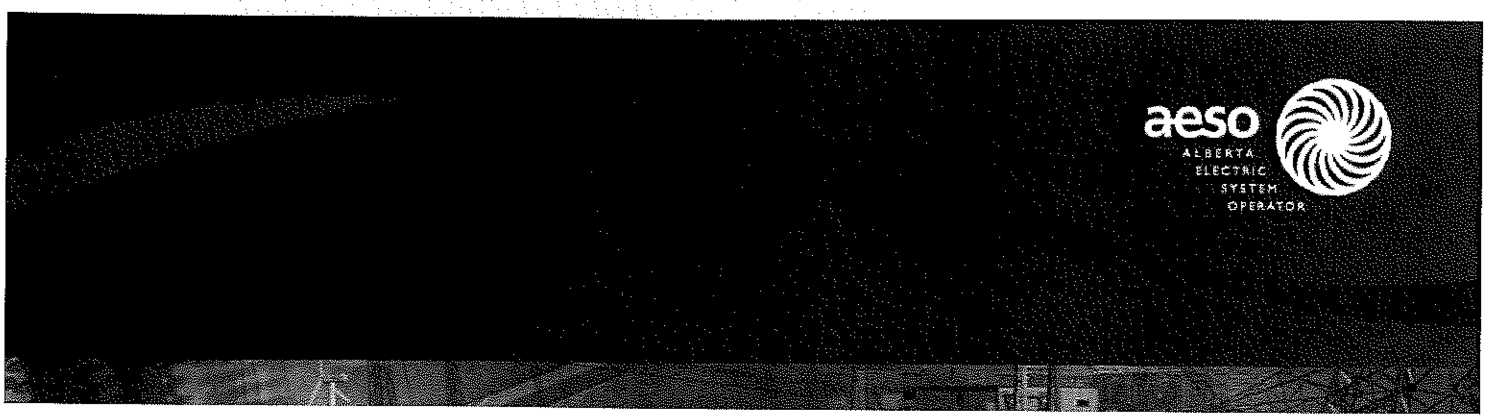


Fortis Okotoks 678S and High River 65S Upgrades
Project Number: 1670

The attached engineering study report has been prepared by a third party as part of the AESO Connection Process. The AESO has reviewed the report and the conclusions that it contains, and finds it acceptable for the purpose of assessing potential impacts of the Project on the transmission system.

Information regarding the AESO Connection Process can be found at: http://www.aeso.ca/8602.html

Date: July 28, 2016

Function	Name	Company	Signature	Date
Senior Engineer	Ralph Liu, Ph.D., P. Eng.	Alberta Electric System Operator	RLiu	July 28, 2016
Manager, Projects & System Access Studies	Mohamed Kamh, Ph.D., P. Eng.	Alberta Electric System Operator	[illegible]	July 28, 2016

While the DFO's plans are considered during the transmission planning process, the AESO, in exercising its duties to plan the transmission system, does not oversee distribution planning or the development of specific DFO planning criteria.

2500, 330-5th Avenue SW, Calgary, Alberta T2P 0L4 Phone: 403-539-2450 Fax: 403-539-2949
www.aeso.ca www.poweringalberta.com

ALTALINK
A BERKSHIRE HATHAWAY ENERGY COMPANY

Connection Engineering Study Report for AUC Application

Fortis Okotoks 678S and High River 65S Upgrades

AESO Project 1670

Revision: 1
Revision Date: 2016-07-27

	Name	Date	Signature
Prepared	Joby Varghese, P. Eng. (AltaLink)	July 27/2016	Joby Varghese
Reviewed/ Approved	Ryan Cui, P. Eng. (AltaLink)	July 27, 2016	[illegible]

AltaLink APEGA Permit Number P-7862

PROFESSIONAL ENGINEER
JOBY VARGHESE
ALBERTA

Joby Varghese
July 27/16

Executive Summary

Project Overview

FortisAlberta Inc. (FortisAlberta), in its capacity as the legal owner of distribution facilities (DFO), submitted a system access service request (SASR) to the Alberta Electric System Operator (AESO) to meet the DFO's distribution system criteria and serve load growth in the towns of Okotoks, Black Diamond, and the surrounding areas.

The SASR includes a request for Rate DTS, *Demand Transmission Service*, contract capacity increases of approximately 31 MW (from 18.8 MW to 49.3 MW), for the system access service provided at the Okotoks 678S substation, and approximately 24 MW (from 31.5 MW to 55.7 MW) for the system access service provided at the High River 65S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested upgrades to the existing Okotoks 678S substation and modifications to the existing High River 65S substation.

The scheduled in-service date for the Project is May 15, 2017.

This report details the system performance studies undertaken to assess the impact of the Project on the Alberta interconnected electric system (AIES).

Existing System

Geographically, the Project is located in the AESO planning area of High River (Area 46), which is part of the AESO South Planning Region. The High River area is adjacent to the planning areas of Seebe (Area 44), Calgary (Area 6), Strathmore / Blackie (Area 45), Stavely (Area 49), and Fort Macleod (Area 53).

From a transmission system perspective, the High River planning area consists primarily of 138 kV and 69 kV transmission systems. The Foothills 237S substation is a 240/138 kV source substation, which is connected to the Okotoks 678S and High River 65S substations through the 138 kV transmission lines 646L and 434L. The High River planning area also connects to Strathmore / Blackie planning area via the 138 kV transmission lines 850L and 753L. The 240/138 kV Janet 74S substation serves as a main source for the Strathmore / Blackie planning area.

Existing constraints in South Planning Region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management*. A remedial action scheme (RAS) is used in the Strathmore / Blackie planning area (Area 45) to mitigate constraints associated with thermal criteria violations on the existing 138 kV transmission line 876L.

Study Summary

Study area for the Project

The Study Area for the Project is defined as the AESO planning areas of High River (Area 46) and Strathmore / Blackie (Area 45), including the tie lines connecting these planning areas to the rest of the AIES. All transmission facilities within the Study Area were studied and monitored to assess the impact of the Project on the AIES, including any violations of the Reliability Criteria (as defined in Section 2.1.1).

Analyses performed for the Project

Power flow analysis was performed for the 2017 summer peak (SP) and 2017 winter peak (WP) pre-Project and post-Project scenarios.

Voltage stability analysis was performed for the 2017 WP post-Project scenario.

Results of the pre-Project studies

The following is a summary of the pre-Project studies results. Results and applicable mitigation measures for pre-Project contingencies are shown in greater detail in Table E-1 below.

Category A conditions

No Reliability Criteria violations were observed under Category A conditions for any of the pre-Project scenarios.

Category B contingency conditions

The pre-Project power flow analysis identified a number of system performance issues under Category B contingency conditions, including thermal criteria violations and POD bus voltage deviations.

Connection alternatives examined for the Project

This report examined four transmission alternatives to meet the DFO's request for system access service.

Alternative 1– Upgrade Okotoks 678S substation

Alternative 1 involves upgrading the Okotoks 678S substation, and includes adding one 138/25 kV transformer, three 138 kV circuit breakers, and a minimum of four 25 kV circuit breakers.

Alternative 2 – Upgrade Okotoks 678S substation and modify High River 65S substation

Alternative 2 involves upgrading the Okotoks 678S substation, and includes adding one 138/25 kV transformer, three 138 kV circuit breakers, and a minimum of two 25 kV circuit breakers.

This alternative also involves modifying the High River 65S substation, including adding two 25 kV circuit breakers.

Alternative 3 – New POD substation in the Okotoks area

Alternative 3 involves adding a new POD substation in the Okotoks area, including a 138/25 kV transformer and four 25 kV circuit breakers. The new POD substation would be connected to the existing 138 kV transmission line 727L using an in/out configuration, which includes adding two 138 kV circuits.

Alternative 4 – New POD substation in the Okotoks area and upgrade Black Diamond 392S substation

Alternative 4 involves adding a new POD substation in the Okotoks area, including adding a 138/25 kV transformer and two 25 kV circuit breakers. The new POD would be connected to the existing Okotoks 678S and Black Diamond 392S substations by adding two 138 kV transmission circuits.

Alternative 4 also involves upgrading the existing Black Diamond 392S substation, including replacing the existing 69/25 kV transformer with a 138/25 kV transformer, which also has a higher capacity.

Connection alternatives not selected for further studies

Alternative 1

Alternative 1 is considered technically feasible. However, the DFO has advised that the distribution system developments associated with Alternative 1 result in a less reliable distribution system than Alternative 2. The DFO has advised that Alternative 1 could negatively impact the reliability of the distribution system.

Furthermore, compared to Alternative 2, Alternative 1 requires the addition of a greater number of distribution feeders at the Okotoks 678S substation. Thus, Alternative 1 would restrict the possibility of future distribution system developments at the Okotoks 678S substation. The DFO has advised that the expected load growth at the Okotoks 678S substation exceeds the expected load growth at the High River 65S substation, and that it would be preferable to maintain the ability to add additional distribution feeders at the Okotoks 678S substation rather than to serve expected load growth in the Okotoks area from the High River 65S substation, which the DFO has advised would be inefficient.

Based on the distribution system reliability and expandability concerns that are associated with Alternative 1, the AESO considers that Alternative 1 is an inferior option to Alternative 2. Alternative 1 was not selected for further study.

Alternative 3 and Alternative 4

Alternative 3 and Alternative 4 are considered technically feasible. These alternatives involve increased transmission developments and hence, increased costs compared to Alternative 2. Alternative 3 and Alternative 4 were not selected for further study.

Connection alternatives selected for further studies

Alternative 2 is considered technically feasible and was selected for further study.

Results of the post-Project studies

The following is a brief summary of the post-Project studies results. The post-Project studies results, Project impact on the performance of the AIES, and applicable mitigation measures are summarized in Table E-1, below.

Category A conditions

No Reliability Criteria violations were observed under Category A conditions for any of the post-Project scenarios.

Category B contingency conditions

The post-Project power flow analysis identified a number of system performance issues under Category B contingency conditions, including thermal criteria violations and POD bus voltage deviations.

Project interdependencies

No project interdependencies were identified.

Conclusions and Recommendation

Analysis and Conclusions

Table E- 1 provides analysis of, and conclusions about, the impact of the Project for selected contingencies, including mitigation measures for observed Reliability Criteria violations. The contingencies in Table E-1 were selected because, in the post-Project scenarios, either new Reliability Criteria violations were observed or Reliability Criteria violations observed in the pre-Project scenarios were materially worsened.

Table E- 1 Project Impact and Mitigation Measures (Selected Contingencies)

Identified Reliability Criteria Violation		Occurrence	Impact Level of Project	System Condition	Mitigation Measures (Pre- and Post-Project)
Violation	Contingency				
Thermal criteria violation on the 138 kV transmission line 876L (Blackie 253S – Gleichen 179S)	691L (Janet 74S – planned Chestermere 419S)	Pre-Project and Post-Project	Marginal	2017 SP	**Pre:** The planned RAS that is associated with Project 1631 (Chestermere RAS). **Post:** Same as pre-Project
		Pre-Project and Post-Project	Significant	2017 WP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)	PCES01L (Namaka 428S – Cavalier power plant)	Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
		Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
	138/13.8 kV transformer at the Cavalier power plant	Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
		Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
	876L (Blackie 253S – Gleichen 179S)	Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
	434L (Foothills 237S - High River 65S)	Post-Project only	Significant	2017 SP	**Pre:** None required **Post:** Chestermere RAS
	434L (Foothills 237S - High River 65S)	Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
			Significant	2017 SP	**Pre:** None required

Identified Reliability Criteria Violation		Occurrence	Impact Level of Project	System Condition	Mitigation Measures (Pre- and Post-Project)
Violation	Contingency				
	646L (Foothills 237S – Okotoks 678S)	Post-Project only			**Post:** Real-time operational practices
	753L (High River 65S – Blackie 253S)	Post-Project only	Significant	2017 SP	**Pre:** None required
					Post: Real-time operational practices

The connection assessment identified a number of pre-Project and post-Project system performance issues. Real-time operational practices and the Chestermere RAS can be used to mitigate all of the identified pre- and post-Project system performance issues. The Project does not impact the effectiveness of existing RASs in the Study Area, nor does the Project create the need for new RASs in the Study Area. Based on the studies results, Alternative 2 is technically viable. The minimum transformation capacity required for the 138/25 kV transformer in Alternative 2 is 28 MVA.

Recommendations

It is recommended to proceed with the Project using Alternative 2 as the preferred option to respond to the DFO's request for system access service. It is also recommended to use real-time operational practices and the Chestermere RAS to mitigate the identified system performance issues.

For Alternative 2, a transformer size of 42 MVA would be recommended based on good electric industry practice and under advisement from the legal owner of transmission facilities regarding its asset management and inventory practices.

Contents

Attachments

Attachment A: Pre-Project Load Flow Diagrams (Scenario 1 to 2)
Attachment B: Post-Project Load Flow Diagrams (Scenario 3 to 4)
Attachment C: Post-Project Voltage Stability Diagrams (Scenario 4)

Figures

Tables

1. Introduction

This report presents the results of the engineering studies conducted to assess the impact of the Project (as defined below) on the Alberta Interconnected Electrical System (AIES).

1.1. Project

1.1.1. Project Overview

FortisAlberta Inc. (FortisAlberta), in its capacity as the legal owner of distribution facilities (DFO), submitted a system access service request (SASR) to the Alberta Electric System Operator (AESO) to meet the DFO's distribution system criteria and serve load growth in the towns of Okotoks, Black Diamond, and the surrounding area.

The SASR includes a request for Rate DTS, *Demand Transmission Service*, contract capacity increases of approximately 31 MW (from 18.8 MW to 49.3 MW) at the Okotoks 678S substation, and approximately 24 MW (from 31.5 MW to 55.7 MW) at the High River 65S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested upgrades to the existing Okotoks 678S substation and modifications to the existing High River 65S substation.

The scheduled in-service date for the Project is May 15, 2017.

1.1.2. Load Component

- The existing Rate DTS contract capacity at the Okotoks 678S substation is 18.8 MW.
- The existing Rate DTS contract capacity at the High River 65S substation is 31.5 MW.
- The requested load addition at Okotoks 678S substation is 30.5 MW by May 2017.
- The requested load addition at High River 65S substation is 24.2 MW by May 2017.
- The load will be studied assuming a 0.9 power factor (PF) lagging.
- Load type: farm, residential, commercial and industrial loads
- Currently there is no plan for future expansion beyond the requested developments associated with the DFO's SASR.

1.1.3. Generation Component

- There is no generation component associated with the Project.

1.2. Study Scope

1.2.1. Study Objectives

The objectives of the study are as follows:

1. Assess the impact of the Project on the performance of the AIES.

2. Identify any violations of the relevant criteria, standards, or requirements of the AESO, both pre-and post-Project.
3. Recommend mitigation measures, if required, to enable the reliable connection of the Project to the AIES.

1.2.2. Study Area

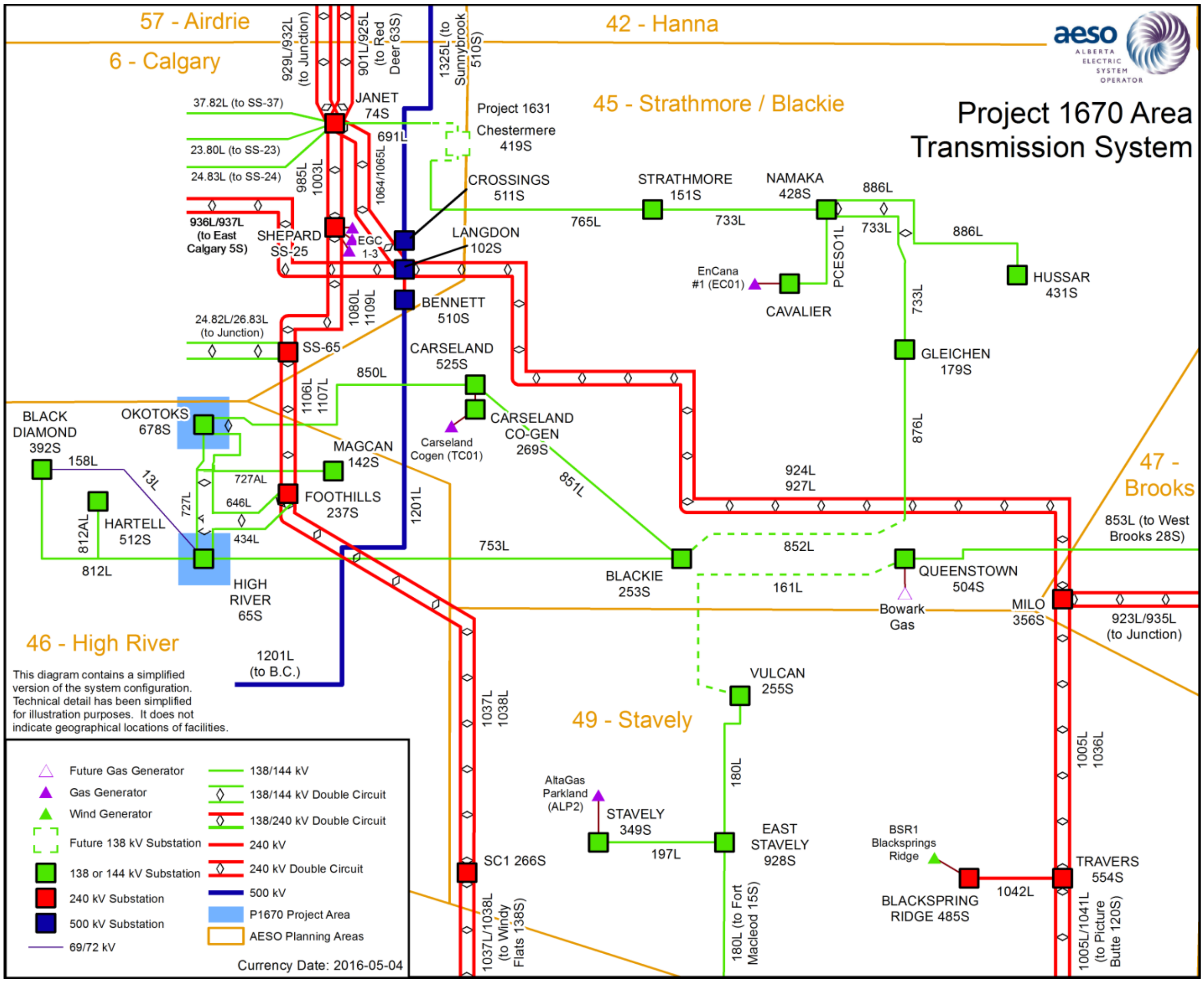
1.2.2.1. Study Area Description

Geographically, the Project is located in the AESO planning area of High River (Area 46), which is part of the AESO South Planning Region. The High River area is adjacent to the planning areas of Seebe (Area 44), Calgary (Area 6), Strathmore / Blackie (Area 45), Stavely (Area 49), and Fort Macleod (Area 53).

From a transmission system perspective, the High River planning area consists primarily of 138 kV and 69 kV transmission systems. The Foothills 237S substation is a 240/138 kV source substation, which is connected to the Okotoks 678S and High River 65S substations through the 138 kV transmission lines 646L and 434L. The High River planning area also connects to Strathmore / Blackie planning area via the 138 kV transmission lines 850L and 753L. The 240/138 kV Janet 74S substation serves as a main source for the Strathmore / Blackie planning area. Figure 1-1 shows a schematic representation of the expected transmission system in the Study Area in 2017.

The Study Area for the Project is defined as the AESO planning areas of High River (Area 46) and Strathmore / Blackie (Area 45), including the tie lines connecting these planning areas to the rest of the AIES. All transmission facilities within the Study Area were studied and monitored for violations of the Reliability Criteria (as defined in Section 2.1.1).

Figure 1-1: Study Area Transmission System in 2017



1.2.2.2. Existing Constraints

Existing constraints in the South Planning Region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule). A remedial action scheme (RAS) is used in the Strathmore / Blackie planning area (Area 45) to mitigate constraints associated with thermal criteria violations on the existing 138 kV transmission line 876L.

1.2.2.3. AESO Long-Term Transmission Plans (LTP)

The *AESO 2015 Long-term Plan* (2015 LTP)[1] includes the following system developments in the Study Area in the near term (to 2020):[2]

- Upgrade protection on 138 kV Strathmore–Namaka–Gleichen line

1.2.3. Studies Performed

The following analyses were performed for the pre-Project scenarios:

- Power flow analysis (Category A conditions and Category B contingencies)

The following studies were performed for the post-Project scenarios:

- Power flow analysis (Category A conditions and Category B contingencies)
- Voltage stability analysis (Category A conditions and Category B contingencies)

1.3. Report Overview

The Executive Summary provides a high-level summary of the report and its conclusions. Section 1 provides an introduction of the Project. Section 2 describes the criteria, system data, and study assumptions used in this study. Section 3 presents the methodology used for this study. Section 4 discusses the pre-Project assessment of the system. Section 5 presents the connection alternatives examined. Section 6 provides a technical analysis of the post-Project system assessment for the alternatives that were selected for further study. Section 7 discusses project interdependencies, if any. Section 8 presents the conclusions and recommendations of this report.

[1] The 2015 LTP document is available on the AESO website.

[2] The 2015 LTP identifies the transmission developments in the Strathmore-Blackie-High River sub-region on page 36.

2. Criteria, System Data, and Study Assumptions

2.1. Criteria, Standards, and Requirements

2.1.1. Transmission Planning Standards and Reliability Criteria

The Transmission Planning (TPL) Standards, which are included in the Alberta Reliability Standards, and the AESO's *Transmission Planning Criteria – Basis and Assumptions* [3] (collectively, the Reliability Criteria) were applied to evaluate system performance under Category A system conditions (i.e., all elements in-service) and following Category B contingencies (i.e., single element outage), prior to and following the studied alternatives. Below is a summary of Category A and Category B system conditions.

Category A, often referred to as the N-0 condition, represents a normal system with no contingencies and all facilities in service. Under this condition, the system must be able to supply all firm load and firm transfers to other areas. All equipment must operate within its applicable rating, voltages must be within their applicable range, and the system must be stable with no cascading outages.

Category B events, often referred to as an N-1 or N-G-1 with the most critical generator out of service, result in the loss of any single specified system element under specified fault conditions with normal clearing. These elements are a generator, a transmission circuit, a transformer, or a single pole of a DC transmission line. The acceptable impact on the system is the same as Category A. Planned or controlled interruptions of electric supply to radial customers or some local network customers, connected to or supplied by the faulted element or by the affected area, may occur in certain areas without impacting the overall reliability of the interconnected transmission systems. To prepare for the next contingency, system adjustments are permitted, including curtailments of contracted firm (non-recallable reserved) transmission service electric power transfers.

The Alberta Reliability Standards include the Transmission Planning (TPL) standards that specify the desired system performance under different contingency categories with respect to the Applicable Ratings. The transmission system performance under various system conditions is defined in Appendix 1 of the TPL standards. For the purpose of applying the TPL standards to this study, the Applicable Ratings shall mean:

- Seasonal continuous thermal rating of the line's loading limits.
- Highest specified loading limits for transformers.
- For Category A conditions: Voltage range under normal operating condition should follow the AESO Information Document ID #2010-007RS, which relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage*. For the busses not listed in ID #2010-007RS, Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions* applies.
- For Category B conditions: The extreme voltage range values per Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions*.

[3] Filed under a separate cover

- Desired post-contingency voltage change limits for three defined post event timeframes as provided in Table 2.1-1, below.

Table 2.1-1: Post-Contingency Voltage Deviation Guidelines

Parameter and reference point	Time Period		
	Post Transient (up to 30 sec)	Post Auto Control (30 sec to 5 min)	Post Manual Control (Steady State)
Voltage deviation from steady state at POD low voltage bus.	±10%	±7%	±5%

2.1.2. AESO Rules and IDs

The AESO ID #2010-007RS will be applied to establish pre-contingency voltage profiles in the Study Area. The TCM Rule will be followed in setting up the study scenarios and assessment of the impact of the Project. In addition, due regard will be given to the AESO's Connection Study Requirements and the AESO's Generation and Load Interconnection Standard.

2.2. Study Scenarios

The scheduled ISD for the Project is May 15, 2017. Hence, the study was conducted using the 2017 summer peak (SP) and 2017 winter peak (WP) scenarios.

Table 2.2-1 provides a list of the study scenarios. Scenario 1 and Scenario 2 are the pre-Project 2017 SP and 2017 WP scenarios. Scenario 3 and Scenario 4 are the post-Project 2017 SP and 2017 WP scenarios, respectively, with the requested Rate DTS contract capacity increase of 30.5 MW at the Okotoks 678S substation and 24.2 MW at the High River 65S substation. A 0.9 PF lagging was used for the new Project load.

Table 2.2-1: Summary of Study Scenario Assumptions

Scenario No.	Year/Season Load	Project Load (MW)	
		Okotoks 678S	High River 65S
Pre-Project System			
1	2017 SP	18.8	31.5
2	2017 WP	18.8	31.5
Post-Project System			
3	2017 SP	49.3	55.7
4	2017 WP	49.3	55.7

2.3. Load and Generation Assumptions

2.3.1. Load Assumptions

The load forecast used for this connection study is shown in Table 2.3-1 and is based on the *AESO 2016 Long-term Outlook* (2016 LTO). In this study the active power to reactive power ratio in the base case scenarios was maintained when modifying the planning area loads.

Table 2.3-1: Forecast Area Load (2016 LTO at South Planning Region Peak)

Region Name and Season		Forecast Peak Load (MW)
		2017
South Planning Region	Summer peak	1,487
	Winter peak	1,489
AIL w/o Losses	Summer peak	10,940
	Winter peak	11,899

Note: The South Planning Region in the 2016 LTO consists of the following AESO planning areas: 4, 43, 44, 45, 46, 47, 48, 49, 52, 53, 54, and 55.

2.3.2. Generation Assumptions

The generation conditions for this connection study are described in Table 2.3-2. The study identified the Carseland Generator Unit “2”, connected to the Carseland 525S substation, as the critical generator, and will be turned off to represent the N-G study condition for all analyses. The distributed generation Mazeppa power plant will be switched off in order to assess the impact of the Project, which includes the requested Rate DTS contract capacity at the High River 65S substation.

Table 2.3-2: Local Generation (MW) in the Study Cases

Plant Name	Bus Name/ID	Bus Number	Planning Area	Pmax (MW)	2017 SP Generation Net to Grid (MW)	2017 WP Generation Net to Grid (MW)
Cavalier	CAVAL_A ‘1’ 13.800 ‘G1’	3247	45	64.1	28.3	33.7
	CAVAL_B ‘2’ 13.800 ‘G2’	4247	45	64.1		
	CAVAL_B ‘3’ 13.800 ‘G3’	4247	45	26.5		
Carseland	CARSELA1 ‘1’ 13.800 ‘G4’	4251	45	64.1	15.2	22.2
	CARSELA1 ‘2’ 13.800 ‘1’	3251	45	64.1	OFF	OFF
BowArk Energy Queenstown	200S13.8 ‘G1’	4758	45	49	0	0

Plant Name	Bus Name/ID	Bus Number	Planning Area	Pmax (MW)	2017 SP Generation Net to Grid (MW)	2017 WP Generation Net to Grid (MW)
Power Plant (Project #1336)	200S13.8 ‘G2’	4758	45	49		

2.3.3. Intertie Flow Assumptions

Intertie assumptions are included for the B.C., MATL, and Saskatchewan interties. Details on the intertie flow assumptions can be found in Table 2.3-3.

Table 2.3-3: Intertie Flow Assumptions

Year/Season Load	Intertie Flow (MW)		
	Import (+) from /Export (-) to BC	Import (+) from /Export (-) to Saskatchewan	Import (+) from /Export (-) to MATL
Pre-Project System			
2017 SP	530	150	300
2017 WP	530	150	300
Post-Project System			
2017 SP	530	150	300
2017 WP	530	150	300

2.3.4. HVDC Power Order

The flows in the Study Area are not influenced by the AIES HVDC facilities. As a result, HVDC assumptions are kept consistent with that in the AESO planning base cases and not adjusted for this study.

2.4. System Projects

Table 2.4-1 lists the system transmission projects in or near the Study Area that were modeled in the study scenarios.

Table 2.4-1: Summary of System Projects Included in the Study Cases

Project	Project No.	Description	ISD
Southern Alberta Transmission Reinforcement (SATR)[4]	787-11	Blackie Region 138 kV Upgrade	In service

2.5. Customer Connection Projects

Customer connection projects within the Study Area that have passed through Gate 2 of the AESO Connection Process as of July 2016 were modelled in the study scenarios based on their respective positions in the AESO Connection Queue. Table 2.5-1 summarizes the customer connection project assumptions that were used in the study. It should be noted that the information in this table is subject to change as projects progress.

Table 2.5-1: Summary of Customer Connection Projects in Study Area

Planning Area	Queue Position*	Planned In-Service Date	Project Name	Project #	Gen (MW)	Load (MW)	Modelled in the study cases
45	25	Q2 2017	BowArk Energy Queenstown Power Plant	1336	80	0.5	Yes
45	74	Q3 2017	Fortis Chestermere New POD	1631	0	43.7	Yes
46	86	Q2 2017	Fortis Okotoks 678S-High River 65S Upgrades	1670	0	54.8	Yes

* Per the AESO Connection Queue posted in July 2016. The projects in the study area, if any that have queue positions after Project 1670 are not listed in this table and were not modelled in the study cases.

2.6. Facility Ratings and Shunt Elements

The legal owner of transmission facilities (TFO) provided the seasonal continuous thermal ratings and the short-term emergency ratings for key the transmission lines in the Study Area, as shown in Table 2.6-1.

[4] The *Southern Alberta Transmission Reinforcement* NID was originally approved by the Alberta Utilities Commission in Decision 2009-126 on September 8, 2009, and issued NID Approval No. U2009-340 on September 17, 2009.

Table 2.6-1: Summary of Key Transmission Line Ratings in the Study Area (*MVA based on voltage class*)

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)		Short-term Rating (MVA)	
			Summer	Winter	Summer	Winter
13L/158L	High River 65S – Black Diamond 392S	69	16	20	18	22
812L	Black Diamond 392S – JCT 812AL	138	85	90	94	99
812L	JCT 812AL – High River 65S	138	48	48	72	72
727L	High River 65S – Mag Tap	138	119	143	131	161
727L	Mag Tap – Okotoks 678S	138	119	146	131	161
727AL	Magcan 142S – 727L Tap	138	121	148	133	163
434L	Foothills 237S – High River 65S	138	279	287	307	373
646L	Foothills 237S – Okotoks 678S	138	230	285	253	314
850L	Okotoks 678S – Carseland 525S	138	89	109	98	120
851L	Carseland 525S – Blackie 253S	138	85	90	94	99
753L	Blackie 253S – High River 65S	138	121	143	133	143
733L	Strathmore 151S – Namaka 428S	138	120	143	132	163
733L	Namaka 428S – Gleichen 179S	138	120	148	132	163
876L	Blackie 253S – Gleichen 179S	138	85	90	94	99
691L*	Janet 74S – Chestermere 419S	138	85	90	93.5	99

Note:* indicates future new/re-configured transmission lines

The TFO also provided the facility ratings for the existing transformers in the Study Area, as shown in Table 2.6-2.

Table 2.6-2: Summary of Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
Foothills 237S	237ST1	240/138	400
	237ST2	240/138	400
Janet 74S	74ST1	240/138	400
	74ST2	240/138	400
High River 65S	65ST1	138/69/4.16	18.8
	65ST2	138/25	42
	65ST3	138/25	42

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
Okotoks 678S	678ST1	138/25	28.1
	678ST2	138/25	42
Black Diamond 392S	392ST2	69/25	25
	392ST3	138/25	25

The details of shunt elements in the Study Area are given in Table 2.6-3. No reactors are present in the Study Area.

