Engineering Connection Assessment

P2382 Freer 2043S Substation

ATCO Electric Ltd

PROFESSIONAL ENGINEER ALBERTA
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NOTE:

The conclusions and recommendations in this report are based on the results presented in *Attachment 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.

Contents

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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.

Attached to this Engineering Connection Assessment are the results of the engineering studies (see Attachment A) and the scope and methodology used to perform the studies (see Attachment A1 to Attachment 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. (Market Participant), 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 a new customer load in the Fort McMurray area.

The Market Participant's request includes a new system access service in the Fort McMurray planning area (Area 25) and a request for transmission development (collectively, the Project). The Market Participant has requested a staged Rate DTS, *Demand Transmission Service* contract: the first stage includes a Rate DTS of 5 MW with a contract capacity start date of February 1, 2023 and the second stage includes an increase of 23.8 MW, to a total Rate DTS of 28.8 MW, with a contract capacity start date of May 1, 2023.

The scheduled in-service date (ISD) for the Project is February 1, 2023.

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 Fort McMurray (Area 25), which is part of the AESO North East planning region. Fort McMurray (Area 25) is surrounded by the planning areas of High River (Area 18), Peace River (Area 19), High Prairie (Area 21), and Athabasca/ Lac La Biche (Area 27).

From a transmission system perspective, Fort McMurray (Area 25) consists primarily of a 240 kV and 144 kV transmission system. Fort McMurray (Area 25) is connected to Peace River (Area 19) and High Prairie (Area 21), and Athabasca/ Lac La Biche (Area 27) through the 260 kV transmission system.

Existing constraints in the North East 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 Attachment A1).

3 Connection Alternatives

3.1 Overview

The AESO, in consultation with the TFO in the Study Area and the Market Participant, examined five 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 existing 144 kV transmission line 7L121

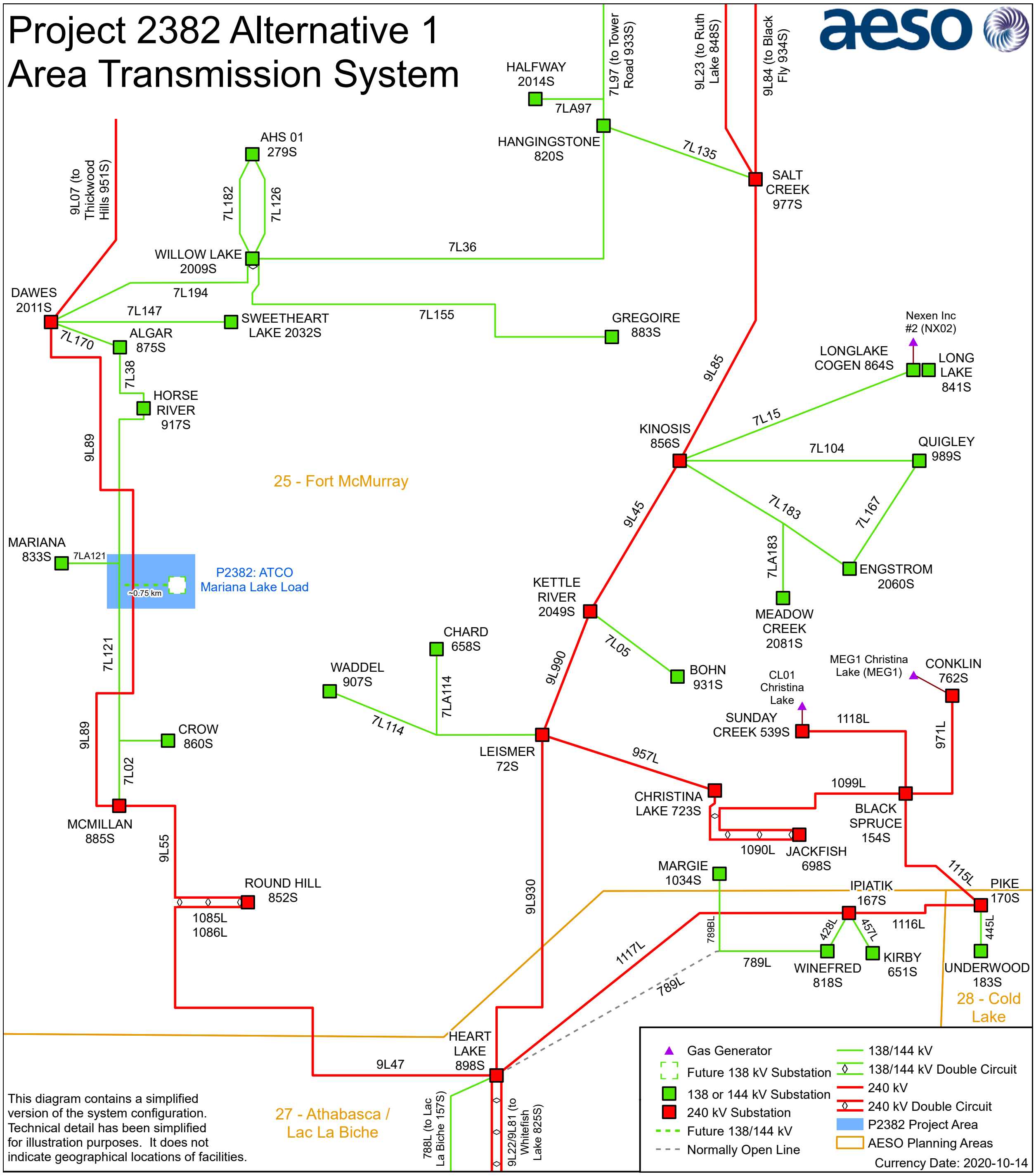
This alternative includes the following developments:

- Add one new 144/25kV Point of Delivery (POD) substation, to be designated Freer 2043S substation, including one 144/25 kV transformer, one 144 kV circuit breaker and two 25 kV feeder breakers;
- Add one 144 kV circuit, approximately 2 km in length, to connect the proposed Freer 2043S substation to the existing 144 kV transmission line 7L121 (between Mariana 833S and Crow 860S Substations) using a T-tap configuration;
- 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 Electric Ltd *Distribution Deficiency Report – Mariana Lake Load Addition*, which is filed under a separate cover.

Figure 3-1: Connection Alternative 1



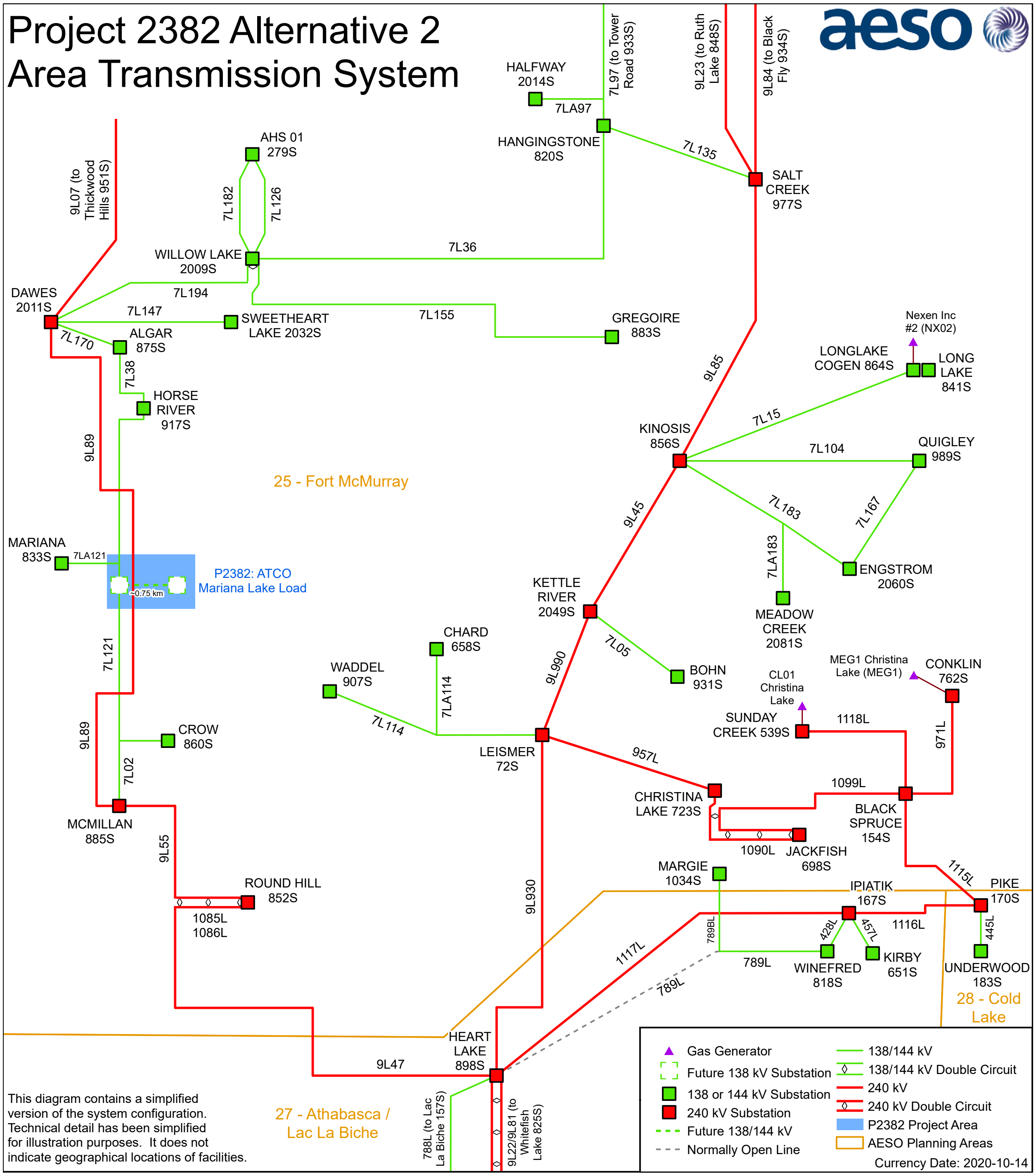
Alternative 2 – New POD with an in-and-out connection to the existing 144 kV transmission line 7L121

This alternative includes the following developments:

- Add one new 144/25kV POD substation, to be designated Freer 2043S substation, including one 144/25 kV transformer, three 144 kV circuit breakers and two 25 kV feeder breakers;
- Add one 144 kV circuit, approximately 2 km in length, to connect the proposed Freer 2043S substation to the existing 144 kV transmission line 7L121 (between Mariana 833S and Crow 860S Substations) using an in-and-out configuration;
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-2.

Figure 3-2: Connection Alternative 2



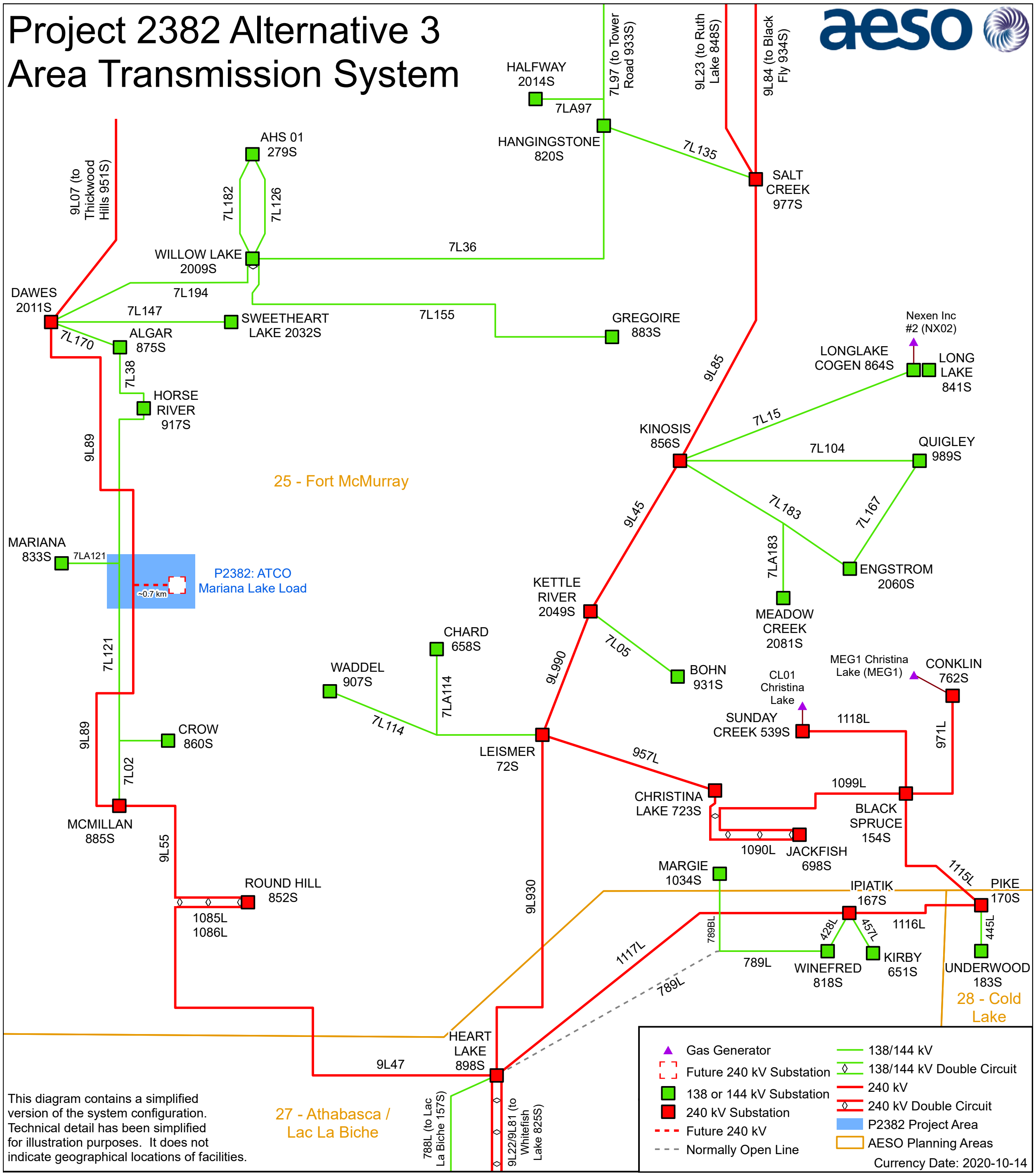
Alternative 3 – New POD with a T-tap connection to the existing 240 kV transmission line 9L89

This alternative includes the following developments:

- Add one new 240/25kV POD substation, to be designated Freer 2043S substation, including one 240/25 kV transformer, one 240 kV circuit breaker and two 25 kV feeder breakers;
- Add one 240 kV circuit, approximately 2 km in length, to connect the proposed Freer 2043S substation to the existing 240 kV transmission line 9L89 (between McMillan 885S and Dawes 2011S Substations) using a T-tap configuration;
- Add or modify associated equipment as required for the above transmission developments.

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

Figure 3-3: Connection Alternative 3



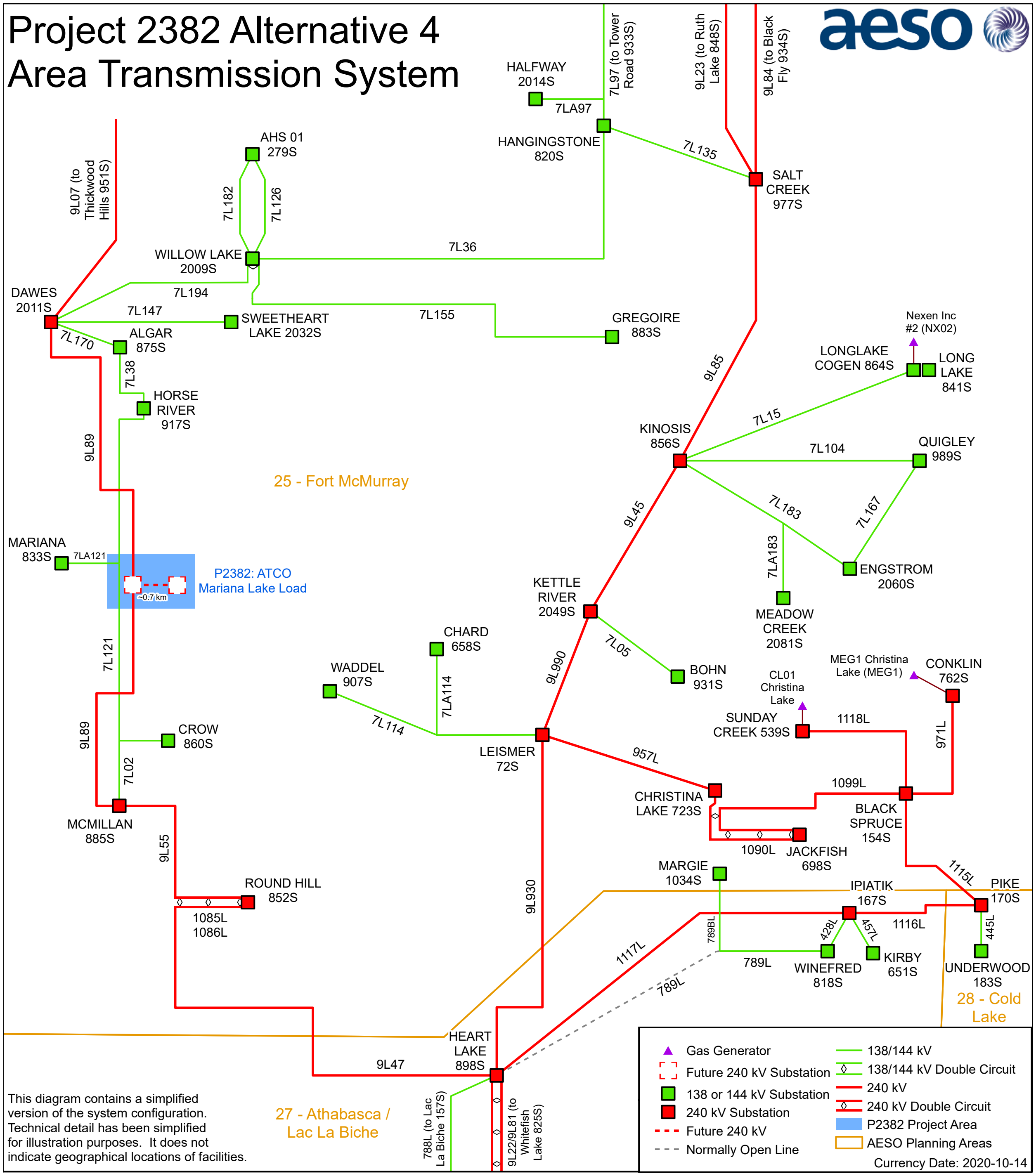
Alternative 4 – New POD with an in-and-out connection to the existing 240 kV transmission line 9L89

