder would be removed and the new feeder would supply the entire load on the existing feeder BW1 with a larger primary conductor of 477 ASC. Conductor sizes are shown in Figure 6.

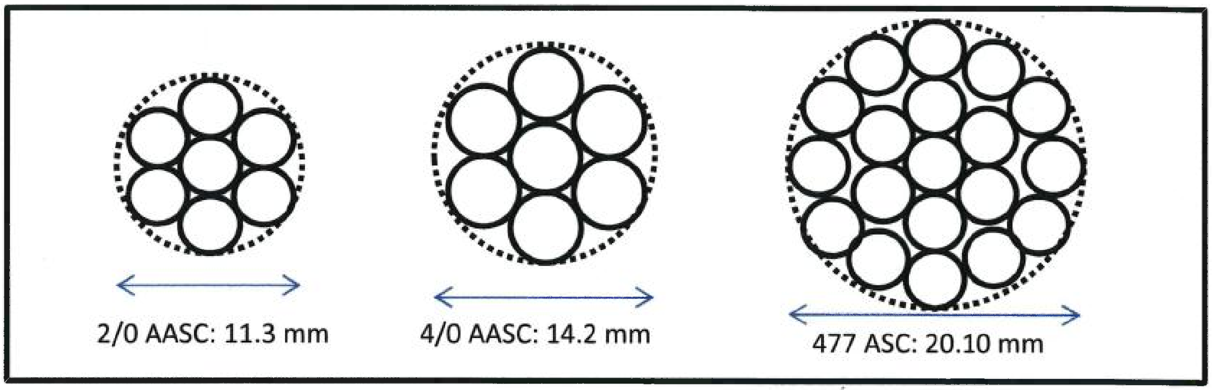


Figure 6: Conductor Types

This alternative does not require any terminal station work or new voltage regulators as the existing equipment can be used. However, it does include the cost to decommission the existing BW1 feeder. This project would take less than one year to complete.

Table 5 shows the capital costs for Alternative 3.

Table 5: Alternative 3 Capital Costs

Item	Cost ($000)
Supply and install 25 km of three phase 477 ASC distribution line	3,248.0
Decommission BW1 along main Highway	428.0
Total	**3,676.0**

4.4 Alternative 4 – Construct a New Terminal Station at Ming's Bight

This alternative involves constructing a new 138 kV terminal station near the intersection of Highway 414 and Highway 418 to supply power to feeder BW1. The new terminal station would include a new 10 MVA, 138/25 kV transformer that would convert the transmission level voltage from TL260 to 25 kV to be used on the distribution system. This project would likely take multiple years to complete. A map showing this alternative is shown Figure 7.

Figure 7: Map of Alternative 4

Table 6 shows the capital costs for Alternative 4.

Table 6: Alternative 4 Capital Costs

Item	Cost ($000)
Construct New 138/25 kV Terminal Station Near Highway to Ming's Bight	10,745.0
Total	10,745.0

5.0 Evaluation of Alternatives

All of the alternatives considered are technically viable and would prevent any distribution planning criteria violations within the next 20 years. As such, each of the above alternatives requires an economic analysis to effectively choose the most economically viable, or least-cost, alternative. This included analyzing the capital costs required on the distribution system over a 40-year period, the electrical losses, loss on disposal, operation and maintenance, and the salvage value of assets removed from service. A 40-year study period was used to align with the 40 year composite average life of a distribution line.

Tables 7and 8 presents the Cumulative Present Worth (CPW) of each alternative and the difference in CPW between each alternative for the base case forecast respectively, to determine which option is the least cost alternative.

Table 7: CPW of Alternatives using Base Case Forecast

Alternative	CPW ($000)	CPW Difference between Alternative and the Least Cost Alternative ($000)
Alt 1. NP interconnection - 16.6 MVA	5,537.5	164.0
Alt 2. New Feeder Bottom Waters (4/0 AASC conductor)	5,373.5	0.0
Alt 3. Replace Feeder BW1	5,966.0	592.5
Alt 4. New Terminal Station	10,745.0	5,371.4

Based on the foregoing analysis, Alternative 2 is the preferred alternative as it has the lowest Cumulative Present Worth of all the alternatives, can be completed in the least amount of time to satisfy the customer requests when compared to the other alternatives, and will also technically satisfy the high growth forecast.