Table 2.6-3: Summary of Shunt Elements in the Study Area

Substation Name and Number	Voltage Class (kV)	Capacitors			
		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Status in Study (on or off)	
				2017 SP	2017 WP
Magcan 142S	138	1 x 24.46 MVAr	24.46	on	on
Blackie 253S	138	1 x 24.46 MVAr	24.46	off	off
Hussar 431S	138	1 x 9.17 MVAr	9.17	on	on
Strathmore 151S	138	1 x 24.35 MVAr	24.35	on	on

2.7. Voltage Profile Assumptions

The AESO ID #2010-007RS is used to establish normal system (i.e. pre-contingency) voltage profiles for key area busses prior to commencing any studies. Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions* applies for all the busses not included in the ID #2010-007RS. These voltages will be used to set the voltage profile for the study base cases prior to power flow analysis.

A list of operating voltages for the key busses in the Study Area and its vicinity are listed in Table 2.7-1.

Table 2.7-1: Operating Voltages at Key Nodes in the Study Area and Vicinity

Substation Name and Number	Area	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)		Maximum Operating Limit (kV)
Janet 74S	6	240	246	248	254	264
		138	138	138	142	142
Langdon 102S	6	500	510	510	535	540

Substation Name and Number	Area	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)		Maximum Operating Limit (kV)
		240	250	251	255	258

3. Study Methodology

The analyses performed in this connection assessment were completed using PTI PSS/E version 33.

3.1. Study Objectives

The objectives of the study are the following:

- Assess the impact of the Project on the performance of the AIES.
- Identify any violations of the relevant criteria, standards or requirements of the AESO, both pre- and post- Project.
- Recommend mitigation measures, if required, to enable the reliable connection of the Project to the AIES.

3.2. Connection Studies Carried Out

The following analyses were performed for the pre-Project scenarios:

- Power flow analysis (Category A conditions and Category B contingencies)

The following studies were performed for the post-Project scenarios:

- Power flow analysis (Category A conditions and Category B contingencies)
- Voltage stability analysis (Category A conditions and Category B contingencies)

Table 3.2-1 summarizes the studies that were carried out for this connection assessment.

Table 3.2-1: Summary of Studies Performed

Scenario(s) Studied		Studies Performed	System Conditions Studied
Pre-Project	Post-Project		
1, 2	3, 4	Power flow	Category A and Category B
-	4	Voltage stability	Category A and Category B

3.3. Power Flow Analysis

Pre-Project and post-Project power flow analysis was conducted to identify thermal and voltage criteria violations as per the Reliability Criteria, and to identify any deviations from the desired limits in Table 2.1-1. The purpose of the power flow analysis is to quantify any incremental violations in the Study Area after the Project is connected. Transformer taps and switched shunt reactive compensation devices such as shunt capacitors and reactors will be locked and continuous shunt devices will be enabled when performing Category B load flow analysis.

Point-of-delivery (POD) low voltage bus deviations were assessed by first locking all tap changers and area capacitors to identify any post-transient voltage deviations above 10%. Second, tap changers were allowed to move while capacitors remained locked to determine if any voltage deviations above 7% were found in the area. Third, all taps and capacitor controls were allowed to adjust, and voltage deviations above 5% were reported for both the pre-Project and post-Project scenarios

3.3.1. Contingencies Studied

The study included all Category B contingencies (69 kV facilities and above) within the Study Area, including the tie lines connecting the Study Area to the surrounding planning areas.

For the power flow analysis, all transmission facilities in the Study Area were monitored for voltage criteria violations and thermal criteria violations under Category A conditions and under Category B contingency conditions.

3.4. Voltage Stability (PV) Analysis

The objective of the voltage stability analysis is to determine the ability of the network to maintain voltage stability at all the busses in the system under normal and abnormal system conditions. The power-voltage (PV) curve is a representation of voltage change as a result of increased power transfer between two systems. The reported incremental transfers will be to the collapse point. As per the AESO requirements, no assessment based upon other criteria such as minimum voltage will be made at the PV minimum transfer.

Voltage stability analysis was performed for one post-Project scenario. For load connection projects, the load level modelled in post-Project scenarios is the same or higher than in pre-Project scenarios. Therefore, voltage stability analysis for pre-Project scenarios would only be performed if the post-Project scenarios show voltage stability criteria violations.

Voltage stability (PV) analysis will be performed according to the Western Electricity Coordinating Council (WECC) Voltage Stability Assessment Methodology. WECC voltage stability criteria state, for load areas, post-transient voltage stability is required for the area modeled at a minimum of 105% of the reference load level for system normal conditions (Category A) and for single contingencies (Category B). For this standard, the reference load level is the maximum established planned load.

Typically, voltage stability analysis is carried out assuming the worst case scenarios in terms of loading. The analysis was performed by increasing load in the Study Area and by increasing generation in the Wabamun planning area (Area 40).

3.4.1. Contingencies Studied

Voltage stability analysis was performed for Category A conditions and all Category B contingencies (69 kV facilities and above) in the Study Area.

4. Pre-Project System Assessment

4.1. Pre-Project Power Flow Analysis

This section provides the analysis of the pre-Project power flow studies and includes the studies results and the mitigation measures for observed Reliability Criteria violations, if any. The pre-Project power flow diagrams are provided in Attachment A.

4.1.1. Scenario 1 (2017 SP Pre-Project)

Category A conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions

Thermal criteria violations and POD bus voltage deviations beyond the desired limits provided in Table 2.1-1 were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table 4.1-1.

- Loading above the short-term emergency rating of the 138 kV transmission line 876L (between the Blackie 253S and Gleichen 179S substations) was observed following the loss of the 138 kV transmission line 691L (between the Janet 74S and planned Chestermere 419S substations). This thermal criteria violation can be mitigated by the planned RAS that is associated with Project 1631 (the Chestermere RAS).[5]
- Loading below the short-term emergency rating of the 138 kV transmission line 691L was observed following a number of Category B contingencies, as follows:
    - Loss of the 138 kV transmission line PCES01L (between the Namaka 428S substation and the Cavalier power plant);
    - Loss of a 138/13.8 kV transformer at the Cavalier power plant; or
    - Loss of the 138 kV transmission line 876L.

  These thermal criteria violations can be managed by using real-time operational practices.

[5] Project 1631 is also referred to as the Fortis Chestermere New POD project, which currently has a scheduled ISD of Q3 2017. The transmission developments associated with Project 1631 include the addition of a planned new 138/25 kV POD substation, to be designated the Chestermere 419S substation. The Chestermere RAS that is planned as part of the scope of Project 1631 would trip load at the planned Chestermere 419S substation under the following conditions: (a) when a thermal criteria violation is detected on the 138 kV transmission line 691L; or (b) when a voltage range criteria violation is detected at the planned Chestermere 419S substation; or (c) following the loss of the 138 kV transmission line 691L under specific pre-contingency loading conditions. The specifics of the Chestermere RAS are outside the scope of the Project, and would be included in a separate application for Project 1631 to be filed with the Alberta Utilities Commission.

Table 4.1-1: Summary of system performance before and after applying mitigation measures (thermal loading[6]) – Scenario 1 (Category B contingency conditions)

Contingency	Limiting Branch	Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Details of Constraints		Mitigation	
				Load flow (MVA)	% Loading	Mitigation Measure	Performance After Applying Mitigation Measure % Loading
691L (Janet 74S – planned Chestermere 419S)	876L (Blackie 253S – Gleichen 179S)	85	93.5	102.5	120	Chestermer e RAS	69
PCES01L (Namaka 428S – Cavalier power plant)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	90.2	106	Real-time operational practices	<100%
138/13.8 kV transformer at Cavalier power plant	691L (Janet 74S – planned Chestermere 419S)	85	93.5	90.0	106	Real-time operational practices	<100%
876L (Blackie 253S – Gleichen 179S)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	91.4	107	Real-time operational practices	<100%

The POD bus voltage deviations beyond the desired limits, which are also described below, are shown in Table 4.1-2.

- POD bus voltage deviations at the planned Chestermere 419S substation were observed following the loss of the 138 kV transmission line 691L. Mitigation measures are not developed to address POD bus voltage deviations that exceed the desired limits in Table 2.1-1.[7] However, this system performance issue can be mitigated by the Chestermere RAS, which would be activated under the same system conditions that are associated with the thermal criteria violation observed on the 138 kV transmission line 876L following the loss of the 138 kV transmission line 691L. In other words, these observed POD bus voltage deviations can be mitigated as a byproduct of the Chestermere RAS.

Table 4.1-2: Summary of system performance before applying mitigation measures (POD bus voltage deviations) – Scenario 1 (Category B contingency conditions)

Contingency	Substation Name and Number	Bus No.	Nominal kV	Initial Voltage (kV)	Voltage Deviations for POD Busses Only					
					Post Transient (kV)	% Change	Post Auto (kV)	% Change	Post Manual (kV)	% Change
691L (Janet 74S – planned Chestermere 419S)	(planned) Chestermere 419S	3949	25	25.4	22.8	10.1	--	--	--	--

[6] Throughout the report, all line flows associated with the power flow analysis are reported as percentage loading relative to normal line rating as shown in Table 2.6-1.

[7] The AESO's desired post-contingency voltage deviations for low voltage busses represent guidelines rather than criteria. A POD bus voltage deviation that exceeds the desired limits shown in Table 2.1-1 does not represent a Reliability Criteria violation.

		4949	25	25.4	22.8	10.1	--	--	--	--

4.1.2. Scenario 2 (2017 WP pre-Project)

Category A conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions

A thermal criteria violation was observed under Category B contingency conditions. The thermal criteria violation and the applicable mitigation measure are described below and shown in Table **4.1-3**:

- Loading below the short-term emergency rating of the existing 138 kV transmission line 876L was observed following the loss of the 138 kV transmission line 691L. This thermal criteria violation can be mitigated by using real-time operational practices.

Table 4.1-3**: Summary of system performance before and after applying mitigation measures (thermal loading) – Scenario 2 (Category B contingency conditions)**

Contingency	Limiting Branch	Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Details of Constraints		Mitigation	
				Load flow (MVA)	% Loading	Mitigation Approach	Post Mitigation Performance % Loading
691L (Janet 74S – planned Chestermere 419S)	876L (Blackie 253S – Gleichen 179S)	90	99	96.1	107	Real-time operational practices	<100%

5. Connection Alternatives

5.1. Overview

Four transmission alternatives were examined to meet the DFO's request for system access service, as detailed in Section 5.2.

5.2. Connection Alternatives Identified

Below is a description of the developments associated with the transmission alternatives that were examined for the Project.[8]

Alternative 1– Upgrade Okotoks 678S substation

Alternative 1 involves upgrading the existing Okotoks 678S substation, including adding a 138/25 kV transformer and a minimum of four 25 kV circuit breakers to accommodate the addition of four 25 kV distribution feeders. In order to meet the DFO's reliability requirements, Alternative 1 also involves adding three 138 kV circuit breakers at the Okotoks 678S substation (two for the two existing transformers and one for the planned third transformer).

The DFO has advised that two of the four 25 kV feeders at the Okotoks 678S substation would provide back-up support for the Black Diamond 392S substation. The two feeders would be configured as a 23 km 25 kV double-circuit (D/C) line as opposed to a combination of 25 kV D/C and single-circuit (S/C) lines, as contemplated by Alternative 2.

Alternative 2 – Upgrade Okotoks 678S substation and modify High River 65S substation

Alternative 2 involves upgrading the existing Okotoks 678S substation, including adding a 138/25 kV transformer and a minimum of two 25 kV circuit breakers to accommodate the addition of two 25 kV distribution feeders. In order to meet the DFO's reliability requirements, Alternative 2 also involves adding three 138 kV circuit breakers at the Okotoks 678S substation (two for the two existing transformers and one for the planned third transformer).

Alternative 2 also involves modifying the existing High River 65S substation, including adding two 25 kV circuit breakers to accommodate the addition of two 25 kV distribution feeders. The DFO has advised that the two feeders at the High River 65S substation would provide back-up support for the Black Diamond 392S substation, and would be configured as a combination of 25 kV D/C line, approximately 11 km in length, and two 25 kV S/C lines, each approximately 20 km in length.

Alternative 3 – New POD substation in the Okotoks area

Alternative 3 involves adding a new POD substation in the Okotoks area, including a 138/25 kV transformer and four 25 kV circuit breakers to accommodate the addition of four 25 kV distribution

[8] These alternatives reflect more up to date engineering design than the alternatives identified in the FortisAlberta *Need for Development for the Okotoks-Black Diamond Area* report, which is filed under a separate cover.

feeders. The new POD substation would be connected to the existing 138 kV transmission line 727L using an in/out configuration, which includes adding two 138 kV circuits.

Alternative 4 – New POD substation in the Okotoks area and upgrade Black Diamond 392S substation

Alternative 4 involves adding a new POD substation in the Okotoks area, including adding a 138/25 kV transformer and two 25 kV circuit breakers to accommodate the addition of two 25 kV distribution feeders. The new POD would be connected to the existing Okotoks 678S and Black Diamond 392S substations by adding two 138 kV transmission circuits.

Alternative 4 also involves upgrading the existing Black Diamond 392S substation, including replacing the existing 69/25 kV 15/20/25 MVA transformer with a 138/25 kV transformer, which also has a higher capacity.

5.2.1. Connection Alternatives Selected for Further Studies

Alternative 2 is considered technically feasible and was selected for further study.

5.2.2. Connection Alternatives Not Selected for Further Studies

Alternative 1

Alternative 1 is considered technically feasible. However, the DFO has advised that the distribution system developments associated with Alternative 1 result in a less reliable distribution system than Alternative 2. The DFO has advised that Alternative 1 could negatively impact the reliability of the distribution system because the use of D/C 25 kV line is less reliable from a distribution system perspective than the use of S/C 25 kV lines.

Furthermore, compared to Alternative 2, Alternative 1 requires the addition of a greater number of distribution feeders at the Okotoks 678S substation. Thus, Alternative 1 would restrict the possibility of future distribution system developments at the Okotoks 678S substation. The DFO has advised that the expected load growth at the Okotoks 678S substation exceeds the expected load growth at the High River 65S substation, and that it would be preferable to maintain the ability to add additional distribution feeders at the Okotoks 678S substation rather than to serve expected load growth in the Okotoks area from the High River 65S substation, which the DFO has advised would be inefficient.

Based on the distribution system reliability and expandability concerns that are associated with Alternative 1, the AESO considers that Alternative 1 is an inferior option to Alternative 2. Alternative 1 was not selected for further study.

Alternative 3 and Alternative 4

Alternative 3 and Alternative 4 are considered technically feasible. These alternatives involve increased transmission developments and hence, increased costs compared to Alternative 2. Alternative 3 and Alternative 4 were not selected for further study.

6. Technical Analysis of the Connection Alternative

This section provides the analysis of the post-Project power flow and voltage stability studies and includes the studies results and the mitigation measures for observed Reliability Criteria violations, if any.

6.1. Power Flow

The post-Project power flow diagrams are provided in Attachment B.

6.1.1. Scenario 3 (2017 SP post-Project)

Category A conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions

A number of thermal criteria violations and POD bus voltage deviations beyond the desired limits were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table **6.1-1**. A number of these system performance issues were identified in the pre-Project Scenario 1.

- Loading above the short-term emergency rating of the 138 kV transmission 876L was observed following the loss of the 138 kV transmission line 691L. The magnitude of this violation was greater than the thermal criteria violation that was observed in the pre-Project Scenario 1. Similar to the pre-Project Scenario 1, this thermal criteria violation can be mitigated by the Chestermere RAS.
- Loading above the short-term emergency rating of the 138 kV transmission line 691L was observed following a number of Category B contingencies, as follows:
  - Loss of the 138 kV transmission line PCES01L. The magnitude of this violation was greater than the thermal criteria violation that was observed in the pre-Project Scenario 1.
  - Loss of a 138/13.8 kV transformer at the Cavalier power plant. The magnitude of this violation was greater than the thermal criteria violation that was observed in the pre-Project Scenario 1.
  - Loss of the 138 kV transmission line 876L. The magnitude of this violation was greater than the thermal criteria violation that was observed in the pre-Project Scenario 1.
  - Loss of the 138 kV transmission line 434L (between the Foothills 237S and High River 65S substations). This violation was not observed in the pre-Project Scenario 1.

  These thermal criteria violations can be managed by using the Chestermere RAS.
- Loading below the short-term emergency rating of the 138 kV transmission line 691L was observed following a number of Category B contingencies, as follows:

- Loss of the 138 kV transmission line 646L (between the Foothills 237S and Okotoks 678S substations). This violation was not observed in the pre-Project Scenario 1.
- Loss of the 138 kV transmission line 753L (between the High River 65S and Blackie 253S substations). This violation was not observed in the pre-Project Scenario 1.

These thermal criteria violations can be managed by using real-time operational practices.

Table 6.1-1: **Summary of system performance before and after applying mitigation measures (thermal loading) – Scenario 3 (Category B contingency conditions)**

Contingency	Limiting Branch	Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Details of Constraints		Mitigation	
				Load flow (MVA) (*Pre-* / Post-Project)	% Loading (*Pre-* / Post-Project)	Mitigation Measure (*Pre-* / Post-Project)	Performance After Applying Mitigation Measure % Loading (*Pre-* / Post-Project)
691L (Janet 74S – planned Chestermere 419S)	876L (Blackie 253S – Gleichen 179S)	85	93.5	*102.5 /* 103.8	*120 /* 122	*Chestermere RAS /* Chestermere RAS	*69 /* 73
434L (Foothills 237S - High River 65S	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*NA /* 98.4	*NA /* 116	*NA /* Chestermere RAS	*NA /* 84
PCES01L (Namaka 428S – Cavalier power plant)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*90.2 /* 96.0	*106 /* 113	*Real-time operational practices /* Chestermere RAS	*<100% /* 66
138/13.8 kV transformer at Cavalier power plant	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*90.2 /* 95.9	*106 /* 113	*Real-time operational practices /* Chestermere RAS	*<100% /* 66
876L (Blackie 253S – Gleichen 179S)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*91.4 /* 94.6	*107 /* 111	*Real-time operational practices /* Chestermere RAS	*<100% /* 80
646L (Foothills 237S – Okotoks 678S)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*NA /* 86.0	*NA /* 101	*NA /* Real-time operational practices	*NA /* <100%
753L (High River 65S – Blackie 253S)	691L (Janet 74S – planned Chestermere 419S)	85	93.5	*NA /* 85.5	*NA /* 101	*NA /* Real-time operational practices	*NA /* <100%

The POD bus voltage deviations beyond the desired limits, which are also described below, are shown in Table 6.1-2.

- POD bus voltage deviation at the planned Chestermere 419S substation was observed following the loss of the 138 kV transmission line 691L. As stated under Scenario 1, mitigation measures are not developed to address POD bus voltage deviations that exceed the desired values in Table 2.1-1. However, this system performance issue can be mitigated by the Chestermere RAS, which would be activated under the same system conditions that are associated with the thermal criteria violation observed on the 138 kV transmission line 876L following the loss of the 138 kV transmission line 691L. In other words, these observed POD bus voltage deviations can be mitigated as a byproduct of the Chestermere RAS.

Table 6.1-2: Summary of system performance before applying mitigation measures (POD bus voltage deviations) – Scenario 3 (Category B contingency conditions)*

Contingency	Substation Name and Number	Bus No.	Nominal kV	Initial Voltage (kV) *(Pre- /* Post-Project)	Voltage Deviations for POD Busses Only					
					Post Transient (kV) *(Pre- /* Post-Project)	% Change *(Pre- /* Post-Project)	Post Auto (kV)	% Change	Post Manual (kV)	% Change
691L (Janet 74S – planned Chestermere 419S)	(planned) Chestermere 419S	3949	25	*25.4 /* 25.16	*22.8 /* 22.02	*10.1 /* 12.5	--	--	--	--
		4949	25	*25.4 /* 25.16	*22.8 /* 22.02	*10.1 /* 12.5	--	--	--	--

Note: This table does not summarize the system performance after applying mitigation measures. The effect of the Chestermere RAS would be to trip the load at the planned Chestermere 419S substation, after which no POD bus voltage deviation would be observed.

6.1.2. Scenario 4 (2017 WP, post-Project)

Category A conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions

A number of thermal criteria violations were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table **6.1-3**. One of these system performance issues was identified in the pre-Project Scenario 2.

- Loading above the short-term emergency rating of the 138 kV transmission 876L was observed following the loss of the 138 kV transmission line 691L. The magnitude of this violation was greater than the thermal criteria violation that was observed in the pre-Project Scenario 2. This thermal criteria violation can be mitigated by the Chestermere RAS.

- Loading below the short-term emergency rating of the 138 kV transmission line 691L was observed following a number of Category B contingencies, as follows:

- Loss of the 138 kV transmission line PCES01L. This violation was not observed in the pre-Project Scenario 2.
- Loss of a 138/13.8 kV transformer at the Cavalier power plant. This violation was not observed in the pre-Project Scenario 2.
- Loss of the 138 kV transmission line 434L. This violation was not observed in the pre-Project Scenario 2.

These thermal criteria violations can be managed by using real-time operational practices.

Table 6.1-3: **Summary of system performance before and after applying mitigation measures (thermal loading) – Scenario 4 (Category B contingency conditions)**

Contingency	Limiting Branch	Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Details of Constraints		Mitigation	
				Load flow (MVA) (*Pre- /* Post-Project)	% Loading (*Pre- /* Post-Project)	Mitigation Measure (*Pre- /* Post-Project)	Performance After Applying Mitigation Measure % Loading (*Pre- /* Post-Project)
691L (Janet 74S – planned Chestermere 419S)	876L (Blackie 253S – Gleichen 179S	90	99	*96.1 /* 99.9	*107 /* 111	*Real-time operational practices /* Chestermere RAS	*<100% /* 64
434L (Foothills 237S - High River 65S)	691L (Janet 74S – planned Chestermere 419S)	90	99	*NA /* 94.2	*NA /* 105	*NA /* Real-time operational practices	*NA /* <100%
PCES01L (Namaka 428S – Cavalier Power Plant	691L (Janet 74S – planned Chestermere 419S)	90	99	*NA /* 92.5	*NA /* 103	*NA /* Real-time operational practices	*NA /* <100%
138/13.8 kV transformer at Cavalier power plant	691L (Janet 74S – planned Chestermere 419S)	90	99	*NA /* 92.4	*NA /* 103	*NA /* Real-time operational practices	*NA /* <100%

6.2. Voltage Stability

Voltage stability analysis was conducted using Scenario 4 to investigate the system active power margins after the Project under Category A conditions and under Category B contingency conditions. The voltage stability diagrams are provided in Attachment C.

6.2.1. Scenario 4 (2017 WP, post-Project)

For Scenario 4, the reference load level in the Study Area is 282.7 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load, or 14.135 MW, to meet the voltage stability criteria (282.7 MW x 0.05 = 14.135 MW). Table 6.2-1 summarizes the voltage stability results for Category A and for the five worst contingencies under Category B system conditions.

The voltage stability margin was met for all conditions.

Table 6.2-1: Voltage stability analysis results – Scenario 4 (Minimum transfer = 14.135 MW)

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System normal		170	Yes
691L	Janet 74S	Chestermere 419S	40	Yes
434L	High River 65S	Foothills 237S	70	Yes
646L	Foothills 237S	Okotoks 678S	130	Yes
733L	Namaka 428S	Gleichen 179S	140	Yes
876L	Gleichen 179S	Blackie 253S	150	Yes

6.3. Results Summary

The Reliability Criteria violations observed during the connection assessment studies are summarized in Table 6.3-1.

Table 6.3-1: Project impact and mitigation measures

Identified Reliability Criteria Violation		Occurrence	Impact Level of Project	System Condition	Mitigation Measures (Pre- and Post-Project)
Violation	Contingency				
Thermal criteria violation on the 138 kV transmission line 876L (Blackie 253S – Gleichen 179S)	691L (Janet 74S – planned Chestermere 419S)	Pre-Project and Post-Project	Marginal	2017 SP	**Pre:** Chestermere RAS **Post:** Same as pre-Project
Thermal criteria violation on the 138 kV transmission line 876L (Blackie 253S – Gleichen 179S)	691L (Janet 74S – planned Chestermere 419S)	Pre-Project and Post-Project	Significant	2017 WP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)	PCES01L (Namaka 428S – Cavalier power plant)	Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)	PCES01L (Namaka 428S – Cavalier power plant)	Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)	138/13.8 kV transformer at the Cavalier power plant	Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices **Post:** Chestermere RAS
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)	138/13.8 kV transformer at the Cavalier power plant	Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
Thermal criteria violation on the 138 kV transmission line 691L (Janet 74S – planned Chestermere 419S)		Pre-Project and Post-Project	Significant	2017 SP	**Pre:** Real-time operational practices

Identified Reliability Criteria Violation		Occurrence	Impact Level of Project	System Condition	Mitigation Measures (Pre- and Post-Project)
Violation	**Contingency**				
	876L (Blackie 253S – Gleichen 179S)				**Post:** Chestermere RAS
	434L (Foothills 237S - High River 65S)	Post-Project only	Significant	2017 SP	**Pre:** None required **Post:** Chestermere RAS
	434L (Foothills 237S - High River 65S)	Post-Project only	Significant	2017 WP	**Pre:** None required **Post:** Real-time operational practices
	646L (Foothills 237S – Okotoks 678S)	Post-Project only	Significant	2017 SP	**Pre:** None required **Post:** Real-time operational practices
	753L (High River 65S – Blackie 253S)	Post-Project only	Significant	2017 SP	**Pre:** None required **Post:** Real-time operational practices

The power flow study results identified post-Project system performance issues under Category B contingency conditions. Real-time operational practices and the Chestermere RAS can be used to mitigate all of the pre-Project and post-Project system performance issues.

The post-Project voltage stability analysis confirms that the voltage stability margin of the Study Area was met under all studied conditions.

Based on the studies results, Alternative 2 is technically viable.

7. Project Interdependencies

No project interdependencies were identified.

8. Conclusions and Recommendations

Based on the study results, Alternative 2 is technically viable. The connection assessment identified a number of pre-Project and post-Project system performance issues.

Real-time operational practices and the Chestermere RAS can be used to mitigate all of the pre- and post-Project system performance issues. The Project does not impact the effectiveness of existing RASs in the Study Area, nor does the Project create new RASs in the Study Area.

This report demonstrated that the Chestermere RAS, which is associated with Project 1631, can be used to mitigate a number of system performance issues that were identified in the pre-Project and post-Project assessments. However, the Chestermere RAS would not be required for the purposes of the Project if the Project were energized before Project 1631, given that any remaining post-Project system performance issues could be managed by using real-time operational practices, as required. Therefore, the energization of the Project is not dependent on the energization of Project 1631.

It is recommended to proceed with the Project using Alternative 2 as the preferred alternative to respond to the DFO’s request for system access service. It is also recommended to use real-time operational practices and the Chestermere RAS to mitigate the identified system performance issues.

The minimum transformation capacity required for the 138/25 kV transformer in Alternative 2 is 28 MVA. A transformer size of 42 MVA would be recommended based on good electric industry practice and under advisement from the legal owner of transmission facilities regarding its asset management and inventory practices.