This alternative includes the following developments:

- Add one new 240/25kV POD substation to be designated Freer 2043S substation, including one 240/25 kV transformer, three 240 kV circuit breakers and two 25 kV feeder breakers;
- Add one 240 kV circuit, approximately 2 km in length, to connect the proposed Freer 2043S substation to the existing 240 kV transmission line 9L89 (between McMillan 885S and Dawes 2011S Substations) using an in-and-out configuration;
- 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



Alternative 5 – Upgrade the existing Mariana 833S Substation

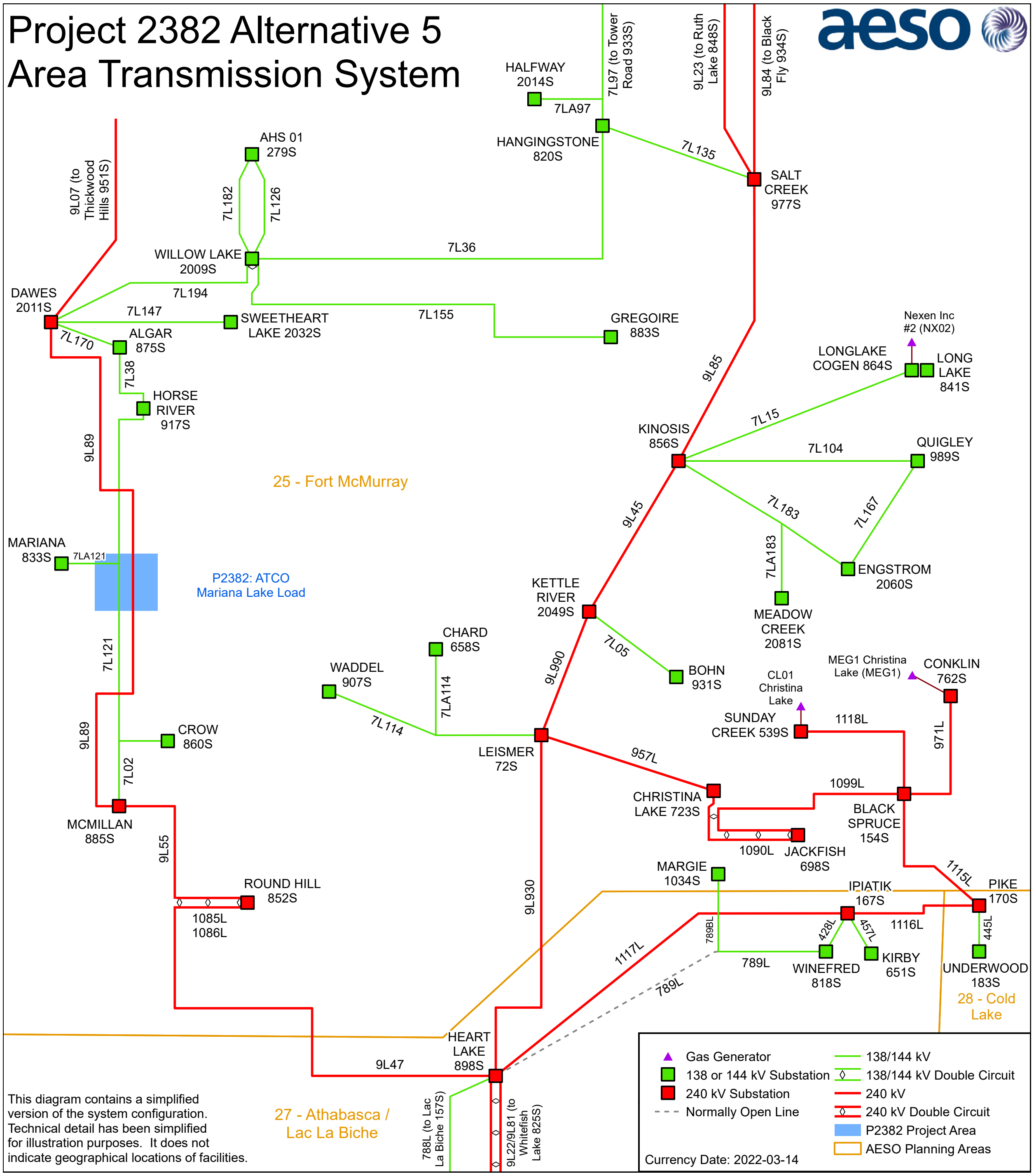
This alternative includes the following developments:

- Upgrade the existing Mariana 833S substation, including adding one 144/25kV transformer; and
- Add or modify associated equipment as required for the above transmission developments.

The Market Participant has advised that this alterative would also require the addition of one 25 kV double circuit distribution feeder, approximately 2 km in length.

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

Figure 3-5: Connection Alternative 5



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

The Market Participant has advised that Alternative 5 requires expansion of the Mariana 833S substation which is not feasible as the Mariana 833S substation is surrounded by pipelines which would prevent its expansion. Therefore, Alternative 5 was 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 Attachment A (see Attachment A1).

4.2 Studies Performed

At the time of study, the scheduled ISD for the Project is May 1, 2023. Therefore, studies were performed using scenarios for 2023 Summer Peak (SP) and 2024 Winter Peak (WP). The AESO notes that the Market Participant's request for system access service indicated a rate DTS contract capacity of 28 MW which was used in all studies. Subsequently a change proposal was submitted by the Market Participant which increased the rate DTS contract capacity to 28.8 MW. The AESO confirms that the incremental increase of 0.8 MW would have no impact to the studies.

Short-circuit studies were performed using the 2024 WP pre-Project scenario, 2024 WP and 2031 WP post-Project scenarios.

Table 4-1 lists the study scenarios. Post-Project scenarios reflect the final requested Rate DTS contract capacity of 28 MW at the Freer 2043S 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	2023 Summer Peak (SP)	Low Northeast Generation	2023 SP Pre-Project	0	0
2	2024 Winter Peak (WP)	Low Northeast Generation	2024 WP Pre-Project	0	0
Post-Project					
3	2023 SP	Low Northeast Generation	2023 SP Post Project	28	0
4	2024 WP	Low Northeast Generation	2024 WP Post Project	28	0
5	2031 WP	All Generation In Service	2031 WP Post-Project	28	0

The AESO Planning Region load forecasts used for the connection studies were based on the AESO's 2021 Long-term Outlook (2021 LTO).

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 POD low voltage bus voltage deviations beyond the limits listed in Table 3-1 of Attachment A1.[2]

Power flow studies were performed for 2023 Summer Peak (SP) and 2024 Winter Peak (WP) pre-Project scenarios, and for 2023 SP and 2024 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 2024 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 2024 WP pre-Project scenario, 2024 WP and 2031 WP post-Project scenarios.

[2] 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 Attachment A1 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 Attachment A1.

5 Results

5.1 Overview

Under Category A and Category B conditions, no Reliability Criteria violations or POD bus voltage deviations were observed for both the pre-Project and post-Project scenarios.

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

Detailed study results are provided in Attachment A.

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 and will not adversely affect the performance of the transmission system. The connection assessment did not identify any system performance issues in the pre-Project and post-Project scenarios studied.

The AESO recommends proceeding with the Project using Alternative 1 as the preferred alternative to respond to the Market Participant's request for system access service.

Alternative 1 involves adding a new POD substation, to be designated Freer 2043S substation, including one 144/25 kV transformer, one 144 kV circuit breaker and two 25 kV feeder breakers. This alternative would require adding one 144 kV circuit, approximately 2 km in length, to connect the proposed Freer 2043S substation to the existing 144 kV transmission line 7L121 (between Mariana 833S and Crow 860S Substations) using a T-tap configuration.

The conductor used for the 144 kV circuit should have a minimum thermal rating similar to the existing 144 kV transmission line 7L121. The 144/25 kV LTC transformer being added should have a capacity of 30/40/50 MVA to meet the Market Participant's requested rate DTS.

Attachment A:
Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

P2382 ATCO Mariana Lake Load

ATCO Electric Ltd.

Date: February 8, 2022

Version: V1

Classification: Public

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Feb. 8, 2022

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1 Introduction

This report presents the results of the engineering studies that were completed by ATCO Electric Ltd. (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 33.

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 A2.

2.1.1 Scenario 1: 2023 Summer Peak

Category A Conditions

No Reliability Criteria (as defined in Section 3.1 of Attachment A1) violations were observed under Category A conditions.

Category B Conditions

No Reliability Criteria violations were observed under Category B conditions.

2.1.2 Scenario 2: 2024 Winter Peak

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 Reliability Criteria violations were observed under Category B conditions.

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 Attachment A1, the post-Project studies were performed using Alternative 1.

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 A3. All behind fence areas were not reported for violations as we may not have accurate information on the Customer sites.

3.1.1 Scenario 3: 2023 Summer Peak (Alternative 1)

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

No Reliability Criteria violations were observed under Category B conditions.

3.1.2 Scenario 4: 2024 Winter Peak (Alternative 1)

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

No Reliability Criteria violations were observed under Category B conditions.

3.2 Voltage Stability Studies

3.2.1 Scenario 4: 2024 WP Post-Project (Alternative 1)

Voltage stability analysis was performed for the 2024 WP post-Project Scenario 4. The reference load level for the Study Area (Area 25) is 2456.8 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 122.8 MW (0.05 x 2456.8 MW = 122.8 MW), in order to meet the voltage stability criteria.

Table 3-1 provides the voltage stability study results under the Category A condition and for the five 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 3-1: Voltage Stability Study Results under Category B Conditions for Scenario 4

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		590.0	Yes
9L101	Secord 2005S	McCLELLAND 957S	270.6	Yes
1090L	Christina Lake 723S	Jackfish 698S	369.4	Yes
1115L	Black Spruce 154S	Pike 170S	468.8	Yes
1099L	Jackfish 698S	Black Spruce 154S	477.5	Yes
9L32	Joslyn 849S	Secord 2005S	485.6	Yes

4 Short Circuit Studies

4.1 Pre-Project Results

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

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)
Mariana 833S	138	147.1	4.2	0.030479+j0.10104	3.4	0.039832+j0.174002
McMillan 885S	240	266.0	5.0	0.009079+j0.050144	4.6	0.009482+j0.06249
	138	148.6	5.0	0.013954+j0.086423	5.8	0.004823+j0.050369
Crow 860S	138	148.5	4.8	0.015612+j0.089271	5.2	0.009598+j0.06932
Dawes 2011S	240	268.6	6.9	0.00635+j0.036124	10.7	0.000199+j-0.002186
	138	145.8	7.8	0.009865+j0.055526	8.3	0.003028+j0.04619

4.2 Post-Project Results

4.2.1 Scenario 4: 2024 Winter Peak

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)
Mariana 833S	138	145.5	4.2	0.032664+j0.098965	3.9	0.022947+j0.12587
McMillan 885S	240	265.4	5.0	0.009359+j0.049971	4.6	0.009404+j0.061885
	138	148.0	5.0	0.01489+j0.085995	5.9	0.004805+j0.049207
Crow 860S	138	147.8	4.9	0.01664+j0.088783	5.3	0.009364+j0.066994
Dawes 2011S	240	268.3	6.9	0.006532+j0.036041	10.7	0.000204+j-0.002211

[1] 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.

	138	145.7	7.8	0.010353+j0.055449	8.3	0.003125+j0.045684
Freer 2043S	138	145.3	4.0	0.035149+j0.104095	3.8	0.021587+j0.128209

4.2.2 Scenario 5: 2031 Winter Peak

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)
Mariana 833S	138	143.0	4.3	0.031478+j0.097384	4.0	0.022638+j0.124319
McMillan 885S	240	261.1	5.1	0.008608+j0.048476	4.7	0.009406+j0.061802
	138	145.3	5.1	0.01397+j0.084585	6.0	0.00481+j0.049154
Crow 860S	138	145.1	4.9	0.01569+j0.087379	5.4	0.009368+j0.06691
Dawes 2011S	240	263.6	7.3	0.005726+j0.033927	11.4	0.000203+j-0.002178
	138	144.3	8.0	0.009657+j0.054224	8.5	0.003091+j0.045169
Freer 2043S	138	142.7	4.1	0.033985+j0.102524	3.8	0.021274+j0.12657

5 Mitigation Measure Development and Evaluation

In all scenarios (pre-Project and post-Project), no thermal or voltage criteria violations were observed under Category B conditions.

ATTACHMENT A1

Engineering Connection Assessment: Study Scope

Study Scope

Freer 2043S Substation

ATCO Electric Ltd

AESO Project Number: P2382

Date:	Nov. 16th , 2021
Version:	V2
Classification:	Public

Company Name	Name and Credentials	Date	Signature
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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

ATCO Electric Ltd. (Market Participant), 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 a new customer load of 28 MW located in Fort McMurray area.

The DFO's request includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity of 5 MW for a new system access service in the Fort McMurray planning area (area 25) and a request for transmission development (collectively, the Project). Specifically, the DFO requested a new point of delivery (POD) substation. The Market Participant has indicated that it plans to request an increase to this Rate DTS which is planned for May 2023 and would result in a final Rate DTS of 28 MW.

The Project in-service date (ISD) used for the purpose of the studies is May 1, 2023.

Load and generation components of the Project are listed in Table 1-1.

Table 1-1: Project Load and Generation Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	No existing contract
	Requested Rate DTS	5 MW on February 1, 2023 28 MW on May 1, 2023
	Type	Oil and Gas
	Motors (number and size)	2 x 20,000 HP motors with VFD 1.9 MW other small motors
	Power factor	0.9 lagging

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) and their neighbouring ties 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

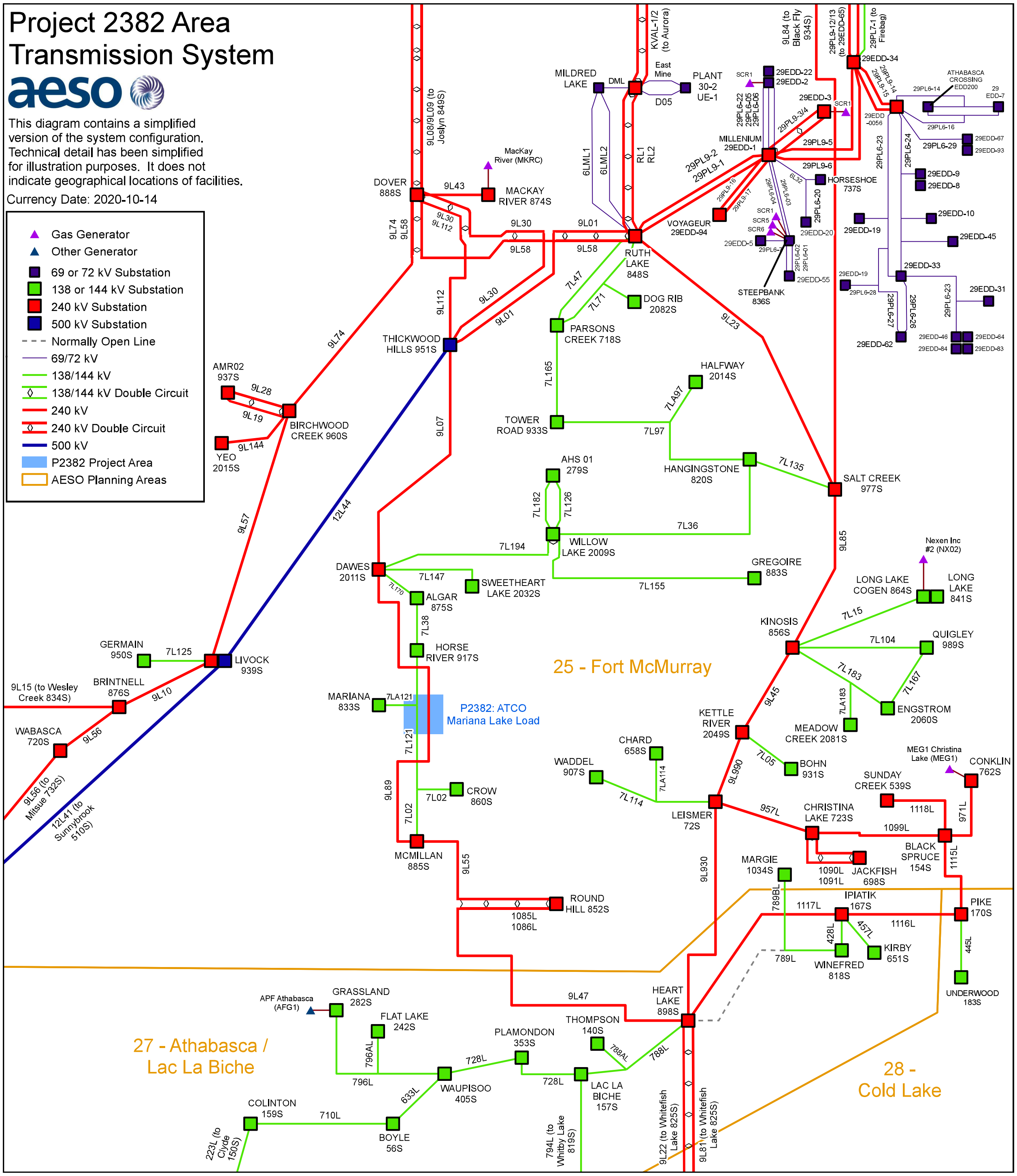
Existing constraints in the Study Area are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule).