6.0 Budget Estimate and Schedule

Table 8 shows the estimated cost for Alternative 2. Table 9 shows the schedule for the project.

Table 8: Project Budget Estimate

Project Cost:*($ x1,000)*	**2016**	**2017**	**Beyond**	**Total**
Material Supply	0.0	935.9	0.0	935.9
Labour	0.0	310.0	0.0	310.0
Consultant	0.0	3.8	0.0	3.8
Contract Work	0.0	1,358.5	0.0	1,358.5
Other Direct Costs	0.0	7.3	0.0	7.3
Interest and Escalation	0.0	121.8	0.0	121.8
Contingency	0.0	307.8	0.0	307.8
TOTAL	0.0	3,045.0	0.0	3,045.0

Table 9: Project Schedule

Activity		Start Date	End Date
Planning	Resource Planning	February 2017	February 2017
Design	Assessment Completed	February 2017	February 2017
Procurement	Materials Ordered	February 2017	February 2017
Construction	Monitor Construction Activities	April 2017	June 2017
Commissioning & Energization	Inspection Performed by Local Operations Crews	June 2017	June 2017
Closeout	Project Closeout	July 2017	August 2017

While the requirement for this work is mainly driven by load additions from two customers, the upgrades will ensure that Hydro's service to existing customers on feeder BW1 remains within its planning criteria and avoids voltage unbalances. As such, Hydro did not seek contributions in aid of construction from the customers.

7.0 Conclusion

In May 2016, Hydro received two service requests from customers that will result in the addition of over 2 MW of additional load on one of the feeders in the Bottom Waters distribution system. System analysis indicates that the current distribution system is unable to support the proposed additional load as voltage conditions would violate Hydro's distribution planning criteria. If the system is not upgraded and Hydro permits the additional load to be connected to the system, the system will, at times, operate outside of Hydro's System Planning criteria and some customers on the distribution system will experience voltage conditions which could damage customer-owned equipment.

In-depth analysis has determined that the least cost, long term solution to accommodate the proposed load growth is for Hydro to construct a fourth Bottom Waters feeder and to transfer the load in the Ming's Bight area to the fourth feeder at an estimated capital cost of $3,045,000.

APPENDIX A

Distribution Planning Criteria

1.0 Distribution Planning Criteria Standard

Newfoundland and Labrador Hydro's (Hydro) Distribution Planning Criteria ensures an adequate supply of power to customers served on Hydro's distribution systems. As a general rule, the following criteria guide Hydro's planning activities.

2.0 Voltage Level Criteria

A) The range of normal operating voltage is based on the Canadian Standard CSA CAN3-C235-83 ("Preferred Voltage Levels") and the CEA "Distribution Planner's Guide".

B) Voltage balance – maximum 2% voltage unbalance.

C) Voltage Flicker Limit – maximum of 5% voltage flicker.

D) Temporary Overvoltage – maximum 110% overvoltage.

Hydro uses the CSA standard *CAN3–C235–83 – Preferred Voltage Levels for AC Systems 0 – 50,000 V* as the guide for determining acceptable steady-state voltage limits at customers' service entrances. This is a National Standard of Canada that establishes a guideline for voltage standards for AC Systems in Canada. It was adopted by Hydro as its standard for the range of acceptable voltages that will be provided to customers and is used by utilities across Canada. A standard for voltage levels is necessary because devices connected to the electrical system are designed to operate within a certain range of voltages. When voltages supplied to a device deviate from this acceptable range, the device can be damaged or fail to function properly. The standard is meant to ensure that devices connected to the electrical system receive voltage within their normal operating range so that they function normally and damage does not occur.

The standard refers to two separate operating conditions, normal and extreme. The normal operating condition is applied when the distribution system is operating as designed and not experiencing continuous operation outside design limits. The extreme operating condition is applied during continuous operation of a power system outside of design limits and planned capital or operating work is scheduled to be carried out to correct the issue. In this situation, the system is operating within Normal Operating Conditions most of the time and only operates within Extreme Operating Conditions at times of peak demand. These conditions do not include voltage levels experienced during fault conditions or heavy starting loads.

