Engineering Connection Assessment

P2741 Transmission Enhancements in the Fort McMurray Area

ATCO Electric Ltd.

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NOTE:

The conclusions and recommendations in this report are based on the results presented in *Appendix A: Engineering Connection Assessment: Study Results*, which was prepared by a third party consultant in accordance with the AESO Connection Process.

The AESO has reviewed the *Engineering Connection Assessment: Study Results*, and finds it acceptable for the purpose of assessing the potential impacts of the proposed connection on the performance of the Alberta interconnected electric system.

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1 Introduction

This AESO Engineering Connection Assessment describes the engineering studies that were completed to assess the impact of the Project (as defined below) on the performance of the Alberta interconnected electric system (AIES). This report also provides the AESO's conclusions and recommendations based on the results of the engineering studies.

An appendix to this Engineering Connection Assessment are the results of the engineering studies and the scope and methodology used to perform the studies (see Appendix A). These attachments provide details regarding the technical criteria, assumptions, and methods for performing these engineering studies, and the results of the engineering studies.

1.1 Project Overview

ATCO Electric Ltd., in its capacity as the legal owner of an electric distribution system (DFO), has submitted a request for system access service to the Alberta Electric System Operator (AESO) to serve an industrial load in the Fort McMurray area.

The DFO's request includes: a request for a new system access service in the area, with a staged Rate DTS, *Demand Transmission Service*, contract capacity of 5 MW in Dec. 2026, increasing to 51 MW in May 2027; and a request for transmission development (collectively, the Project).

The scheduled in-service date (ISD) for the Project is December 1, 2026.

2 Assessment Scope

2.1 Objectives

The objectives of the AESO Engineering Connection Assessment are as follows:

- Assess the impact of the Project on the performance of the AIES.
- Evaluate Project connection alternatives and identify the AESO's preferred alternative.
- Recommend mitigation measures, if required, to reliably connect the Project to the AIES.
- Identify Project dependencies, including any TFO projects or AESO plans to expand or enhance the transmission system that must be completed prior to connection.

2.2 Existing System

Geographically, the Project is located in the AESO planning area of Fort McMurray (Area 25), which is part of the AESO's Northeast planning region. Fort McMurray (Area 25) is surrounded by the planning areas of High Level (Area 18), Peace River (Area 19), High Prairie (Area 21), Swan Hills (Area 26), Athabasca/ Lac La Biche (Area 27), and Cold Lake (Area 28).

From a transmission system perspective, Fort McMurray consists primarily of 240 kV and 144 kV transmission systems. The Fort McMurray West 500 kV transmission line (12L41/12L44) connects the Fort McMurray area to Wabamun (Area 40).

Existing constraints in the Northeast 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).

2.3 Study Area

The Study Area for the Project consists of the AESO Planning area of Fort McMurray (Area 25), including the tie lines connecting this planning area to the rest of the AIES. All transmission facilities within the Study Area will be studied and monitored for violations of the Reliability Criteria (defined in Section 3.1 of Appendix A – A1: Engineering Connection Assessment Scope).

3 Connection Alternatives

3.1 Overview

The AESO, in consultation with the TFO in the Study Area and the DFO, examined 6 transmission alternatives to meet the DFO's request for system access service, as detailed in Section 3.2.[1]

3.2 Connection Alternatives Examined

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

Alternative 1 – New Point of Delivery with a T-tap connection to the 240 kV transmission line 9L74

This alternative includes the following developments:

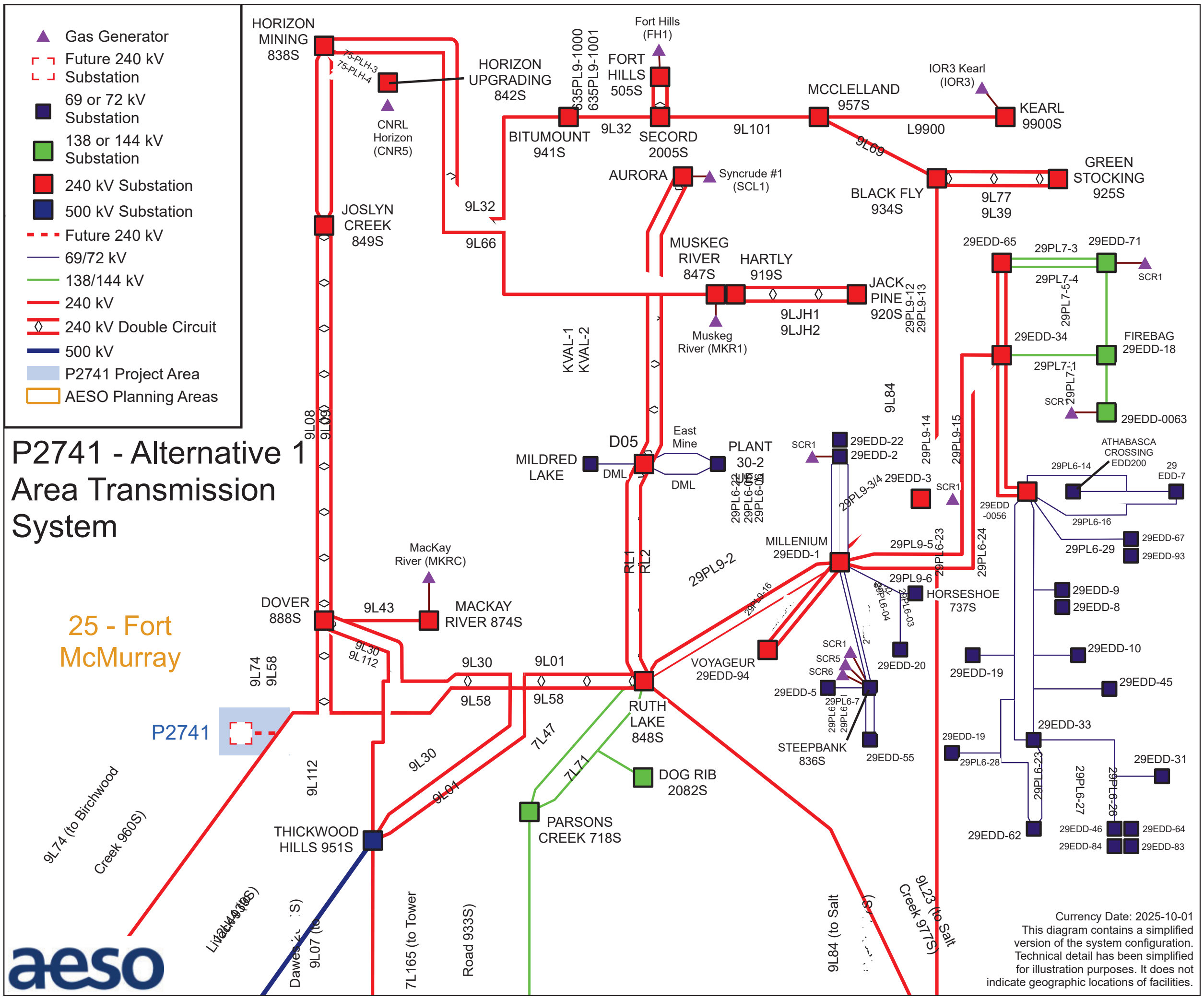
- Add a new 240/25 kV Point of Delivery (POD) substation, designated as Armistead 2102S, including two 240 kV circuit breakers and two 240/25 kV transformers;
- Add one 240 kV circuit, approximately 0.4 kilometers (km)[2] in length, to connect the proposed Armistead 2102S substation to the existing 240 kV transmission line 9L74 using a T-tap configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-1.

[1] These alternatives reflect more up to date engineering design than the alternatives identified in ATCO *Distribution Deficiency Report*, which is filed under a separate cover.

[2] Exact line length to be determined by the TFO.

Figure 3-1: Connection Alternative 1



Alternative 2 – New POD with an In-and-Out connection to the 240 kV transmission line 9L74

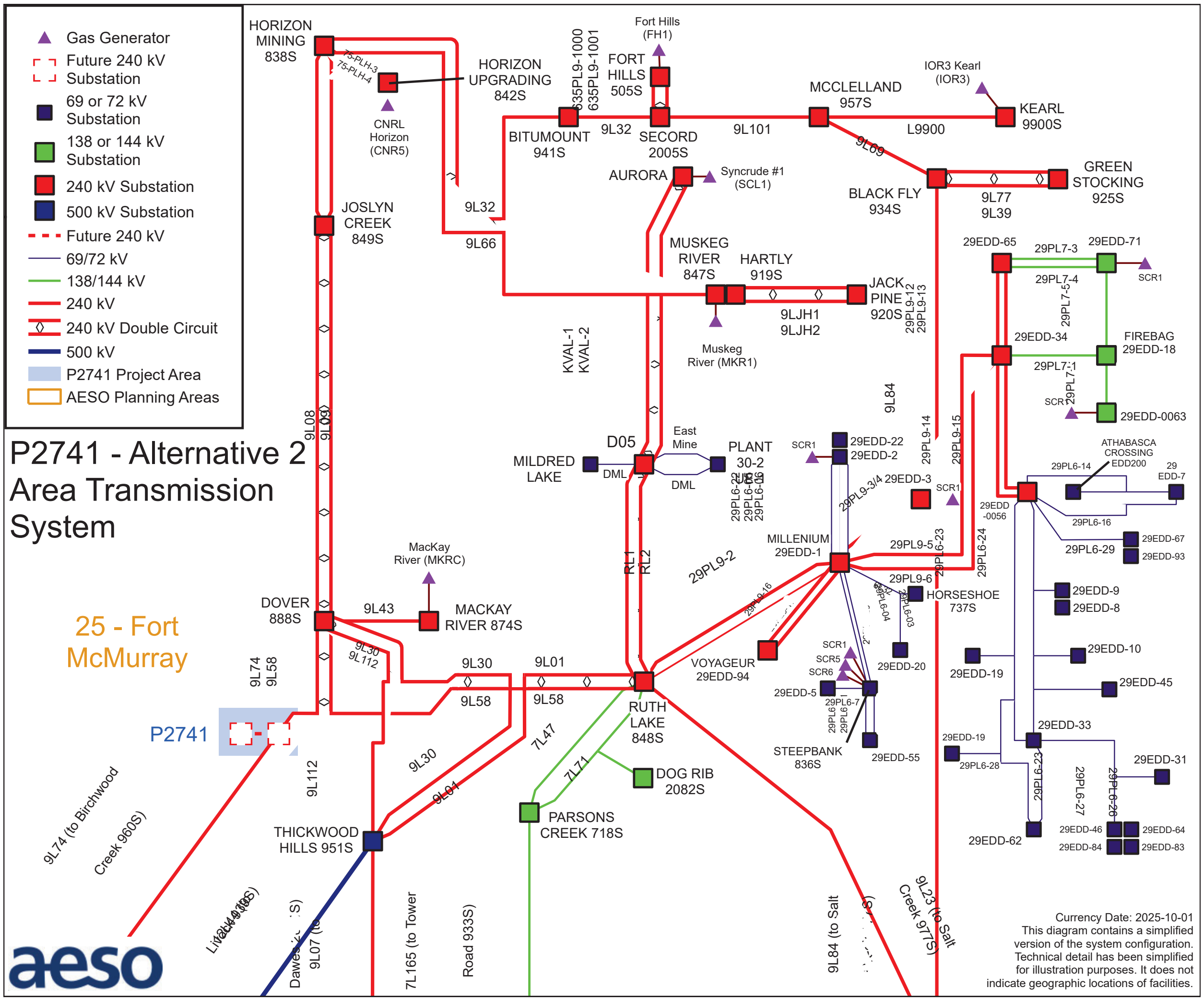
This alternative includes the following developments:

- Add a switching substation, including three 240 kV circuit breakers, to be connected to the existing 240 kV transmission line 9L74 using an in-and-out configuration;
- Add a new 240/25kV POD substation, designated as Armistead 2102S, including two 240 kV circuit breakers and two 240/25 kV transformers;
- Add one 240 kV circuit, approximately 0.4 km[3] in length, to connect the proposed Armistead 2102S substation to the proposed 240 kV substation using a radial configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-2

[3] Exact line length to be determined by the TFO

Figure 3-2: Connection Alternative 2



Alternative 3 – New POD with a T-tap connection to the 240 kV transmission line 9L58

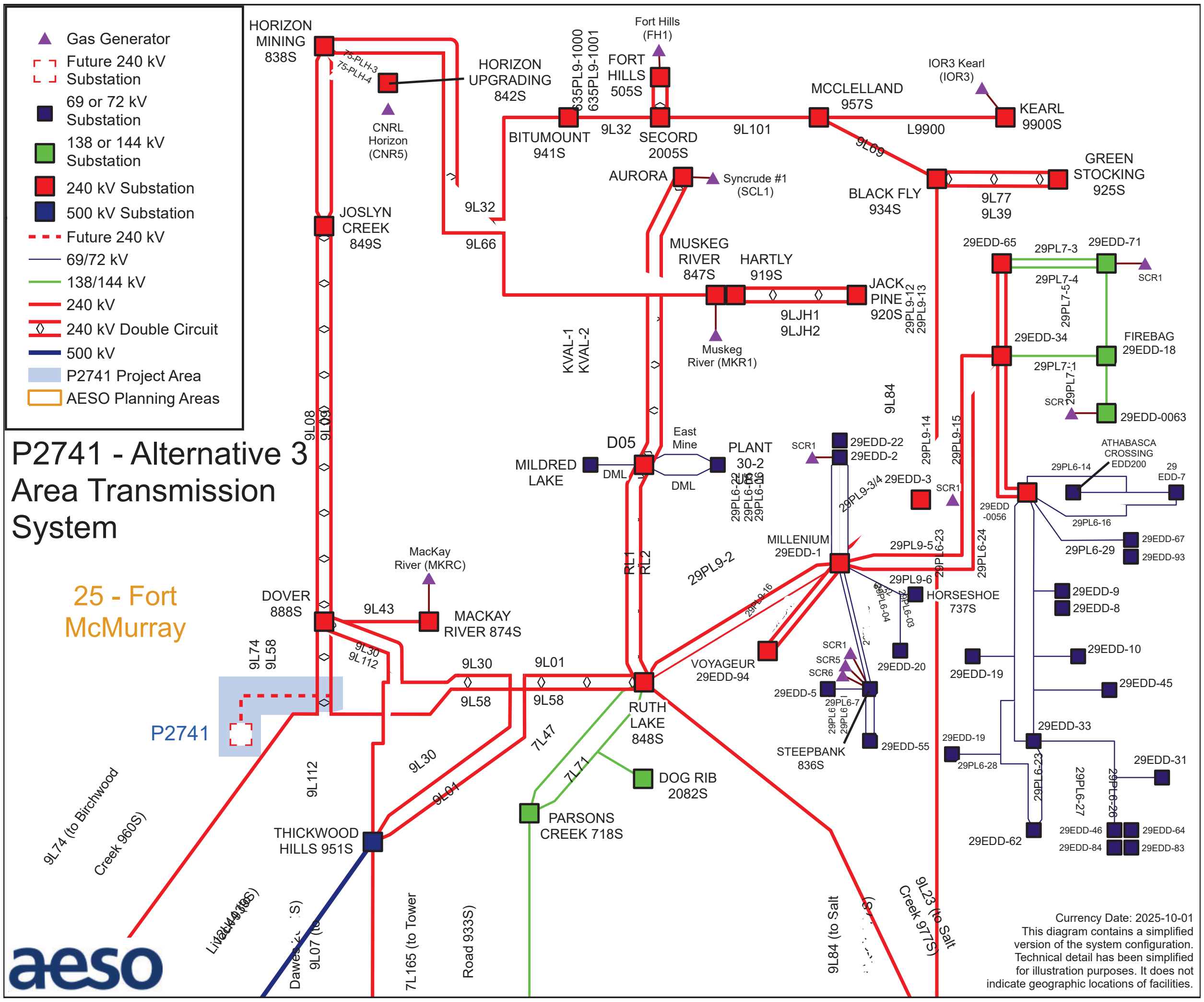
This alternative includes the following developments:

- Add a new 240/25kV POD substation, designated as Armistead 2102S, including two 240 kV circuit breakers and two 240/25 kV transformers;
- Add one 240 kV circuit, approximately 4 km[4] in length, to connect the proposed Armistead 2102S substation to the existing 240 kV transmission line 9L58 using a T-tap connection configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-3.

[4] Exact line length to be determined by the TFO

Figure 3-3: Connection Alternative 3



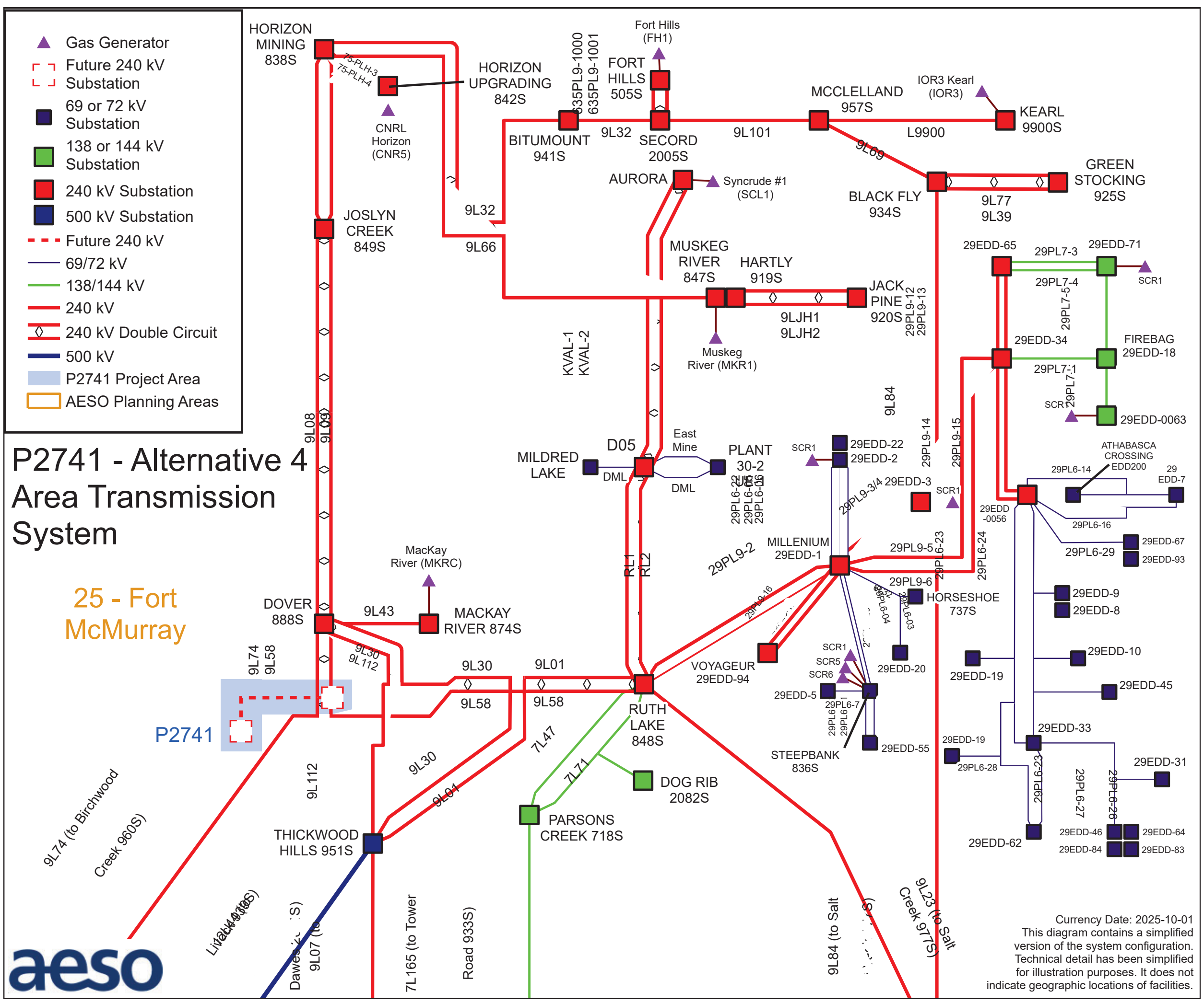
Alternative 4 – New POD with an In-and-Out connection to the 240 kV transmission line 9L58

This alternative includes the following developments:

- Add a switching substation, including three 240 kV circuit breakers, connected to the existing 240 kV transmission line 9L58 using and in-and-out configuration;
- Add a new 240/25kV POD substation, designated as Armistead 2102S, including two 240 kV circuit breakers and two 240/25 kV transformers;
- Add one 240 kV circuit, approximately 4 km[5] in length, to connect the proposed Armistead 2102S substation to the proposed 240 kV substation using a radial configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-4.

Figure 3-4: Connection Alternative 4



[5] Exact line length to be determined by the TFO

Alternative 5 – New POD with a radial connection to the Dover 888S substation

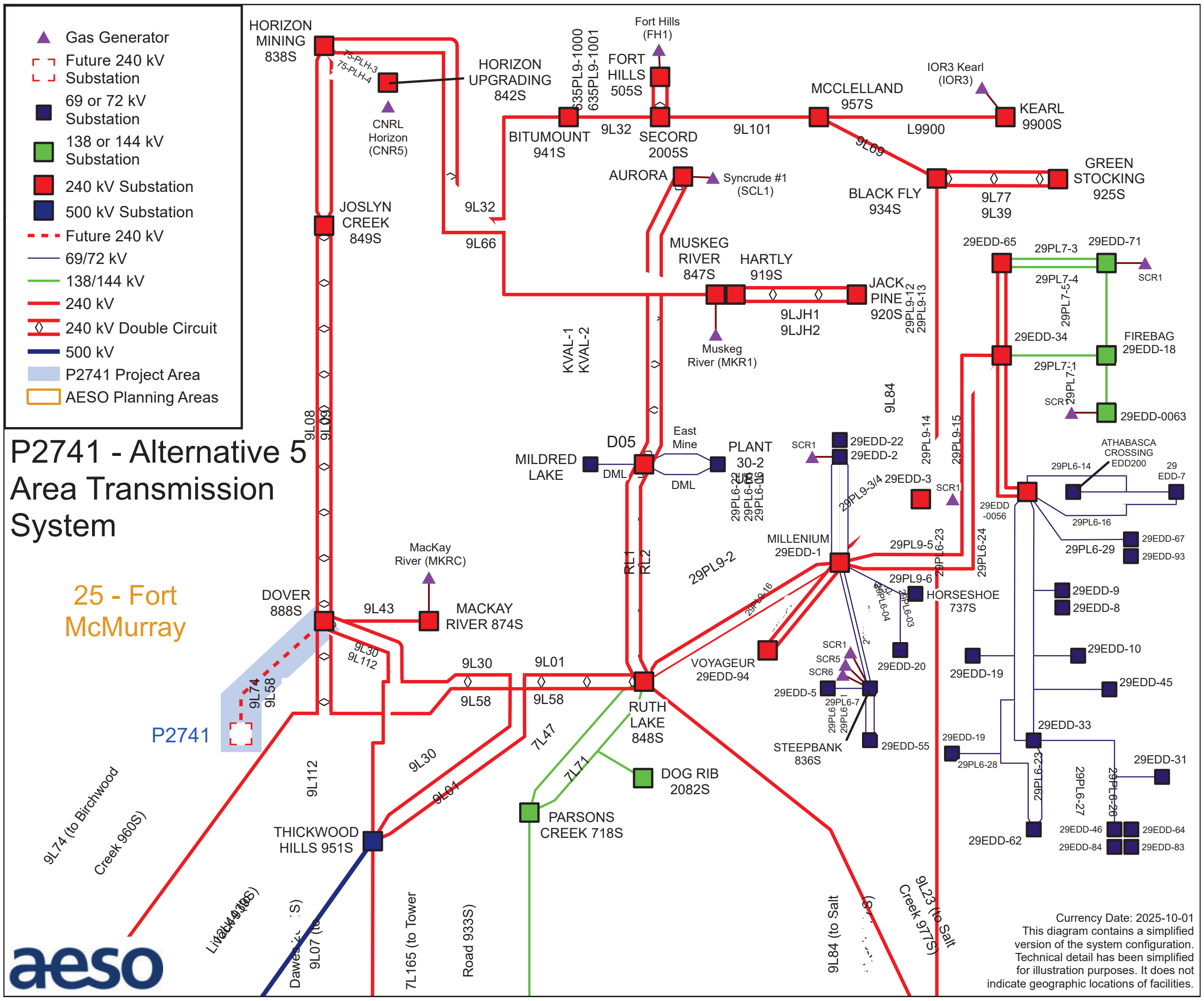
This alternative includes the following developments:

- Add a new 240/25kV POD substation, designated as Armistead 2102S, including one 240/25 kV transformer and one 240 kV circuit breaker;
- Add one 240 kV circuit, approximately 20 km[6] in length, to connect the proposed Armistead 2102S substation to the existing Dover 888S using a radial configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-5.

