APPENDIX A CONNECTION ASSESSMENT

Engineering Connection Assessment

Abee 993S Substation Upgrade

Enbridge Pipelines (Woodlands) Inc.

AESO Project Number: P2050

Date: August 29, 2019

Version: V1

Classification: Public

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APEGA
Permit-to-Practice
P-8200
Sept. 16, 2019

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.

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Attachments

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

Enbridge Pipelines (Woodlands) Inc. (Market Participant) has submitted a request for system access service to the Alberta Electric System Operator (AESO) to serve a new demand for electricity in the Thorhild County area.

The Market Participant's request includes a request for a new Rate DTS, *Demand Transmission Service*, contract capacity of 13.0 MW at the existing Abee 933S substation; and a request for transmission development (collectively, the Project).

The Project is located in the Thorhild County area within the AESO planning area of Athabasca/Lac La Biche (Area 27).

The scheduled in-service date (ISD) for the Project is March 1, 2021.

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 on the southern edge of the AESO planning area of Athabasca/Lac La Biche (Area 27), but is electrically connected to the AESO planning area of Fort Saskatchewan (Area 33). The Fort Saskatchewan area is part of the AESO Northeast Planning Region.

From a transmission system perspective, Fort Saskatchewan (Area 33) consists primarily of a 138 kV and 240 kV transmission system. Fort Saskatchewan (Area 33) is connected to the AIES by several 500 kV, 240 kV and 138 kV transmission lines to the AESO planning areas of Edmonton (Area 60) and Cold Lake (Area 28). Additionally, Fort Saskatchewan (Area 33) is connected to the AIES via the East Alberta Transmission Line (EATL) High Voltage Direct Current (HVDC) line.

Existing constraints in the AESO's 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 Saskatchewan (Area 33), including the tie lines connecting this planning area to the rest of the AIES. All transmission facilities within the Study Area were 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 two transmission alternatives to meet the Market Participant's request for system access service, as detailed in Section 3.2.

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 – Abee 993S Substation Upgrade (Transformer Addition)

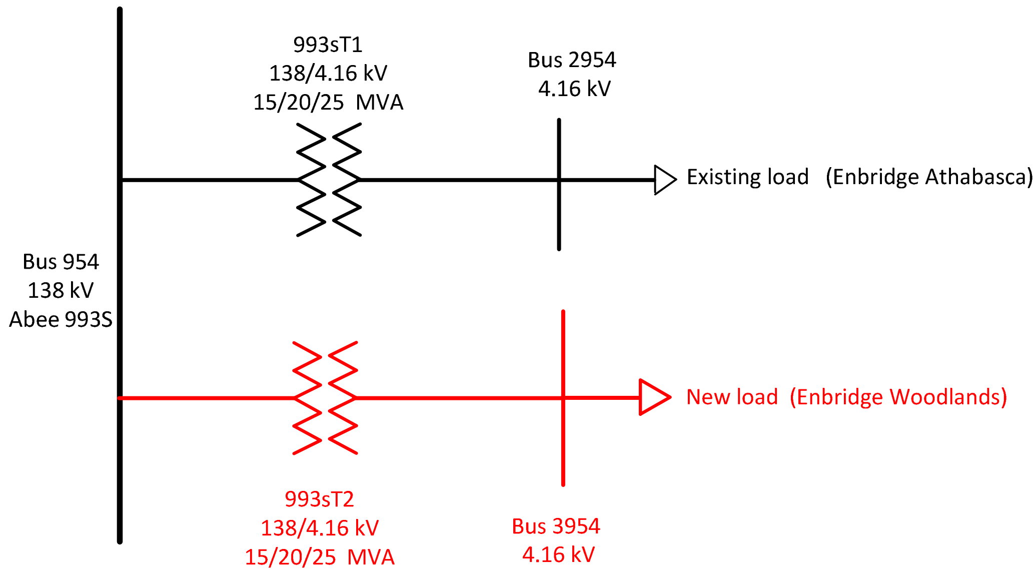
This alternative includes the following developments:

- Add one 138/4.16 kV transformer at the existing Abee 993S substation.
- Add or modify associated equipment as required for the above transmission developments.

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

Figure 3-1: Connection Alternative 1

Alternative 1: Abee 993S Upgrade (Transformer Addition)



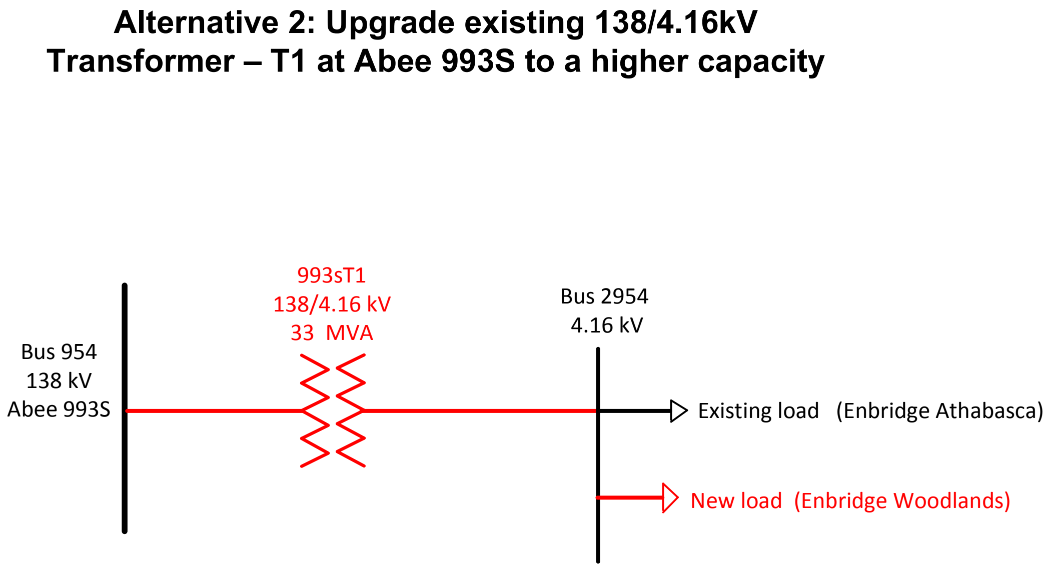
Alternative 2 – Abee 993S Substation Upgrade (Transformer Replacement)