Attachment A

Pre-Project Power Flow Diagrams (Scenarios 1 to 2)

Table 1: Summary of System Performance without Applying Mitigation (Element Loading) - 2017 SP Pre-Project Category B

Contingency	Thermal Overloads	Overload %	Figure in Attachment A
N-G: Normal Operation	None	--	A-1
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	120	A-2
434L High River 65S to Foothills 237S	None	--	A-3
646L Okotoks 678S to Foothills 237S	None	--	A-4
753L High River 65S to Blackie 253S	None	--	A-5
PCES01L Namaka 428S to Cavalier Power Plant	691L Janet 74S – Chestermere 419S	106	A-6
Cavalier transformer	691L Janet 74S – Chestermere 419S	106	A-7
876L Blackie 253S to Gleichen 179S	691L Janet 74S – Chestermere 419S	107	A-8
733L Namaka 428S to Gleichen 179S	None	-	A-9

Table 2: Summary of System Performance without Applying Mitigation (Element Loading) - 2017 WP Pre-Project Category B

Contingency	Thermal Overloads	Overload %	Figure in Attachment A
N-G: Normal Operation	None	--	A-10
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	107	A-11
434L High River 65S to Foothills 237S	None	--	A-12
646L Okotoks 678S to Foothills 237S	None	--	A-13
753L High River 65S to Blackie 253S	None	--	A-14

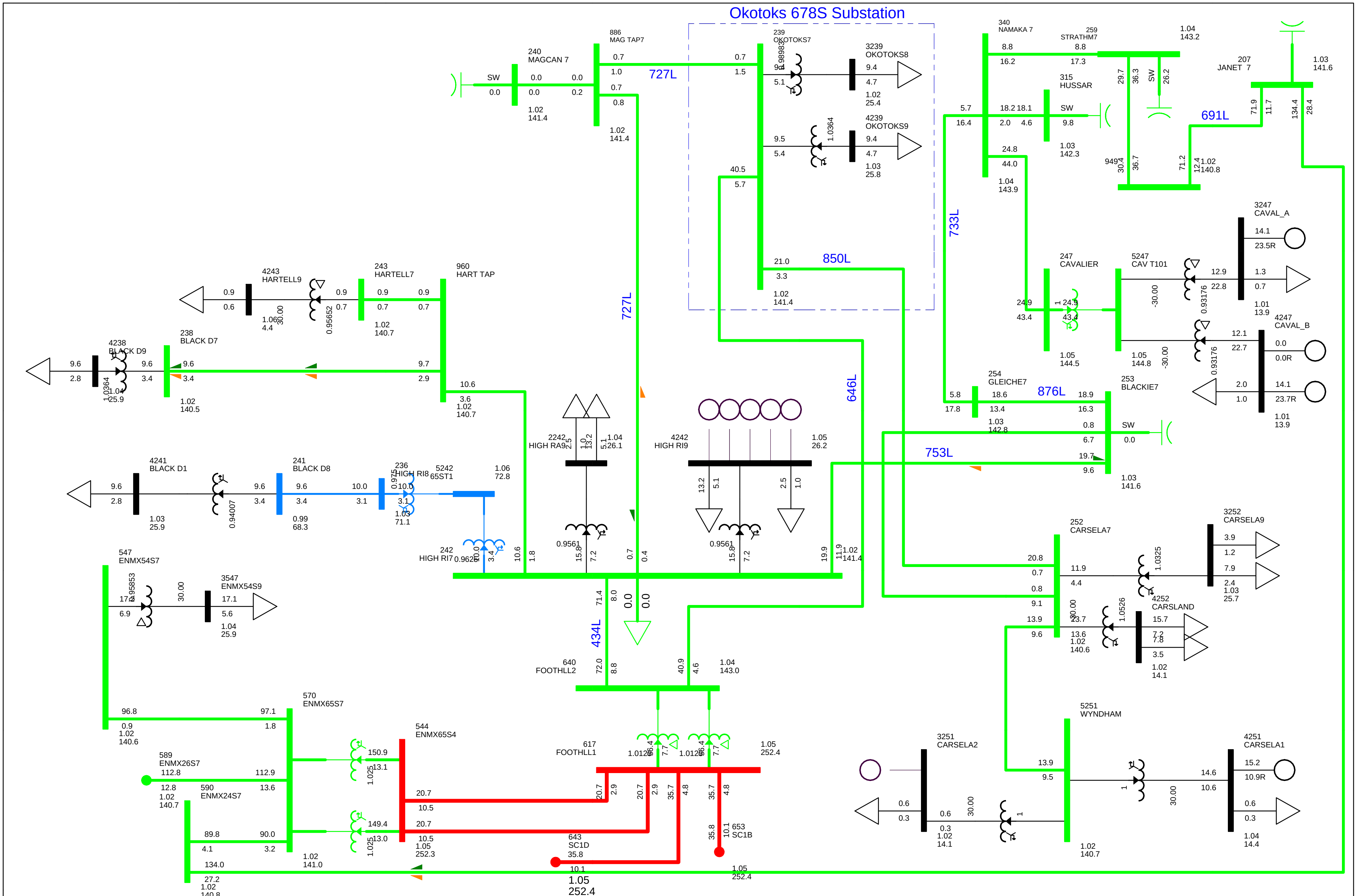
PCES01L Namaka 428S to Cavalier Power Plant	None	--	A-15
Cavalier transformer	None	--	A-16
876L Blackie 253S to Gleichen 179S	None	--	A-17
733L Namaka 428S to Gleichen 179S	None	--	A-18

Table 3: Summary of System Performance with Mitigation (Element Loading) - 2017 SP Pre-Project Category B

Contingency	Thermal Overloads	Overload %	Mitigation Approach	Post Mitigation Performance % Loading	Figure in Attachment A
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	120	Project 1631 SPS	69	A-19
PCES01L Namaka 428S to Cavalier Power Plant	691L Janet 74S – Chestermere 419S	106	Real-time operational practice	N/A	N/A
Cavalier transformer	691L Janet 74S – Chestermere 419S	106	Real-time operational practice	N/A	N/A
876L Blackie 253S to Gleichen 179S	691L Janet 74S – Chestermere 419S	107	Real-time operational practice	N/A	N/A

Table 4: Summary of System Performance with Mitigation (Element Loading) - 2017 WP Pre-Project Category B

Contingency	Thermal Overloads	Overload %	Mitigation Approach	Post Mitigation Performance % Loading	Figure in Attachment A
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	107	Real-time operational practice	N/A	N/A



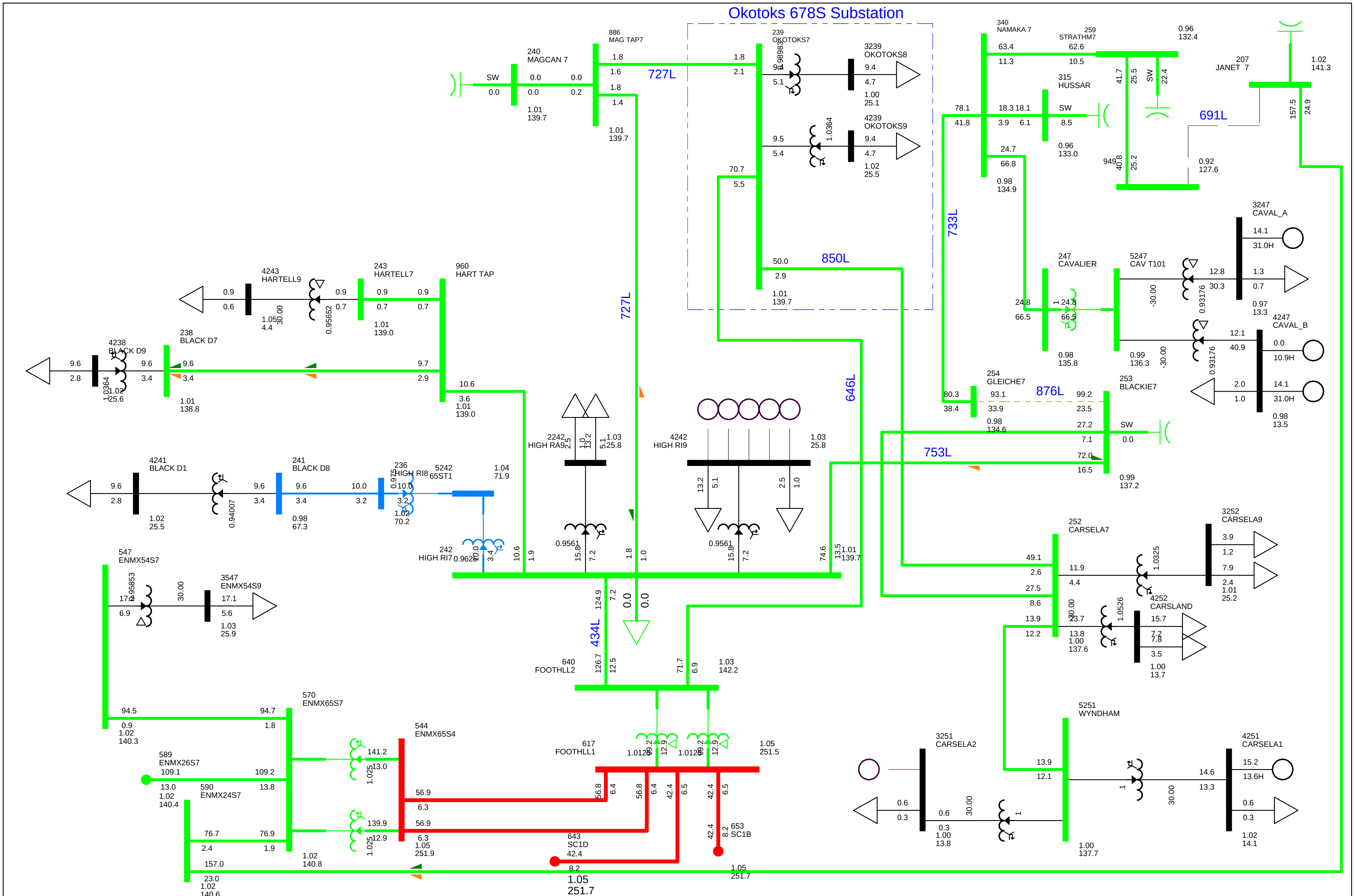
Okotoks 678S and

High River 65S Upgrades

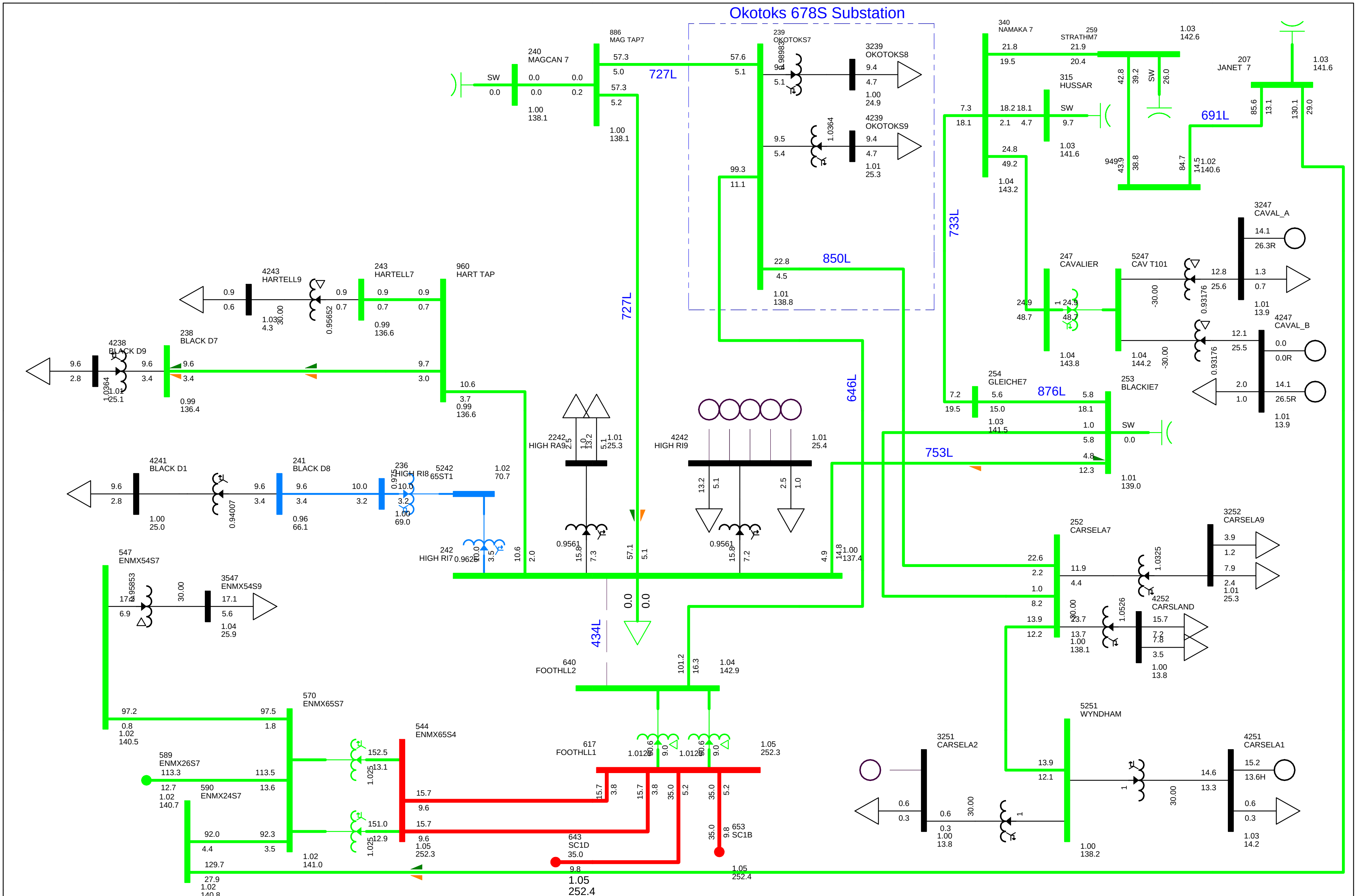
2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-1
N-0: NORMAL OPERATION
THU, MAY 26 2016 12:39

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 PRE-CONNECTION - DIAGRAM A-2 N-1: 691L JANET 74S TO CHESTERMERE 419S THU, MAY 26 2016 12:40	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



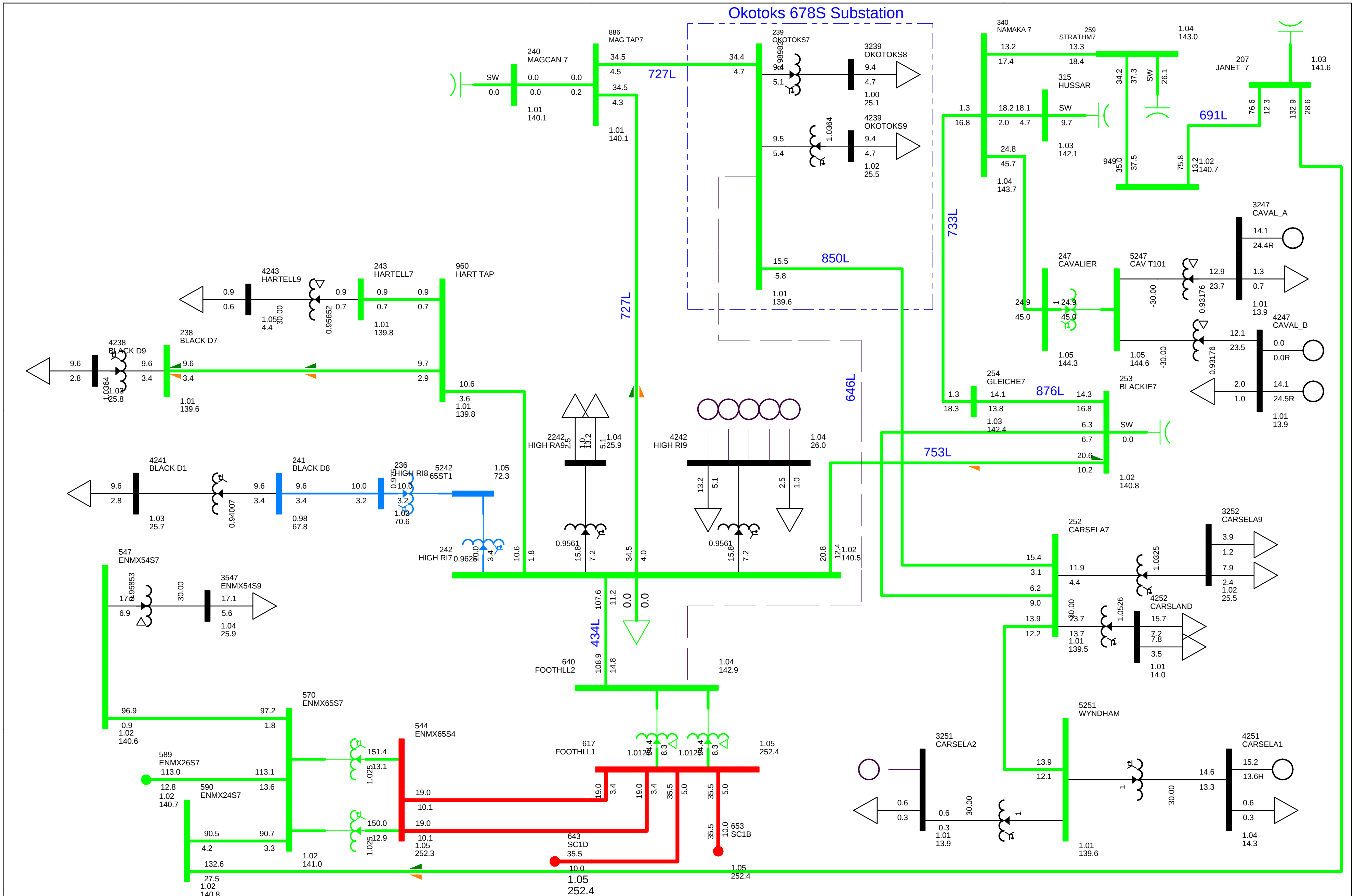
Okotoks 678S and

High River 65S Upgrades

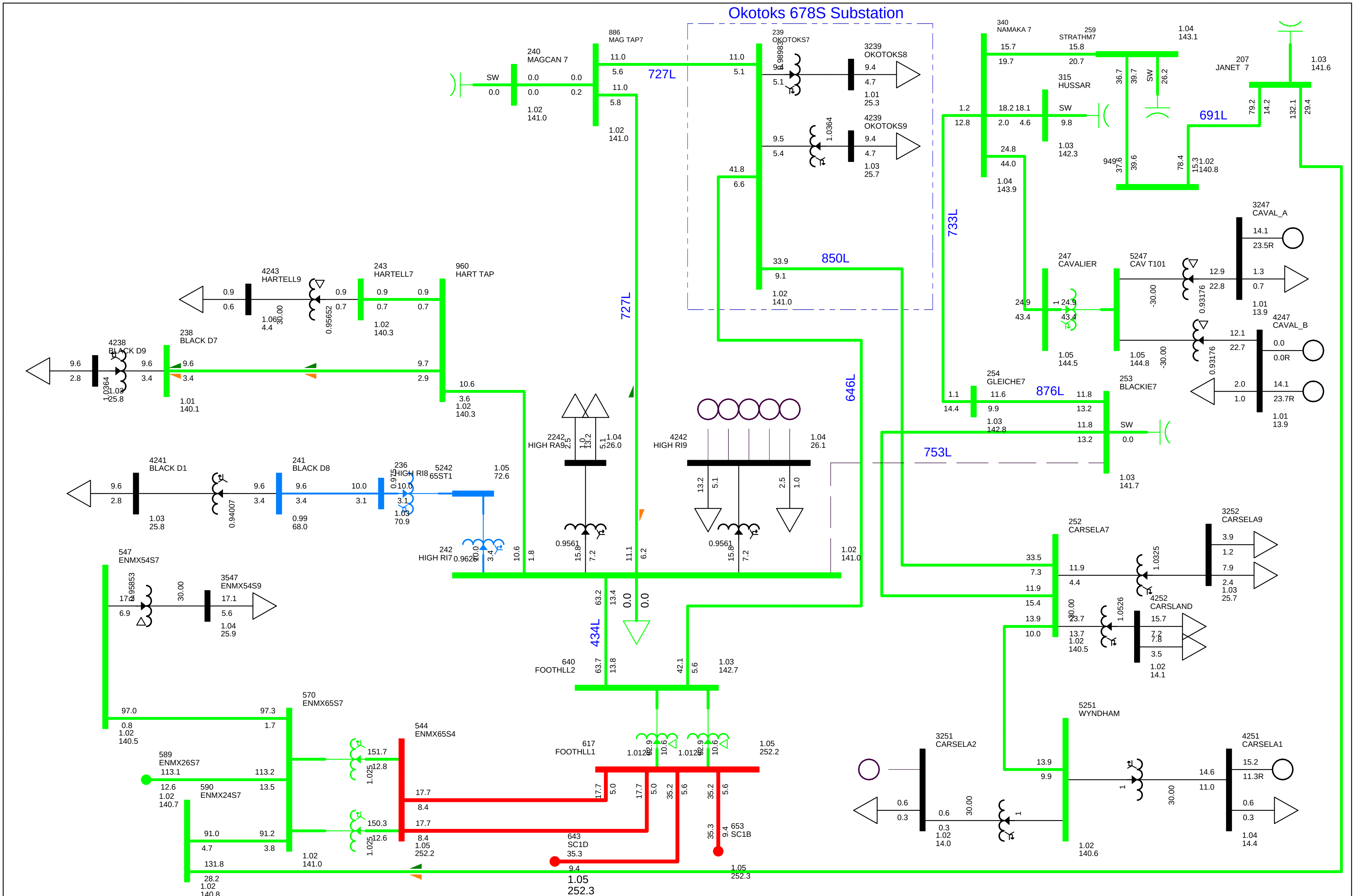
2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-3
N-1: 434L HIGH RIVER 65S TO FOOTHILLS 237S
THU, MAY 26 2016 12:40

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 PRE-CONNECTION - DIAGRAM A-4 N-1: 646L OKOTOKS 678S TO FOOTHILLS 237S THU, MAY 26 2016 12:40	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

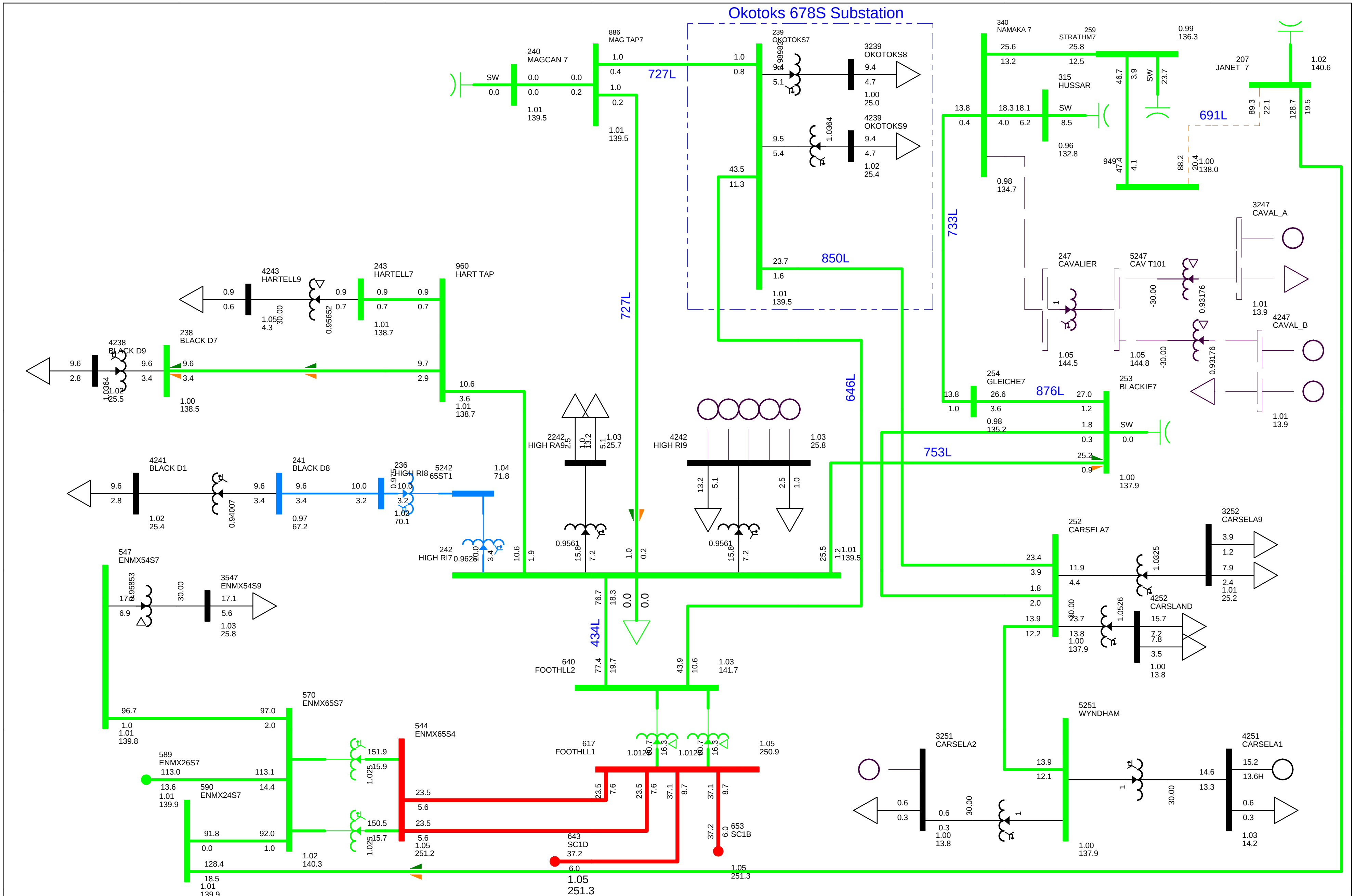


Okotoks 678S and High River 65S Upgrades

2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-5
N-1: 753L HIGH RIVER 65S TO BLACKIE 253S
THU, MAY 26 2016 12:40

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



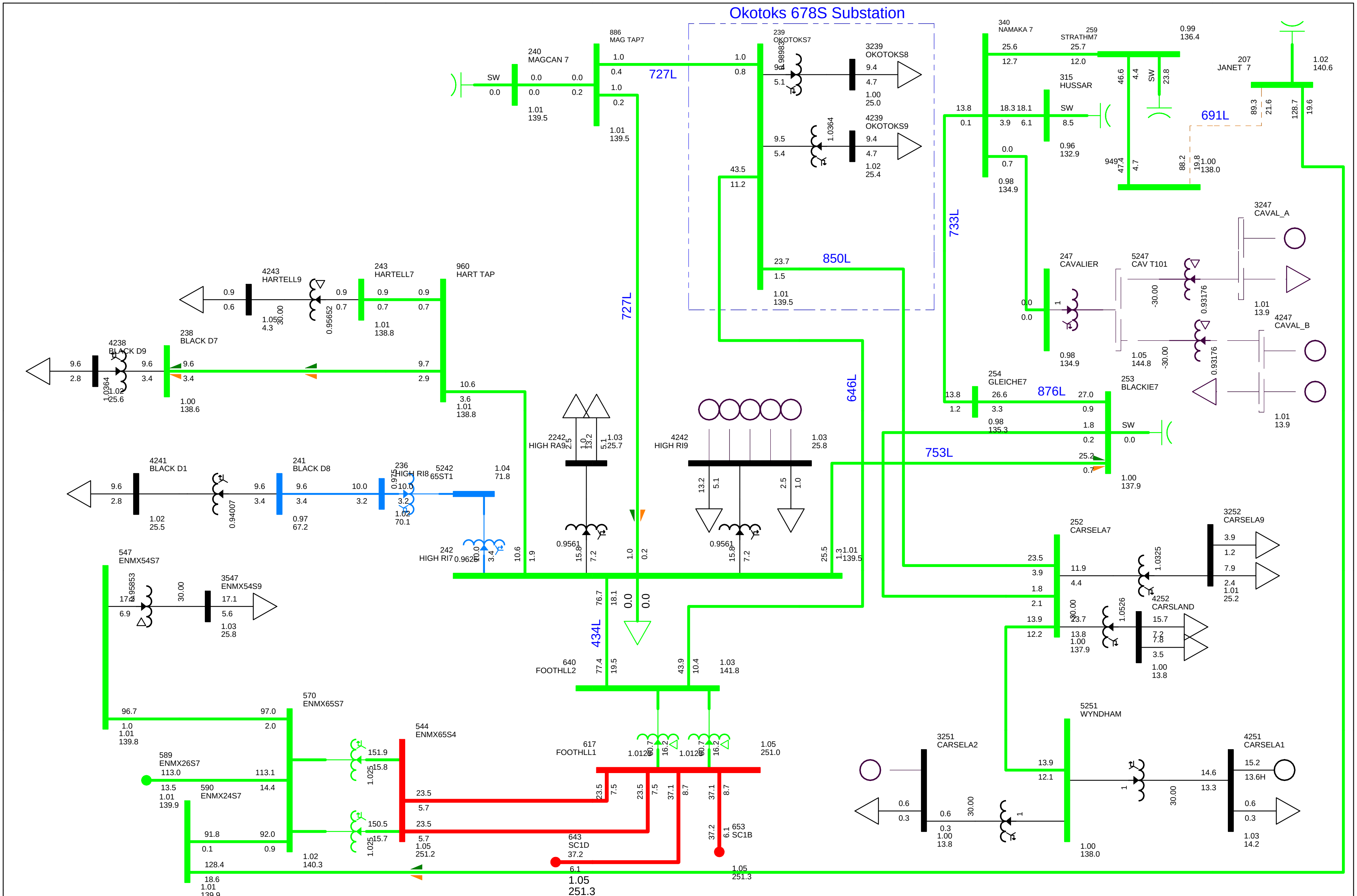
Okotoks 678S and

High River 65S Upgrades

2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-6
N-1: PCES01L NAMAKA 428S TO CAVALIER POWER PLANT
THU, MAY 26 2016 12:40

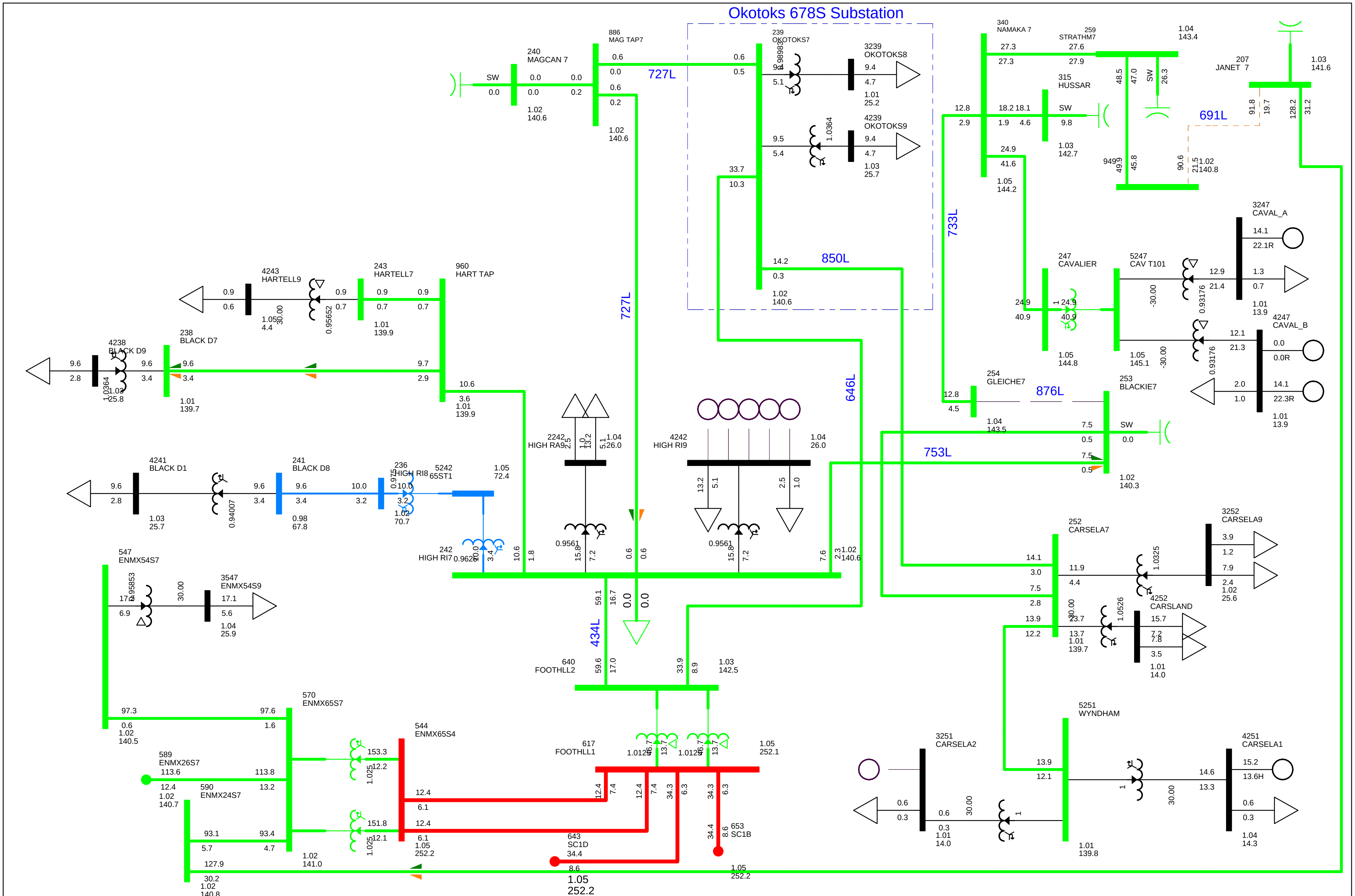
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-7
N-1: CAVALIER TRANSFORMER
THU, MAY 26 2016 12:40

