APPENDIX E DFO NEED FOR DEVELOPMENT REPORT

Need for Development

Bullshead 523S Upgrade

June 14, 2016

	Name	Signature	Date
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Executive Summary

The Medicine Hat area is served by distribution systems connected to Bullshead 523S substation. Load studies indicate a reliability concern in the Medicine Hat area. Upon loss of 523S transformer T1 or voltage regulator VR1, there is an existing 11.9 MVA of unsupplied load in 2014, as indicated by table 3-1. If left unaddressed, the unsupplied load could be 19.5 MVA in 2024.

This exceeds FortisAlberta Inc. (FortisAlberta) planning criteria for electrical load restoration.

Potential solutions were assessed to address the reliability concern in the Medicine Hat area. Based on technical merit and lowest estimated distribution capital cost, the preferred solution involves transmission upgrades at the Bullshead 523S substation:

- Addition of a 138/25 kV 25/33/42 MVA on-load tap changing (LTC) source transformer.

The estimated distribution capital cost associated with this recommendation is $0.32 million (±30%, 2017$).

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

The requested In-Service Date (ISD) for the recommended Bullshead 523S facility upgrade is August 1, 2017.

With the requested transmission system upgrade project, FortisAlberta requests a Demand Transmission Service (DTS) increase to a contract of 15.7 MW at the Bullshead 523S substation.

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1. Project Description

1.1 Background

The Bullshead 523S substation is located at LSD 09 SEC 04 TWP 12 RGE 06 W 4, approximately 9 km southwest of the City of Medicine Hat. The substation has one 138/24.94 kV 15/20/25//28 MVA off-circuit tap changer (OCTC) source transformer paired with a 24.94 kV 18.75/25//28.1 MVA voltage regulator supplying three 25 kV distribution feeders.

The distribution system supplied by the Bullshead 523S substation serves an area comprised of residential, farm, commercial, and industrial services. This distribution system has three-phase distribution feeder ties to adjacent substations. See Figure A-1, Appendix A.

A reliability concern exists and is predicted to worsen within the 10-year planning horizon. With the forecasted growth and committed load additions for the distribution systems supplied by the area substations, upon loss of Bullshead 523S transformer T1 or voltage regulator VR1, there could be 11.9 MVA of unsupplied load in 2014. If left unaddressed, the unsupplied load could be 19.5 MVA in 2024.

This exceeds FortisAlberta planning criteria for electrical load restoration.

2. Criteria

The analysis for the recommended development in the area served by Bullshead 523S substation 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 ratings.

3. Existing System Assessment

The existing substations and distribution systems in the Medicine Hat area are shown in Figure A-1 in Appendix A.

3.1 Load Forecast

Table 3-1 provides FortisAlberta historical and forecast peak load levels for the substations and feeders in the subject 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 3-1: FortisAlberta Load Forecast: Existing System