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

The following alternative will be examined:

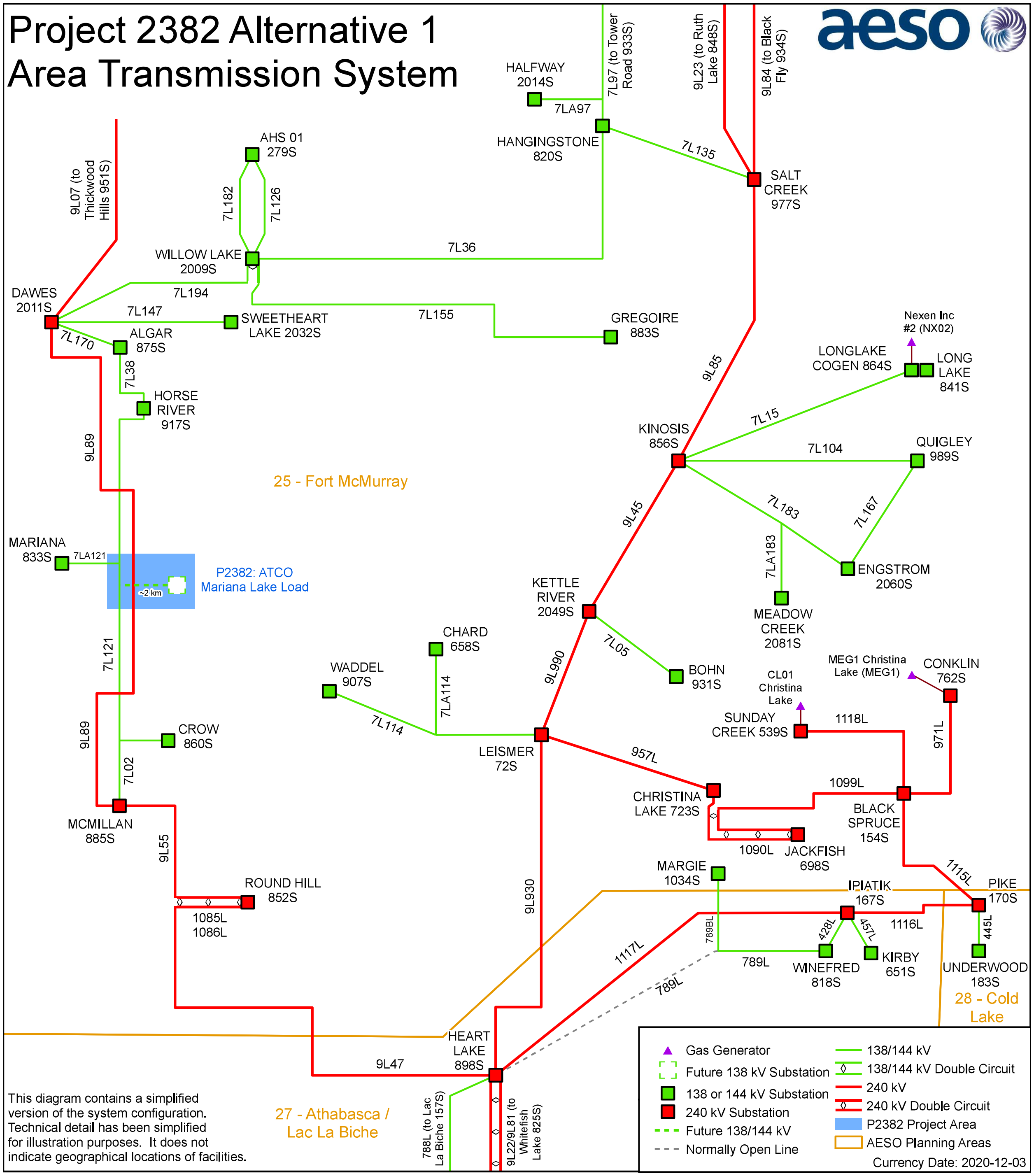
2.1 Alternative 1 – New Point of Delivery with a T–tap connection to the existing transmission line 7L121

This alternative included the following developments:

- Add a new Point of Delivery (POD) substation, including one 144/25 kV LTC transformer with a capacity of 30/40/50 MVA, and one 144 kV circuit breaker;
- Add one 144 kV circuit, approximately 2 km in length, to connect the POD to the existing 144 kV transmission line 7L121 (between Mariana 833S and Crow 860S substations) using a T-Tap configuration.
- Add or modify associated equipment as required for the above transmission developments.

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

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*;
- The AESO's *Generation and Load Interconnection Standard*;
- 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)
Pre-Project				
1	2023 Summer Peak (SP)	Low Northeast Generation	2023 SP Pre-Project	0
2	2024 Winter Peak (WP)		2024 WP Pre-Project	0
Post-Project				
3	2023 Summer Peak (SP)	Low Northeast Generation	2023 SP Post Project	28
4	2024 Winter Peak (WP)		2024 WP Post Project	28
5	2031 Winter Peak (WP)	All Generation ON	2031 WP Post-Project	28

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 Connection Project Assumptions

The pre-Project and post-Project connection assessment will not include any other connection projects in the Study Area.

4.2.3 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 2021 Long-term Outlook (2021 LTO)[1] 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.

[1] The 2021 LTO is available on the AESO website.

Table 4-2: Forecast Load (at AESO Northeast Planning Region Peak)

AESO Planning Area or Region Name	Forecast Peak Load by Year/Season (MW)	
	2023 SP	2024 WP
Northeast Planning Region[1]	3,230	3,491

Note:
[1] The Northeast Region comprises the following AESO planning areas: Fort McMurray (Area 25), Athabasca/Lac La Biche(Area 27), Fort Saskatchewan (Area 33)

Study case files contain non-motor loads in zones 34, 36, and 351. These loads are not accounted for in the forecasted peak loads shown above and should not be considered when scaling load. The AESO engineer will provide guidance to load scaling procedures as required.

4.2.4 Generation Assumptions

The generation forecast to be used for the studies is based on the 2021 LTO with modifications to incorporate the latest forecast intelligence. The generation assumptions for the studies will assume Low Northeast regional generation dispatch. Additional studies may be required in the event of changes to the AESO's corporate forecast.

The non-renewable 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 Non-Renewable Generation Dispatch Conditions

Facility Name	Bus No. & Unit No.	Pmax (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) per Scenario	
				2023 SP NE -Low-Gen	2024 WP NE -Low-Gen
CNRL Horizon (CNR5)	18264_G1,19264_5 2268_G2	203	25	166	171
MEG1 Christina Lake (MEG1)	2405_1, 3405_2	202	25	126	132
MacKay River (MKRC)	18274_1	207	25	171	196
Nexen Inc #2 (NX02)	11241_G3, 11241_G4, 12249_G2, 13249_G1	220	25	156	173
Syncrude #1 (SCL1)	16233_12, 17209_G3, 17210_G4, 17233_11, 18206_2, 18207_1, 18209_G2, 18210_G5, 19209_G, 19210_G6	510	25	351	409
IOI Kearl (IOR3)	1695_ST	84	25	37	10

Facility Name	Bus No. & Unit No.	Pmax (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) per Scenario	
				2023 SP NE -Low-Gen	2024 WP NE -Low-Gen
Fort Hills (FH1)	14781_G1 14782_G2	199	25	141	184
Christina Lake (CL01)	4379_G1 4380_G2	100	25	68	47
Muskeg River (MKR1)	10236_1 12236_2	202	25	155	176
Base Plant (SCR1)	16218_G1 18218_G2	923	25	541	630
Firebag (SCR6)	3273, 16219, 18208, 18223, 19208				
Poplar Creek (SCR5)	16297, 17297, 18297, 19297				

Notes:
[a] "Unit Net Generation" refers to gross generating unit output (MW) less unit service load.
[b] "N-G" indicates the critical generating unit that is assumed by the AESO to be offline to test the N-G contingency condition

4.2.5 *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.

4.2.6 *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. WATL and EATL are not expected to have a material impact on the connection assessment. Therefore, the HVDC assumptions shall be the same as in the AESO planning base cases and will not be adjusted for the studies.

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

4.2.7 Transmission Facility Ratings

The legal owner of transmission facilities (TFO) provided the thermal ratings assumptions for the existing transmission lines in the Study Area. Table 4-5 shows the normal ratings and emergency ratings for the key transmission lines in the Study Area, which will be used to perform the engineering studies.

Table 4-5: Thermal Rating Assumptions for Key Transmission Lines in the Study Area

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
29PL9-1	Ruth Lake 848S - Millennium 29EDD-1	240	485	590	509	648
29PL9-2	Ruth Lake 848S - Millennium 29EDD-1	240	485	590	509	648
9L01	Thickwood 951S - Ruth Lake 848S	240	641	808	788	831CT
9L07	Thickwood 951S – Dawes 2011S	240	640	811	787	831GS
9L08	Dover 888S - Joslyn 849S	240	457 bus cond	578 bus cond	714 bus cond	831GS
9L09	Dover 888S - Joslyn 849S	240	457 bus cond	578 bus cond	714 bus cond	831GS
9L10	Livock 939S – Brintnell 876S	240	491	658	583	798
9L15	Brintnell 876S – Wesley Creek 834S	240	546	734	666	831GS
9L101	Secord 2005S – Mcclelland 957S	240	759	831CT	831CT	831CT
9L19	Birchwood Creek 960S - Amr02 937S	240	433	498CT	433	498CT
9L23	Ruth Lake 848S - Salt Creek 977S	240	553	742	670	831GS
9L28	Birchwood Creek 960S - Amr02 937S	240	433	498CT	433	498CT
9L32	Secord 2005S – Bitumount 941S – Joslyn 849S	240	761	831GS	831GS	831GS
9L39	Blackfly 934S – Green Stocking 925S	240	560	753	689	831CT

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
9L43	Dover 888S – Mackay River 874S	240	457 bus cond	578 bus cond	653	831GS
9L45	Kettle River 2049S – Kinosis 856S	240	560	757	664	831CT
9L47	Round Hill 852S – Heart Lake 898S	240	457 bus cond	578 bus cond	667	831CT
9L55	Mcmillan 885S – Round Hill 852S	240	499 bus cond	609 bus cond	662 bus cond	831GS
9L56	Brintnell 876S – Mitsue 732S	240	493	661	587	663CT
9L57	Birchwood Creek 960S – Livock 939S	240	493	660	584	800
9L58	Dover 888S – Ruth Lake 848S	240	416	565	585	831
9L66	Joslyn 849S – Muskeg River 847S	240	380	515	517	725
9L69	Blackfly 934S – Mcclelland 957S	240	777	831CT	831CT	831CT
9L74	Birchwood Creek 960S – Dover 888S	240	423	575	501	691
9L77	Blackfly 934S – Green Stocking 925S	240	560	753	689	831GS
9L84	Blackfly 934S – Salt Creek 977S	240	775	831CT	831CT	831CT
9L85	Kinosis 856S – Salt Creek 977S	240	559	750	661	831CT
9L89	Dawes 2011S- Mcmillan 885S	240	499 bus cond	609 bus cond	683 bus cond	831GS
9L930	Leismer 72S – Heart Lake 898S	240	535	717	665	831GS
9L990	Kettle River 2049S – Leismer 72S	240	556	748	660	831CT
957L	Leismer 72S – Christina Lake 723S	240	594	713	654	773
1085L	Round Hill 852S - ATCO 9L55 Str. 215A	240	603	723	663	784
1086L	Round Hill 852S – ATCO 9L47 Str. 215B	240	603	723	663	784
1090L	Christina Lake 723S – Jackfish 698S	240	594	713	654	773
1099L	Black Spruce 154S – Jackfish 698S	240	624	764	749	917
1115L	Black Spruce 154S – Pike 170S	240	931	1117	1024	1210
7L47	Ruth Lake 848S – Parsons Creek 718S	144	100CT	100CT	100CT	100CT
7L71	Ruth Lake 848S – Parsons Creek 718S	144	100CT	100CT	100CT	100CT
7L165	Parsons Creek 718S – Tower Road 933S	144	116	150GS	129	150GS
7L97	Tower Road 933S – Hangingstone 820S	144	117	155	130	176

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
7L135	Hangingstone 820S - Salt Creek 977S	144	151 bus cond	190 bus cond	194 bus cond	252 bus cond
7L36	Hangingstone 820S – Willow Lake 2009s	144	117	156	130	178
7L194	Dawes 2011S – Willow Lake 2009S	144	116	154	129	176
7L170	Dawes 2011S – Algar 875S	144	130	163	146	187
7L38	Algar 875S – Horse River 917S	144	116	155	130	178
7L121	Crow Lake 860S - Horse River 917S	144	114	152	128	174
7L02	McMillan 885S - Crow Lake 860S	144	115	153	128	175

Note:

Unless otherwise noted, the line ratings provided are limited by the line conductor

"CT" indicates that the transmission line is limited by current transformer.
"GS" indicates that the transmission line rating is limited by the gang switch.

"bus cond" indicates that the transmission line rating is limited by the bus conductor.

The TFO provided the details of the substation transformers in the Study Area. The key transformers in the Study Area are shown in Table 4-6.

Table 4-6: Summary of Key Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	Transformer Rating (MVA)
Ruth Lake 848S	901T	260/72	100 MVA
	902T	260/72	107.2 MVA
Salt Creek 977S	901T	260/144	300 MVA
McMillan 885S	902T	260/144	200 MVA
Dawes 2011S	901T	260/144	300 MVA
Kettle River 2049S	901T	260/144	200 MVA
Kettle River 2049S	902T	260/144	200 MVA
Pike 170S	T1	260/144	200 MVA
Pike 170S	T2	260/144	200 MVA
LEISMER 72S	T2	260/144	400 MVA
KINOSIS 856S	903T	260/144	300 MVA
KINOSIS 856S	902T	260/144	200 MVA

The TFO provided the details of the shunt elements in the Study Area. The key shunt elements in the Study Area are shown in Table 4-7.

Table 4-7: Summary of Key Shunt Elements in the Study Area

Substation Name and Number	Voltage Class (kV)	Capacitors		Reactors	
		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)
Dover 888S	240	1	100	1	-40
Horizon Upgrading 842S	34	1	21.11		
Horizon Upgrading 842S	34	1	10.56		
Horizon Upgrading 842S	34	1	21.11		
Horizon Upgrading 842S	34	1	10.56		
Horse River 917S	138	2	27.6		
Horizon Mining 838S	34 bus 1	1	29.95		
Horizon Mining 838S	34 bus 1	1	29.95		
KEARL 9900S	69	3	33.06		
Wabasca 720S	25			3	-15
Horizon Mining 838S	34	1	29.95		
Salt Creek 977S	240			1	-34.96
Sunc_R67	13.8	1	8.17		
Ruth Lake 848S	14.4			3	-15
Ruth Lake 848S	14.4			1	-20
Hangingstone 820S	25 bus 1	2	10		
Hangingstone 820S	25 bus 2	2	10		
Sunc_R68	13.8	1	8.17		
Leismer 72S	138	2	27.19		
Kinosis 856S	138	2	55.1		
Kinosis 856S	25			2	-20
Mcmillan 885S	25			1	-20
Kettle River 2049S	138	2	55.1		

4.2.8 Protection Fault Clearing Times

Not Applicable.

4.2.9 Project Dynamic Data

Dynamic data for the Project will be based on the Stage 1 Project Data Update Package (PDUP-1).

4.2.10 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	2023 SP LG	X	X							
2	2024 WP LG	X	X							X
Post-Project										
3	2023 SP LG	X	X							
4	2024 WP LG	X	X	X	X					X
5	2031 WP All Gen ON									X

For the engineering studies, all transmission facilities 240 kV and 144/138 kV, within the Study Area and the transmission lines connecting this planning area to neighbouring 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 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.

5.1.1 Contingencies to be Studied

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

5.2 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.

5.2.1 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.

5.3 Transient Stability Studies

Not Applicable.

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:

- Mariana 833S
- Crow 860S
- Dawes 2011S
- McMillan 885S
- 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[2] 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 B conditions.

[2] 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 include the AESO's current corporate forecast (2021 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. 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

ATTACHMENT A2
Pre-Project Power Flow Diagrams
(Scenarios 1 and 2)

Pre-Project Load Flow Results

Load Flow Diagrams

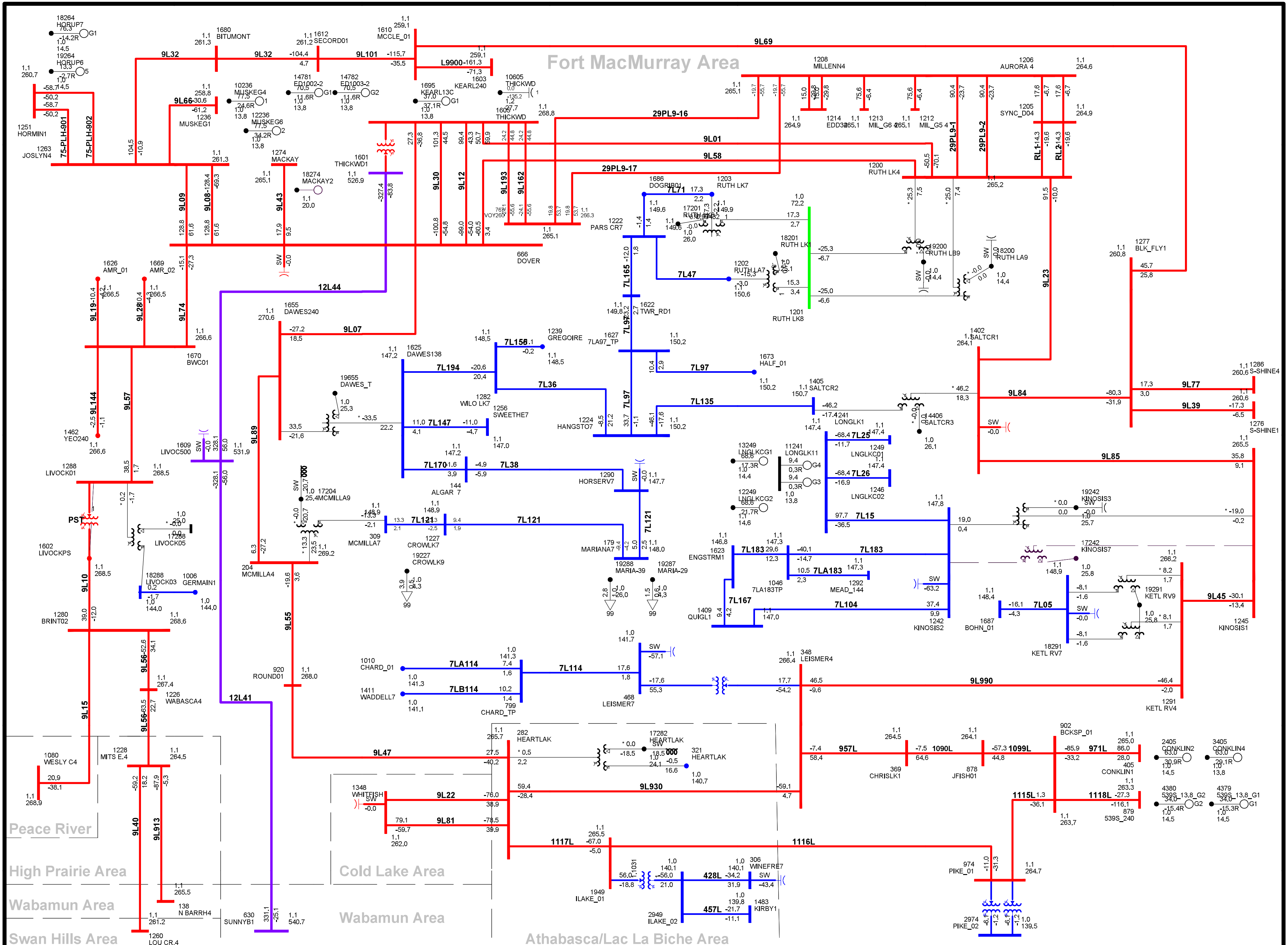
The pre-project load flow diagrams for Category A and five selected Category B contingencies are provided in this attachment as identified in the following tables.