Under normal operating conditions where there are no operational anomalies and the feeder is performing as designed, the customer service entrance voltage must be held between a minimum of 110 V for single-phase customers and 112 V for three-phase customers and a maximum of 125 V for a nominal 120 V service.

Table 1: displays the normal and extreme operating condition nominal voltage ranges for many types of electrical services.

Table 1: Recommended Voltage Variation Limits for Circuits up to 1000V, at Service Entrances[1]

Nominal System Voltages	**Voltage Variation Limits Applicable at Service Entrances**			
	Extreme Operating Conditions			
		Normal Operating Conditions		
Single-phase (V)	**Lower Limit**		**Upper Limit**	
120/240	106/212	110/220	125/250	127/254
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635
Three-phase 4-Conductor (V)				
120/208Y	110/190	112/194	125/216	127/220
240/416Y	220/380	224/338	250/432	254/440
277/480Y	245/424	254/440	288/500	293/508
347/600Y	306/530	318/550	360/625	367/635
Three-Phase 3-Conductor (V)				
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635

[1] CSA standard CAN3–C235–83 (R2006) – Preferred Voltage Levels for AC Systems 0 – 50,000 V, Table 3 - Recommended Voltage Variation Limits for Circuits up to 1000 V, at Service Entrances.

The Distribution Planning Criteria standard also states that primary service voltages are to be supplied within six percent of the nominal system voltage.

Under extreme operating conditions, the distribution system is operating outside of the normal operating voltage limits and an operational anomaly has been identified on the system. In this case, work must be planned to correct the deficiency so that voltages remain within the normal operating condition limits. During extreme operating conditions, the customer service entrance nominal voltage must range from a minimum of 106 V for single-phase customers and 110 V for three-phase customers to a maximum of 127 V for a nominal 120 V service (single-phase and three-phase).

If the customer service entrance nominal voltage falls outside of the extreme voltage range as outlined in the CSA standard, emergency work must be completed as soon as possible to rectify the issue. If not, damage to customer equipment is likely. Hydro is responsible for ensuring voltage levels up to the service entrance (i.e. the weatherhead) are within stated limits.

The above CSA standard has been adopted by Hydro to ensure customer service entrance voltages remain within the stated limits. However, planning engineers complete system design and analysis using nominal voltages on primary distribution feeders. To relate the two, the System Planning Department references the CEA Distribution Planners Manual. The manual provides estimates of the average voltage drop that can be anticipated between the primary and the service entrance to define a minimum and maximum planning voltage on a 120 V base for the primary distribution line.

Table 2 and Table 3 outline the Hydro standard voltage drop for each line section and transformer between the primary conductor and the service entrance for single-phase and three phase customers respectively.

Table 1: Preferred Voltage at the Primary for Single-phase Customers

		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

Note: Some customers are supplied from express service drops. Therefore, no secondary voltage drop occurs under the light load condition.
*** Hydro is responsible for voltage up to the service entrance.**

Table 2: Preferred Voltage at the Primary for Three-phase Customers

		Voltage (120 V Base)	
		Heavy Load	**Light Load**
Service Entrance Voltage*		112	125
Voltage Drop at	Service Drop Wire	1	0.375
	Secondary Conductor	-	-
	Distribution Transformer	3	1.125
Total Voltage Drop from Primary to Service Entrance		4	1.5
Voltage at Primary		116	126.5

Note: 3Φ General Service Customers are normally supplied from express drops off their own transformer bank. Therefore, no secondary voltage drop occurs.
*** Hydro is responsible for voltage up to the service entrance.**

Therefore, Hydro uses a planning voltage range of 116 V to 126.5 V on distribution primary lines, assuming a 120 V base.

Voltage unbalance occurs when loads are not equally distributed across all three-phases of a distribution feeder. The percentage voltage unbalance is calculated as the maximum phase voltage deviation from the average voltage, divided by the average voltage, multiplied by 100%. It is common on many Hydro distribution systems to have long single-phase lines with large end of line loads that can increase voltage unbalance. A feeder experiencing a high percentage of voltage unbalance can cause excessive motor heating, increasing the likelihood of failure.