[6] Exact line length to be determined by the TFO

Figure 3-5: Connection Alternative 5



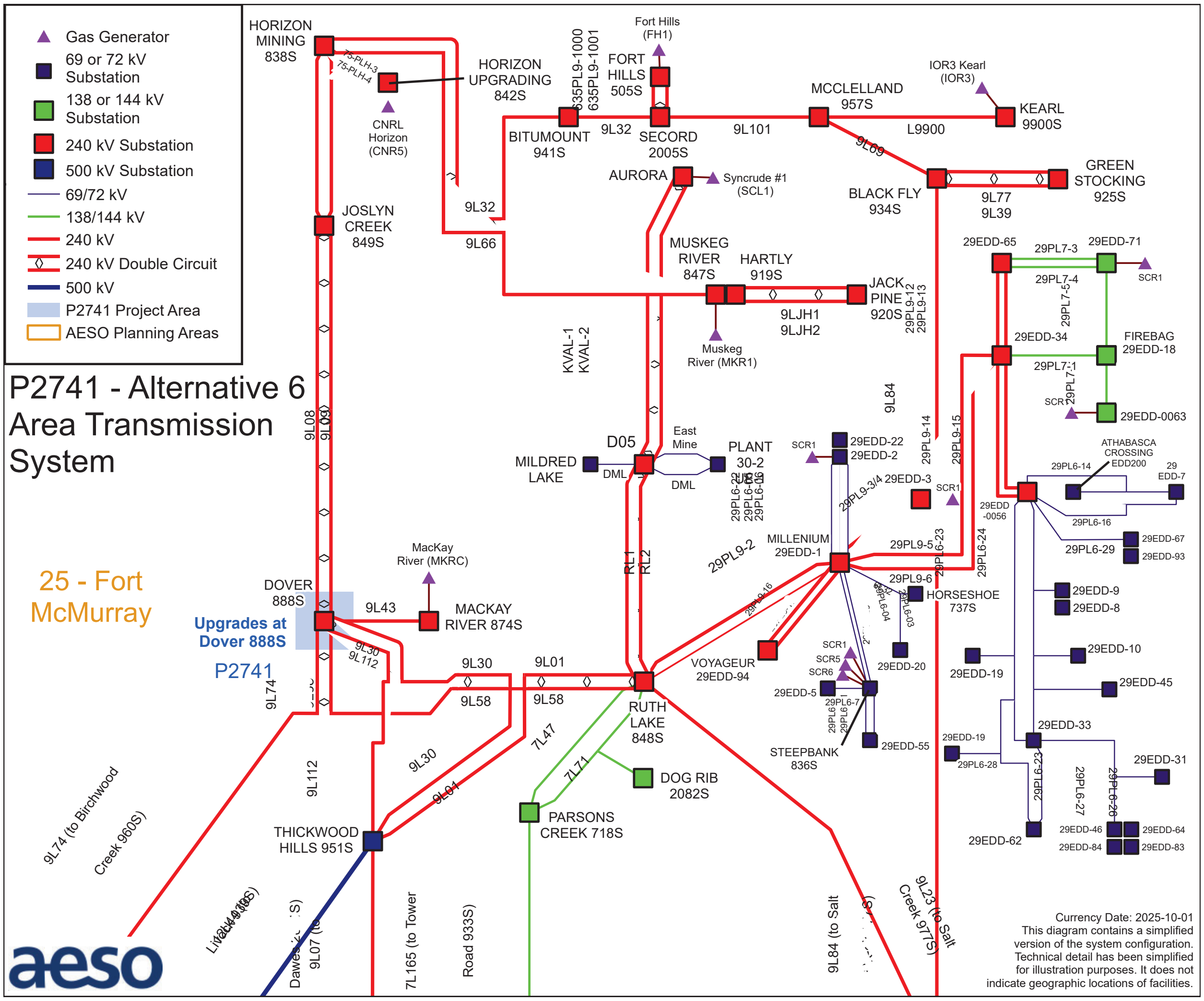
Alternative 6 – Upgrade the Dover 888S substation

This alternative includes the following developments:

- Upgrade the existing Dover 888S substation, including adding two 240/25kV transformers and two 240 kV circuit breakers; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-6.

Figure 3-6: Connection Alternative 6



3.3 Connection Alternatives Selected for Further Study

Alternative 1 is considered technically feasible and was selected for further study.

3.4 Connection Alternatives Not Selected for Further Study

Alternatives 2, 3, 4, and 5 would involve increased transmission development and hence, increased cost, compared to Alternative 1. Therefore, Alternatives 2, 3, 4, and 5 are not selected for further study.

DFO has advised that alternative 6 would results in violations to the ATCO DFO Planning Criteria. Therefore, Alternative 6 is not selected for further study.

4 Assessment Approach

4.1 Standards, Criteria and Assumptions

A detailed description of the standards, criteria, and assumptions that were used for the connection assessment is provided in Appendix A.

4.2 Studies Performed

The scheduled ISD for the Project is December 1, 2026. Therefore, studies were performed using scenarios for 2028 Summer Peak (SP) and 2028 Winter Peak (WP).

Short-circuit studies were performed using the 2028 SP pre-Project scenario, 2028 SP and 2033 Winter Peak (WP) post-Project scenarios.

Table 4-1 lists the study scenarios. Post-Project scenarios reflect the requested final Rate DTS contract capacity of 51 MW at the proposed Armistead 2102S substation.

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	Project Load (MW)	Project Generation (MW)
Pre-Project					
1	2028 Summer Peak (SP)	Low Generation (LG)	2028 SP LG Pre-Project	0	0
2	2028 Winter Peak (WP)	LG	2028 WP LG Pre-Project	0	0
Post-Project					
3	2028 SP	LG	2028 SP LG Post-Project	51	0
4	2028 WP	LG	2028 WP LG Post -Project	51	0
5	2033 WP	LG	2033 WP LG Post -Project	51	0

The AESO Planning Region load forecasts used for the connection studies were based on the *AESO's 2023 Preliminary Long-term Outlook* (2023 LTO).

While the AESO has updated its regional forecasts since the connection studies were performed, the use of the current AESO forecast, the 2024 Long-term Outlook (2024 LTO), would not materially alter the connection study results or affect the conclusions and recommendations in this report.

4.2.1 Power Flow Studies

The purpose of the power flow studies is to identify and quantify any thermal and voltage criteria violations in the Study Area.

In addition, power flow studies are also used to identify point of delivery (POD) low voltage bus voltage deviations beyond the limits listed in Table 3-1 of Appendix A – A1: Engineering Connection Assessment Scope.[7]

Power flow studies were performed for 2028 SP and 2028 WP pre-Project scenarios, and for 2028 SP and 2028 WP post-Project scenarios.

4.2.2 Voltage Stability Studies

The purpose of the voltage stability studies is to determine the ability of the transmission system to maintain voltage stability at the busses in the Study Area.

Voltage stability studies were performed for 2028 SP and 2028 WP post-Project scenarios.

4.2.3 Short-Circuit Current Level Studies

The purpose of short-circuit current level studies is to determine the expected system short-circuit current levels in the vicinity of the Project.

Short circuit studies were performed for the 2028 WP pre-Project scenario and for 2028 WP and 2033 WP post-Project scenarios.

4.3 Mitigation Measure Development and Evaluation

As explained in Appendix A, mitigation measures were developed to address system performance issues that were identified in the post-Project scenarios. Studies performed to assess the effectiveness of mitigation measures are briefly outlined below.

4.3.1 Post-Mitigation Studies

Power flow studies were performed to assess the impact of the Project on the performance of the AIES following implementation of the AESO's proposed mitigation measures.

[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 3-1 of Appendix A - Engineering Connection Assessment Scope does not represent a Reliability Criteria violation. Mitigation measures would not be developed to specifically address POD bus voltage deviations that exceed the desired values in Table 3-1 of Appendix A.

5 Interpretation of Results

5.1 Results Overview

This section provides an assessment of the impact of the Project on the performance of the AIES. The Reliability Criteria violations observed during the connection assessment studies, and the proposed mitigation measures are summarized in Attachment A.

- Section 5.2 includes an overview of the pre-Project studies results.
- Section 5.3 includes an overview of the post-Project studies results.
- Section 5.4 includes an overview of the post-mitigation studies results.

Detailed study results are provided in Appendix A.

5.2 Pre-Project Study Results

5.2.1 Category A Conditions

No Reliability Criteria violations were observed under the Category A conditions (i.e., all elements in service) for any of the pre-Project scenarios.

The short-circuit fault levels were found to be within the typical capabilities of the nearby facilities.

5.2.2 Category B Conditions

The pre-Project power flow studies identified voltage range violations under Category B conditions (i.e., loss of a single system element); see Attachment A for details.

In addition, under Category B conditions, voltage deviations were observed that were beyond the limits listed in Table 3-1 of Appendix A – A1: Engineering Connection Assessment Scope at point-of-delivery (POD) low voltage busses (subsequently referred to as POD bus voltage deviations). See Attachment A for details.

5.3 Post-Project Study Results

5.3.1 Category A Conditions

No Reliability Criteria violations were observed under Category A conditions for any pre-Project scenarios. Post-Project short-circuit fault levels were not significantly higher than pre-Project levels.

The long term short circuit levels were found to be within the designed capabilities of the nearby facilities.

Post-Project short-circuit fault levels were not significantly higher than pre-Project levels.

5.3.2 Category B Conditions

Post-Project power flow studies identified system performance issues under Category B conditions. Following the connection of the Project, the voltage range violations observed in the pre-Project scenarios marginally increased.

POD bus voltage deviations were observed under Category B conditions.

The voltage stability margin was met for all studied conditions.

5.4 Mitigation Measures

This section discusses the AESO's proposed mitigation measures to address the system performance issues that were identified pre-Project and post-Project.

As part of this Project, mitigation measures will not be specifically developed for the POD bus voltage deviations observed under certain Category B conditions during pre-Project and post-Project scenarios.

5.4.1 Pre-Project

Prior to connection of the Project, all of the observed voltage range criteria violations under Category B system conditions can be managed by the existing Remedial Action Scheme (RAS) 155.

5.4.2 Post-Project

After connection of the Project, all of the voltage range criteria violations observed under Category B system conditions can be mitigated by the existing RAS 155.

5.4.3 Post Mitigation Study Results

Under Category B conditions, all of the observed Reliability Criteria violations requiring RAS were mitigated.

6 Project Dependencies

The Project does not require the completion of any other AESO plans to expand or enhance the transmission system prior to connection.

7 Conclusions and Recommendations

Based on the study results, Alternative 1 is technically viable. The connection assessment identified pre-Project and post-Project system performance issues. The voltage range criteria violations under Category B conditions can be mitigated through the use of existing RAS 155. With implementation of these mitigation measures, connecting the project with the preferred alternative does not adversely affect the performance of the AIES.

The AESO recommends proceeding with the Project using Alternative 1 as the preferred alternative to respond to the DFO's request for system access service. Alternative 1 includes adding a new POD substation, designated Armistead 2102S substation, including two 240 kV breakers and two 240/25 kV transformers; and adding one 240 kV circuit to connect the proposed Armistead 2102S substation to the existing 240 kV transmission line 9L74 in a T-tap configuration.

The conductor used for the 240 kV circuit connecting the proposed Armistead 2102S substation to existing 240 kV transmission line 9L74 should have a minimum capacity of 57 MVA, equal to the conductor rating of 9L74. The transformers at Armistead 2102S should have a minimum total capacity of 57 MVA to meet the DFO's requested DTS.

Attachment A:
Table A-1: Summary of Category B Reliability Criteria Violations, Project Impact and Mitigation Measures- All Scenarios

Table A-1: Summary of Category B Reliability Criteria Violations, Project Impact and Mitigation Measures

Scenario	Type of Reliability Criteria Violation		Contingency (System Element Lost)	Details of Violation	Project Impact	Pre-Project Mitigation Measures	Post-Project Mitigation Measures
	Pre-Project	Post-Project					
2028 SP	Voltage range-below emergency minimum	Voltage -below emergency minimum	9L101 (McClelland 957S – Secord 2005S)	Kearl Main 9900S	Marginally Increased	RAS 155	RAS 155
	Voltage range-below emergency minimum	Voltage -below emergency minimum	9L101 (McClelland 957S – Secord 2005S	Mcclelland 957S	Marginally Increased	RAS 155	RAS 155
2028 WP	Voltage range-below emergency minimum	Voltage -below emergency minimum	9L101 (McClelland 957S – Secord 2005S)	Kearl Main 9900S	Marginally Increased	RAS 155	RAS 155
	Voltage range-below emergency minimum	Voltage -below emergency minimum	9L101 (McClelland 957S – Secord 2005S	Mcclelland 957S	Marginally Increased	RAS 155	RAS 155

Notes:

- Marginally increased (or marginally decreased) refers to a percent loading difference (post-Project percent loading minus pre-Project percent loading) between 0% and 3% (or -3%).
- RAS 155 is an existing RAS.

Appendix A:
Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

P2741 Great Plains Load

ATCO Electric Ltd.

Date: 12-12-2024

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1 Introduction

This report presents the results of the engineering studies that were completed by ATCO Electric (the Studies Consultant) to assess the impact of the Project (as defined in Attachment A1: AESO Engineering Connection Assessment Scope) on the performance of the Alberta interconnected electric system (AIES). The studies were performed in accordance with Attachment A1: AESO Engineering Connection Assessment: Study Scope, which was prepared by the AESO.

The power system network analysis tool that was used for the studies in this connection assessment was PSS/E version 34.

2 Pre-Project Study Results

This section describes the results of the pre-Project power flow studies.

2.1 Power Flow Studies

Power flow diagrams illustrating the pre-Project power flow studies results for Category A and Category B conditions are provided in Attachment A1.

2.1.1 Scenario 1: 2028 Summer Peak Low Generation Pre-Project

Category A Conditions

No Reliability Criteria (as defined in the AESO's Study Scope) violations were observed under Category A conditions.

Category B Conditions

No Thermal criteria violations were observed under Category B conditions.

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 2-1.

Table 2-1: Voltage Criteria Violations under Category B Conditions for Scenario 1

Contingency (System Element Lost)	Violation Location Details		Voltage Ratings (kV)			Pre-Project Results	
	Substation Name and No.	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	259.6	228.8
	Mcclelland 957S	1610	260	234	275	259.7	228.8
	Kearl Main 9900S (Imperial)	1664	72	65	78	71.9	61.2
	Kearl Main 9900S (Imperial)	1681	72	65	78	73.7	62

	Kearl Main 9900S (Imperial)	1682	72	65	78	72.1	61.6

Low Voltage Buses Bus Voltage Deviations

Low Voltage Buses Voltage deviations were observed under certain Category B conditions as shown in Table 2-2.

Table 2-2: Low Voltage Buses Voltage Deviations under Category B Conditions for Scenario 1

Contingency (System Element Lost)	Voltage Deviation Location Details			Pre-Project Results						
					Voltage Deviations at Low Voltage Buses					
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1683	13.8	15.1	13.3	13.3%	13.1	14.4%	13.1	14.4%
	Kearl Main 9900S (Imperial)	1684	13.8	14.3	12.6	12.5%	12.4	13.5%	12.4	13.5%
	Kearl Main 9900S (Imperial)	1695	13.8	14.1	12.2	13.7%	12.6	10.7%	12.6	10.7%
	Green Stocking 925S	18276	25	25.9	23.3	10.4%	–	–	–	–
	Green Stocking 925S	19276	25	25.9	23.3	10.4%	–	–	–	–

2.1.2 Scenario 2: 2028 Winter Peak Low Generation Pre-Project

Category A Conditions

No Reliability Criteria (as defined in the AESO's Study Scope) violations were observed under Category A conditions.

Category B Conditions

No Thermal criteria violations were observed under Category B conditions.

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 2-3.

Table 2-3: Voltage Criteria Violations under Category B Conditions for Scenario 2

Contingency (System Element Lost)	Violation Location Details		Voltage Ratings (kV)			Pre-Project Results	
	Substation Name and No.	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	260.6	233.4
	Mcclelland 957S	1610	260	234	275	260.6	233.4
	Kearl Main 9900S (Imperial)	1664	72	65	78	72.8	64.6
	Kearl Main 9900S (Imperial)	1681	72	65	78	74.6	64.2

	Kearl Main 9900S (Imperial)	1682	72	65	78	73.3	65

Low Voltage Buses Voltage Deviations

Low Voltage Buses Voltage deviations were observed under certain Category B conditions as shown in Table 2-4.

Table 2-4: Low Voltage Buses Voltage Deviations under Category B Conditions for Scenario 2

Contingency (System Element Lost)	Voltage Deviation Location Details			Pre-Project Results						
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Voltage Deviations at Low Voltage Buses					
					Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1683	13.8	15.4	13.7	11.9%	13.6	13.1%	13.6	13.1%
	Kearl Main 9900S (Imperial)	1684	13.8	14.7	13.2	11.2%	13	12.4%	13	12.4%

3 Post-Project Study Results

This section describes the results of the post-Project power flow studies and voltage stability studies.

As described in Section 2 of the AESO's Study Scope, the post-Project studies were performed using Alternative 1A.

3.1 Power Flow Studies

Power flow diagrams illustrating the post-Project power flow studies results for Category A and Category B conditions are included in Attachment A2.

3.1.1 Scenario 3: 2028 Summer Peak Low Generation Post Project Main Scenario

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

No Thermal criteria violations were observed under Category B conditions.

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 3-1.

Table 3-1: Voltage Criteria Violations under Category B Conditions for the Scenario 3

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Pre-Project Results		Post-Project Results		% Voltage Difference (kV)
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Initial Voltage (kV)	Post-contingency Steady State (kV)	
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	259.6	228.8	259.9	228.6	-0.1%
	Mcclelland 957S	1610	260	234	275	259.7	228.9	260	228.7	-0.1%
	Kearl Main 9900S (Imperial)	1664	72	65	78	71.9	61.2	72	61.2	-0.1%
	Kearl Main 9900S (Imperial)	1681	72	65	78	73.7	62.1	73.8	62	-0.1%
	Kearl Main 9900S (Imperial)	1682	72	65	78	72.1	61.6	72.2	61.6	-0.1%

Low Voltage Buses Voltage Deviations

Low Voltage Buses Voltage deviations were observed under certain Category B conditions as shown in 2.

Table 3-2: Voltage Criteria Violations under Category B Conditions for the Scenario 3

Contingency (System Element Lost)	Voltage Deviation Location Details			Post-Project Results						
					Voltage Deviations at Low Voltage Buses					
	Substation Name and Number	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage[a] (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1683	13.8	15.1	13.3	13.4%	13.1	14.6%	13.1	14.6%
	Kearl Main 9900S (Imperial)	1684	13.8	14.3	12.5	12.6%	12.4	13.7%	12.4	13.7%
	Kearl Main 9900S (Imperial)	1695	13.8	14.1	12.2	13.9%	12.6	10.9%	12.6	10.9%
	Green Stocking 925S	18276	25	25.9	23.3	10.5%	–	–	–	–
	Green Stocking 925S	19276	25	25.9	23.3	10.5%	–	–	–	–

3.1.2 Scenario 4: 2028 Winter Peak Low Generation Post Project Main Scenario

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

No Thermal criteria violations were observed under Category B conditions.

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 3-3.

Table 3-3: Voltage Criteria Violations under Category B Conditions for the Scenario 4

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Pre-Project Results		Post-Project Results		% Voltage Difference (kV)
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Initial Voltage (kV)	Post-contingency Steady State (kV)	
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	260.6	233.3	260.7	233	-0.1%
	Mcclelland 957S	1610	260	234	275	260.6	233.4	260.8	233.1	-0.1%
	Kearl Main 9900S (Imperial)	1664	72	65	78	72.8	64.6	72.8	64.5	-0.1%
	Kearl Main 9900S (Imperial)	1681	72	65	78	74.6	64.2	74.7	64.1	-0.2%
	Kearl Main 9900S (Imperial)	1682	72	65	78	73.3	65	73.4	64.9	-0.1%

Low Voltage Buses Voltage Deviations

Low Voltage Buses Voltage deviations were observed under certain Category B conditions as shown in Table 3-4.

Table 3-4: Voltage Deviations at Low Voltage Buses under Category B Conditions for the Scenario 4

Contingency (System Element Lost)	Voltage Deviation Location Details			Post-Project Results						
					Voltage Deviations at Low Voltage Buses					
	Substation Name and Number	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage[a] (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1683	13.8	15.4	13.7	12.1%	13.5	13.3%	13.5	13.3%
	Kearl Main 9900S (Imperial)	1684	13.8	14.7	13.1	11.4%	13	12.6%	13	12.6%
	Kearl Main 9900S (Imperial	1695	13.8	14.1	12.8	10.1%	12.6	11.4%	12.6	11.4%

3.2 Voltage Stability Studies

3.2.1 Scenario 3: 2028 Summer Peak Low Generation Post Project

Voltage stability analysis was performed for the scenario 3 2028 Summer peak low generation post project study. The reference load level for the Study Area is 2227 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 111.4 MW (0.05 x 2227 MW = 111.4 MW), to meet the voltage stability criteria.

Table 3-5 provides the voltage stability study results under Category A condition and for the six worst contingencies under Category B conditions. The voltage stability diagrams are provided in Attachment A4.

The voltage stability margin was met for all studied conditions.

Table 3-5: Voltage Stability Study Results under Category B Conditions for Scenario 3[1]

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		836.7	Yes
12L44	Thickwood 951S	Livock 939S	539.8	Yes
12L41	Livock 939S	Sunny Brook 510S	533.6	Yes
1201T	Thickwood 951S 1201T		541.4	Yes
9L84	Salt Creek 977S	Black Fly 934S	629.7	Yes
9L32	Secord 2005S	Horizon Expansion 838S	518.8	Yes
9L69	Black Fly 934S	McClelland 957S	674.2	Yes

3.2.2 Scenario 4: 2028 Winter Peak Low Generation Post Project

Voltage stability analysis was performed for the scenario 4 2028 Winter peak low generation post project study. The reference load level for the Study Area is 2369 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 118.5 MW (0.05 x 2369 MW = 118.5 MW), to meet the voltage stability criteria.

Table 3-6 provides the voltage stability study results under Category A condition and for the six worst contingencies under Category B conditions. The voltage stability diagrams are provided in Attachment A4.