This alternative includes the following developments:

- Replace the existing Abee 993S substation 138/4.16 kV transformer T1 with a 138/4.16 kV transformer of higher capacity.
- 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



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

Alternative 2 was not selected for further study as serving both existing and new load from a single transformer did not meet the market participants requested reliability or operational requirements.

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

The scheduled ISD for the Project is March 1, 2021. Therefore, studies were performed using scenarios for 2021 Winter Peak (WP) and 2022 Summer Peak (SP).

Short-circuit studies were performed using the 2021 WP pre-Project, and 2021 WP and 2028 WP post-Project scenarios.

Table 4-1 lists the study scenarios. Post-Project scenarios reflect the requested new Rate DTS contract capacity of 13.0 MW at the Abee 993S substation, and a total DTS contract capacity of 24.2 MW at Abee 993S 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	2022 Summer Peak (SP)	Low Northeast Generation	2022 SP Pre-Project	0	0
2	2021 Winter Peak (WP)	Low Northeast Generation	2021 WP Pre-Project	0	0
Post-Project					
3	2022 Summer Peak (SP)	Low Northeast Generation	2022 SP Post-Project	13	0
4	2021 Winter Peak (WP)	Low Northeast Generation	2021 WP Post-Project	13	0
5	2028 Winter Peak (WP)	Base Case	2028 WP Post-Project	13	0

The AESO Fort Saskatchewan Area Peak load forecasts used for the connection studies were based on the *AESO 2017 Long-term Outlook* (2017 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 point of delivery (POD) low voltage bus voltage deviations beyond the limits listed in Table 3-1 of Attachment A1.[1]

Power flow studies were performed for 2021 WP and 2022 SP pre-Project and 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 2021 WP post-Project scenario.

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 2021 WP pre-Project scenario, and 2021 WP and 2028 WP post-Project scenarios.

[1] 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 Interpretation of Results

5.1 Results Overview

This section provides an assessment of the impact of the Project on the performance of the AIES.

- 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 a description of the proposed mitigation measures to address observed Reliability Criteria violations.
- Section 5.5 includes an overview of the post-mitigation studies results.

Detailed study results are provided in Attachment 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

No Reliability Criteria violations or POD bus voltage deviations were observed under Category B conditions for any of the pre-Project scenarios.

5.3 Post-Project Study Results

5.3.1 Category A Conditions

No Reliability Criteria violations were observed under Category A conditions for any post-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.

5.3.2 Category B Conditions

No Reliability Criteria violations or POD bus voltage deviations were observed under Category B conditions.

The voltage stability margin was met for all studied conditions.

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 request for system access service.

Alternative 1 involves adding a 138/4.16 kV transformer and associated equipment at the Abee 993S substation. A minimum transformation capability of 14.5 MVA is recommended for the 138/4.16 kV transformer to meet the requested new DTS contract capacity of 13.0 MW.

Attachment A:
Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

Enbridge Abee 993S Upgrade

Enbridge Pipeline (Woodlands) Inc.

AESO Project Number: P2050

Date: **August 14, 2019**

Version: V1

Role	Name	Organization	Date	Signature
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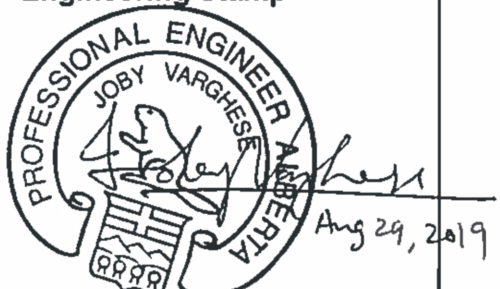
Engineering Stamp



APEGA Permit - Practice: P-7862

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1. Introduction

This report presents the results of the engineering studies that were completed by AltaLink Management Ltd., in its capacity as general partner of AltaLink L.P., (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, which was prepared by the Alberta Electric System Operator (AESO). The following sections describe the results of the studies.

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 in the Study Area are included in Attachment A2.

2.1.1. Scenario 1: 2022 Summer Peak (SP) Pre-Project

Category A condition

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

Category B conditions

No Reliability Criteria violations or voltage deviations beyond the limits listed in Table 3-1 of Attachment A1 (hereafter referred to as, point of delivery (POD) bus voltage deviations) were observed under Category B conditions.

2.1.2. Scenario 2: 2021 Winter Peak (WP) Pre-Project

Category A condition

No Reliability Criteria violations were observed under the Category A condition.

Category B conditions

No Reliability Criteria violations or POD bus voltage deviations were observed under Category B conditions.

3. Post-Project Study Results

This section describes the results of the post-Project power flow and voltage stability studies. As described in Section 2 of Attachment A1, the post-Project studies were performed using Alternative 1.

Post-Project sensitivity studies were not performed as study results for the main scenarios did not identify any Reliability Criteria violations.

3.1. Power Flow Studies

Power flow diagrams illustrating the post-Project power flow studies results for Category A and Category B conditions in the Study Area are provided in Attachment A3.

3.1.1. Scenario 3: 2022 SP Post-Project

Category A condition

No Reliability Criteria violations were observed under the Category A condition.

Category B conditions

No Reliability Criteria violations or POD bus voltage deviations were observed under Category B conditions.