Voltage flicker is a transient phenomenon that occurs when large loads are switched on the system causing an instantaneous change in voltage. Usually this is experienced during motor starting or pick-up of a large customer load. In these cases, a dip in voltage is experienced due to the increase in current flow, causing lights to flicker. This can dim lighting and interrupt motor operation. Hydro will allow a maximum of 5% voltage flicker before work must be initiated to correct the problem. If voltage flicker worsens, the problem becomes much more noticeable and pronounced. Hydro addresses flicker at the operational level by setting limitations on the amount of current the system can supply to a customer without causing disturbances to other customers on the system.

Temporary overvoltage is an increase in ac voltage greater than 1.1 pu for a duration longer than 1 min. Overvoltages can be the result of load switching (e.g., switching off a large load) or of variations in the reactive compensation on the system (e.g., switching on a capacitor bank). Poor system voltage regulation capabilities or controls can cause overvoltages.

3.0 Loading Criteria

Equipment loading is no greater that 100% of its continuous rating:

A) Conductor ampacity is seasonally adjusted for appropriate temperature during the peak.
B) Short term overloading on transformers is permitted.

Loading of equipment should not exceed nameplate ratings and the conductor ampacity must be adjusted for the ambient temperature during periods of peak loading. Distribution power transformers, however, are permitted to be loaded to 110% of nameplate rating for short durations. This is due to the cooling effect of the oil surrounding the transformer core and windings during short periods of overloading.

Increases in customer load on distribution feeders can lead to overloading of overhead conductor and/or related equipment. A detailed load flow analysis will indicate areas that are experiencing current overloads during periods of peak loading. Equipment affected by overloads includes transformers, circuit breakers, reclosers, voltage regulators and switches.

Overloads on bare overhead conductor are identified during load flow analysis for the particular distribution feeder. Hydro has adopted the IEEE738[2] method for calculating the ampacity of overhead conductor based on ambient temperatures and uses a 100% ampacity rating for all planning related design and analysis.

Hydro has two standard types of switches, group operated switches (gang switch) and single-phase cutouts. Group operated switches are rated for load breaking and are operated by a single handle to break all phases at the same time. These switches do not use any fuses for line protection. Single-phase cutouts are used for isolating sections of line once they have been de-energized, as they are not rated to break load. Cutouts, however, can be fused to a number of ratings depending on the protection requirements. For planning and analysis purposes, the System Planning Department uses 100% of the continuous current rating for switches. Gang switches are rated for 600A per phase, where solid blade (no fuse) cutouts are rated for 300A. If the cutout is fused, the rating then becomes the rating of the installed fuse.

The planning rating for reclosers is 100% of the rated continuous and interrupting current of the unit. Circuit breaker planning ratings are the same for reclosers; 100% of the rated continuous and interrupting current rating of the unit.

[2] IEEE738 - IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors

Overloads on power transformers in distribution substations are identified during the feeder load flow analysis. Hydro uses a planning rating of 110% of the nameplate rating of the transformer. Voltage regulators on the Hydro system are analyzed using a planning rating of 100% of the continuous current rating of the series winding of the device. Table 3 contains a list of the planning loading limits for all distribution system equipment.

Table 3: Planning Limits for Loading of Distribution System Equipment

Equipment Type	Nominal %	Planning %	Comments
Breaker	100	100	
Recloser	100	100	
Fuse	100	100	
Sectionalizer	100	100	
Switch	100	100	
Aerial Conductor	100	100	Seasonally adjusted for temperature.
Insulated Cable	100	100	Adjusted for installation location and type.
Regulator	100	100	
Transformer	100	110	Where overload is short term.

Load imbalance occurs when customer loads are not equally distributed across all three-phases of a distribution feeder. The percentage of load imbalance is calculated as the maximum phase load deviation from the average load, divided by the average load, multiplied by 100%. A highly unbalanced load on a feeder can lead to a high degree of voltage unbalance along the feeder due to varying voltage drop on the phase conductors. An unbalanced feeder will experience higher losses due to currents flowing in the neutral circuit.

By comparing the planning ratings to the forecast load, Hydro determines the required timing of capacity additions.

