APPENDIX E DFO NEED FOR DEVELOPMENT REPORT

Need for Development
Transmission Facility Upgrades
Provost Area

January 9, 2018

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Executive Summary

The Provost area is served by distribution systems connected to Edgerton 899S, Hayter 277S, Killarney Lake 267S, Metiskow 648S, and Provost 545S substations.

Hayter 277S substation and Killarney Lake 267S substation are radially supplied by 138 kV transmission line 749AL. Provost 545S substation is radially supplied by 138 kV transmission line 715L.

Load study indicates reliability concerns exist at the Provost area:

- Upon loss of 138 kV transmission line 749AL, there could have been 30.9 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 49.8 MVA in 2026.
- Upon loss of 138 kV transmission line 715L, there could have been 1.3 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 5.9 MVA in 2026.
- Upon loss of 267S transformer T1, there could be 2.2 MVA of unsupplied load in 2017. If left unaddressed, the unsupplied load could be 5.3 MVA in 2026.
- Upon loss of 545S transformer T1, there could have been 1.3 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 5.9 MVA in 2026.

These exceed FortisAlberta Inc. (FortisAlberta) planning criteria for electrical load restoration.

Potential solutions were assessed to address the reliability concerns in the Provost area. Based on information available to FortisAlberta, technical merit and capital cost, the FortisAlberta preferred alternative involves transmission upgrades in the Provost area:

- Build a new 138 kV transmission line connection between Hayter 277S substation and Provost 545S substation.

Distribution upgrades associated with this alternative include: rebuilding ~56 km of existing distribution line; installation of two new voltage regulators and one new feeder tie air switch.

The estimated distribution capital costs associated with this preferred alternative is $6.7 million (±30%, 2020$).

An estimate for the associated transmission system capital cost will be provided by the Transmission Facility Owner (TFO), AltaLink Management Limited (AltaLink).

Based on existing reliability concerns and in consideration of the target timelines for the Alberta Electric System Operator (AESO) Connection Process, the requested In-Service Date (ISD) for the Provost Area transmission upgrade is October 1, 2018.

No Demand Transmission Services (DTS) change is requested at the Edgerton 899S, Hayter 277S, Killarney Lake 267S, Metiskow 648S, and Provost 545S substations.

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1. Background

The Provost area is located approximately 250 km south-east of the City of Edmonton near the Alberta-Saskatchewan border. The area is served by the distribution systems connected to Edgerton 899S, Hayter 277S, Killarney Lake 267S, Metiskow 648S, and Provost 545S substations. The distribution system in the Provost area supplies residential, industrial and commercial loads.

See Appendix A, Figure A-1, for a simplified sketch of the existing transmission and distribution facilities in this area.

Hayter 277S and Killarney Lake 267S substations are radially supplied by 138 kV transmission line 749AL. Upon loss of line 749AL, there could have been 30.9 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 49.8 MVA in 2026.

Provost 545S substation is radially supplied by 138 kV transmission line 715L. Upon loss of line 715L, there could have been 1.3 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 5.9 MVA in 2026.

Upon loss of 267S transformer T1, there could be 2.2 MVA of unsupplied load in 2017. If left unaddressed, the unsupplied load could be 5.3 MVA in 2026.

Upon loss of 545S transformer T1, there could have been 1.3 MVA of unsupplied load in 2016. If left unaddressed, the unsupplied load could be 5.9 MVA in 2026.

These levels of unsupplied load exceed FortisAlberta planning criteria for electrical load restoration.

There is also a capacity concern that load on the 25 kV distribution feeder 277S-464L is predicted to exceed the 13.0 MVA distribution planning criteria in 2017.

2. Criteria

The analysis for the requested development in the Provost area has been conducted based upon the following criteria:

- The maximum normal loading of FortisAlberta 25 kV distribution feeders is 13.0 MVA.
- FortisAlberta planning criteria for electrical load restoration requires that adequate backup supply for contingency situations be available subject only to switching time. Backup capability refers to the ability to restore service after an interruption without necessarily first repairing the cause of the interruption.
- Transmission equipment must not be operated at load levels in excess of the equipment nameplate rating.

- Distributed Energy Resources (DER) are not dispatchable by FortisAlberta and are not considered for the purposes of solving the identified deficiencies.

- Delivered voltage on the distribution system must comply with the requirements of CSA Standard *C235 - Preferred Voltage Levels for AC Systems, 0 to 50,000 V.*

3. Forecasting Methodology

FortisAlberta's load forecasting approach is performed on all of the company's 25 kV distribution feeders that are connected to POD substations.

A consistent bottom-up load forecast approach, as described below, is utilized that incorporates localized influences specific to the area supplied by the distribution feeders and the associated POD substation. The load forecast involves statistical trending of historical recorded peaks, and includes aggregated committed load and the application of distribution system planning and engineering judgement. The resultant load forecast identifies the upper bounds of electric system peak capacity that would be required annually to address customer needs.

Committed loads include individual customer-contracted peak demands and load allocated to committed subdivision developments where FortisAlberta holds signed contracts with developers. Differences between the forecast and actual committed loads occur when customers do not make full use of their committed contracted demand.

On an annual basis, the peak demand load of each distribution feeder is obtained from meters located at the substation that serves the feeder. This recorded meter data is reviewed over a date range of March 1st of the current year through February 28 of the following year to capture the yearly distribution feeder peak loads.

Individual 25 kV feeder loads are then summed up, with the application of a coincidence factor to the individual distribution feeder peaks, to determine the predicted loading on the specific substation transformer that the 25 kV feeders are connected to. The resultant loads on the substation transformers are then totaled, with the application of a coincidence factor to the individual calculated transformer loads, to determine the total substation loads.

For individual substation load forecasting, the forecast increase from year 0 to year 1 is the result of the following four factors:

- forecasted aggregated customer load growth;
- new contracted committed load additions;
- existing contracted committed loads; and
- planned load transfers.

The DTS contract level of each project is determined from the load forecast table in the NFD document, that is associated with the preferred solution. This is done by identifying the predicted peak load at the Point of Delivery (POD) substation and during the year of

the project's ISD. A conversion of power units is needed to contract for DTS. This is accomplished by multiplying the POD forecast by the substation power factor (pf). The resultant is subsequently multiplied by a POD load coincidence factor of 0.9, to determine the DTS level that FortisAlberta requests from the AESO.