3.1.2. Scenario 4: 2021 WP Post-Project

Category A condition

No Reliability Criteria violations were observed under the Category A condition.

Category B conditions

No Reliability Criteria violations or POD bus voltage deviations were observed under Category B conditions.

3.2. Voltage Stability Studies

Power-voltage (PV) diagrams illustrating the post-Project voltage stability studies results for Category A and Category B conditions in the Study Area are provided in Attachment A4. The voltage stability margin was met for all studied conditions.

3.2.1. Scenario 4: 2021 WP Post-Project

Voltage stability studies were performed for the 2021 WP post-Project study scenario. The reference load level for AESO planning area of Fort Saskatchewan (Area 33) is 865 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load or 43.3 MW to meet the voltage stability criteria (0.05 x 865 MW = 43.3 MW).

Table 3-1 summarizes the voltage stability results for Category A and the worst five contingencies for voltage stability transfer margins the 2021 WP post-Project study scenario.

Table 3-1: Voltage Stability Study Results for Scenario 4: 2021 WP Post-Project

Contingency (System Element Lost)	Transmission System Element Description	Maximum Incremental Transfer (MW)	Meets Criteria (Y/N)
N-0	System Normal	630	Yes
708L	Beamer 233S - Lamoureux 71S	560	Yes
997L	Josephburg 410S - Lamoureux 71S	560	Yes
921L	Lamoureux 71S - Clover Bar 987S	560	Yes
13ST2	Deerland 13S 240/138 kV transformer T2	580	Yes
410ST1	Josephburg 410S 240/138 kV transformer T1	580	Yes

4. Short-Circuit Studies

4.1. Pre-Project Results

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

Table 4-1: Pre-Project Short-Circuit Current Levels for Scenario 2: 2021 WP Pre-Project

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)
Abee 993S	138	141.8	2.9	0.058077+ j0.139698	2.0	0.101238+ j0.335540
Weasel Creek 947S	138	142.0	3.7	0.044391+ j0.110166	2.6	0.069875+ j0.253223
Deerland 13S	138	144.0	12.6	0.006896+ j0.034061	14.4	0.001477+ j0.022454
	240	251.2	14.0	0.003027+ j0.017799	12.9	0.002734+ j0.022941
Whitefish Lake 825S	240	260.7	9.0	0.005867+ j0.028628	6.0	0.016039+ j0.070685
Amelia 108S	240	248.6	14.0	0.003004+ j0.017660	12.2	0.004151+ j0.025866
Heartland 12S	240	249.8	14.7	0.002347+ j0.017056	12.0	0.005006+ j0.028627
	500	533.7	9.3	0.001678+ j0.013304	7.1	0.005305+ j0.025291
Bannerman 681S	240	247.2	12.9	0.003122+ j0.019026	11.1	0.004201+ j0.028684
Josephburg 410S	138	141.9	25.4	0.003595+ j0.016639	25.6	0.002019+ j0.016736
	240	247.2	16.8	0.002770+ j0.014589	17.4	0.001836+ j0.013449
Lamoureux 71S	138	143.3	27.3	0.003457+ j0.015638	26.1	0.002704+ j0.018170
	240	247.6	19.7	0.002576+ j0.012401	17.9	0.002790+ j0.016408
Bruderheim 127S	138	144.1	11.1	0.008971+ j0.038474	9.2	0.012280+ j0.062622
Redwater 171S	138	141.2	10.4	0.013709+ j0.038991	7.7	0.024650+ j0.082213

[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.

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)
Beamer 233S	138	141.0	19.6	0.005421+ j0.021208	16.7	0.006402+ j0.033005

4.2. Post-Project Results

Post-Project short-circuit current levels are provided in Table 4-2, and Table 4-3.

Table 4-1: Post-Project Short-Circuit Current Levels for Scenario 4: 2021 WP Post-Project

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)
Abee 993S	138	138.8	2.9	0.059006+ j0.136380	2.0	0.101241+ j0.335533
Weasel Creek 947S	138	139.6	3.6	0.044989+ j0.108117	2.6	0.069878+ j0.253216
Deerland 13S	138	143.2	12.6	0.006956+ j0.033919	14.3	0.001477+ j0.022451
	240	250.4	14.0	0.003027+ j0.017746	12.9	0.002733+ j0.022935
Whitefish Lake 825S	240	260.4	9.0	0.005864+ j0.028614	6.0	0.016039+ j0.070685
Amelia 108S	240	247.7	14.0	0.003001+ j0.017601	12.1	0.004149+ j0.025854
Heartland 12S	240	249.2	14.7	0.002344+ j0.017018	12.0	0.005005+ j0.028623
	500	533.1	9.3	0.001674+ j0.013284	7.1	0.005305+ j0.025288
Bannerman 681S	240	246.3	12.9	0.003115+ j0.018976	11.1	0.004199+ j0.028672
Josephburg 410S	138	141.2	25.4	0.003596+ j0.016553	25.6	0.002015+ j0.016715
	240	246.2	16.8	0.002764+ j0.014526	17.3	0.001832+ j0.013433
Lamoureux 71S	138	142.5	27.3	0.003430+ j0.015524	26.2	0.002682+ j0.018081
	240	246.7	19.7	0.002566+ j0.012345	17.9	0.002776+ j0.016370
Bruderheim 127S	138	143.3	11.1	0.009014+ j0.038348	9.2	0.012277+ j0.062611
Redwater 171S	138	140.2	10.4	0.013759+ j0.038801	7.6	0.024649+ j0.082202
Beamer 233S	138	140.2	19.6	0.005427+ j0.021107	16.7	0.006400+ j0.032987

Table 4-2: Post-Project Short-Circuit Current Levels for Scenario 5: 2028 WP Post-Project