Table A2-1: List of pre-Project Scenario 1 2023 SP Load Flow Diagrams

Scenario	Load flow diagram	Page number
2023 SP Scenario 1	N-0, System Normal Condition	A2-3
	N-1, Loss of 9L58 (Dover 888S – Ruth Lake 848S)	A2-4
	N-1, Loss of 9L09 (Dover 888S – Joslyn 849S)	A2-5
	N-1, Loss of 9L89 (Dawes 2011S – McMillan 885S)	A2-6
	N-1, Loss of 12L44 (Thickwood 951S – Livock 939S)	A2-7
	N-1, Loss of 9L101 (Secord 2005S – McClelland 957S)	A2-8

Table A2-2: List of pre-Project Scenario 2 2024 WP Load Flow Diagrams

Scenario	Load flow diagram	Page number
2024 WP Scenario 2	N-0, System Normal Condition	A2-9
	N-1, Loss of 9L58 (Dover 888S – Ruth Lake 848S)	A2-10
	N-1, Loss of 9L09 (Dover 888S – Joslyn 849S)	A2-11
	N-1, Loss of 9L89 (Dawes 2011S – McMillan 885S)	A2-12
	N-1, Loss of 12L44 (Thickwood 951S – Livock 939S)	A2-13
	N-1, Loss of 9L101 (Secord 2005S – McClelland 957S)	A2-14



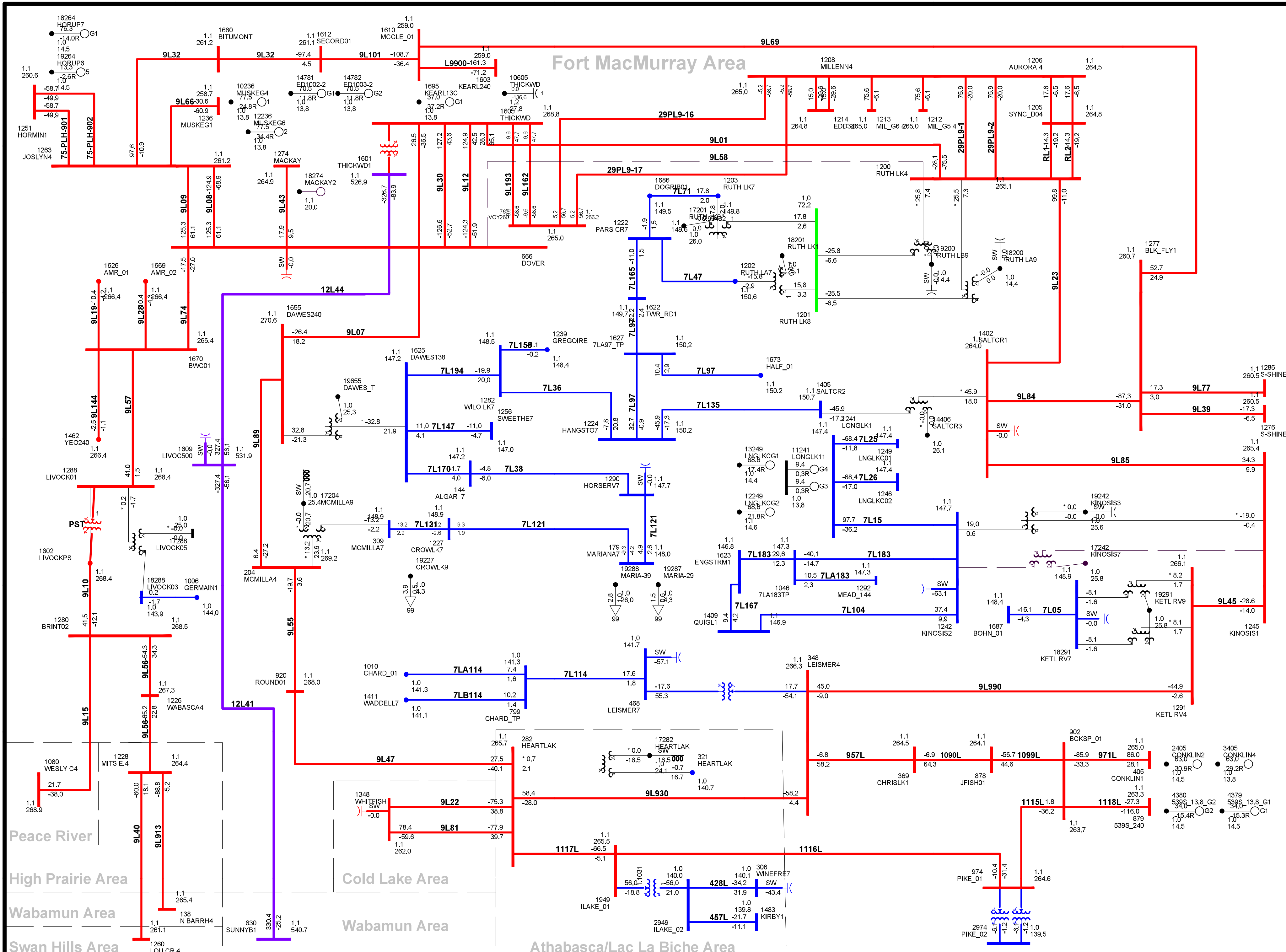
P2382 - ATCO Mariana Lake Load

CATEGORY A, N-0
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:21

A2-3

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

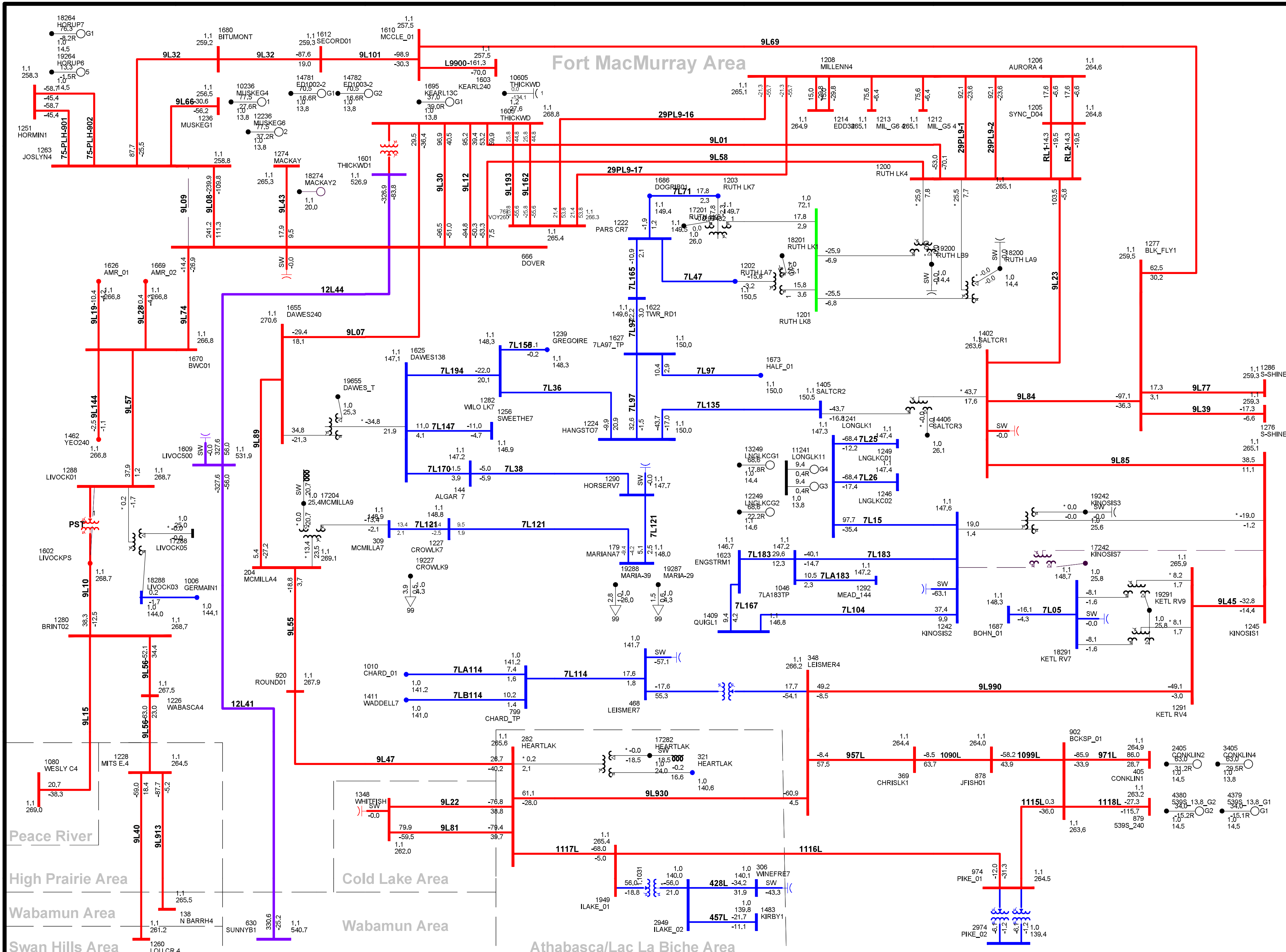


P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L58
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:21

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



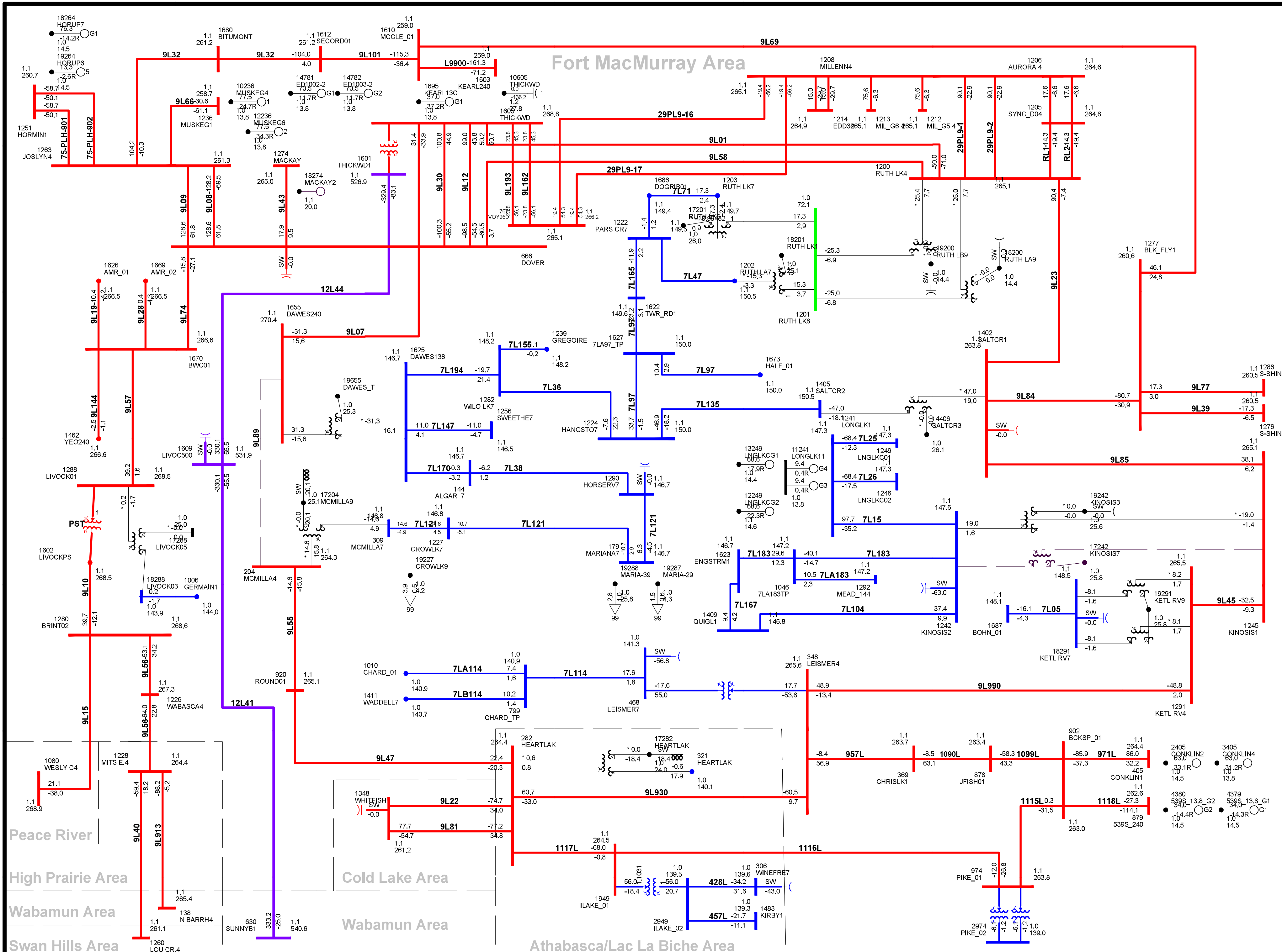
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L09
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:21

A2-5

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



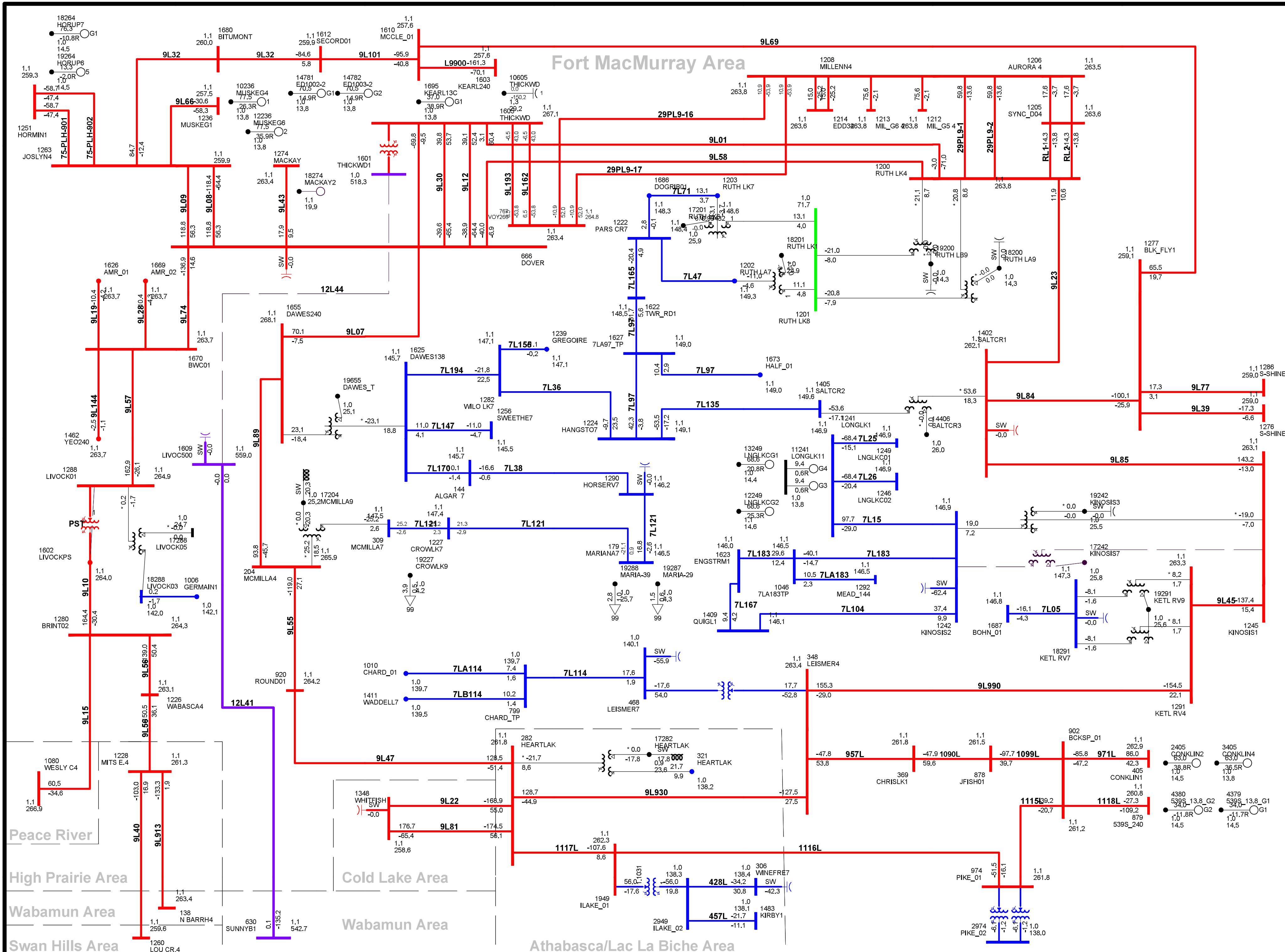
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L89
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:21