4. Existing System Assessment

The existing transmission and distribution systems in the Provost area are shown in Figure A-1 in Appendix A.

4.1 Load Forecast

Table 4-1 provides FortisAlberta historical and forecast peak load levels for the substations and feeders in the study area. The load forecast is based on historical data, expected development trends and contracted new loads. This load forecast was used to assess all the alternatives presented in this Need for Development document.

Table 4-1: FortisAlberta Historic and Forecast Load: Existing System

					MVA LOADING - RECORDED						MVA LOADING - PREDICTED									
				W	2012	2013	2014	2015	2016		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
SUB		CAPACITY		or	Peak	Peak	Peak	Peak	Peak	PF	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak
No	Feeder	T/R	MVA	S	MVA	MVA	MVA	MVA	MVA		MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA
267S	Killarney Lake	T1	25/33/ 42	W	**27.7**	**27.7**	**26.1**	**22.8**	**21.7**	93%	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
267S	2054L			W	10.5	10.8	9.9	8.4	8.3	94%	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6
267S	2055L			W	11.1	10.9	10.4	8.6	7.8	94%	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.5
267S	2120L			W	6.5	6.5	6.2	6.0	5.9	92%	6.1	6.2	6.3	6.3	6.4	6.4	6.5	6.6	6.6	6.7
277S	Hayter	T1	25/33/42// 47	W	**31.8**	**32.7**	**32.2**	**10.8**	**9.6**	96%	**12.8**	**12.9**	**13.0**	**13.2**	**13.3**	**13.4**	**13.5**	**13.7**	**13.8**	**13.9**
277S	324LN			W	5.7	6.0	5.7	2.3	1.8	99%	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.4
277S	324LS			W	5.0	4.7	4.9	7.4	6.4	95%	7.4	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1
277S	464L			W	9.4	9.5	9.5			93%										
277S	2187L			W	12.6	13.1	12.9			97%										
277S	2525L (2015)			W				1.7	1.9	96%	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
277S	Hayter (2015)	T2	25/33/ 42	W				**13.7**	**18.0**	95%	**23.3**	**23.5**	**23.7**	**23.9**	**24.1**	**24.3**	**24.5**	**24.7**	**24.9**	**25.1**
277S	464L			W				7.0	10.3	93%	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.2	15.3
277S	2187L			W				7.0	9.0	97%	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2
277S	Total Station							**24.0**	**26.6**	95%	**35.1**	**35.4**	**35.7**	**36.0**	**36.3**	**36.6**	**36.9**	**37.2**	**37.5**	**37.9**
545S	Provost	T1	25/33/ 42	W	**23.5**	**25.2**	**25.9**	**25.8**	**25.6**	95%	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
545S	2011L			W	6.4	7.3	8.0	8.0	8.0	94%	9.3	9.4	9.5	9.6	9.6	9.7	9.8	9.9	10.0	10.1
545S	2054L			W	8.2	8.6	7.3	7.7	7.6	94%	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1
545S	462LE			W	6.5	6.8	7.3	7.5	7.5	96%	9.5	9.7	9.9	10.1	10.3	10.5	10.8	11.0	11.2	11.5
545S	461LE			W	3.4	4.0	3.5	3.3	3.8	94%	3.9	3.9	3.9	4.0	4.0	4.0	4.0	4.0	4.1	4.1
648S	Metiskow	T1	15/20/ 25							96%										
648S		VR2	15/20/ 25	W	**11.9**	**11.9**	**10.3**	**8.5**	**8.2**	96%	**11.5**	**11.6**	**11.7**	**11.8**	**11.8**	**11.9**	**12.0**	**12.1**	**12.1**	**12.2**
648S	2011L			W	5.0	4.9	3.8	2.6	2.8	95%	3.5	3.5	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8
648S	2102LW			W	4.8	4.8	4.8	4.2	4.2	97%	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.1	6.1
648S	2166L			W	2.5	2.5	2.4	1.9	1.6	95%	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.0	3.0
899S	Edgerton	T3	15/20/ 25	W	**9.2**	**9.4**	**8.9**	**8.6**	**8.5**	98%	**9.7**	**9.9**	**10.0**	**10.2**	**10.4**	**10.6**	**10.7**	**10.9**	**11.1**	**11.3**
899S	373LW			W	3.3	3.2	3.0	3.1	3.1	98%	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.7	3.7	3.7
899S	95LE			W	5.9	6.2	6.1	5.5	5.5	98%	6.2	6.3	6.5	6.6	6.8	6.9	7.1	7.3	7.4	7.6
Total Area Load:					**104.1**	**106.9**	**103.4**	**89.7**	**90.6**		**112.5**	**113.7**	**114.8**	**116.0**	**117.1**	**118.3**	**119.5**	**120.7**	**122.0**	**123.2**

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
N-1 Contingency @ 749AL (267S & 277S)	Total Load:	**48.3**	**61.2**	**61.7**	**62.3**	**62.8**	**63.3**	**63.8**	**64.4**	**64.9**	**65.5**	**66.1**
	Back up from 545S:	9.6	9.1	9.2	9.2	9.3	9.3	9.4	9.5	9.6	9.7	9.8
	Back up from 648S:	4.6	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.5
	Back up from 899S:	3.2	3.0	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2.0
	N-1 Unsupplied Load:	**30.9**	**44.9**	**45.5**	**46.2**	**46.6**	**47.2**	**47.7**	**48.2**	**48.7**	**49.3**	**49.8**

Notes:

1.) Killarney Lake 267S and Hayter 277S substations are radially fed by 138 kV transmission line 749AL.

2.) Provost 545S substation is radially fed by 138 kV transmission line 715L.