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



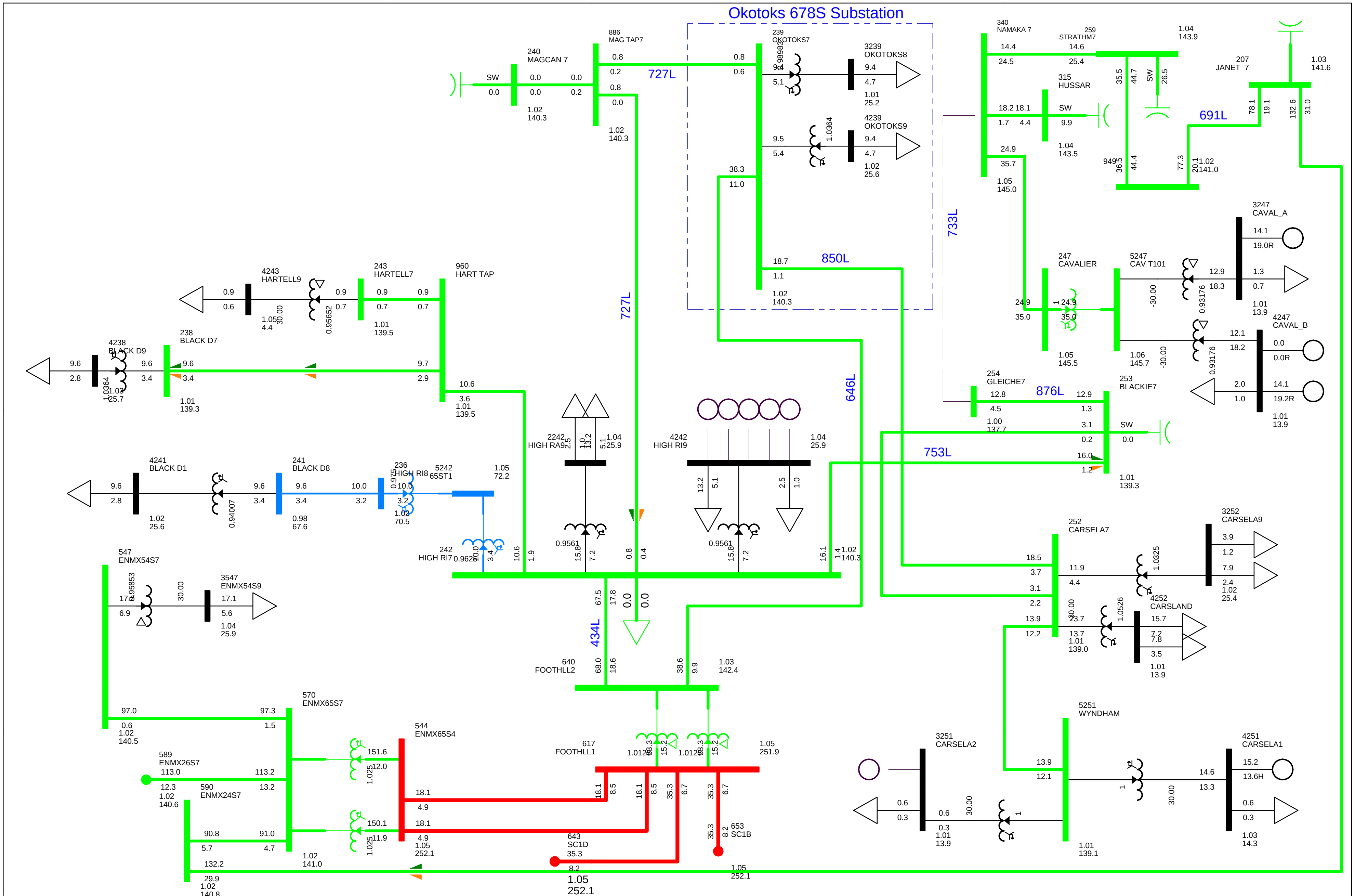
Okotoks 678S and

High River 65S Upgrades

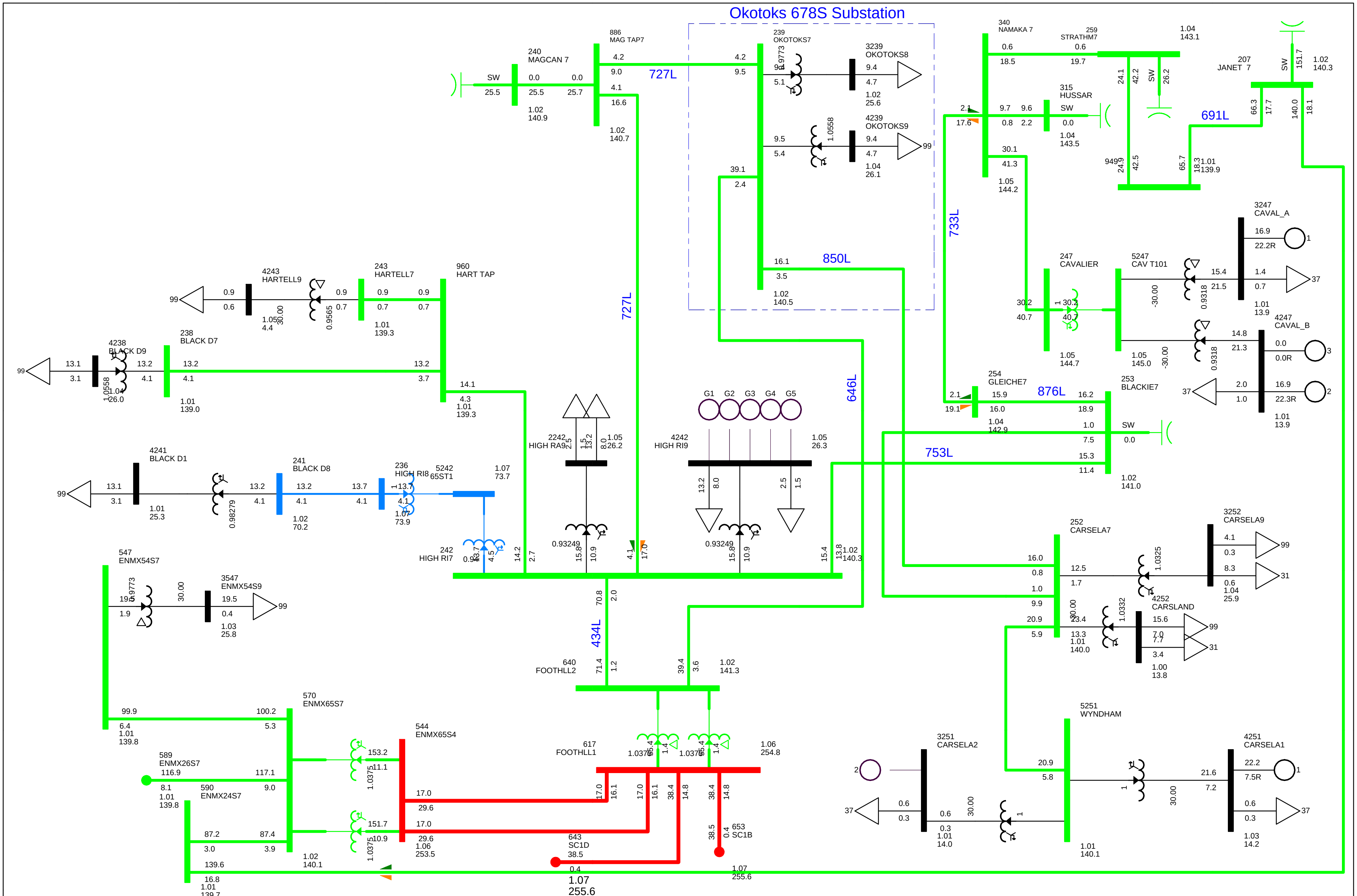
2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-8
N-1: 876L BLACKIE 253S TO GLEICHEN 179S
THU, MAY 26 2016 12:40

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 PRE-CONNECTION - DIAGRAM A-9 N-1: 733L NAMAKA 428S TO GLEICHEN 179S THU, MAY 26 2016 12:40	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



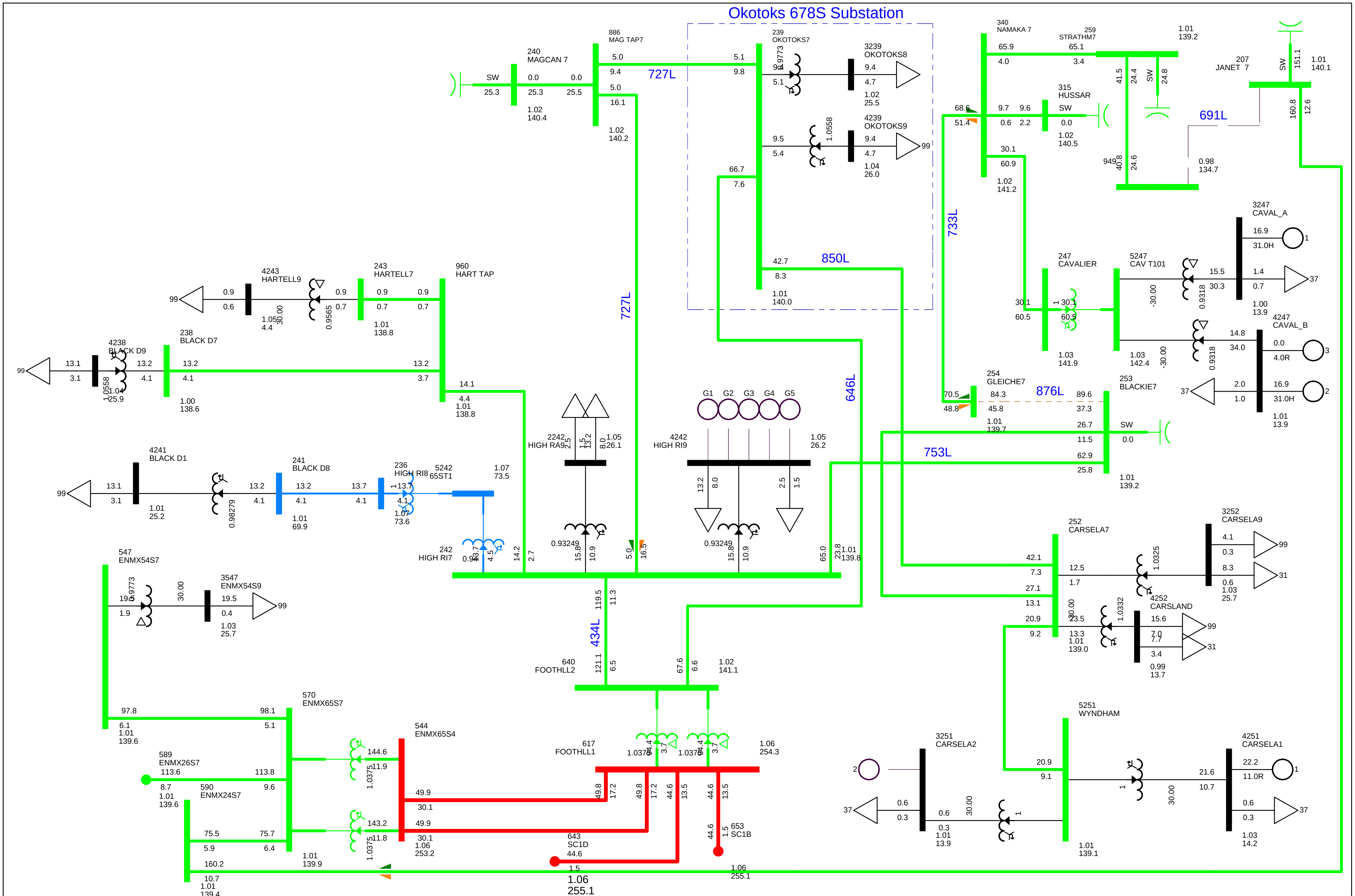
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 PRE-CONNECTION - DIAGRAM A-10
N-0: NORMAL OPERATION
THU, MAY 26 2016 12:45

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



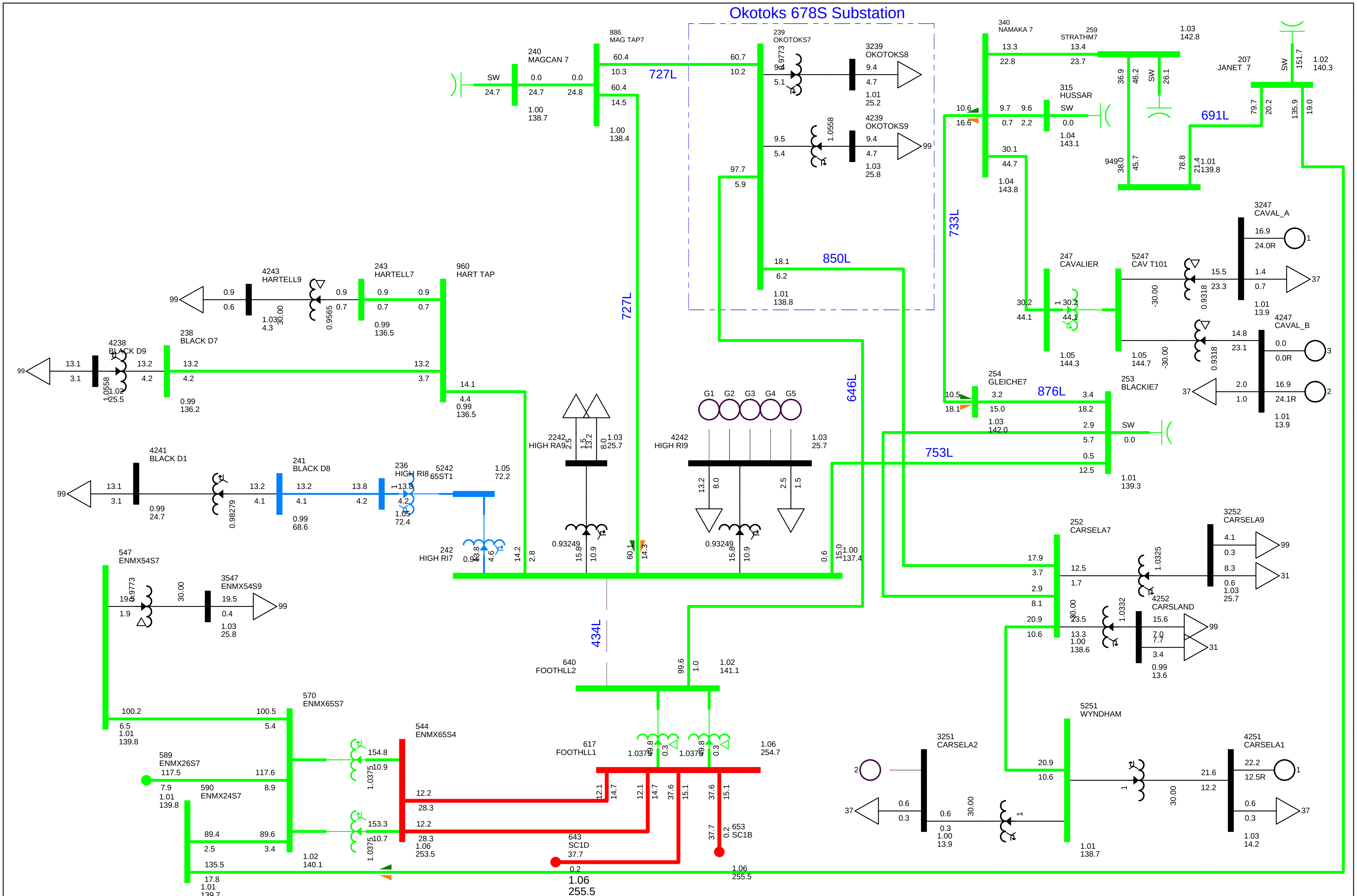
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 PRE-CONNECTION - DIAGRAM A-11
N-1: 691L JANET 74S TO CHESTERMERE 419S
THU, MAY 26 2016 12:45

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



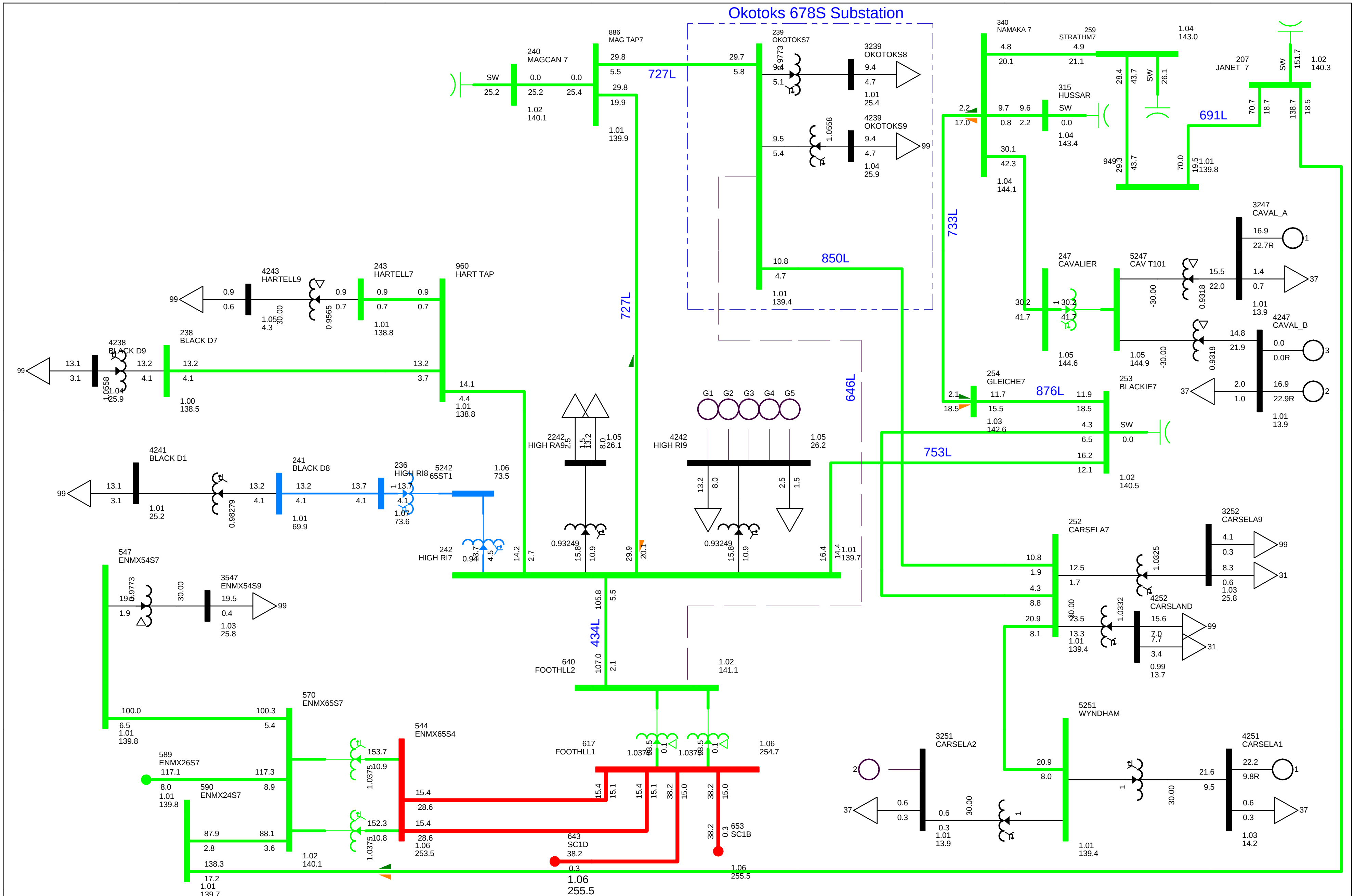
Okotoks 678S and

High River 65S Upgrades

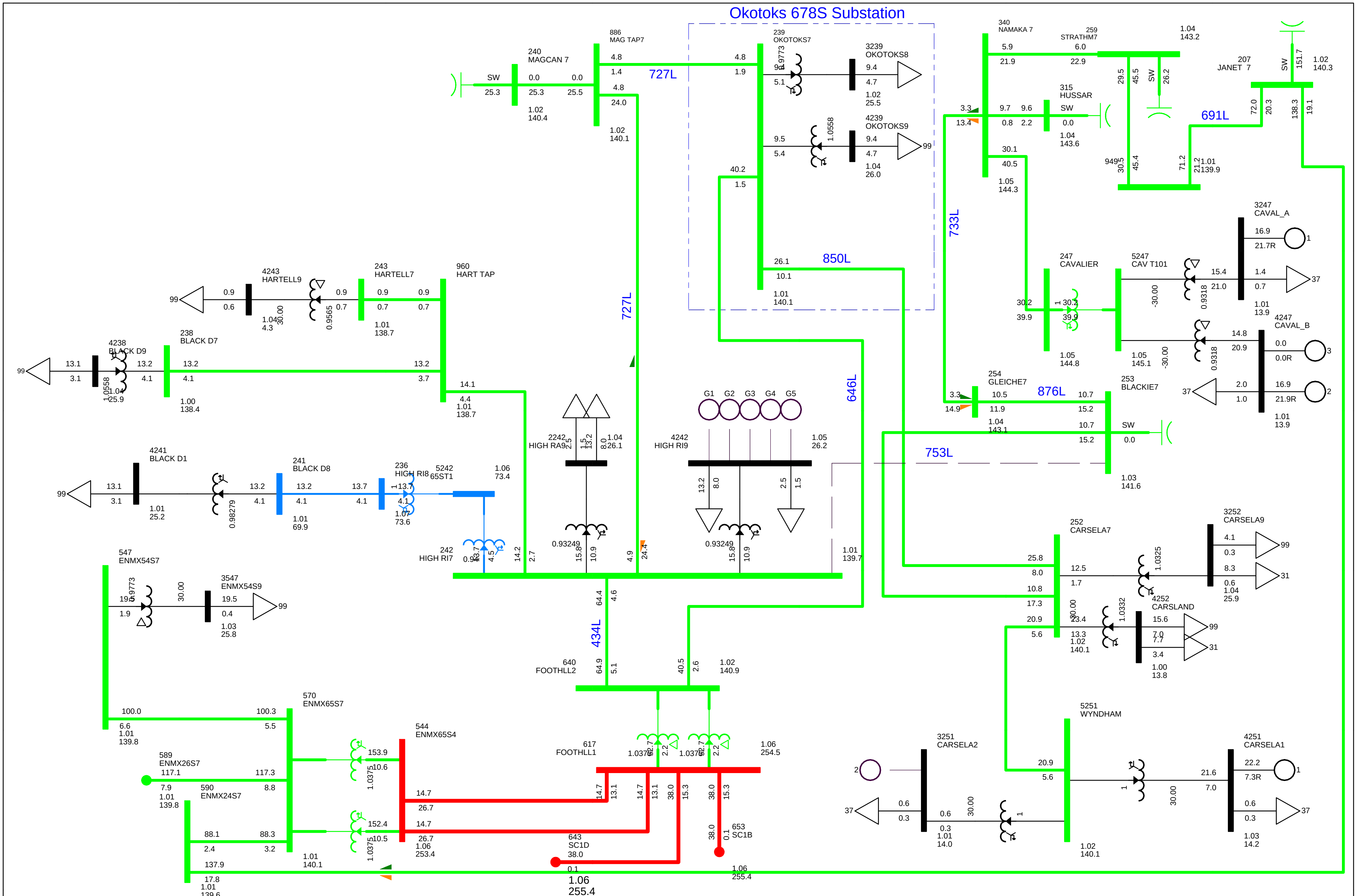
2017 WP

P1670 PRE-CONNECTION - DIAGRAM A-12
N-1: 434L HIGH RIVER 65S TO FOOTHILLS 237S
THU, MAY 26 2016 12:45

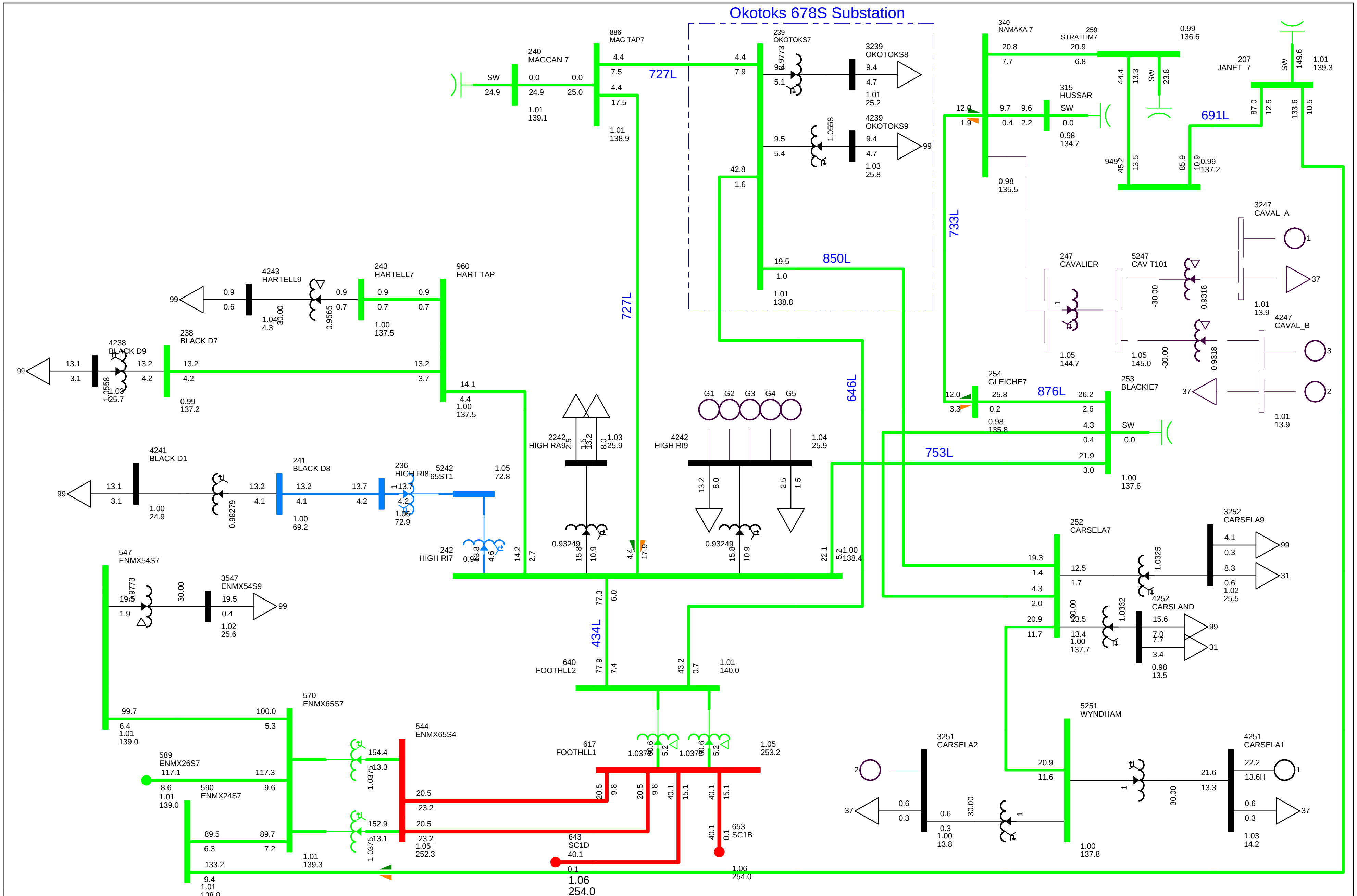
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



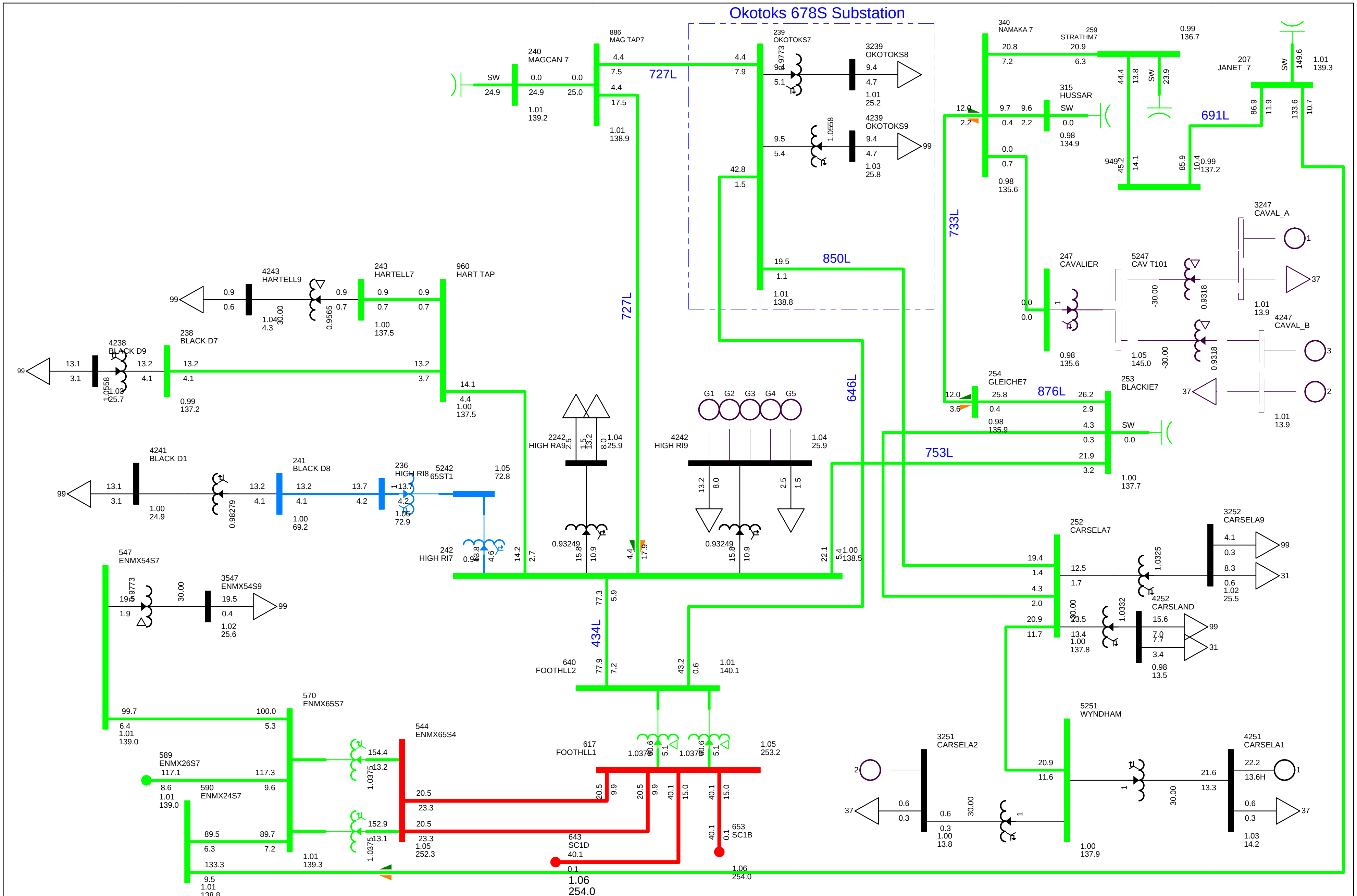
Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 PRE-CONNECTION - DIAGRAM A-13 N-1: 646L OKOTOKS 678S TO FOOTHILLS 237S THU, MAY 26 2016 12:45	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



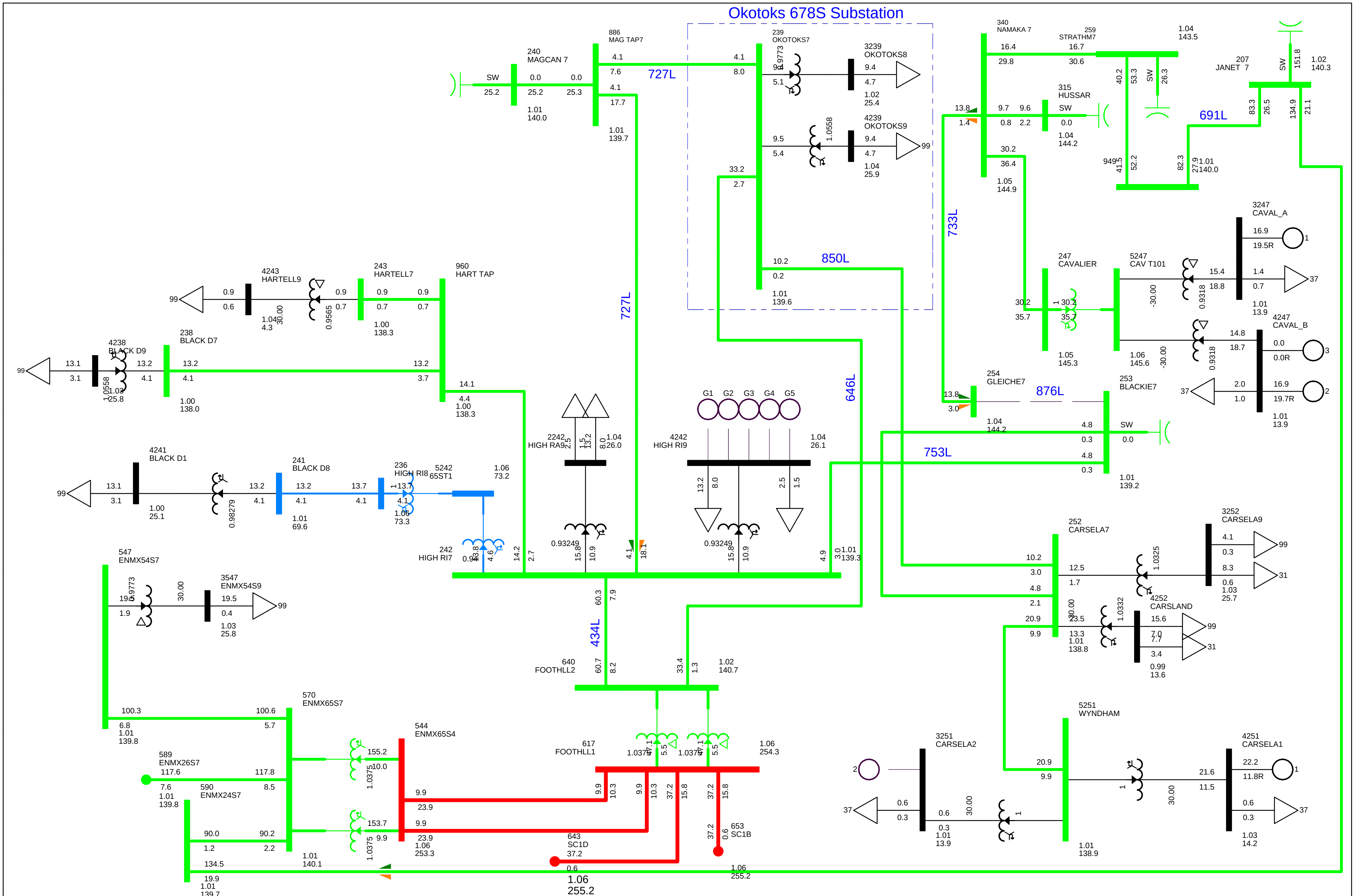
Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 PRE-CONNECTION - DIAGRAM A-14 N-1: 753L HIGH RIVER 65S TO BLACKIE 253S THU, MAY 26 2016 12:45	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 PRE-CONNECTION - DIAGRAM A-15 N-1: PCES01L NAMAKA 428S TO CAVALIER POWER PLANT THU, MAY 26 2016 12:46	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 PRE-CONNECTION - DIAGRAM A-16 N-1: CAVALIER TRANSFORMER THU, MAY 26 2016 12:46	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