					MVA LOADING - RECORDED					PREDICTED - MVA LOADING									
SUBSTATION No.	Feeder	CAPACITY T/R	MVA	PF	W or S	2010 Peak MVA	2011 Peak MVA	2012 Peak MVA	2013 Peak MVA	2014 Peak MVA	2015 Year 1 MVA	2016 Year 2 MVA	2017 Year 3 MVA	2018 Year 4 MVA	2019 Year 5 MVA	2020 Year 6 MVA	2021 Year 7 MVA	2022 Year 8 MVA	2023 Year 9 MVA	2024 Year 10 MVA	Fore-cast Growth
523S	Bullshead	T1	15/20/25// 28																		
523S		VR1	18.75/25// 28.1	91%	S	**14.0**	**16.0**	**16.0**	**15.0**	**16.6**	**18.4**	**18.8**	**19.2**	**19.6**	**20.0**	**20.4**	**20.8**	**21.2**	**21.6**	**22.1**	**2.1%**
523S	122LE			99%	S/W	5.0	5.0	5.0	5.0	5.1	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.5	7.8	8.1	3.5%
523S	381LW			88%	S	4.0	6.0	6.0	5.0	4.9	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	1.6%
523S	406LW			88%	S	6.0	6.0	7.0	6.0	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	1.2%
649S	Chappice Lake	T1	10/13.3// 15.0			**8.0**	**9.0**	**9.0**	**9.0**	**9.3**	**13.7**	**13.9**	**14.1**	**14.3**	**14.5**	**14.7**	**14.9**	**15.1**	**15.3**	**15.5**	**1.5%**
649S		VR1	15																		
649S	2058L			97%	W	8.0	9.0	9.0	9.0	9.3	**13.7**	**13.9**	**14.1**	**14.3**	**14.5**	**14.7**	**14.9**	**15.1**	**15.3**	**15.5**	1.5%
895S	Suffield	T2	15/20/ 25																		
895S		VR1	15/20/25// 28	90%	S	**7.0**	**6.0**	**7.0**	**8.0**	**7.1**	**9.2**	**9.3**	**9.4**	**9.5**	**9.6**	**9.7**	**9.8**	**9.9**	**10.0**	**10.1**	**1.0%**
895S	2272L			90%	S	7.0	6.0	7.0	8.0	7.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	1.0%
895S	Suffield	T3	25/33/ 42	95%	S/W	**24.0**	**23.0**	**22.0**	**22.0**	**21.6**	**25.0**	**25.3**	**25.7**	**26.1**	**26.5**	**26.9**	**27.3**	**27.7**	**28.1**	**28.5**	**1.4%**
895S	188LS			96%	S/W	8.0	7.0	7.0	7.0	7.1	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	1.5%
895S	288LN			93%	S/W	8.0	9.0	8.0	8.0	8.1	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	1.5%
895S	2219L			92%	S/W	10.0	9.0	8.0	9.0	8.8	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	1.2%
895S	Total Station			94%	S/W	**28.0**	**27.0**	**28.0**	**28.0**	**27.3**	**32.1**	**32.5**	**33.0**	**33.5**	**33.9**	**34.4**	**34.9**	**35.3**	**35.8**	**36.3**	**1.4%**

Load additions (MW) 2015	
895S 2272L	1.50
895S 288LN	1.58

N-1 Contingency @ 523S	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total Load	**16.6**	**18.4**	**18.8**	**19.2**	**19.6**	**20.0**	**20.4**	**20.8**	**21.2**	**21.6**	**22.1**
Available 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
BU from Suffield 895S	3.0	3.0	3.0	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.6
BU from Chappice Lake 649S	1.7	1.3	1.1	0.9	0.7	0.5	0.3	0.1	0.0	0.0	0.0
Total Unsupplied Load (MVA)	**11.9**	**14.1**	**14.7**	**15.4**	**16.0**	**16.7**	**17.3**	**17.9**	**18.5**	**18.9**	**19.5**

- The level of unsupplied load under N-1 contingency at the Bullshead 523S substation: at 11.9 MVA in 2014 and if left unaddressed could be 19.5 MVA in 2024, exceeds FortisAlberta planning criteria for electrical load restoration (as indicated by the red text).

4. Alternatives Analysis

A number of alternatives were considered and based on both technical merit and cost, three alternatives presented in this document. These three alternatives have either the least distribution system development or the lowest estimated distribution capital cost.

4.1. Alternative 1: Distribution Upgrades

4.1.1 Description

Upgrades of the distribution system to establish increased back-up capability from adjacent distribution systems was considered. However, in order for either the Suffield 895S or Chappice Lake 649S substation to provide an adequate level of back-up support, in addition to the upgrades of the distribution system, transmission upgrades would be required at the substation providing the back-up support.

Distribution upgrades alone will not be sufficient to eliminate the reliability concern at Bullhead 523S substation.

