APPENDIX A CONNECTION ASSESSMENT

ATCO Fox Creek 25kV Breaker Addition
Project Number: 1616

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.
After completing the studies for the Project, the ISD of the Project shifted from July 2016 to November 2016. The shift in the ISD does not materially impact the results of this connection assessment, and does not change the conclusions and recommendations contained in this report.

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

Date: April 27, 2016

Function	Name	Company	Signature	Date
Senior Engineer	Hamed Golestanifar, PhD, P.Eng.	Alberta Electric System Operator	H Golestanifar	April 27, 2016
Manager, Projects & System Access Studies	Mohamed Kamh, PhD, P.Eng.	Alberta Electric System Operator		April 27, 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.

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Connection Engineering Study Report for AUC Application

ATCO Electric Ltd.
Fox Creek 741S - 25 kV Breaker Addition

File No. 1616

Revision: 1

Revision Date: 2016-04-20

	Name	Date	Signature
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APEGA Permit to Practice P0850

Executive Summary

Project Overview

ATCO Electric Ltd. (ATCO), 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 serve load growth and a new industrial load in the Town of Fox Creek area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase from 21.681 MW to 47.43 MW for the system access service provided at the existing Fox Creek 741S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Fox Creek 741S substation.

The scheduled in-service date for the Project is November 1, 2016.

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 Fox Creek (Area 24), which is part of the AESO Northwest Planning Region. The Fox Creek area is surrounded by the planning areas of Valleyview (Area 23), Swan Hills (Area 26), Grand Cache (Area 22), and Hinton / Edson (Area 29).

From a transmission system perspective, the Fox Creek area consists of a 138/144 kV transmission system. The Fox Creek area is connected to the Little Smoky 813S substation in the Valleyview area via the 144 kV transmission line 7L90. It is also connected to the Swan Hills and Hinton / Edson areas via the 138 kV transmission lines 199L and 685L, respectively.

Study Summary

Study area for the Project

The study area for the Project consists of the AESO planning areas of Fox Creek (Area 24), Valleyview (Area 23), and Swan Hills (Area 26). The study area also includes the tie lines connecting these planning areas to neighbouring planning areas. 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).

Studies performed for the Project

Power flow analysis was performed for the 2016 summer peak (SP) and winter peak (WP) pre- and post-connection scenarios.

Voltage stability analysis was performed for the 2016 SP and 2016 WP post-connection scenarios.

Results of the pre-connection studies

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

Category A (N-G-0) conditions

Under Category A conditions, no Reliability Criteria violations were observed for any of the pre-connection scenarios.

Category B (N-G-1) contingency conditions

Under Category B conditions, no Reliability Criteria violations were observed for any of the pre-connection scenarios.

Table E-1: Overview of Pre-Connection Studies Results

Condition	Scenario	Results		Mitigation Measure
		Contingency	Result	
Category A	2016 SP	Not applicable	No violations	None required
	2016 WP	Not applicable	No violations	None required
Category B	2016 SP	All	No violations	None required
	2016 WP	All	No violations	None required

Connection alternatives examined for the Project

ATCO, as the DFO, examined and ruled out load shifting on the distribution system to serve load growth and a new industrial load in the Town of Fox Creek area.

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

Alternative 1: Modify the existing Fox Creek 741S substation, including adding a 25 kV circuit breaker.

Alternative 2: Modify the existing Simonette 733S substation, including adding a 25 kV circuit breaker.

Alternative 3: Modify the existing Goose River 725S substation, including adding a 25 kV circuit breaker.

Alternative 4: Upgrade the existing Fox Creek 347S substation to a 25 kV point of delivery substation, including adding a 138/25 kV transformer and other associated equipment.

Connection alternative selected for further examination

Alternative 1 was selected for further study.

The DFO indicated that Alternative 2 and Alternative 3 did not satisfy the DFO's distribution planning guidelines. The DFO determined that Alternative 2 and Alternative 3 were not technically viable; therefore, Alternative 2 and Alternative 3 were not selected for further study.

Alternative 4 involves additional transmission facilities development and hence, additional cost compared to Alternative 1. Alternative 4 was not selected for further study.

Results of the post-connection studies

The following is a brief summary of the post-connection studies results. The post-connection studies results and applicable mitigation measures are shown in greater detail in Table E-2, below.

Category A (N-G-0) conditions

Under Category A conditions, no Reliability Criteria violations were observed for any of the post-connection scenarios.

Category B (N-G-1) contingency conditions

The post-connection power flow analysis identified a system performance issue under Category B contingency conditions. A thermal criteria violation was observed on a segment of the 138 kV transmission line 199L (between the Fox Creek 347S substation and the tap point for the Chickadee Creek 259S substation) following the loss of the 138 kV transmission line 854L (between the Bickerdike 39S and Deer Hill 1012S substations).

Table E-2: Overview of Post-Connection Studies Results

Condition	Scenario	Results			Mitigation Measure
		Contingency	Result	Impact after Project	
Category A	2016 SP	Not applicable	No violations	No impact	None required
	2016 WP	Not applicable	No violations	No impact	None required
Category B	2016 SP	Loss of the 138 kV transmission line 854L	Thermal criteria violation on a segment of the 138 kV transmission line 199L	New thermal criteria violation	Manage by using real time operational practices
	2016 WP	All	No violations	No impact	None required

Mitigation Measures

As indicated in Table E-2, the Reliability Criteria violation that was identified in the post-connection studies can be managed by using real time operational practices.

Conclusions and Recommendation

Based on the study results, Alternative 1 is technically viable. The connection assessment identified a system performance issue. Real time operational practices can be used to manage the identified post-connection system performance issue.

It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service, and to use real time operational practices to manage the identified system performance issue.

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1. Introduction

This Engineering Study Report presents the results of the study conducted to assess the impact of the Project (as defined below) on the performance of the Alberta interconnected electric system (AIES).

1.1. Project

1.1.1. Project Overview

ATCO Electric Ltd. (ATCO), 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 serve load growth and a new industrial load in the Town of Fox Creek area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase from 21.681 MW to 47.43 MW for the system access service provided at the existing Fox Creek 741S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Fox Creek 741S substation.

The scheduled in-service date (ISD) for the Project is November 1, 2016.

1.1.2. Load Component

The existing Rate DTS contract capacity for the system access service provided at the existing Fox Creek 741S substation is 21.681 MW.

The DFO has requested a Rate DTS contract capacity increase to 47.43 MW.

This connection assessment will assume a 0.9 lagging power factor (pf) for the load associated with the Project.

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 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-connection of the Project.
- 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

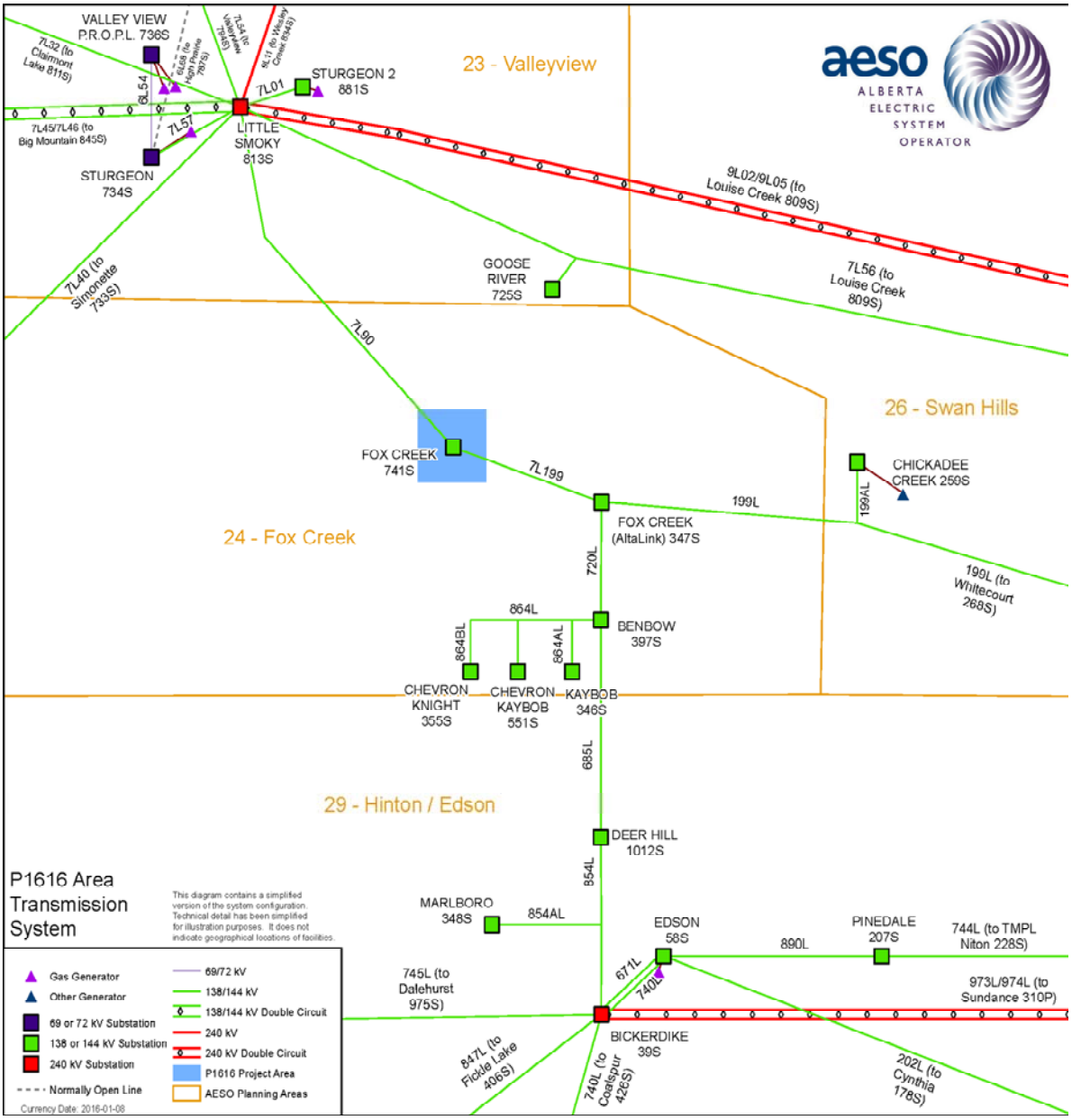
Geographically, the Project is located in the AESO planning area of Fox Creek (Area 24), which is part of the AESO Northwest Planning Region. The Fox Creek area is surrounded by the planning areas of Valleyview (Area 23), Swan Hills (Area 26), Grand Cache (Area 22), and Hinton / Edson (Area 29).

From a transmission system perspective, the Fox Creek area consists of a 138/144 kV transmission system. The Fox Creek area is connected to the Little Smoky 813S substation in the Valleyview area via the 144 kV transmission line 7L90. It is also connected to the Swan Hills and Hinton / Edson areas via the 138 kV transmission lines 199L and 685L, respectively.

The study area for the Project consists of the AESO planning areas of Fox Creek (Area 24), Valleyview (Area 23), and Swan Hills (Area 26). The study area also includes the tie lines connecting these planning areas to neighbouring planning areas. 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).

The existing transmission system in the region is shown in Figure 1-1.

Figure 1-1: Fox Creek Area Transmission System



1.2.2.2. Existing Constraints

Existing constraints in the Northwest 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).

1.2.2.3. AESO Long-Term Plans

The *AESO 2015 Long-term Transmission Plan* (2015 LTP)[1] includes the following system developments that are in the vicinity of the study area in the near term (by 2020):[2]

- Increase 240/144 kV transformer capacity at Little Smoky substation
- Add new 240 kV lines from Little Smoky substation to Fox Creek 741S substation
- Expand Fox Creek substation to include 240/144 kV facilities
- Add new 240 kV lines from Fox Creek substation to Bickerdike substation near Edson
- Open 144 kV line between Fox Creek and Little Smoky substations
- Add voltage support at Fox Creek substation

1.2.3. Studies Performed

The following studies were performed for the pre-connection analysis:

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

The following studies were performed for the post-connection analysis:

- 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 and describes the study scope. Section 2 describes the criteria, system data, and other study assumptions used in this study. Section 3 describes 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 connection alternatives selected for further study. Section 7 discusses the project interdependencies, if any. Section 8 presents the conclusions and recommendations of this study.

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

[2] The 2015 LTP identifies the near-term transmission developments in the Fox Creek-Valleyview area on page 51.

2. Criteria, System Data, and Study Assumptions

2.1. Criteria, Standards, and Requirements

2.1.1. AESO 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 include 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 TPL standards, TPL-001-AB-0 and TPL-002-AB-0, have referenced Applicable Ratings when specifying the required system performance under Category A and Category B events. For the purpose of applying the TPL standards to the studies documented in this report, Applicable Ratings are defined as follows:

- 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 per AESO Information Document ID# 2010-007RS. 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*.
- Desired post-contingency voltage change limits for three defined post event timeframes as provided in Table 2-1, below.

[3] Filed under a separate cover

Table 2-1: Post Contingency Voltage Deviations Guidelines for Low Voltage Busses

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 low voltage bus	± 10%	± 7%	± 5%

2.1.2. Authoritative Documents (ADs)

AESO Information document ID# 2010-007RS, *General Operating Practices - Voltage Control*, which relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage*, was applied to establish system normal (i.e., pre-contingency) voltage profiles in the study area and its vicinity. The TCM Rule will be followed to assess any criteria violations identified as a result of the connection studies.