A2-6
1

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



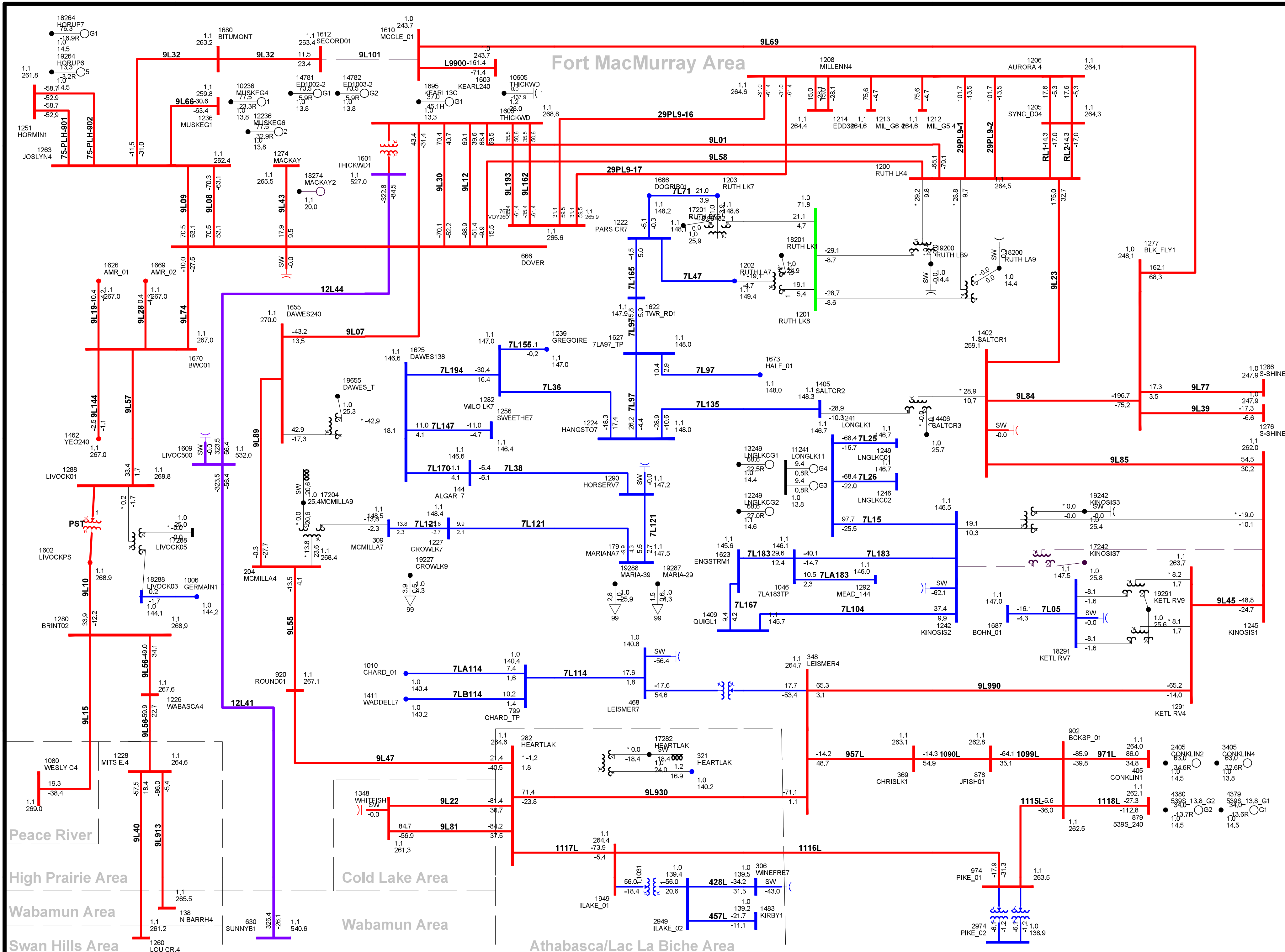
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 12L44
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:21

A2-7

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



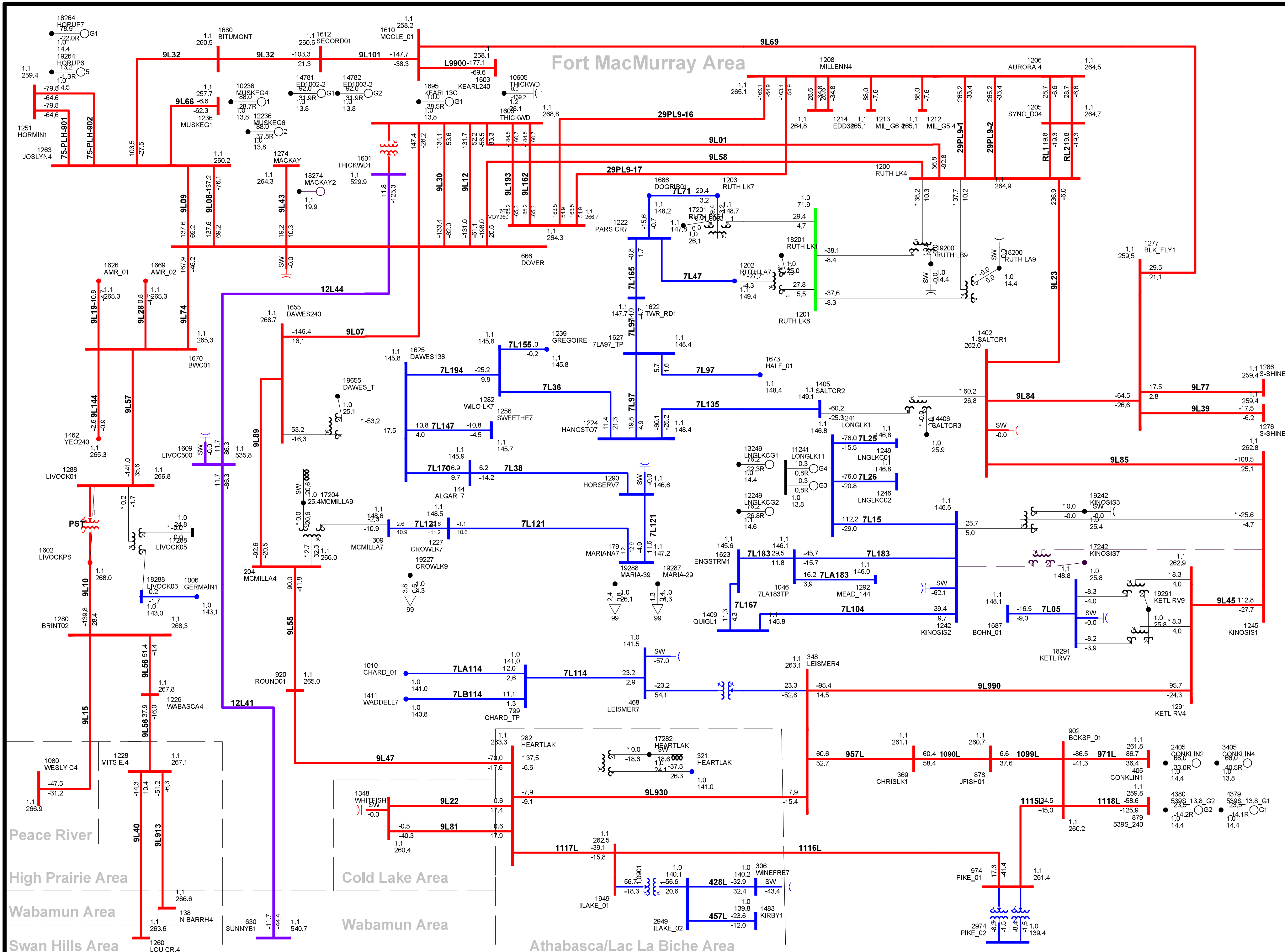
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L101
PRE-PROJECT 2023 SP
FRI, JAN 21 2022 14:22

A2 - 8

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



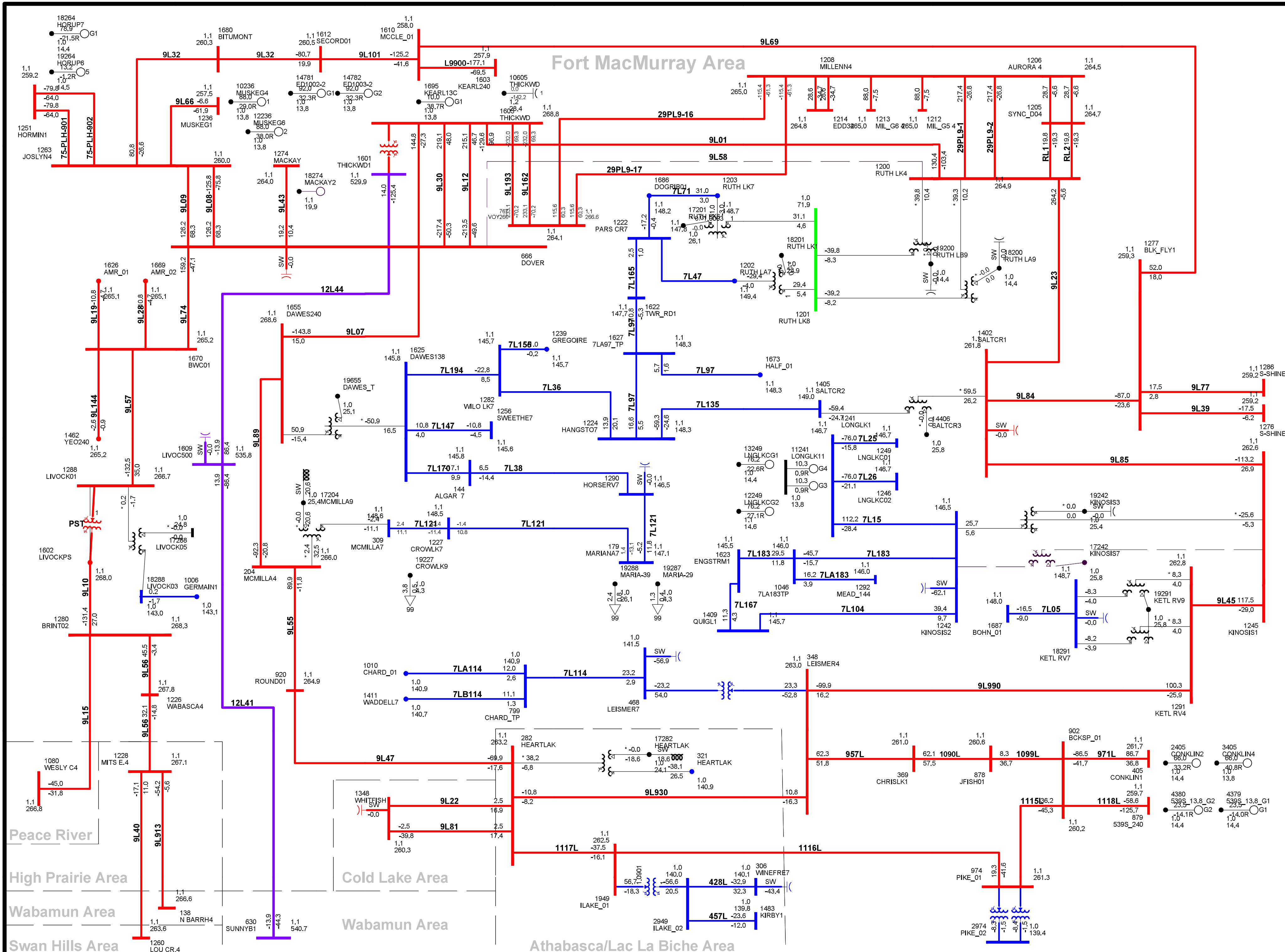
P2382 - ATCO Mariana Lake Load

CATEGORY A, N-0
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:43

A2-9

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



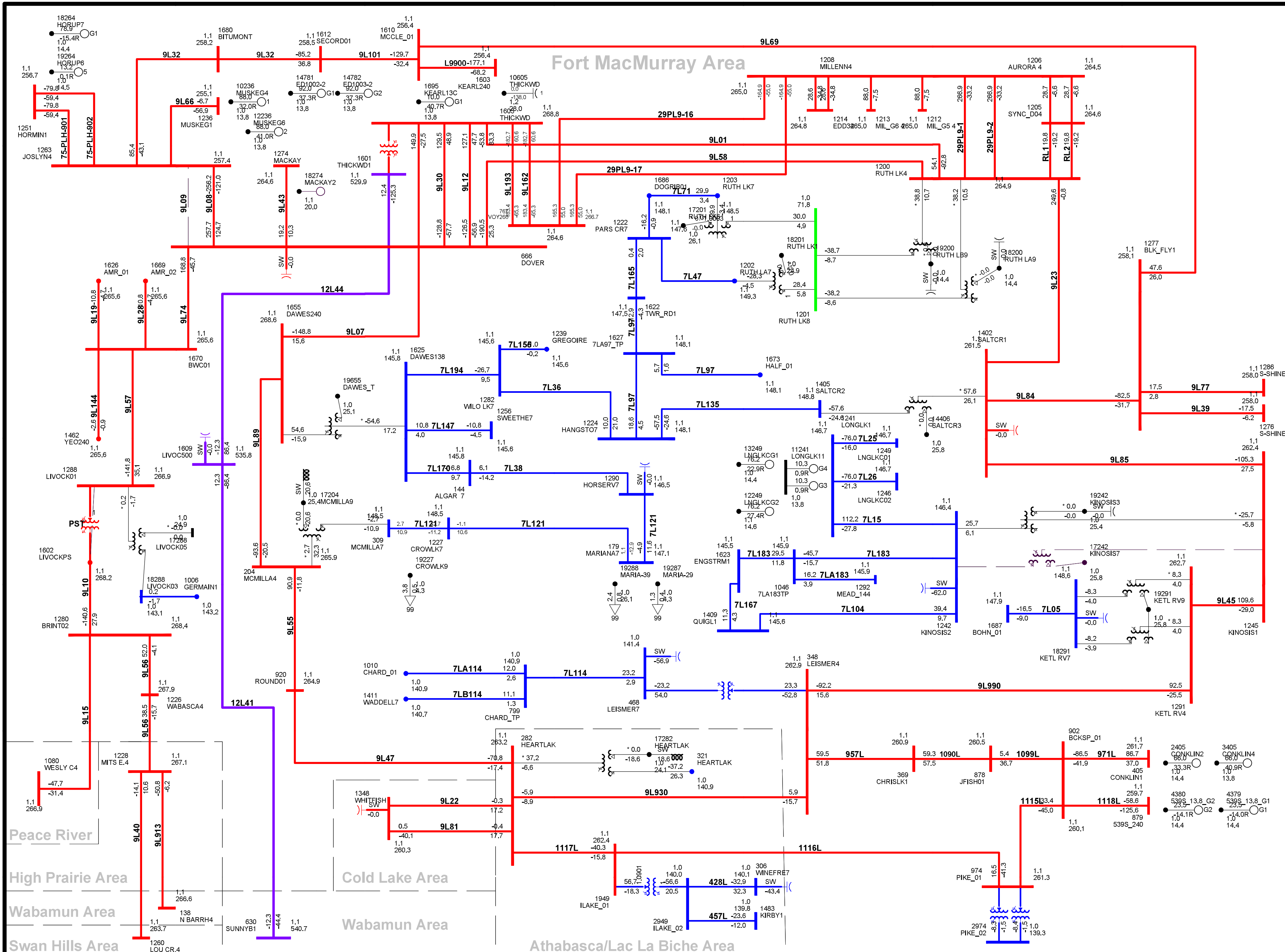
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L58
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:43

A2-10

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



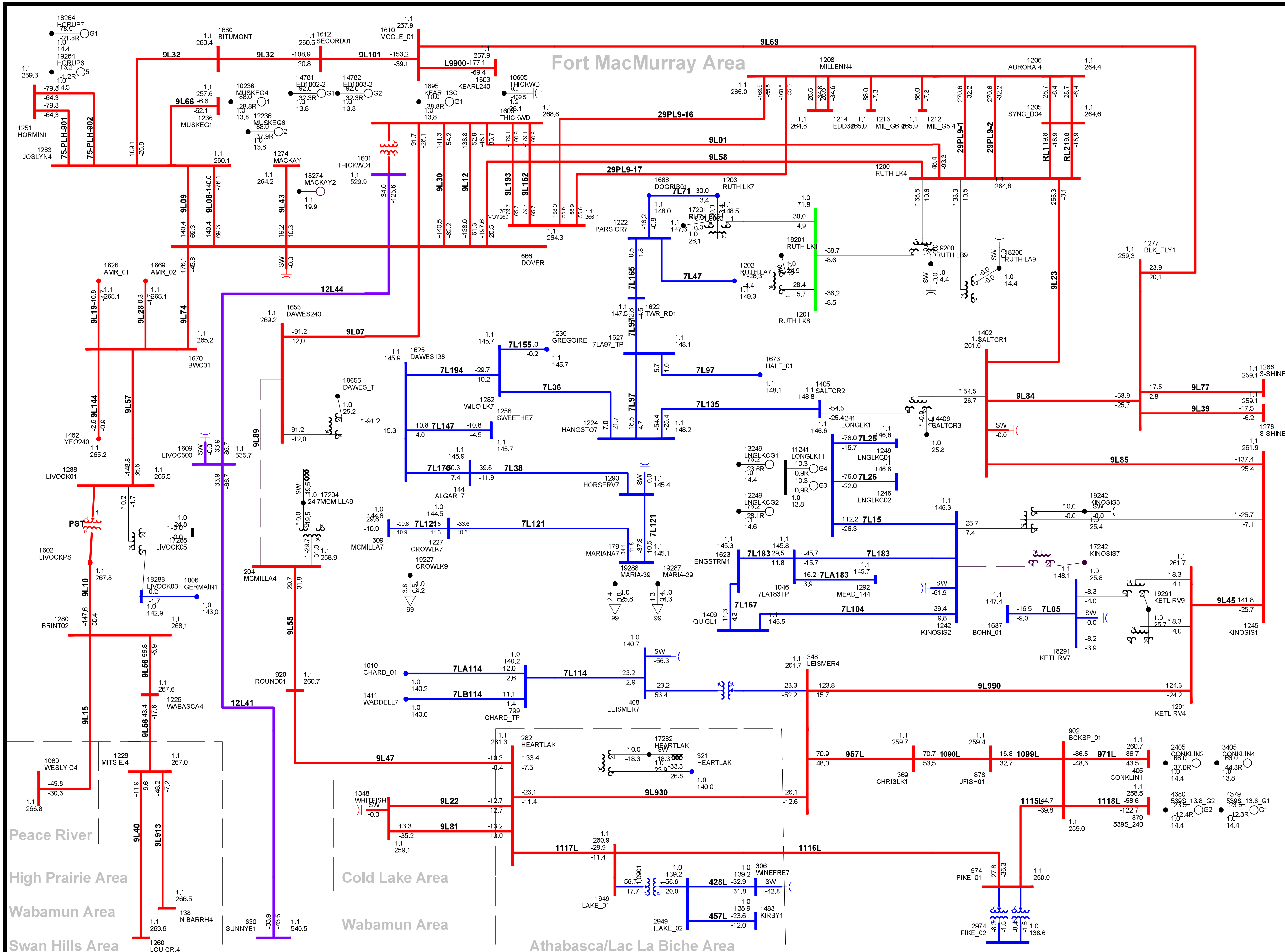
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L09
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:43