[1] Contingencies 9L101 and Kearl T4 were excluded from the report as these contingencies are far away from the project and the project does not contribute to these contingencies.

The voltage stability margin was met for all studied conditions.

***Table 3-6: Voltage Stability Study Results under Category B Conditions for Scenario 4*[2]**

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		899.2	Yes
12L44	Thickwood 951S	Livock 939S	686.7	Yes
12L41	Livock 939S	Sunny Brook 510S	684.4	Yes
1201T	Thickwood 951S 1201T		672.7	Yes
9L84	Salt Creek 977S	Black Fly 934S	692.2	Yes
9L32	Secord 2005S	Horizon Expansion 838S	716.4	Yes
9L69	Black Fly 934S	McClelland 957S	728.9	Yes

4 Short Circuit Studies

4.1 Pre-Project Results

4.1.1 Scenario 2: 2028 Winter Peak Low generation Pre Project

Pre-Project short-circuit current levels for Scenario 2 are provided in Table 4-1[3].

Table 4-1: Pre-Project Short-Circuit Current Levels for Scenario 2

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Dover 888S	240	265.06	17.44	0.002186+j0.01432	14.31	0.004486+j0.02377
Ruth Lake 848S	240	262.80	21.47	0.001583+j0.01166	22.03	0.001375+j0.010755
Joslyn 849S	240	262.74	13.71	0.002987+j0.018179	11.63	0.004157+j0.028464
Birchwood Creek 960S	240	265.42	7.16	0.006089+j0.034772	5.76	0.007003+j0.06087
Ruth Lake 848S	138	148.83	3.54	0.029684+j0.120492	3.53	0.013307+j0.125387

[2] Contingencies 9L101 and Kearl T4 were excluded from the report as these contingencies are far away from the project and the project does not contribute to these contingencies.

[3] Short-circuit current studies were based on modeling information provided to the AESO by third parties. The authenticity of the modeling information has not been validated. Fault levels could change as a result of system developments, new customer connections, or additional generation in the area. It is recommended that these changes be monitored and fault levels reviewed to ensure that the fault levels are within equipment operating limits. The information provided in this study should not be used as the sole source of information for electrical equipment specifications or for the design of safety-grounding systems.

Ruth Lake 848S	138	148.22	3.60	0.029783+j0.118428	3.78	0.011634+j0.104217

4.2 Post-Project Results

4.2.1 Scenario 4: 2028 Winter Peak Low Generation Post Project

Post-Project short-circuit current levels for Scenario 4 are provided in Table 4-2.

Table 4-2: Post-Project Short-Circuit Current Levels for Scenario 4

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Dover 888S	240	264.56	17.50	0.00224+j0.014259	14.60	0.004241+j0.022869
Ruth Lake 848S	240	262.69	21.50	0.001602+j0.01164	22.08	0.001372+j0.010718
Joslyn 849S	240	262.42	13.74	0.003021+j0.018137	11.69	0.004113+j0.028216
Birchwood Creek 960S	240	264.17	7.19	0.006237+j0.034597	5.93	0.006414+j0.057363
Great Plain Load tap	240	263.83	10.27	0.00422+j0.024227	8.69	0.004184+j0.03802
Ruth Lake 848S	138	148.76	3.54	0.029697+j0.120473	3.53	0.013307+j0.125386
Ruth Lake 848S	138	148.15	3.60	0.029796+j0.118409	3.78	0.011633+j0.104215

4.2.2 Scenario 5: 2033 Winter Peak All Generation Post Project

Post-Project short-circuit current levels for Scenario 5 are provided in Table 4-3.

Table 4-3: Post-Project Short-Circuit Current Levels for Scenario 5

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Dover 888S	240	262.33	17.77	0.002182+j0.014043	14.91	0.004024+j0.022274
Ruth Lake 848S	240	263.54	21.66	0.001611+j0.011549	22.29	0.001358+j0.010581
Joslyn 849S	240	259.40	13.86	0.00297+j0.017987	11.76	0.004068+j0.028133
Birchwood Creek 960S	240	262.73	7.24	0.006125+j0.03433	5.98	0.006328+j0.05695
Great Plain Load tap	240	261.92	10.37	0.004143+j0.024001	8.77	0.004123+j0.037746
Ruth Lake 848S	138	149.26	3.55	0.03038+j0.120136	3.58	0.013087+j0.120854
Ruth Lake 848S	138	148.60	3.60	0.030533+j0.118009	3.82	0.011732+j0.101466

5 Mitigation Measure Development and Evaluation

The Studies Consultant, in consultation with the AESO, determined that real time operational practices would mitigate the system performance issues that were identified in the post-Project scenarios. Existing remedial action schemes (RASs) are described in the AESO's Connection Study Scope.

As part of this Project, mitigation measures will not be specifically developed for the Low Voltage Buses Voltage deviations observed under certain Category B conditions during pre-Project and post-Project scenarios.[4]

5.1 Pre-Project

Pre-Project mitigation measures are for Scenario 1 2028 Summer Peak and Scenario 2 2028 Winter peak are summarized in Table 5-1.

Table 5-1: Pre-Project Mitigation Measures

Mitigation Measure	Location of Observed Violation	Contingency
RAS 155	Kearl Main 9900S (Imperial)	9L101 (McClelland 957S - Secord 2005S)
	Mcclelland 957S	

5.2 Post-Project

Post-Project mitigation measures for Scenario 3 2028 Summer Peak and Scenario 4 Winter Peak are summarized in Table 5-2.

Table 5-2: Post-Project Mitigation Measures

Mitigation Measure	Location of Observed Violation	Contingency
RAS 155	Kearl Main 9900S (Imperial)	9L101 (McClelland 957S - Secord 2005S)
	Mcclelland 957S	

[4] The AESO's desired post-contingency voltage deviations for low voltage Buses represent guidelines rather than criteria. A Low Voltage Buses Voltage deviation that exceeds the desired limits shown in Table 3-1 of the AESO's Connection Study Scope does not represent a Reliability Criteria violation.

5.3 Evaluation of Mitigation Measures

This section describes the results of the power flow studies that were performed to assess the impact of the Project on the performance of the AIES following the implementation of proposed mitigation measures.

The post mitigation measures included under Category B for Scenario 3, and Scenario 4, using RASs as described in previous section.

The post-mitigation power flow diagrams are provided in Attachment A3. Post-mitigation power flow diagrams present only those contingencies that result in low voltage issues that require RAS mitigation. Contingencies that result in thermal and voltage criteria violations that can be mitigated by real-time operational practices were not studied.

5.3.1 Scenario 3: 2028 Summer Peak Low Generation Post-Project Main Scenario

Category B condition

Low voltage violation observed under certain Category B condition in the Post-Project studies were mitigated by RAS as shown in Table 5-3.

Table 5-3: Post-RAS Power Flow Study Results for Scenario 3 2028 SP Post Project Scenario

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Post-Project		Post-RAS Action Results
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Post-contingency-RAS Steady State (kV)
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	260.6	233.2	248.7
	Mcclelland 957S	1610	260	234	275	260.7	233.3	248.7
	Kearl Main 9900S (Imperial)	1664	72	65	78	72.8	64.6	72.8
	Kearl Main 9900S (Imperial)	1681	72	65	78	74.7	64.2	70.2
	Kearl Main 9900S (Imperial)	1682	72	65	78	73.3	65	73.4

5.3.2 Scenario 4: 2028 Winter Peak Low Generation Post-Project Main Scenario

Category B condition

Low voltage violation observed under certain Category B condition in the Post-Project studies were mitigated by RAS as shown in Table 5-4.

Table 5-4: Post-RAS Power Flow Study Results for Scenario 4 2028 WP Post Project Scenario

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Post-Project		Post-RAS Action Results
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Post-contingency-RAS Steady State (kV)
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	260	234	275	260.7	233	248.6
	Mcclelland 957S	1610	260	234	275	260.8	233.1	248.6
	Kearl Main 9900S (Imperial)	1664	72	65	78	72.8	64.5	72.8
	Kearl Main 9900S (Imperial)	1681	72	65	78	74.7	64.1	70.1
	Kearl Main 9900S (Imperial)	1682	72	65	78	73.4	64.9	73.4

ATTACHMENT A1

Pre-Project Power Flow Diagrams

(Scenarios 1 and 2)

Pre-Project Power Flow Results

Power Flow Diagrams

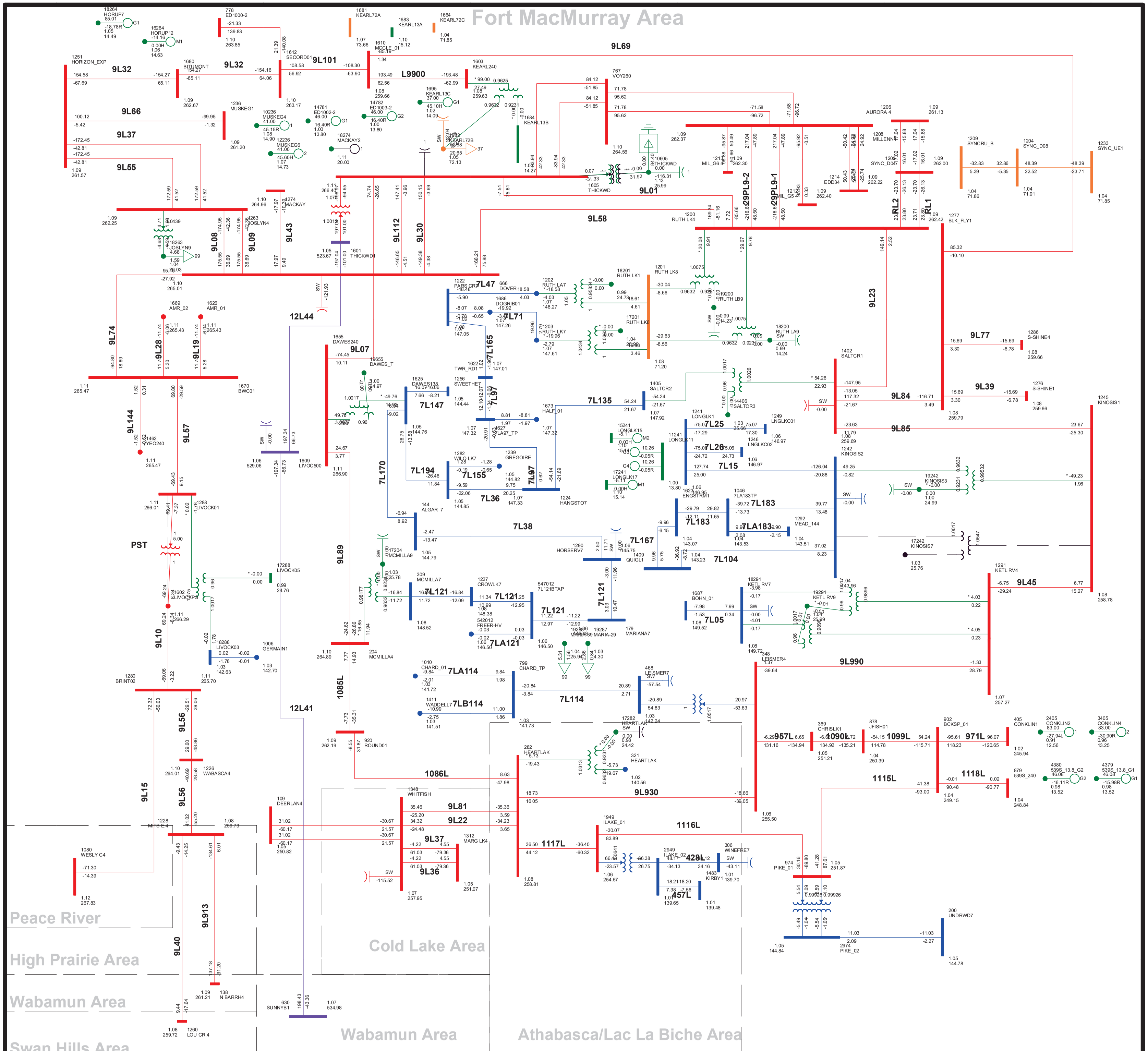
Pre-Project power flow diagrams for Scenario 1 2028 SP, and Scenario 2 2028 WP, under Category A condition and Category B contingencies are provided in this attachment as identified in the following tables.

Table A1-1: List of Pre-Project Scenario 1 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Pre Project Scenario 1	CATEGORY A, System Normal Condition	A1-3
	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A1-4

Table A1-2: List of Pre-Project Scenario 2 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Pre Project Scenario 2	CATEGORY A, System Normal Condition	A1-5
	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A1-6



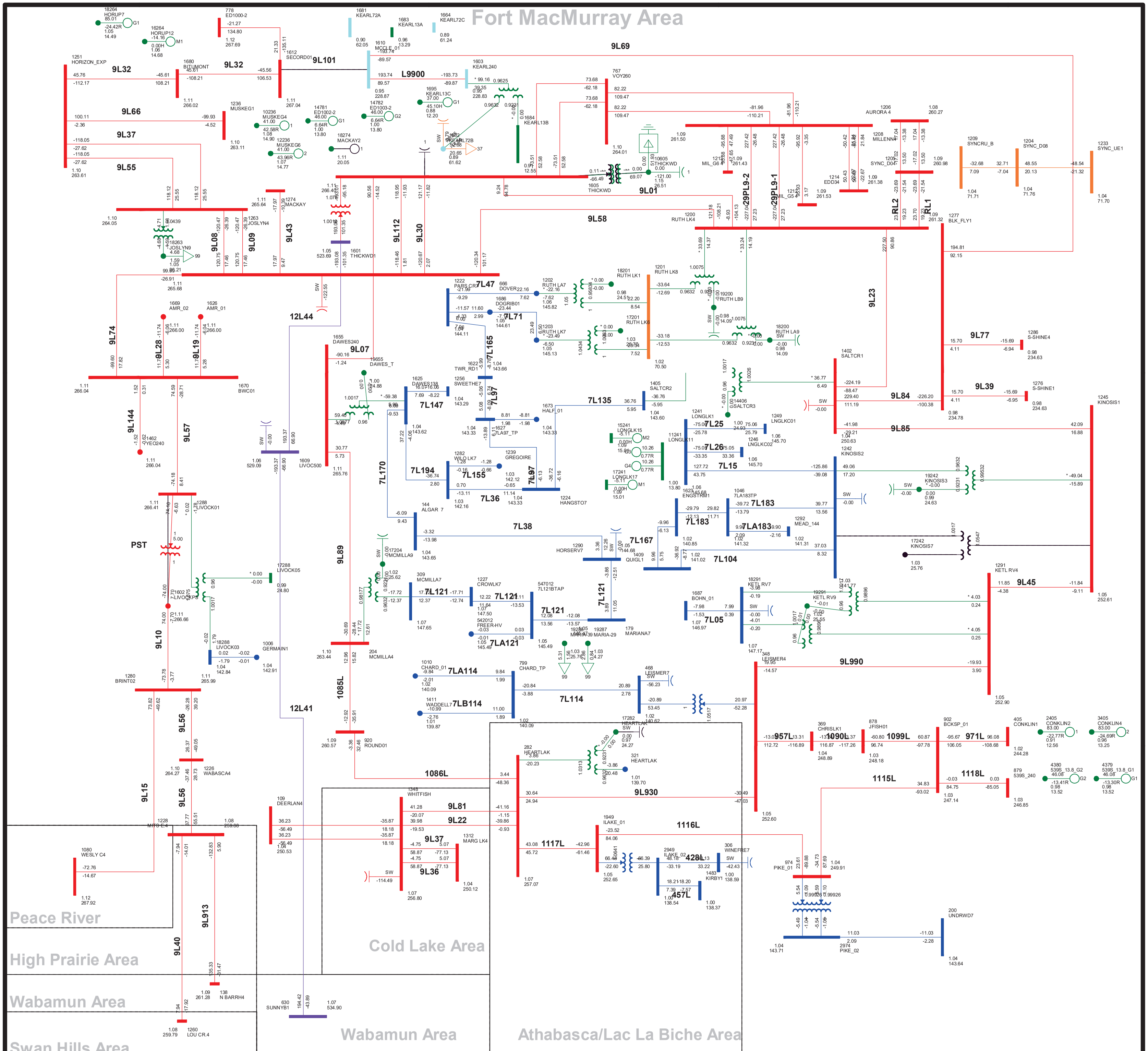
P2741 - Great Plains Load

CATEGORY A, N-0
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUL 01 2024 1:23

A1 - 3

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=13.800 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



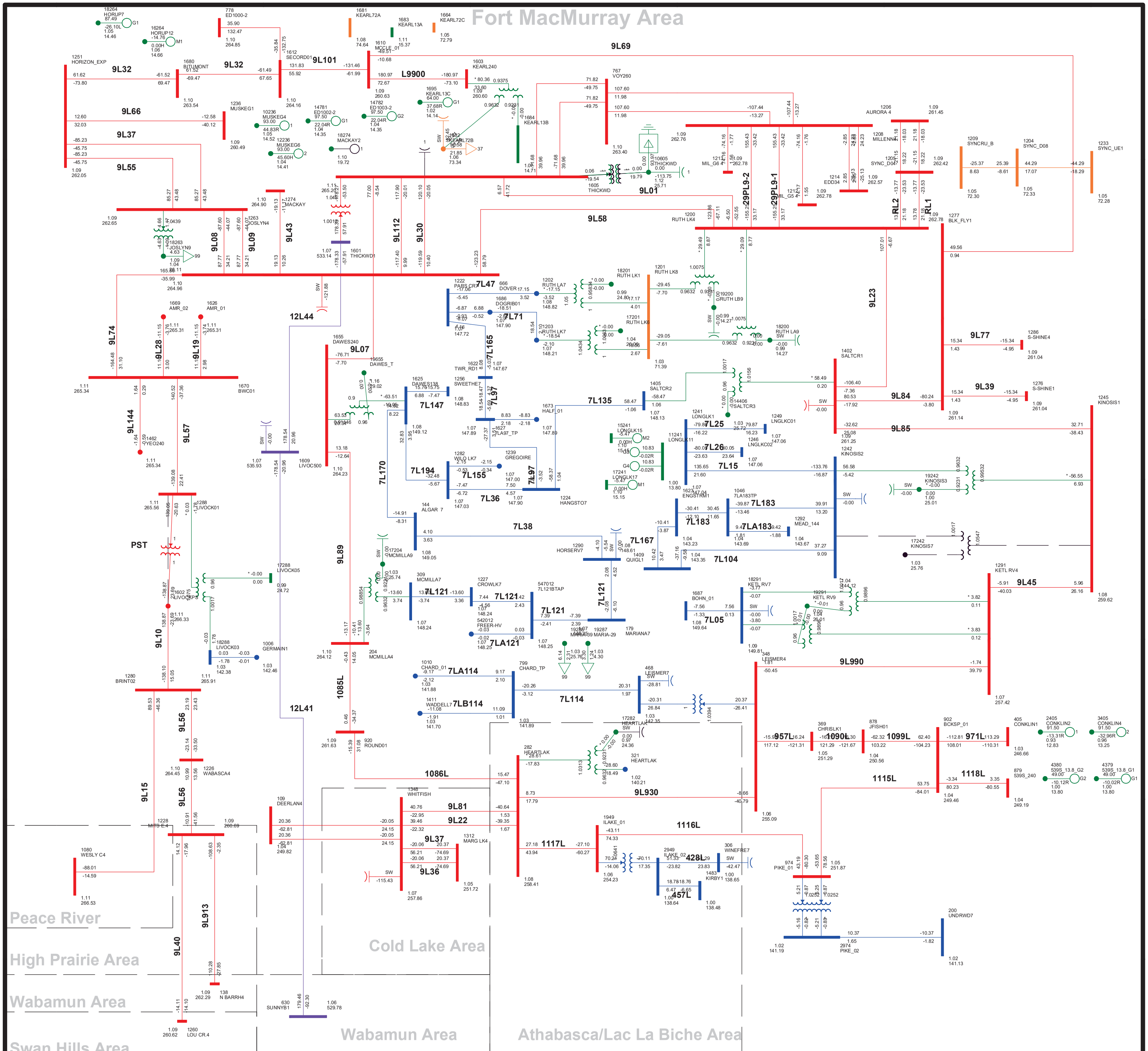
P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUL 01 2024 14:45

A1 - 4

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000



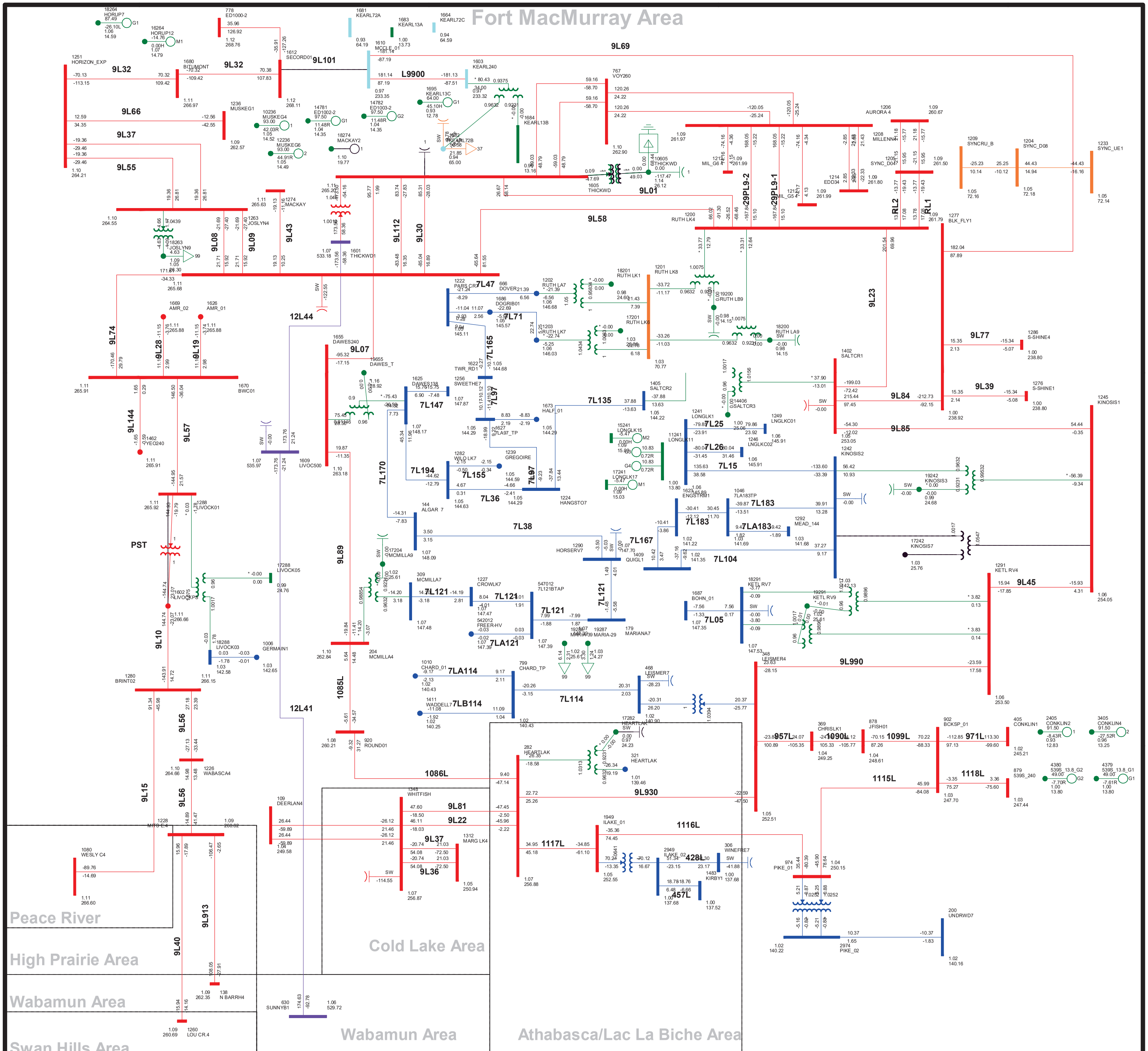
P2741 - Great Plains Load

CATEGORY A, N-0
SCENARIO 2_2028 WINTER PEAK PRE PROJECT
MON, JUL 01 2024 1:37

A1 - 5
1

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=13.800 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 2_2028 WINTER PEAK PRE PROJECT
MON, JUL 01 2024 14:58