2.2. Load and Generation Assumptions

2.2.1. Load Assumptions

The study area load forecast used for this connection study is reflected in Table 2-2 and is at Northwest Region Peak, which was based on the *AESO 2014 Long-term Outlook* (2014 LTO).

Table 2-2: Load Forecast: 2014 LTO at NW Region Peak

Planning Area	Description	Peak Condition	Forecast Load (MW)
			2016
23	Valley View	Summer Peak	17.2
		Winter Peak	21.1
24	Fox Creek	Summer Peak	91.9
		Winter Peak	95.1
26	Swan Hills	Summer Peak	318.7
		Winter Peak	350.6
NW Region	North West	Summer Peak	1,184.8
		Winter Peak	1,345.4
AIL	AIL w/o Losses	Summer Peak	10,833.9
		Winter Peak	12,154.4

2.2.2. Generation Assumptions

Table 2-3 provides the generation assumptions used in the study scenarios.

Whitecourt Power Generator is considered to be the critical generating unit for the purpose of the studies, and is assumed offline for the power flow and voltage stability analyses.

Table 2-3: Dispatch Levels of Existing Generators in the Vicinity of the Study Area

Generator Name	Bus Number	Area	Maximum Capability (MW)	Dispatch Level in the Study Scenarios (MW)	
				2016 SP	2016 WP
Whitecourt Power	408	26	25	Offline	
Weyerhaeuser	1146	20	48	34	41
H.R. Milner	1148	22	144	90	144
Valley View1	1171	23	50	0	0
Valley View2	1173	23	50	0	0
Poplar Hill	16118	20	48	0	0
GP-CHP1a	17101	20	27	11	18
Lowe1	17120	20	105	0	67
Bear Creek GT	18142	20	64	0	44
Bear Creek ST	19142	20	36	12	12
Gold Creek 1	19145	20	5	0	0
ElmworthG5	20134	20	3	0	0
ElmworthG6	20134	20	3	0	0
ElmworthG7	20134	20	2	0	0
ElmworthG8	20134	20	2	0	0
AB Newsprint	2296, 4296	26	63	29	35
NRGreen	2674	26	19	11	14
P1499 Elmworth G9	20134	20	9.3	0	0
P1321 Shell Carmon Creek	14074	19	230	Offline	
	15074	19	230		
	16074	19	230		

2.2.3. Intertie Flow and HVDC Assumptions

The Alberta-BC, Alberta-Montana, and Alberta-Saskatchewan intertie points are deemed to be too far away to have any material impact on the connection assessment for the Project. Therefore, the intertie flows were dispatched the same as in the AESO's base cases.

The Western Alberta Transmission HVDC Line (WATL) and the Eastern Alberta Transmission HVDC Line (EATL) assumptions were expected to have minimal impact for the connection studies. Therefore, HVDC assumptions are kept consistent with that in the AESO planning base cases and not adjusted for this study.

2.3. System Projects

No system projects were included in the study scenarios.

2.4. Customer Connection Projects

Table 2-4 identifies customer connection projects in the study area.

Table 2-4: Summary of Customer Projects in the Study Area

Planning Area	Queue Position*	Project Number	Project Description	Planned ISD	Modelled** in the Study cases
24	74	1638	Fortis Benbow 397S Transformer Upgrade	Q2-2016	No***
24	79	1616	ATCO Fox Creek 25 kV Breaker Addition	Q4-2016	Yes

* Per the AESO Connection Queue posted in April 2016. The projects in the study area, if any, that have lower queue positions than Project 1616 are not listed in this table and were not modelled in the study cases.

** These projects are dispatched per the load and generation levels set out in Section 2.2.1 and Section 2.2.2.

*** The developments associated with this connection project include a transformer replacement without a Rate DTS increase. This connection project will not affect the results of this connection assessment or the conclusions and recommendations contained in this report.

2.5. Facility Ratings and Shunt Elements

Table 2-5 provides the ratings for the main transmission lines in the study area.

Table 2-5: Main Transmission Lines in the Study Area (MVA on a 138 kV Base)

Transmission Line	Summer (MVA)	Winter (MVA)
7L90 (Fox Creek 741S – Little Smoky 813S)	109.2	138.9
7L199 (Fox Creek 741S – Fox Creek 347S)	109.2	138.9
720L (Fox Creek 347S – Benbow 397S)	86	91
854L (Bickerdike 39S - 854L tap point)	263	263
854L (854L tap point - Deer Hill 1012S)	283	287
685L (Benbow 397S - Deer Hill 1012S	167	201
864L (Benbow 397S – 864AL tap point)	99	133
864L (864AL tap point – 864BL tap point)	86	91
864L (864BL tap point – Chevron Kaybob 551S)	99	133
864AL (864L tap point – Kaybob 346S)	99	133
864BL (864L tap point – Chevron Knight 216S)	99	133
199L (Fox Creek 347S – Whitecourt 268S)	85	90

Note: Emergency line ratings will be provided, where applicable, for the pre- and post-connection study results.

Table 2-6 provides the shunt elements in the study area.

Table 2-6: Summary of Shunt Elements in the Study Area

Station Name and Number	Voltage (kV)	Capacitor (MVar)	Reactor (Mvar)	SVC (Mvar)	Synchronous Condenser (MVAR)
Fox Creek 741S	25	1x4.8	-	-	-

2.6. Voltage Profile Assumptions

The AESO ID# 2010-007RS is used to establish system normal (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 utilized to set the voltage profile for the study base cases prior to power flow analysis. The key bus voltages for the study area for the project are shown in Table 2-7.

Table 2-7: Summary of the Voltage at Key Nodes in Study Scenarios

Substation	Nominal Voltage (kV)	ID# 2010-007RS			Voltage in the Study Case (kV) N-G-0			
					Pre-Connection		Post-Connection	
		Minimum Operating Limit (kV)	Desire Range (kV)	Maximum Operating Limit (kV)	2016SP	2016WP	2016SP	2016WP
Rycroft 730S	144	136.8	142.6-154.1	155.5	148.4	148.8	148.4	148.2
H.R. Milner 740S	144	144	146-150	151	148.2	149.0	148.3	149.2
Crystal Lake 722S	144	144	147-151	155	149.9	150.2	149.5	150.3
Flyingshot Lake 749S	144	144	147-151	155	149	149.1	148.6	149.3
Poplar Hill 790S	144	142	144-151	155	150.5	150.6	148.8	150.9
Clairmont Lake 811S	144	144	147-151	155	150.2	150.5	149.7	150.6
Little Smoky 813S	240	255	257-268	275	258.8	264.8	261.4	267.9
	144	146	148-152	155	151.4	151.4	151.4	151.4
Goodfare 815S	144	142	144-151	155	150	148.9	147.4	149.3
Big Mountain 845S	144	145	147-151	155	148.9	149.1	148.7	149.3

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-connection of the Project.
- Recommend mitigation measures, if required, to enable the reliable integration of the project to the AIES.

3.2. Study Scenarios

The scheduled ISD for the project is November 1, 2016. Hence, the study was conducted using the 2016 summer peak (SP) and winter peak (WP) scenarios.

Table 3-1 summarizes the study scenarios used for the connection assessment. This connection assessment will assume a 0.9 lagging power factor (pf) for the load associated with the Project.

Table 3-1: Summary of Study Scenario Assumptions

Scenario No.	Year/Season Load	Project Load (MW)
Pre-connection System		
1	2016 SP	21.68
2	2016 WP	21.68
Post-connection System		
3	2016 SP	47.43
4	2016 WP	47.43

3.3. Connection Studies Carried Out

The following studies were performed for the pre-connection analysis:

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

The following studies were performed for the post-connection analysis:

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

Table 3-2 summarizes the studies that were carried out for this connection assessment.

Table 3-2: Summary of Studies Performed

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

3.4. Power Flow Analysis

Pre- and post-connection power flow analysis was conducted to identify thermal overloads or transmission voltage violations as per the Reliability Criteria, and to identify any deviations from the desired limits in Table 2-1. The purpose of the power flow analysis is to quantify any incremental violations in the study area after the Project is connected.

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%. Tap changers were then allowed to move while capacitors remained locked to determine if any voltage deviations above 7% were found in the area. Once all taps and capacitor controls were allowed to adjust, voltage deviations above 5% were reported for both the pre-connection and post-connection networks.

3.4.1. 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 violations under Category A conditions and under Category B contingency conditions.

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

The voltage stability analysis was performed according to the Western Electricity Coordinating Council (WECC) Voltage Stability Assessment Methodology. WECC voltage stability criteria states, 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 voltage stability analysis was performed by increasing load in the Fox Creek, Valley View, and Swan Hills planning areas (Areas 24, 23 and 26, respectively) and by increasing the corresponding generation in the Calgary and Sheerness planning areas (Areas 6 and 43, respectively).

3.5.1. Contingencies Studied for PV Analysis

The 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-Connection System Assessment

4.1. Pre-Connection Power Flow Analysis

Table 4-1 provides an overview of the pre-connection power flow analysis and applicable mitigation measures.

Table 4-1: Overview of Pre-Connection Studies Results

Condition	Scenario	Results		Mitigation Measure
		Contingency	Result	
Category A	2016 SP	Not applicable	No violations	None required
	2016 WP	Not applicable	No violations	None required
Category B	2016 SP	All	No violations	None required
	2016 WP	All	No violations	None required

4.1.1. Scenario #1: 2016 SP (Pre-Connection)

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 4-2 and shown in the power flow diagrams in Attachment A.

Table 4-2: Summary of Pre-Connection System Performance – Scenario #1

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

4.1.2. Scenario #2: 2016 WP (Pre-Connection)

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 4-3 and shown in the power flow diagrams in Attachment A.

Table 4-3: Summary of Pre-Connection System Performance – Scenario #2

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

5. Connection Alternatives

5.1. Overview

ATCO, as the DFO, examined and ruled out load shifting on the distribution system to serve load growth and a new industrial load in the Town of Fox Creek area.[4]

This report examined four transmission alternatives to meet the DFO's request for system access service.[5]

5.2. Connection Alternatives Examined

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

Alternative 1 – Modify the Fox Creek 741S substation

Alternative 1 involves modifying the existing Fox Creek 741S substation, including adding a 25 kV circuit breaker.

Alternative 2 – Modify the Simonette 733S substation

Alternative 2 involves modifying the existing Simonette 733S substation, including adding a 25 kV circuit breaker.

Alternative 3 – Modify the Goose River 725S substation

Alternative 3 involves modifying the existing Goose River 725S substation, including adding a 25 kV circuit breaker.

[4] The DFO's analysis is reported in section 4 of the ATCO *Distribution Deficiency Report, Fox Creek 741S Breaker Addition*, filed under a separate cover.

[5] These alternatives reflect more up to date engineering design than the alternatives identified in the ATCO *Distribution Deficiency Report, Fox Creek 741S Breaker Addition*, which is filed under a separate cover.

Alternative 4 – Upgrade the Fox Creek 347S substation

Alternative 4 involves upgrading the existing Fox Creek 347S substation to a 25 kV point of delivery substation.

This alternative includes the following:

- Add one 138/25 kV transformer;
- Other associated equipment

5.2.1. Connection Alternatives Selected for Further Studies

Alternative 1 was selected for further study.

5.2.2. Connection Alternatives Not Selected for Further Studies

The DFO indicated that Alternative 2 and Alternative 3 did not satisfy the DFO's distribution planning guidelines. The DFO determined that Alternative 2 and Alternative 3 were not technically viable; therefore, Alternative 2 and Alternative 3 were not selected for further study.

Alternative 4 involves additional transmission facilities development and hence, additional cost compared to Alternative 1. Alternative 4 was not selected for further study.

6. Technical Analysis of the Connection Alternative

6.1. Alternative 1

Table 6-1 provides an overview of the post-connection analysis. Mitigations measures, where applicable, are discussed in Section 6.3.

Table 6-1: Overview of Post-Connection Studies Results

Condition	Scenario	Results			Mitigation Measure
		Contingency	Result	Impact after Project	
Category A	2016 SP	Not applicable	No violations	No impact	None required
	2016 WP	Not applicable	No violations	No impact	None required
Category B	2016 SP	Loss of the 138 kV transmission line 854L	Thermal criteria violation on a segment of the 138 kV transmission line 199L	New thermal criteria violation	Manage by using real time operational practices
	2016 WP	All	No violations	No impact	None required

6.1.1. Power Flow Analysis

6.1.1.1. Scenario #3: 2016 SP (Post-Connection)

No Reliability Criteria violations were observed under Category A conditions.

No voltage criteria violations or POD bus voltage deviations were observed under Category B contingency conditions.

A thermal criteria violation was observed under Category B contingency conditions, as follows:

- Loading below the emergency line rating on a segment of the 138 kV transmission line 199L (between the Fox Creek 347S substation and the tap point for the Chickadee Creek 259S substation) following the loss of the 138 kV transmission line 854L (between the Bickerdike 39S and Deer Hill 1012S substations).

Table 6-2 provides further detail about the observed thermal criteria violation under Category B contingency conditions.

The results of the power flow analysis are shown in the power flow diagrams in Attachment B.