4.2 Alternative 2: Upgrades at the Bullshead 523S Substation

4.2.1 Description

In 2017 at the Bullshead 523S substation:

- **Add one 138/25 kV 25/33/42 MVA LTC transformer**
- **Supply 25 kV feeder 523S-122LE from the new transformer**

Refer to Appendix B, Figure B-1 showing the recommended 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, 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 TFO 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.

4.2.2 Load Forecast

The load forecast resulting from this alternative is provided in Table 4-1.

Table 4-1: FortisAlberta Load Forecast for Alternative 2 – Upgrades at Bullshead 523S

					MVA LOADING - RECORDED					PREDICTED - MVA LOADING									
SUBSTATION		CAPACITY	PF	W or S	2010 Peak MVA	2011 Peak MVA	2012 Peak MVA	2013 Peak MVA	2014 Peak MVA	2015 Year 1 MVA	2016 Year 2 MVA	2017 Year 3 MVA	2018 Year 4 MVA	2019 Year 5 MVA	2020 Year 6 MVA	2021 Year 7 MVA	2022 Year 8 MVA	2023 Year 9 MVA	2024 Year 10 MVA	Fore-cast Growth
No.	Feeder	T/R MVA																		
523S	Bullshead	T1 15/20/25// 28																		
523S		VR1 18.75/25// 28.1	91%	S	**14.0**	**16.0**	**16.0**	**15.0**	**16.6**	**18.4**	**18.8**	**12.6**	**12.9**	**13.2**	**13.5**	**13.8**	**14.1**	**14.4**	**14.7**	**2.1%**
523S	122LE		99%	S/W	5.0	5.0	5.0	5.0	5.1	6.0	6.2									3.5%
523S	381LW		88%	S	4.0	6.0	6.0	5.0	4.9	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	1.6%
523S	406LW		88%	S	6.0	6.0	7.0	6.0	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	1.2%
523S	Bullshead	T2 25/33/ 42	99%									**6.4**	**6.6**	**6.8**	**7.0**	**7.2**	**7.5**	**7.8**	**8.1**	**3.5%**
523S	122LE (moved)		99%	S/W								6.4	6.6	6.8	7.0	7.2	7.5	7.8	8.1	3.5%
523S	Total Station				**14.0**	**16.0**	**16.0**	**15.0**	**17.0**	**18.0**	**19.0**	**19.0**	**20.0**	**20.0**	**20.0**	**21.0**	**21.0**	**22.0**	**22.0**	**2.1%**
649S	Chappice Lake	T1 10/13.3// 15.0			**8.0**	**9.0**	**9.0**	**9.0**	**9.3**	**13.7**	**13.9**	**14.1**	**14.3**	**14.5**	**14.7**	**14.9**	**15.1**	**15.3**	**15.5**	**1.5%**
649S		VR1 15																		
649S	2058L		97%	W	8.0	9.0	9.0	9.0	9.3	**13.7**	**13.9**	**14.1**	**14.3**	**14.5**	**14.7**	**14.9**	**15.1**	**15.3**	**15.5**	1.5%
895S	Suffield	T2 15/20/ 25																		
895S		VR1 15/20/25// 28	90%	S	**7.0**	**6.0**	**7.0**	**8.0**	**7.1**	**9.2**	**9.3**	**9.4**	**9.5**	**9.6**	**9.7**	**9.8**	**9.9**	**10.0**	**10.1**	**1.0%**
895S	2272L		90%	S	7.0	6.0	7.0	8.0	7.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	1.0%
895S	Suffield	T3 25/33/ 42	95%	S/W	**24.0**	**23.0**	**22.0**	**22.0**	**21.6**	**25.0**	**25.3**	**25.7**	**26.1**	**26.5**	**26.9**	**27.3**	**27.7**	**28.1**	**28.5**	**1.4%**
895S	188LS		96%	S/W	8.0	7.0	7.0	7.0	7.1	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	1.5%
895S	288LN		93%	S/W	8.0	9.0	8.0	8.0	8.1	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	1.5%
895S	2219L		92%	S/W	10.0	9.0	8.0	9.0	8.8	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	1.2%
895S	Total Station		94%	S/W	**28.0**	**27.0**	**28.0**	**28.0**	**27.3**	**32.1**	**32.5**	**33.0**	**33.5**	**33.9**	**34.4**	**34.9**	**35.3**	**35.8**	**36.3**	**1.4%**

Notes

1. 25 kV feeder 523S-122LE to be supplied by new transformer 523S-T2.
2. The high predicted feeder and transformer load levels at the Chappice Lake 649S substation will be addressed in a separate upgrade application.