N-1 Contingency @ 715L (545S)	Total Load:	**25.6**	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
	Back up from 267S:	3.8	3.9	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.1	4.2
	Back up from 277S:	14.3	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0
	Back up from 648S:	6.2	6.7	6.7	6.7	6.6	6.6	6.6	6.5	6.5	6.5	6.5
	N-1 Unsupplied Load:	**1.3**	**3.4**	**3.7**	**3.9**	**4.2**	**4.5**	**4.8**	**5.1**	**5.4**	**5.7**	**5.9**

N-1 Contingency @ T1, 267S	Total Load:	**21.7**	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
	N-1 Capacity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 277S:	14.2	13.2	13.3	13.5	13.7	13.9	14.0	14.1	14.3	14.5	14.5
	Back up from 545S:	8.0	10.7	11.0	11.2	10.8	10.4	10.0	9.6	9.2	8.8	8.4
	Back up from 648S:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 899S:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N-1 Unsupplied Load:	**0.0**	**2.2**	**2.0**	**1.9**	**2.3**	**2.7**	**3.3**	**3.8**	**4.2**	**4.7**	**5.3**

N-1 Contingency @ T1, 545S	Total Load:	**25.6**	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
	N-1 Capacity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 267S:	3.8	3.9	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.1	4.2
	Back up from 277S:	14.3	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0
	Back up from 648S:	6.2	6.7	6.7	6.7	6.6	6.6	6.6	6.5	6.5	6.5	6.5
	N-1 Unsupplied Load:	**1.3**	**3.4**	**3.7**	**3.9**	**4.2**	**4.5**	**4.8**	**5.1**	**5.4**	**5.7**	**5.9**

The Provost area was assessed with the following reliability concerns observed from Table 4-1:

- In 2016, a reliability concern exists on both Hayter 277S and Killarney Lake 267S substations during n-1 contingency at 138 kV transmission line 749AL. The total unsupplied load could exist at levels as high as 30.9 MVA. If left unaddressed, it is predicted to increase to 49.8 MVA by 2026. This exceeds FortisAlberta planning criteria for electrical load restoration.

- In 2016, a reliability concern exists on the Provost 545S substation during n-1 contingency at 138 kV transmission line 715L. The unsupplied load could exist at levels as high as 1.3 MVA. If left unaddressed, it is predicted to increase to 5.9 MVA by 2026. This exceeds FortisAlberta planning criteria for electrical load restoration.

- In 2017, a reliability concern is predicted at the Killarney Lake 267S substation. The unsupplied load could exist at levels as high as 2.2 MVA. If left unaddressed, it is predicted to increase to 5.3 MVA by 2026. This exceeds FortisAlberta planning criteria for electrical load restoration.

- In 2016, a reliability concern exists at the Provost 545S substation. The unsupplied load could exist at levels as high as 1.3 MVA. If left unaddressed, it is predicted to increase to 5.9 MVA by 2026. This exceeds FortisAlberta planning criteria for electrical load restoration.

Also the 25 kV distribution feeder 277S-464L is predicted to exceed the 13.0 MVA distribution planning criteria in 2017, and it will be addressed by subsequent distribution and/or transmission system upgrades.

5. Alternatives Analysis

A number of potential solutions to address the reliability concerns at the Provost area were considered, based on both technical merit and cost, three alternatives are presented in this document.

5.1 Alternative 1: Distribution Upgrades and Load Shifting

5.1.1 Description

FortisAlberta has investigated the option of distribution upgrades and load shifting to address the reliability concerns in the area. However as per Table 4-1, starting from 2017, the predicted total area load (112.5 MVA at 2017) will be higher than the N-1 transmission transformation capacity of 92 MVA in the area during N-1 contingency on 138 kV transmission line 749AL. Distribution upgrades and load shifting will not be able to address the unsupplied load under N-1 contingency on 138 kV transmission line 749AL affecting Hayter 277S and Killarney Lake 267S substations.

Therefore, this alternative was not pursued further.

5.2 Alternative 2: Upgrades at the Provost 545S and Edgerton 899S Substations

5.2.1 Description

To establish back-up support during the recognized contingencies as listed in Table 4-1, the following transmission upgrades would have to be completed in 2020:

- Install one additional 138/25 kV, 25/33/42 MVA On-Load Tap Changer (LTC) transformer, and three additional 25 kV feeder breakers at the Provost 545S substation.
- Upgrade the existing 138/25 kV, 15/20/25 MVA transformer to a 138/25 kV, 25/33/42 MVA LTC transformer, and install one additional 25 kV feeder breaker at the Edgerton 899S substation.

Distribution upgrades associated with this alternative include:

- Build three (3) new feeders out of the new transformer at Provost 545S substation, including ~42 km of double circuit (DC) 477 MCM line, ~54 km of 477 MCM line, ~10 km of 3/0 MCM line, ~4.7 km of underground (UG) 750 MCM line, install five (5) 400A voltage regulators (VR), two (2) 200A VRs and convert 8kV services on 545S-2054L.
- Build/rebuild two (2) feeders out of the upgraded transformer at Edgerton 899S substation, including ~16 km of DC 477 MCM line, ~7.5 km of 477 MCM line, ~37 km of 3/0 MCM line, ~200 m of UG 750 MCM line, install two (2) 200A VRs, convert 8 kV services and relocate a rural 8 kV substation on 899S-95LE.
- Rebuild portions of 648S-2166L and 648S-2011L, including ~20 km to 477 MCM line, ~30 m to UG 750 MCM line, and install one (1) 300A VR at 648S-2166L.

Refer to Appendix B, Figure B-1 showing Alternative 2 system development.

All 25 kV overhead conductors, new and existing, exiting the substation and distribution feeder ties shall be 477 MCM. All underground feeder cables, new and existing, exiting the substation and distribution feeder ties shall be 750 MCM. All transmission components on the secondary side of the 25 kV source transformers, new and existing, shall be sized to enable the feeders to simultaneously supply 26 MVA per feeder. All 25 kV feeder breakers shall be equipped with associated equipment to enable under-frequency load shedding.

Transmission facilities must be equipped with the appropriate equipment for interconnection with FortisAlberta's Automated Metering system. Provisions should be made for interconnecting the substation transformer neutrals with the distribution line neutrals as per the AltaLink standard.

All 138 kV and 25 kV buses shall have adequate switch points and protection to minimize frequency and duration of outages associated with the maintenance or failure of substation components upstream of the 25 kV bus. Failure of such upstream components must not result in a total substation outage.

5.2.2 Load Forecast

The load forecast resulting from Alternative 2 is provided in Table 5-1.