Table 6-2: Scenario #3, 2016 SP (Post-Connection): N-G-1 Line Loading Above Continuous Summer Rating (MVA using 138 kV base)

Contingency	Limiting Branch	Line Rating	Pre-Connection		Post-Connection		% Loading Difference
		Normal/ Emergency (MVA)	Load Flow (MVA)	% Loading	Load Flow (MVA)	% Loading	
854L (Bickerdike 39S - Deer Hill 1012S)	199L (Fox Creek 347S - Chickadee Creek 259S Tap)	85.0 / 94.0	80.0	94.1	89.17	104.9	10.8

6.1.1.2. Scenario #4: 2016 WP (Post-Connection)

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 6-3 and shown in the power flow diagrams in Attachment B.

Table 6-3: Summary of Post-Connection System Performance – Scenario #4

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

6.2. Voltage Stability Analysis

Voltage stability analysis was conducted using the 2016 SP and WP post-connection scenarios to investigate the system active power margins after the Project under Category A conditions and Category B contingency conditions.

6.2.1. Scenario #3: 2016 SP (Post Connection)

Voltage stability analysis was performed for the 2016 SP scenario. The reference load level for the Fox Creek (Area 24), Valley View (Area 23), and Swan Hills (Area 26) areas is 427.8 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load, or 21.4 MW to meet the voltage stability criteria (0.05 x 427.8 MW = 21.4 MW). Table 6-4 summarizes the voltage stability transfer margins results for Category A and for the three worst contingencies under Category B system conditions.

The voltage stability margin is met for all studied conditions.

Table 6-4: Post-Connection Voltage Stability Results for Category A and for Three Worst Category B Contingencies – Scenario #3

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System normal		438.13	Yes
Category B (Minimum Transfer = 21.4 MW)				
854L	Bickerdike 39S	Deer Hill 1012S	338.75	Yes
685L	Benbow 397S	Deer Hill 1012S	351.25	Yes
907L	Sagitawa 77S	Alberta Newsprint 122S	367.5	Yes

6.2.2. Scenario #4: 2016 WP (Post-Connection)

Voltage stability analysis was performed for the 2016 WP scenario. The reference load level for the Fox Creek (Area 24), Valley View (Area 23), and Swan Hills (Area 26) areas is 466.8 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load, or 23.3 MW to meet the voltage stability criteria (0.05 x 466.8 MW = 23.3 MW). Table 6-5 summarizes the voltage stability results for Category A and for the three worst contingencies under Category B system conditions.

The voltage stability margin is met for all conditions.

Table 6-5: Post-Connection Voltage Stability Results for Category A and for Three Worst Category B Contingencies – Scenario #4

Contingency	From	To	Maximum incremental transfer (MW)	Meets transfer criteria?
N-G-0	System normal		430.63	Yes
Category B (Minimum Transfer = 23.3 MW)				
854L	Bickerdike 39S	Deer Hill 1012S	205	Yes
685L	Benbow 397S	Deer Hill 1012S	225.63	Yes
7L90	Little Smoky 813S	Fox Creek 741S	264.38	Yes

6.3. Mitigation Measures

The connection assessment identified a post-connection system performance issue. Real time operational practices can be used to manage the identified post-connection system performance issue.

Table 6-6 summarizes the applicable mitigation measures to manage the post-connection system performance issue.

Table 6-6: Scenario #3, 2016 SP (Post-Connection): N-G-1 Line Loading Above Continuous Summer Rating and Mitigation

Contingency	Limiting Branch	Line Rating Normal/ Emergency (MVA)*	Post-Connection		Mitigation
			Load Flow (MVA)	% Loading	
854L (Bickerdike 39S - Deer Hill 1012S)	199L (Fox Creek 347S - Chickadee Creek 259S Tap)	85.0 / 94.0	89.17	104.9	Manage by using real time operational practices

6.4. Conclusions and Recommendations

Based on the study results, Alternative 1 is technically viable. The study results confirm that the voltage stability margin of the study area meets the AESO requirements after the Project.

Power flow results identified a post-connection system performance issue under Category B contingency conditions. Real time operational practices can be used to manage the identified post-connection system performance issue.

It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service, and to use real time operational practices to manage the identified system performance issue.

7. Project Interdependencies

No project interdependencies were identified.

8. Conclusions and Recommendations

Project Overview

ATCO, in its capacity as the DFO, submitted a SASR to the AESO to serve load growth and a new industrial load in the Town of Fox Creek area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase from 21.681 MW to 47.43 MW for the system access service provided at the existing Fox Creek 741S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Fox Creek 741S substation.

The scheduled in-service date for the Project is November 1, 2016.

This report detailed the system performance studies undertaken to assess the impact of the Project on the AIES.

Conclusions and Recommendation

Based on the study results, Alternative 1 is technically viable. The connection assessment identified a system performance issue. Real time operational practices can be used to manage the identified post-connection system performance issue.

It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service, and to use real time operational practices to manage the identified system performance issue.

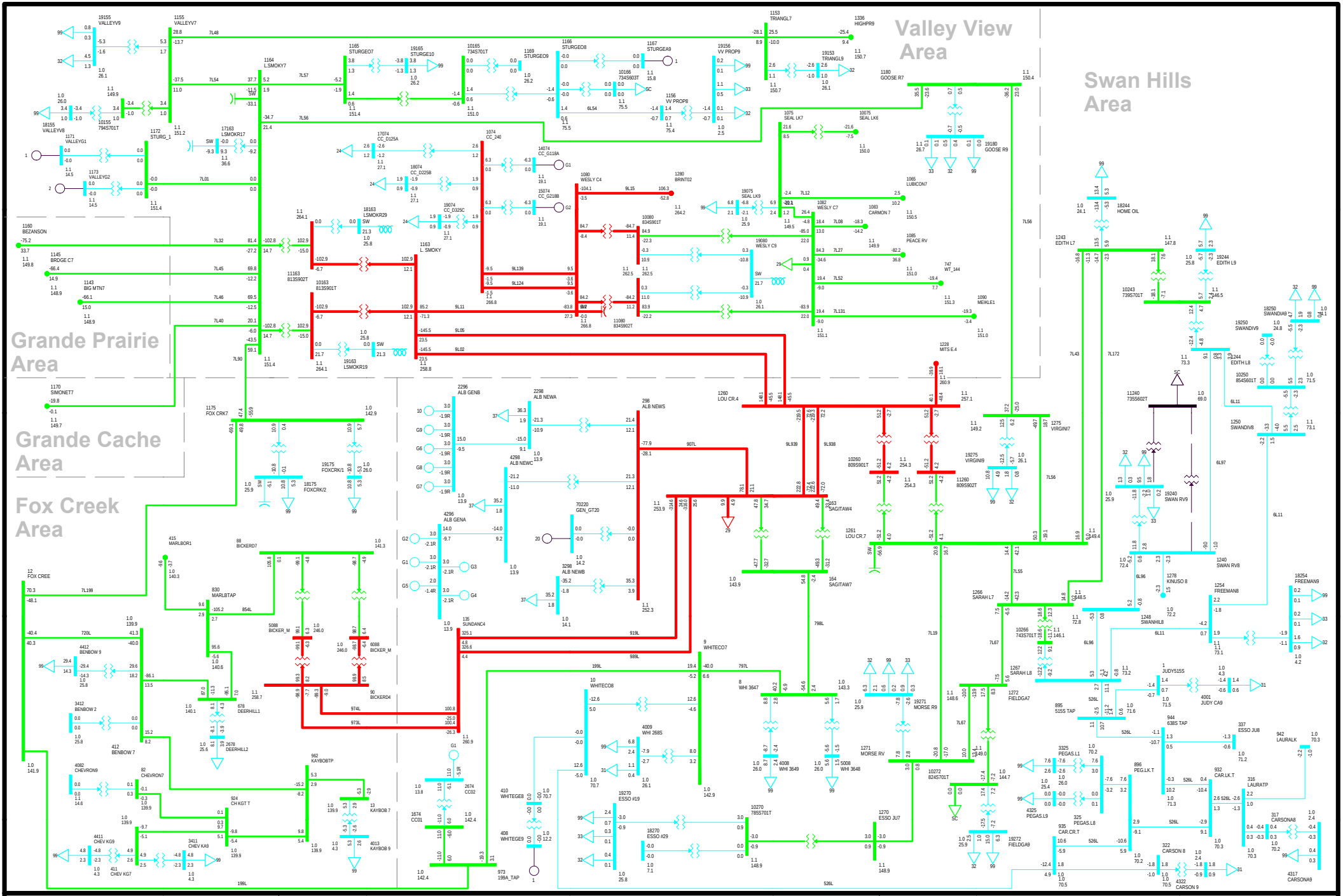
ATTACHMENT A
Pre-Connection System Power Flow Plots

Existing System Power Flow Results

Power Flow Diagrams

The pre-connection power flow diagrams for Category A and B contingencies are provided in this section. The following table presents the list of the power flow diagrams. Please note that Whitecourt generator is turned off for the analyzed cases.