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

A2-11



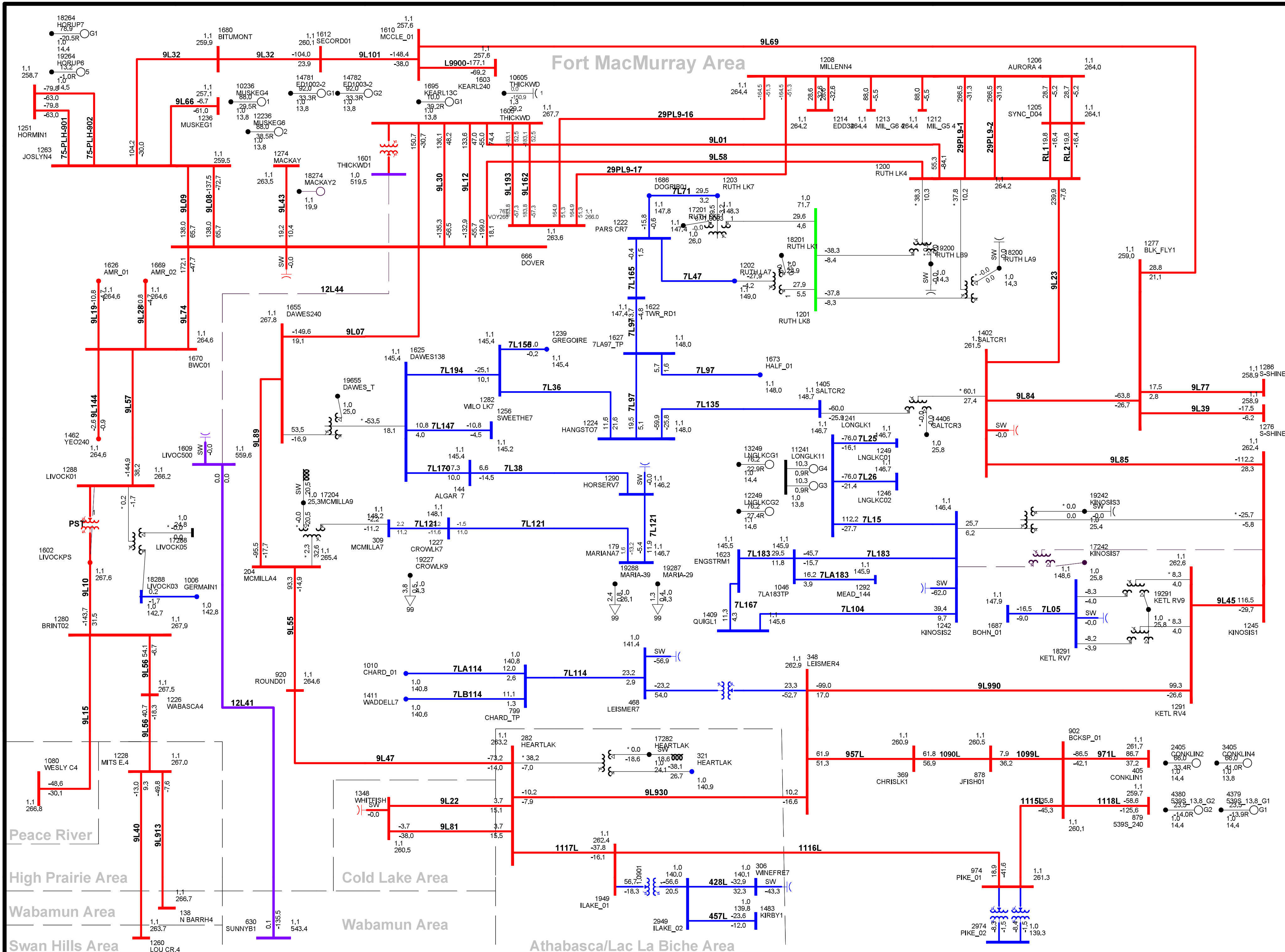
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L89
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:43

A2-12

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



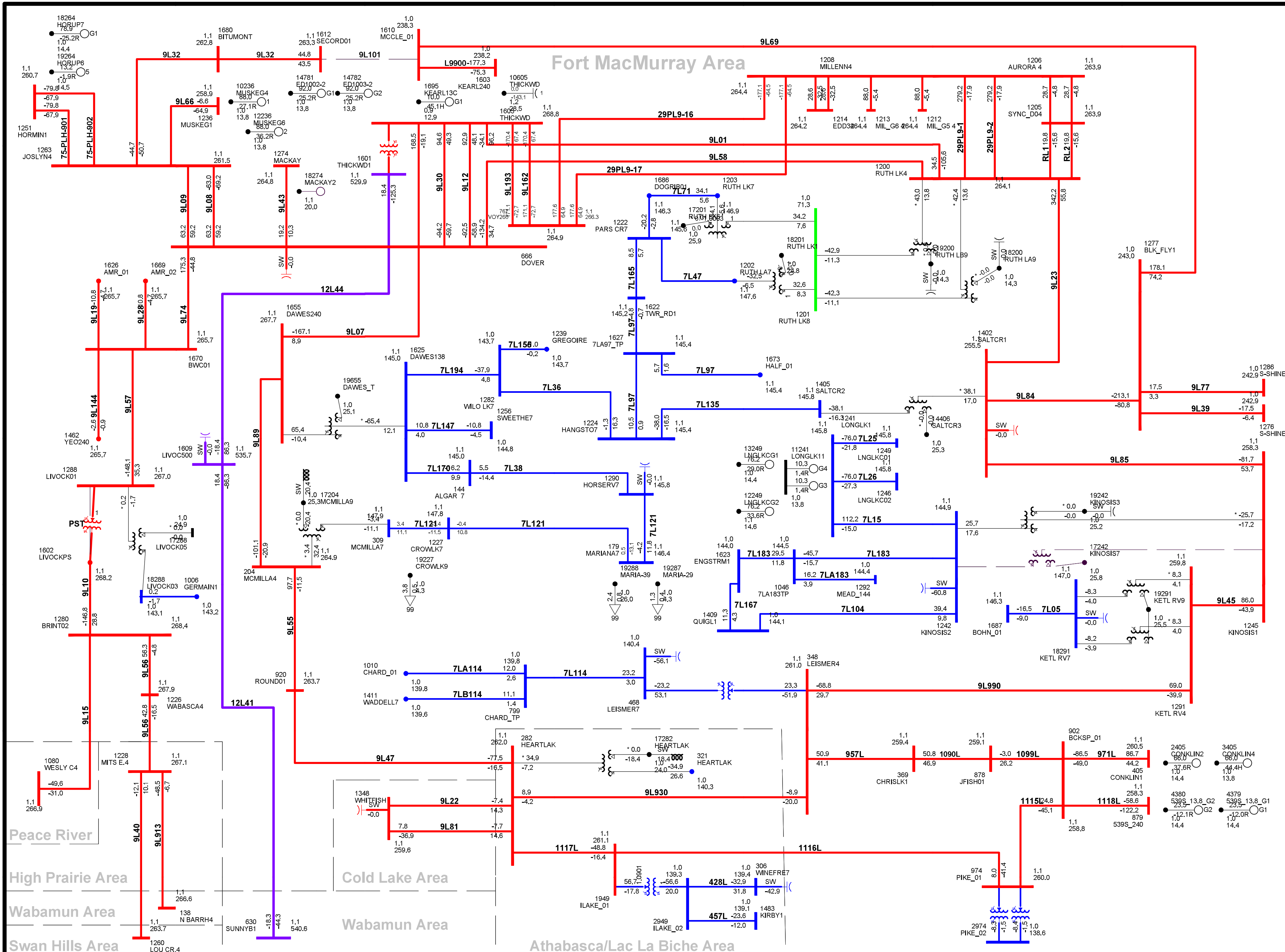
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 12L44
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:43

A2-13

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L101
PRE-PROJECT 2024 WP
FRI, JAN 21 2022 14:44

A2-14

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

ATTACHMENT A3
Post-Project Power Flow Diagrams
(Scenarios 3 and 4)

Post-Project Load Flow Results

Load Flow Diagrams

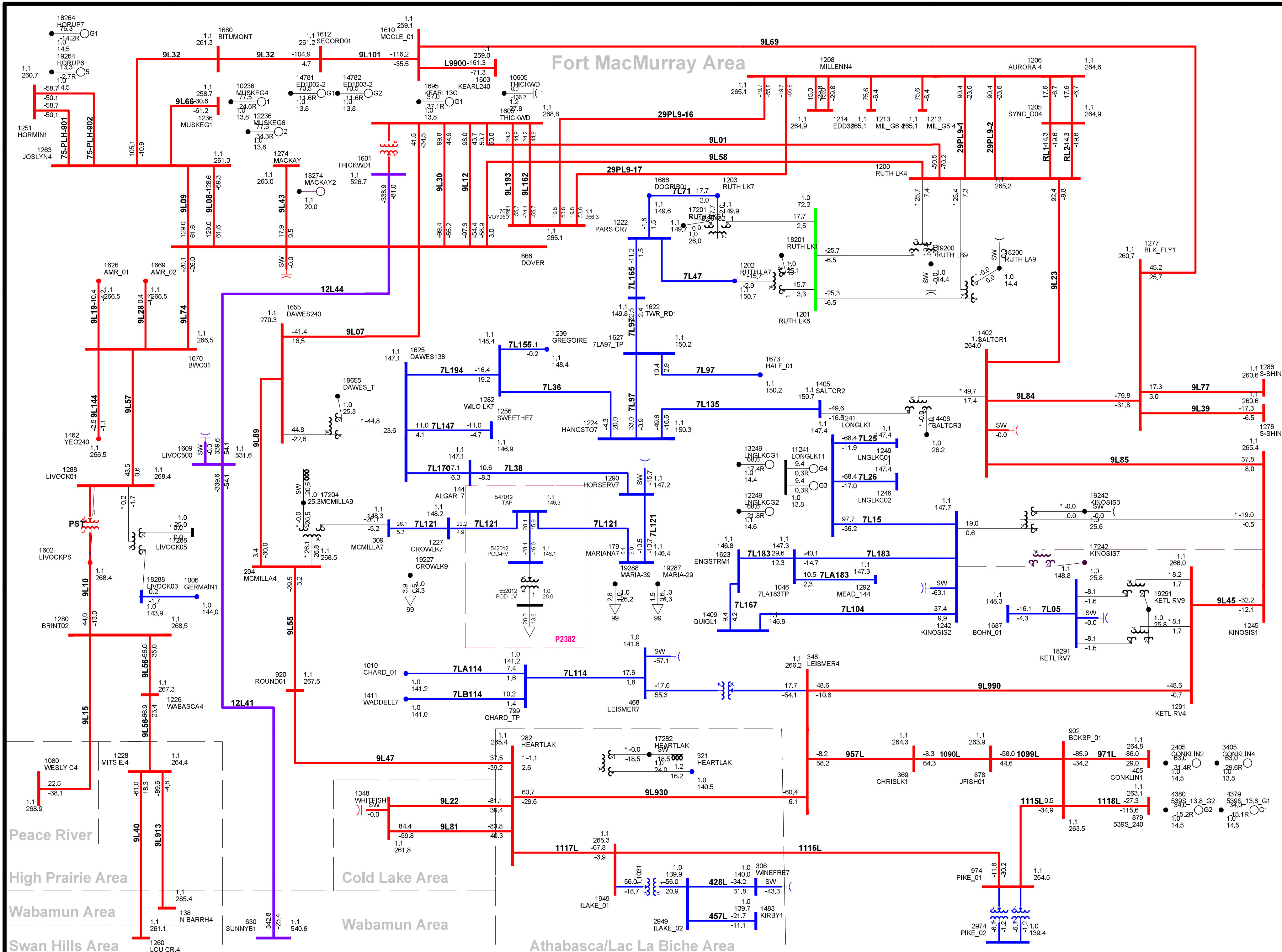
The post-project Alternative 1 load flow diagrams for Category A and five selected Category B contingencies are provided in this attachment as identified in the following tables.

Table A3-1: List of post-Project Scenario 3 2023 SP Load Flow Diagrams

Scenario	Load flow diagram	Page number
2023 SP Scenario 3	N-0, System Normal Condition	A3-3
	N-1, Loss of 9L58 (Dover 888S – Ruth Lake 848S)	A3-4
	N-1, Loss of 9L09 (Dover 888S – Joslyn 849S)	A3-5
	N-1, Loss of 9L89 (Dawes 2011S – McMillan 885S)	A3-6
	N-1, Loss of 12L44 (Thickwood 951S – Livock 939S)	A3-7
	N-1, Loss of 9L101 (Secord 2005S – McClelland 957S)	A3-8

Table A3-2: List of post -Project Scenario 4 2024 WP Load Flow Diagrams

Scenario	Load flow diagram	Page number
2024 WP Scenario 4	N-0, System Normal Condition	A3-9
	N-1, Loss of 9L58 (Dover 888S – Ruth Lake 848S)	A3-10
	N-1, Loss of 9L09 (Dover 888S – Joslyn 849S)	A3-11
	N-1, Loss of 9L89 (Dawes 2011S – McMillan 885S)	A3-12
	N-1, Loss of 12L44 (Thickwood 951S – Livock 939S)	A3-13
	N-1, Loss of 9L101 (Secord 2005S – McClelland 957S)	A3-14



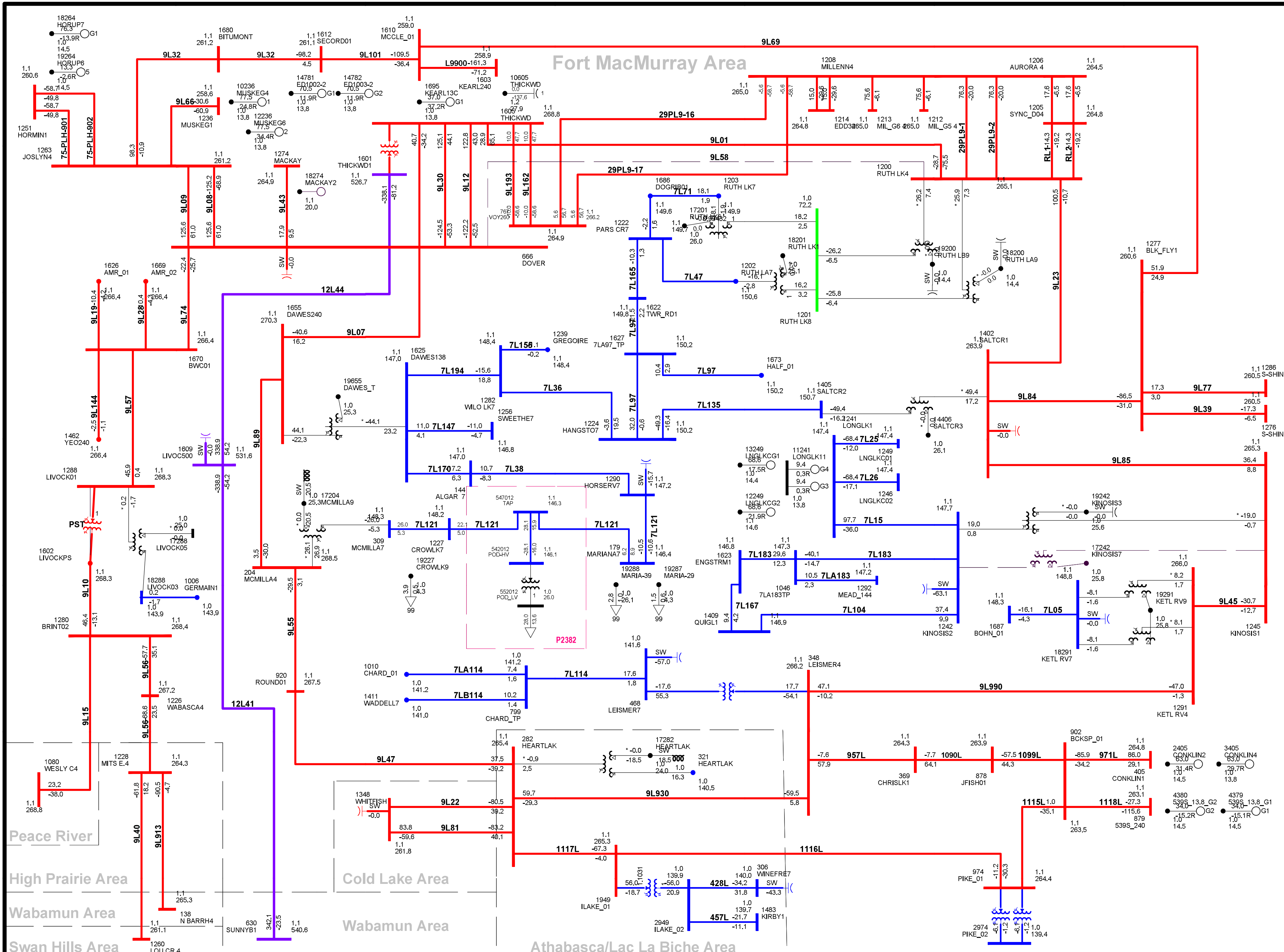
P2382 - ATCO Mariana Lake Load

CATEGORY A, N-0
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:52

A3 - 3

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



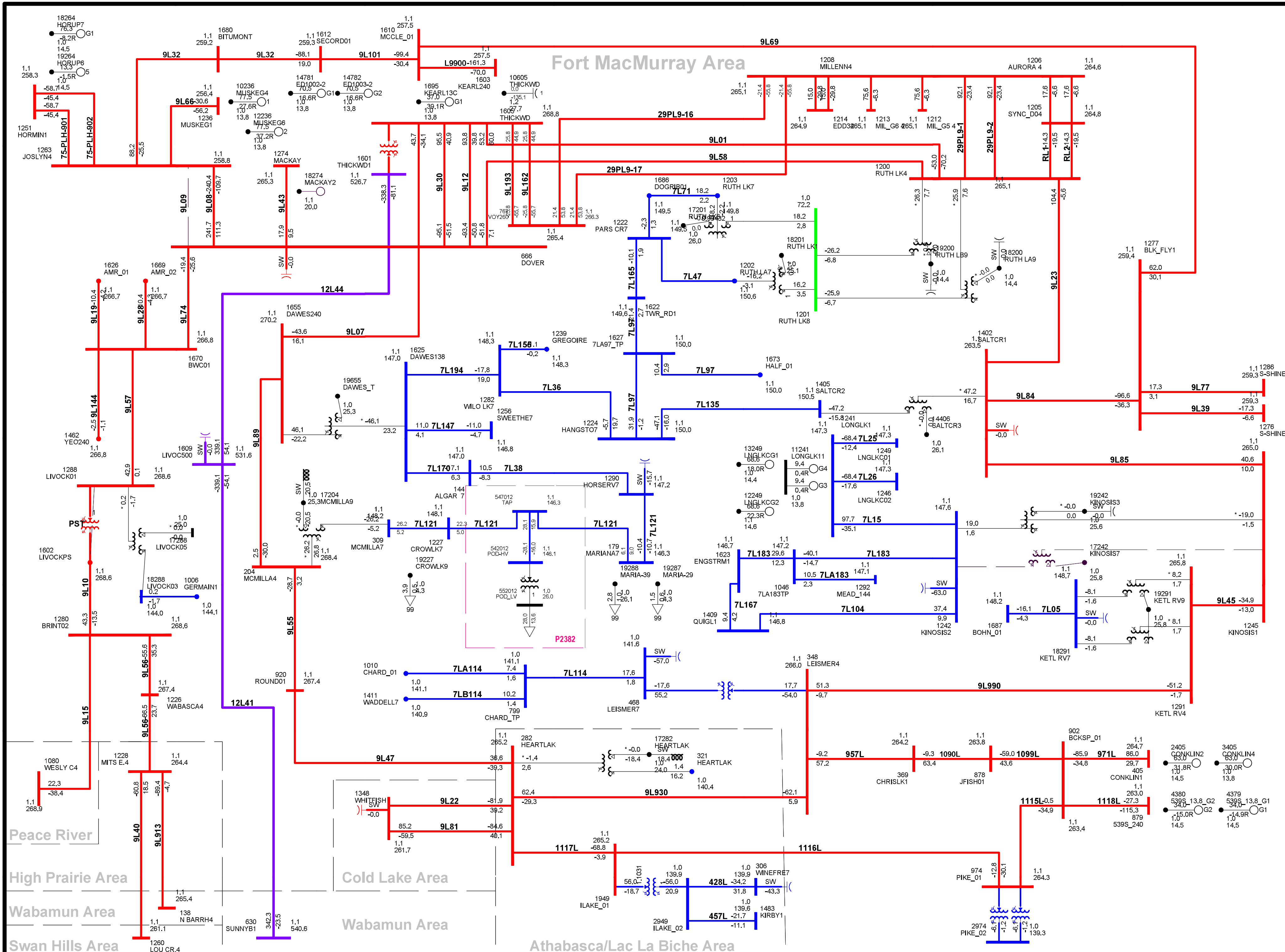
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L58
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:52