Table 5-1: FortisAlberta Historic and Forecast Load: Alternative 2 – Upgrades at Provost 545S Substation and Edgerton 899S Substation

					MVA LOADING - RECORDED						MVA LOADING - PREDICTED									
				W	2012	2013	2014	2015	2016		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
SUB		CAPACITY		or	Peak	Peak	Peak	Peak	Peak	PF	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak
No	Feeder	T/R	MVA	S	MVA	MVA	MVA	MVA	MVA		MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA
267S	Killarney Lake	T1	25/33/ 42	W	**27.7**	**27.7**	**26.1**	**22.8**	**21.7**	93%	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
267S	2054L			W	10.5	10.8	9.9	8.4	8.3	94%	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6
267S	2055L			W	11.1	10.9	10.4	8.6	7.8	94%	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.5
267S	2120L			W	6.5	6.5	6.2	6.0	5.9	92%	6.1	6.2	6.3	6.3	6.4	6.4	6.5	6.6	6.6	6.7
277S	Hayter	T1	25/33/42// 47	W	**31.8**	**32.7**	**32.2**	**10.8**	**9.6**	96%	**12.8**	**12.9**	**13.0**	**13.2**	**13.3**	**13.4**	**13.5**	**13.7**	**13.8**	**13.9**
277S	324LN			W	5.7	6.0	5.7	2.3	1.8	99%	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.4
277S	324LS			W	5.0	4.7	4.9	7.4	6.4	95%	7.4	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1
277S	464L			W	9.4	9.5	9.5			93%										
277S	2187L			W	12.6	13.1	12.9			97%										
277S	2525L (2015)			W				1.7	1.9	96%	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
277S	Hayter (2015)	T2	25/33/ 42	W				**13.7**	**18.0**	95%	**23.3**	**23.5**	**23.7**	**23.9**	**24.1**	**24.3**	**24.5**	**24.7**	**24.9**	**25.1**
277S	464L			W				7.0	10.3	93%	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.2	15.3
277S	2187L			W				7.0	9.0	97%	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2
277S	Total Station							**24.0**	**26.6**	95%	**35.1**	**35.4**	**35.7**	**36.0**	**36.3**	**36.6**	**36.9**	**37.2**	**37.5**	**37.9**
545S	Provost	T1	25/33/ 42	W	**23.5**	**25.2**	**25.9**	**25.8**	**25.6**	95%	**30.1**	**30.5**	**30.8**	**20.5**	**20.8**	**21.2**	**21.4**	**21.7**	**22.1**	**22.3**
545S	2054L			W	8.2	8.6	7.3	7.7	7.6	94%	8.3	8.4	8.5	7.3	7.3	7.4	7.4	7.5	7.6	7.7
545S	462LE			W	6.5	6.8	7.3	7.5	7.5	96%	9.5	9.7	9.9	9.6	9.8	10.1	10.3	10.5	10.7	10.9
545S	461LE			W	3.4	4.0	3.5	3.3	3.8	94%	3.9	3.9	3.9	3.9	4.0	4.0	4.0	4.0	4.1	4.1
545S	2011L			W	6.4	7.3	8.0	8.0	8.0	94%	9.3	9.4	9.5							
545S	Provost (2020)	T2	25/33/ 42	W						95%				**11.4**	**11.4**	**11.5**	**11.7**	**11.9**	**12.0**	**12.1**
545S	2011L			W						94%				9.6	9.6	9.7	9.8	9.9	10.0	10.1
545S	NEW01 (2020)			W						96%				0.4	0.4	0.4	0.4	0.5	0.5	0.5
545S	NEW02 (2020)			W						95%				1.2	1.2	1.2	1.3	1.3	1.3	1.3
545S	NEW03 (2020)			W						96%				0.4	0.4	0.4	0.4	0.4	0.4	0.4
545S	Total Station													**31.2**	**31.6**	**32**	**32.4**	**32.8**	**33.2**	**33.6**
648S	Metiskow	T1	15/20/ 25							96%										
648S		VR2	15/20/ 25	W	**11.9**	**11.9**	**10.3**	**8.5**	**8.2**	96%	**11.5**	**11.6**	**11.7**	**11.8**	**11.8**	**11.9**	**12.0**	**12.1**	**12.1**	**12.2**
648S	2011L			W	5.0	4.9	3.8	2.6	2.8	95%	3.5	3.5	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8
648S	2102LW			W	4.8	4.8	4.8	4.2	4.2	97%	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.1	6.1
648S	2166L			W	2.5	2.5	2.4	1.9	1.6	95%	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.0	3.0
899S	Edgerton	T3	15/20/ 25	W	**9.2**	**9.4**	**8.9**	**8.6**	**8.5**	98%	**9.7**	**9.9**	**10.0**	**10.2**	**10.4**	**10.6**	**10.7**	**10.9**	**11.1**	**11.3**
899S	373LW	T3(2020)	25/33/42	W	3.3	3.2	3.0	3.1	3.1	98%	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.7	3.7	3.7
899S	95LE			W	5.9	6.2	6.1	5.5	5.5	98%	6.2	6.3	6.5	6.5	6.7	6.9	7.0	7.2	7.3	7.5
899S	NEW01 (2020)			W										0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Area Load:					**104.1**	**106.9**	**103.4**	**89.7**	**90.6**		**112.5**	**113.7**	**84.0**	**116.0**	**117.1**	**118.4**	**119.5**	**120.7**	**121.9**	**123.2**

2020	Load Transfers (MVA)	
	From:	To:
0.1	899S-95LE	899S-NEW01
1.2	545S-2054L	545S-NEW02
0.4	545S-462LE	545S-NEW01
0.4	545S-461LE	545S-NEW03
9.6	545S-T1	545S-T2