N-1 Contingency @ 523S	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total Load	**16.6**	**18.4**	**18.8**	**19.0**	**20.0**	**20.0**	**20.0**	**21.0**	**21.0**	**22.0**	**22.0**
Available N-1 Capacity	0.0	0.0	0.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
BU from Suffield 895S	3.0	3.0	3.0	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.6
BU from Chappice Lake 649S	1.7	1.3	1.1	0.9	0.7	0.5	0.3	0.1	0.0	0.0	0.0
Total Unsupplied Load (MVA)	**11.9**	**14.1**	**14.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

4.2.3 Cost Estimate

The transmission capital cost for this alternative will be provided by AltaLink.

The distribution capital cost for this alternative is estimated to be $0.32 million (2017$, ±30%).

4.3 Alternative 3: Upgrades at an adjacent substation

4.3.1 Description

Transmission upgrade options at adjacent substations were considered. This included the addition of a transformer and 25 kV breaker at the Chappice Lake 649S substation (31 km northeast of Bullshead 523S) and the replacement of the source transformer T2 and the voltage regulator VR1 pair with a 42 MVA LTC source transformer at the Suffield 895S substation (42 km northwest of Bullshead 523S). In addition, extensive distribution system upgrades would be required between Bullshead 523S substation and the back-up substations.

As per section 5.1.3, an extensive distribution system upgrades between the Bullhead 523S substation and the back-up substations are expected to cost significantly higher than other alternatives. As a result, load forecasts and costs for this alternative were not included in this document.

5. Alternatives Assessment

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

5.1 Technical and Economic Analysis

5.1.1 Alternative 1 – Distribution Upgrades

As per section 4.1.1, distribution upgrades alone could not eliminate the reliability concern at the Bullshead 523S substation. Therefore, this alternative is not acceptable.

5.1.2 Alternative 2 – Upgrades at the Bullshead 523S Substation

The addition of a 42 MVA source transformer and supplying the 25kV feeder 523S-122LE from the new source transformer could eliminate the reliability concern at Bullshead 523S substation. This is an acceptable technical solution and the preferred alternative.

5.1.3 Alternative 3 – Upgrades at an adjacent substation

As per section 4.3.1, transmission upgrades to enable the provision of back-up support from the Chappice Lake 649S (31 km northeast of Bullshead 523S) and the Suffield 895S (42 km northwest of Bullshead 523S) substations were considered. However, the costs associated with the extensive distribution system upgrades

between the Bullshead 523S substation and the back-up substations are significantly greater than the distribution capital costs of the preferred alternative.

6. Conclusion

After considering the alternatives to address the reliability concern at the Bullshead 523S substation, the preferred transmission upgrades at the Bullshead 523S substation includes :

- Installation of one 138/25 kV 25/33/42 MVA LTC source transformer
- Supply 25 kV feeder 523S-122LE from the new source transformer