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)
Abee 993S	138	139.4	2.9	0.057601+ j0.137226	2.0	0.101206+ j0.335382
Weasel Creek 947S	138	140.0	3.6	0.043922+ j0.108371	2.6	0.069843+ j0.253065
Deerland 13S	138	142.6	12.9	0.006338+ j0.033081	14.6	0.001407+ j0.022257
	240	251.8	14.8	0.002587+ j0.016883	13.7	0.002410+ j0.021276
Whitefish Lake 825S	240	262.2	9.5	0.005215+ j0.027254	6.0	0.018379+ j0.074422
Amelia 108S	240	249.7	14.5	0.002628+ j0.017120	12.5	0.004071+ j0.025419
Heartland 12S	240	250.0	15.4	0.001994+ j0.016245	12.4	0.004931+ j0.027914
	500	532.9	10.2	0.001335+ j0.012067	7.6	0.005272+ j0.024613
Bannerman 681S	240	247.4	13.3	0.002817+ j0.018478	11.3	0.004151+ j0.028371
Josephburg 410S	138	141.0	26.1	0.003168+ j0.016119	26.2	0.001961+ j0.016410
	240	248.4	17.3	0.002456+ j0.014217	17.8	0.001832+ j0.013392
Lamoureux 71S	138	142.8	28.0	0.003166+ j0.015202	26.6	0.002679+ j0.018009
	240	247.8	20.5	0.002307+ j0.011964	18.4	0.002771+ j0.016282
Bruderheim 127S	138	141.9	11.3	0.008261+ j0.037271	9.4	0.011571+ j0.060846
Redwater 171S	138	140.3	10.5	0.013276+ j0.038386	7.7	0.024610+ j0.082024
Beamer 233S	138	140.7	20.0	0.004976+ j0.020855	16.9	0.006375+ j0.032823

ATTACHMENT: A1

AESO Engineering Connection

Assessment Scope

Engineering Connection Assessment: Study Scope

Abee 993S Substation Upgrade

Enbridge Pipeline (Woodlands) Inc.

AESO Project Number: P2050

Date: **August 29, 2019**

Version: **V1**

Classification: Public

Company Name	Name and Credentials	Date	Signature
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Market Participant	Terry Lindholm	Sept 11/19	[illegible]

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1 Introduction

This Study Scope provides an overview of the engineering studies to be completed by AltaLink Management Ltd., in its capacity as general partner of AltaLink L.P., (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

Enbridge Pipelines (Woodlands) Inc., has submitted a request for system access service to the Alberta Electric System Operator (AESO) to serve a new demand for electricity in the Thorhild County area.

The Market Participant's request includes a request for a new Rate DTS, *Demand Transmission Service*, contract capacity of 13.0 MW at the existing Abee 993S substation; and a request for transmission development (collectively, the Project).

The scheduled in-service date (ISD) for the Project is March 1, 2021.

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

There are no generation components of the Project.

Table 1-1: Project Load Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	A contract for 11.2 MW is held by Enbridge Pipelines (Athabasca) Inc. at Abee 933S substation.
	Requested Rate DTS	A new contract for 13.0 MW to be held by Enbridge Pipelines (Woodlands) Inc. The total Rate DTS contract capacity at Abee 993S substation will be 24.2 MW.
	Type	Oil & Gas
	Motors (number and size)	3 x 5750 hp motors, each with a dedicated Variable Frequency Drive (VFD); ▪ One motor will be randomly started one at a time and no simultaneous starting of motors ▪ Motors will always start with VFD ▪ No across the line starting
	Power factor	The new load will be studied assuming 0.9 power factor (pf) lagging
	Future load expansion plans	No

1.2 Existing System Overview

1.2.1 Study Area

Geographically, the Project is located on the southern edge of the AESO planning area of Athabasca/Lac La Biche (Area 27).

The Project is electrically connected to the AESO planning area of Fort Saskatchewan (Area 33) because Abee 993S substation is radially connected to the Fort Saskatchewan area through the 138 kV transmission line 808L. Therefore, the Study Area consists of the AESO planning area of Fort Saskatchewan (Area 33), including the tie lines connecting this planning area to the rest of the AIES.

The existing transmission system in the Study Area is shown in **Error! Reference source not found.**.