A3-4

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

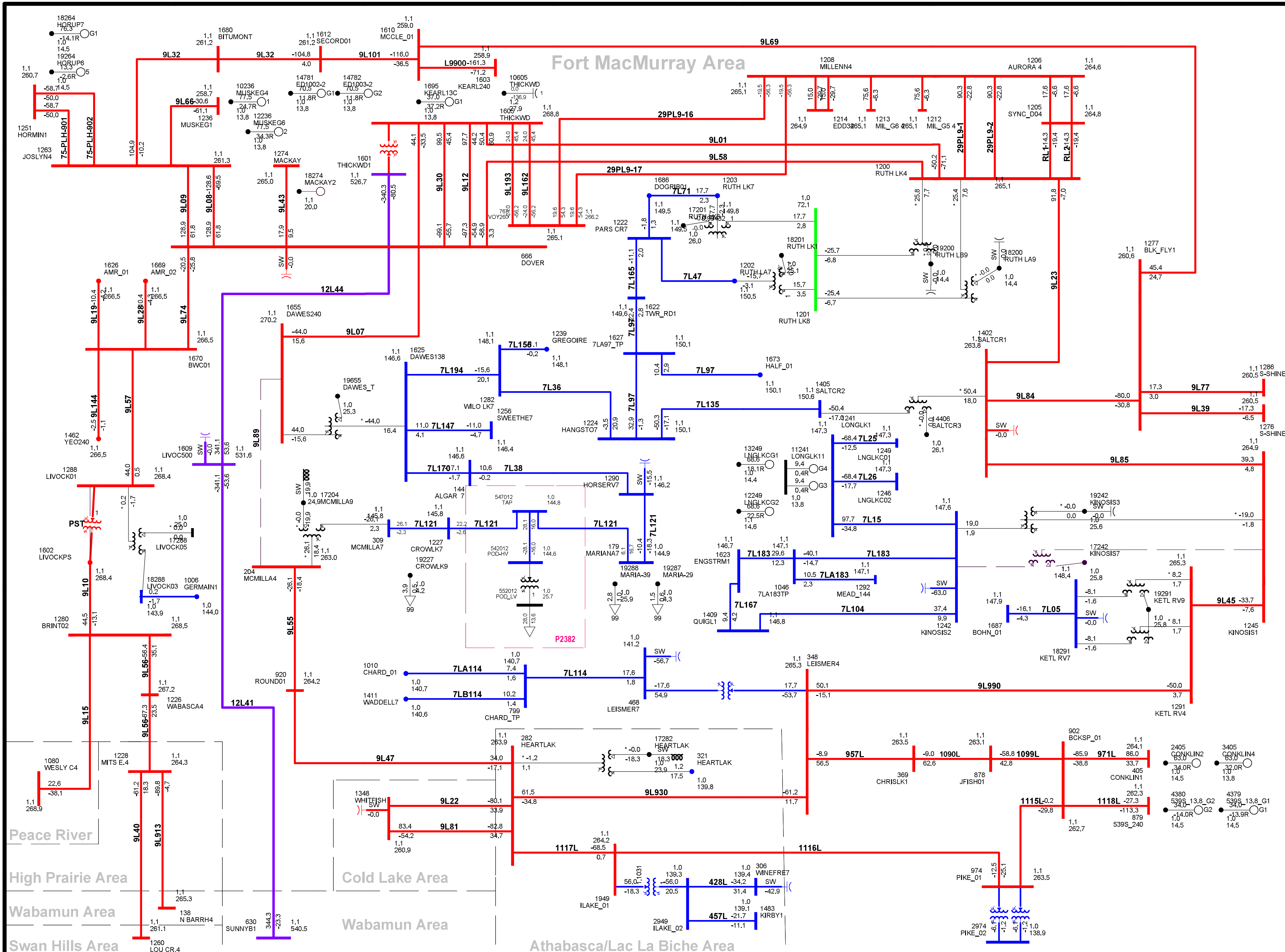


P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L09
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:52

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



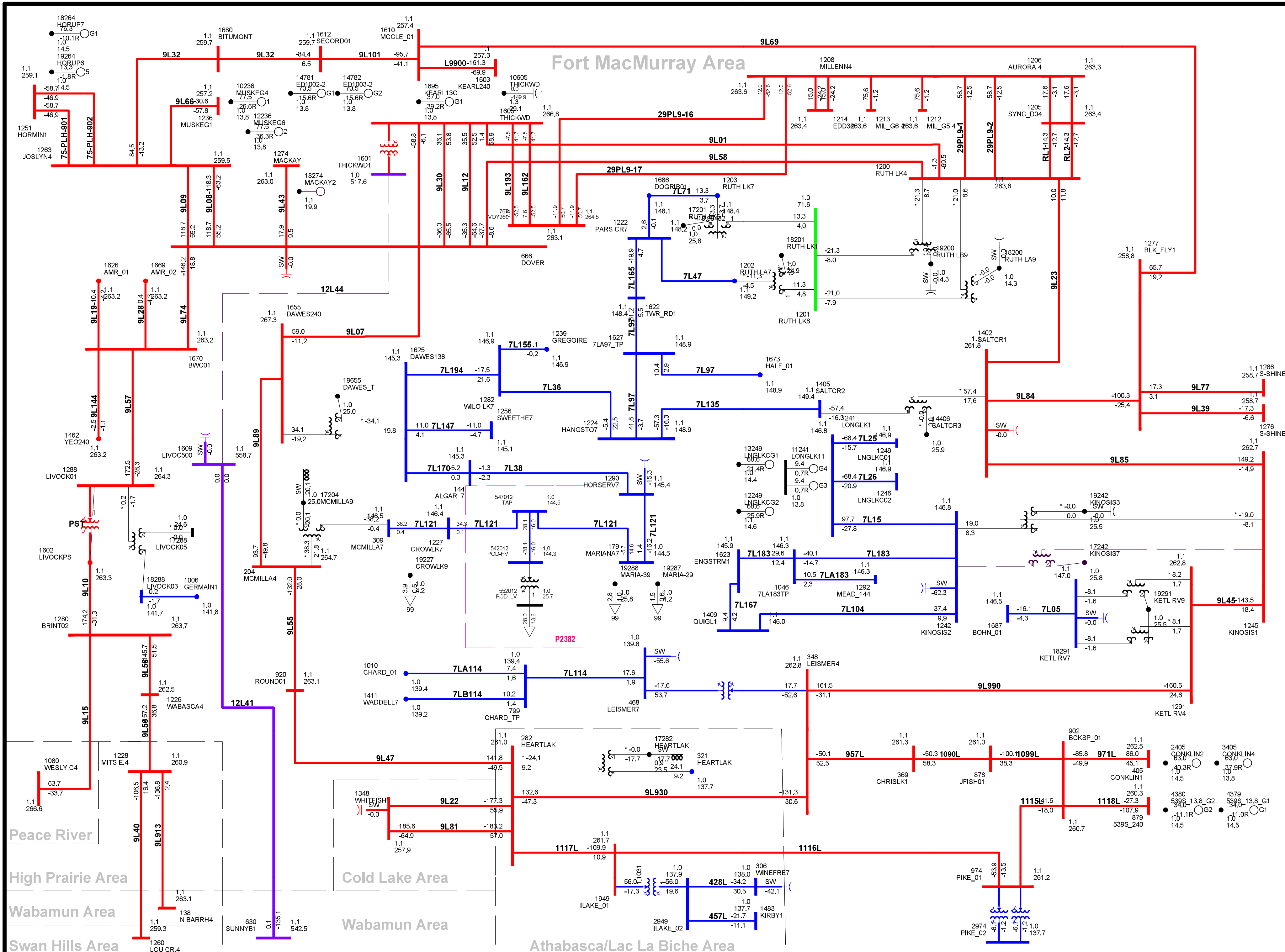
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L89
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:53

A3-6

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



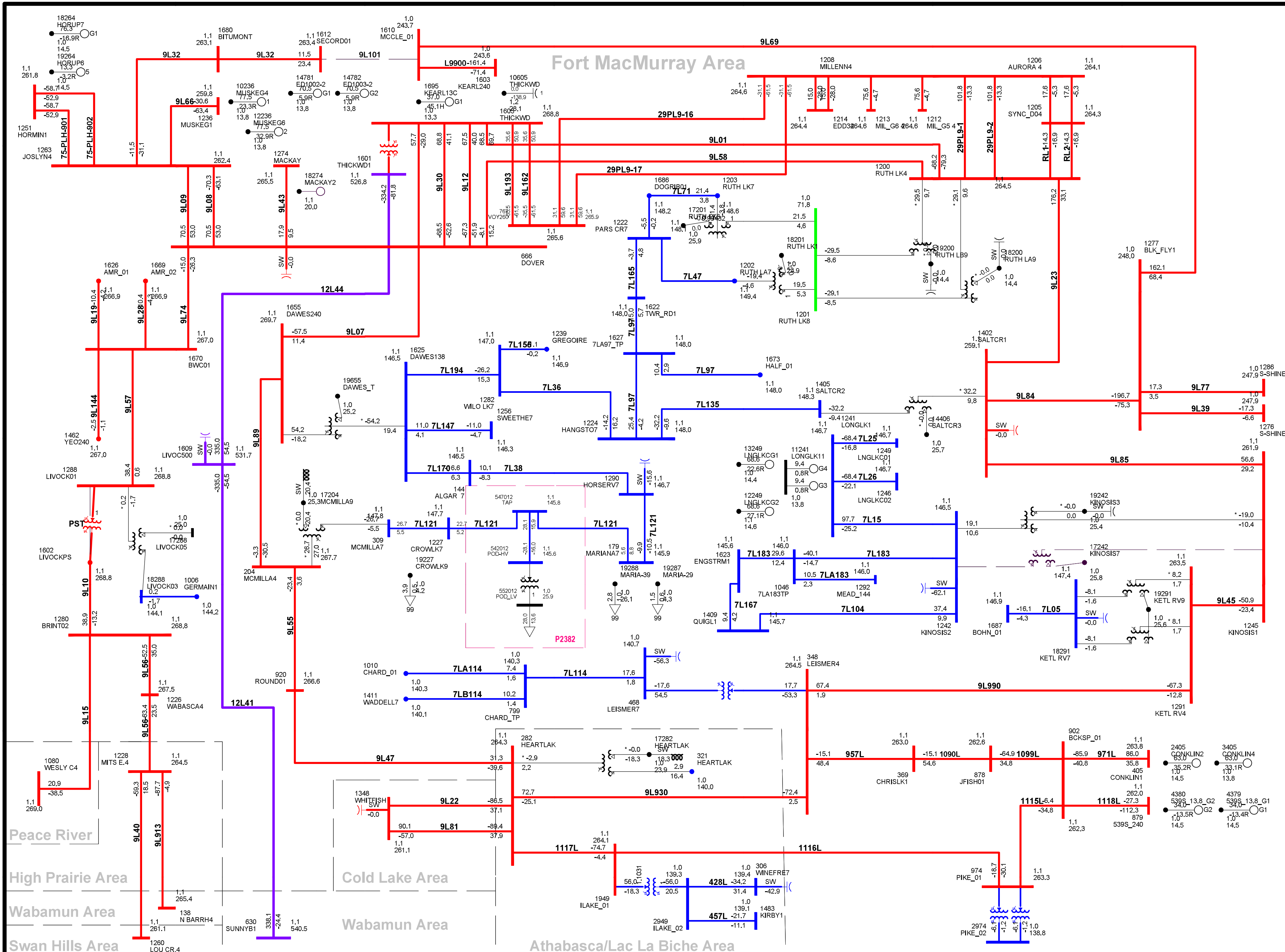
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 12L44
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:53

A3 - 7

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



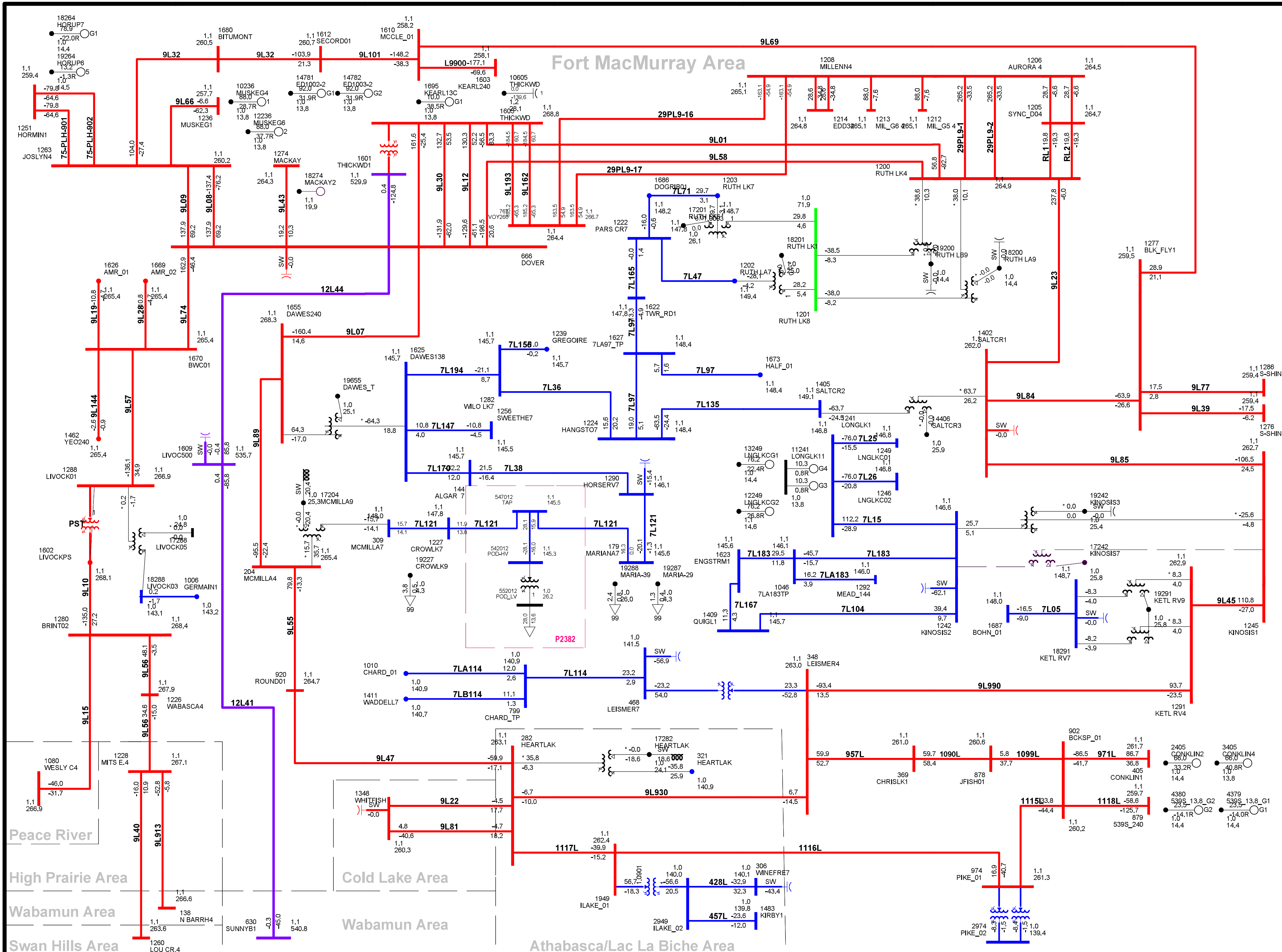
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L101
POST-PROJECT 2023 SP
FRI, JAN 21 2022 14:53