Table A-1: List of pre-connection power flow diagrams

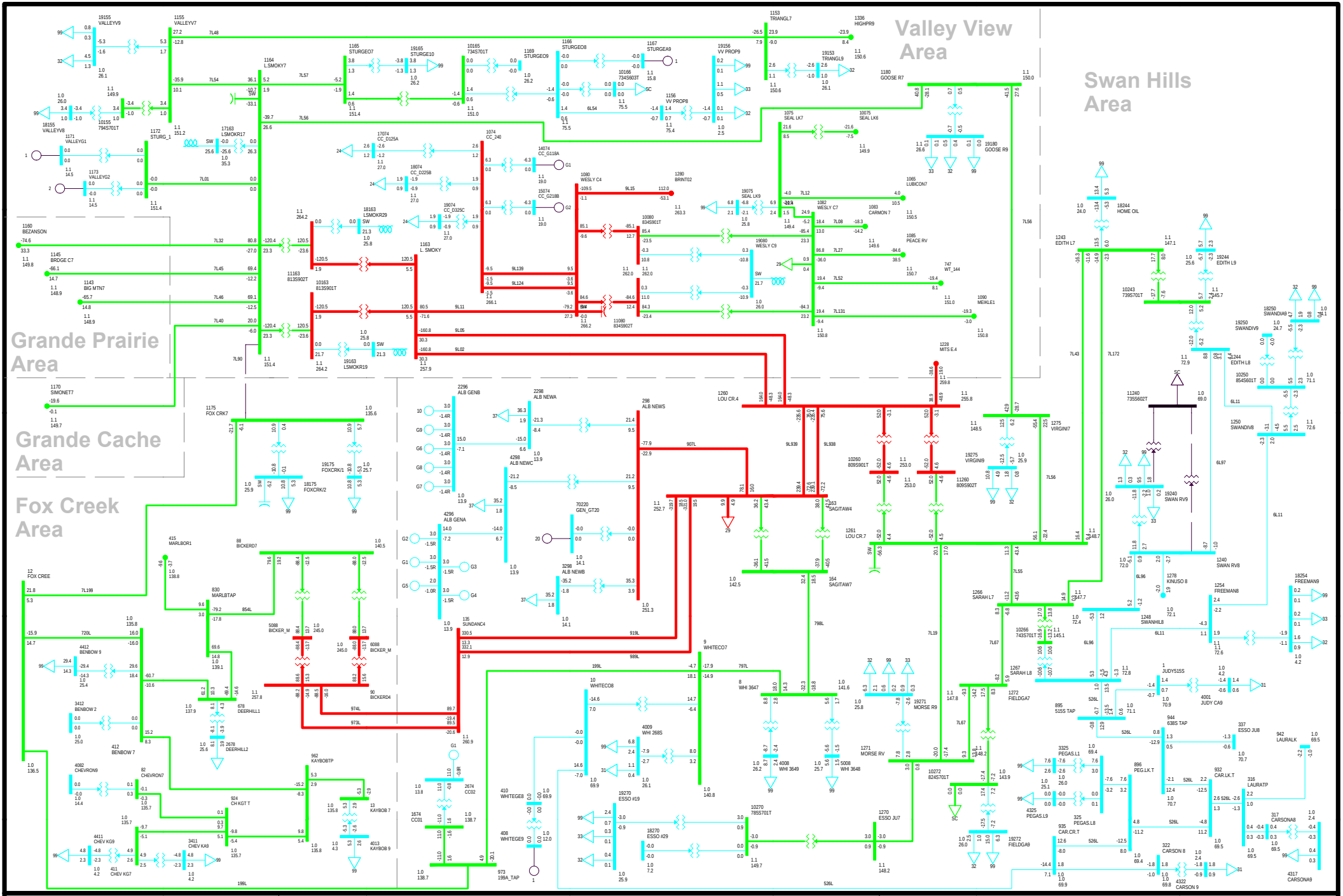


P1616 - Fox Creek
25kV Breaker Addition

CATEGORY A, N-G-0
2016SP PRE-CONNECTION
THU, APR 14 2016 11:34

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar

100.0%Rate A
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000

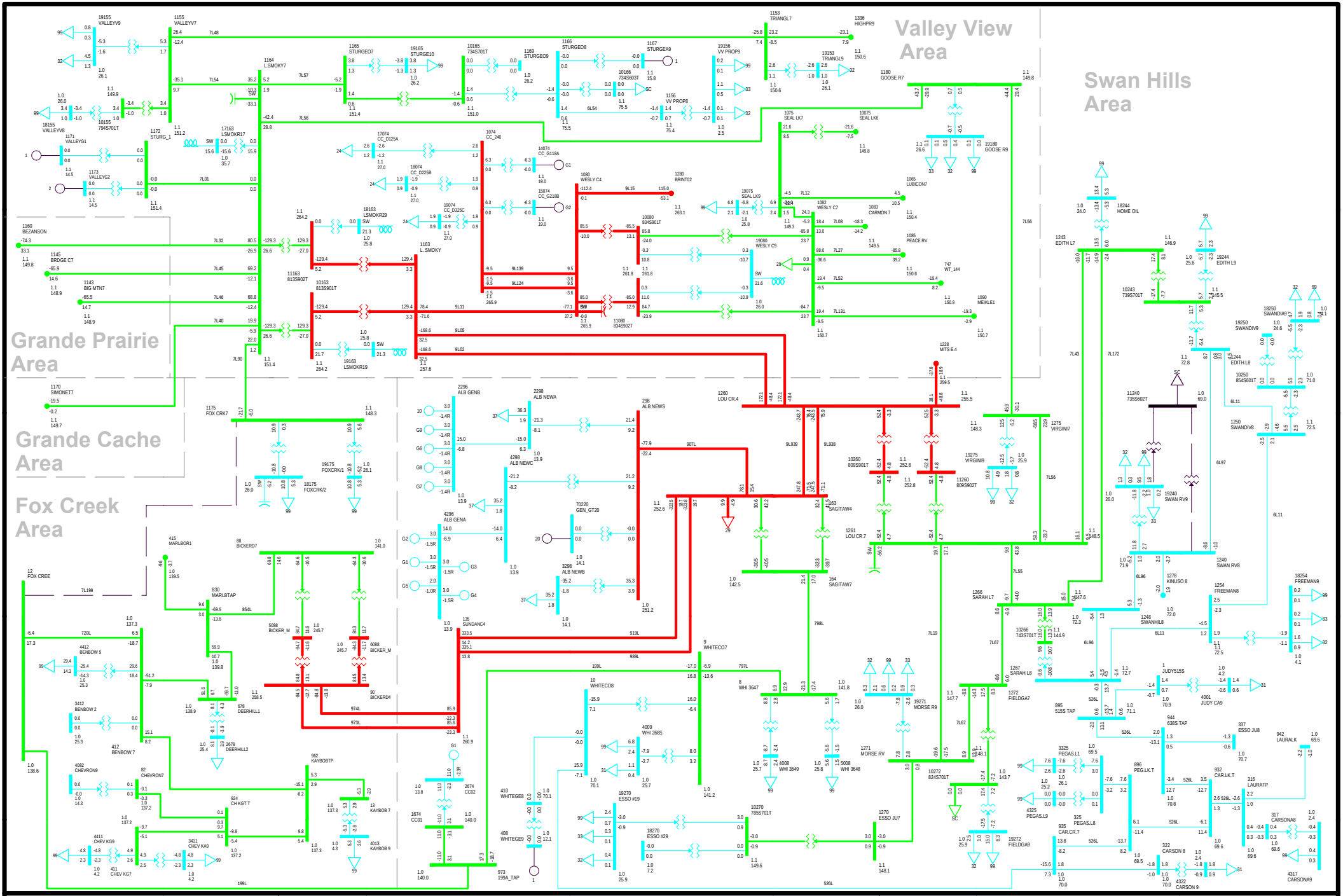


P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L90
2016SP PRE-CONNECTION
THU, APR 14 2016 11:34

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar

100.0%Rate A
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000

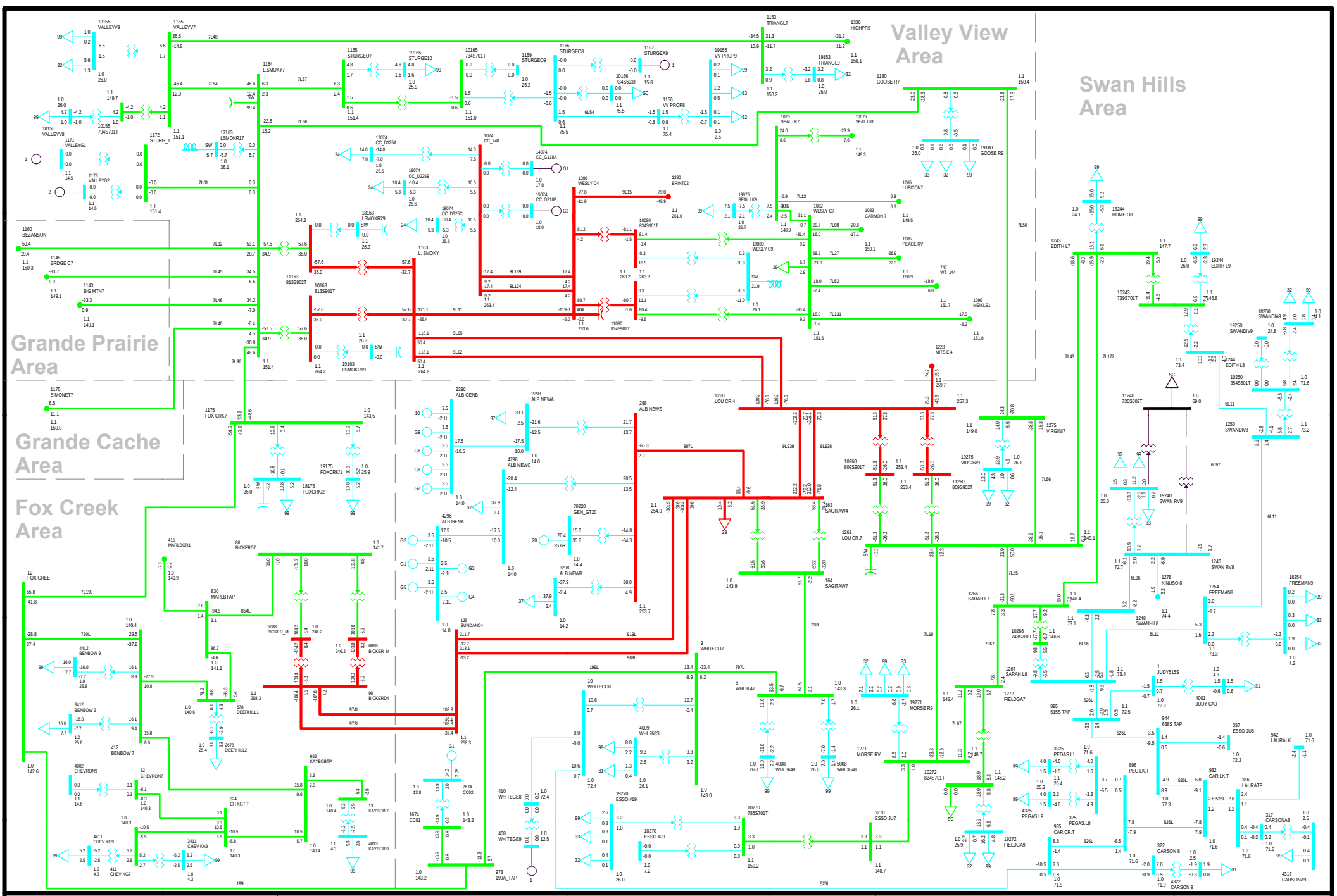


P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L199
2016SP PRE-CONNECTION
THU, APR 14 2016 11:34

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar

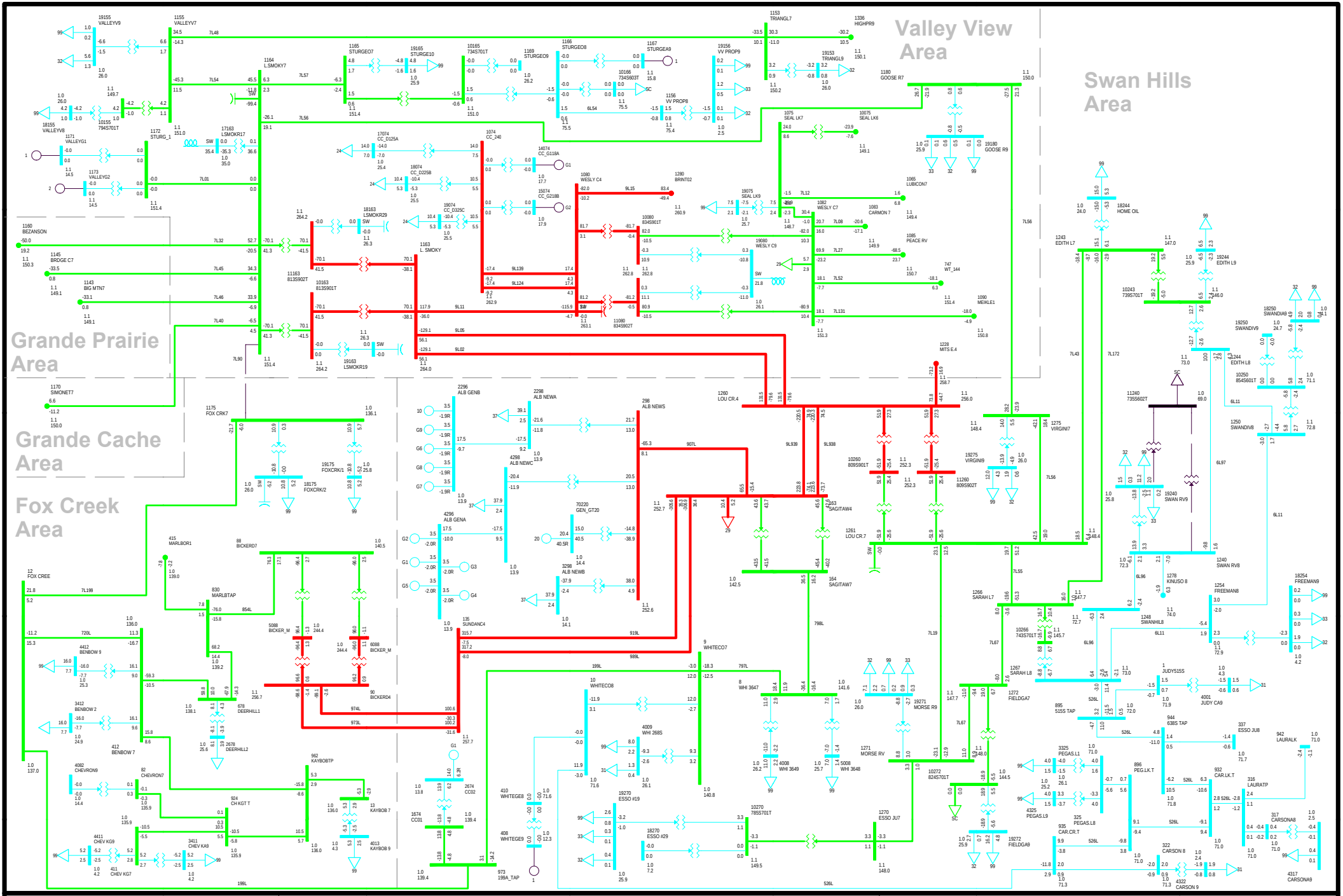
100.0%Rate A
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY A, N-G-0
2016WP PRE-CONNECTION
THU, APR 14 2016 11:34

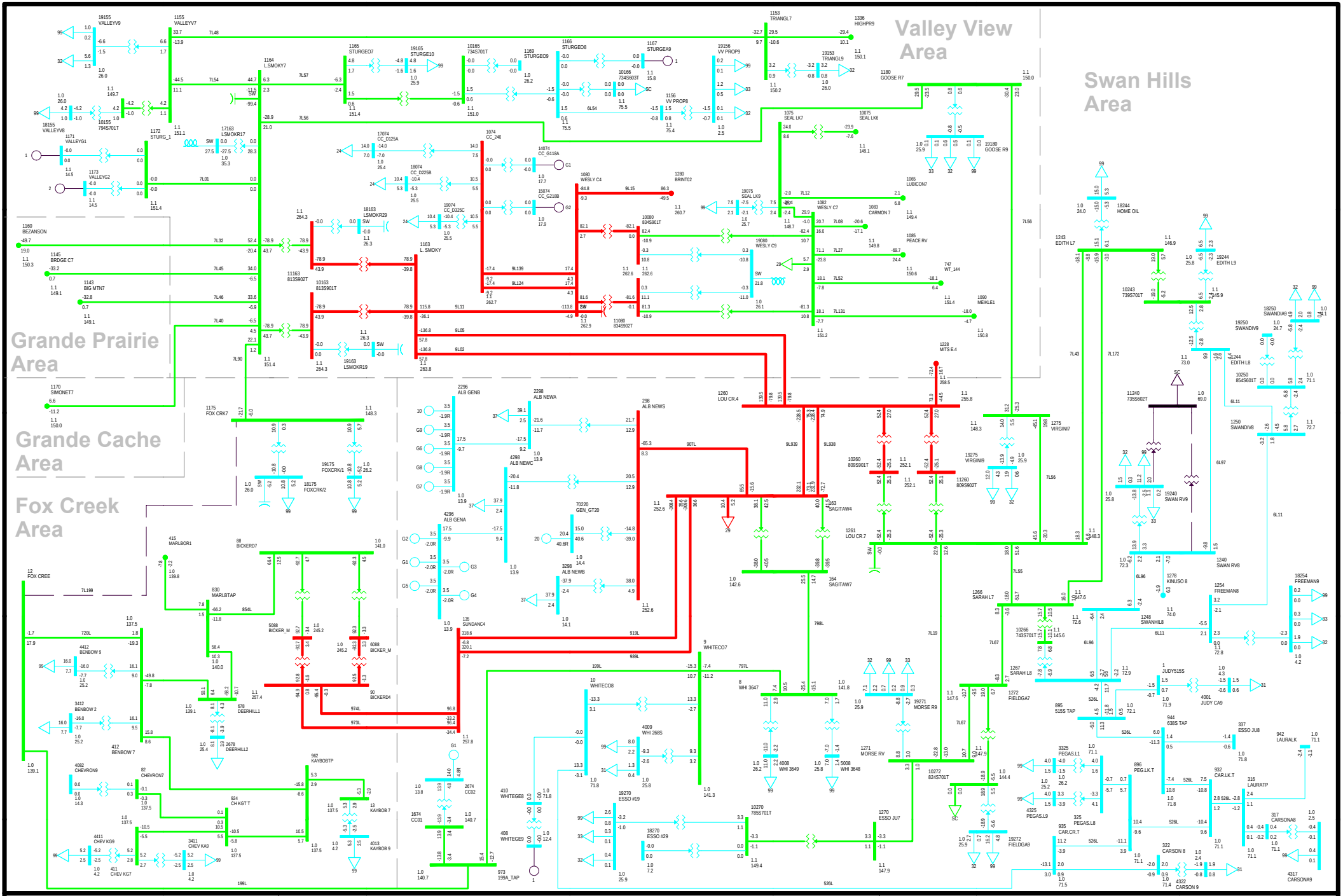
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L90
2016WP PRE-CONNECTION
THU, APR 14 2016 11:35