A1 - 6

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000

ATTACHMENT A2
Alternative 1A Power Flow Diagrams
(Scenarios 3 and 4)

Post-Project Power Flow Results

Power Flow Diagrams

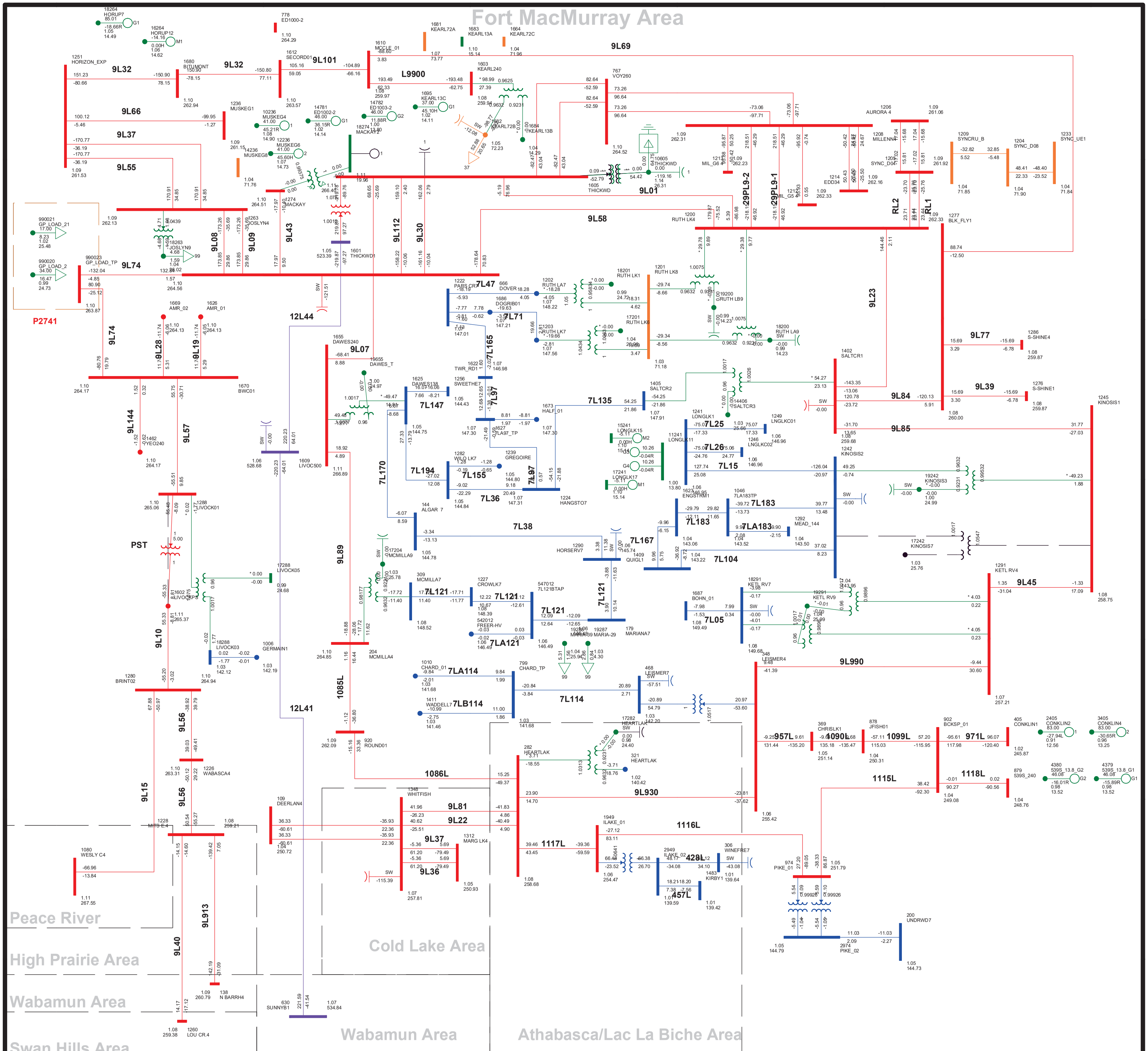
The Post-Project power flow diagrams for Scenario 3 2028 SP, and Scenario 4 2028 WP, under Category A condition and Category B contingencies are provided in this attachment as identified in the following tables.

Table A2-1: List of Post-Project Scenario 3 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Post Project Scenario 3	CATEGORY A, System Normal Condition	A2-3
	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A2-4

Table A2-2: List of Post-Project Scenario 4 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Post Project Scenario 4	CATEGORY A, System Normal Condition	A2-5
	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A2-6



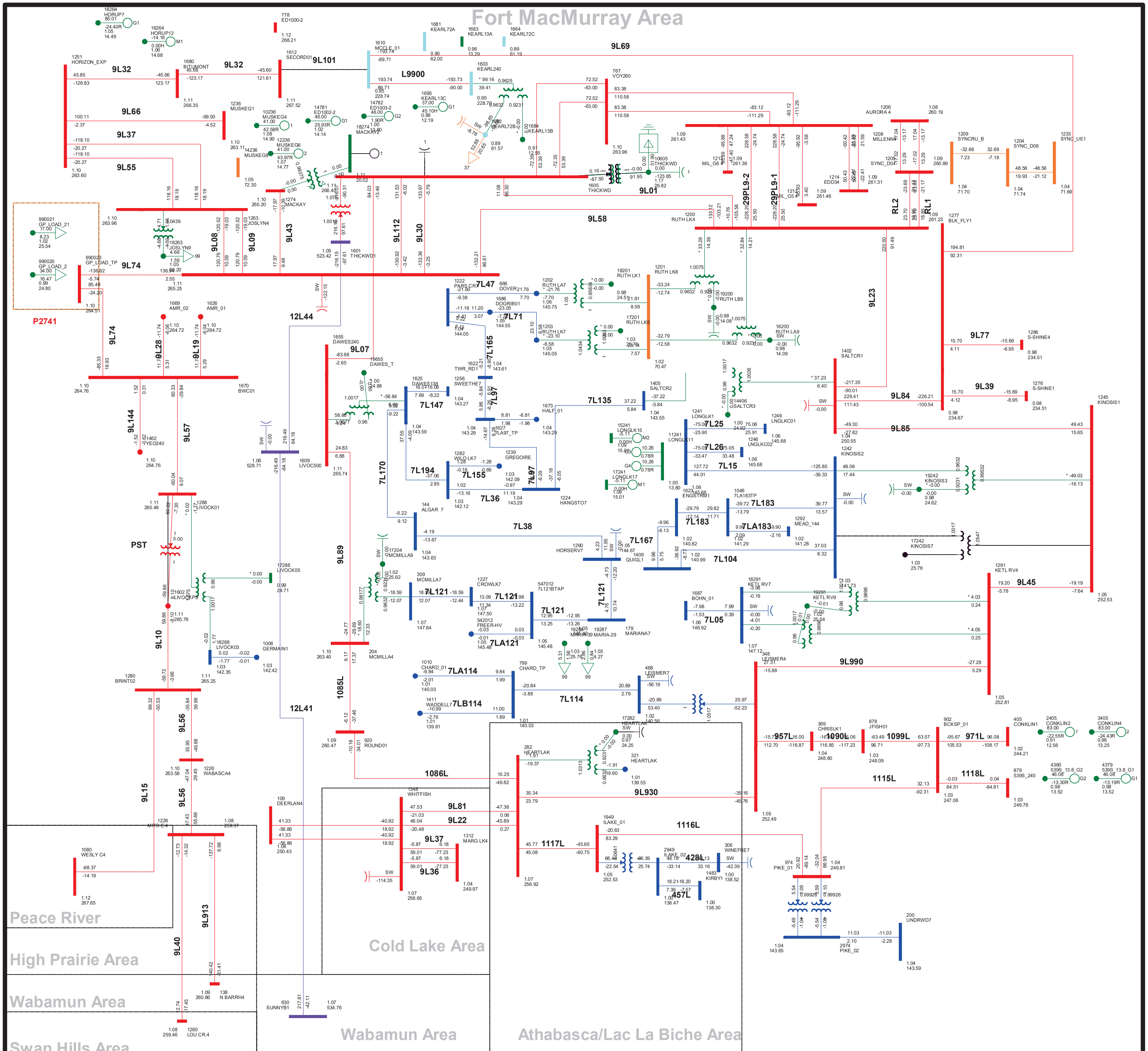
P2741 - Great Plains Load

CATEGORY A, N-0
SCENARIO 3_2028 SUMMER PEAK POST PROJECT

A2 - 3

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=13.800 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



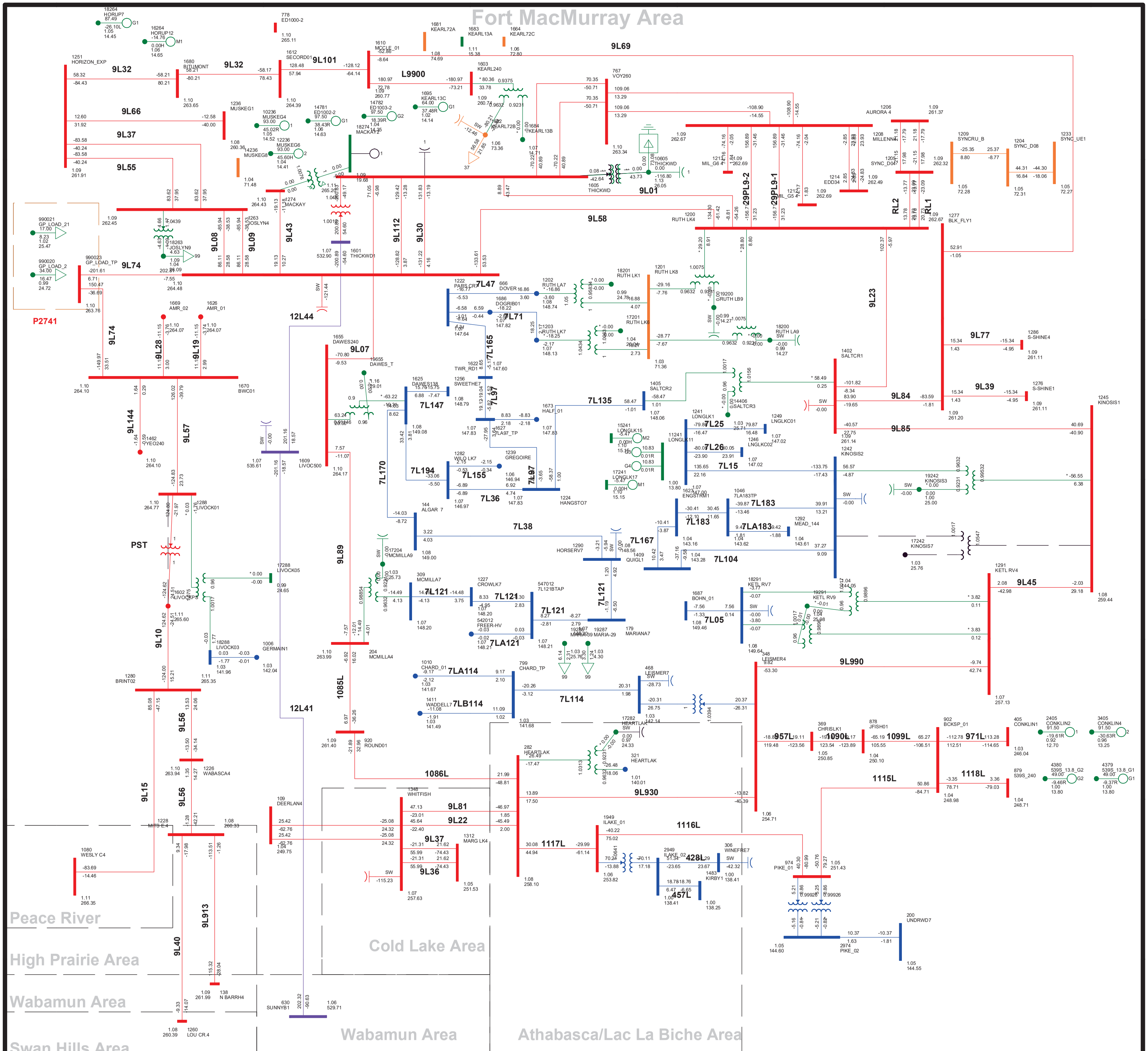
P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 3_2028 SUMMER PEAK POST PROJECT

A2 - 4

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000



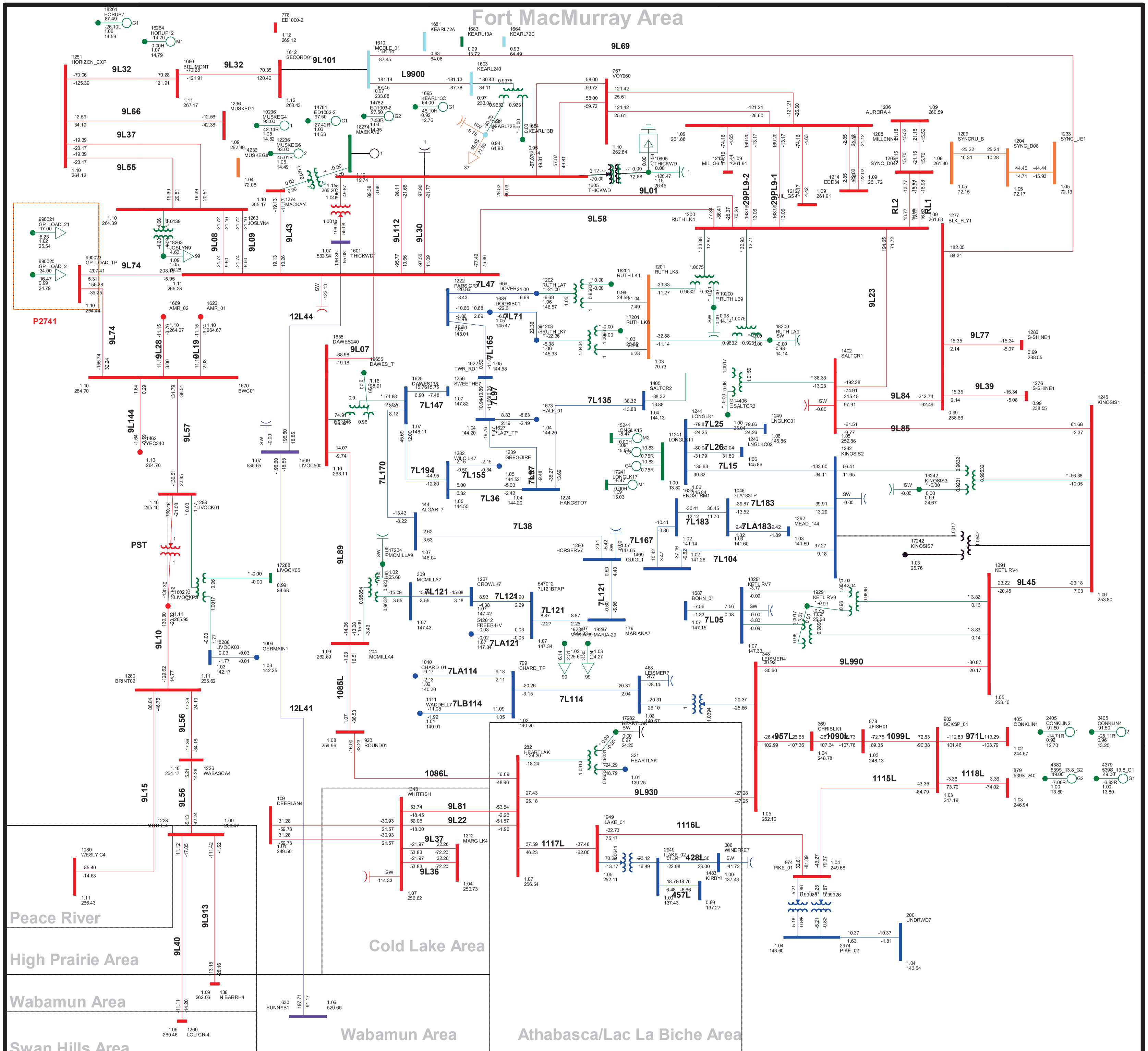
P2741 - Great Plains Load

CATEGORY A, N-0
SCENARIO 4_2028 WINTER PEAK POST PROJECT

A2 - 5
1

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=13.800 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 4_2028 WINTER PEAK POST PROJECT
MON, JUL 01 2024 17:48

A2 - 6

1

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000

ATTACHMENT A3

Alternative 1A Post- Mitigation Power Flow Diagrams

(Scenarios 3 and 4)

Post-Project Power Flow Results

Power Flow Diagrams

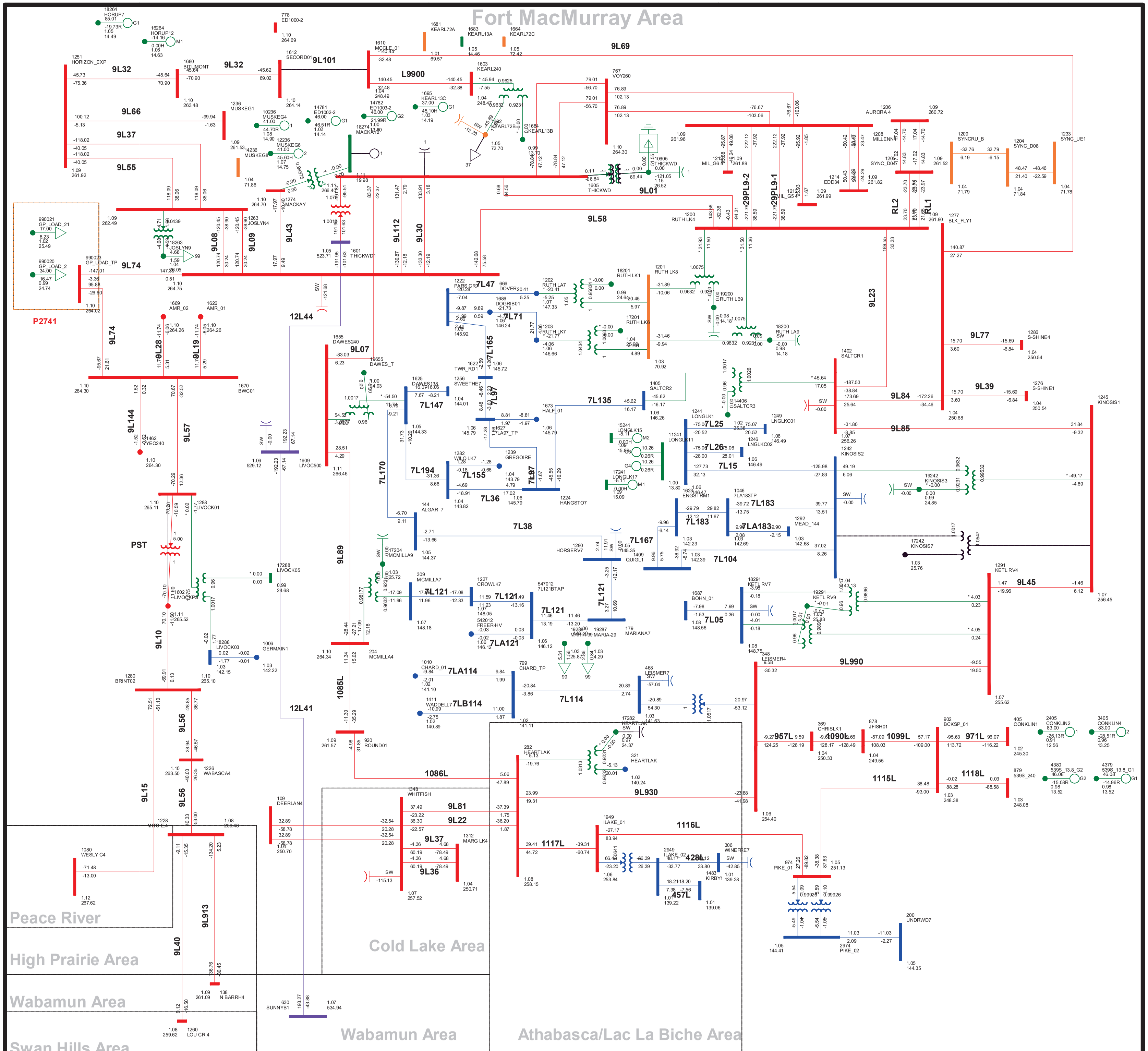
The post-Mitigation power flow diagrams for Scenario 3 2028 SP, and Scenario 4 2028 WP, under Category B contingencies are provided in this attachment as identified in the following tables.