1.2.2 Existing Constraints

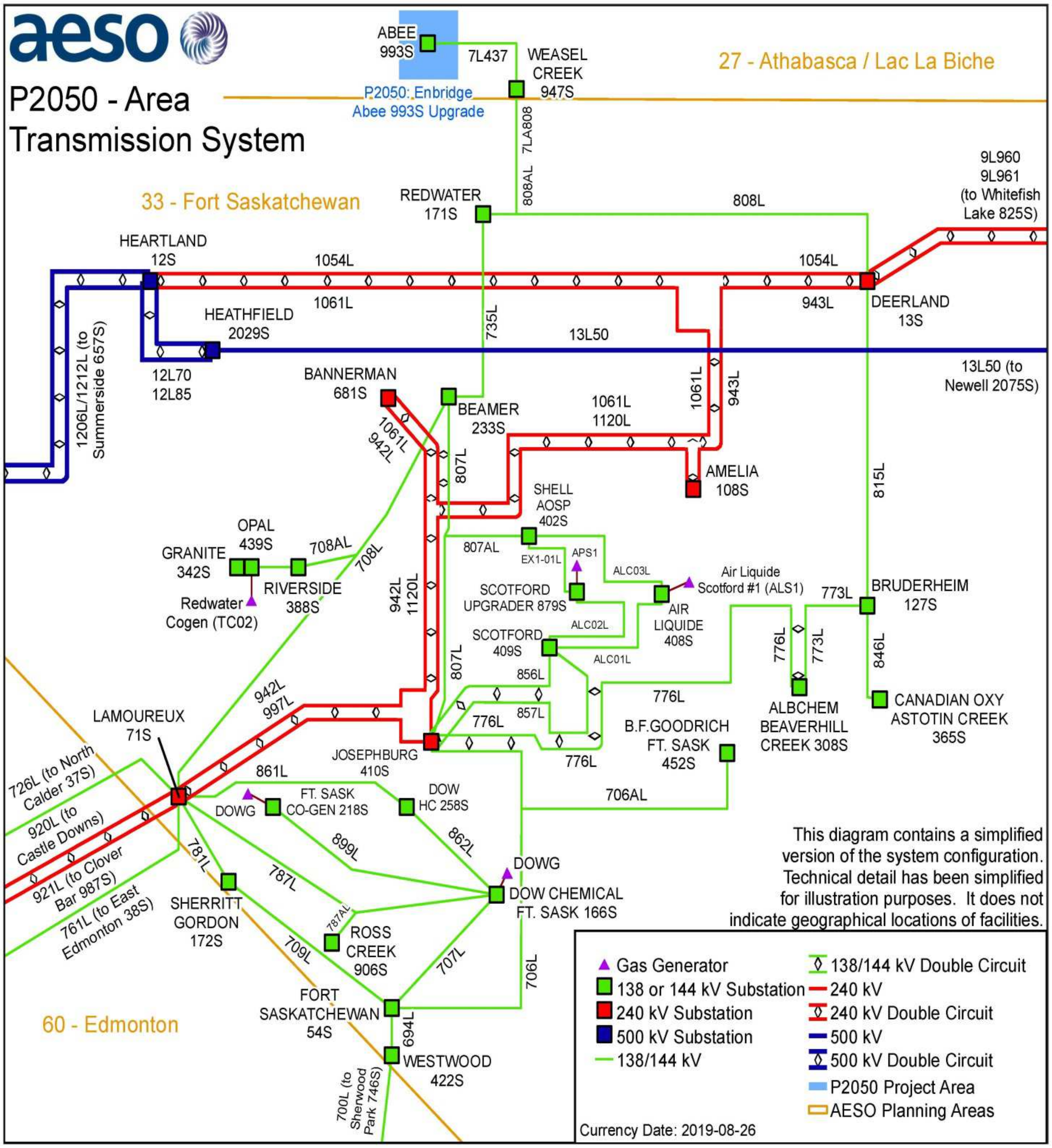
Existing constraints in the Study Area are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule).

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 are used to manage constraints in the study area:

- 149 - EATL HVDC

Figure 1-1: Existing Transmission System in the Study Area



2 Connection Alternative(s) to be Studied

The following alternative will be studied.

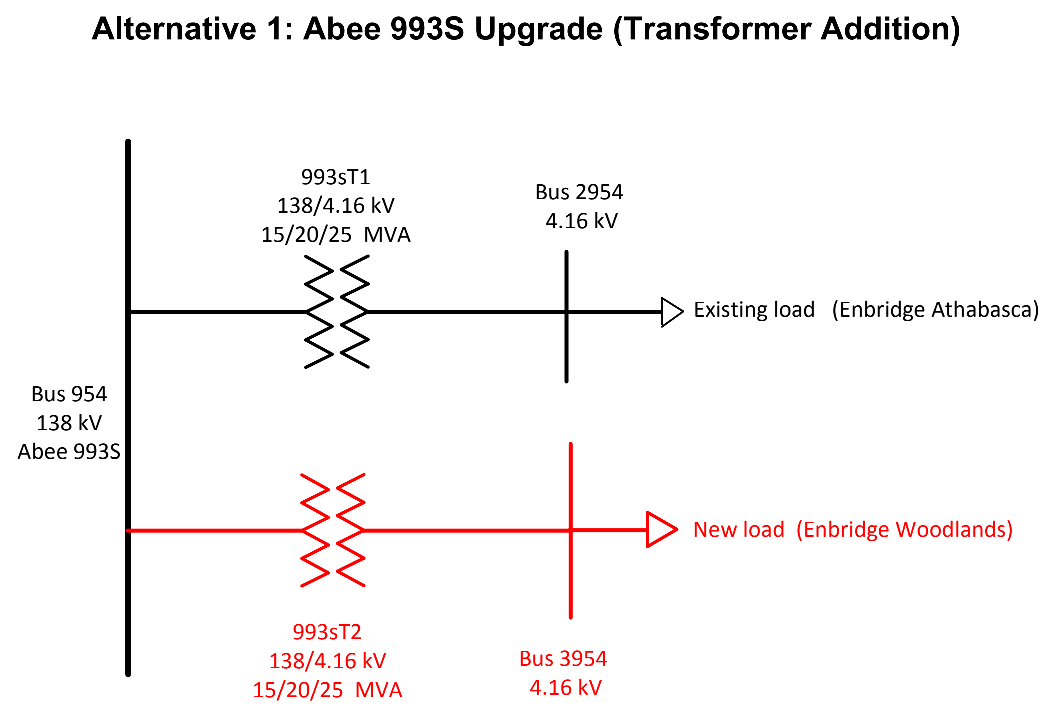
2.1 Alternative 1 – Abee 993S Substation Upgrade (Transformer Addition)

This alternative included the following developments:

- Add one 138/4.16 kV transformer at the existing Abee 993S substation.
- 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 AESO's *Connection Study Requirements*, the AESO's *Generation and Load Interconnection Standard*, and Section 502.5 of the ISO rules *Generating Unit Technical Requirements*, and Section 502.6 of the ISO rules *Generating Unit Operating 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	2022 Summer Peak (SP)	Low Northeast Generation	2022 SP Pre-Project	0	0
2	2021 Winter Peak (WP)	Low Northeast Generation	2021 WP Pre-Project	0	0
Post-Project					
3	2022 Summer Peak (SP)	Low Northeast Generation	2022 SP Post-Project	13	0
4	2021 Winter Peak (WP)	Low Northeast Generation	2021 WP Post-Project	13	0
5	2028 Winter Peak (WP)	Base Case	2028 WP Post-Project	13	0

4.2 Assumptions

4.2.1 System Project Assumptions

The pre-Project and post-Project connection assessment will not include any system transmission projects in the main study scenarios 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

Table 4-3 summarizes the connection projects in the Study Area that should be included but not dispatched in the studies, as well as the load and generation assumptions to be used.