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L199
2016WP PRE-CONNECTION
THU, APR 14 2016 11:35

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.123OV 0.942UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000

ATTACHMENT B

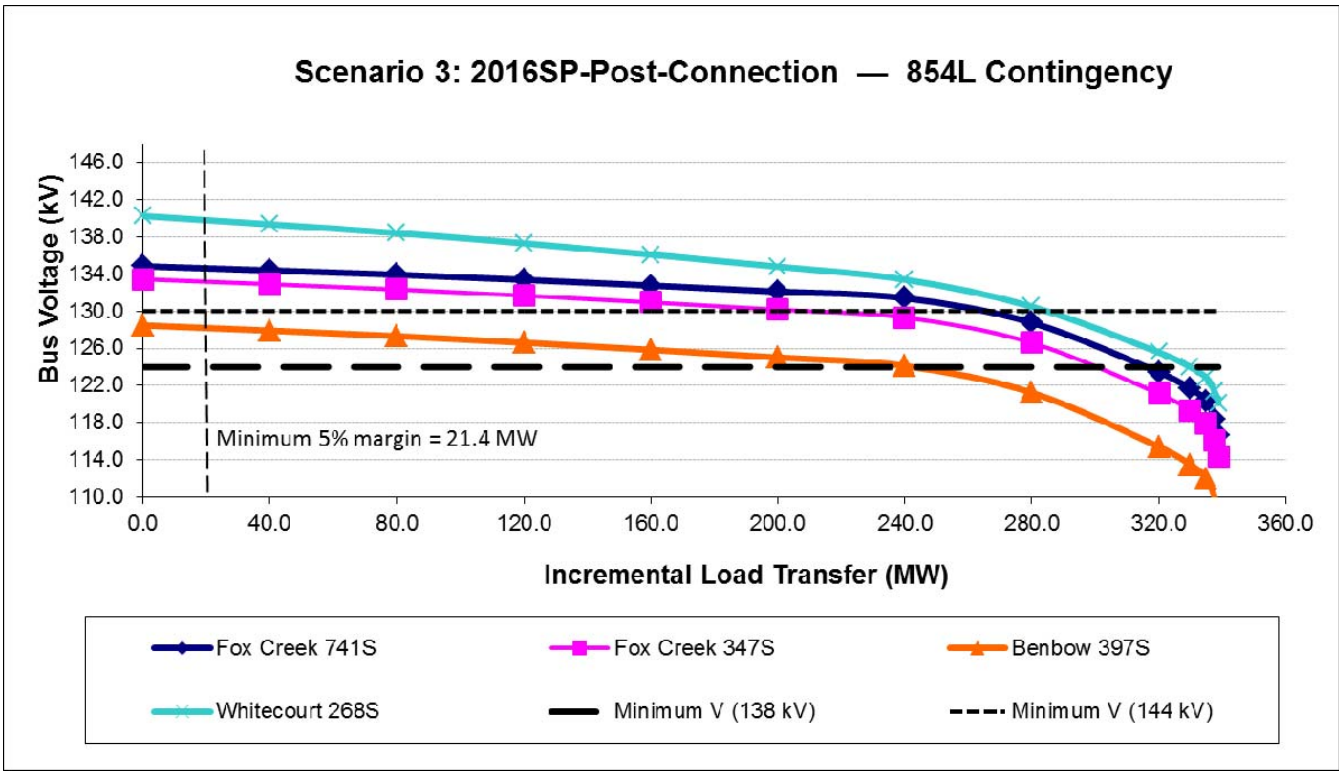
Post-Connection Alternative 1: Voltage Stability Analysis Results and System Power Flow Plots

B.1 Voltage Stability Analysis

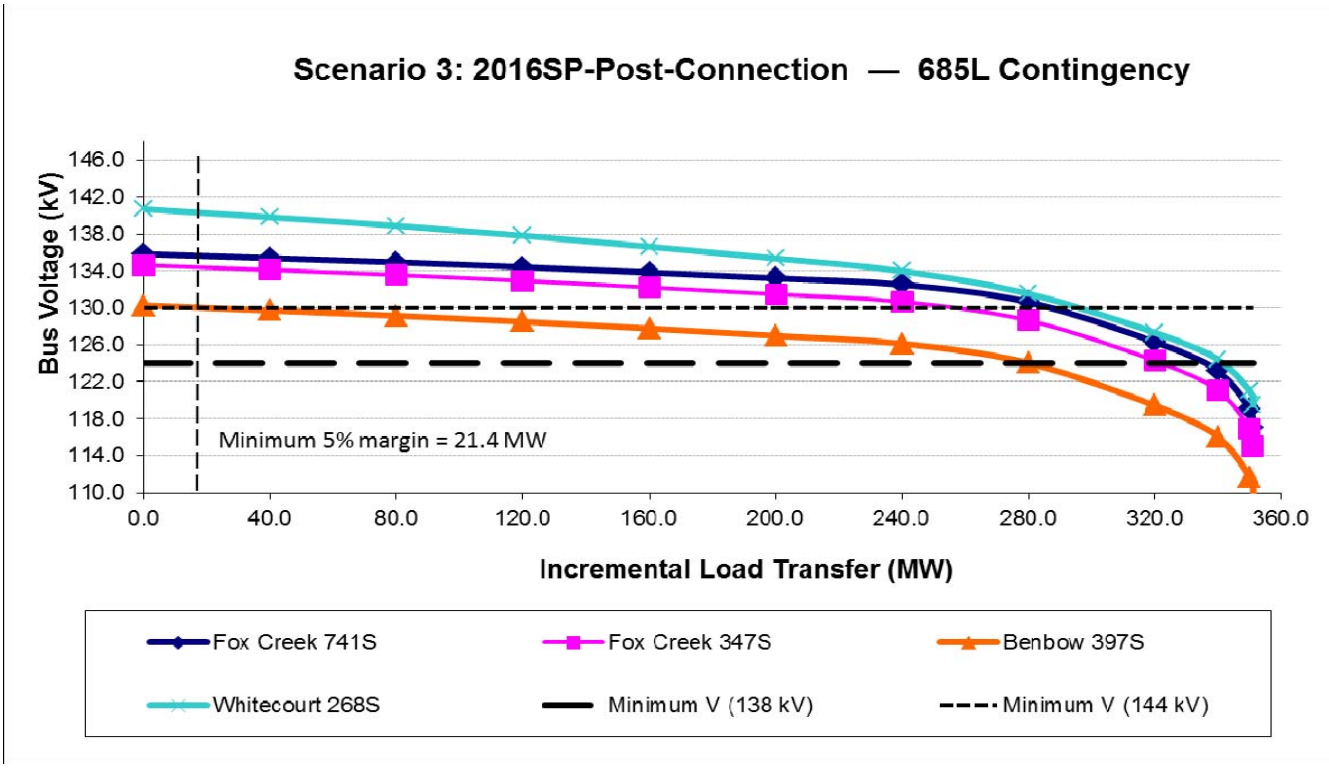
The voltage stability analysis was completed for the post-connection winter peak scenario (2016WP) and summer peak scenario (2016SP). The P-V graphs for the worst contingencies are provided below.

Figure B-1 shows the P-V curve for 854L, 685L and 907L contingencies in the post-connection for scenario 3 in 2016SP.

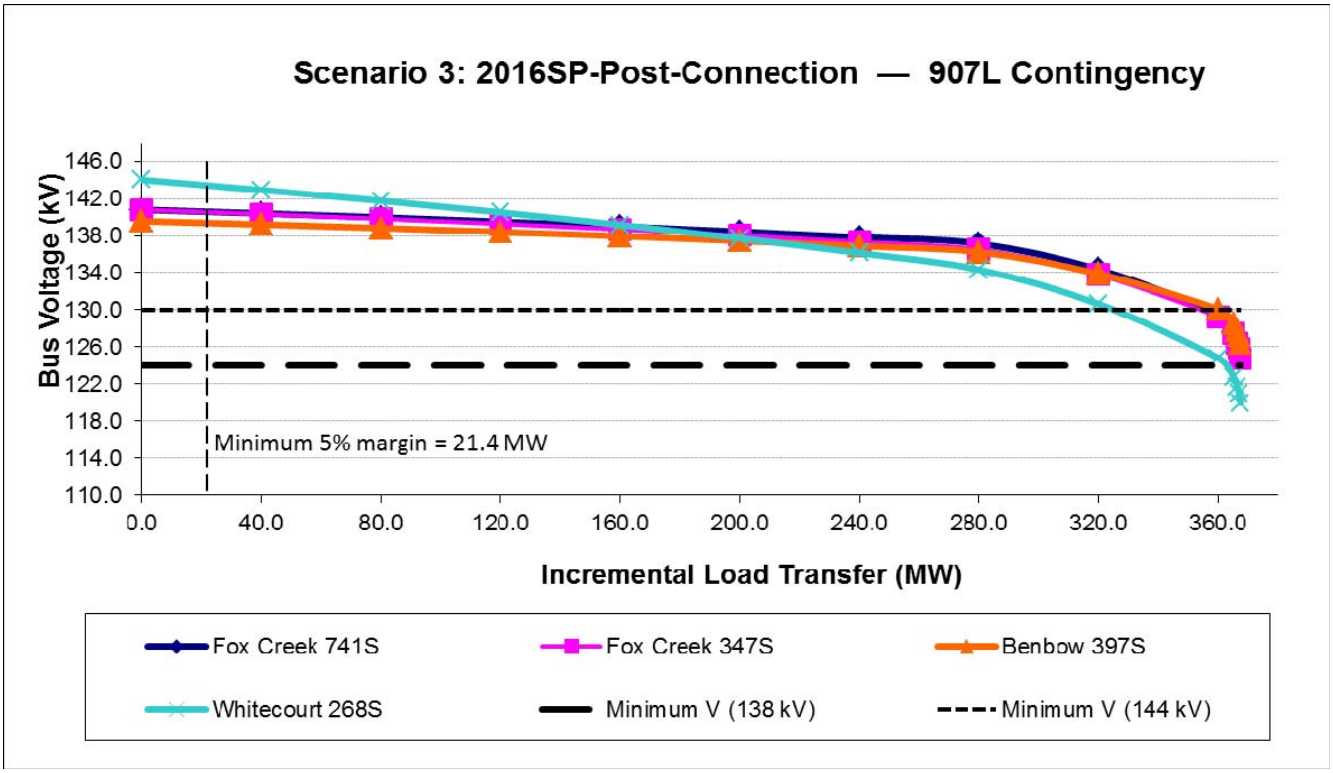
Figure B-1: P-V Curves for Scenario 3 – 2016SP Post-Connection