Table A3-1: List of Post-Mitigation Scenario 3 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Post Project Scenario 3	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A3-3

Table A3-2: List of Post-Mitigation Scenario 4 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Post Project Scenario 4	Category B, Loss of 9L101 (McClelland 957S - Secord 2005S)	A3-4

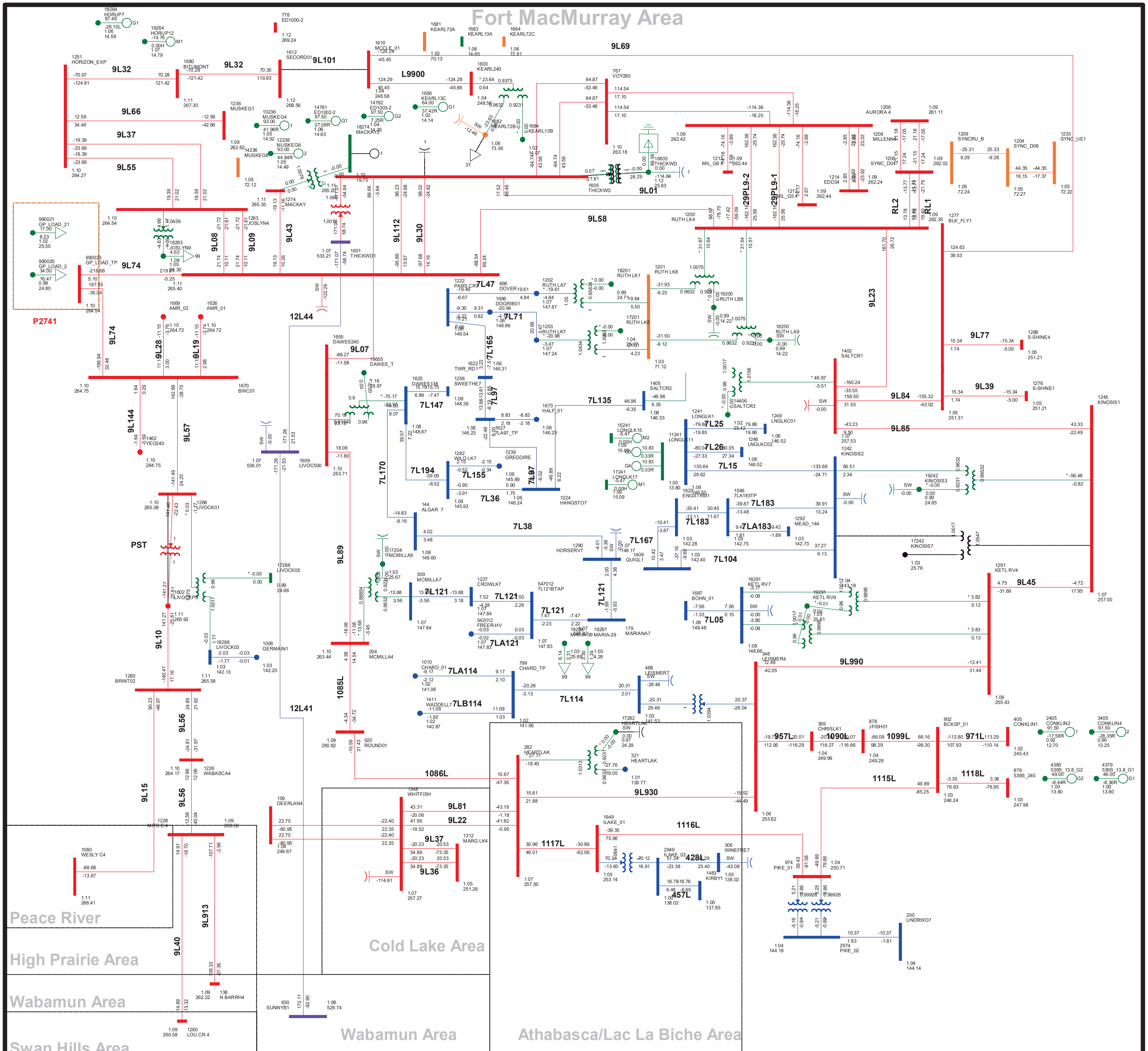


P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 3_2028 SUMMER PEAK POST PROJECT_RAS
A3-3

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000



P2741 - Great Plains Load

CATEGORY B, LOSS OF 9L101 (MCCLELLAND 957S - SECORD 2005S)
SCENARIO 4_2028 WINTER PEAK POST PROJECT_RAS
A3-4

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

kV: >0.000 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 <=500.000 >500.000

ATTACHMENT A4

Alternative 1A Voltage Stability Diagrams (Scenarios 3 and 4)

P2741- Great Plains load – PV Study Results

Voltage stability analysis was performed for the Scenario 3 2028 Summer peak and Scenario 4 2028 Winter peak study scenarios. The reference load level for the study area for scenario 3 and scenario 4, are 2227 MW and 2369 MW respectively. To meet the voltage stability criteria for Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 111.4 MW (0.05 x 2227 MW = 111.4 MW) for scenario 3 and 118.5 MW (0.05 x 2369 MW = 118.5 MW) for scenario 4 respectively. Voltage stability results for the 2028 summer peak and 2028 winter peak study scenarios are plotted for Category A and Category B conditions. Voltage stability assessment includes 6 worst case contingencies. Voltage stability analysis was performed by increasing generation in Wabamun (Area 40), Calgary (Area 6) and Sheerness (Area 43) and increasing load in Fort McMurray (Area 25).

Buses selected for the study:

- Kearl Main 9900S 240 kV(Bus 1603)
- Dover 888S 240 kV(Bus 666)
- Birchwood Creek 960S 240 kV(Bus 1670)
- AMR02 937S 240 kV(Bus 1626)
- Mcclelland 957S (Bus 1610)
- Yeo 2015S 240 kV(Bus 1462)
- Livock 939S-APL 240 kV(Bus 1288)
- Joslyn 849S 240 kV(Bus 1263)
- Thickwood Hills 951S 240 kV(Bus 1605)
- Ruth Lake 848S 240 kV(Bus 1200)
- Great plain load tap (Bus 990023)

Table 4-1 and 4-2 show the summary of the results for Scenario 3 and 4 respectively.

Table 4-1: Summary of Results under Category B Conditions for Scenario 3[1]

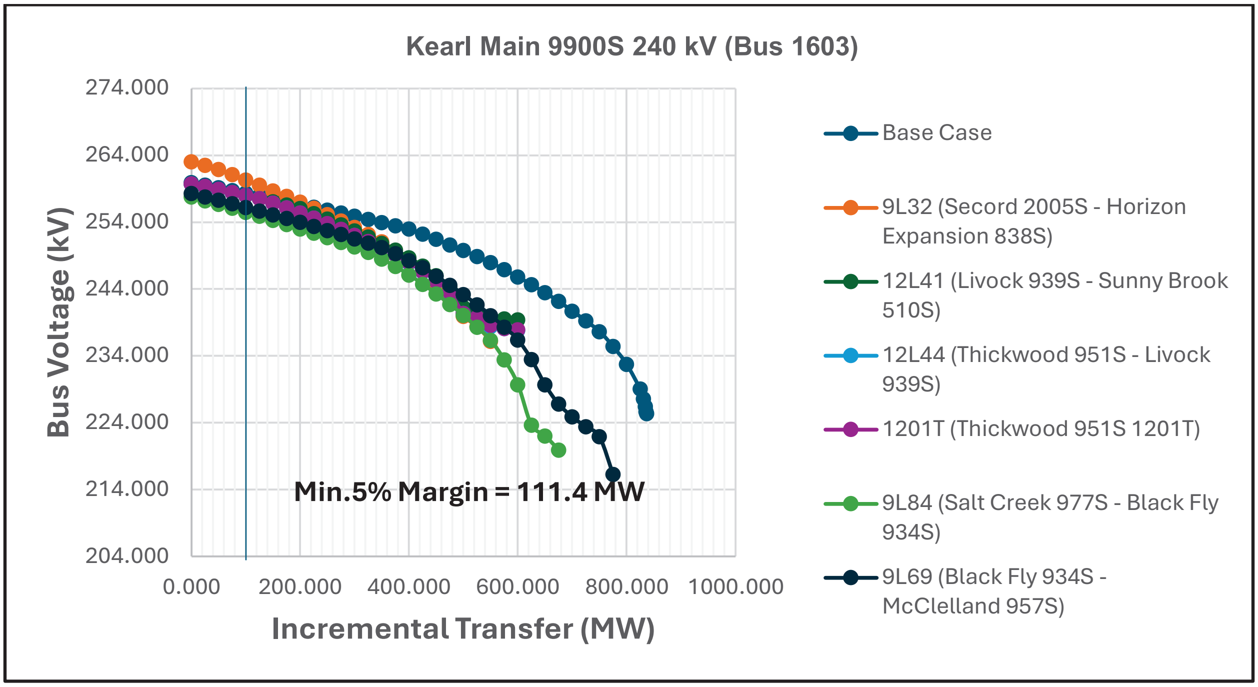
Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		836.7	Yes
12L44	Thickwood 951S	Livock 939S	539.8	Yes
12L41	Livock 939S	Sunny Brook 510S	533.6	Yes
1201T	Thickwood 951S 1201T		541.4	Yes
9L84	Salt Creek 977S	Black Fly 934S	629.7	Yes
9L32	Secord 2005S	Horizon Expansion 838S	518.8	Yes
9L69	Black Fly 934S	McClelland 957S	674.2	Yes

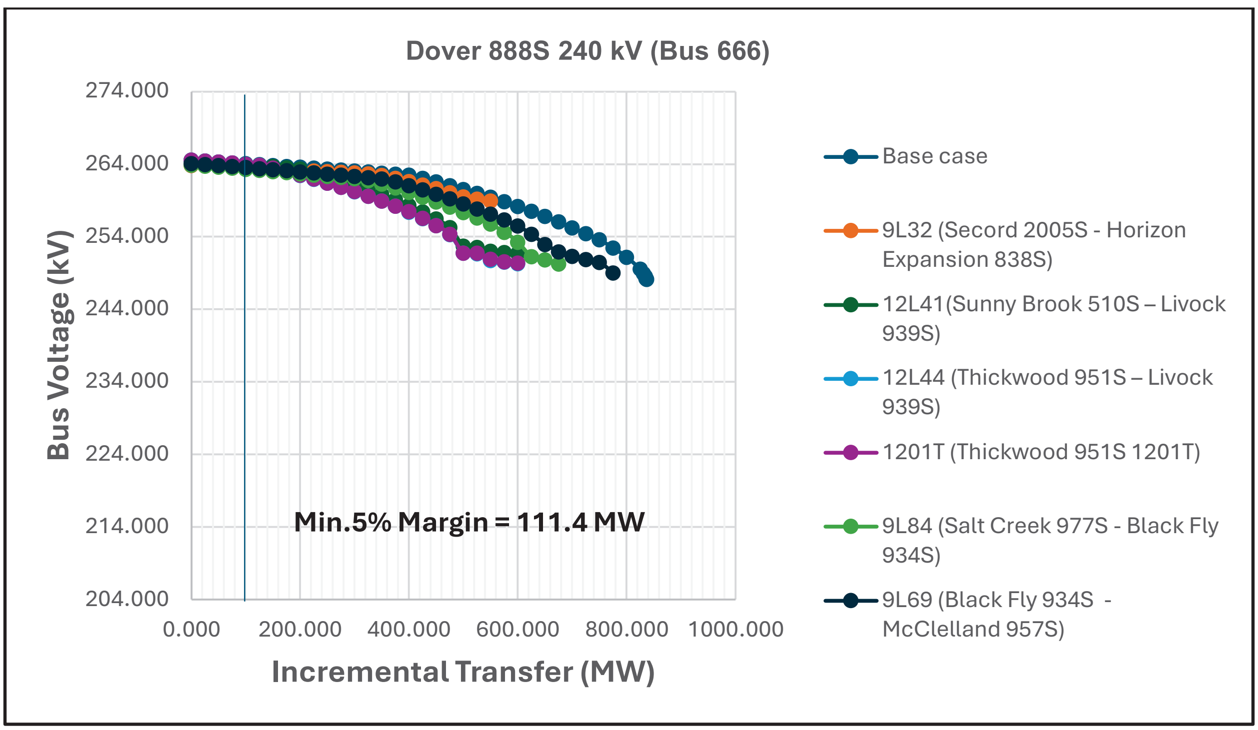
Table 4-2: Summary of Results under Category B Conditions for Scenario 4[1]

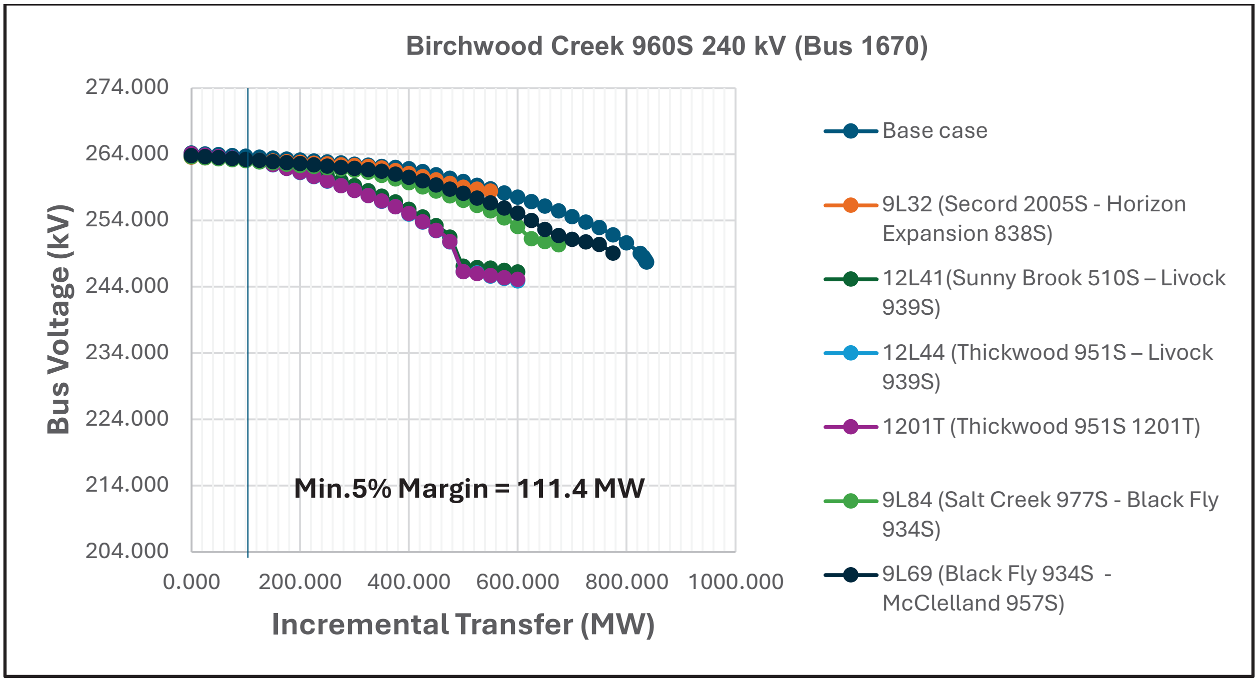
Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		899.2	Yes
12L44	Thickwood 951S	Livock 939S	686.7	Yes
12L41	Livock 939S	Sunny Brook 510S	684.4	Yes
1201T	Thickwood 951S 1201T		672.7	Yes
9L84	Salt Creek 977S	Black Fly 934S	692.2	Yes
9L32	Secord 2005S	Horizon Expansion 838S	716.4	Yes
9L69	Black Fly 934S	McClelland 957S	728.9	Yes

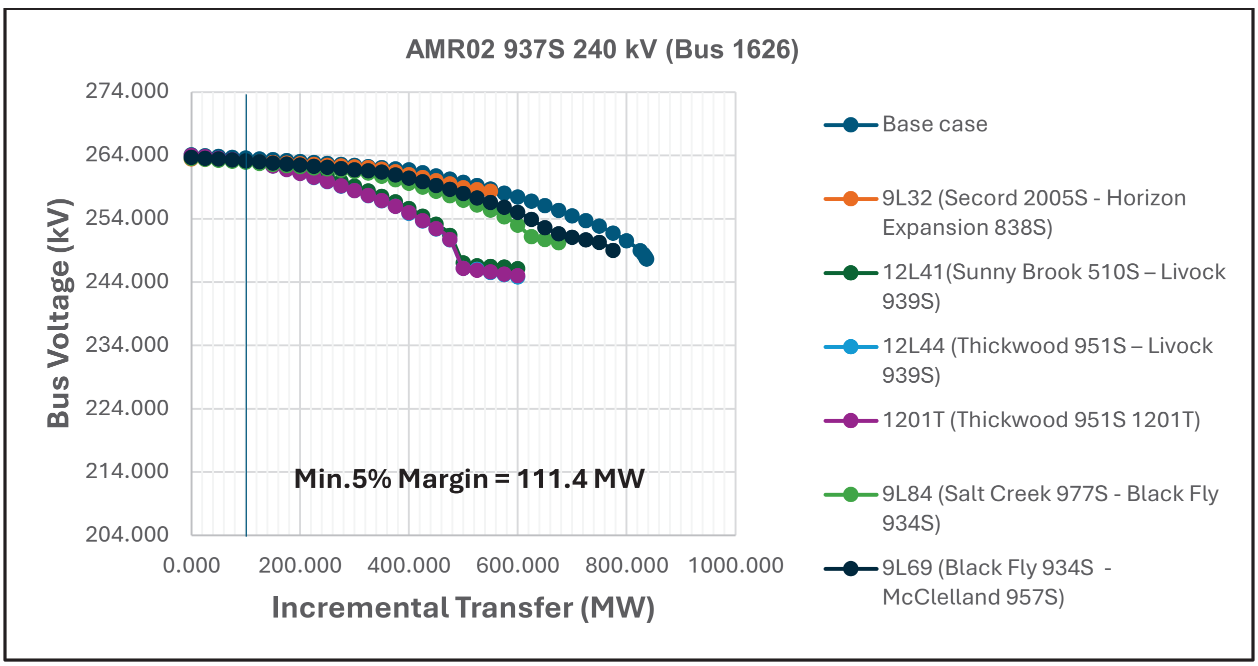
[1] Contingencies 9L101 and Kearl T4 were excluded from the table as these contingencies are far away from the project and the project does not contribute to these contingencies.