Table 4-2: Planned Connection Projects Included in the Studies (not dispatched)

AESO Project Number	AESO Project Name	AESO Planning Area No.	Generation (MW)	Load (MW)	Scheduled ISD	AUC NID Decision No.
1289	Maxim Power Deerland Peaking Station	33	185.8	0.0	Dec 1, 2020	U2014-447
1647	Fengate Strathcona Cogeneration	33	0.0	65.0	Mar 1, 2020	24062-D01-2019
1647	Fengate Strathcona Cogeneration	33	60.0	0.0	Oct 1, 2020	24062-D01-2019

4.2.3 Load Assumptions

The load forecast to be used for the studies is shown in Table 4-4 and is a forecast for the AESO Fort Saskatchewan Area Peak based on the *AESO 2017 Long-term Outlook* (2017 LTO)[1]. For the post-Project studies, when the Study Area loads are modified to align with the regional load forecast in the 2017 LTO, the active power to reactive power ratio in the base case scenarios shall be maintained.

Table 4-4: Forecast Area Peak Load (2017 LTO at AESO Fort Saskatchewan Area Peak)

AESO Planning Area or Region Name	Forecast Peak Load by Year/Season (MW)	
	2022 SP	2021 WP
Fort Saskatchewan (Area 33)	812	865

4.2.4 Generation Assumptions

The generation forecast to be used for the studies is based on the 2017 LTO. The generation assumptions for the studies will assume low Northeast regional generation. 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 4-5.

Air Liquide Unit G1 was determined to be the cirtical generator, and shall be modelled as being offline to simulate the N-G condition in all the study scenarios.

[1] The 2017 LTO is available on the AESO website.

Table 4-5: Existing Generation Dispatch Conditions

Facility Name	Unit No.	Bus No.	Pmax (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
					2022SP	2021WP
Air Liquide	G1	627	96	33	Offline (N-G[b])	Offline (N-G[b])
Scotford Upgrader	GT, ST	4185, 7185	195.1	33	102.81	105.89
Redwater GT	1	3050	92	33	56.8	66.4
Dow Chemical Fort Saskatchewan	G1, G2	54, 454	199	33	47.3	58.5
Dow Hydrocarbon	GT, ST	2030, 2031	140.5	33	76.6	86

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 offline to represent potential unavailability of generation in the Study Area.

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.

4.2.7 Transmission Facility Ratings

The legal owner of the transmission facility (TFO) provided the thermal ratings assumptions for the existing transmission lines in the Study Area. Table 4-6 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 4-6: 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
997L	Josephburg 410S – Lamoureux 71S	240	499	499	654	748
1120L	Josephburg 410S – Amelia 108S	240	594	706	654	773
773L	Albchem Beaverhill Creek 308S – Bruderheim 127S	138	121	127	133	140
776L	Albchem Beaverhill Creek 308S – Josephburg 410S	138	140	140	154	154
815L	Bruderheim 127S – Deerland 13S	138	141	163	155	179
846L	Bruderheim 127S – Canadian Oxy Astotin Creek 365S	138	167	191	184	218
856L	Josephburg 410S – Shell Scotford 409S	138	229	275	252	287
857L	Josephburg 410S – Shell Scotford 409S	138	246	287	271	330
ALC02L	Shell Scotford 409S – Scotford Upgrader 879S	138	228	273	250	296
706L	Josephburg 410S – 706AL Tap	138	119	146	131	161
706L	Fort Saskatchewan 54S – 706AL Tap	138	119	146	131	161
706AL	B.F.Goodrich Fort Saskatchewan 452S – 706AL Tap	138	98	132	108	145
807L	Josephburg 410S – 807AL Tap	138	175	217	193	239
807L	Beamer 233S – 807AL Tap	138	85	90	94	99
807AL	Scotford Expansion 1 402S – 807AL Tap	138	175	217	193	239
9L960/9L961	Whitefish Lake 825S – Deerland 13S	240	498CT	498CT	498CT	498CT
1054L	Deerland 13S – Heartland 12S	240	594	624	654	773
943L	Deerland 13S – Amelia 108S	240	457	457	654	686

Note:
“CT” indicates that the transmission line is limited by current transformer.

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

Table 4-7: Summary of Key Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	Transformer Rating (MVA)
Albchem Beaverhill Creek 308S	T1	138/13.8	30/40/50
Bruderheim 127S	T1	138/26.5	25/33/42
Bruderheim 127S	T2	138/26.5	25/33/42
Josephburg 410S	T1	250/144	180/240/300/336
Josephburg 410S	T2	250/144	180/240/300/336
Deerland 13S	T2	245/144	180/240/300

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 4-8.

Table 4-8: 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)
Fort Saskatchewan 54S	138	1	48.91	N/A	N/A
Lamoureux 71S	138	2	97.82	N/A	N/A
Bruderheim 127S	138	1	45	N/A	N/A
Heathfield 2029S	500	1	250	N/A	N/A

4.2.8 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	C5	A	B	C5	A	B	C5	A	B	
Pre-Project													
1	2022 SP Pre-project	X	X										
2	2021 WP Pre-project	X	X										X
Post-Project													
3	2022 SP Post-project	X	X										
4	2021 WP Post-project	X	X		X	X							X
5	2028 WP Post-Project												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 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 and cases 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 Saskatchewan (Area 33) and increasing generation in Calgary (Area 6).