(a) 854L Contingency



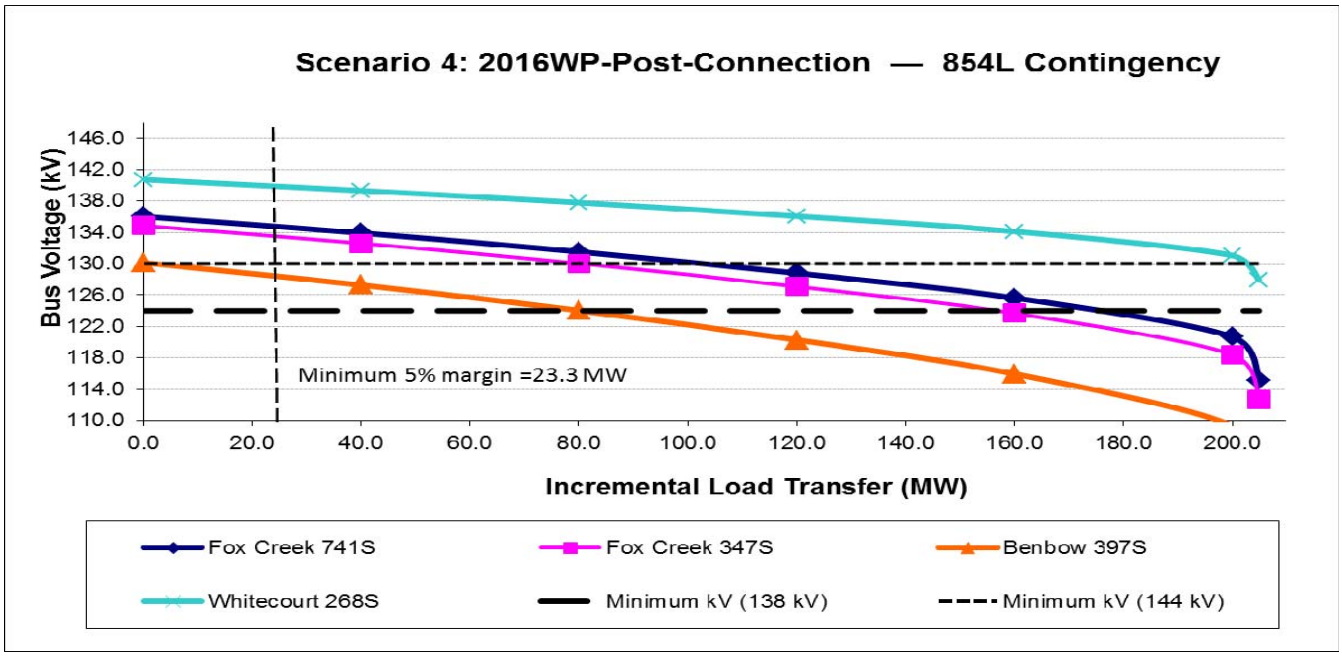
(b) 685L Contingency



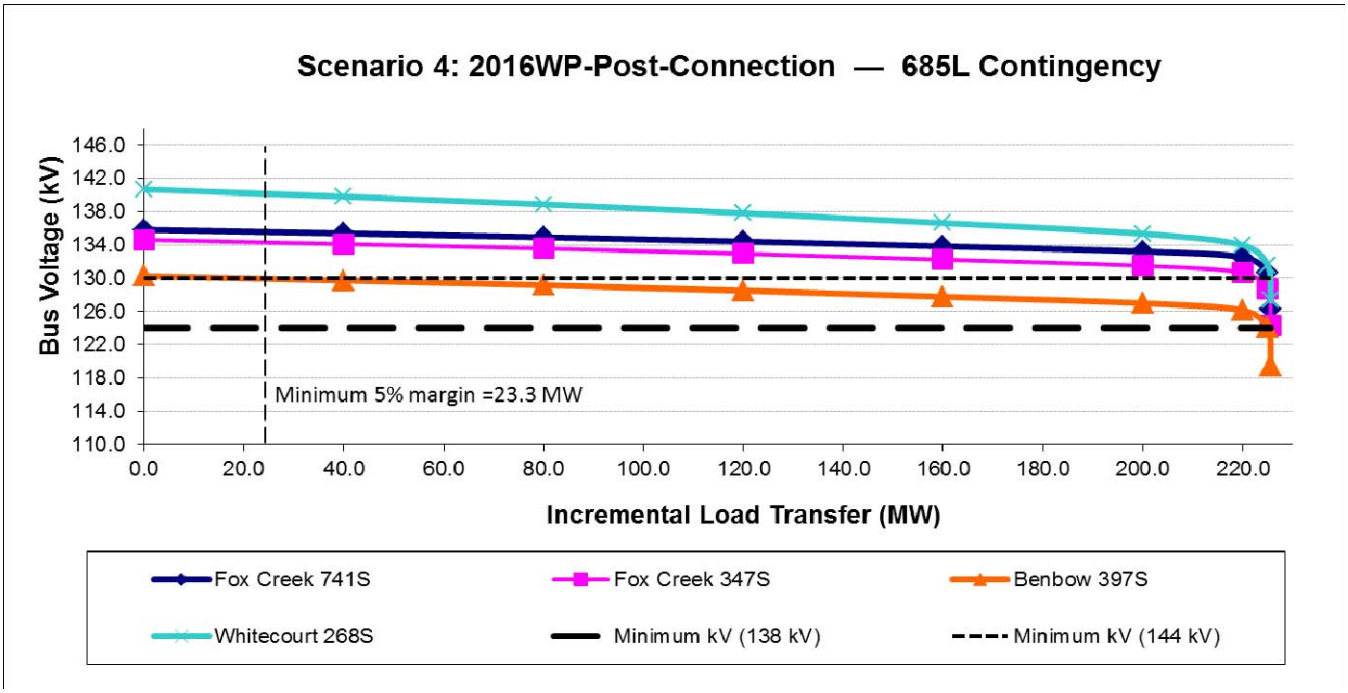
(c) 907L Contingency

Figure B-2 shows the P-V curve for 854L, 685L and 7L90 and contingencies in the post-connection for scenario 4 in 2016WP.

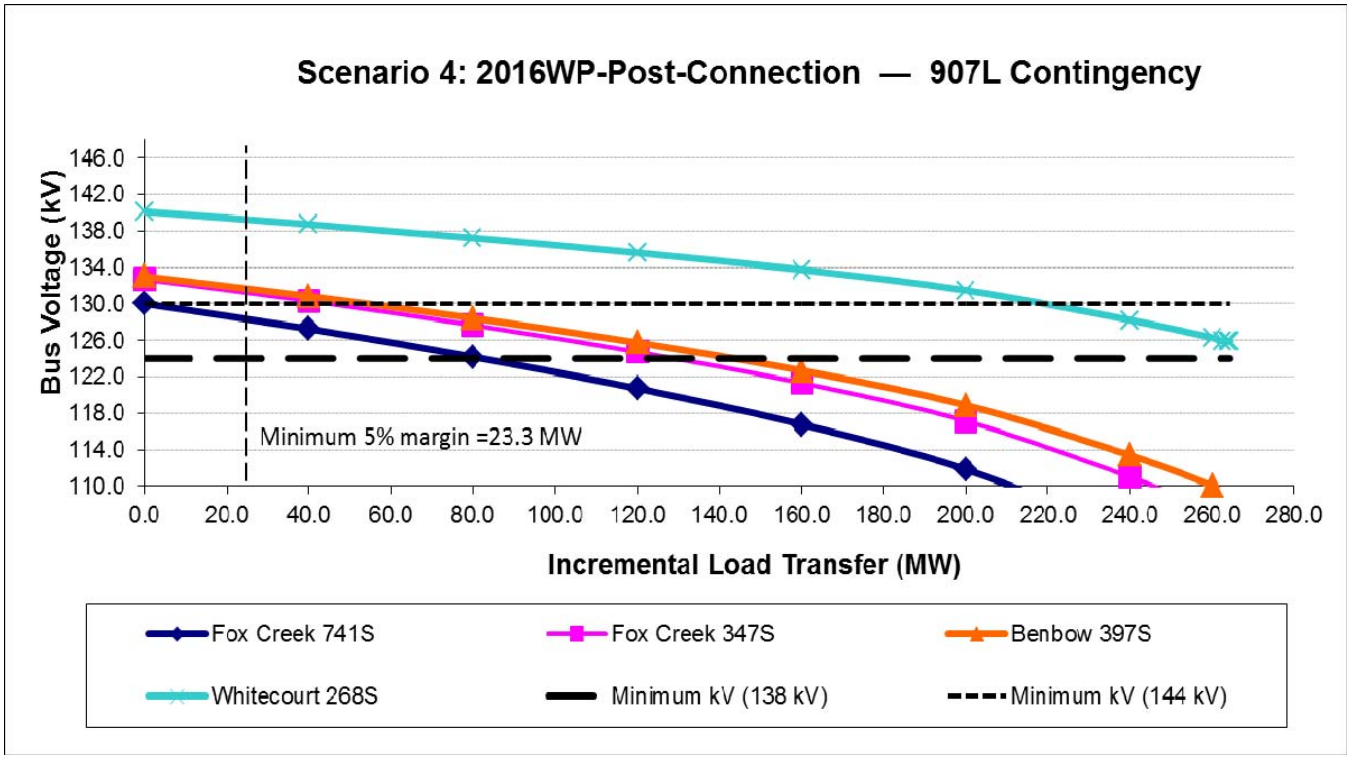
Figure B-2: P-V Curves for Scenario 4 – 2016WP Post-Connection



(a) 854L Contingency



(b) 685L Contingency

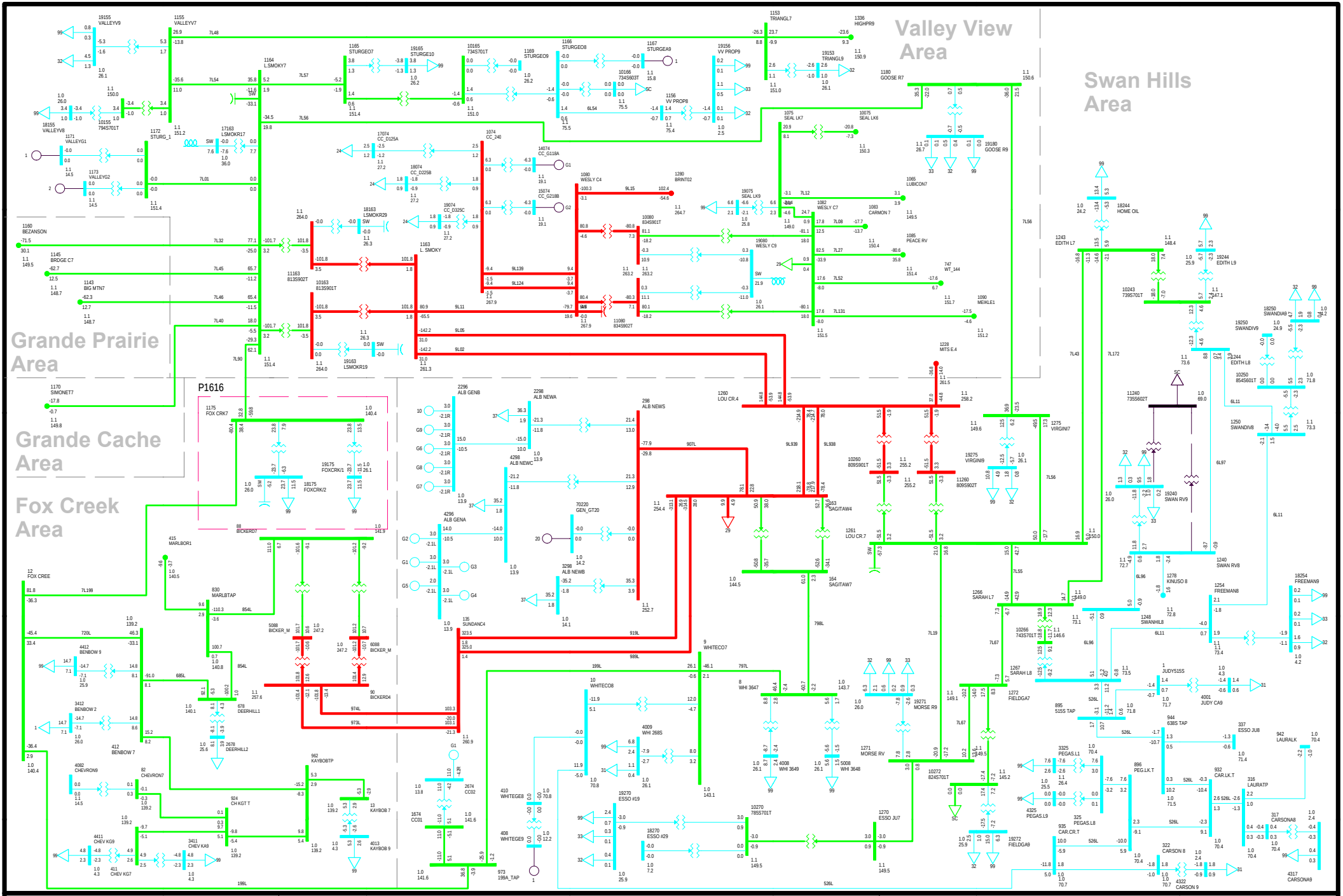


(c) 7L90 Contingency

B.2 Power Flow Diagrams

The post-connection power flow diagrams for Category A and B contingencies are provided in this section. The following table presents the list of the power flow diagrams. Please note that Whitecourt generator is turned off for the analyzed cases.