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
N-1 Contingency @ 749AL (267S & 277S)	Total Load:	**48.3**	**61.2**	**61.7**	**62.3**	**62.8**	**63.3**	**63.8**	**64.4**	**64.9**	**65.5**	**66.1**
	Back up from 545S:	9.6	9.1	9.2	9.2	40.0	40.6	41.2	41.8	42.4	43.0	43.4
	Back up from 648S:	4.6	4.2	4.2	4.2	9.9	10.0	10.1	10.2	10.3	10.4	10.5
	Back up from 899S:	3.2	3.0	2.8	2.7	15.2	15.4	15.6	15.9	16.2	16.4	16.5
	N-1 Unsupplied Load:	**30.9**	**44.9**	**45.5**	**46.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
N-1 Contingency @ 715L (545S)	Total Load:	**25.6**	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
	Back up from 267S:	3.8	3.9	3.9	3.9	2.1	2.1	2.1	2.2	2.2	2.2	2.2
	Back up from 277S:	14.3	16.1	16.2	16.3	20.3	20.7	21.1	21.5	21.8	22.4	22.7
	Back up from 648S:	6.2	6.7	6.7	6.7	10.2	10.4	10.4	10.6	10.6	10.7	10.7
	N-1 Unsupplied Load:	**1.3**	**3.4**	**3.7**	**3.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

N-1 Contingency @ T1, 267S	Total Load:	**21.7**	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
	N-1 Capacity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 277S:	14.2	13.2	13.3	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 545S:	8.0	10.7	11.0	11.2	5.1	5.2	5.2	5.3	5.3	5.4	5.4
	Back up from 648S:	0.0	0.0	0.0	0.0	6.4	6.5	6.5	6.5	6.6	6.6	6.6
	Back up from 899S:	0.0	0.0	0.0	0.0	15.4	15.5	15.7	15.9	16.0	16.2	16.3
	N-1 Unsupplied Load:	**0.0**	**2.2**	**2.0**	**1.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Notes:

1.) Killarney Lake 267S and Hayter 277S substations are radially fed by 138 kV transmission line 749AL.

2.) Provost 545S substation is radially fed by 138 kV transmission line 715L.

N-1 Contingency @ T1, 545S	Total Load:	**25.6**	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
	N-1 Capacity:	0.0	0.0	0.0	0.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
	Back up from 267S:	3.8	3.9	3.9	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 277S:	14.3	16.1	16.2	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 648S:	6.2	6.7	6.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N-1 Unsupplied Load:	**1.3**	**3.4**	**3.7**	**3.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

- The unsupplied load under N-1 contingency at 138 kV transmission line 749AL affecting Hayter 277S and Killarney Lake 267S substations is addressed.
- The unsupplied load under N-1 contingency at 138 kV transmission line 715L affecting Provost 545S substation is addressed.
- The unsupplied load under N-1 transformer contingency at the Killarney Lake 267S substation is addressed.
- The unsupplied load under N-1 transformer contingency at the Provost 545S substation is addressed.
- The capacity concern on 25 kV distribution feeder 277S-464L will be addressed by subsequent distribution and/or transmission system upgrades.

5.2.3 Cost Estimate

If this alternative is selected, AltaLink will prepare a proposal for the requested transmission upgrades. This includes an estimate for the transmission capital cost.

The distribution capital cost for Alternative 2 is estimated to be $31.5 million (2020$, ±30%).

5.3 Alternative 3: New 138 kV Transmission Line Connection between Hayter 277S and Provost 545S substations

5.3.1 Description

To establish back-up support during the recognized contingencies as listed in Table 4-1, the following transmission upgrades would have to be completed in 2020:

- Build a 138 kV transmission line connection between the Hayter 277S substation and the Provost 545S substation.

Distribution upgrades associated with this alternative include:

- Build/rebuild ~22 km line to 3/0 MCM, ~1.5 km line to 477 MCM, install one (1) 200A VR, convert 8 kV services and relocate a rural 8 kV substation on 899S-95LE;
- Rebuild ~9.9 km line to 477 MCM and install one (1) 300A VR on 648S-2166L;
- Rebuild ~9.7 km of line on 648S-2011L to 477 MCM;
- Rebuild ~1.7 km of line on 277S-324LS to 477 MCM;
- Rebuild ~11.2 km of line on 545S-462LE to 477 MCM.

Refer to Appendix C, Figure C-1 showing Alternative 3 system development.

All 25 kV overhead conductors, new and existing, exiting the substation and distribution feeder ties shall be 477 MCM. All underground feeder cables, new and existing, exiting the substation and distribution feeder ties shall be 750 MCM. All transmission components on the secondary side of the 25 kV source transformers, new and existing, shall be sized to enable the feeders to simultaneously supply 26 MVA per feeder. All 25 kV feeder breakers shall be equipped with associated equipment to enable under-frequency load shedding.

Transmission facilities must be equipped with the appropriate equipment for interconnection with FortisAlberta's Automated Metering system. Provisions should be made for interconnecting the substation transformer neutrals with the distribution line neutrals as per the AltaLink standard.

All 138 kV and 25 kV buses shall have adequate switch points and protection to minimize frequency and duration of outages associated with the maintenance or failure of substation components upstream of the 25 kV bus. Failure of such upstream components must not result in a total substation outage.

5.3.2 Load Forecast

The load forecast resulting from Alternative 3 is provided in Table 5-2.

Table 5-2: FortisAlberta Historic and Forecast Load: Alternative 3 – Transmission Upgrades at Provost Area