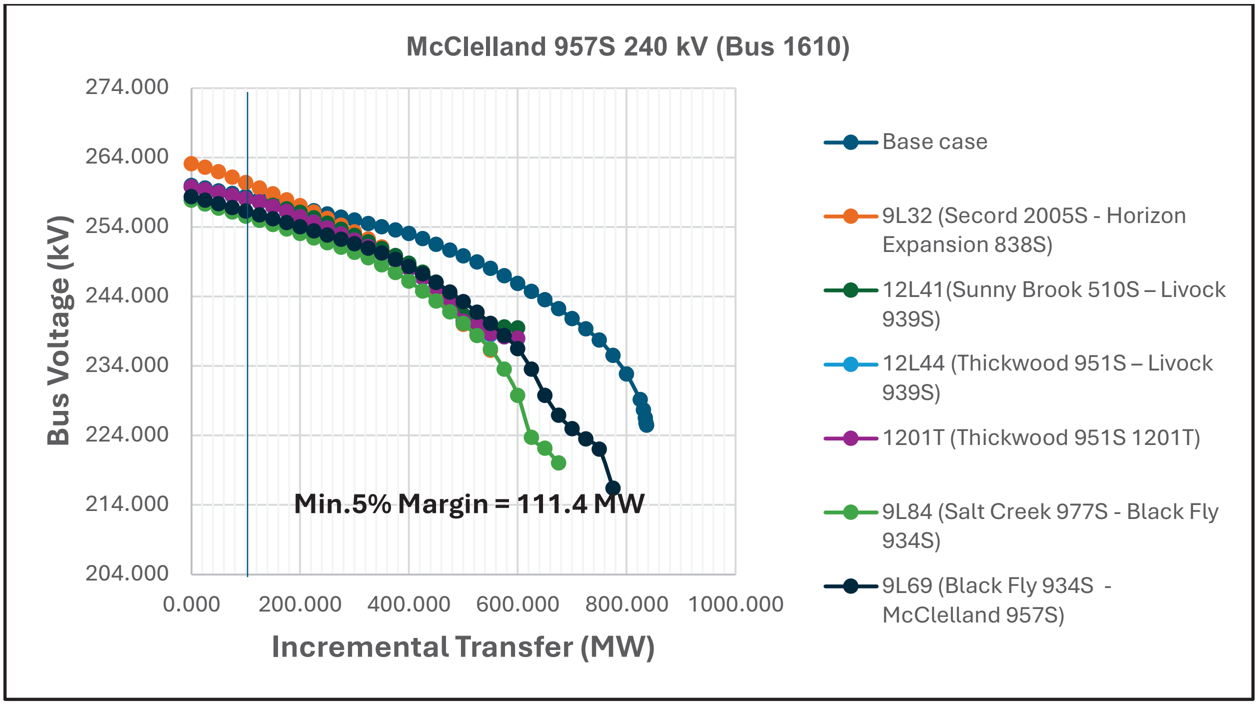
Scenario 3: 2028_SP_NE_LG_POST_Main

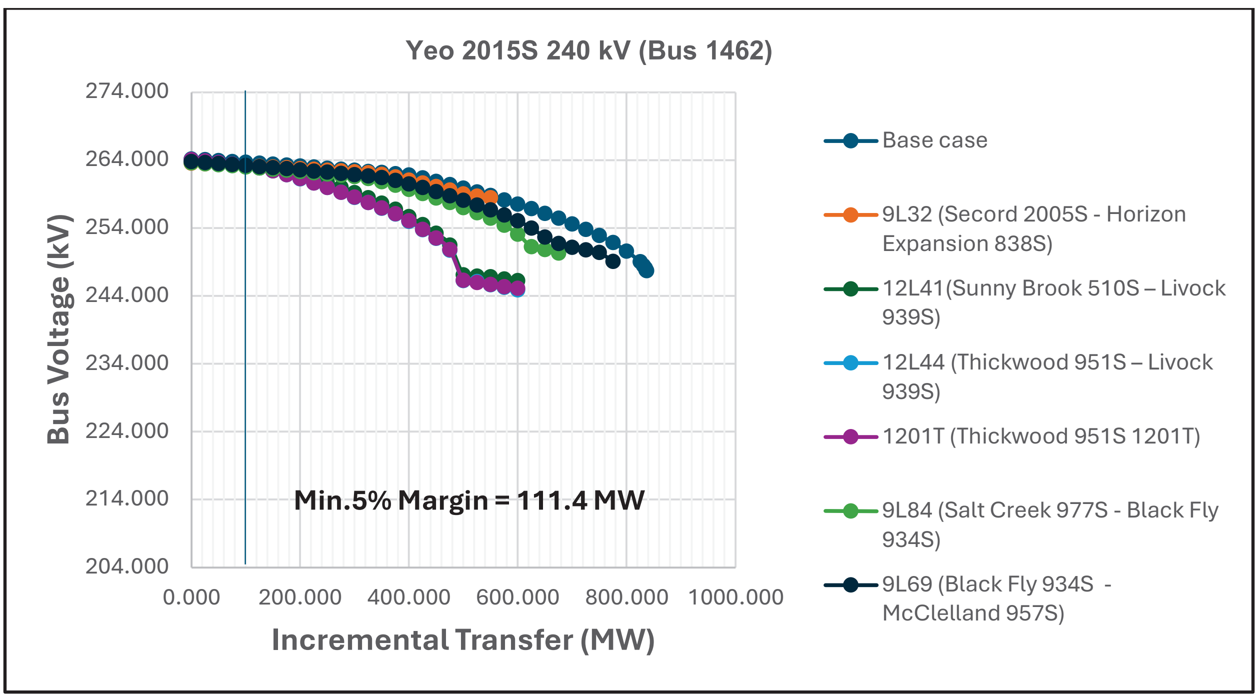


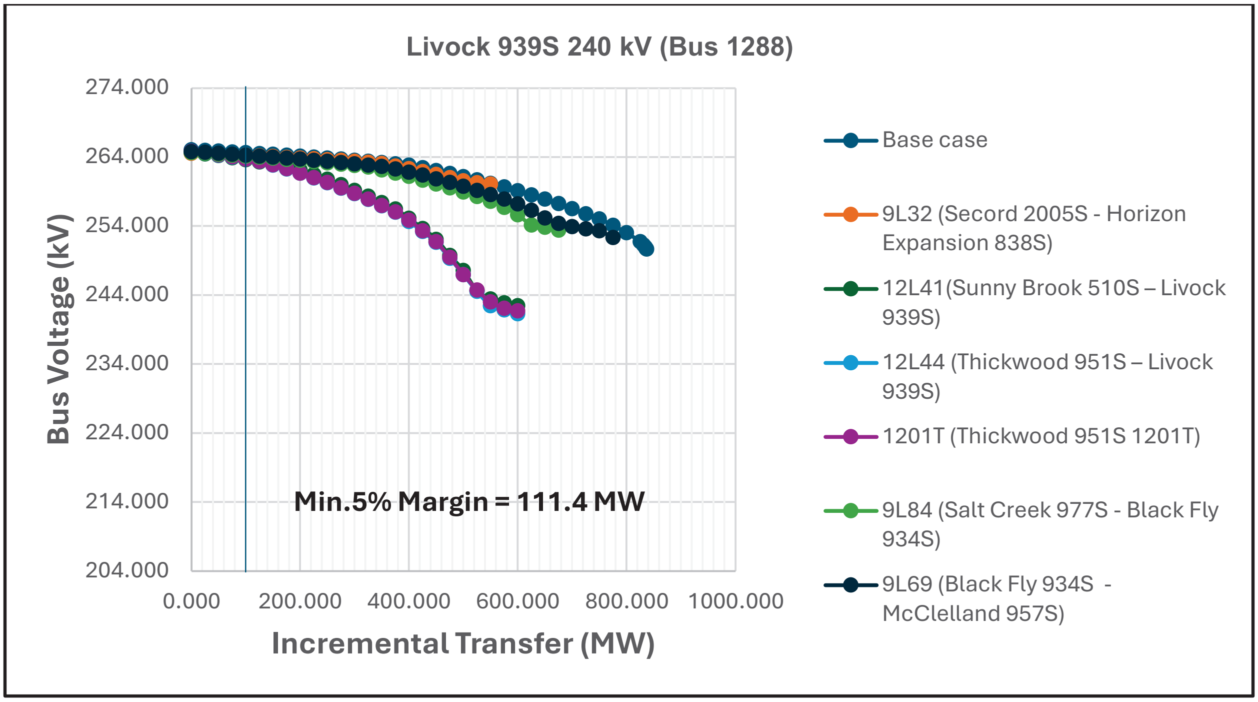


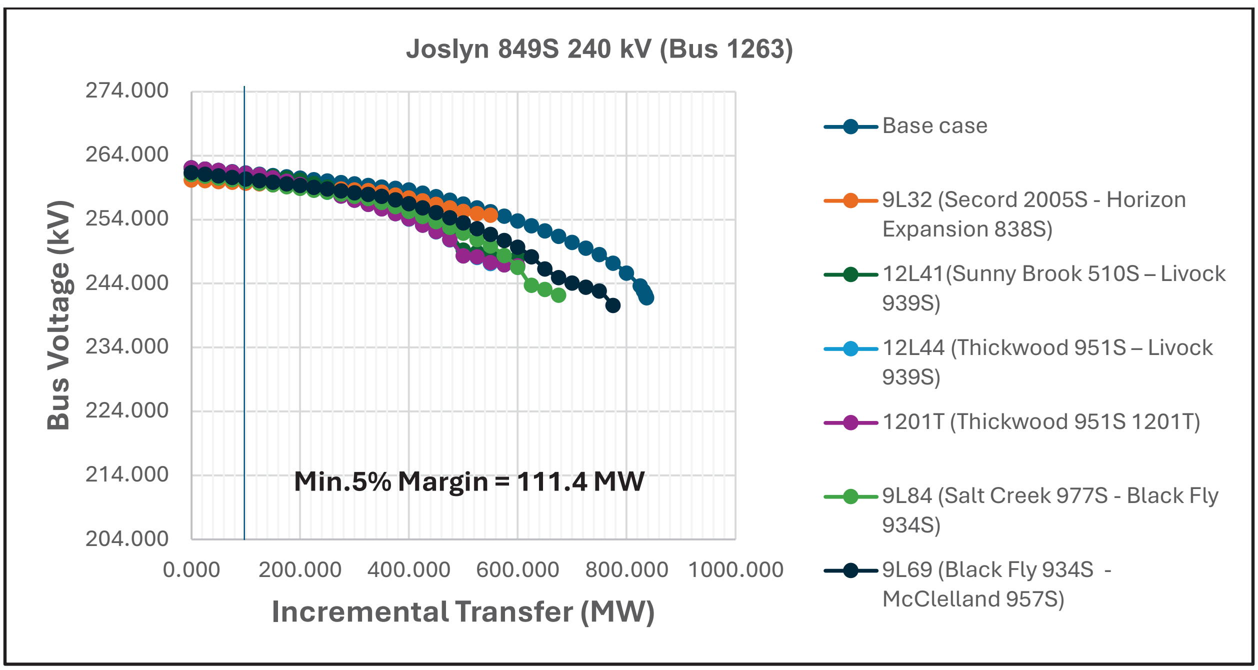

Birchwood Creek 960S 240 kV (Bus 1670)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

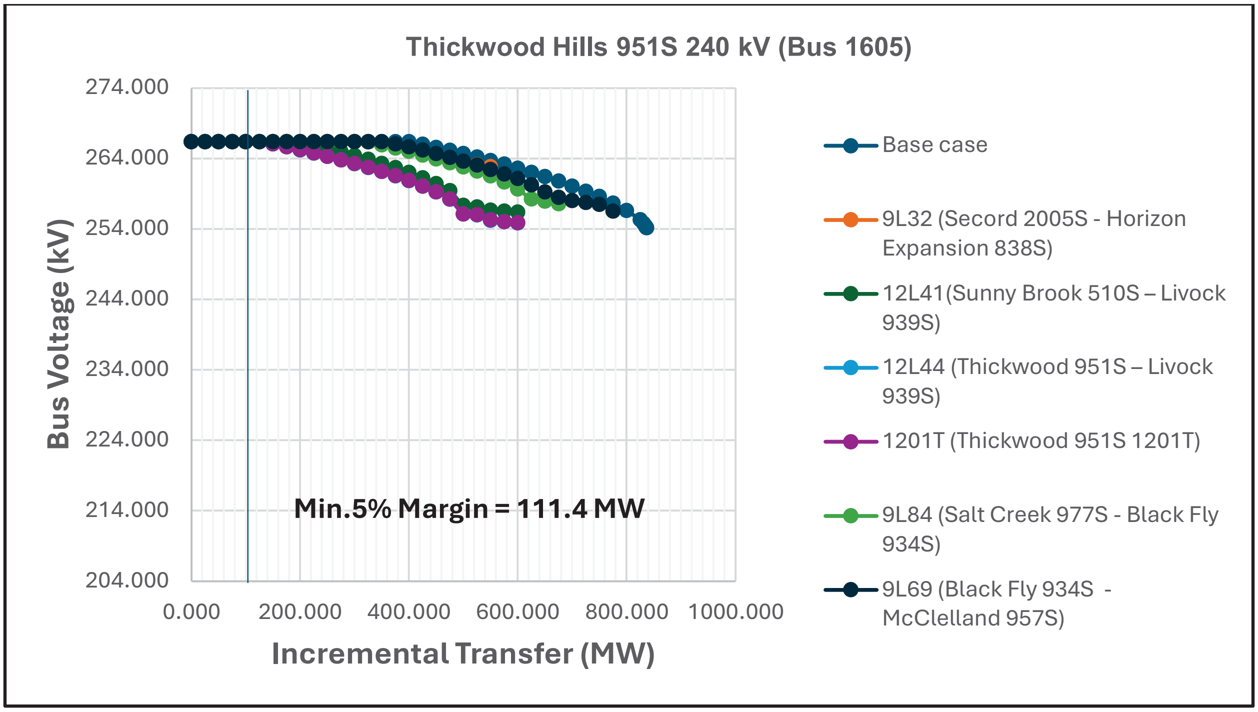

AMR02 937S 240 kV (Bus 1626)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

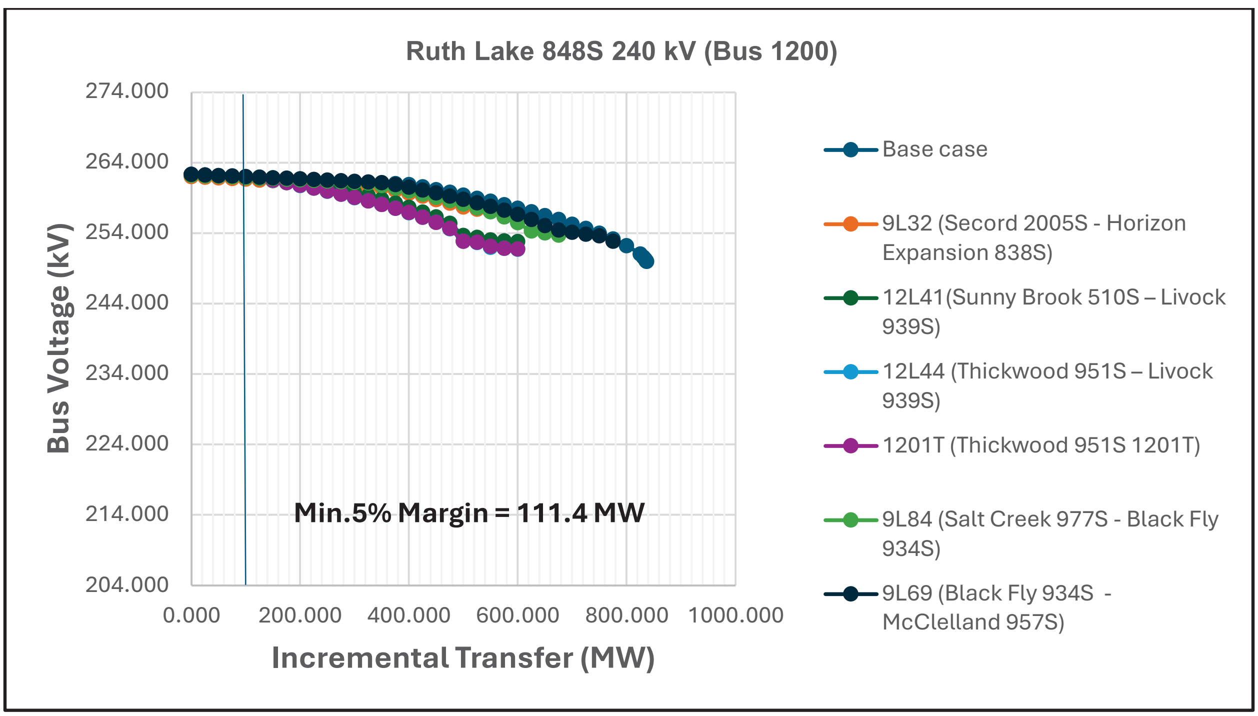

McClelland 957S 240 kV (Bus 1610)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

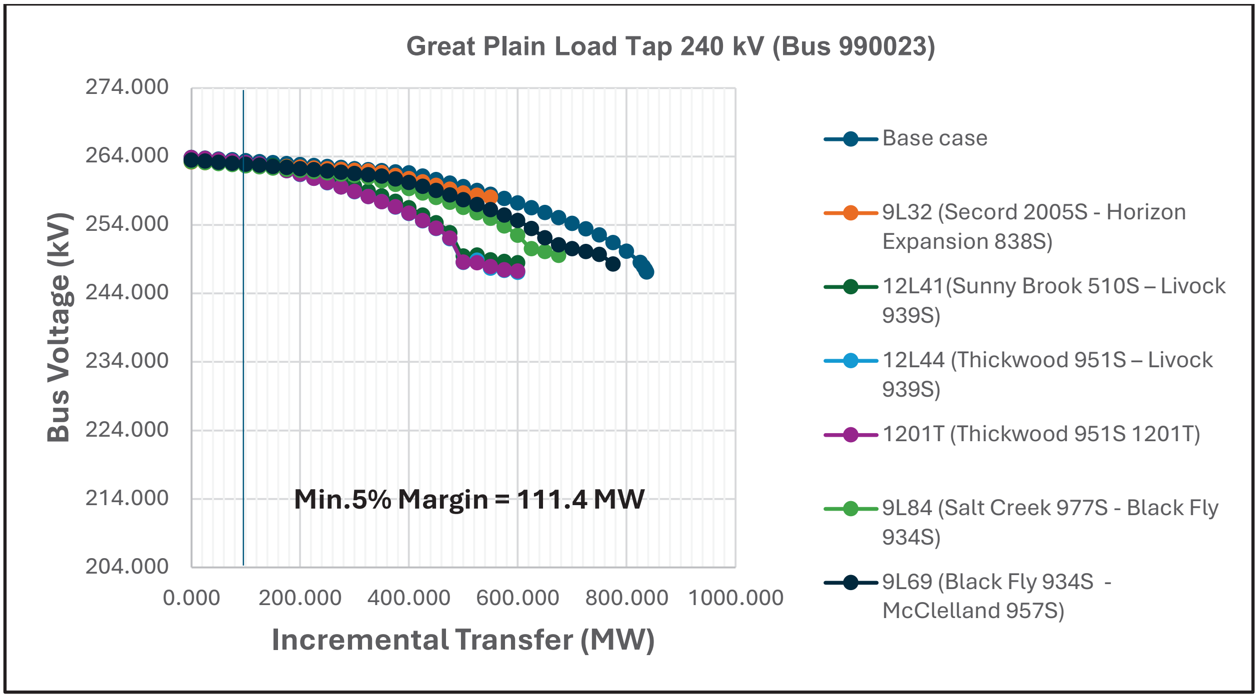

Yeo 2015S 240 kV (Bus 1462)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)


Livock 939S 240 kV (Bus 1288)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

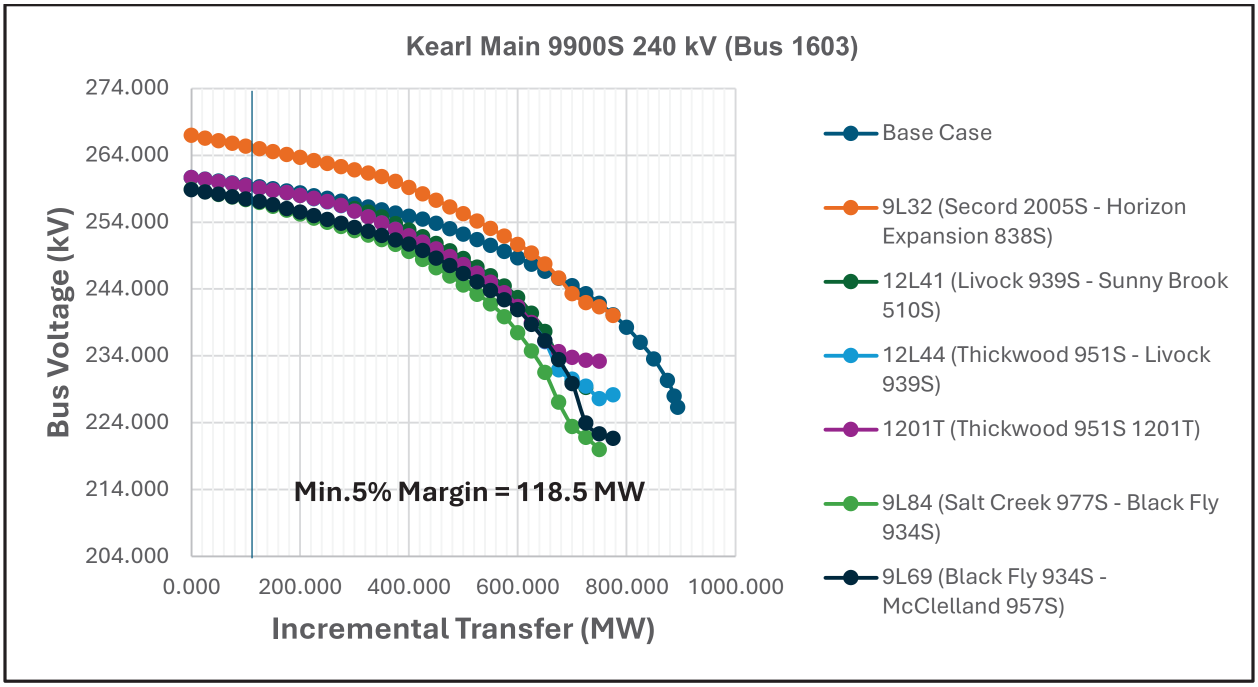

Joslyn 849S 240 kV (Bus 1263)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

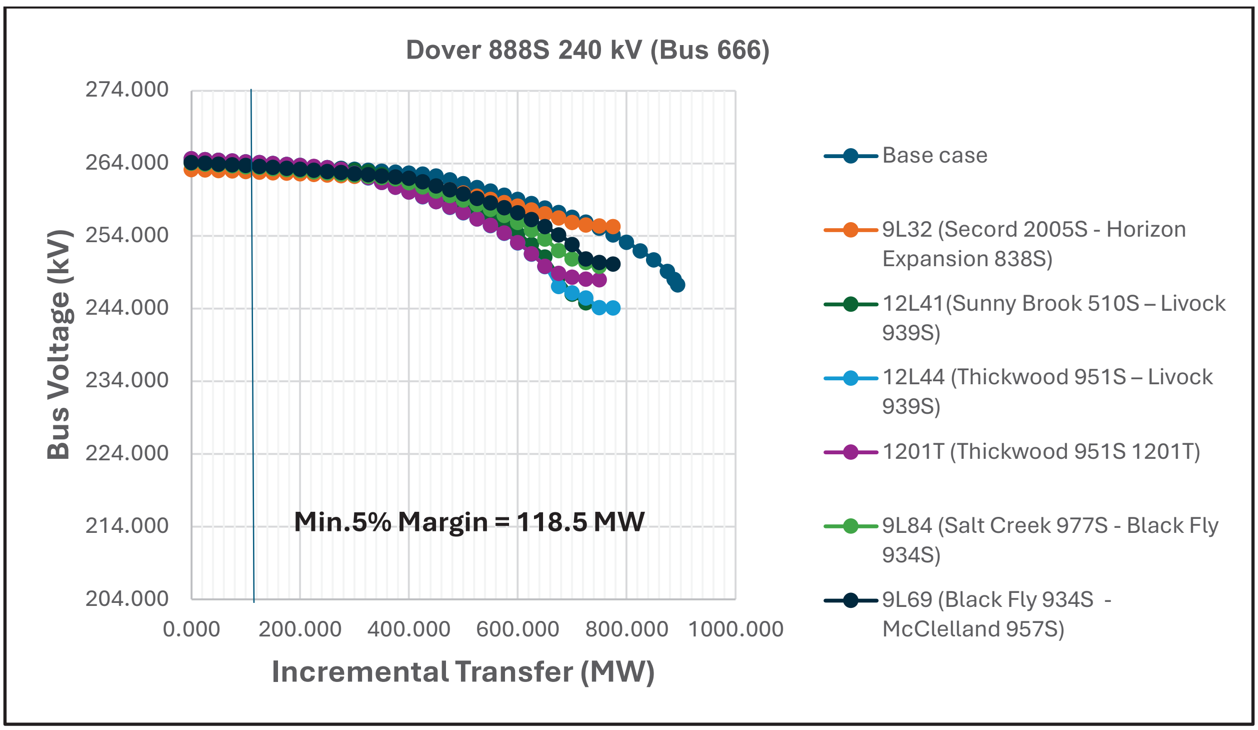

Thickwood Hills 951S 240 kV (Bus 1605)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

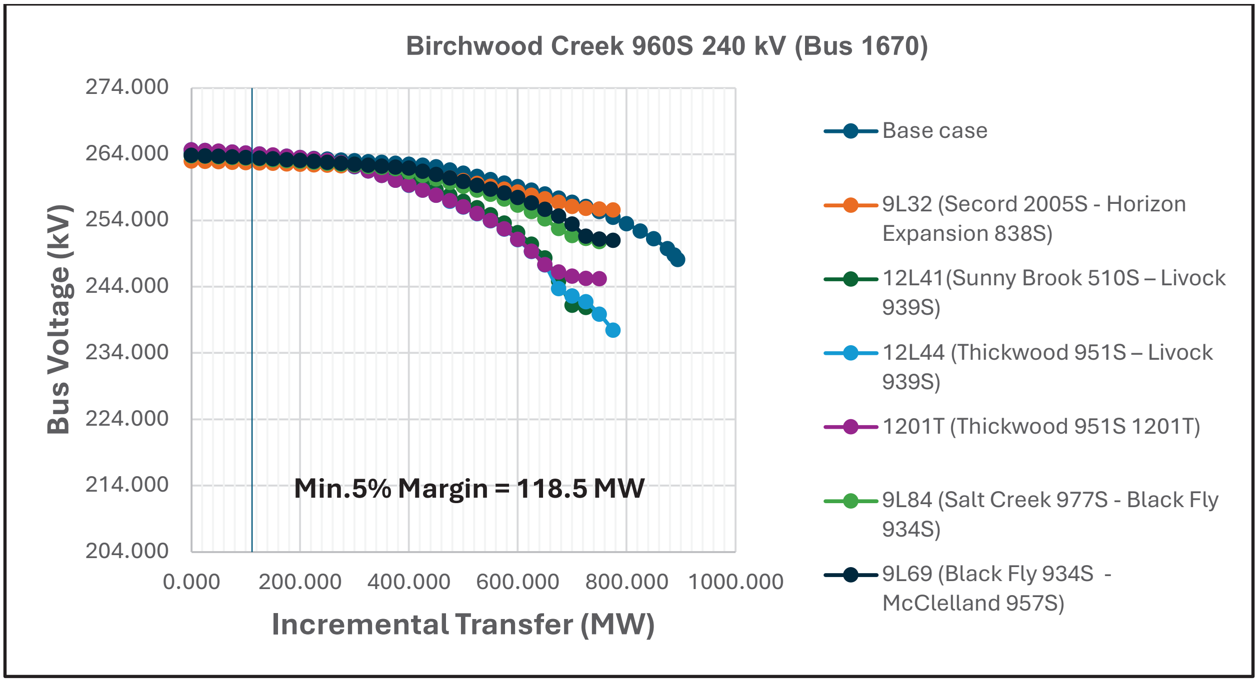

Ruth Lake 848S 240 kV (Bus 1200)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

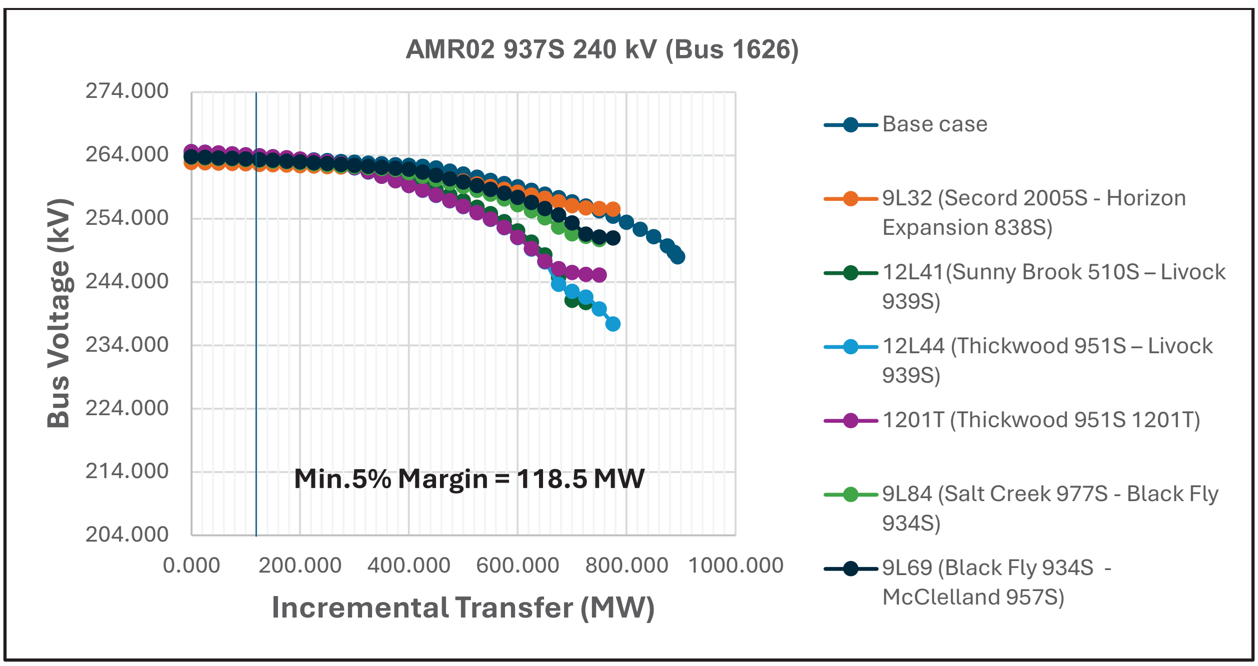

Great Plain Load Tap 240 kV (Bus 990023)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 111.4 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