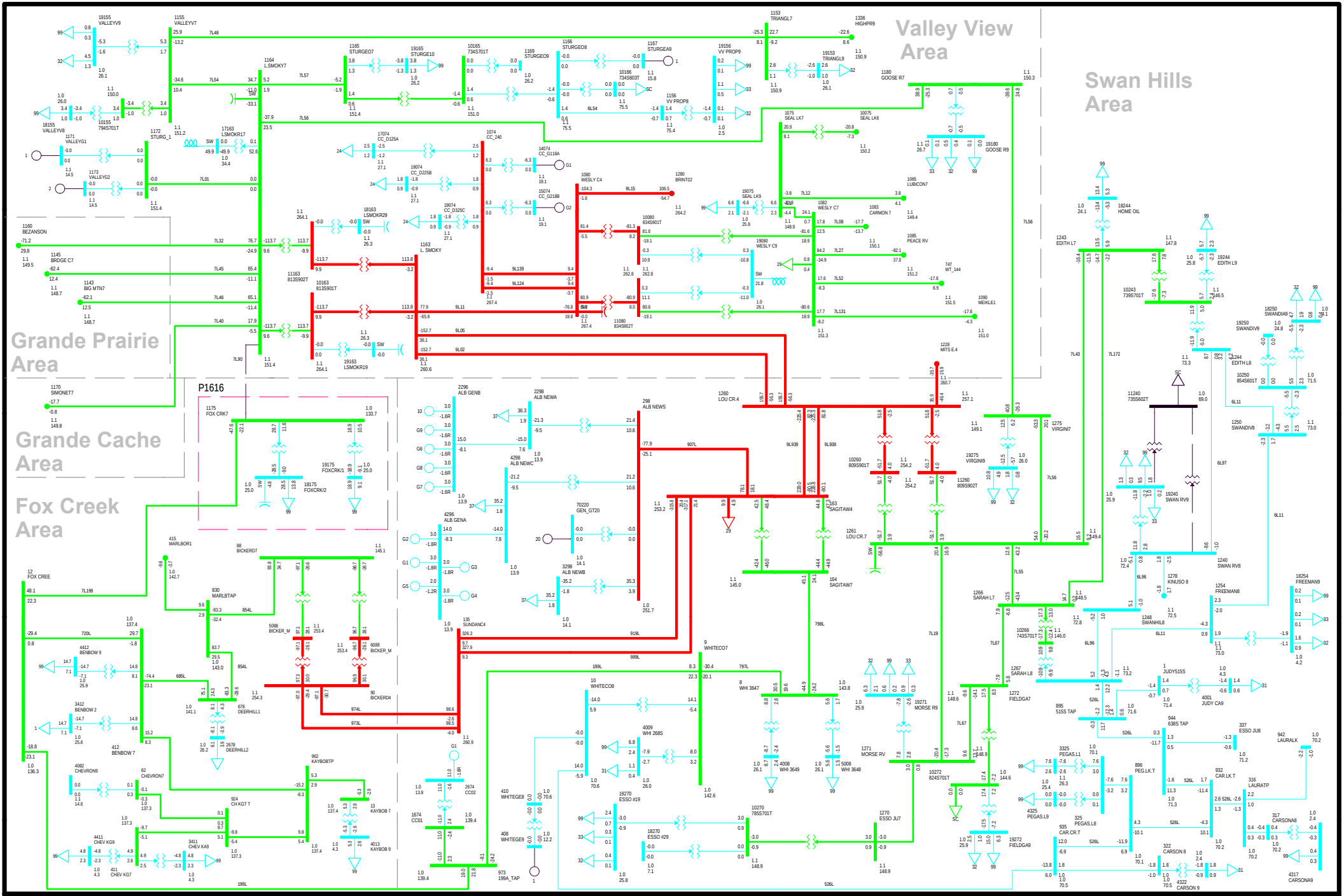
Table B-1: List of post-connection power flow diagrams



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY A, N- G-0
2016SP POST-CONNECTION
THU, APR 14 2016 12:41

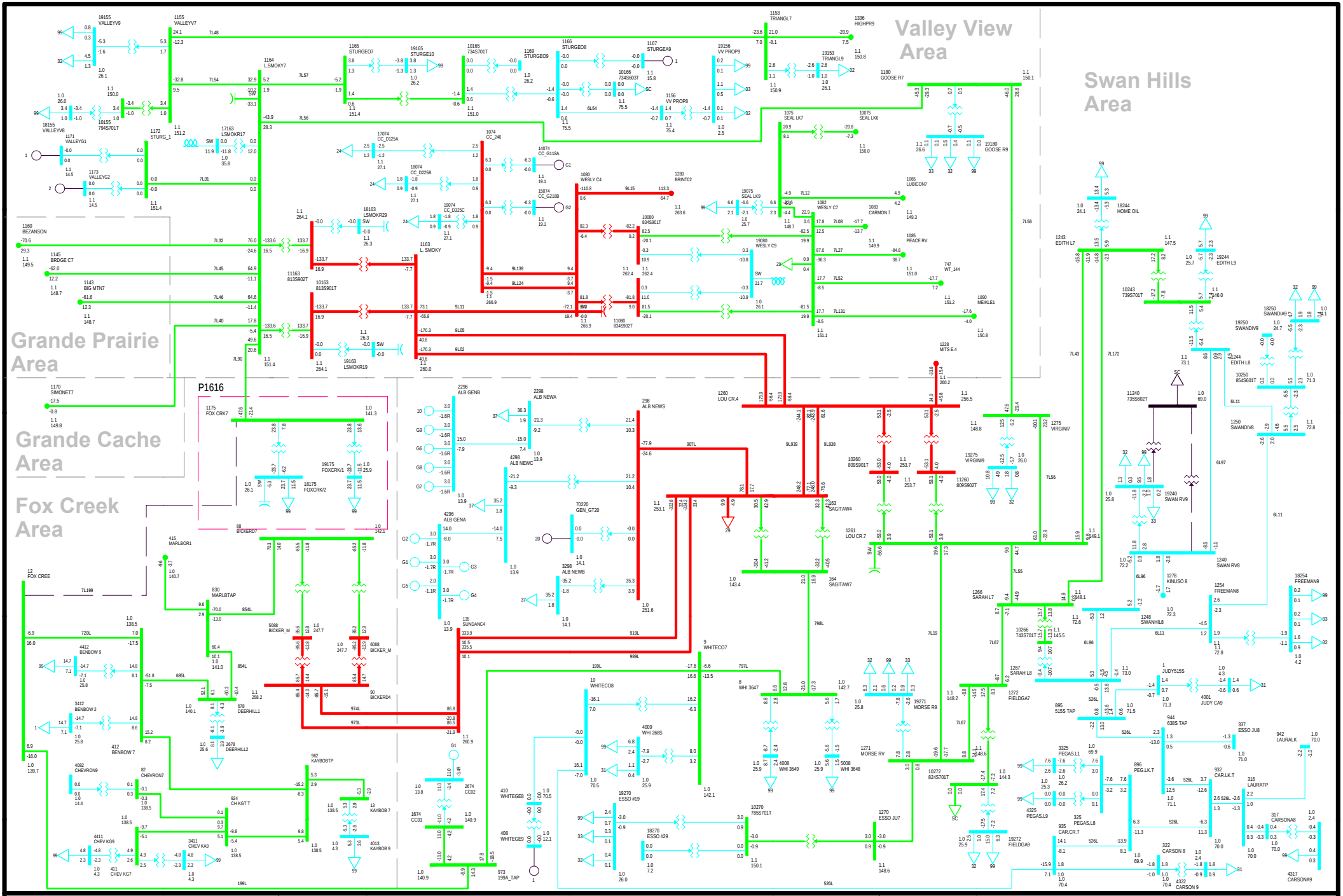
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L90
2016SP POST-CONNECTION
THU, APR 14 2016 13:25

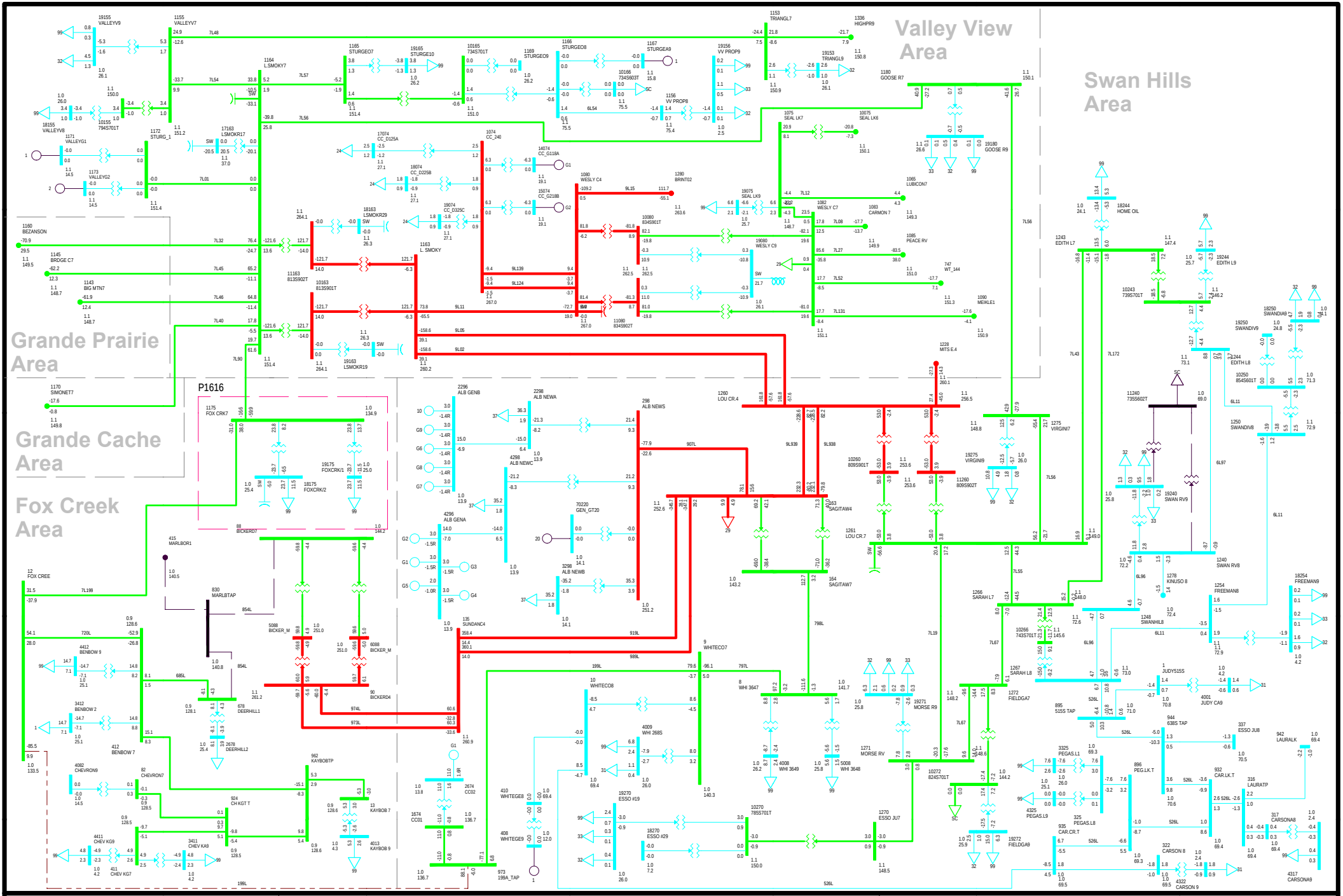
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.00



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L199
2016SP POST-CONNECTION
THU, APR 14 2016 12:41

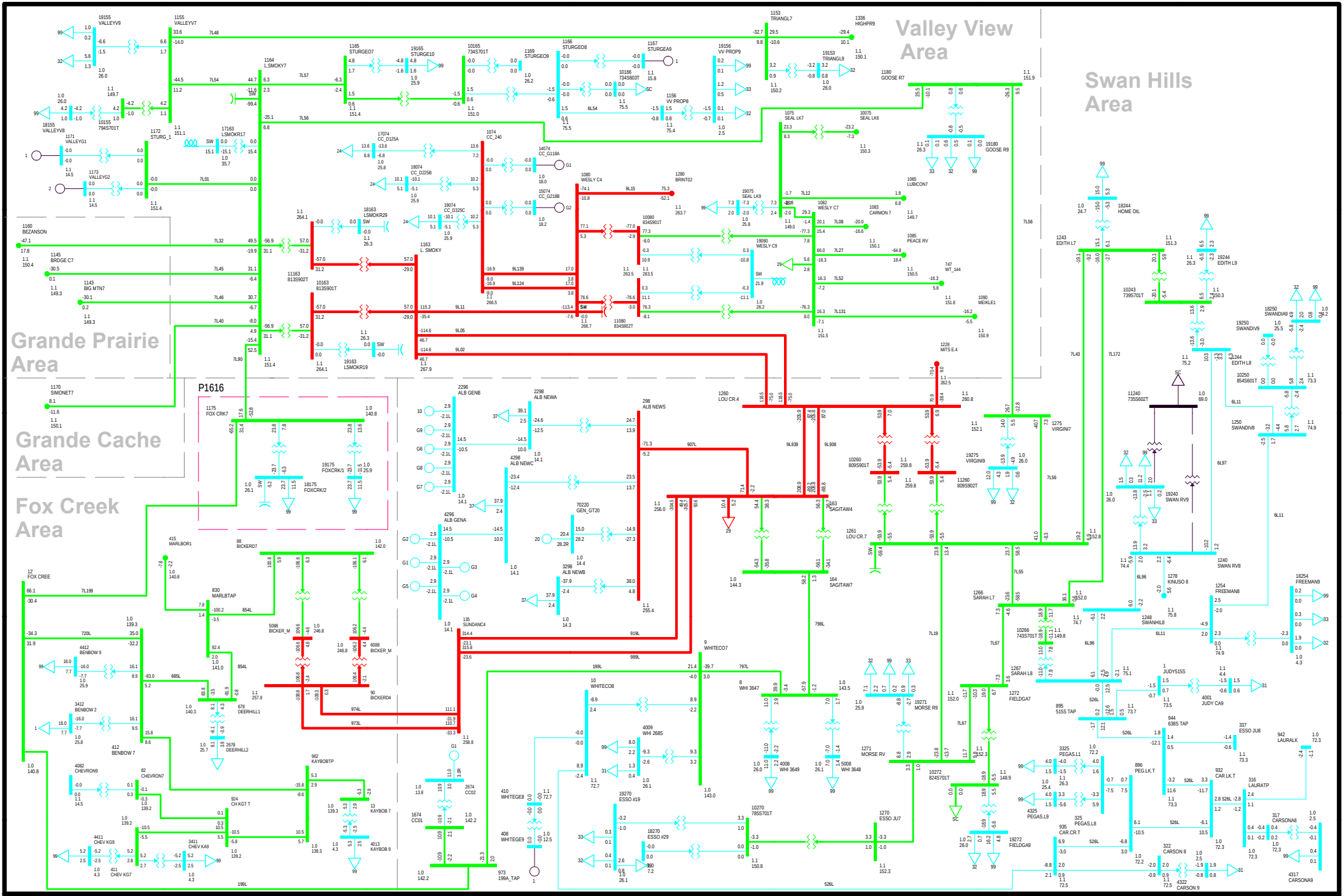
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 854L
2016SP POST-CONNECTION
THU, APR 14 2016 12:42