				MVA LOADING - RECORDED						MVA LOADING - PREDICTED									
			W	2012	2013	2014	2015	2016		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
SUB No	Feeder	CAPACITY T/R MVA	or S	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	PF	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA	Peak MVA
267S	Killarney Lake	T1 25/33/ 42	W	**27.7**	**27.7**	**26.1**	**22.8**	**21.7**	93%	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
267S	2054L		W	10.5	10.8	9.9	8.4	8.3	94%	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6
267S	2055L		W	11.1	10.9	10.4	8.6	7.8	94%	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.5
267S	2120L		W	6.5	6.5	6.2	6.0	5.9	92%	6.1	6.2	6.3	6.3	6.4	6.4	6.5	6.6	6.6	6.7
277S	Hayter	T1 25/33/42// 47	W	**31.8**	**32.7**	**32.2**	**10.8**	**9.6**	96%	**12.8**	**12.9**	**13.0**	**13.2**	**13.3**	**13.4**	**13.5**	**13.7**	**13.8**	**13.9**
277S	324LN		W	5.7	6.0	5.7	2.3	1.8	99%	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.4
277S	324LS		W	5.0	4.7	4.9	7.4	6.4	95%	7.4	7.4	7.5	7.6	7.7	7.8	7.8	7.9	8.0	8.1
277S	464L		W	9.4	9.5	9.5			93%										
277S	2187L		W	12.6	13.1	12.9			97%										
277S	2525L (2015)		W				1.7	1.9	96%	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
277S	Hayter (2015)	T2 25/33/ 42	W				**13.7**	**18.0**	95%	**23.3**	**23.5**	**23.7**	**23.9**	**24.1**	**24.3**	**24.5**	**24.7**	**24.9**	**25.1**
277S	464L		W				7.0	10.3	93%	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.2	15.3
277S	2187L		W				7.0	9.0	97%	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2
277S	Total Station						**24.0**	**26.6**	95%	**35.1**	**35.4**	**35.7**	**36.0**	**36.3**	**36.6**	**36.9**	**37.2**	**37.5**	**37.9**
545S	Provost	T1 25/33/ 42	W	**23.5**	**25.2**	**25.9**	**25.8**	**25.6**	95%	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
545S	2011L		W	6.4	7.3	8.0	8.0	8.0	94%	9.3	9.4	9.5	9.6	9.6	9.7	9.8	9.9	10.0	10.1
545S	2054L		W	8.2	8.6	7.3	7.7	7.6	94%	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.1
545S	462LE		W	6.5	6.8	7.3	7.5	7.5	96%	9.5	9.7	9.9	10.1	10.3	10.5	10.8	11.0	11.2	11.5
545S	461LE		W	3.4	4.0	3.5	3.3	3.8	94%	3.9	3.9	3.9	4.0	4.0	4.0	4.0	4.0	4.1	4.1
648S	Metiskow	T1 15/20/ 25							96%										
648S		VR2 15/20/ 25	W	**11.9**	**11.9**	**10.3**	**8.5**	**8.2**	96%	**11.5**	**11.6**	**11.7**	**11.8**	**11.8**	**11.9**	**12.0**	**12.1**	**12.1**	**12.2**
648S	2011L		W	5.0	4.9	3.8	2.6	2.8	95%	3.5	3.5	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8
648S	2102LW		W	4.8	4.8	4.8	4.2	4.2	97%	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.1	6.1
648S	2166L		W	2.5	2.5	2.4	1.9	1.6	95%	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.0	3.0
899S	Edgerton	T3 15/20/ 25	W	**9.2**	**9.4**	**8.9**	**8.6**	**8.5**	98%	**9.7**	**9.9**	**10.0**	**10.2**	**10.4**	**10.6**	**10.7**	**10.9**	**11.1**	**11.3**
899S	373LW		W	3.3	3.2	3.0	3.1	3.1	98%	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.7	3.7	3.7
899S	95LE		W	5.9	6.2	6.1	5.5	5.5	98%	6.2	6.3	6.5	6.6	6.8	6.9	7.1	7.3	7.4	7.6
Total Area Load:				**104.1**	**106.9**	**103.4**	**89.7**	**90.6**		**112.5**	**113.7**	**114.8**	**116.0**	**117.1**	**118.3**	**119.5**	**120.7**	**122.0**	**123.2**

Notes:

1.) Killarney Lake 267S and Hayter 277S substations are radially fed by 138 kV transmission line 749AL.

2.) Provost 545S substation is radially fed by 138 kV transmission line 715L.

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
N-1 Contingency @ 749AL (267S & 277S)	Total Load:	**48.3**	**61.2**	**61.7**	**62.3**	**62.8**	**63.3**	**63.8**	**64.4**	**64.9**	**65.5**	**66.1**
	Back up from 545S:	9.6	9.1	9.2	9.2	267S and 277S Substations will be fully backed up from Transmission System under N-1 Contingency on 138 kV transmission line 749AL						
	Back up from 648S:	4.6	4.2	4.2	4.2							
	Back up from 899S:	3.2	3.0	2.8	2.7							
	N-1 Unsupplied Load:	**30.9**	**44.9**	**45.5**	**46.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

N-1 Contingency @ 715L (545S)	Total Load:	**25.6**	**30.1**	**30.5**	**30.8**	**31.2**	**31.6**	**32.0**	**32.4**	**32.8**	**33.2**	**33.6**
	Back up from 267S:	3.8	3.9	3.9	3.9	545S Substation will be fully backed up from Transmission System under N-1 Contingency on 138 kV transmission line 715L						
	Back up from 277S:	14.3	16.1	16.2	16.3							
	Back up from 648S:	6.2	6.7	6.7	6.7							
	N-1 Unsupplied Load:	**1.3**	**3.4**	**3.7**	**3.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

N-1 Contingency @ T1, 267S	Total Load:	**21.7**	**26.1**	**26.3**	**26.6**	**26.8**	**27.0**	**27.3**	**27.5**	**27.7**	**28.0**	**28.2**
	N-1 Capacity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 277S:	14.2	13.2	13.3	13.5	9.2	9.3	9.4	9.5	9.6	9.7	9.7
	Back up from 545S:	8.0	10.7	11.0	11.2	5.0	5.1	5.1	5.2	5.2	5.3	5.3
	Back up from 648S:	0.0	0.0	0.0	0.0	6.2	6.3	6.4	6.4	6.4	6.5	6.6
	Back up from 899S:	0.0	0.0	0.0	0.0	6.3	6.4	6.4	6.5	6.5	6.6	6.7
	N-1 Unsupplied Load:	**0.0**	**2.2**	**2.0**	**1.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

N-1 Contingency @ T1, 545S	Total Load:	25.6	30.1	30.5	30.8	31.2	31.6	32.0	32.4	32.8	33.2	33.6
	N-1 Capacity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Back up from 267S:	3.8	3.9	3.9	3.9	5.5	5.6	5.6	5.7	5.7	5.8	5.8
	Back up from 277S:	14.3	16.1	16.2	16.3	20.0	20.0	20.5	20.5	21.0	21.0	21.5
	Back up from 648S:	6.2	6.7	6.7	6.7	7.9	7.9	8.0	8.0	8.1	8.1	8.2
	N-1 Unsupplied Load:	1.3	3.4	3.7	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

- The unsupplied load under N-1 contingency at 138 kV transmission line 749AL affecting Hayter 277S and Killarney Lake 267S substations is addressed.
- The unsupplied load under N-1 contingency at 138 kV transmission line 715L affecting Provost 545S substation is addressed.
- The unsupplied load under N-1 transformer contingency at the Killarney Lake 267S substation is addressed.
- The unsupplied load under N-1 transformer contingency at the Provost 545S substation is addressed.
- The capacity concern on 25 kV distribution feeder 277S-464L will be addressed by subsequent distribution and/or transmission system upgrades.