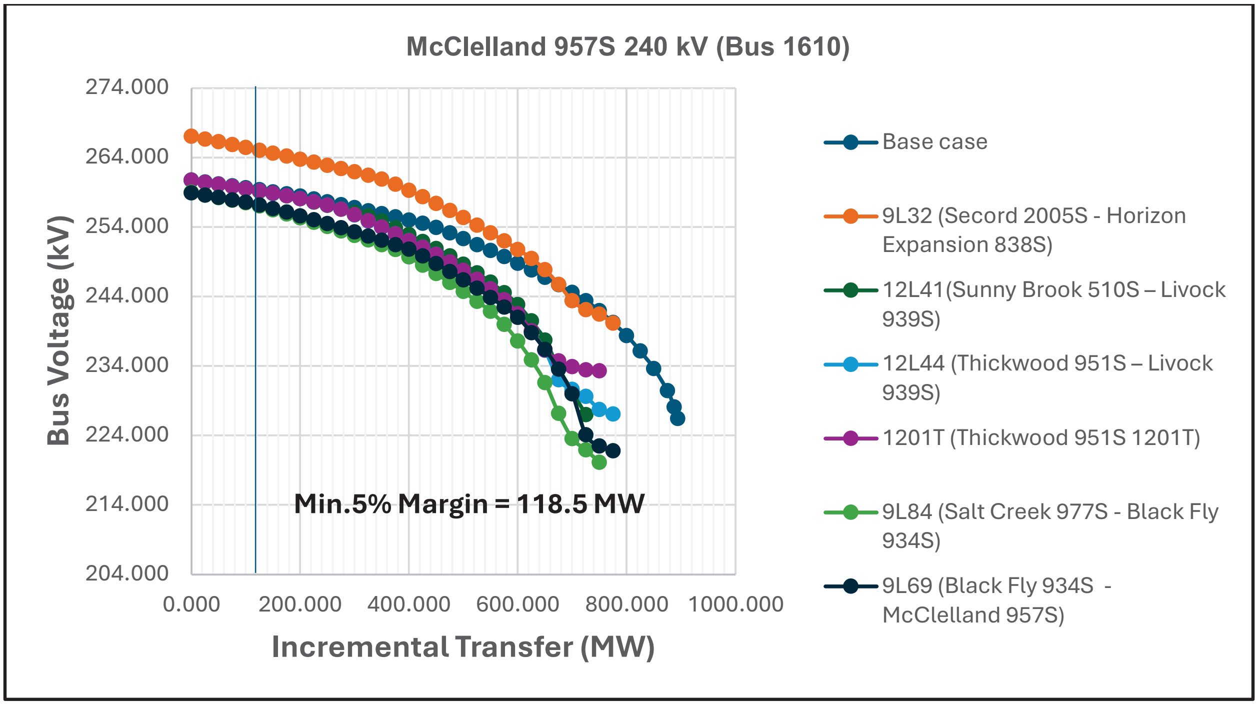
Scenario 4: 2028_WP_NE_LG_POST_Main

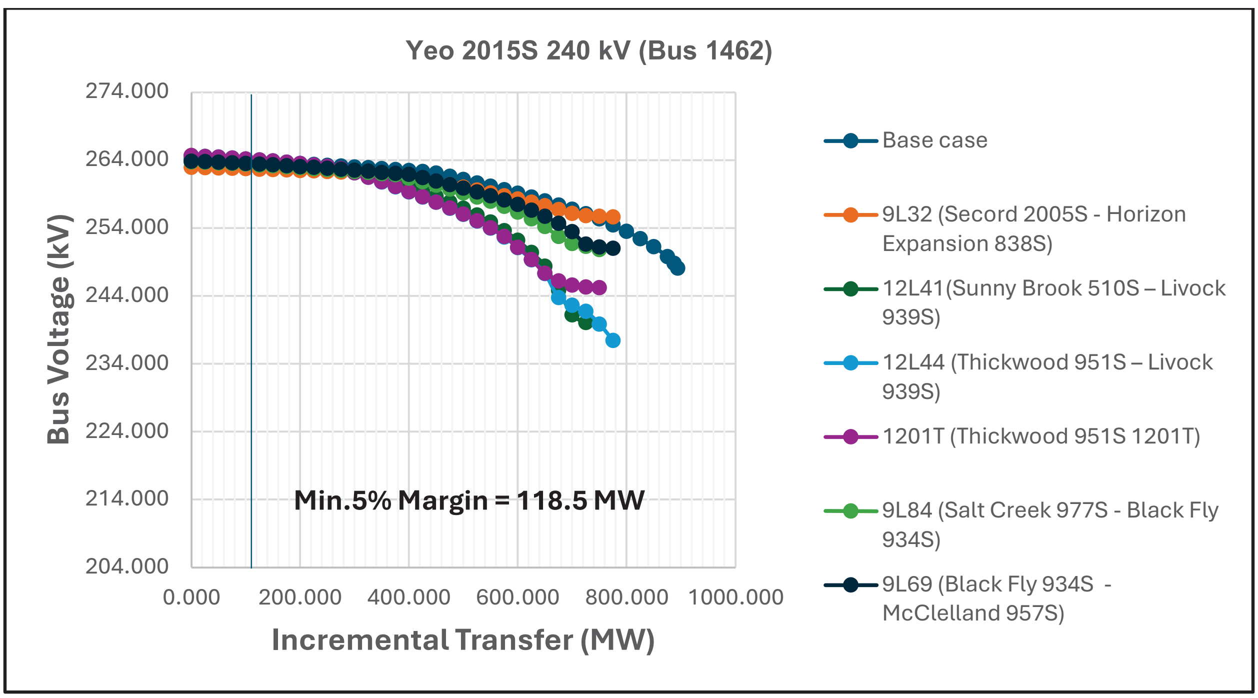


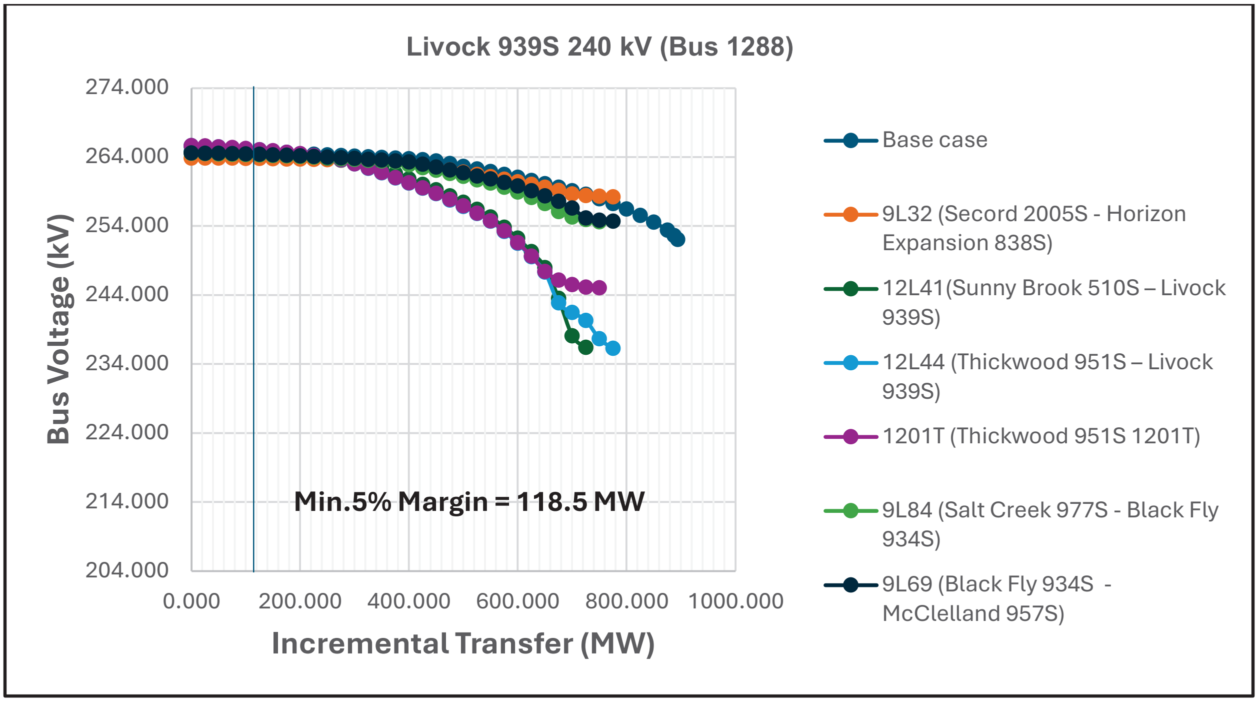



Birchwood Creek 960S 240 kV (Bus 1670)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Bus Voltage (kV)
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

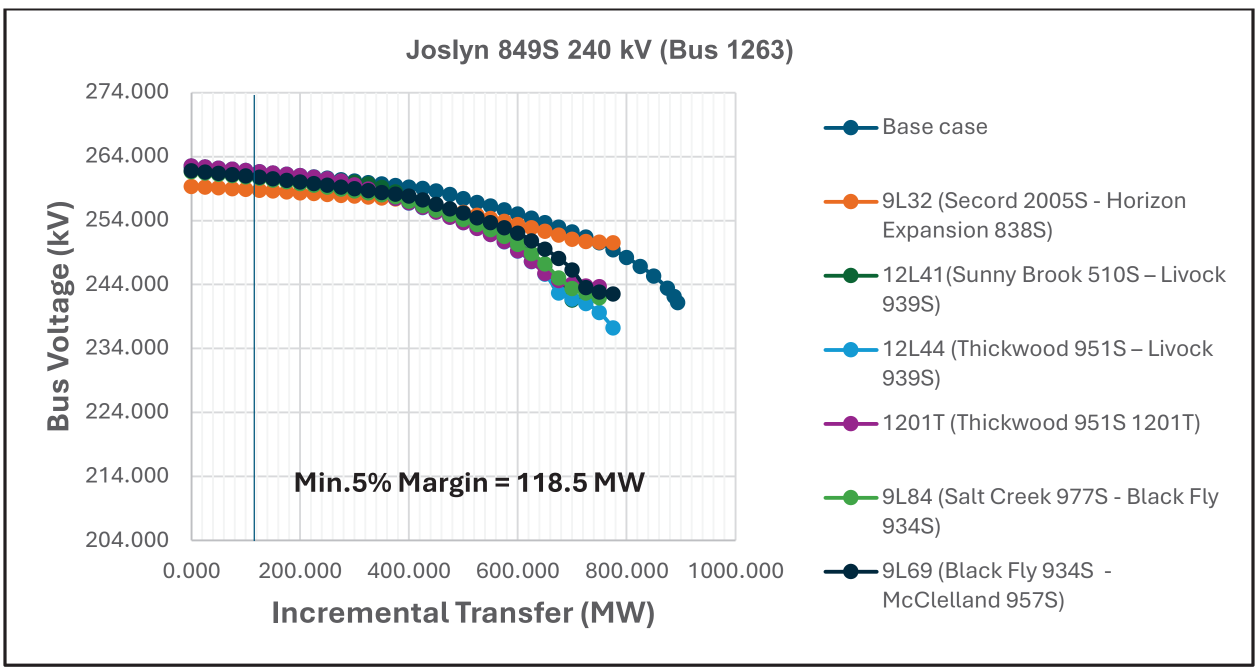

AMR02 937S 240 kV (Bus 1626)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Bus Voltage (kV)
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)


McClelland 957S 240 kV (Bus 1610)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

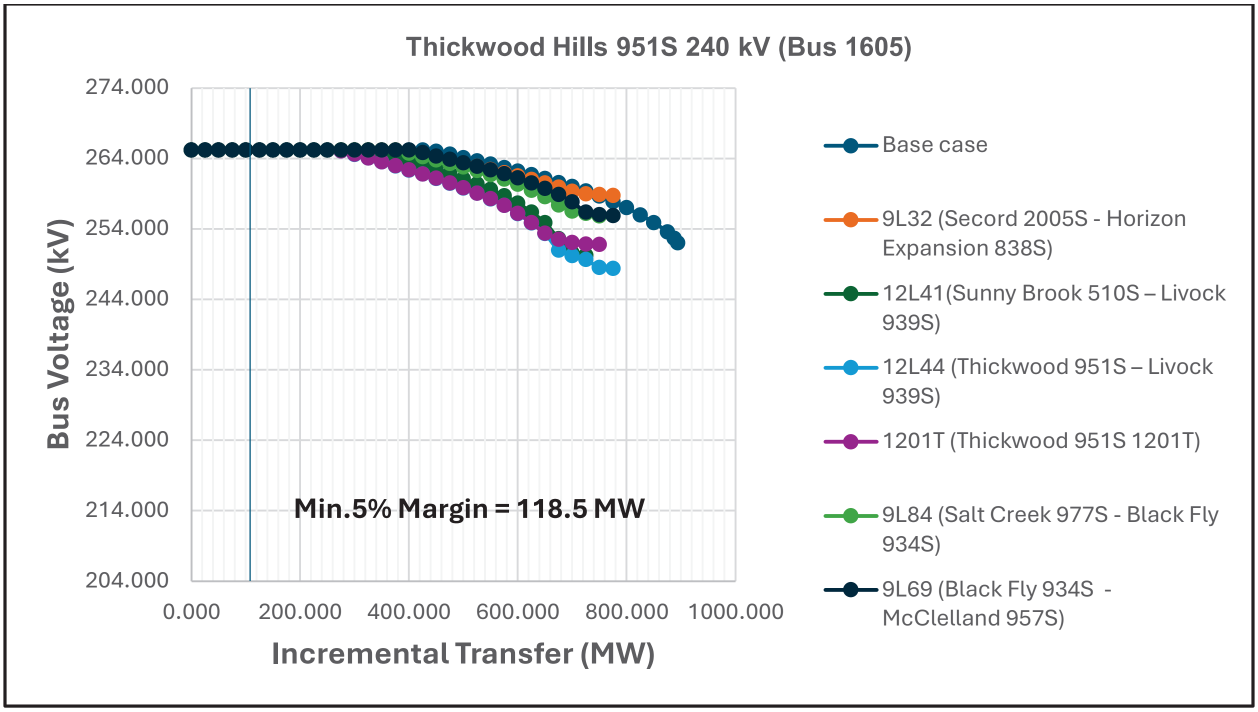

Yeo 2015S 240 kV (Bus 1462)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

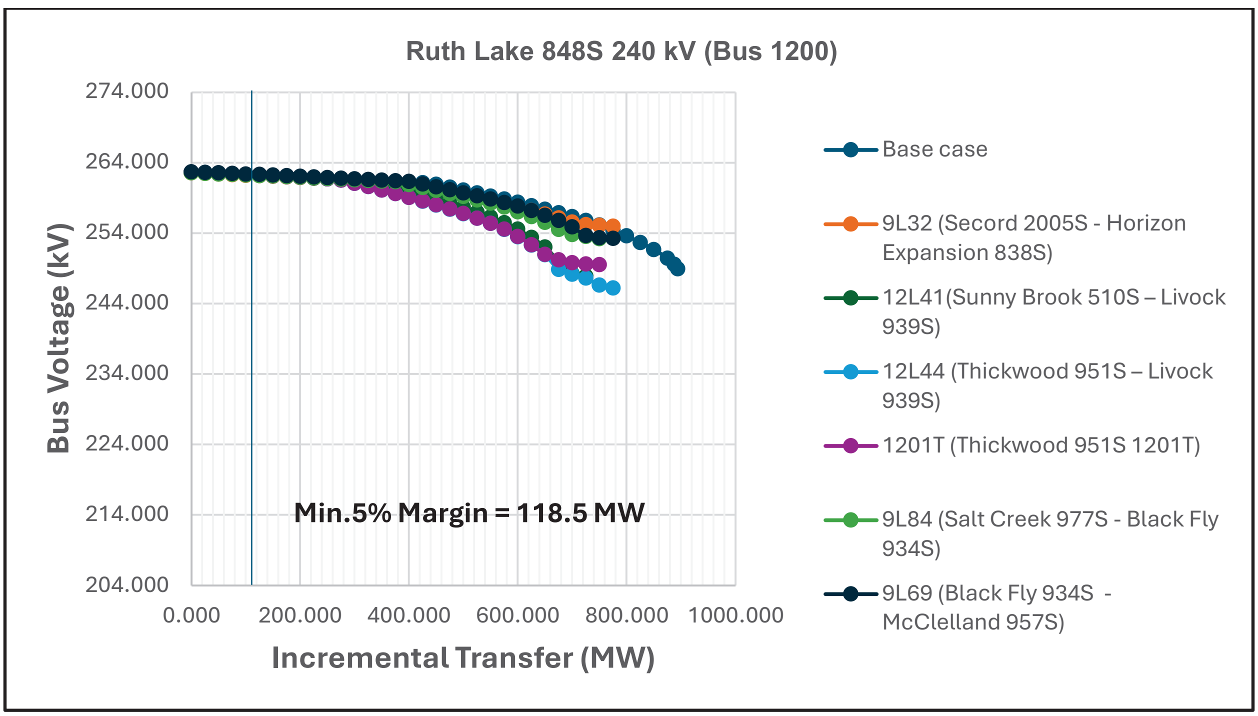


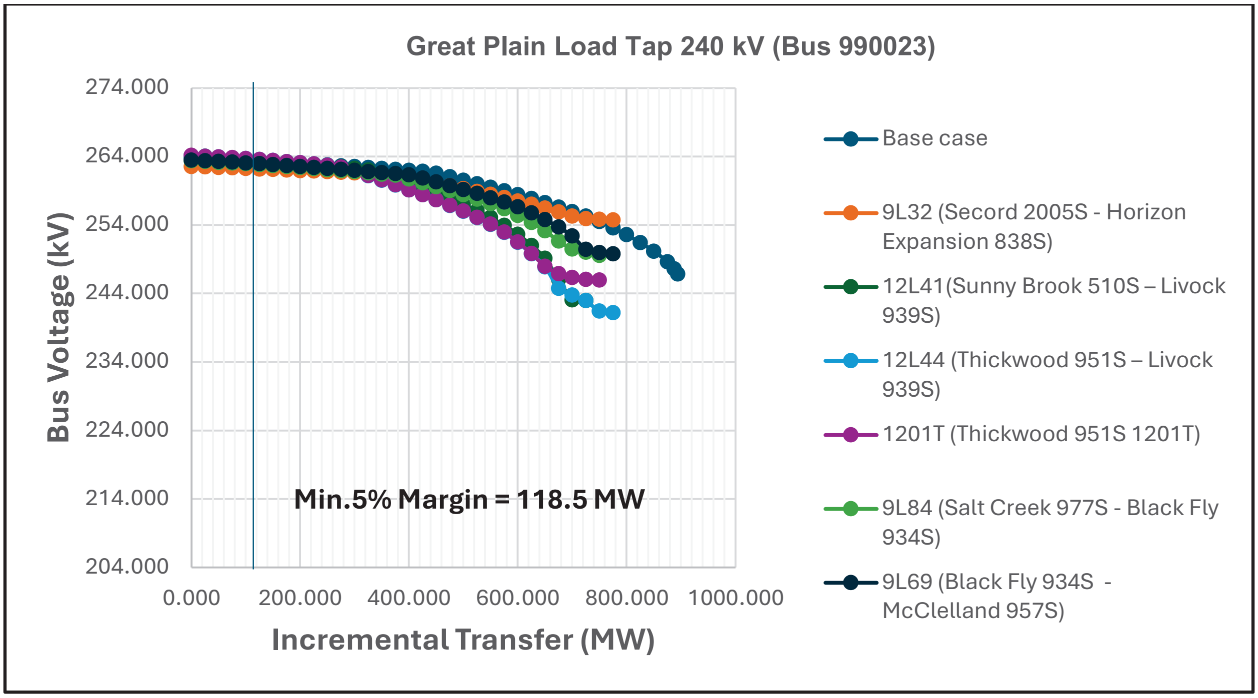
Livock 939S 240 kV (Bus 1288)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Min.5% Margin = 118.5 MW
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)



Joslyn 849S 240 kV (Bus 1263)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Min.5% Margin = 118.5 MW
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)


Thickwood Hills 951S 240 kV (Bus 1605)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)


Ruth Lake 848S 240 kV (Bus 1200)
Bus Voltage (kV)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Min.5% Margin = 118.5 MW
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)



Great Plain Load Tap 240 kV (Bus 990023)
274.000
264.000
254.000
244.000
234.000
224.000
214.000
204.000
Bus Voltage (kV)
Min.5% Margin = 118.5 MW
0.000
200.000
400.000
600.000
800.000
1000.000
Incremental Transfer (MW)
Base case
9L32 (Secord 2005S - Horizon Expansion 838S)
12L41(Sunny Brook 510S – Livock 939S)
12L44 (Thickwood 951S – Livock 939S)
1201T (Thickwood 951S 1201T)
9L84 (Salt Creek 977S - Black Fly 934S)
9L69 (Black Fly 934S - McClelland 957S)

ATTACHMENT A5
Constraints Summary Table – Loading and Voltage Performance
(Scenarios 1, 2, 3, and 4)

Table 5-1: Remedial Action Schemes

RAS Number/Name	RAS Description	Action1
RAS 155	Kearl Voltage stability Mitigation	Trip load 37 at bus 1682

Table 5-2: Voltage Violations

Triggering Events (Element out of Service)	Details of Constraint											Assumed System Conditions	Mitigation Approach (RAS or Procedure, also include post-RAS system performance, ex. %I of MVA loading of nominal rating)	
	Voltage (Steady State)													Post RAS Action
	Substation	Bus #	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Pre-Project Initial Voltage (kV) Pre	Pre-Project Voltage (KV) Pre	Post-Project Initial Voltage (kV) Pre	Post-Project Voltage (KV) Pre	% Voltage Difference (kV)	Stability		Automatic (RAS) Or Real Time Operating Practice	Action 1 Post Project Voltage (kV)
9L101 (McClelland 957S - Secord 2005S)	Kearl Main 9900S (Imperial)	1603	240	234	275	259.6	228.8	259.9	228.7	-0.1%	Yes	2028SP_Main	RAS 155 : Trip load at Kearl substation (bus 1682)	248.7
		1664	72	65	78	71.9	61.2	72	61.2	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	72.8
		1681	72	65	78	73.7	62.1	73.8	62	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	70.2
		1682	72	65	78	72.1	61.6	72.2	61.6	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	73.4
	Mcclelland 957S	1610	240	234	275	259.7	228.9	260	228.7	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	248.7
	Kearl Main 9900S (Imperial)	1603	240	234	275	260.6	233.3	260.7	233	-0.1%	Yes	2028WP_Main	RAS 155 : Trip load at Kearl substation (bus 1682)	248.6
		1664	72	65	78	72.8	64.6	72.8	64.5	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	72.8
		1681	72	65	78	74.6	64.2	74.7	64.1	-0.2%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	70.1
		1682	72	65	78	73.3	65	73.4	64.9	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	73.4
	Mcclelland 957S	1610	240	234	275	260.6	233.4	260.8	233.1	-0.1%	Yes		RAS 155 : Trip load at Kearl substation (bus 1682)	248.6

Engineering Connection Assessment: Study Scope

P2741 Great Plains Load Project Study Scope

ATCO Electric Ltd.

Date: Oct. 04, 2024

Version: V1 Final

Classification: Public

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Tables

Figures

Attachments

1 Introduction

This Study Scope provides an overview of the engineering studies to be completed by ATCO Electric Ltd. (the Studies Consultant) to assess the impact of the Project (as defined in section 1.1) on the performance of the Alberta interconnected electric system (AIES). Technical criteria, assumptions and methods for performing these engineering studies are provided in this document.