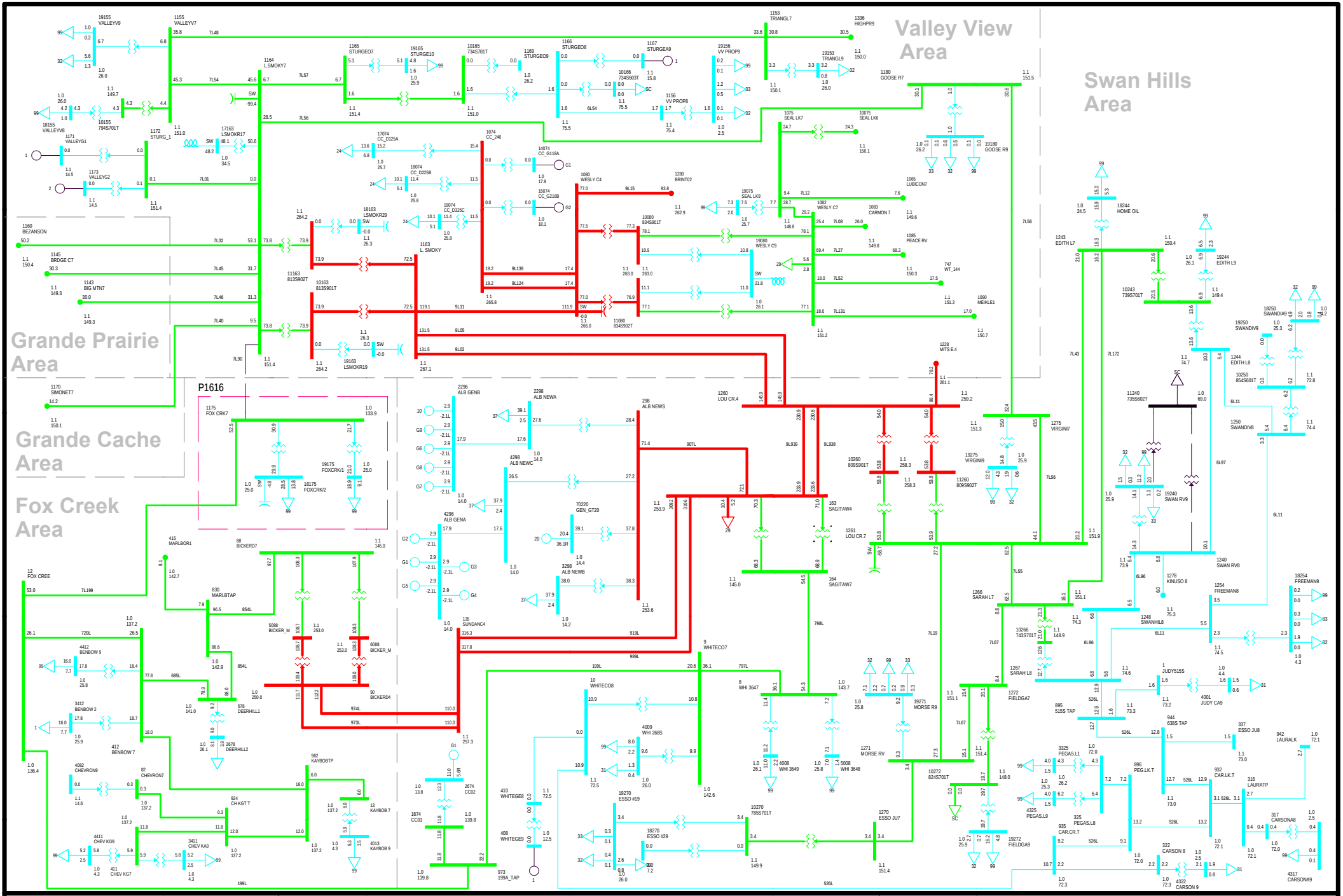
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY A, N -G-0
2016WP POST-CONNECTION
THU, APR 14 2016 12:42

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000

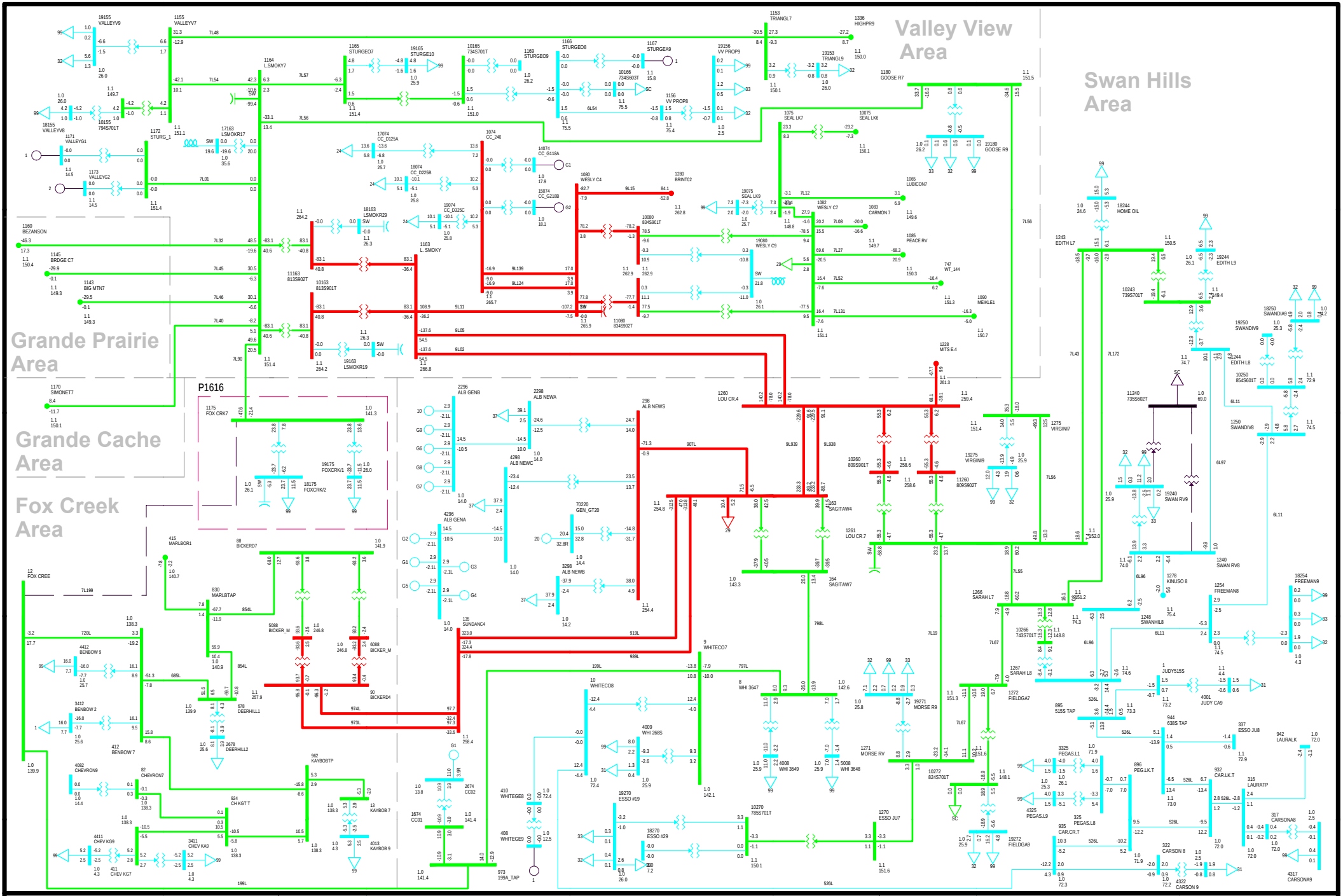


P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L90
2016WP POST-CONNECTION
THU, APR 14 2016 13:43

Bus - Voltage (kV/pu)
Branch - MVA
Equipment - MW/Mvar

100.0%Rate B
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000

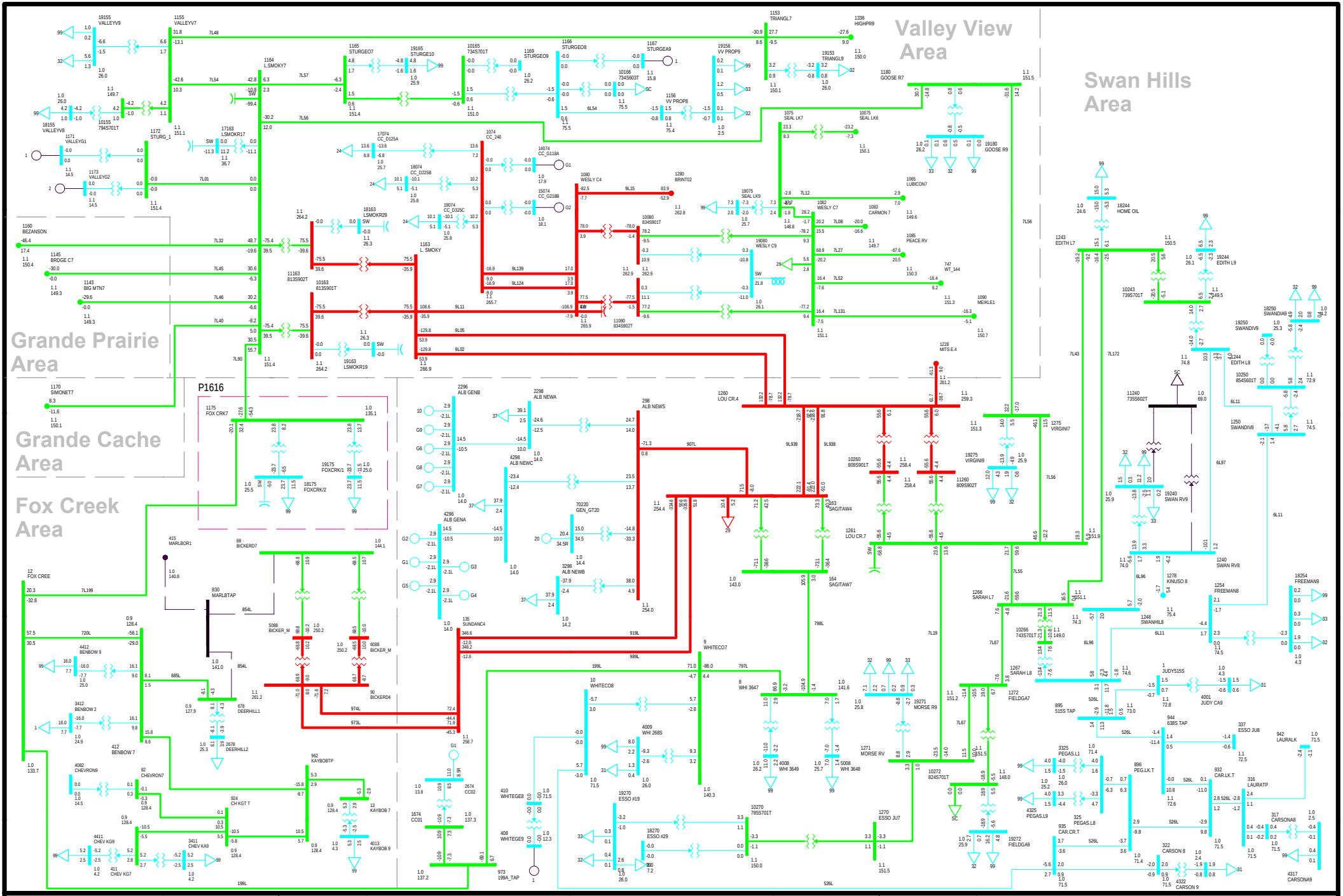


P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 7L199
2016WP POST-CONNECTION
THU, APR 14 2016 12:42

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar

100.0%Rate B
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P1616 - Fox Creek
25kV Breaker Addition

CATEGORY B, LOSS OF 854L
2016WP POST-CONNECTION
THU, APR 14 2016 12:42

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar

100.0%Rate B
1.123OV 0.899UV
kV: <=72.000 <=144.000 <=240.000 <=500.000 >500.000