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 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:

- Abee 993S
- Wealsel Creek 947S
- Deerland 13S
- Whitefish Lake 825S

- Amelia 108S
- Heartland 12S
- Bannerman 681S
- Josephburg 410S
- Lamoureux 71S
- Bruderheim 127S
- Redwater 171S
- Beamer 233S

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 (2017 LTO). 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

Transmission Planning Criteria – Basis and Assumptions

Version 1.1

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1. Introduction

This document presents the reliability standards, criteria, and assumptions to be used as the basis for planning the Alberta Transmission System. The criteria, standards and assumptions identified in this document supersede those previously established.

2. Transmission Reliability Standards and Criteria[1]

The AESO applies the following Alberta Reliability Standards to ensure that the transmission system is planned to meet applicable performance requirements under a defined set of system conditions and contingencies. A brief description of each of these standards is given below:

1. **TPL-001-AB-0: System Performance Under Normal Conditions**

   Category A represents a normal system condition with all elements in service (N-0). All equipment must be within its applicable rating, voltages must be within their applicable ratings and the system must be stable with no cascading outages. Under Category A, electric supply to load cannot be interrupted and generating units cannot be removed from service.

2. **TPL-002-AB1-0: System Performance Following Loss of a Single BES Element**

   Category B events result in the loss of any single element (N-1) under specified fault conditions with normal clearing. The specified elements are a generating unit, a transmission circuit, a transformer or a single pole of a direct current transmission line. The acceptable impact on the system is the same as Category A with the exception that radial customers or some local network customers, including loads or generating units, are allowed to be disconnected from the system if they are connected through the faulted element. The loss of opportunity load or opportunity interchanges is allowed. No cascading can occur.

3. **TPL-003-AB-0: System Performance Following Loss of Two or More BES Elements**

   Category C events result in the loss of two or more bulk electric system elements (sequential, N-1-1 or concurrent, N-2) under specified fault conditions and include both normal and delayed fault clearing. All of the system limits for Category A and B events apply with the exception that planned and controlled loss of firm load, firm transfers and/or generation is acceptable provided there is no cascading.

4. **TPL-004-AB-0: System Performance Following Extreme BES Events**

   Category D represents a wide variety of extreme, rare and unpredictable events, which may result in the loss of load and generation in widespread areas. The system may not be able to reach a new stable steady state, which means a blackout is a possible outcome. The AESO needs to evaluate these events, at its discretion, for risks and consequences prior to creating mitigation plans.

5. **FAC-014-AB1-2: Establishing and Communicating System Operating Limits**

   The AESO is required to establish system operating limits where a contingency is not mitigated through construction of transmission facilities

[1] A complete description of these standards is given in: AESO. *Alberta Reliability Standards*. Available at: https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/

2.1 Thermal Loading Criteria

The AESO Thermal Loading Criteria require that the continuous thermal rating of any transmission element is not exceeded under normal and post-contingency operating conditions. Thermal limits are assumed to be 100% of the respective normal summer and winter ratings. Emergency limits are not considered in the planning evaluations.

2.2 Voltage Range and Voltage Stability Criteria

The normal minimum and maximum voltage limits as specified in the following table are used to identify Category A system voltage violations, while the extreme minimum and maximum limits are used to identify Category B and C system violations. Table 2-1 presents the acceptable steady state and contingency state voltage ranges for the AIES. Table 2-2 provides voltage stability criteria used to test the system performance.

Table 2-1: Acceptable Range of Steady State Voltage (kV)

Nominal Voltage	Extreme Minimum	Normal Minimum	Normal Maximum	Extreme Maximum
500	475	500	525	550
240	216	234	252	264
260 (Northeast & Northwest)*	234	247	266	275
144	130	137	151	155
138	124	135	145	152
72	65	68.5	75.5	79
69	62	65.5	72.5	76

Table 2-2: Voltage Stability Criteria

Performance Level	Disturbance (1)(2)(3)(4) Initiated by: Fault of No Fault DC Disturbance	MW Margin (P-V method) (5)(6)(7)	MVAr Margin (V-Q method) (6)(7)
A	Any element such as: One Generator One Circuit One Transformer One Reactive Power Source One DC Monopole	$\geq$5%	Worst Case Scenario(8)
B	Bus Section	$\geq$5%	50% of Margin Requirement in Level A
C	Any combination of two elements such as: A Line and a Generator A Line and a Reactive Power Source Two Generators Two Circuits Two Transformers Two Reactive Power Sources DC Bipole	$\geq$2.5%	50% of Margin Requirement in Level A
D	Any combination of three or more elements such as: Three or More Circuits on ROW Entire Substation Entire Plant Including Switchyard	> 0	> 0

2.3 Transient Stability Analysis Assumptions

Standard fault clearing times as shown in Table 2-3 are used for the new facilities or when the actual clearing times are not available for the existing facilities. Double line-to-ground faults are applied for the Category C5 events with normal clearing times. Single line-to-ground faults are applied for Category C6 to C9 events with delayed clearing times as depicted in Table 2-4 and Table 2-5.