1.1 Project Overview

Project overview is provided in Table 1-1.

Table 1-1: Project Overview

Market Participant	Type of Project	In-service Date (ISD)
ATCO Electric Ltd.	Connection	Dec. 1, 2026

Project details are listed in Table 1-2.

Table 1-2: Project Load and Generation Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	No existing contract
	Requested Rate DTS	51 MW
	Type	Industrial
	Motors (number and size)	3 x 25,000 HP motors each equipped with VFD
	Power factor	0.9 pf
	Future load expansion plans	No

1.2 Existing System Overview

1.2.1 Study Area

Geographically, the Project is located in the AESO planning area of Fort McMurray (Area 25).

The Study Area consists of the AESO planning area of Fort McMurray (Area 25), including the tie lines connecting the planning area to the rest of the AIES.

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

1.2.2 Existing Constraints

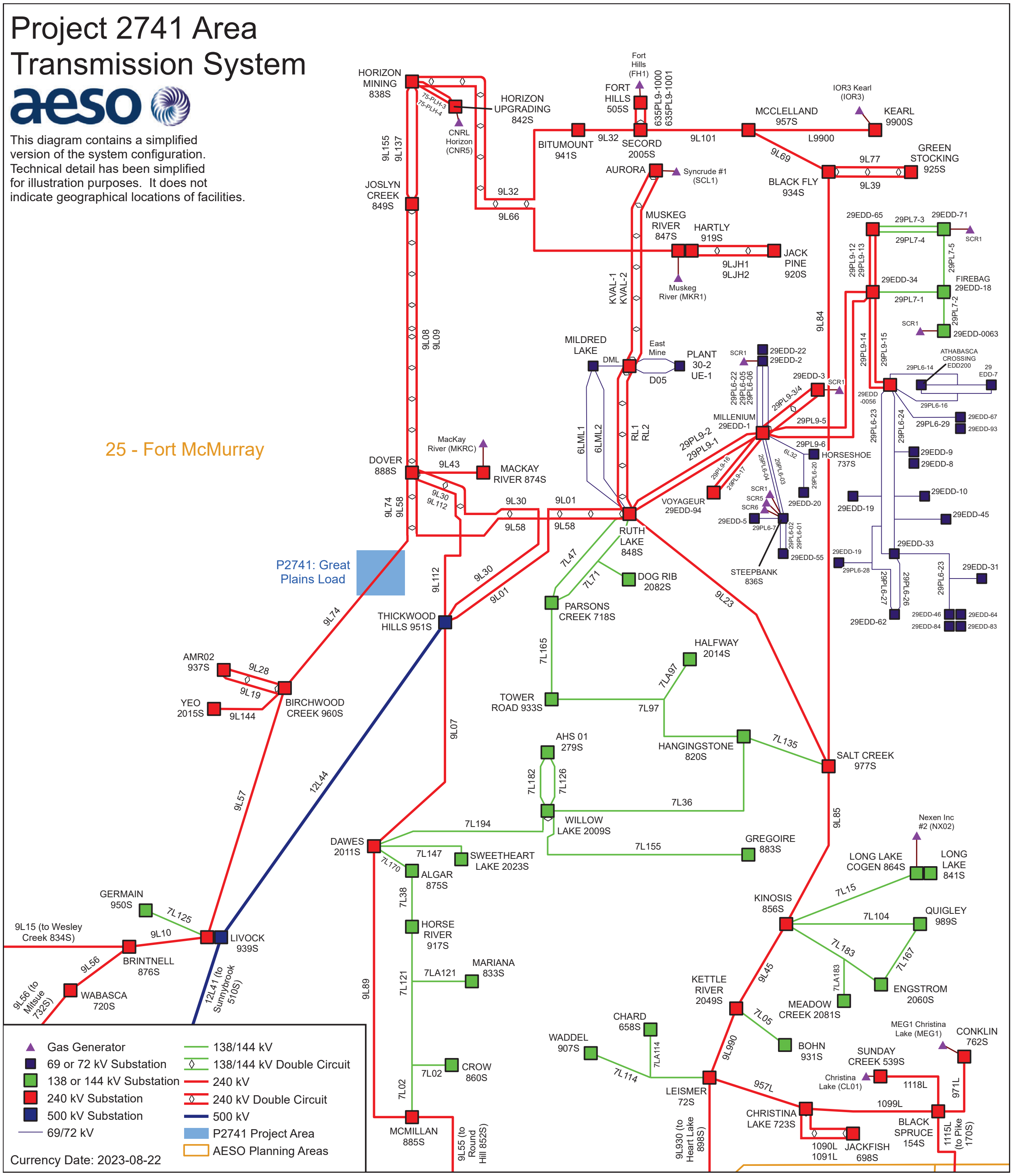
Existing constraints in the Study Area are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule).

There are a number of constraints in the Study Area that are mitigated by existing remedial action schemes (RASs) and/or other protection schemes.

The following existing RASs and/or other protection schemes are used to manage constraints in the area:

- RAS 155: Kearl Voltage Stability Mitigation

Figure 1-1: Transmission System in the Study Area



2 Connection Alternative to Be Studied

The following alternative will be studied:

2.1 Alternative 1 – New 240/25kV Point of Delivery with a T-Tap Connection to 240 kV transmission line 9L74

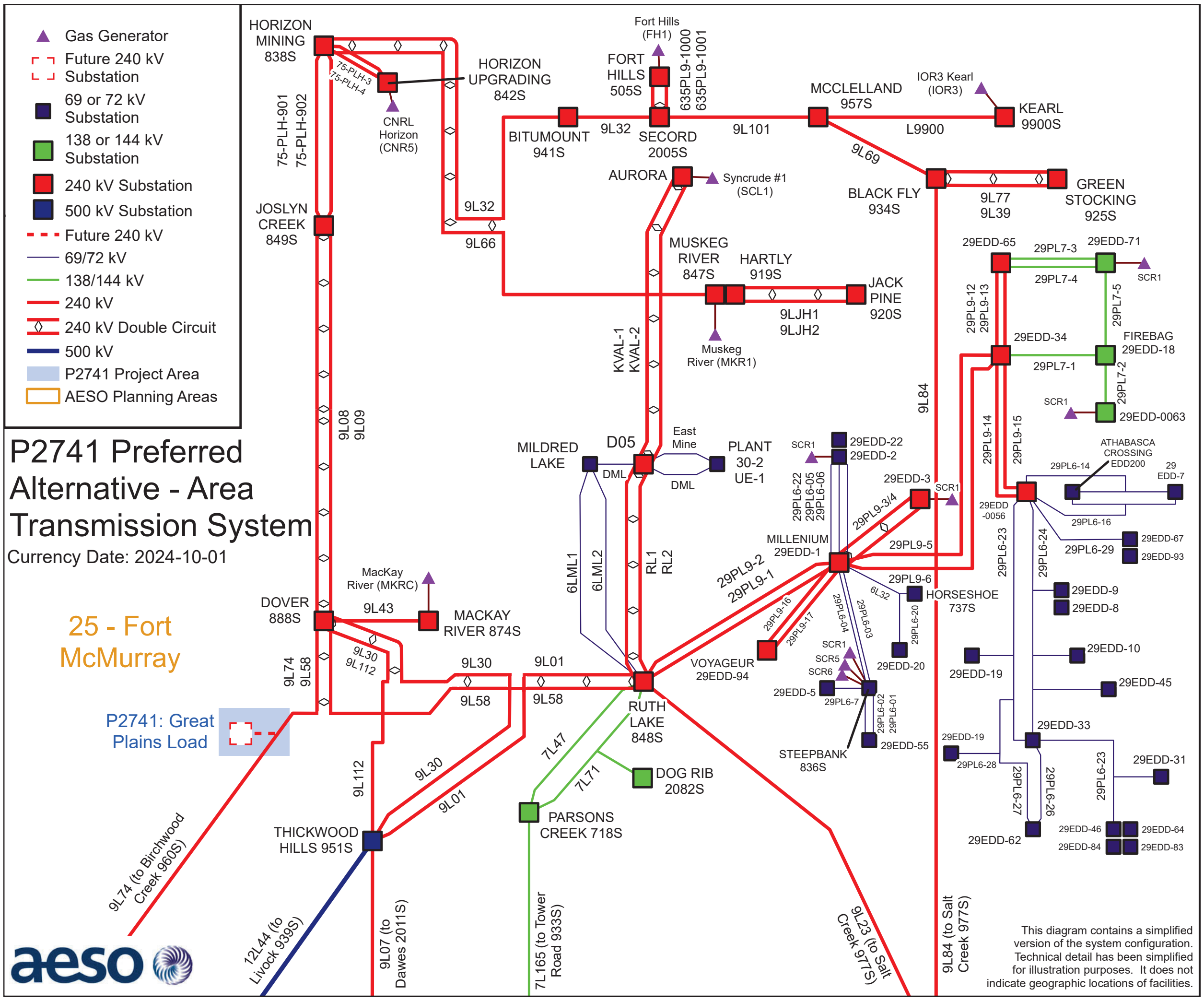
This alternative included the following developments:

- Add a new 240/25kV Point of Delivery (POD) substation, including two 240/25kV transformers[1], three 25kV feeder breakers, and two 240 kV circuit breakers;
- Add one 240 kV circuit, approximately 0.1 km in length, to connect the proposed substation to the existing 240 kV transmission line 9L74 (between Birchwood Creek 960S and Dover 888S substations) using a T-tap configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 2-1.

[1] The customer has requested redundant transformers in the substation for reliability purposes.

Figure 2-1: Connection Alternative 1



3 Criteria, Standards and Requirements

3.1 AESO Reliability Criteria

The Transmission Planning (TPL) Standards, which are included in the Alberta Reliability Standards, and *Transmission Planning Criteria – Basis and Assumptions (see Attachment A),* (collectively, the Reliability Criteria) will be 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 TPL standards, TPL-001-AB-0 and TPL-002-AB1-0, 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:

- Normal thermal rating of the line’s loading limits for each season;
- The highest specified loading limits for transformers;
- For Category A conditions: Voltage range under normal operating condition per AESO Information Document #2010-007RS, *General Operating Practices – Voltage Control* (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; and*
- Desired post-contingency voltage deviation limits for three defined post-event timeframes as provided in Table 3-1.

Table 3-1: Post-Contingency Voltage Deviation 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 point of delivery (POD) low voltage bus.	±10%	±7%	±5%

3.2 ISO Rules and Information Documents

ID #2010-007RS will be used to establish system normal (i.e., pre-contingency) voltage profiles for the Study Area.

The TCM Rule will be followed to set up the study scenarios and assess the impact of the Project. In addition, due regard will be given to the following:

- The AESO's *Connection Study Requirements*;
- Section 502.7 of the ISO rules, *Load Facility Technical Requirements*;

4 Scenarios and Assumptions

4.1 Scenarios

The following section describes the scenarios to be studied and the assumptions to be used in the studies.

Connection scenarios must be studied as outlined in Table 4-1.

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	Project Load (MW)	Project Generation (MW)
Pre-Project					
1	2028 Summer Peak (SP)	Low Generation (LG)	2028 SP Pre-Project	0	0
2	2028 Winter Peak (WP)		2028 WP Pre-Project	0	0
Post-Project					
3	2028 SP	LG	2028 SP Post-Project	0	51
4	2028 WP		2028 WP Post-Project	0	51
5	2033 WP	All generator in Study Area in-service	2033 WP Post-Project	0	51

4.2 Assumptions

4.2.1 System Project Assumptions

The pre-Project and post-Project connection assessment will not include any system transmission projects because there are no planned system transmission developments in the Study Area that are expected to be in service before the scheduled Project ISD.

4.2.2 Load Assumptions

The load forecast to be used for the studies is shown in Table 4-2 and is a forecast for the AESO Northeast Planning Region peak based on the AESO's Preliminary 2023 Long-term Outlook (2023 LTO)[2] with modifications to incorporate the latest forecast intelligence. For the post-Project studies, when the Study Area loads are modified to align with the regional load forecast, the active power to reactive power ratio in the base case scenarios shall be maintained.

Table 4-2: Forecast Load in Northeast Planning Region

[2] The preliminary 2023 LTO is available on the AESO website.

AESO Planning Region Name	Forecast Peak Load by Year/Season (MW)	
	2028 SP LG	2028 WP LG
Fort McMurray (Area 25)[1]	2,317	2,413
Northeast Planning Region	3,548	3,546
AIL	10,091	11,170

Note:
[1] The Northeast Region comprises the following AESO planning areas: 25, 27, and 33.

4.2.3 Generation Assumptions

The generation forecast to be used for the studies is based on the 2023 LTO with modifications to incorporate the latest forecast intelligence. The generation assumptions for the studies will assume Low Generation for Summer Peak and Winter Peak load conditions.

The existing and planned generation dispatch conditions for the study scenarios are described in Table 4-3.

MacKay River (MKRC) was determined to be the critical generator, and shall be modelled as being offline to simulate the N-G condition in all the study scenarios.

Table 4-3: Existing and Planned Generation Dispatch Conditions in the Study Areas

Facility Name	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
				2028 SP LG[b]	2028 WP LG[c]
Christina Lake (CL01)	4379 4380	100	25	92	98
CNRL Horizon (CNR5)	18264, 2268, 19264	203	25	195	201
Fort Hills (FH1)	14781, 14782	199	25	92	195
Kearl (IOR3)	1695	84	25	37	64
MEG1 Christina Lake (MEG1)	2405, 3405	202	25	166	183
Muskeg River (MKR1)	10236 12236	202	25	82	186
MacKay River (MKRC)	18274	207	25	N-G[d]	N-G[d]

Nexen Inc #2 (NX02)	12249, 13249, 11241	220	25	171	182
Suncor Base Plant Cogen (P2082)	2867, 2868	806	25	321	369
Syncrude #1 (SCL1)	16233, 17233, 17209, 18209, 17210, 18210, 19210, 18206, 18207, 19209	510	25	375	408
Base Plant (SCR1)	16218, 18218		25		
Firebag (SCR6)	16219, 18208, 18223, 19208, 3273	923	25	687	531
Poplar Creek (SCR5)	16297, 17297, 18297, 19297		25		

Notes:
[a] “Unit Net Generation” refers to gross generating unit output (MW) less unit service load.
[b] “SP LG” refers to 2028 Summer Peak - Low Generation.
[c] “WP LG” refers to 2028 Winter Peak - Low Generation.
[d] “N-G” indicates the critical generating unit that is assumed by the AESO to be offline to test the N-G contingency condition

4.2.4 Intertie Flow Assumptions

The Alberta-British Columbia (AB-BC), Alberta-Saskatchewan (AB-SK), and Alberta-Montana (MATL) intertie points are deemed to be too far away from the Study Area to have any material impact on the connection assessment. Therefore, intertie flow values shall be set to the AESO planning base case values and will not be adjusted for the studies.

4.2.5 HVDC Power Order Assumptions

The Western Alberta Transmission Line (WATL) and the Eastern Alberta Transmission Line (EATL) are high-voltage direct current (HVDC) transmission lines. The HVDC power order assumptions for the studies will be set to minimize losses for the pre-Project and post-Project study scenarios.

The reactive power limits of the MVAr exchanges between the HVDC terminals (WATL and EATL) and the connected alternating current (AC) transmission systems are shown in Table 4-4. These limits must be maintained when performing the studies.

Table 4-4: HVDC to Adjacent AC System MVAr Exchange Limits

HVDC Facility	North Terminal Reactive Power Limit (MVAr)	South Terminal Reactive Power Limit (MVAr)
EATL	-85 to 75	-35 to 35
WATL	-75 to 75	-35 to 35

4.2.6 Voltage Profile Assumption

ID #2010-007RS will be 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 the busses not included in ID #2010-007RS. These voltages will be used to set the voltage profile for the study base cases prior to the power flow studies.

5 Study Methodology

The studies to be performed for this connection assessment are identified in Table 5-1.

Table 5-1: Summary of the Studies to be Performed

Scenario No. and Name		Power Flow		Voltage Stability		Transient Stability		Motor Starting		Short Circuit
		Category		Category		Category		Category		Category A
		A	B	A	B	A	B	A	B	
Pre-Project										
1	2028 SP LG	X	X	X*	X*					
2	2028 WP LG	X	X	X*	X*					X
Post-Project										
3	2028 SP LG	X	X	X	X					
4	2028 WP LG	X	X	X	X					X
5	2033 WP									X

Notes:
* Only required if post-project studies show potential transient stability issues.

For the engineering studies, all transmission facilities 69 kV and above, within the Study Area and the transmission lines connecting the study areas (as defined in Section 1.2.1) to neighboring planning areas will be studied and monitored to assess the impact of the Project on the performance of the AIES, including any violations of the Reliability Criteria (as defined in Section 3.1).

5.1 Study Case Validation

The study will be conducted on the AIES system model using the AESO's planning base cases. The seasonal light/peak scenarios will be studied as required. The base cases will be modified by the AESO to include the corresponding load and generation forecast information. The resulting cases, or seed cases, will be provided by the AESO to the Studies Consultant. These cases are provided in PSS/E v34. Upon request, the AESO can provide RAW and SEQ files. Software used by the Studies Consultant must be able to read and write these file types. Manual adjustments may be required to ensure full alignment with the details outlined in this Study Scope, as described in the process outlined below. The AESO will provide guidance to the Studies Consultant with regard to the setup of the study cases should any questions arise.

The expected process for the creation of acceptable study cases is as follows:

1. The AESO provides seed cases and any other applicable information required to the Studies Consultant.

2. If the cases show N-0 violations, AESO will work with the Studies Consultants to address the issues. The Studies Consultant verifies and makes adjustments as required to ensure the study cases represent the assumptions outlined within the Study Scope.
3. Upon creating the study cases, all the study cases are forwarded to the AESO for approval.
4. The Studies Consultant proceeds with the required engineering studies only after the study cases are approved by the AESO.

5.2 Power Flow Studies

Power flow studies will be performed to identify thermal and voltage criteria violations as per the Reliability Criteria, and any deviations from the limits listed in Table 3-1.

For information purposes, the Studies Consultant must also provide, as a separate file, a list of any transmission elements where the thermal loading exceeds 95% of the element's normal rating under Category A and Category B conditions.

For the Category B power flow studies, the transformer taps and switched shunt reactive compensating devices such as shunt capacitors and reactors will be locked and continuous shunt devices will be enabled.

Voltage deviations at point-of-delivery (POD) low voltage busses will also be assessed for both the pre-Project and post-Project networks by first locking all tap changers and area shunt reactive compensating devices to identify any post-transient voltage deviations above 10%. Second, tap changers will be allowed to move while shunt reactive compensating devices remained locked to determine if any voltage deviations above 7% would occur in the area. Third, all the taps and shunt reactive compensating devices will be allowed to adjust, and voltage deviations above 5% will be reported.

The scenarios to be studied are shown in Table 5-1.

5.2.1 Contingencies to be Studied

Power flow studies will be performed for the Category A and all Category B conditions in the Study Area.

5.3 Voltage Stability Studies

The objective of the voltage stability studies is to determine the ability of the transmission system to maintain voltage stability margin at all busses under Category A and Category B conditions. The power-voltage (PV) curve is a representation of voltage change as a result of increased power transfer between two systems. The incremental transfers will be reported at the collapse point.

Voltage stability studies will be performed for the post-Project scenarios. For load connection projects, the load level modeled in post-Project scenarios is the same as, or higher than, in pre-Project scenarios. Therefore, voltage stability studies for pre-Project scenarios will only be performed if post-Project scenarios show voltage stability criteria violations.

Voltage stability studies will be 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 margin is required for the area modeled at a minimum of 105% of the reference load level for Category A conditions and for Category B conditions. For this standard, the reference load level is the maximum established planned load.

Typically, voltage stability studies are carried out assuming the worst-case scenarios in terms of loading. In this connection assessment, the voltage stability studies will be performed by increasing load in Fort McMurray (Area 25) and increasing generation in Wabamun (Area 40), Calgary (Area 6), and Sheerness (Area 43).

The scenarios and cases to be studied are shown in Table 5-1.

5.3.1 Contingencies to be Studied

Voltage stability studies will be performed for all Category B contingencies in the Study Area. The Category A condition and the five contingencies with the smallest stability margin will be presented in the results.

5.4 Short-Circuit Current Level Studies

A maximum fault level must be provided for the substations in the vicinity of the Project assuming normal system operation with all transmission elements in service and generation dispatched. Three-phase faults and single line-to-ground faults will be simulated. Polar coordinates and per-unit values will be used for reporting the results.

Winter peak scenarios will be used for the short-circuit studies because winter peak scenarios generally produce higher short-circuit current levels than summer peak scenarios.

Estimated maximum three-phase faults and single line-to-ground short-circuit current levels will be reported for the following substations:

- Dover 888S
- Birchwood Creek 960S
- Joslyn Creek 849S
- Ruth Lake 848S
- The Facility POD (including in post-Project studies only)

Further sensitivity studies, in consultation with the TFO, may be required if the primary short-circuit analysis indicates a potential to exceed or approach the existing fault rating of the transmission facilities.

The scenarios to be studied are as shown in Table 5-1.

6 Mitigation Measures

6.1 Development

Mitigation measures may be required if the post-Project study results identify system performance issues. Mitigation measures for the Project may involve modifying or adding real-time operational practices and/or remedial action schemes (RASs).

The Studies Consultant must notify the AESO of any system performance issues in a timely manner, following which the AESO Studies Engineer may instruct the Studies Consultant as follows:

- Develop tables showing the constraint effective factors[3] for generation or load based on thermal criteria violations that are observed.
- Collaborate with the AESO to propose changes, if any, to the connection alternatives that could remove the requirement for a RAS.
- Collaborate with the AESO to study modifications to existing and/or planned RASs, proposed by the AESO, to ensure the coordination of existing protection schemes with the addition of any proposed protection schemes.
- Collaborate with the AESO to identify and study new RASs, if any, that may be required to ensure system reliability is maintained after connecting the Project to the AIES.

The AESO Studies Engineer will work closely with the Studies Consultant and guide the development and/or modifications of the proposed mitigation measures to ensure system reliability, security and compliance with AESO ID #2018-018T, *Provision of System Access Service and the Connection Process*.

6.2 Evaluation

6.2.1 Post-Mitigation Studies

Studies to evaluate the effectiveness of mitigation measures, if required, will be performed in accordance with the technical criteria, assumptions, and methods provided in this Study Scope and in accordance with further instructions from the AESO.

6.2.2 Constraint Effective Factor Studies

Constraint effective factor analysis are used to determine the generator- and load- constraint effective factors and to identify the most effective generators or loads to manage the thermal criteria violations, if any, that are observed under Category A and/or Category B conditions.

[3] Constraint effective factor studies are performed to determine the generator- and load- constraint effective factors. Constraint effective factors are used to estimate the ability of generators and loads to manage transmission constraints. A generator's or load's constraint effective factor is defined as the change in power flow over a specific transmission line following a change in the generator's energy production or in the load's energy consumption. The greater the constraint effective factor, the more effective a generator or load can be in managing a thermal criteria violation on the specific transmission line.

7 Changes to Study Assumptions

This study will utilize the AESO's planning base cases, which are based on the AESO's current corporate forecast (2023 LTO) with modifications to incorporate the latest forecast intelligence. Sensitivity studies or restudy may be required in the event of revisions to the AESO's corporate forecast, forecast intelligence, or other study assumptions. Additional engineering studies may also be required to assess new connection alternatives, changes to project ISD, or delays in proposed system developments. Any additional or revised study requirements shall be captured in a signed Study Scope Amendment document.

Attachment A:
Transmission Planning Criteria – Basis and Assumptions