5.3.3 Cost Estimate

If this alternative is selected, AltaLink will prepare a proposal for the requested transmission upgrades. This includes an estimate for the transmission capital cost.

The distribution capital cost for Alternative 3 is estimated to be $6.7 million (2020$, ±30%).

6. Alternatives Assessment

The following section presents the technical analysis of the alternatives considered in this Need for Development.

6.1 Technical Analysis

6.1.1 Alternative 1

As per section 5.1, this alternative cannot address the reliability concerns at the Hayter 277S substation and Killarney Lake 267S substation under N-1 contingency on 138 kV transmission line 749AL.

Therefore, this is not a technically acceptable solution.

6.1.2 Alternative 2

This alternative could theoretically address the reliability concerns under recognized contingencies as listed in Table 4-1. However, the typical N-1 contingency that FortisAlberta plans for has been limited by the loss of one substation source transformer and the distribution system downstream of which up to a maximum of four 25 kV distribution feeders at the same time effectively limiting the complexity of the corresponding restoration scheme irrespective of where the back-up comes from.

Under N-1 contingency on the 138 kV transmission line 749AL, the extent of the outage would result in the loss of three substation source transformers and eight 25 kV distribution feeders connected to Killarney Lake 267S and Hayter 277S substations. This increases the complexity of the restoration scheme through distribution switching that requires substantially longer planning and switching time to restore all the affected customer loads. A complex restoration scheme is difficult to maintain valid over the long-term due to limited available options, as several substations and large number of feeders must be utilized at the same time to restore loads. In addition, the increased risk of unfittingly placed new load, on any of the affected feeders or feeders used for backup, would eliminate the ability to transfer between the substations in the area. From the FortisAlberta perspective, the N-1 contingency on the 138 kV transmission line 749AL is equivalent to an N-3 contingency affecting three (3) source transformers at the same time.

Therefore, Alternative 2 is not technically acceptable based on the resulting estimated restoration time, complexity of restoration, onerous requirements to maintain restoration plan valid and increased risk for recognized contingencies.

Also, this alternative involves extensive distribution upgrades and the estimated distribution capital cost is much higher than the preferred alternative.

6.1.3 Alternative 3

The 138 kV transmission loop creates an alternate feed for Killarney Lake 267S, Hayter 277S and Provost 545S substations. It will ensure that in the event of a 138 kV transmission line outage on either 715L or 749AL, the area loads will continue to be served without interruption. It could also address the reliability concerns under the N-1 transformer contingency affecting Provost 545S and Killarney Lake 267S substations.

This alternative involves minimal distribution upgrades with the lowest distribution capital cost as compared with the other alternatives. With no outage to end-use customers under N-1 contingency on 138 kV transmission line 715L or 749AL, this alternative will not require any distribution operation for load restoration under N-1 contingency on 138 kV transmission line 715L or 749AL.

This is a technically acceptable solution, and is the FortisAlberta preferred alternative.

7. Conclusion

After considering the alternatives to address the existing and predicted reliability concerns on the distribution system in the Provost area, Alternative 3 is FortisAlberta's preferred alternative. It involves building a 138 kV transmission line connection between Provost 545S substation and Hayter 277S substation.

An estimate for the transmission system capital cost will be provided by the TFO, AltaLink.

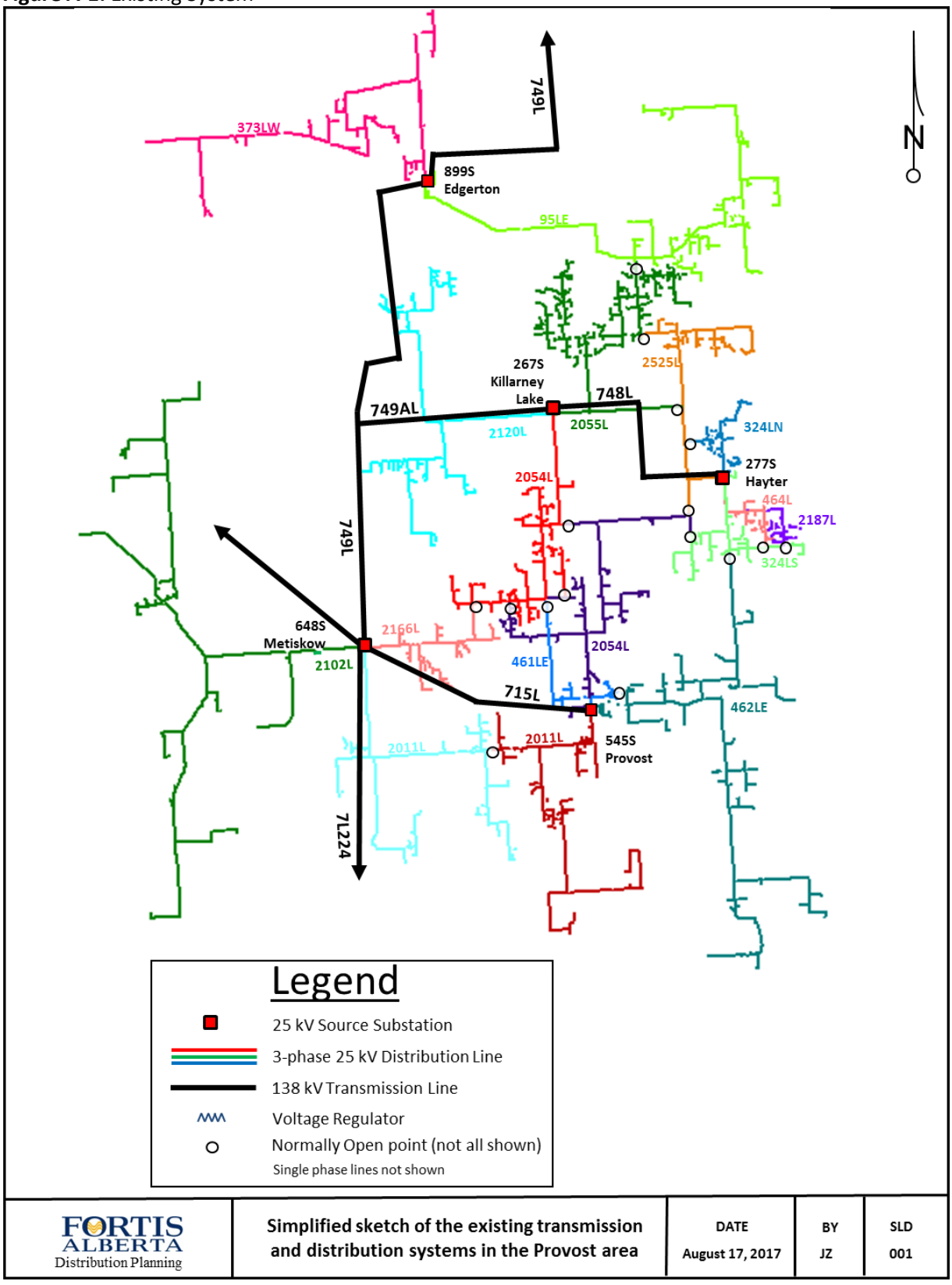
The estimated distribution capital costs associated with this preferred alternative is $6.7 million (±30%, 2020$).