APPENDIX B

Distribution Planning Assumptions

Distribution Planning Assumptions

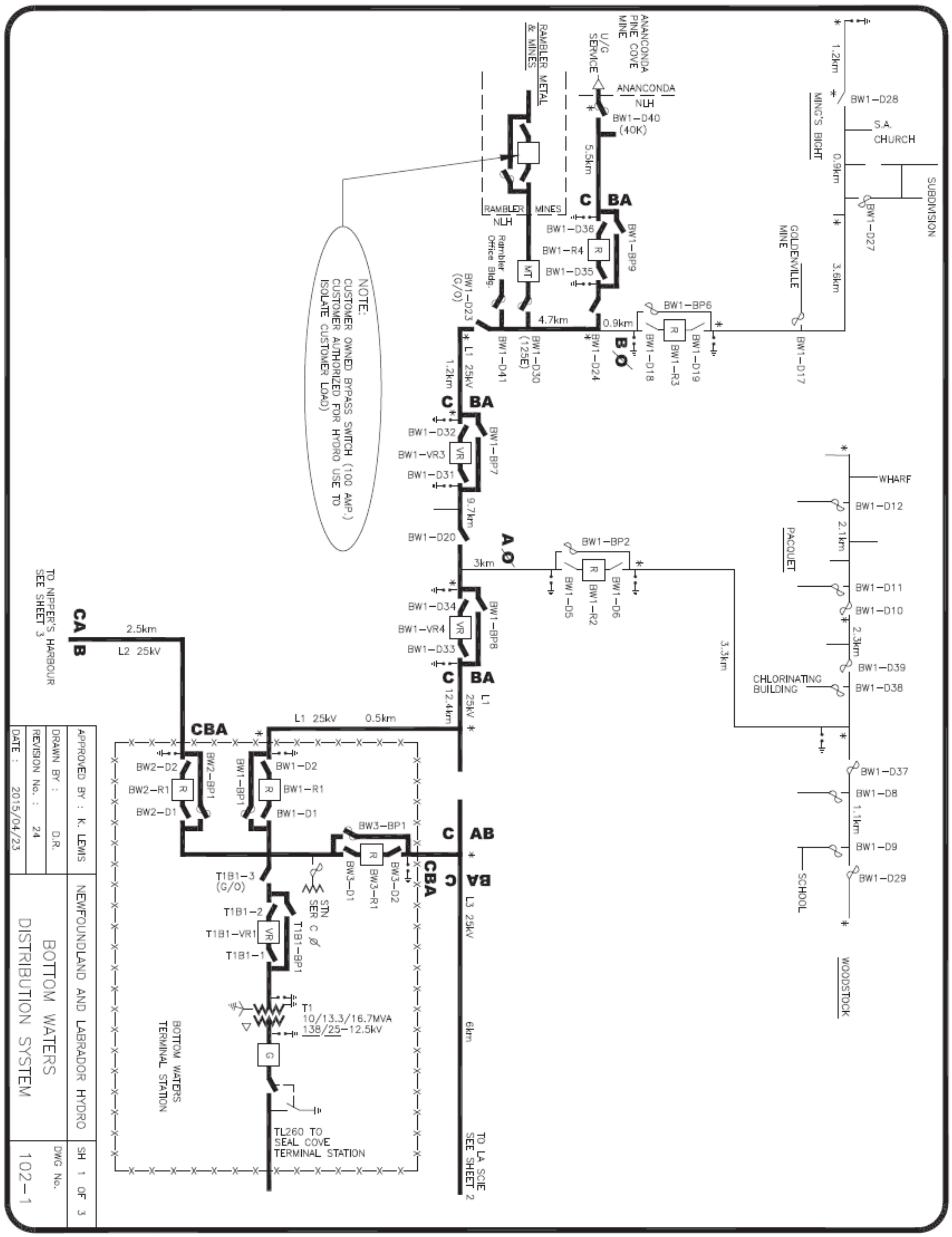
To maintain a consistent approach to all distribution system design and analysis, Newfoundland and Labrador Hydro (Hydro) has developed a set of assumptions for all systems. No equipment, including transformers, regulators, reclosers, circuit breakers or switches is de-rated. Therefore, all equipment is assumed to be capable of operating within design limits.