A3 - 8

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



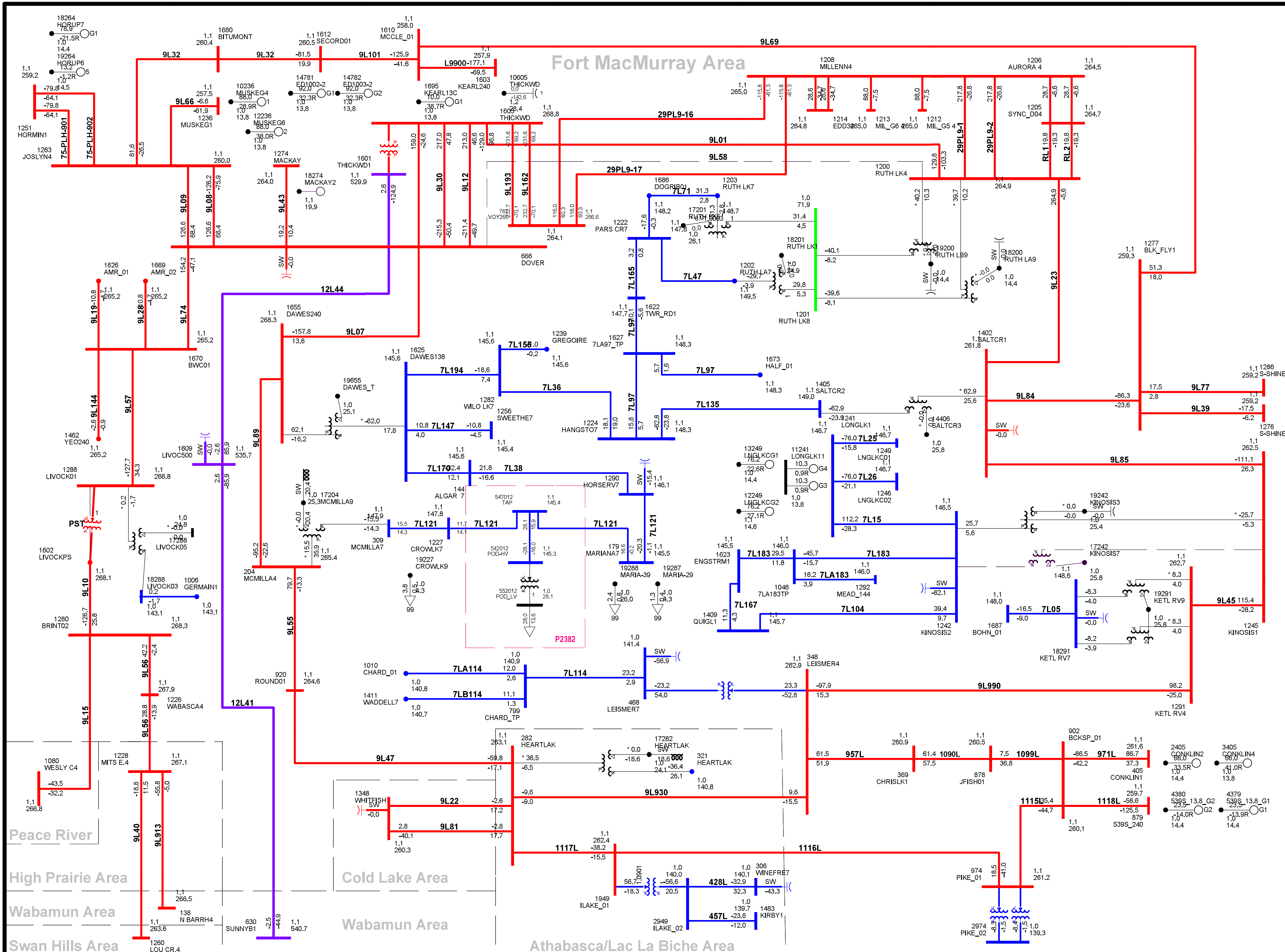
P2382 - ATCO Mariana Lake Load

CATEGORY A, N-0
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:55

A3 - 9

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



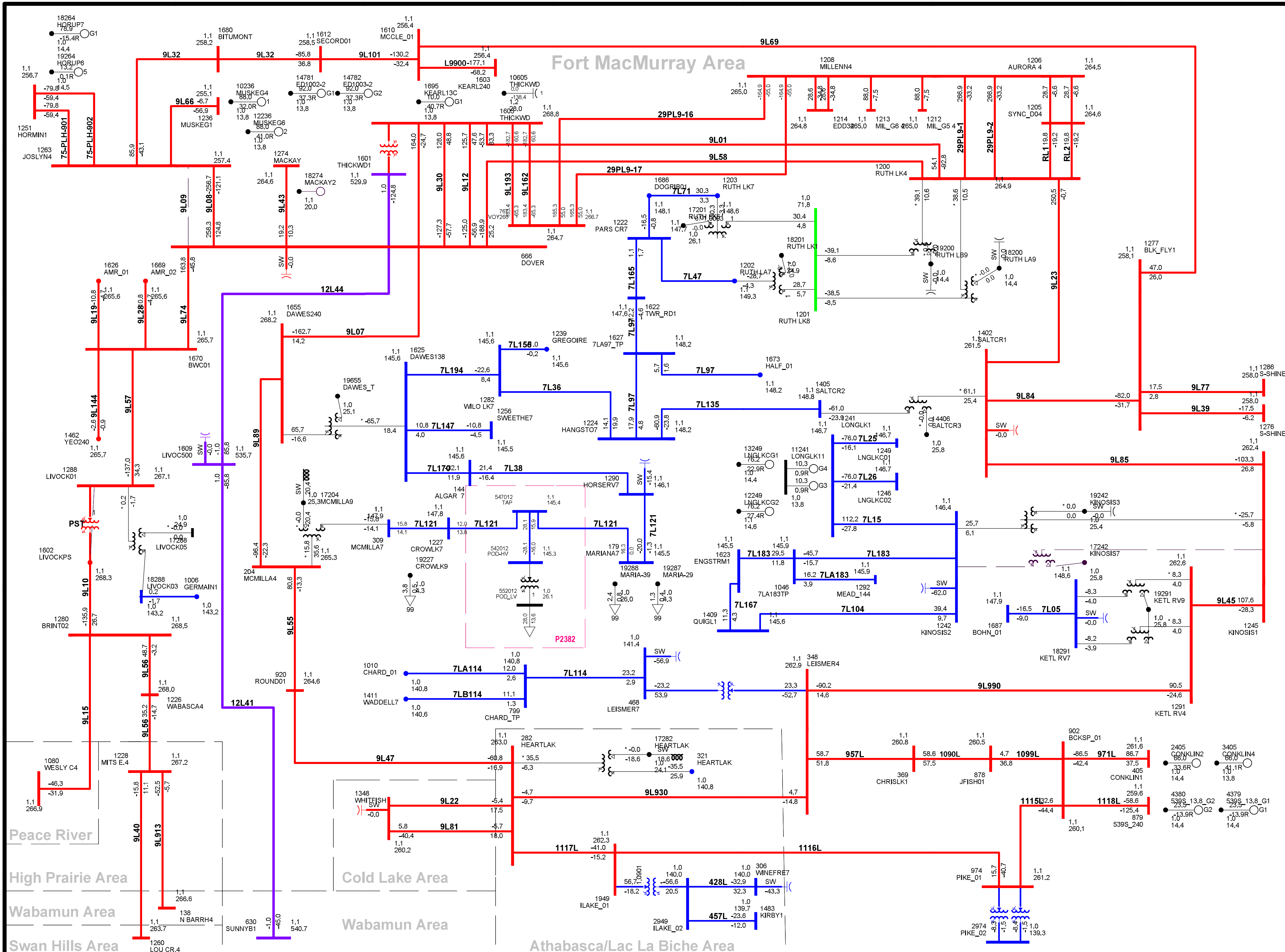
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L58
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:55

A3-10

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



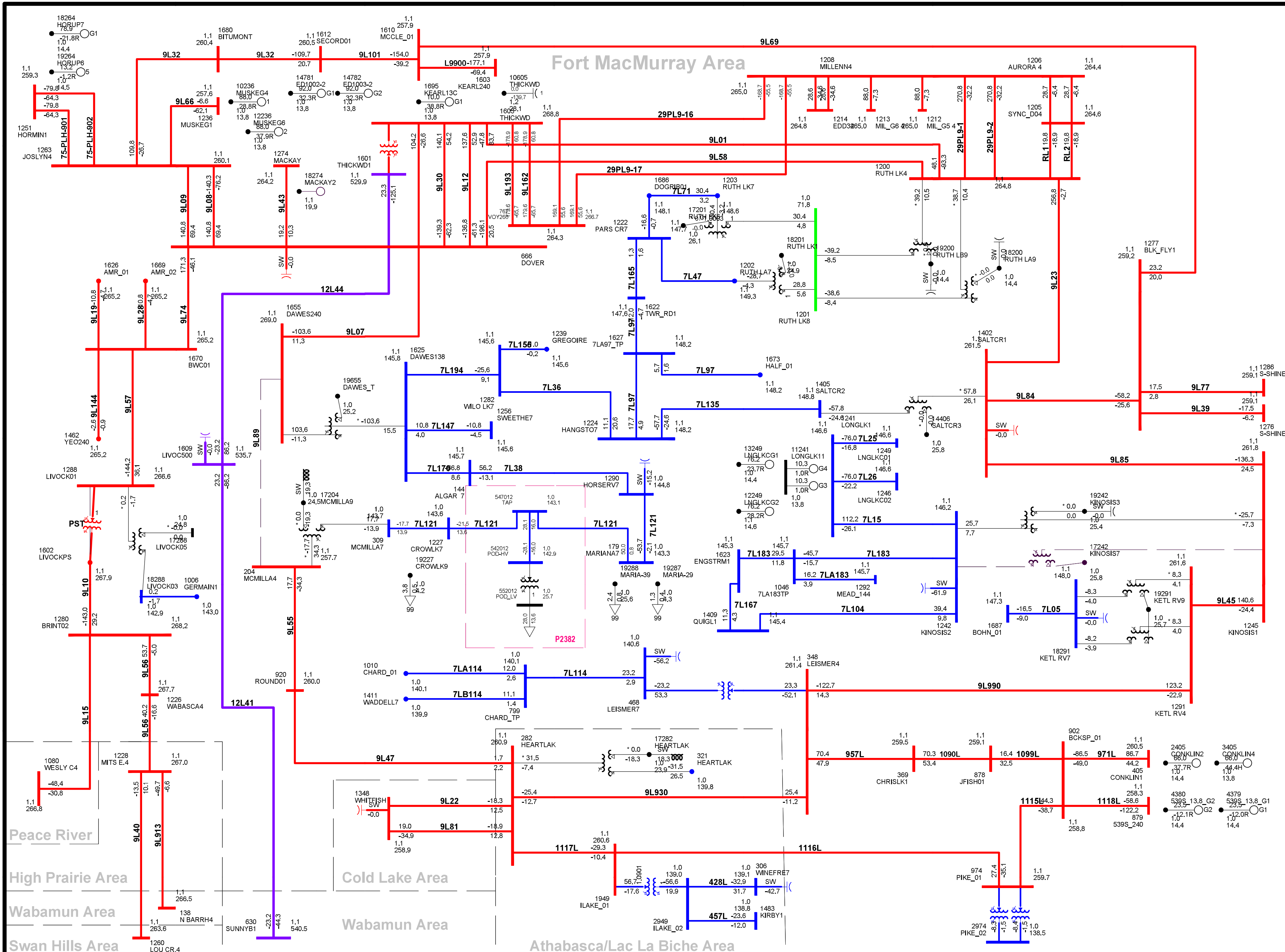
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L09
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:56

A3-11

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



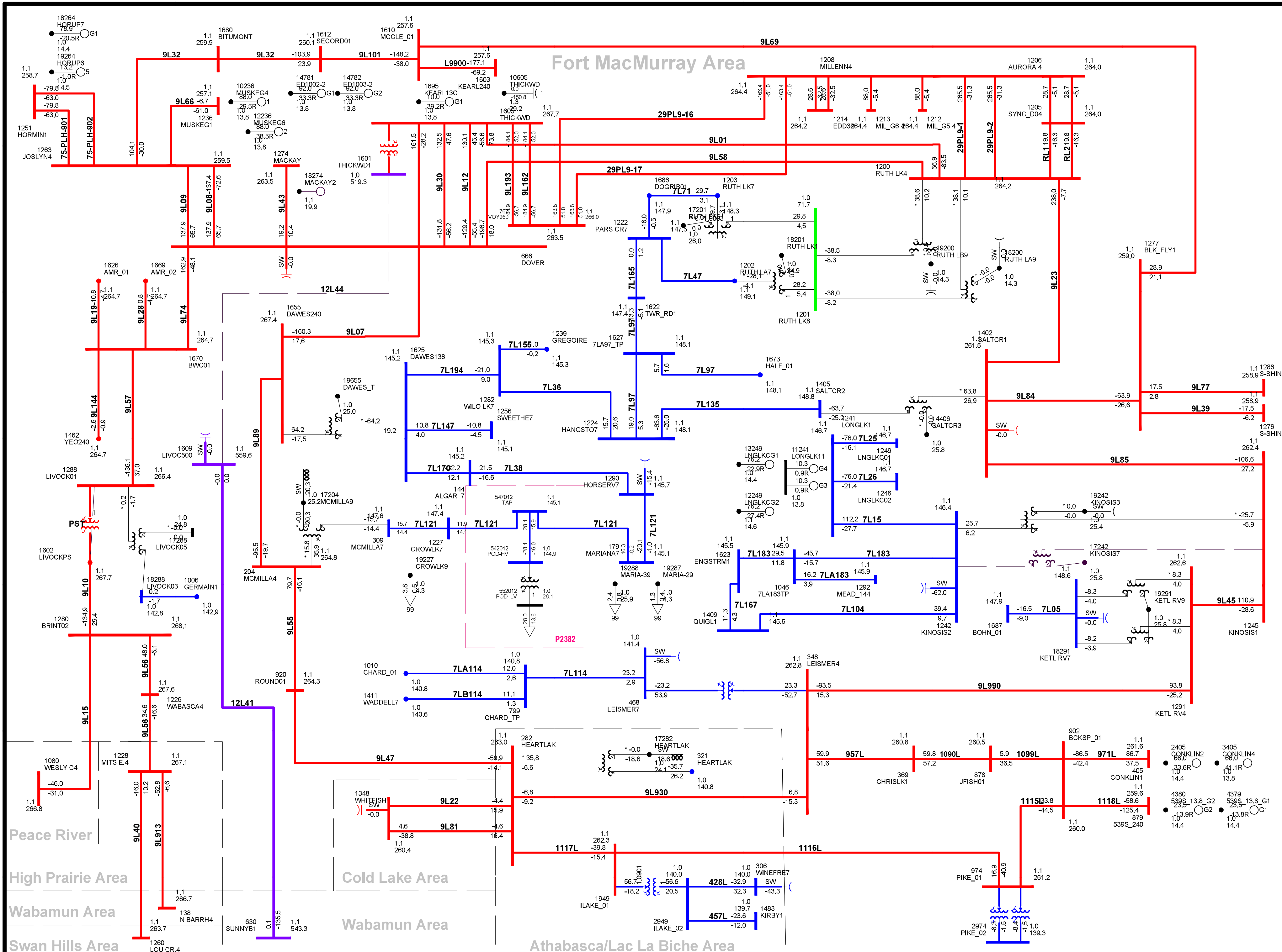
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L89
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:56

A3-12

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



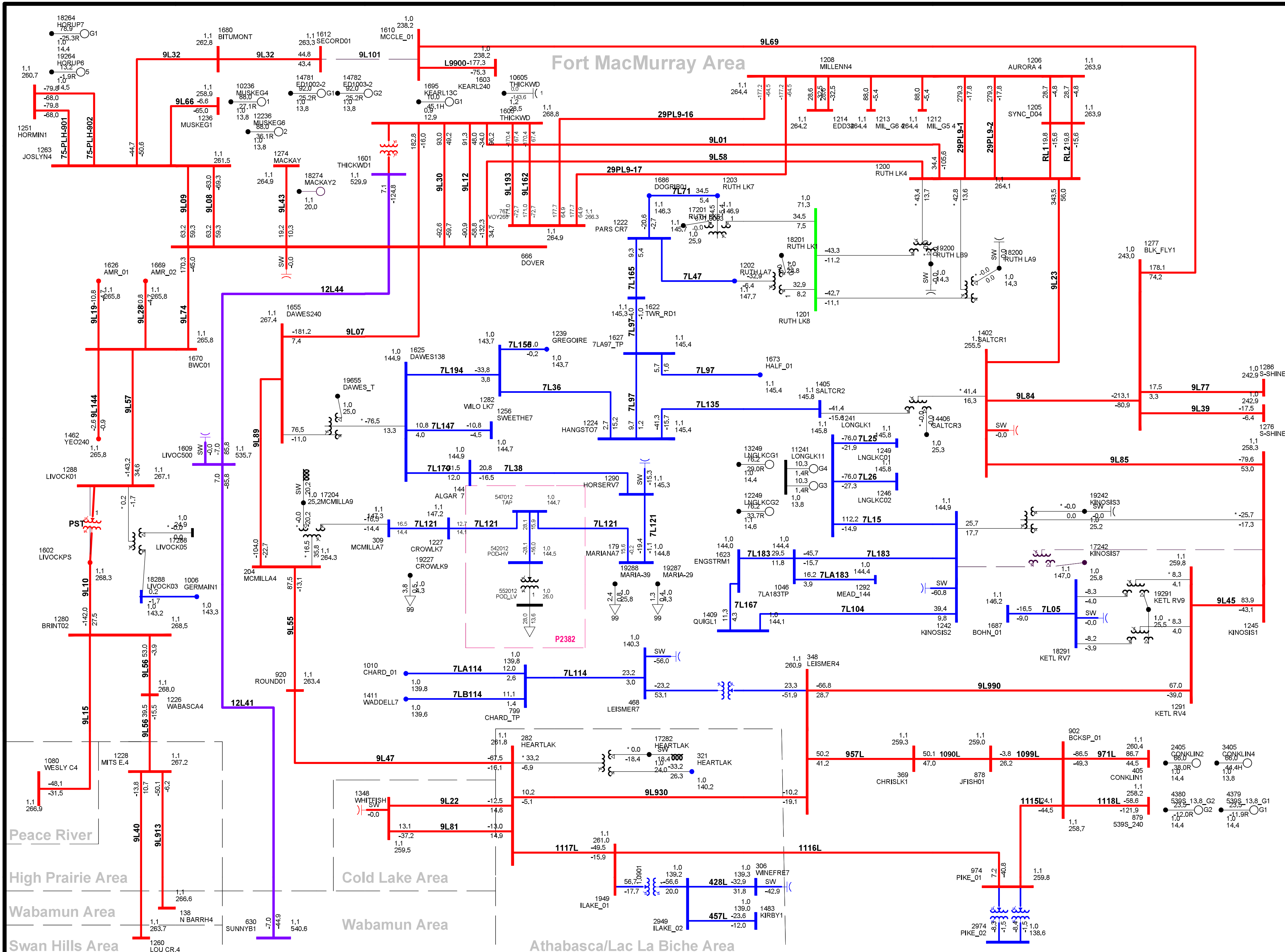
P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 12L44
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:56

A3-13

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000



P2382 - ATCO Mariana Lake Load

CATEGORY B, LOSS OF 9L101
POST-PROJECT 2024 WP
FRI, JAN 21 2022 14:56

A3-14

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

kV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

ATTACHMENT A4
Post-Project Voltage Stability Diagrams

The voltage stability analysis was completed for post-Project winter peak scenario 4 2024WP. The P-V graphs for the worst contingencies are provided below.

Figure A4-1 shows the P-V curves at new POD Freer 2043S 144 kV bus for 9L101, 1090L, 1115L, 1099L and 9L32 contingencies in the post-Project for scenario 4.

Figure A4-1: P-V Curve for Scenario 4 – 2023 WP Post-Project