Based on existing reliability concerns and in consideration of the target timelines for the AESO Connection Process, the requested In-Service Date (ISD) for the Provost Area transmission upgrade is October 1, 2018.

No DTS change is requested at the Edgerton 899S, Hayter 277S, Killarney Lake 267S, Metiskow 648S, and Provost 545S substations.

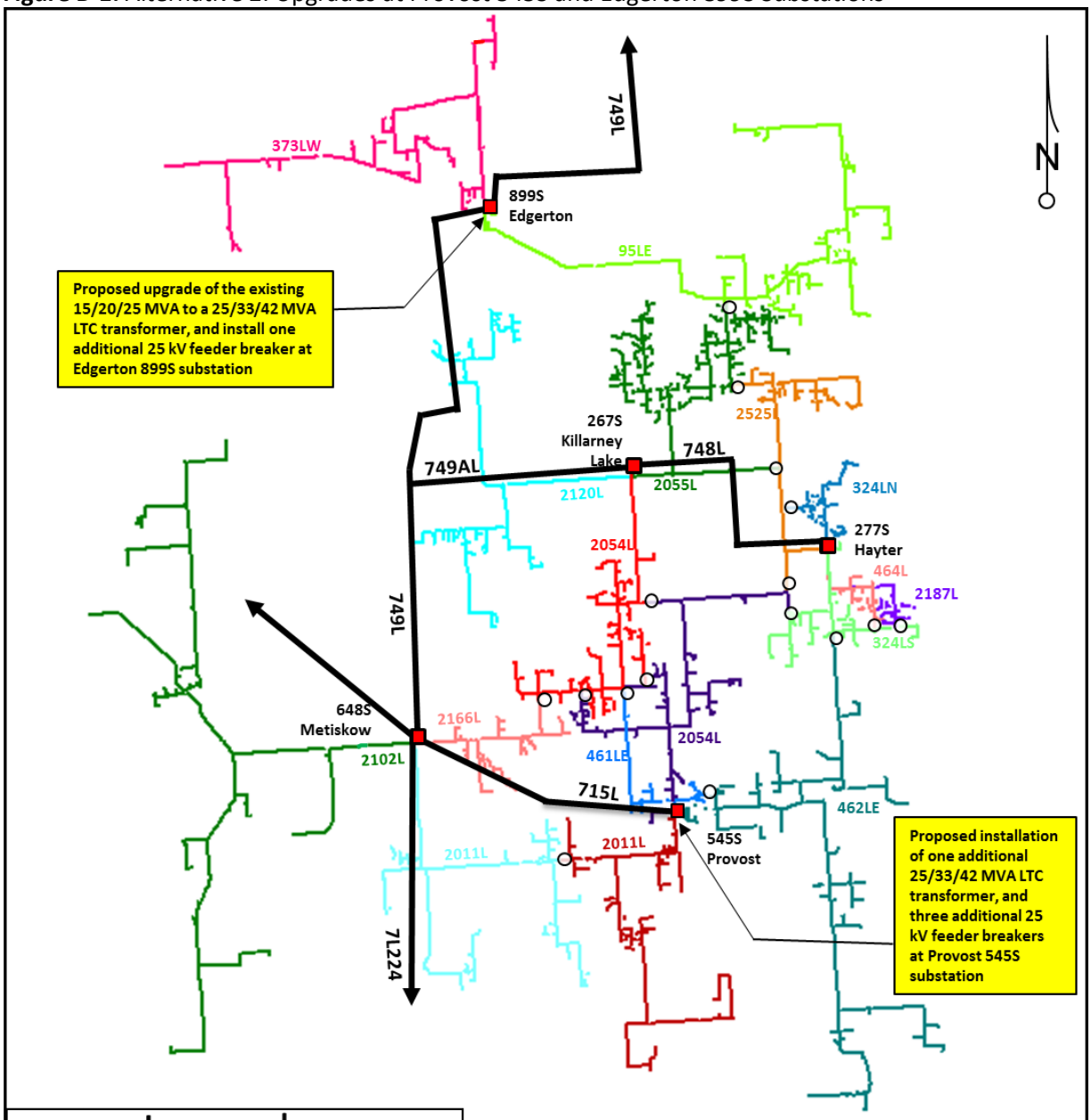
Appendix A – Existing System

Figure A-1: Existing System



Appendix B – Alternative 2 – Upgrades at Provost 545S and Edgerton 899S substations

Figure B-1: Alternative 2: Upgrades at Provost 545S and Edgerton 899S Substations



Appendix C – Alternative 3 – Preferred Transmission Upgrades at Provost Area

Figure C-1: Alternative 3: Preferred Transmission Upgrades at Provost Area