A number of assumptions are made to obtain the ampere rating of a particular sized conductor depending on its construction and geographic location. Generally, the rated capacity of the lines is based on the maximum allowable operating temperature, which is affected by climate. Hydro has adopted the *IEEE738 - IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors*, which outlines the method used to determine the current-temperature of a particular cable. Hydro assumes a maximum conductor rating of 75°C, a temperature rise of 45°C and a 30°C ambient temperature. The operating temperature of an overhead conductor is affected by the heating effects of solar radiation and the cooling effects of wind as well as geographic location. A new overhead conductor is shiny, which reflects solar radiation and is less susceptible to additional heating to that of a weathered conductor, which is dull and absorbs more solar energy. Hydro assumes all conductors to have 50% emissivity and 50% solar absorption, which reflects a weathered (greyed) conductor in full sunshine and a clear atmosphere, located at 50° north latitude at sea level. Cooling of the conductors during normal operation due to light cross winds is assumed. All conductors are assumed to be orientated east to west.

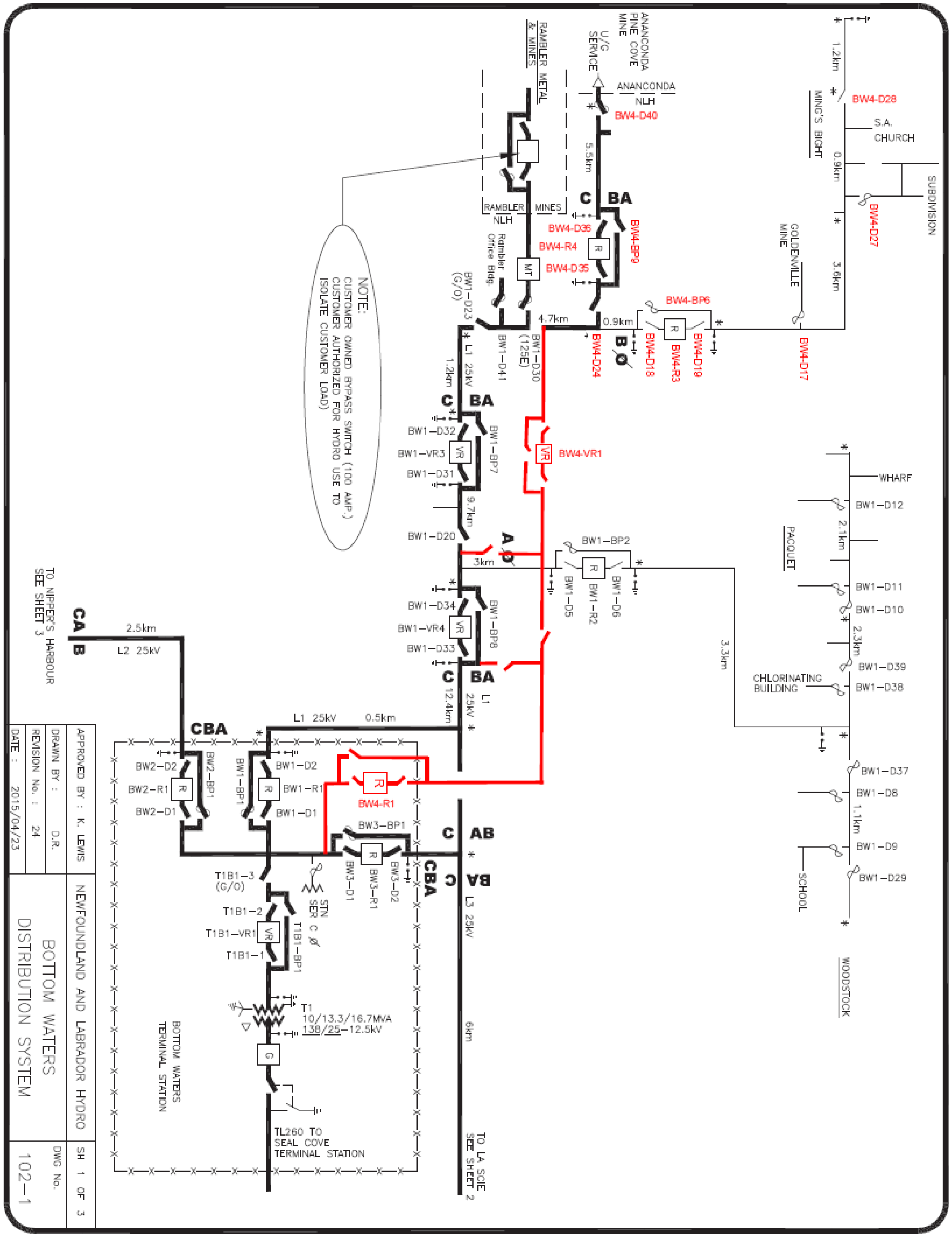
Distribution line ampere ratings are further based on the time of the year in which the peak load occurs on that particular feeder and its location; whether it is located on the Island or in Labrador. For a winter peaking system in Labrador, the ambient temperature is assumed to be -20 °C, where the same system on the Island is assumed to experience an ambient temperature of 0 °C. A summer peaking system is assumed to experience an ambient temperature of 30 °C across all distribution systems. For emergency and temporary situations conductors may be rated based on lower temperatures then indicated above. This depends on the specific location and expected weather during peak conditions. During load flow analysis, unless all the loads are known, all loads are scaled and power factor adjusted so that the substation bus sending power and power factor matches the peak loading EMS data. Furthermore, loads are modelled, unless known, to have a power factor of 0.90 lag if it is primarily a motor load and a power factor closer to unity if the load s primarily electrical resistance heating. The voltage on the substation bus is assumed to be set at its lowest EMS value (if available) during peak loading as a worst case scenario.