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

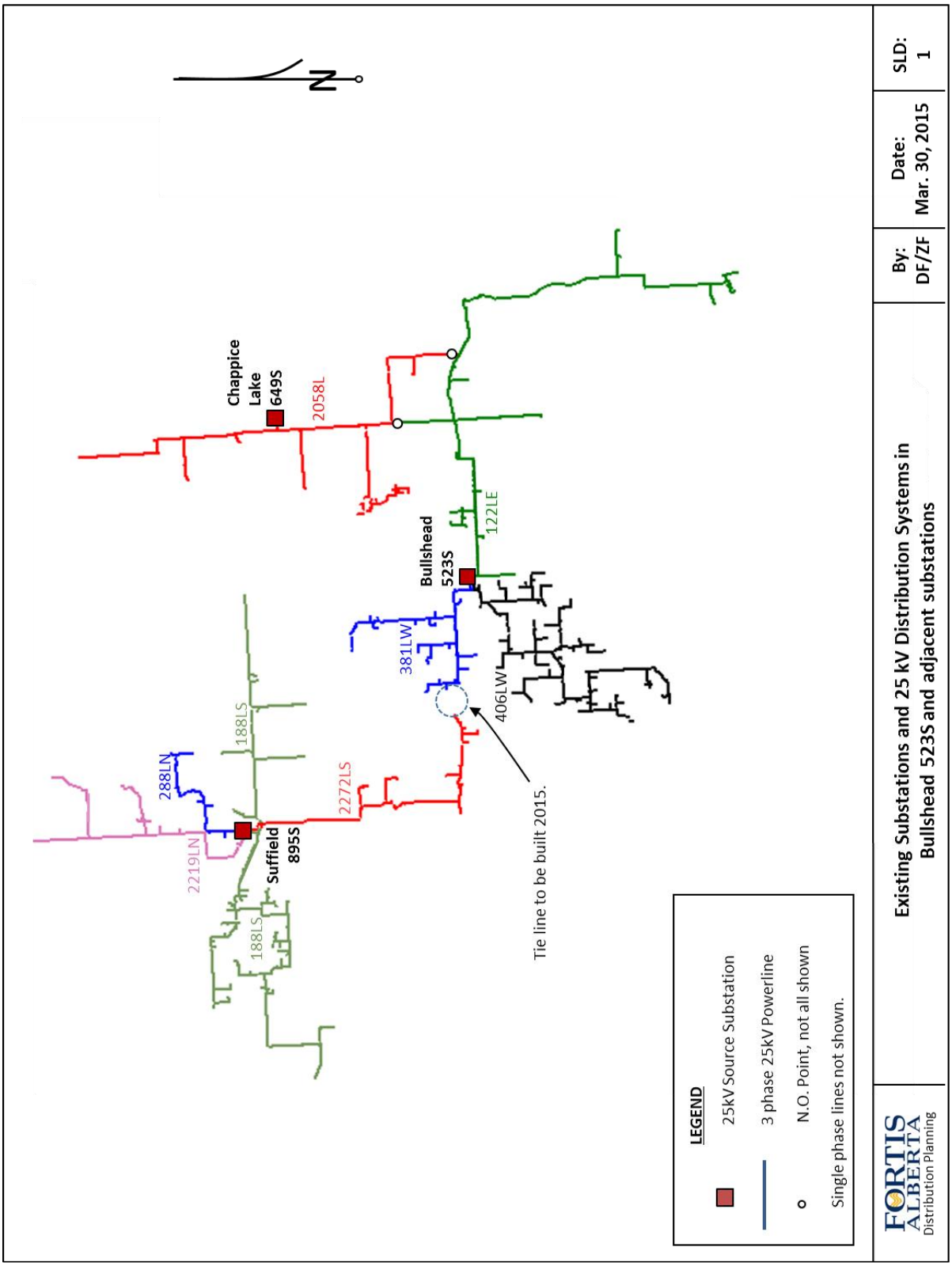
The estimated distribution capital cost associated with this recommendation is $0.32 million (±30%, 2017$).

The requested ISD for the recommended Bullshead 523S facility upgrade is August 1, 2017.

With the requested transmission system upgrade project, FortisAlberta requests a Demand Transmission Service (DTS) increase to a contract of 15.7 MW at the Bullshead 523S substation.

Appendix A – Existing System

Figure A-1: Existing System



Appendix B – Alternative 2 – Upgrades at the Bullshead 523S Substation

Figure B-1: Alternative 2: Upgrades at the Bullshead 523S Substation