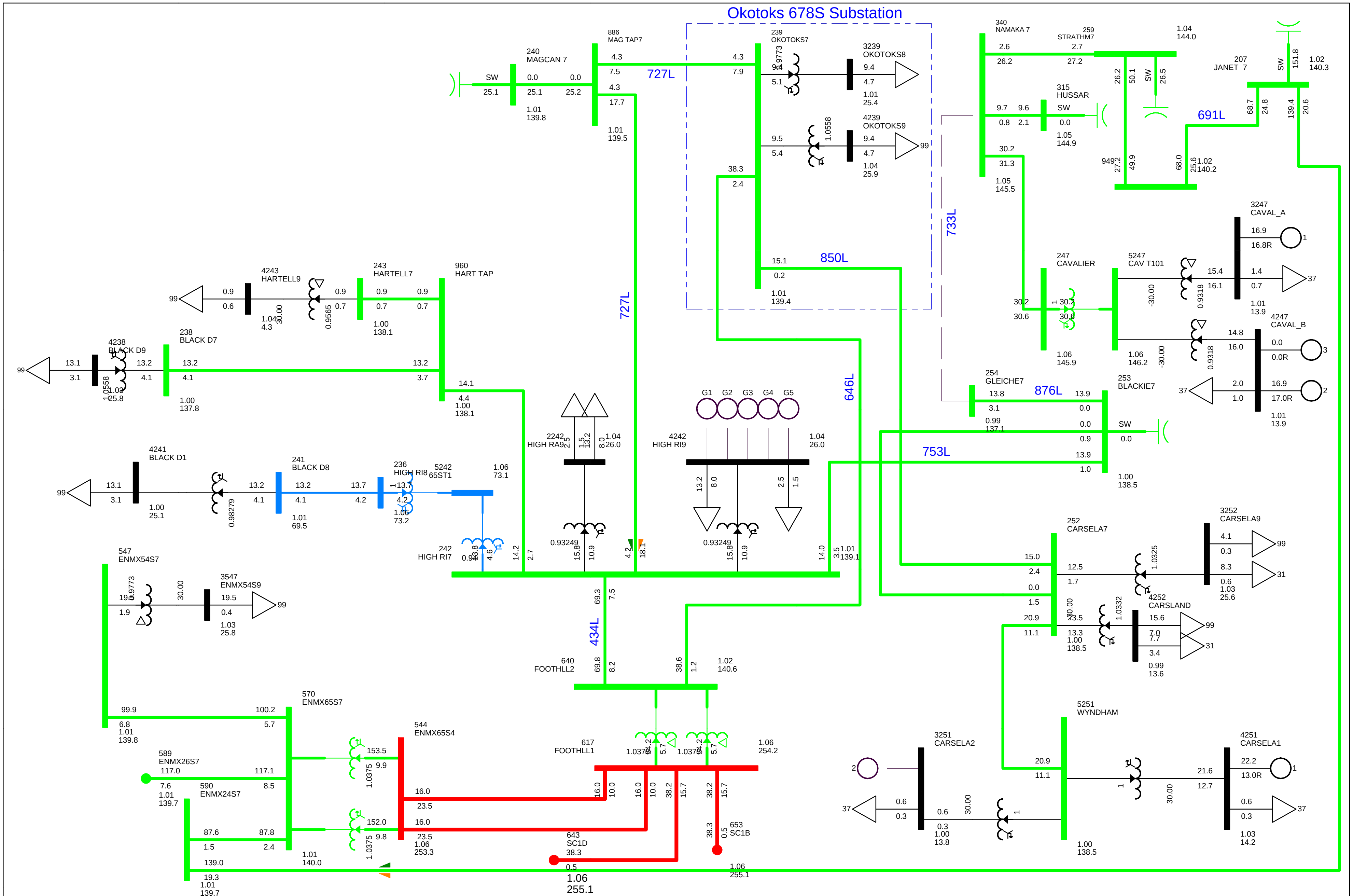
Okotoks 678S and

High River 65S Upgrades

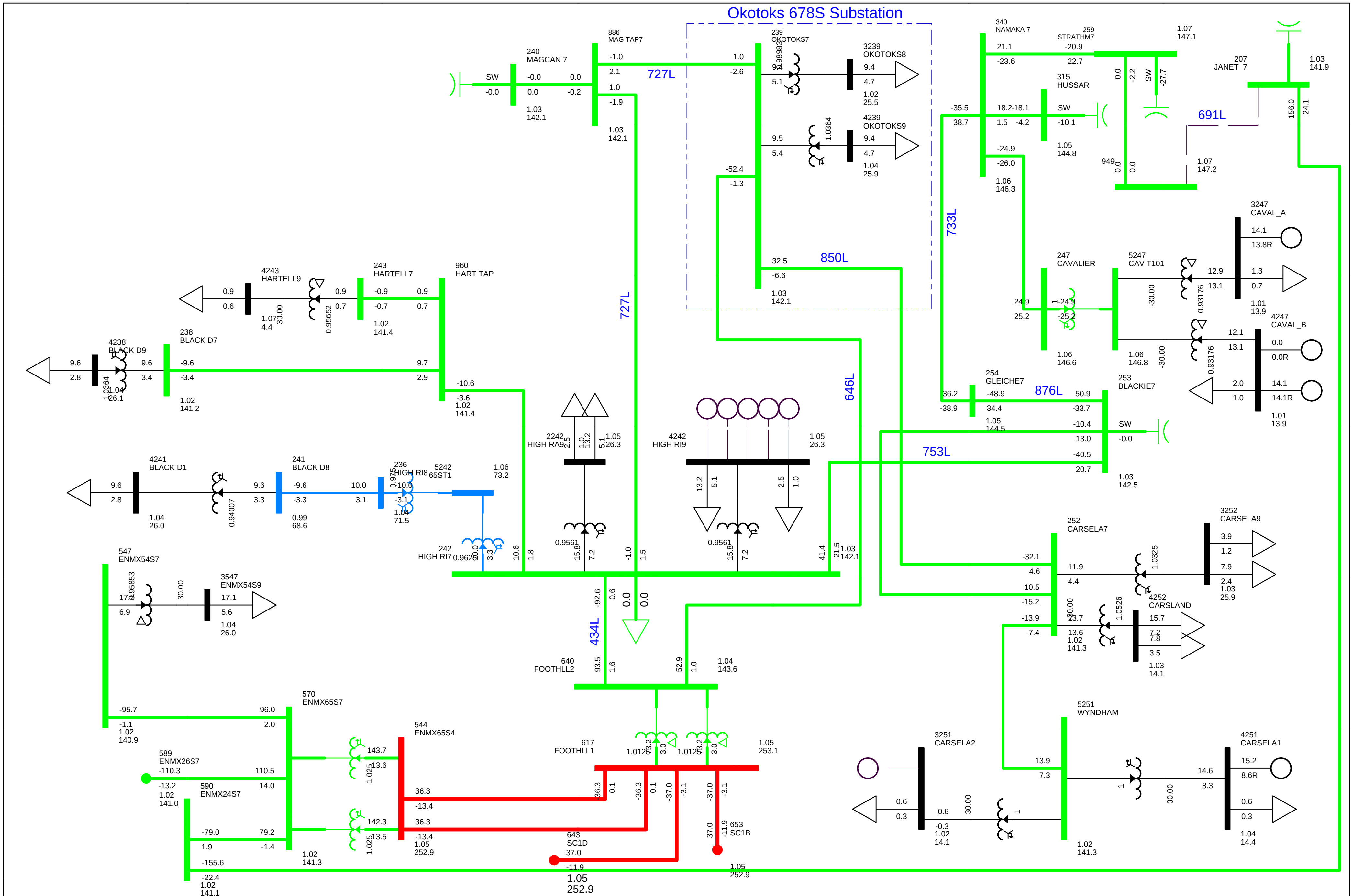
2017 WP

P1670 PRE-CONNECTION - DIAGRAM A-17
N-1: 876L BLACKIE 253S TO GLEICHEN 179S
THU, MAY 26 2016 12:46

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 PRE-CONNECTION - DIAGRAM A-18 N-1: 733L NAMAKA 428S TO GLEICHEN 179S THU, MAY 26 2016 12:46	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.899UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and

High River 65S Upgrades

2017 SP

P1670 PRE-CONNECTION - DIAGRAM A-19
N-1: 691L JANET 74S TO CHESTERMERE 419S
MON, MAY 30 2016 10:53

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment B

Post-Project Power Flow Diagrams (Scenarios 3 to 4)

Table 1: Summary of System Performance without Applying Mitigation (Element Loading) - 2017 SP Post-Project Category B

Contingency	Thermal Overloads	Overload %	Figure in Attachment B
N-G: Normal Operation	None	--	B-1
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	122	B-2
434L High River 65S to Foothills 237S	691L Janet 74S – Chestermere 419S	116	B-3
646L Okotoks 678S to Foothills 237S	691L Janet 74S – Chestermere 419S	101	B-4
753L High River 65S to Blackie 253S	691L Janet 74S – Chestermere 419S	101	B-5
PCES01L Namaka 428S to Cavalier Power Plant	691L Janet 74S – Chestermere 419S	113	B-6
Cavalier transformer	691L Janet 74S – Chestermere 419S	113	B-7
876L Blackie 253S to Gleichen 179S	691L Janet 74S – Chestermere 419S	111	B-8
733L Namaka 428S to Gleichen 179S	None	-	B-9

Table 2: Summary of System Performance without Applying Mitigation (Element Loading) - 2017 WP Post-Project Category B

Contingency	Thermal Overloads	Overload %	Figure in Attachment B
N-G: Normal Operation	None	--	B-10
691L Janet 74S to Chestermere 419S	876L Blackie 253S – Gleichen 179S	111	B-11
434L High River 65S to Foothills 237S	691L Janet 74S – Chestermere 419S	105	B-12
646L Okotoks 678S to Foothills 237S	None	--	B-13
753L High River 65S to Blackie 253S	None	--	B-14

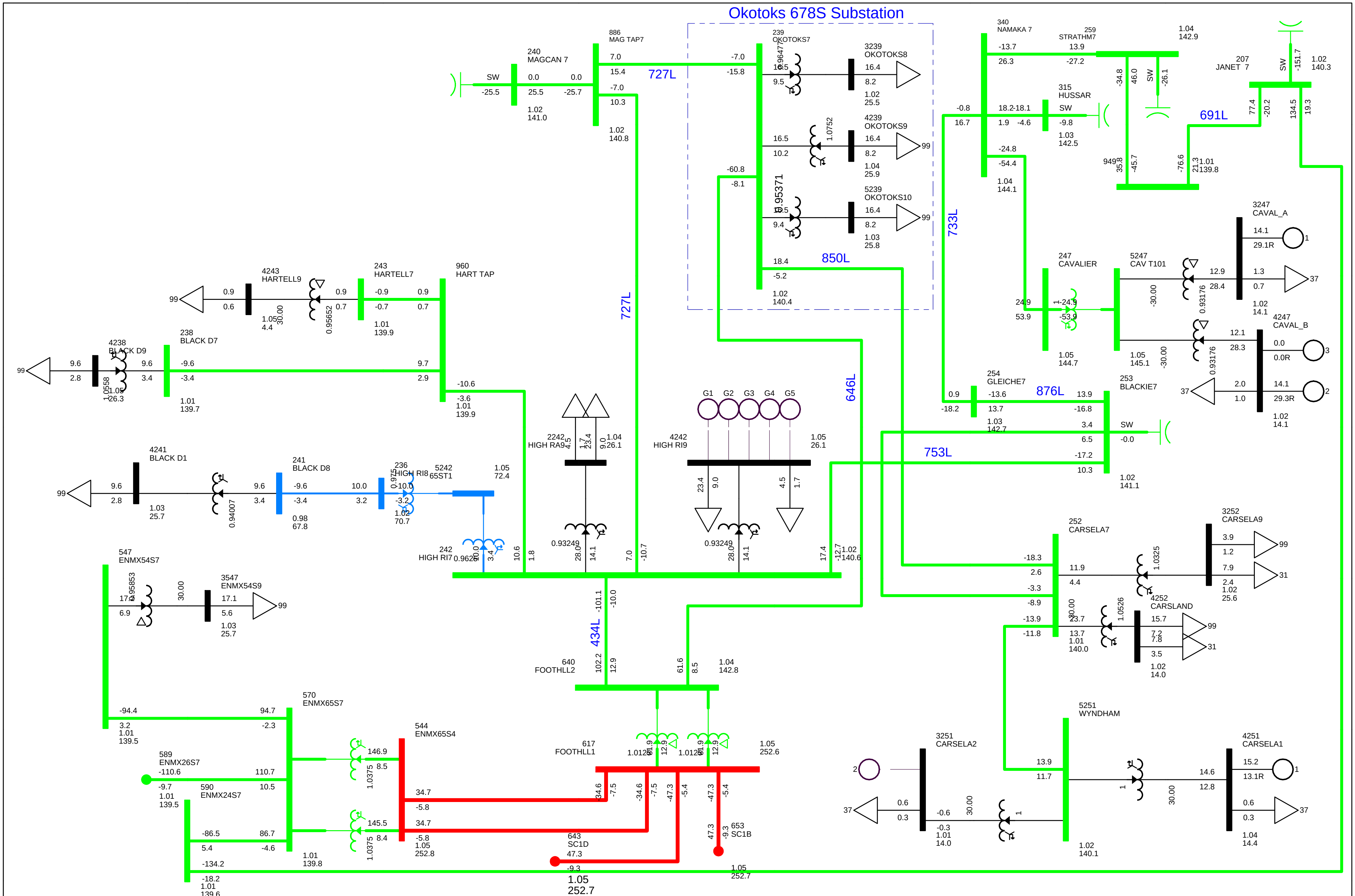
PCES01L Namaka 428S to Cavalier Power Plant	691L Janet 74S – Chestermere 419S	103	B-15
Cavalier 138/13.8 kV transformer	691L Janet 74S – Chestermere 419S	103	B-16
876L Blackie 253S to Gleichen 179S	None	--	B-17
733L Namaka 428S to Gleichen 179S	None	--	B-18

Table 3: Summary of System Performance with Mitigation (Element Loading) - 2017 SP Post-Project Category B

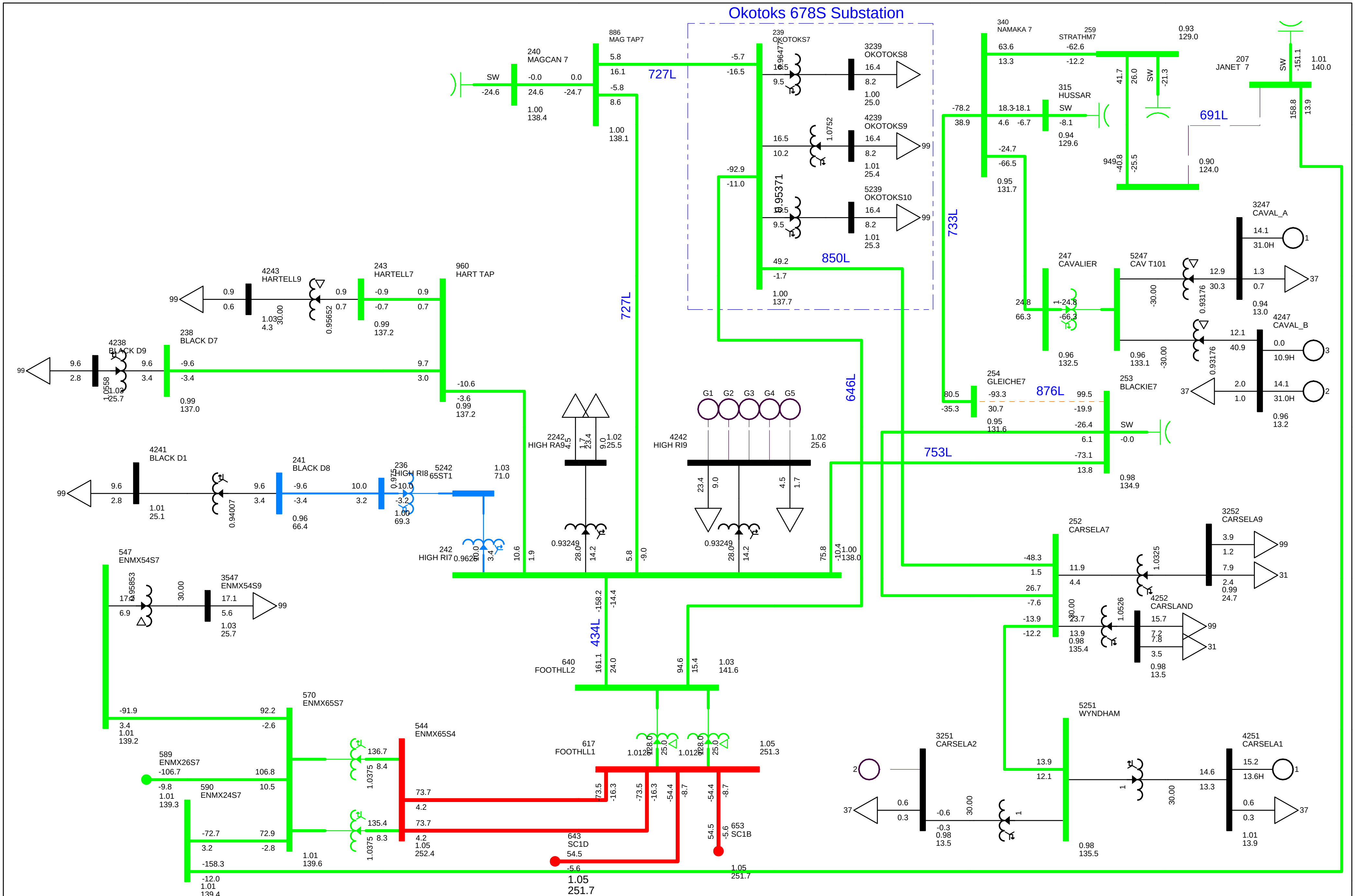
Contingency	Thermal Overloads	Overload %	Mitigation Approach	Post Mitigation Performance % Loading	Figure in Attachment B
691L Janet 74S – Chestermere 419S	876L Blackie 253S – Gleichen 179S	122	Project 1631 SPS	73	B-19
434L Foothills 237S - High River 65S	691L Janet 74S – Chestermere 419S	116	Project 1631 SPS	84	B-20
PCES01L Namaka 428S – Cavalier Power Plant	691L Janet 74S – Chestermere 419S	113	Project 1631 SPS	66	B-21
Cavalier 138/13.8 kV transformer	691L Janet 74S – Chestermere 419S	113	Project 1631 SPS	66	B-22
876L Blackie 253S – Gleichen 179S	691L Janet 74S – Chestermere 419S	111	Project 1631 SPS	80	B-23
646L Foothills 237S – Okotoks 678S	691L Janet 74S – Chestermere 419S	101	Real-time operational practice	N/A	N/A
753L High River 65S – Blackie 253S	691L Janet 74S – Chestermere 419S	101	Real-time operational practice	N/A	N/A

Table 4: Summary of System Performance with Mitigation (Element Loading) - 2017 WP Post-Project Category B

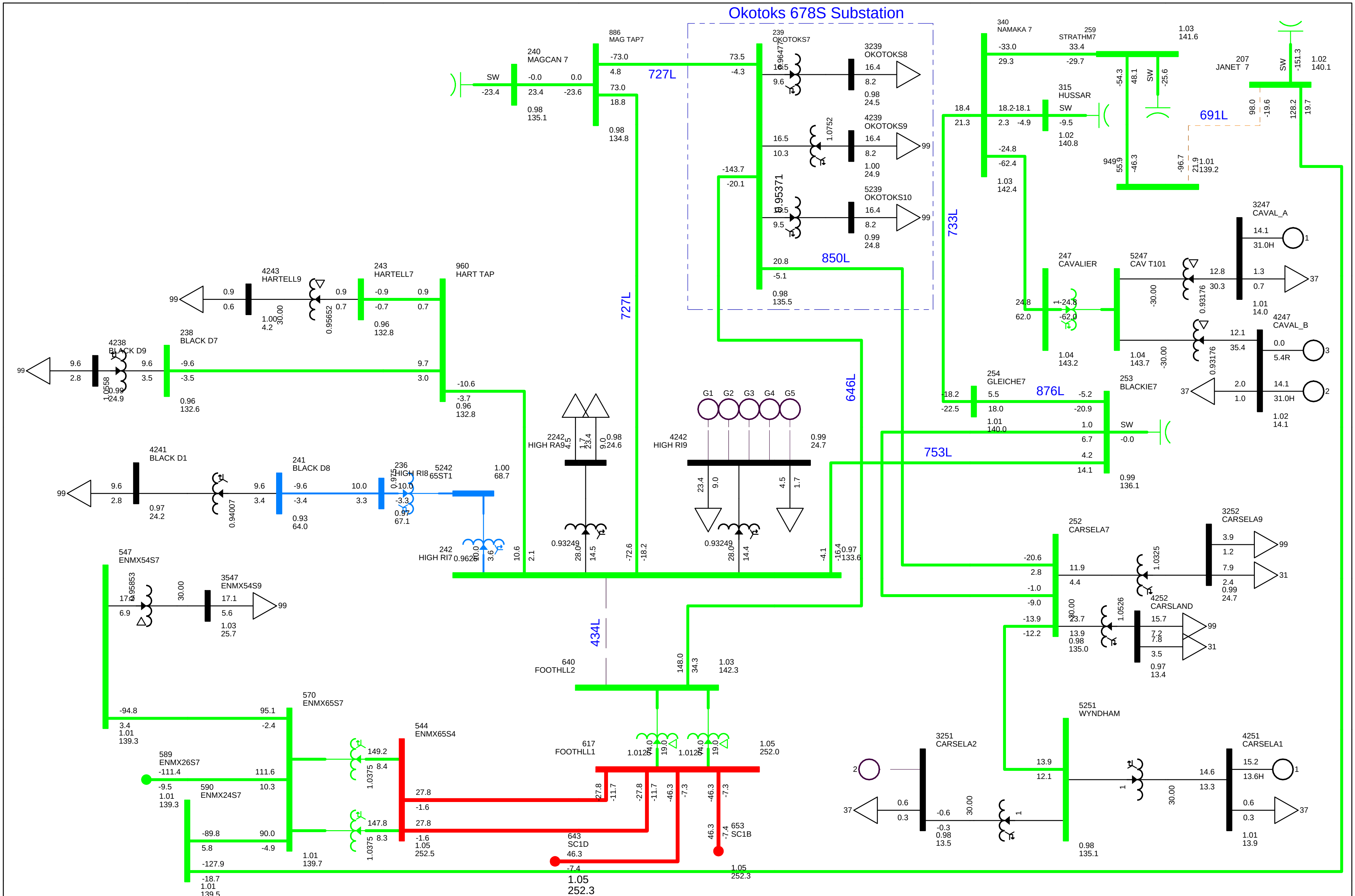
Contingency	Thermal Overloads	Overload %	Mitigation Approach	Post Mitigation Performance % Loading	Figure in Attachment B
691L Janet 74S – Chestermere 419S	876L Blackie 253S – Gleichen 179S	111	Project 1631 SPS	64	B-24
434L Foothills 237S - High River 65S	691L Janet 74S – Chestermere 419S	105	Real-time operational practice	N/A	N/A
Namaka 428S – Cavalier Power Plant	691L Janet 74S – Chestermere 419S	103	Real-time operational practice	N/A	N/A
Cavalier 138/13.8 kV transformer	691L Janet 74S – Chestermere 419S	103	Real-time operational practice	N/A	N/A



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-1 N-0: NORMAL OPERATION THU, MAY 26 2016 13:44	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-2 N-1: 691L JANET 74S TO CHESTERMERE 419S THU, MAY 26 2016 13:44	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