APPENDIX C

Single Line Diagrams



Bottom Waters Line 1 (Status Quo)



Bottom Waters Line 1 (Alternative 2)

IN THE MATTER OF the *Electrical Power Control Act,* RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for approval to construct a fourth distribution feeder at the Bottom Waters Terminal Station.

AFFIDAVIT

I, Kyle B. Tucker, Professional Engineer, of St. John's in the Province of Newfoundland and Labrador, make oath and say as follows:

1. I am the Manager of Regulatory Engineering of Newfoundland and Labrador Hydro, the Applicant named in the attached Application.

2. I have read and understand the foregoing Application.

3. I have personal knowledge of the facts contained therein, except where otherwise indicated, and they are true to the best of my knowledge, information and belief.

SWORN at St. John's in the)
Province of Newfoundland and)
Labrador)
this 24th day of January, 2017,)
before me:)

Tracey Pennell

Barrister – Newfoundland and Labrador

Kyle B. Tucker, M. Eng., P. Eng.

(DRAFT ORDER)
NEWFOUNDLAND AND LABRADOR
BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

AN ORDER OF THE BOARD

NO. P.U. __(2017)

IN THE MATTER OF the *Electrical Power Control Act*, RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for approval to construct a fourth distribution feeder at the Bottom Waters Terminal Station.

WHEREAS Newfoundland and Labrador Hydro (Hydro) is a corporation continued and existing under the *Hydro Corporation Act*, *2007*, is a public utility within the meaning of the Act, and is subject to the provisions of the *Electrical Power Control Act*, 1994; and

WHEREAS Section 41(3) of the Act requires that a public utility not proceed with the construction, purchase or lease of improvements or additions to its property where:

a) the cost of construction or purchase is in excess of $50,000; or

b) the cost of the lease is in excess of $5,000 in a year of the lease,

without prior approval of the Board; and

WHEREAS in Order No. P.U. 45(2016) the Board approved Hydro's 2017 Capital Budget in the amount of $271,265,600; and

WHEREAS on January 16, 2017, Hydro applied to the Board for approval to construct a fourth distribution feeder from the Bottom Waters Terminal Station in order to accommodate two new customer service requests and to keep the distribution system within Hydro’s distribution planning criteria; and

WHEREAS the capital cost of the project is estimated to be $3,045,000; and

WHEREAS the Board is satisfied that the construction of a fourth distribution feeder from the Bottom Waters Terminal Station in order to accommodate two new customer service requests and to keep the distribution system within Hydro's distribution planning criteria are necessary and reasonable to allow Hydro to provide service and facilities which are reasonably safe and adequate and just and reasonable.

IT IS THEREFORE ORDERED THAT:

1. The proposed capital expenditure to construct a fourth distribution feeder from the Bottom Waters Terminal Station in order to accommodate two new customer service requests and to keep the distribution system within Hydro's distribution planning criteria at an estimated capital cost of $3,045,000 is approved.

2. Hydro shall pay all expenses of the Board arising from this Application.

DATED at St. John's, Newfoundland and Labrador, this day of , 2017.

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