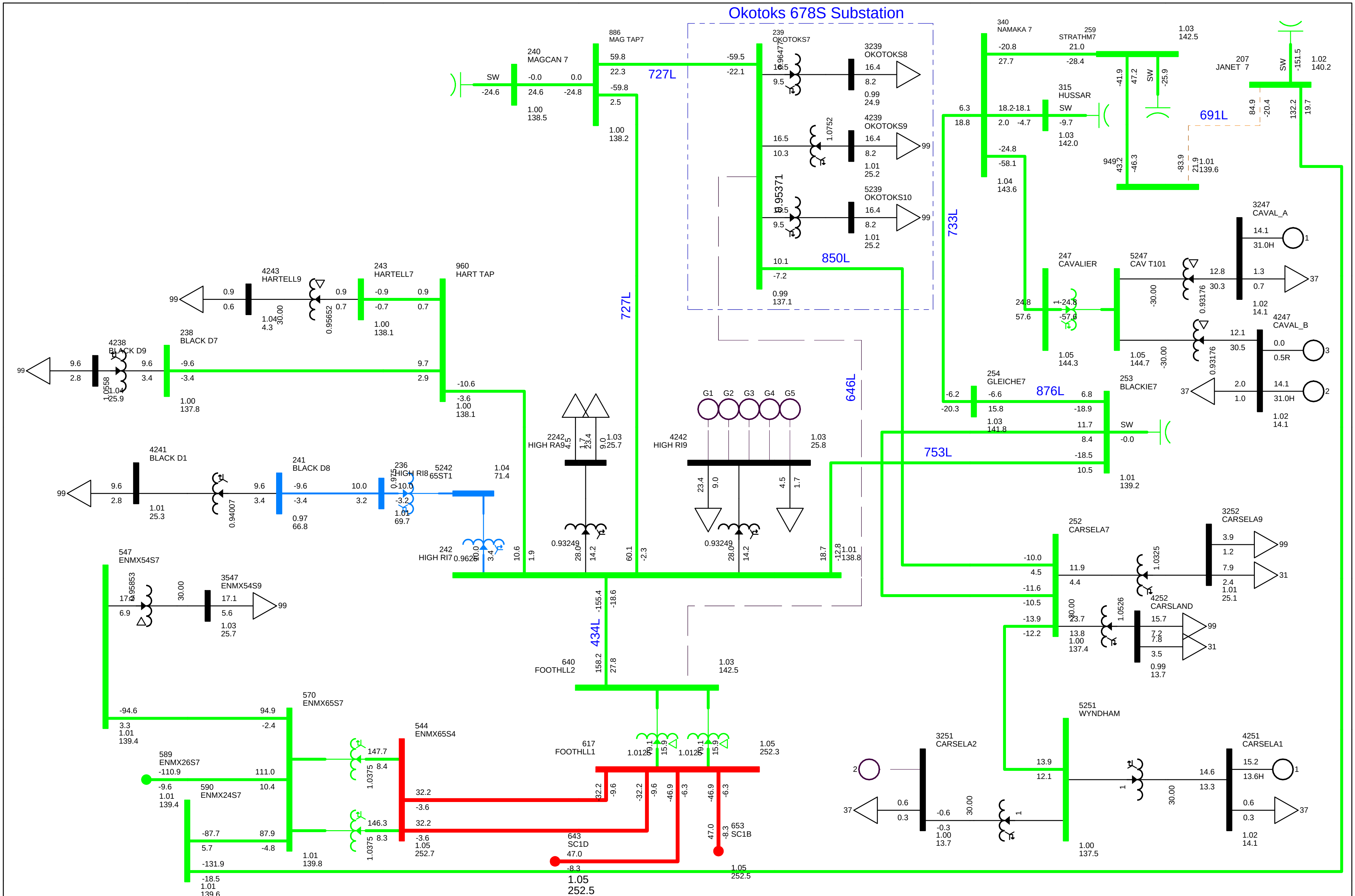
Okotoks 678S and

High River 65S Upgrades

2017 SP

P1670 POST-CONNECTION - DIAGRAM B-3
N-1: 434L HIGH RIVER 65S TO FOOTHILLS 237S
THU, MAY 26 2016 13:45

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



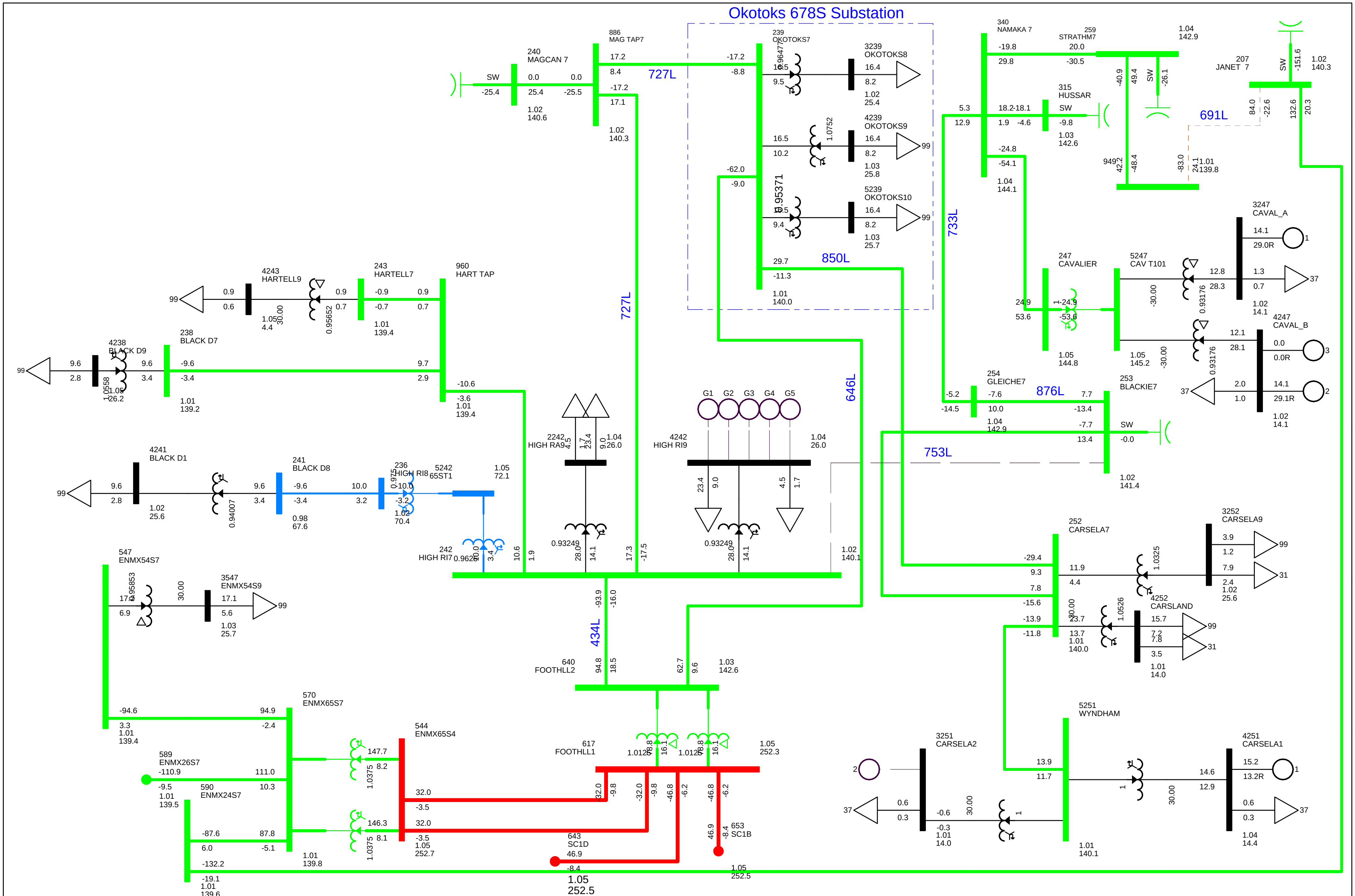
Okotoks 678S and

High River 65S Upgrades

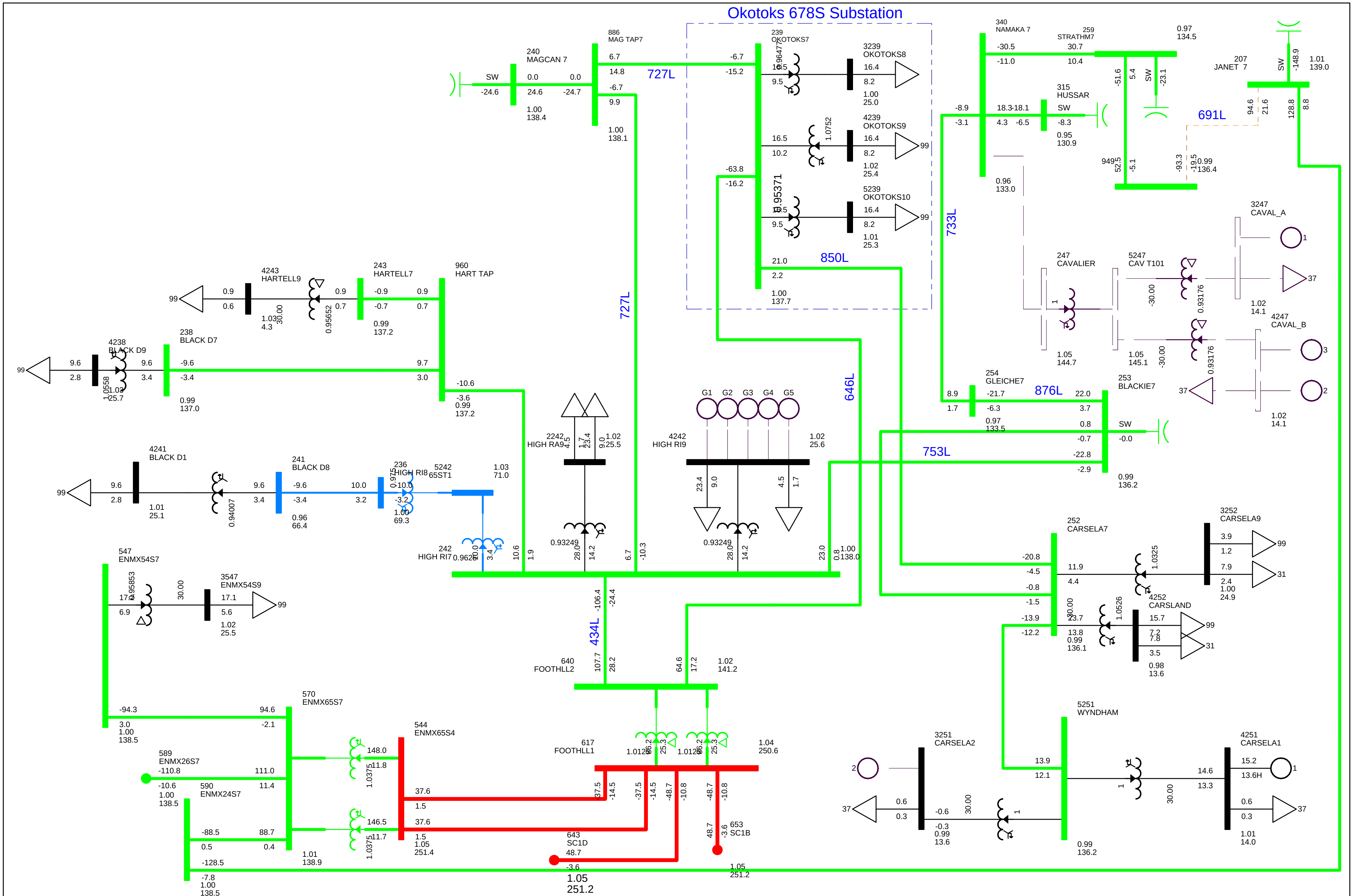
2017 SP

P1670 POST-CONNECTION - DIAGRAM B-4
N-1: 646L OKOTOKS 678S TO FOOTHILLS 237S
THU, MAY 26 2016 13:45

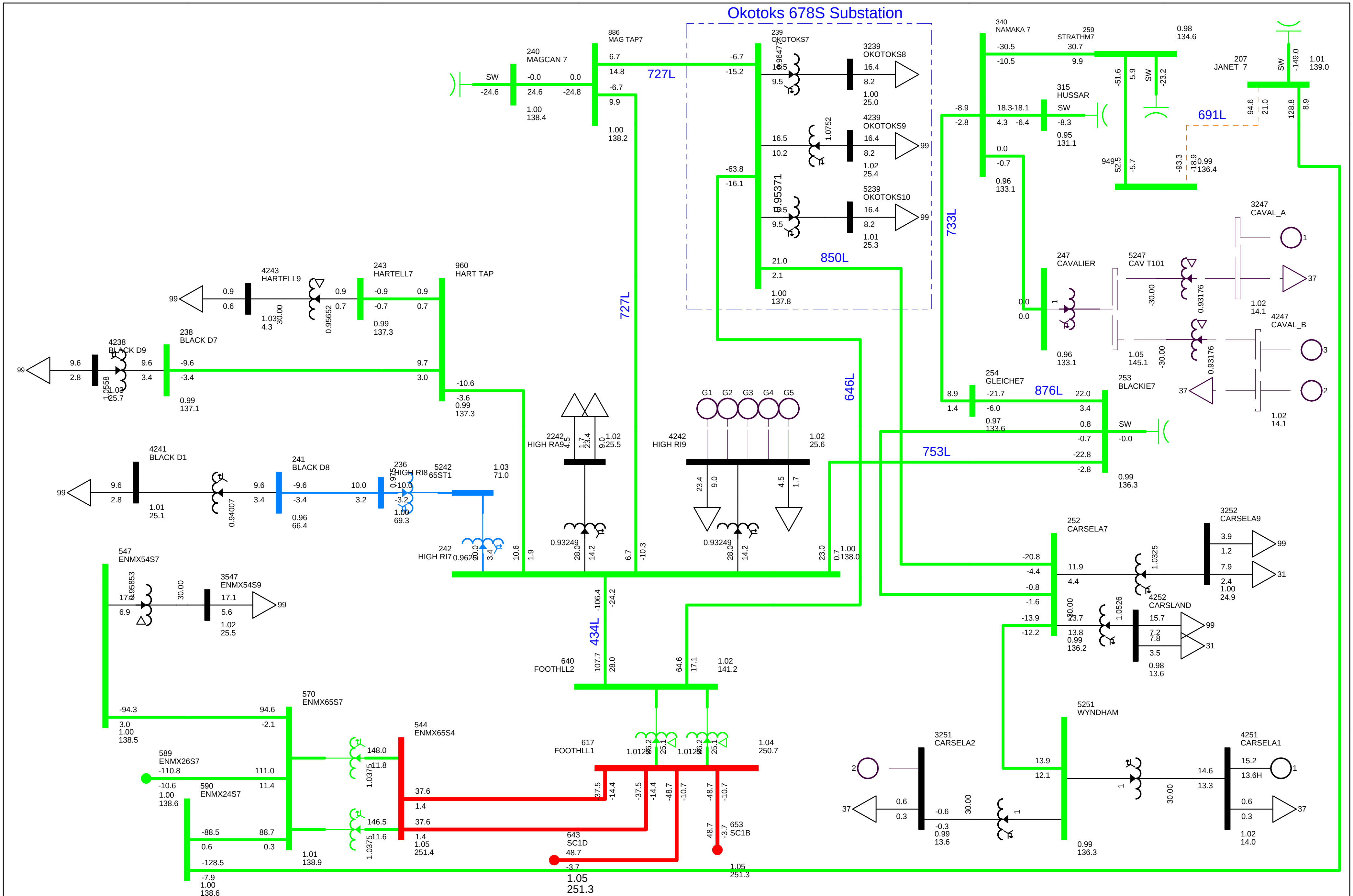
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-5 N-1: 753L HIGH RIVER 65S TO BLACKIE 253S THU, MAY 26 2016 13:45	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-6 N-1: PCES01L NAMAKA 428S TO CAVALIER POWER PLANT THU, MAY 26 2016 13:45	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



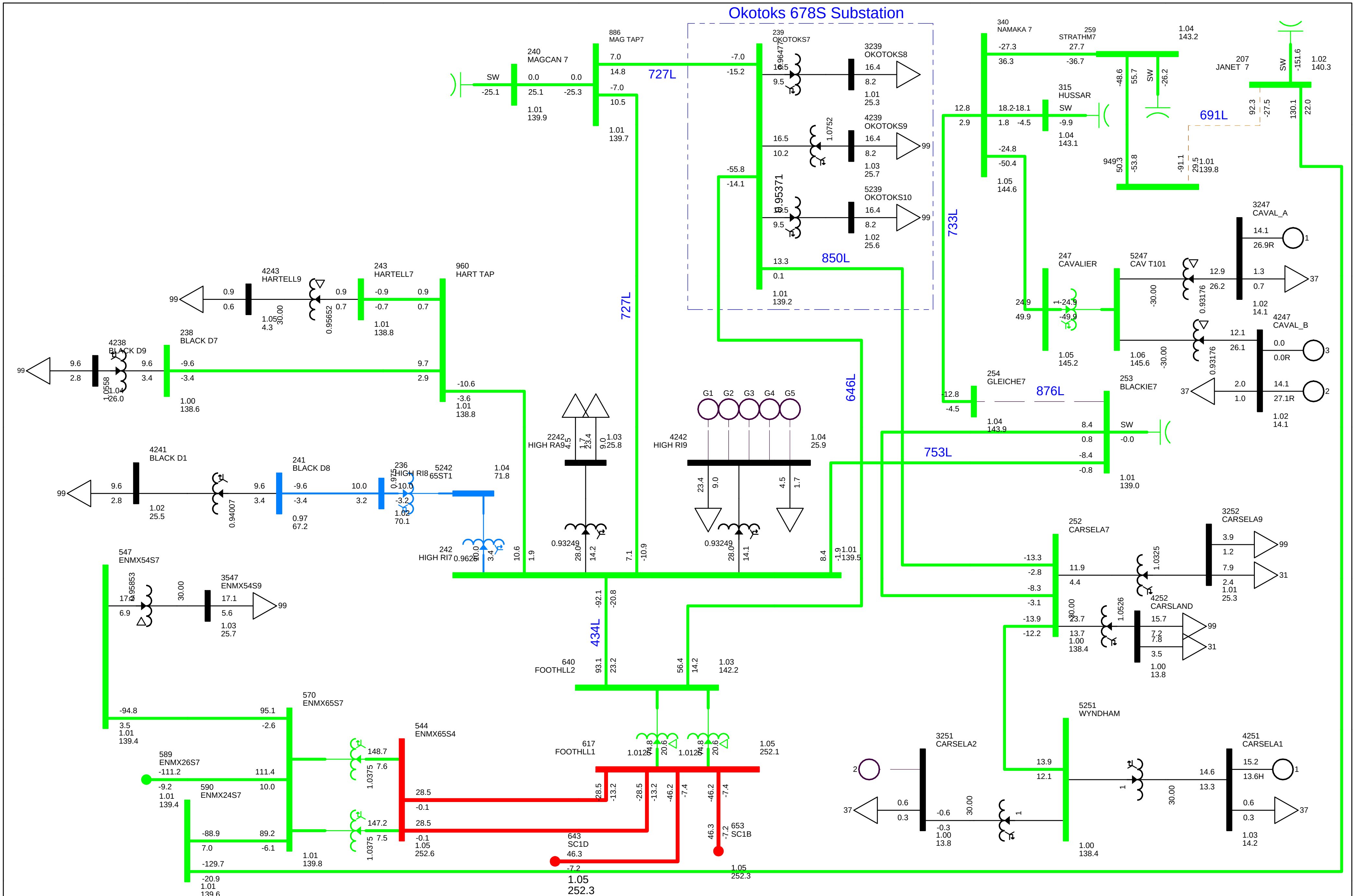
Okotoks 678S and

High River 65S Upgrades

2017 SP

P1670 POST-CONNECTION - DIAGRAM B-7
N-1: CAVALIER TRANSFORMER
THU, MAY 26 2016 13:46

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and

High River 65S Upgrades

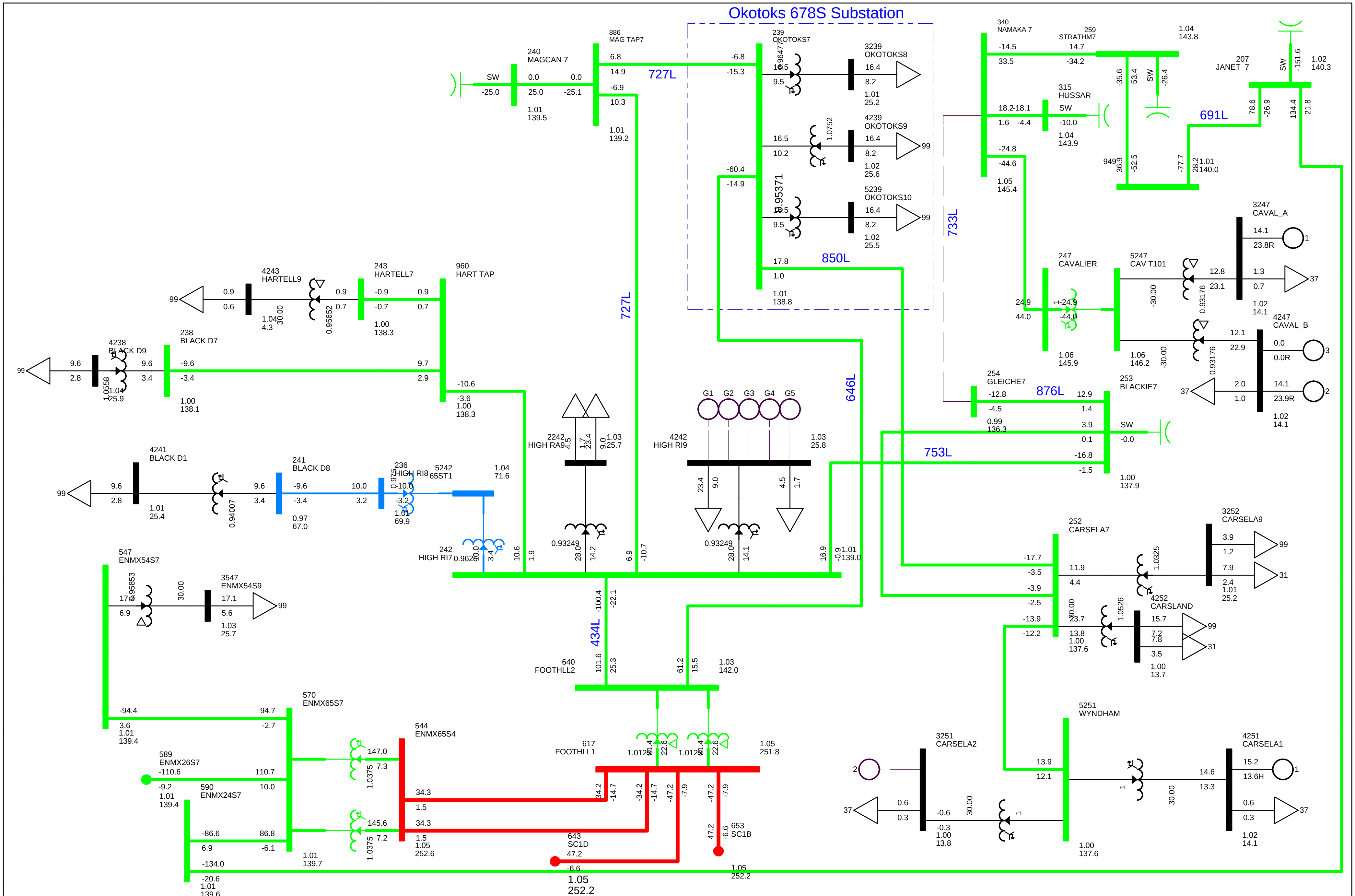
2017 SP

P1670 POST-CONNECTION - DIAGRAM B-8

N-1: 876L BLACKIE 253S TO GLEICHEN 179S

THU, MAY 26 2016 13:46

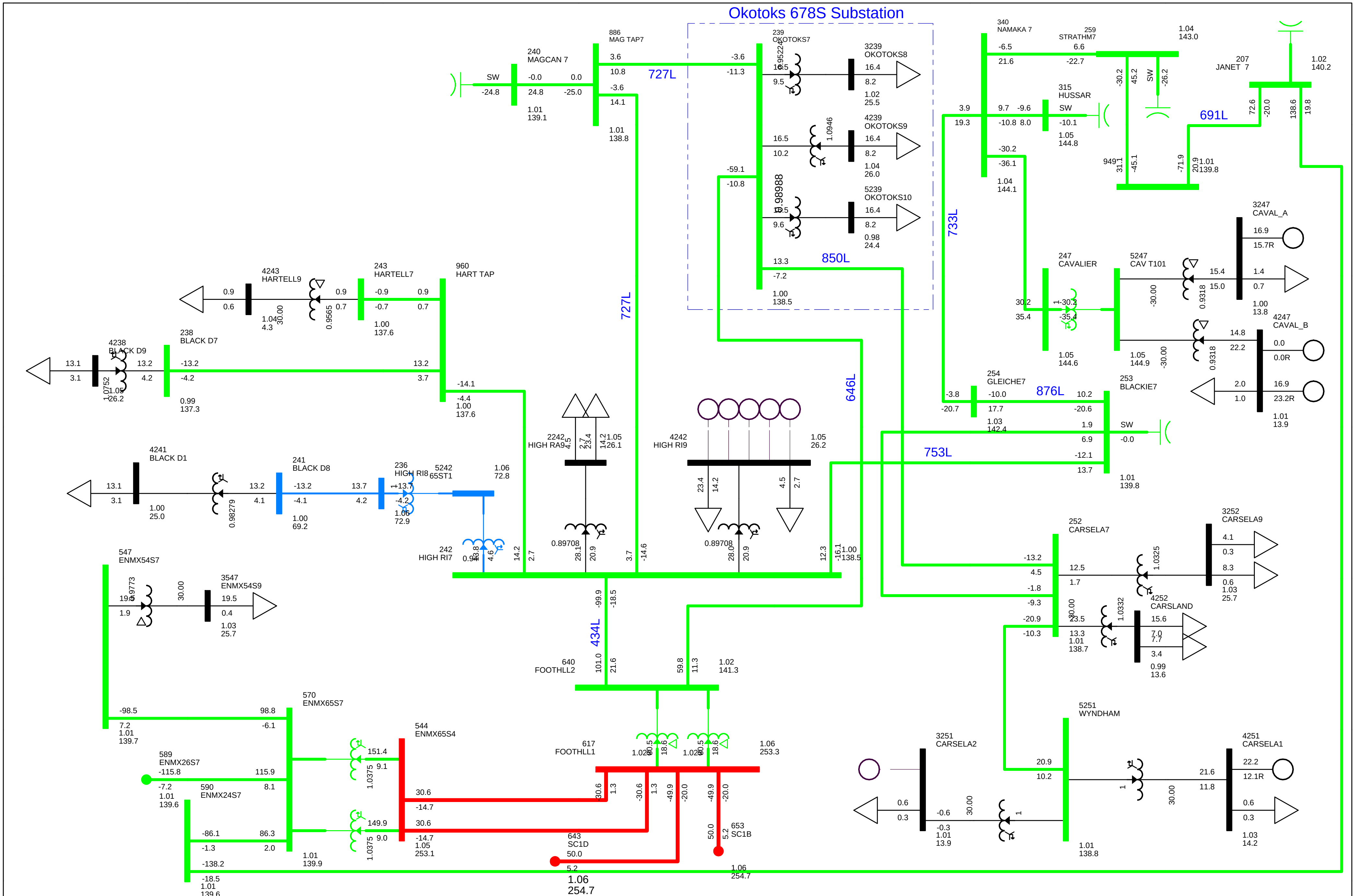
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and
High River 65S Upgrades
2017 SP

P1670 POST-CONNECTION - DIAGRAM B-9
N-1: 733L NAMAKA 428S TO GLEICHEN 179S
THU, MAY 26 2016 13:46

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



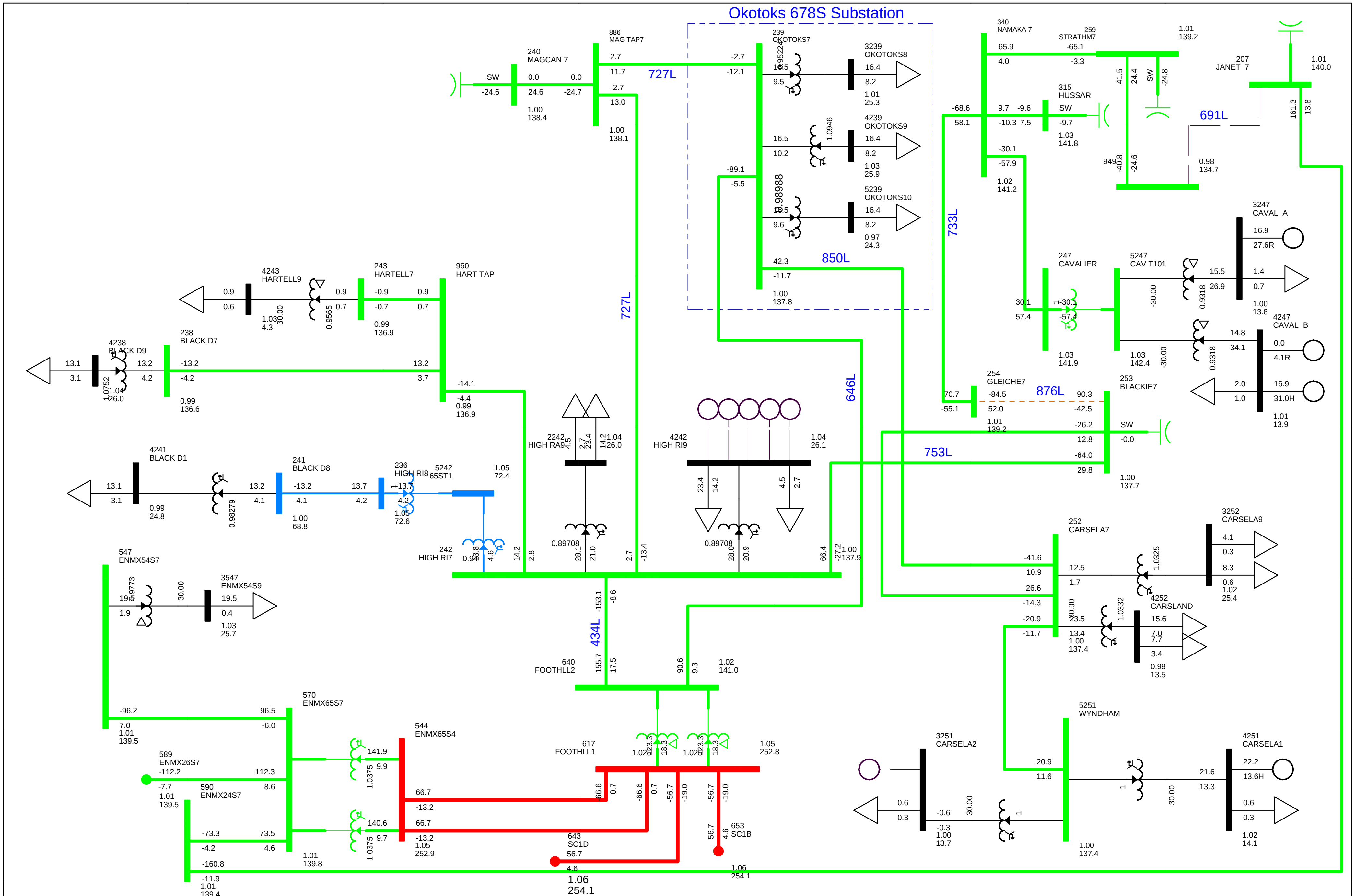
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-10
N-0: NORMAL OPERATION
THU, MAY 26 2016 14:20

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



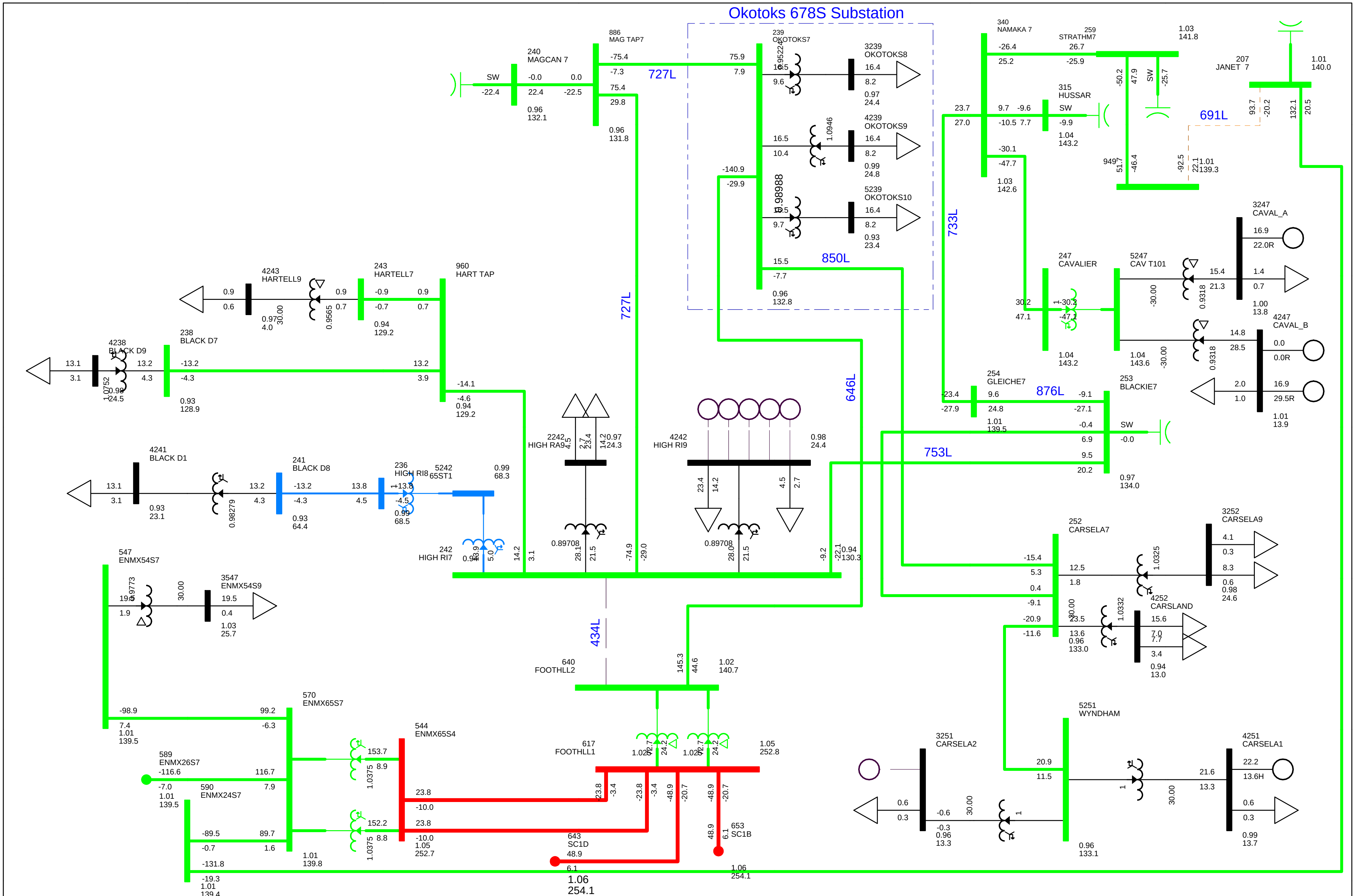
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-11
N-1: 691L JANET 74S TO CHESTERMERE 419S
THU, MAY 26 2016 14:21

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



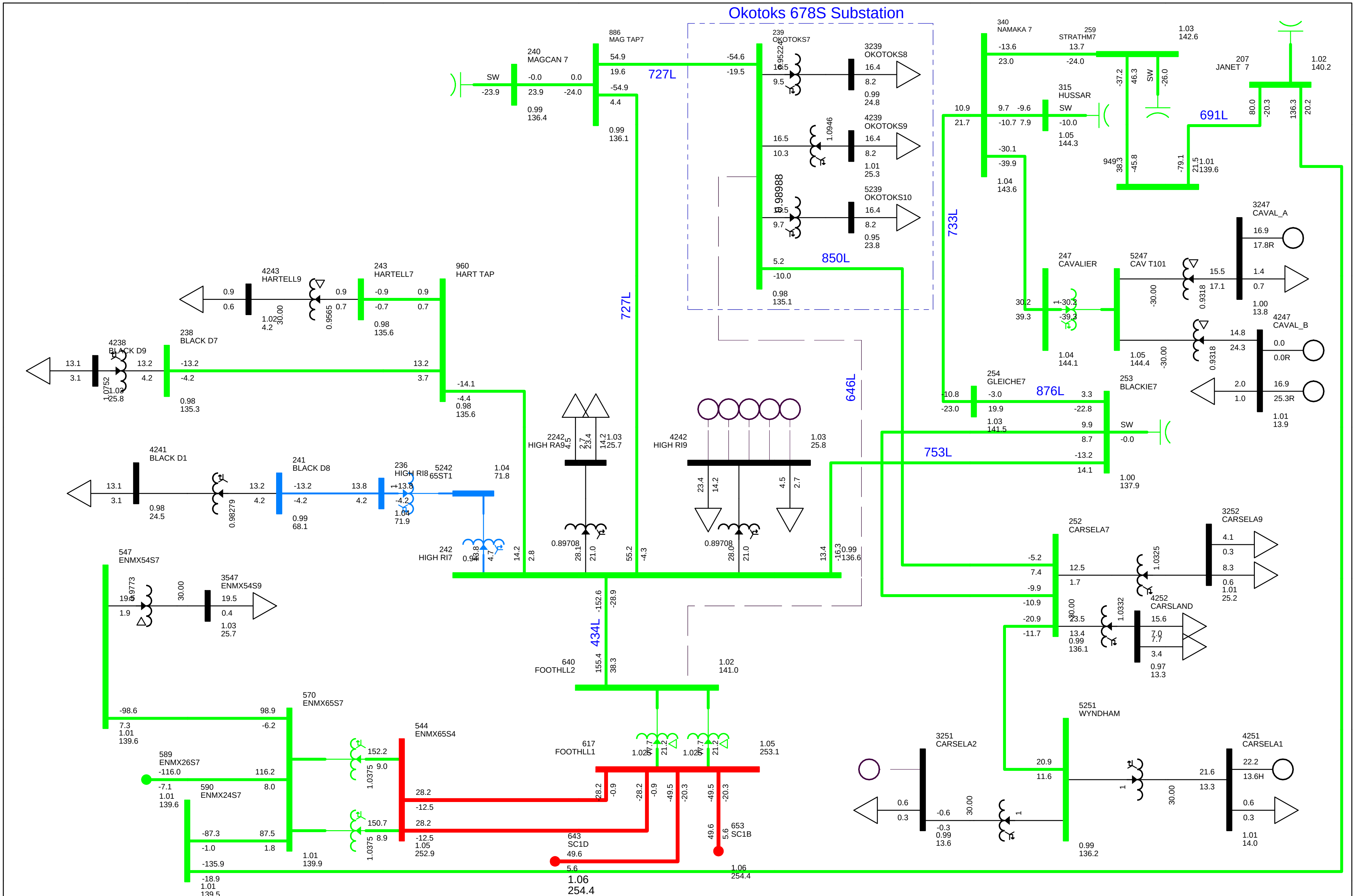
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-12
N-1: 434L HIGH RIVER 65S TO FOOTHILLS 237S
THU, MAY 26 2016 14:21

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



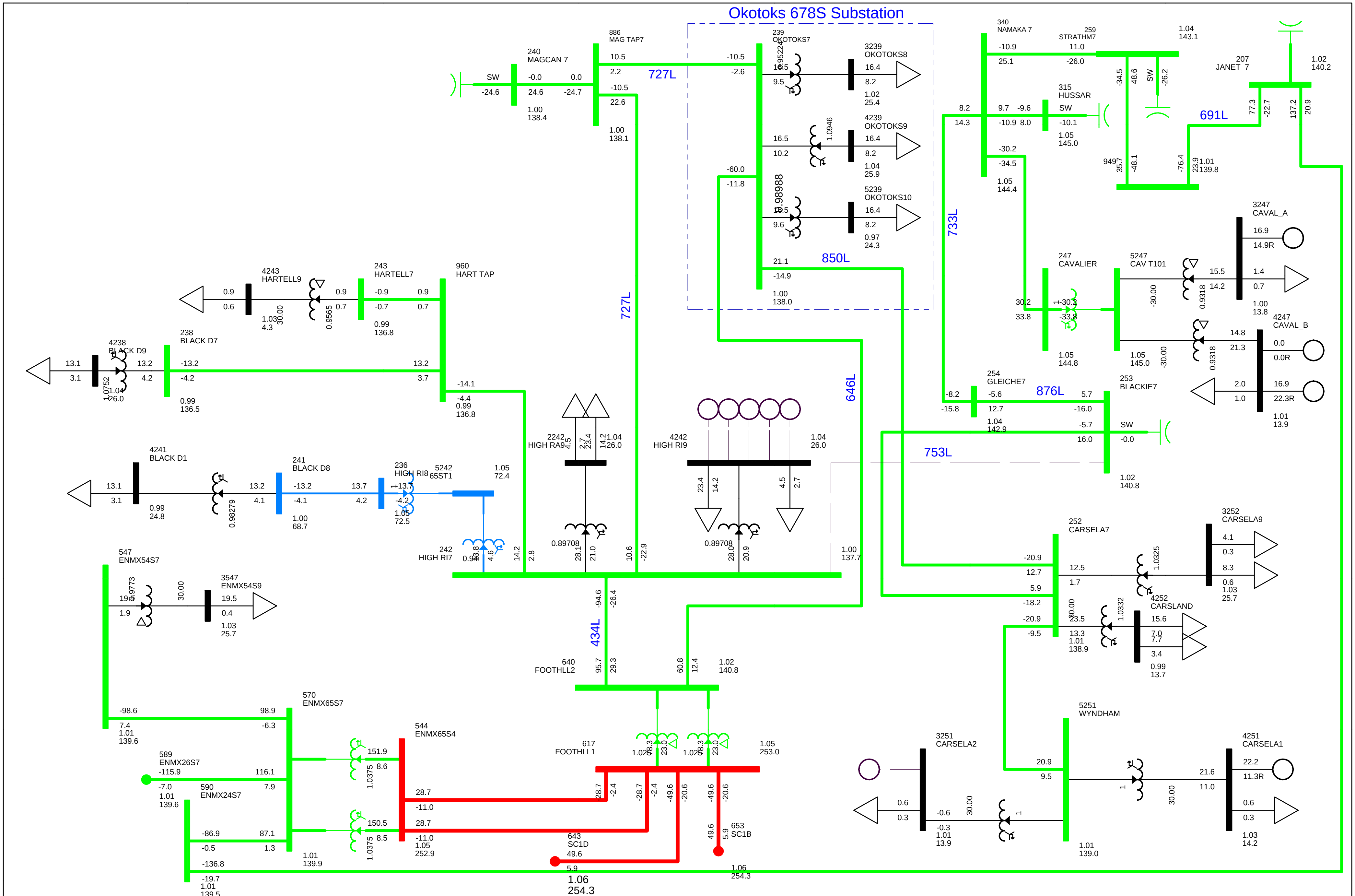
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-13
N-1: 646L OKOTOKS 678S TO FOOTHILLS 237S
THU, MAY 26 2016 14:21

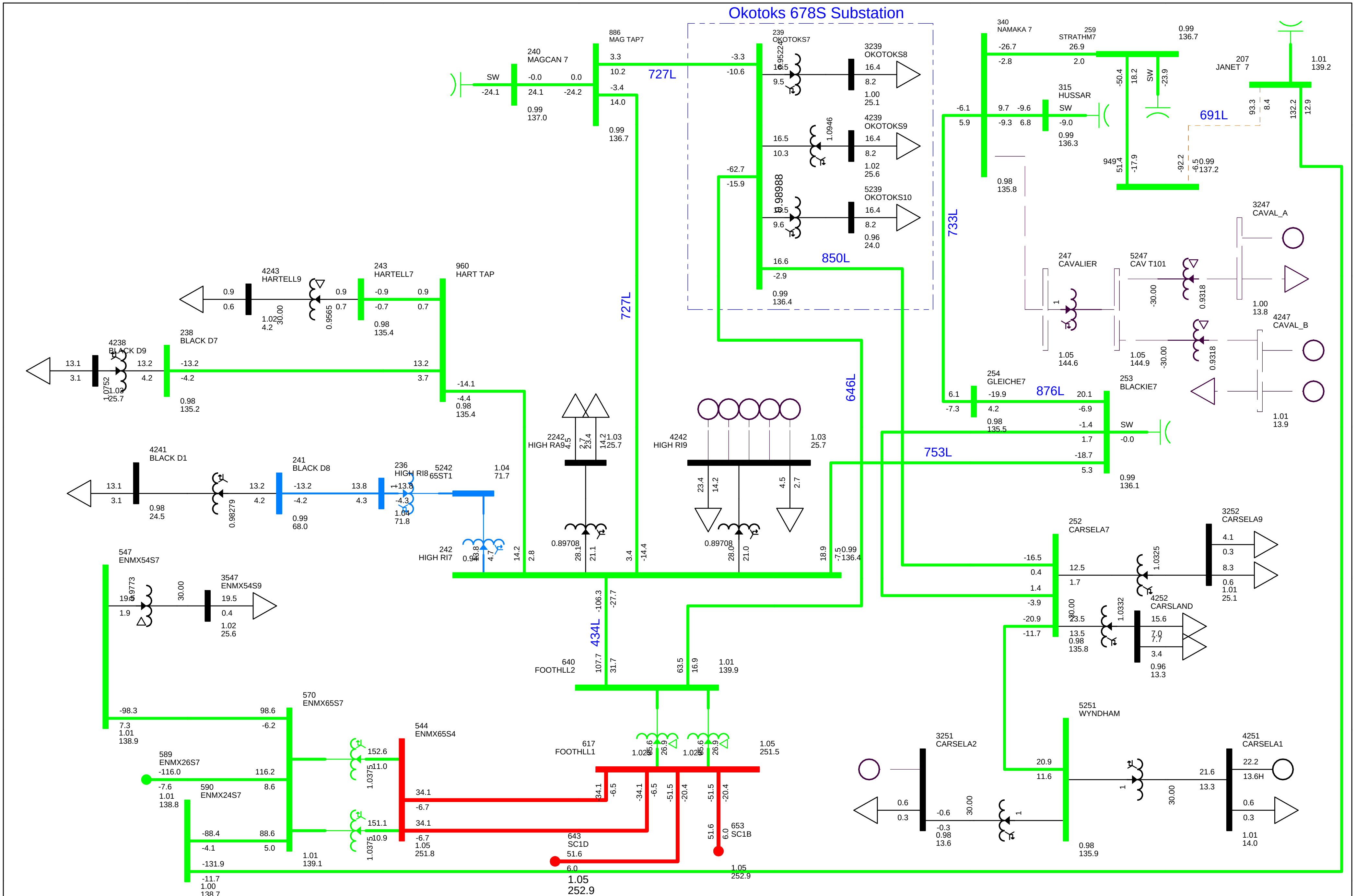
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



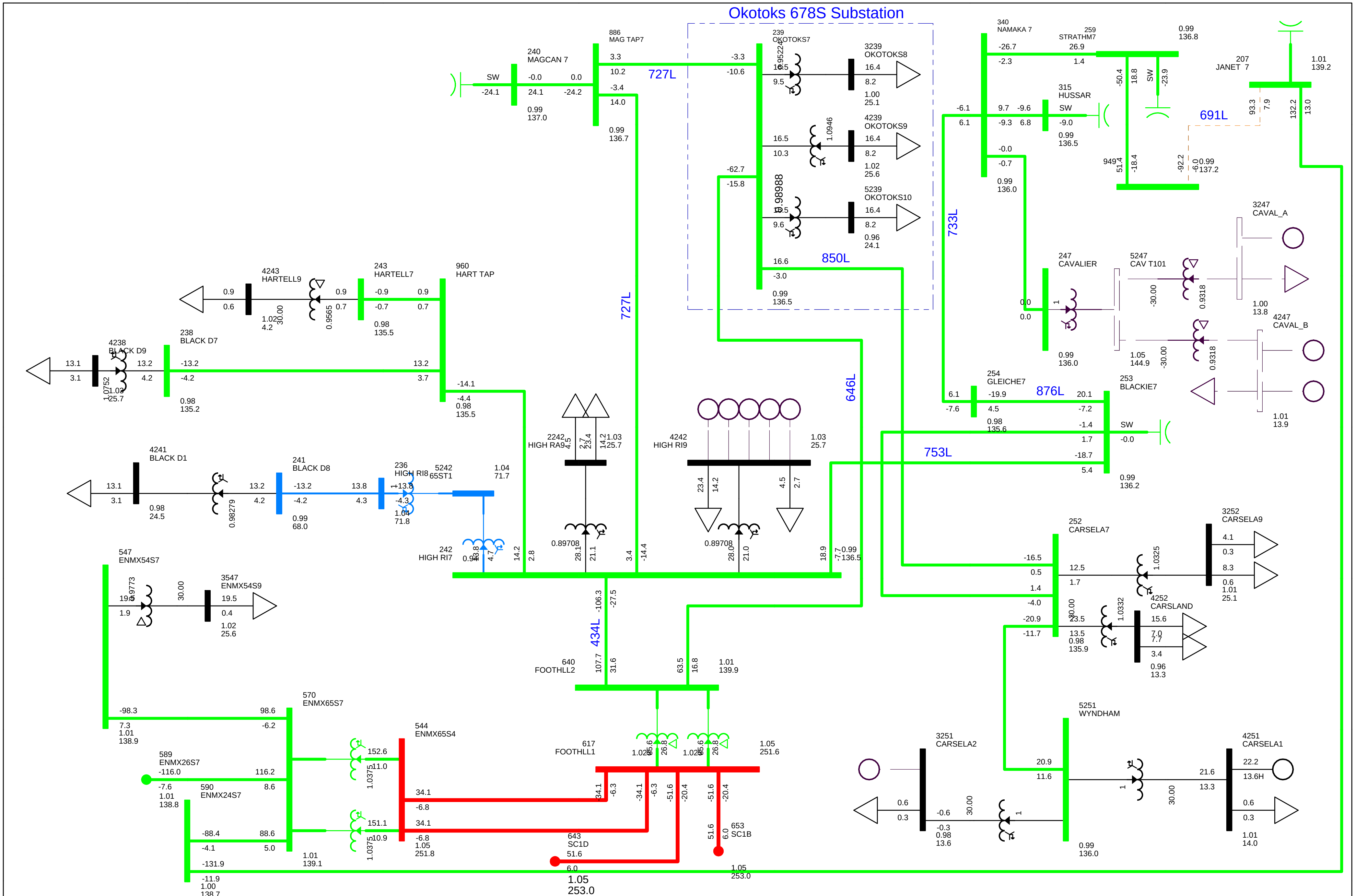
Okotoks 678S and
High River 65S Upgrades
2017 WP

P1670 POST-CONNECTION - DIAGRAM B-14
N-1: 753L HIGH RIVER 65S TO BLACKIE 253S
THU, MAY 26 2016 14:21

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



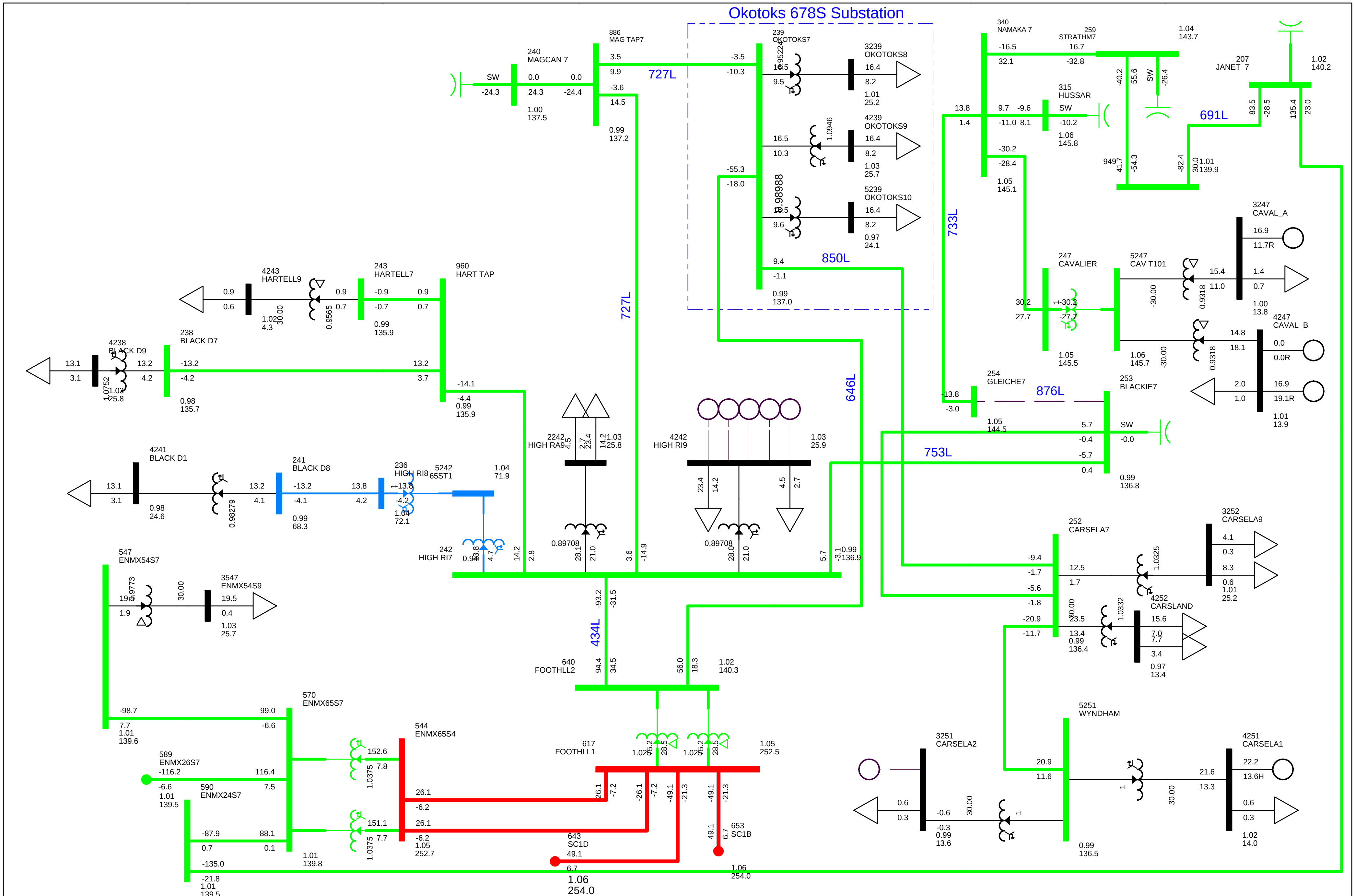
Okotoks 678S and High River 65S Upgrades 2017 WP	P1670 POST-CONNECTION - DIAGRAM B-15 N-1: PCES01L NAMAKA 428S TO CAVALIER POWER PLANT THU, MAY 26 2016 14:21	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 WP

P1670 POST-CONNECTION - DIAGRAM B-16
N-1: CAVALIER TRANSFORMER
THU, MAY 26 2016 14:21

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



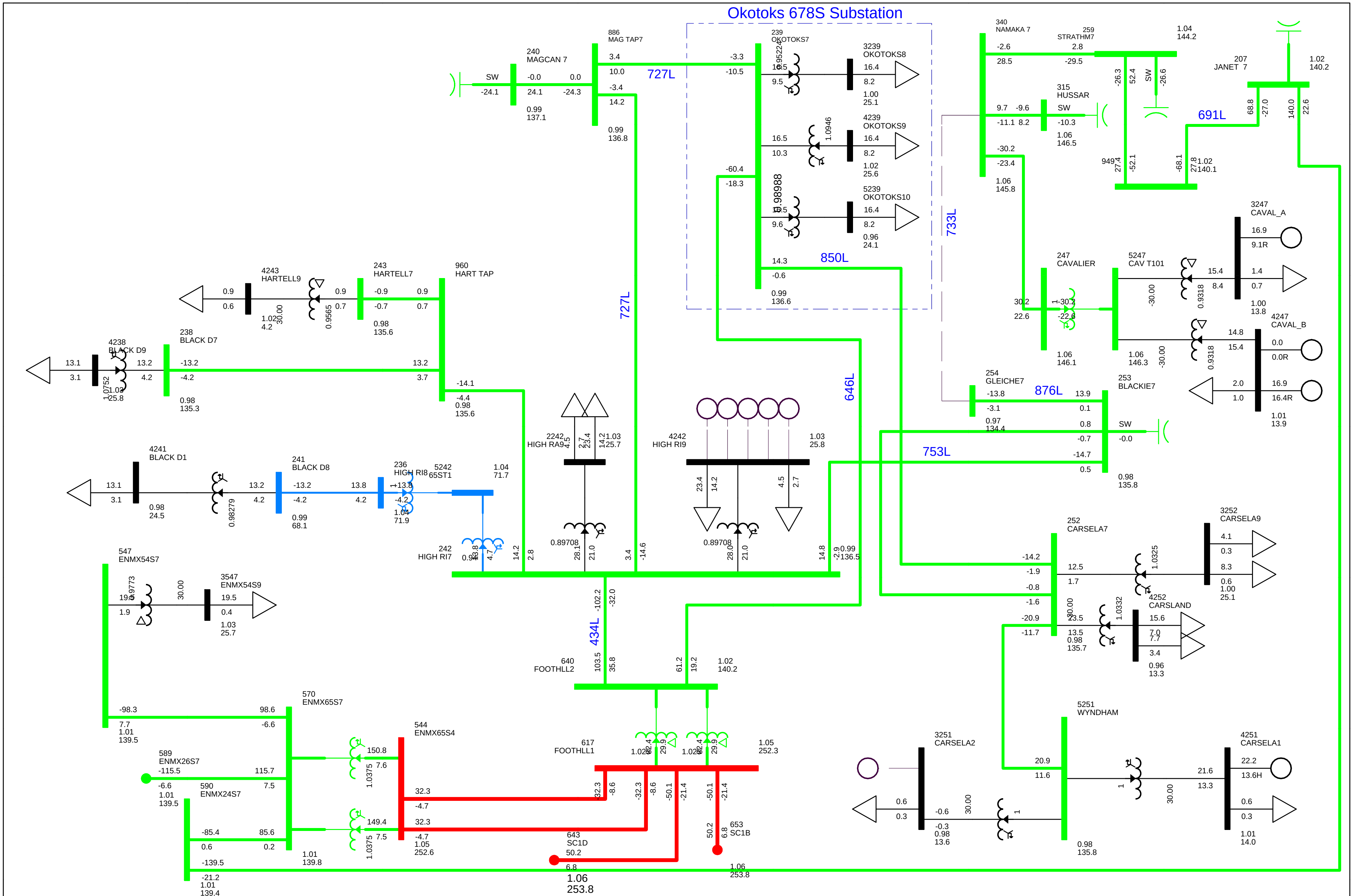
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-17
N-1: 876L BLACKIE 253S TO GLEICHEN 179S
THU, MAY 26 2016 14:21

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



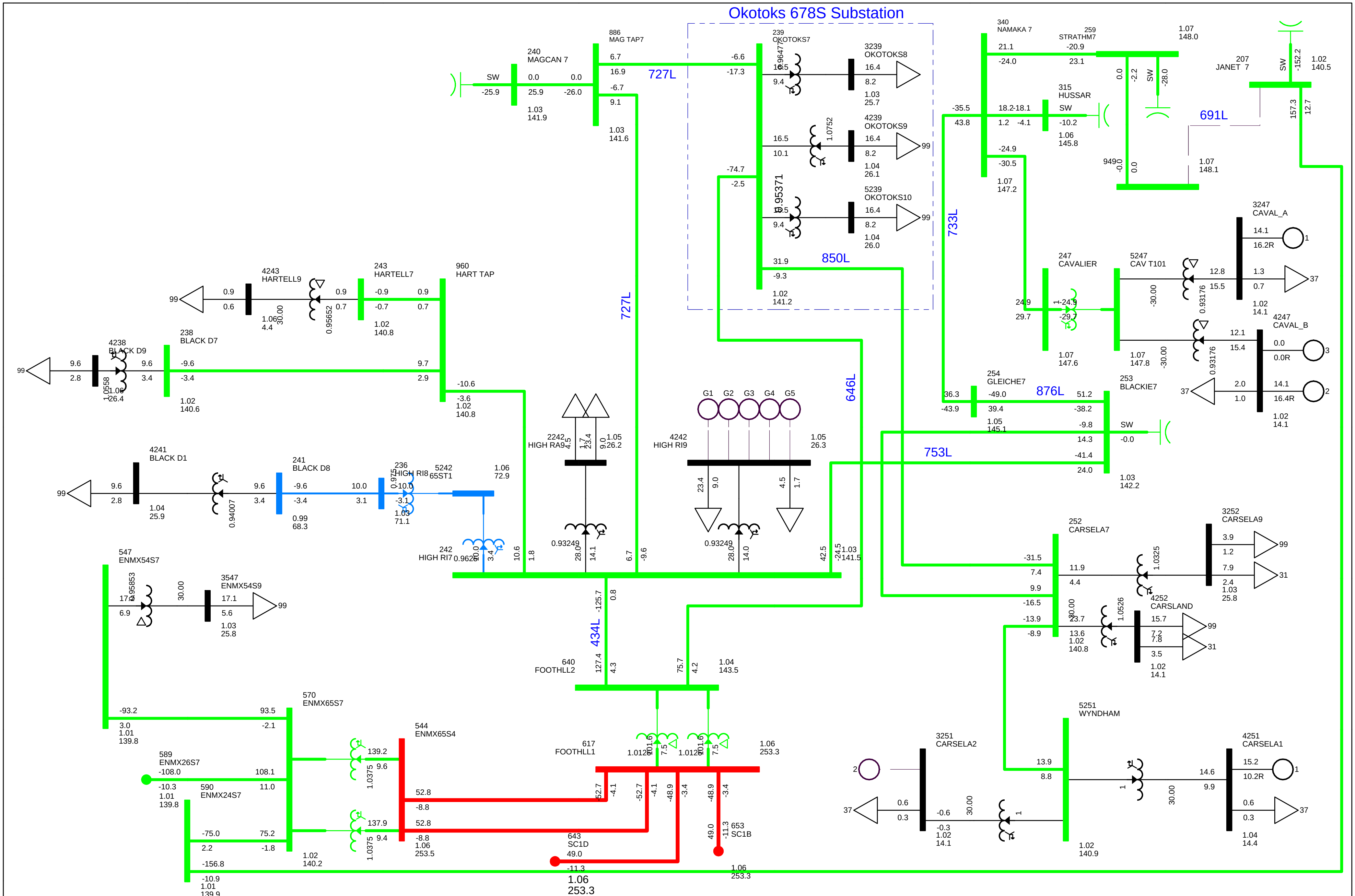
Okotoks 678S and

High River 65S Upgrades

2017 WP

P1670 POST-CONNECTION - DIAGRAM B-18
N-1: 733L NAMAKA 428S TO GLEICHEN 179S
THU, MAY 26 2016 14:23

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



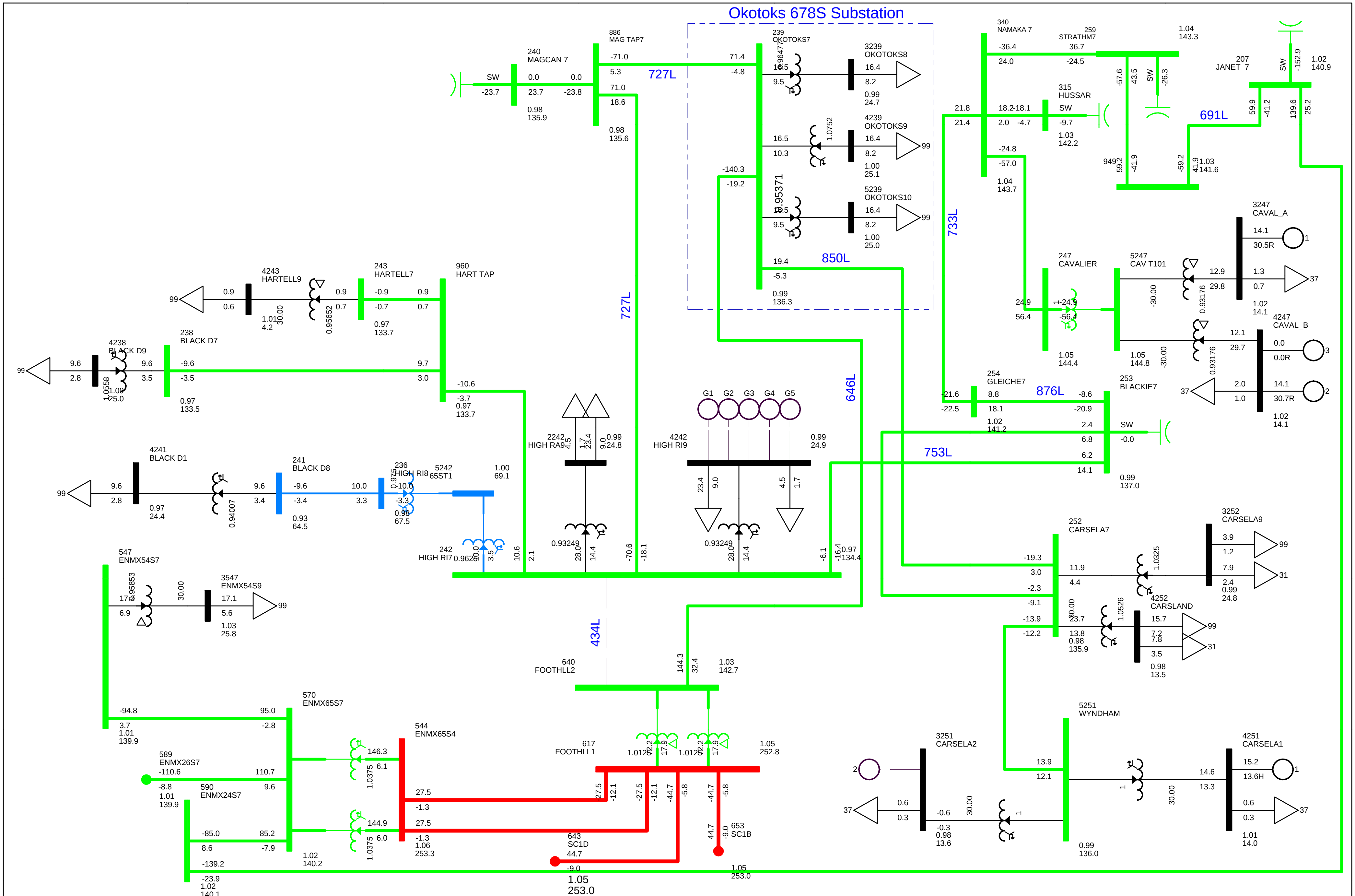
Okotoks 678S and

High River 65S Upgrades

2017 SP

P1670 POST-CONNECTION - DIAGRAM B-19
N-1: 691L JANET 74S TO CHESTERMERE 419S
TUE, MAY 31 2016 8:36

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



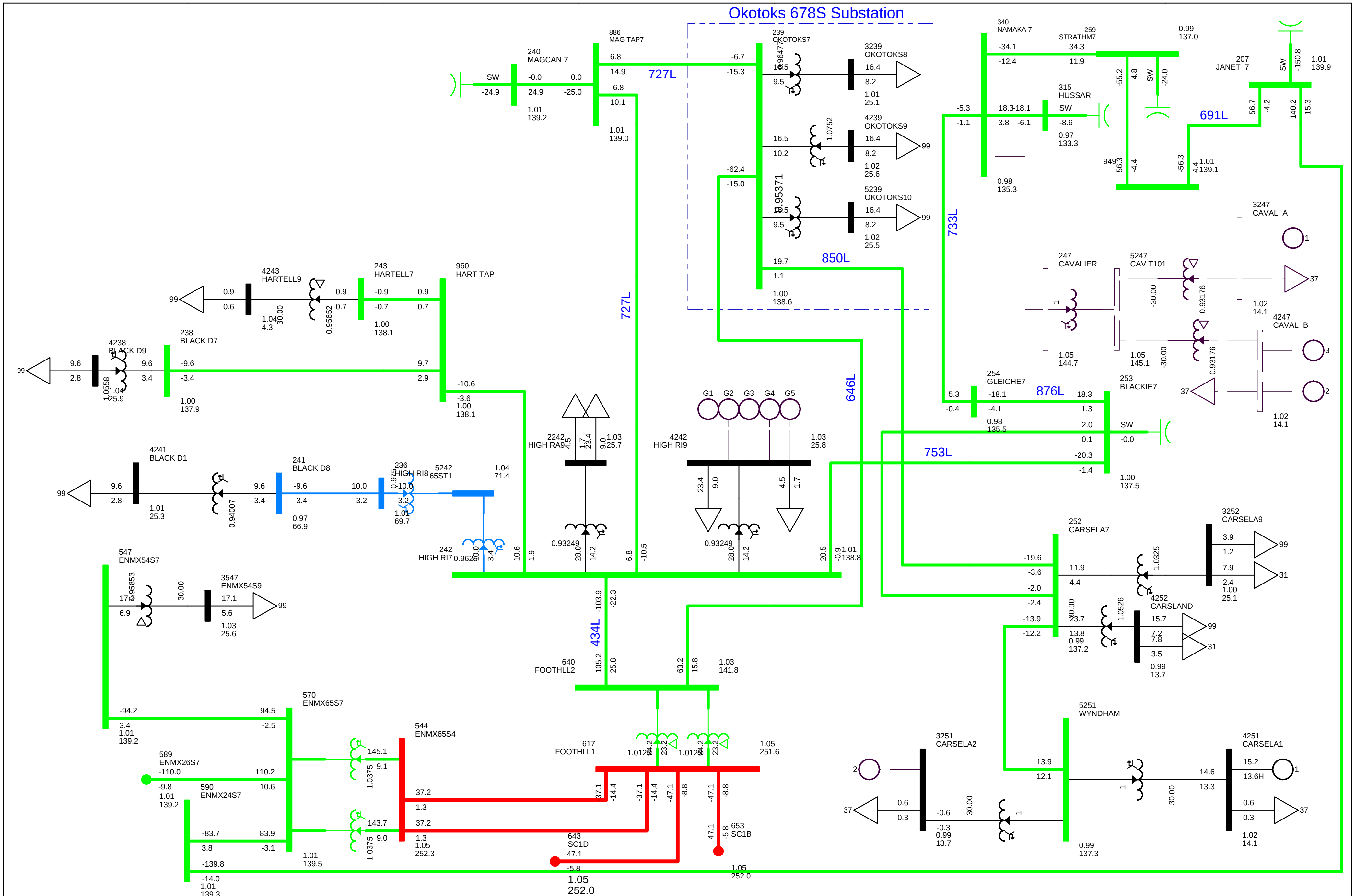
Okotoks 678S and

High River 65S Upgrades

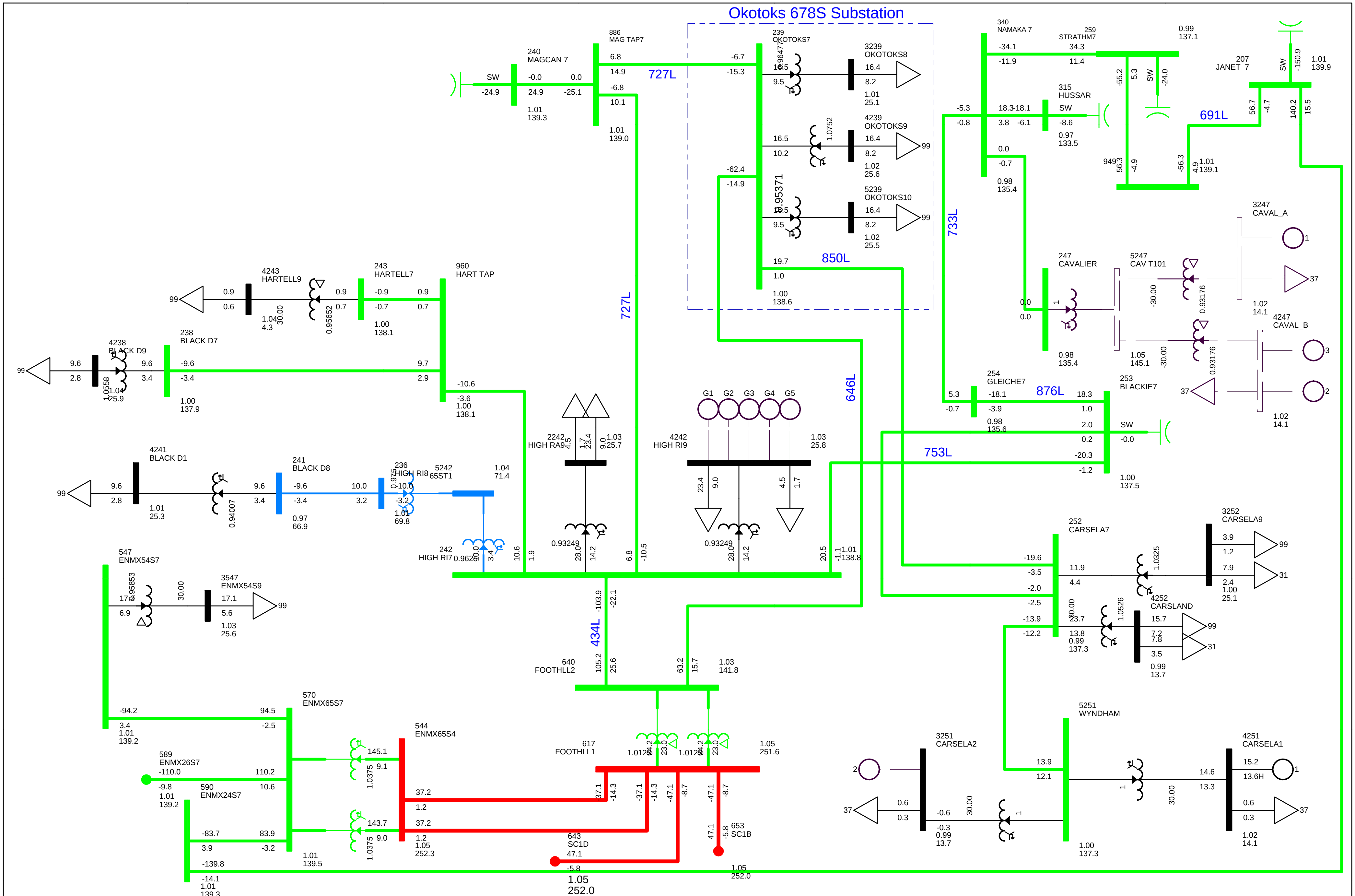
2017 SP

P1670 POST-CONNECTION - DIAGRAM B-20
N-1: 434L FOOTHILLS 237S TO HIGH RIVER 65S
TUE, MAY 31 2016 9:11

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-21 N-1: PCES01L NAMAKA 428S TO CAVALIER POWER PLANT TUE, MAY 31 2016 10:23	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



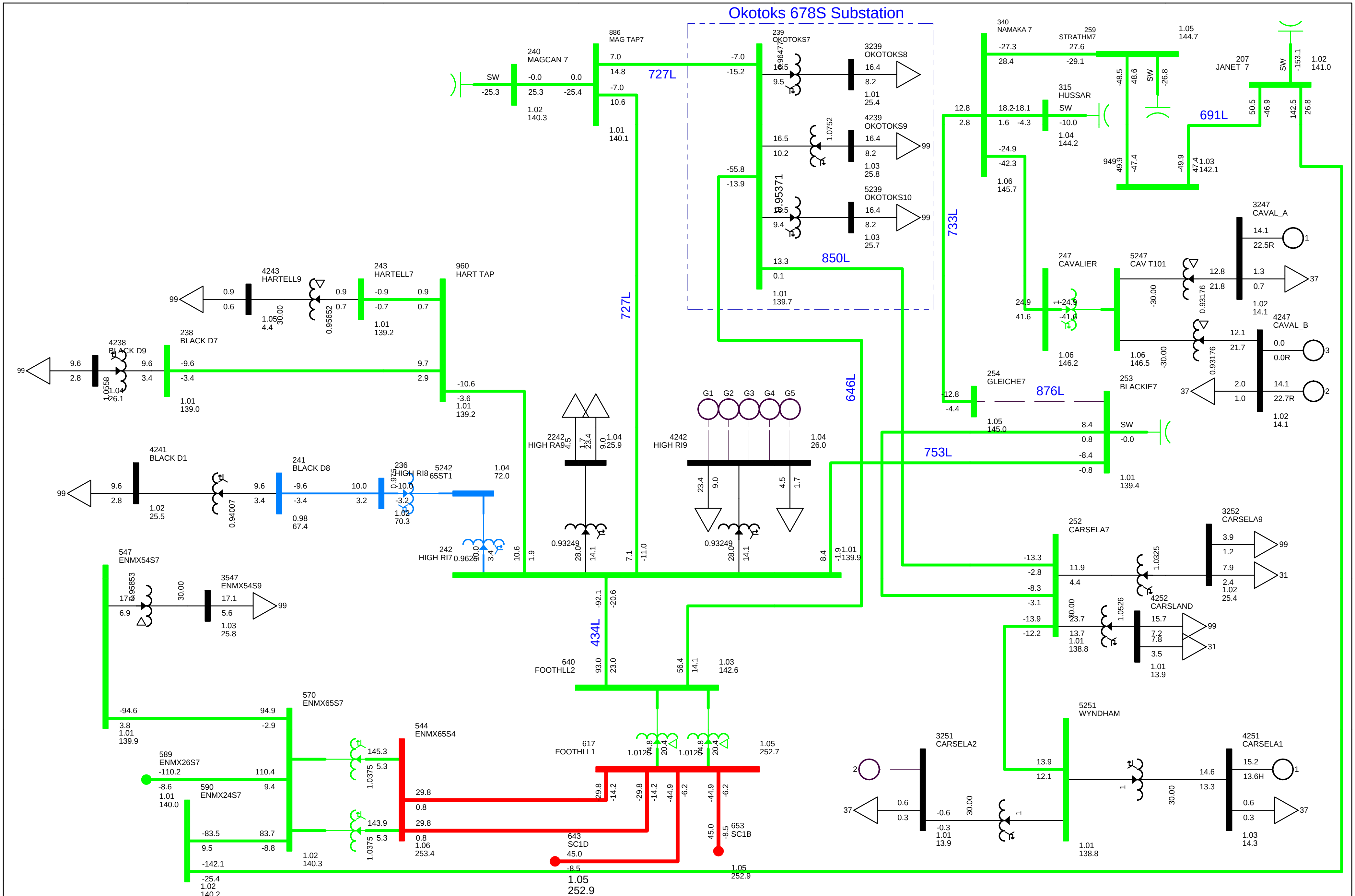
Okotoks 678S and

High River 65S Upgrades

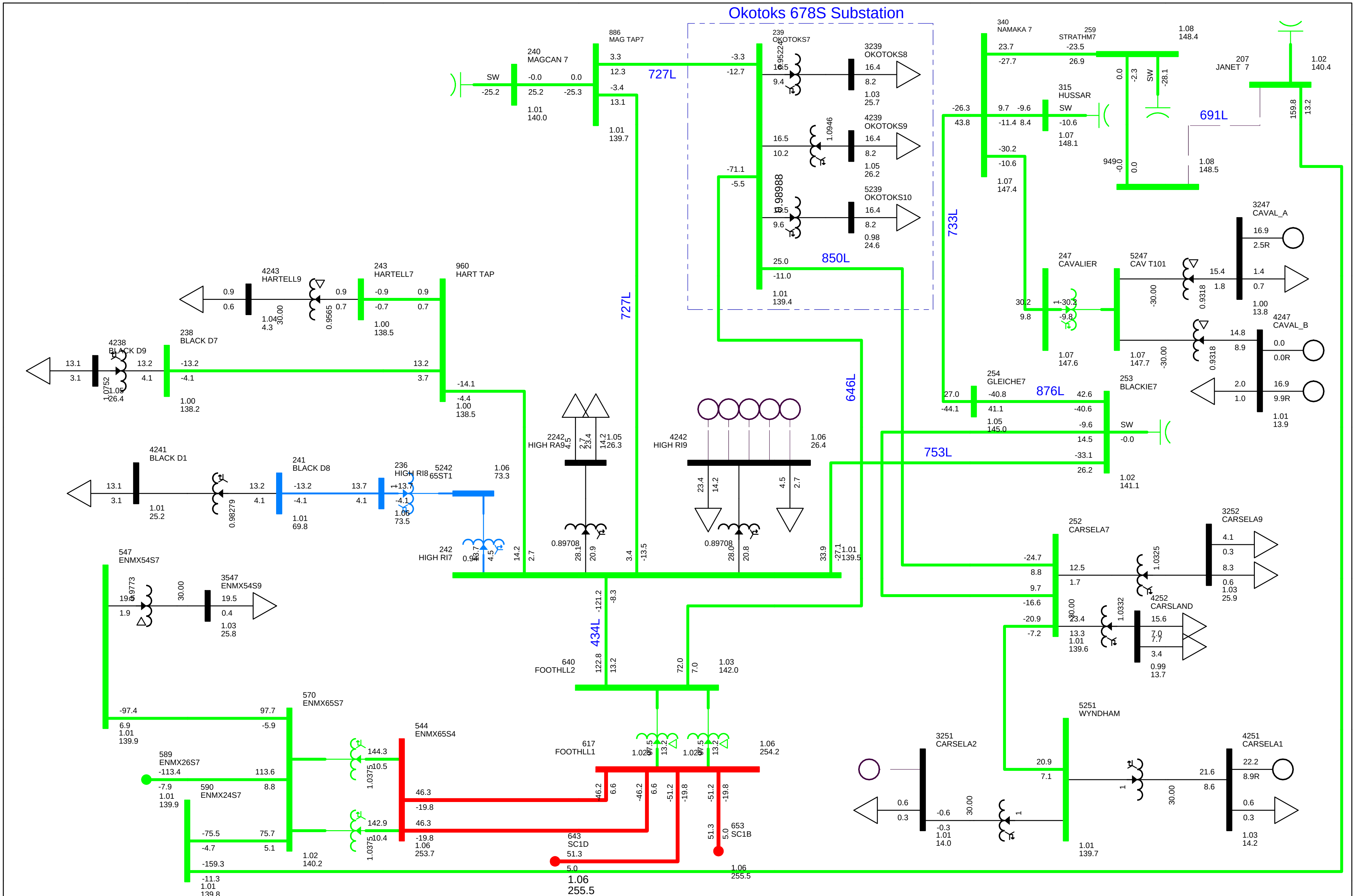
2017 SP

P1670 POST-CONNECTION - DIAGRAM B-22
N-1: CAVALIER 138/13.8 KV TRANSFORMER
TUE, MAY 31 2016 10:24

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and High River 65S Upgrades 2017 SP	P1670 POST-CONNECTION - DIAGRAM B-23 N-1: 876S BLACKIE 253S TO GLEICHEN 179S TUE, MAY 31 2016 9:30	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate A 1.105OV 0.898UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Okotoks 678S and
High River 65S Upgrades
2017 WP

P1670 POST-CONNECTION - DIAGRAM B-24
N-1: 691L JANET 74S TO CHESTERMERE 419S
TUE, MAY 31 2016 10:28

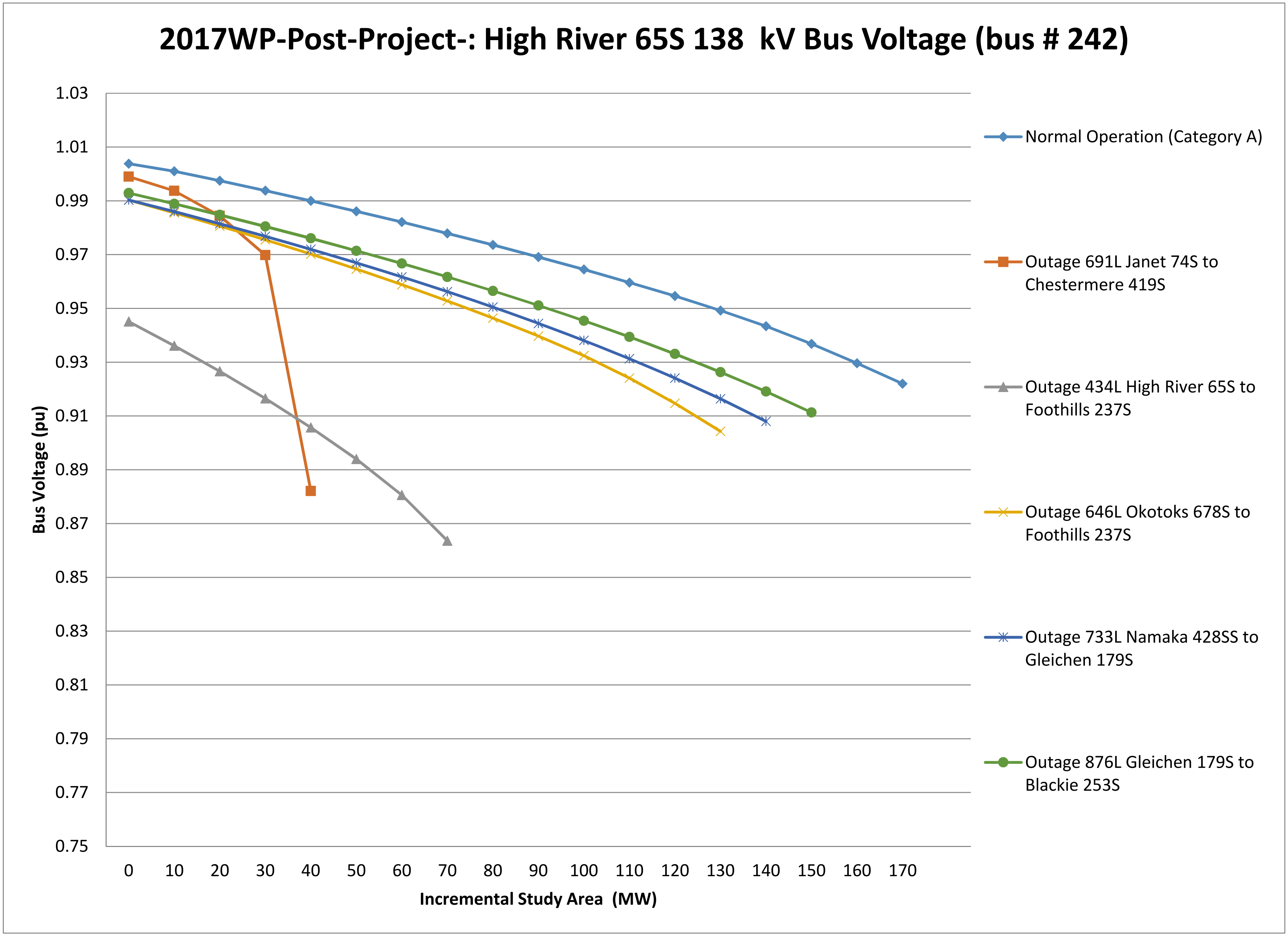
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.898UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

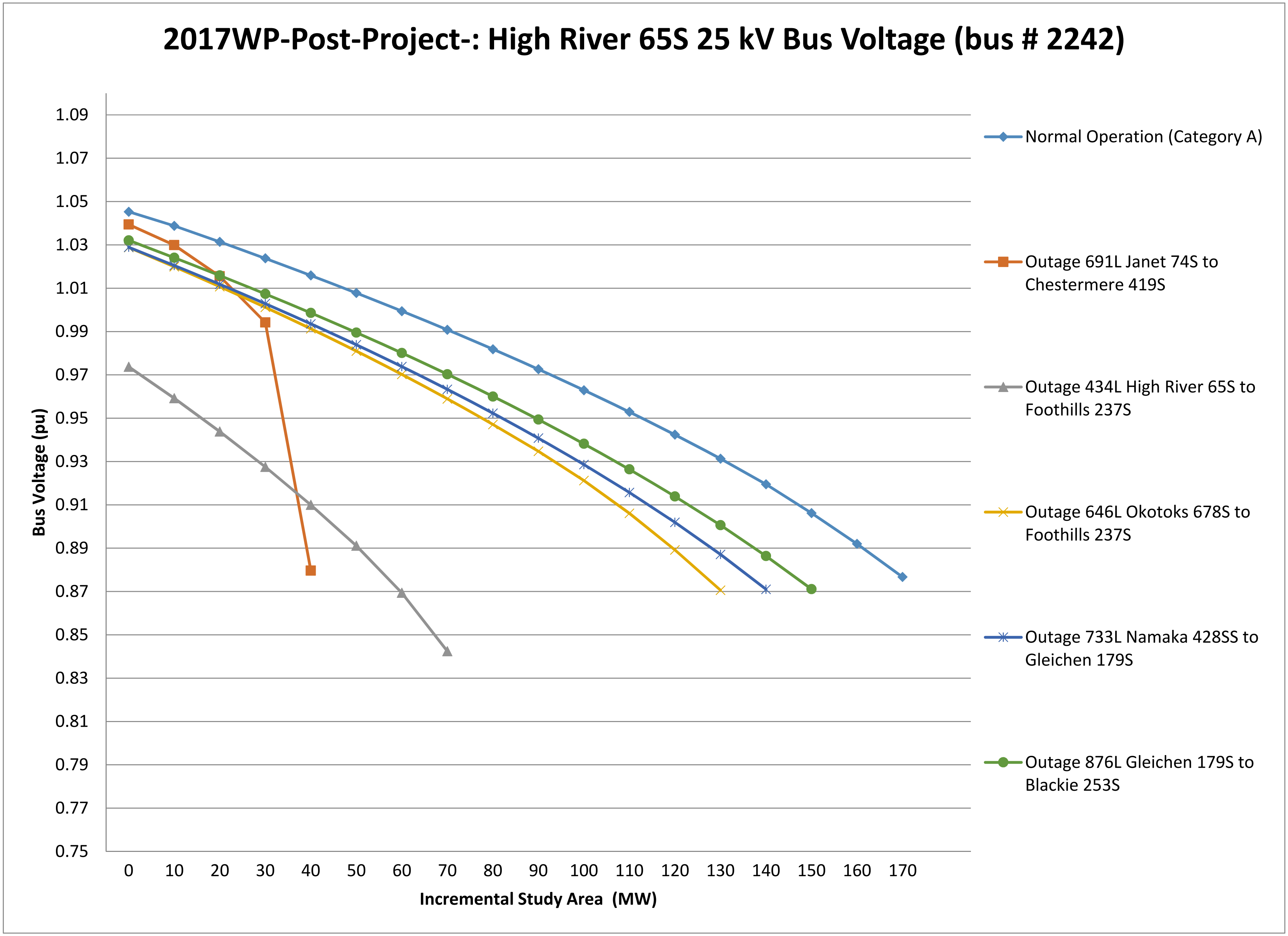
Attachment C

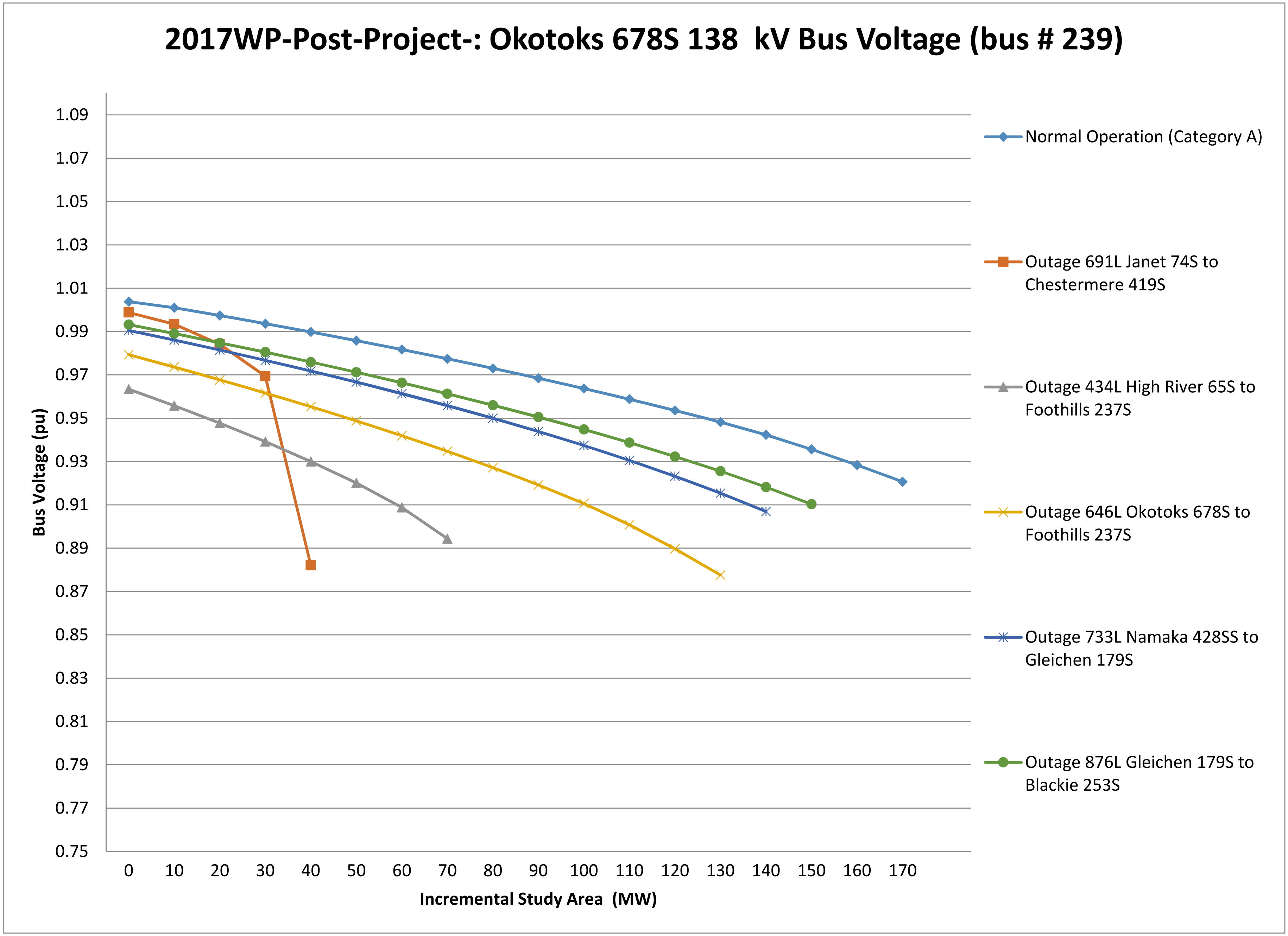
Post-Project Voltage Stability Diagrams (Scenarios 4)

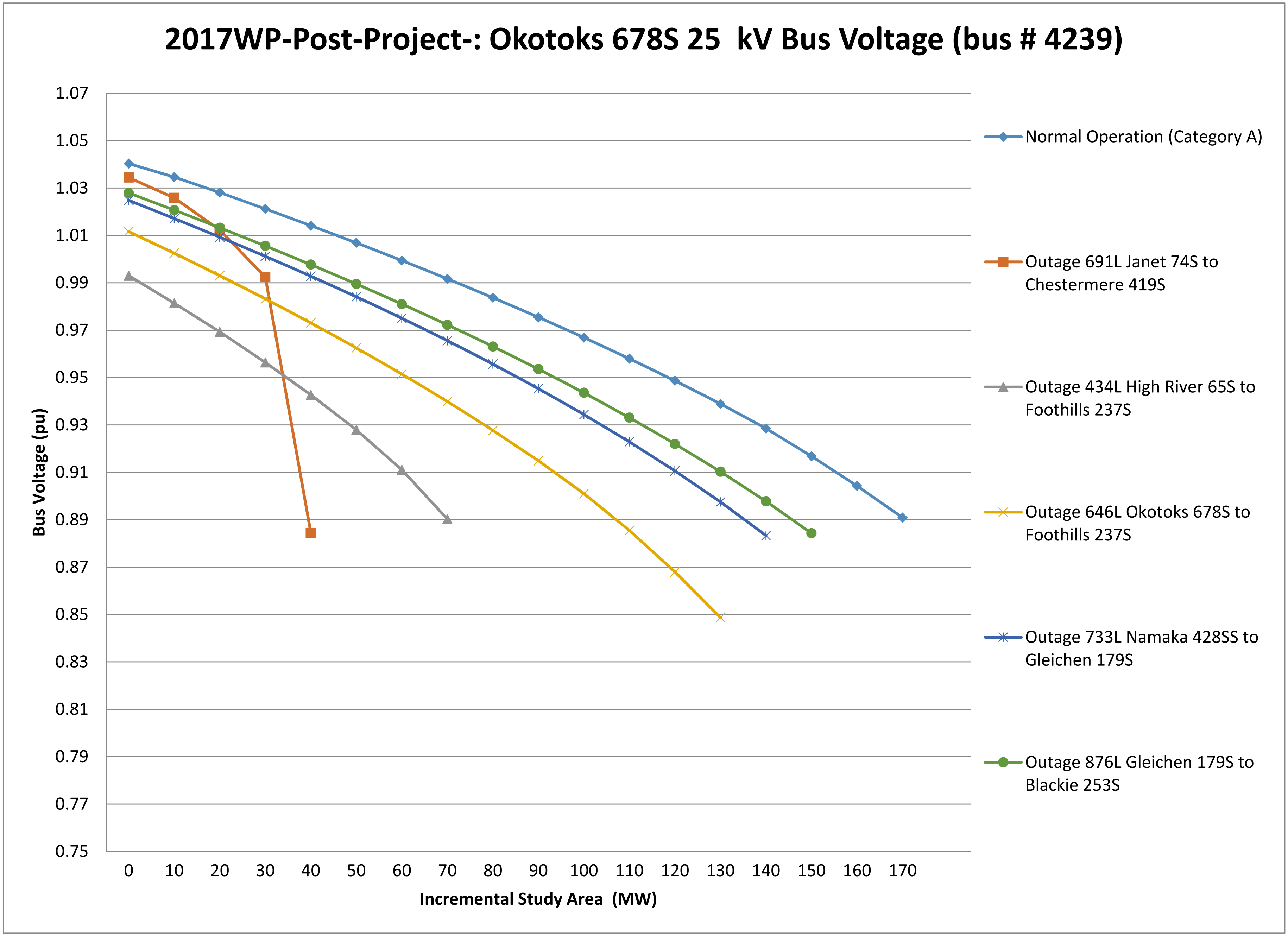
Table 1: Scenario 4: 2017 WP– Voltage stability analysis results (Minimum transfer = 14.135 MW)

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G	*System Normal*		170	*Yes*
691L	*Janet 74S*	*Chestermere 419S*	40	*Yes*
434L	*High River 65S*	*Foothills 237S*	70	*Yes*
646L	*Foothills 237S*	*Okotoks 678S*	130	*Yes*
733L	*Namaka 428S*	Gleichen 179S	140	*Yes*
876L	Gleichen 179S	Blackie 253S	150	*Yes*


2017WP-Post-Project-: High River 65S 138 kV Bus Voltage (bus # 242)
Bus Voltage (pu)
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0.85
0.83
0.81
0.79
0.77
0.75
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Incremental Study Area (MW)
Normal Operation (Category A)
Outage 691L Janet 74S to Chestermere 419S
Outage 434L High River 65S to Foothills 237S
Outage 646L Okotoks 678S to Foothills 237S
Outage 733L Namaka 428SS to Gleichen 179S
Outage 876L Gleichen 179S to Blackie 253S


2017WP-Post-Project-: High River 65S 25 kV Bus Voltage (bus # 2242)
Bus Voltage (pu)
1.09
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0.85
0.83
0.81
0.79
0.77
0.75
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Incremental Study Area (MW)
Normal Operation (Category A)
Outage 691L Janet 74S to Chestermere 419S
Outage 434L High River 65S to Foothills 237S
Outage 646L Okotoks 678S to Foothills 237S
Outage 733L Namaka 428SS to Gleichen 179S
Outage 876L Gleichen 179S to Blackie 253S


2017WP-Post-Project-: Okotoks 678S 138 kV Bus Voltage (bus # 239)
Bus Voltage (pu)
1.09
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0.85
0.83
0.81
0.79
0.77
0.75
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Incremental Study Area (MW)
Normal Operation (Category A)
Outage 691L Janet 74S to Chestermere 419S
Outage 434L High River 65S to Foothills 237S
Outage 646L Okotoks 678S to Foothills 237S
Outage 733L Namaka 428SS to Gleichen 179S
Outage 876L Gleichen 179S to Blackie 253S



2017WP-Post-Project-: Okotoks 678S 25 kV Bus Voltage (bus # 4239)
Bus Voltage (pu)
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0.85
0.83
0.81
0.79
0.77
0.75
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Incremental Study Area (MW)
Normal Operation (Category A)
Outage 691L Janet 74S to Chestermere 419S
Outage 434L High River 65S to Foothills 237S
Outage 646L Okotoks 678S to Foothills 237S
Outage 733L Namaka 428SS to Gleichen 179S
Outage 876L Gleichen 179S to Blackie 253S