Table 2-3: Fault Clearing Times

Nominal (kV)	Near End (Cycles)	Far End (Cycles)
500	4	5
240	5	6
144/138 with telecommunications	6	8
144/138 without telecommunications	6	30

Table 2-4: Stuck Breaker Clearing Times for Lines

Voltage (kV)	Fault Clearing Times (Cycles)		
	Near End	Far End	2nd Ckt (C5 and C7 only)
138/144	15	24	24
240	12	6	14
500	9	5	11

Table 2-5: Stuck Breaker Clearing Times for Transformers

Voltage (kV)	Fault Location	Fault Clearing Times (Cycles)		
		High Side	Low Side	2nd Ckt (breaker fail)
240/138	240 kV side	12	6	14
	138 kV side	5	15	24
500/240	500 kV side	9	5	11
	240 kV side	4	12	14

ATTACHMENT: A2

Pre - Connection: Power Flow Analysis

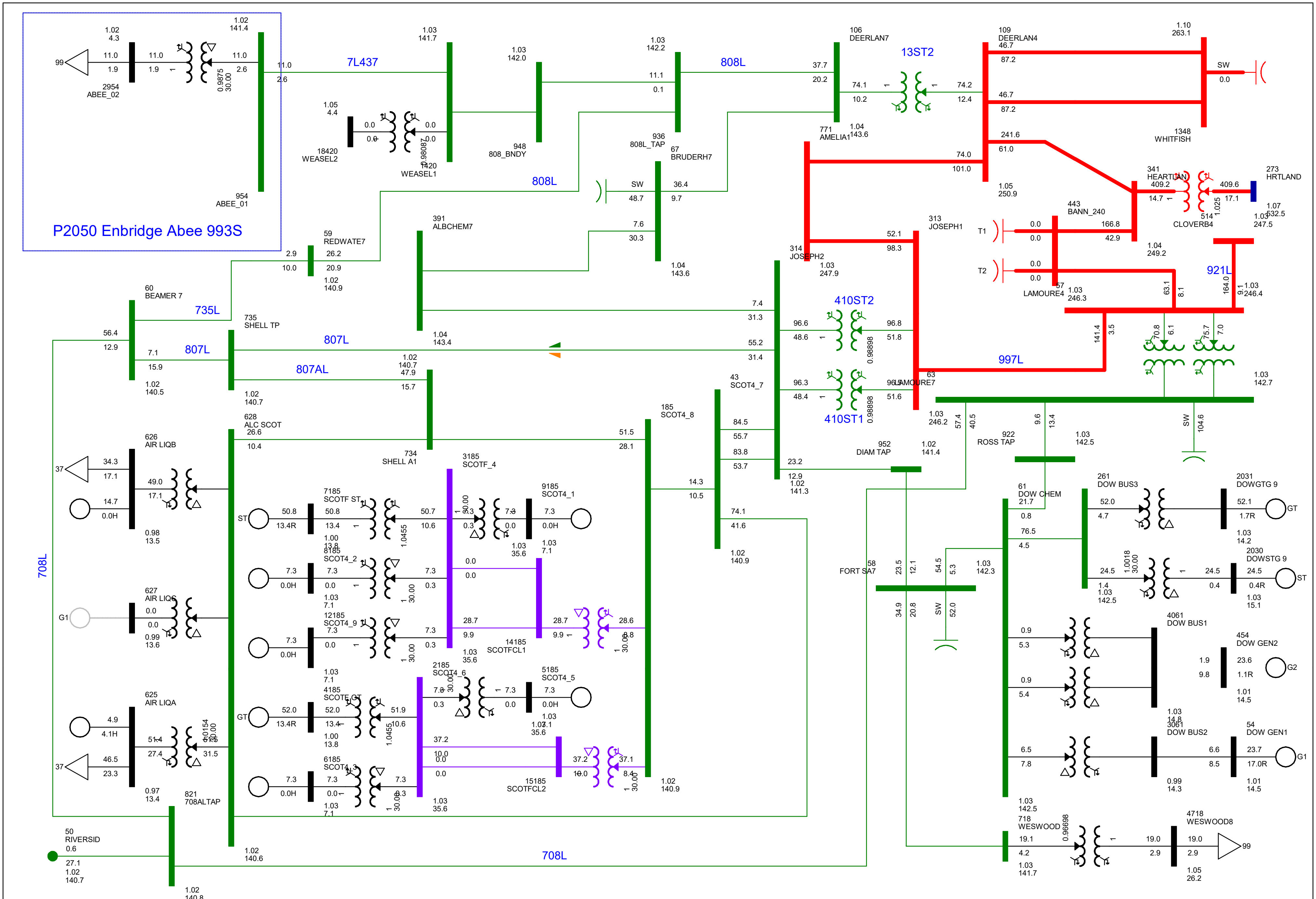
Before P2050

Table 1: Summary of System Performance (Element Loading) Scenario 1: 2022 SP Pre-Project

Contingency	Thermal Overloads	Overload %	Figure in Attachment A2
N-0: Normal Operation	*None*	--	*A2-1*
708L (Beamer 233S - Lamoureux 71S)	*None*	--	*A2-2*
997L (Josephburg 410S - Lamoureux 71S)	*None*	--	*A2-3*
921L (Lamoureux 71S - Clover Bar 987S)	*None*	--	*A2-4*
13ST2 (Deerland 13S 240/138 kV transformer T2)	*None*	--	*A2-5*
410ST1 (Josephburg 410S 240/138 kV transformer T1)	*None*	--	*A2-6*

Table 2: Summary of System Performance (Element Loading) Scenario 2: 2021 WP Pre-Project

Contingency	Thermal Overloads	Overload %	Figure in Attachment A2
N-0: Normal Operation	*None*	--	*A2-7*
708L (Beamer 233S - Lamoureux 71S)	*None*	--	*A2-8*
997L (Josephburg 410S - Lamoureux 71S)	*None*	--	*A2-9*
921L (Lamoureux 71S - Clover Bar 987S)	*None*	--	*A2-10*
13ST2 (Deerland 13S 240/138 kV transformer T2)	*None*	--	*A2-11*
410ST1 (Josephburg 410S 240/138 kV transformer T1)	*None*	--	*A2-12*

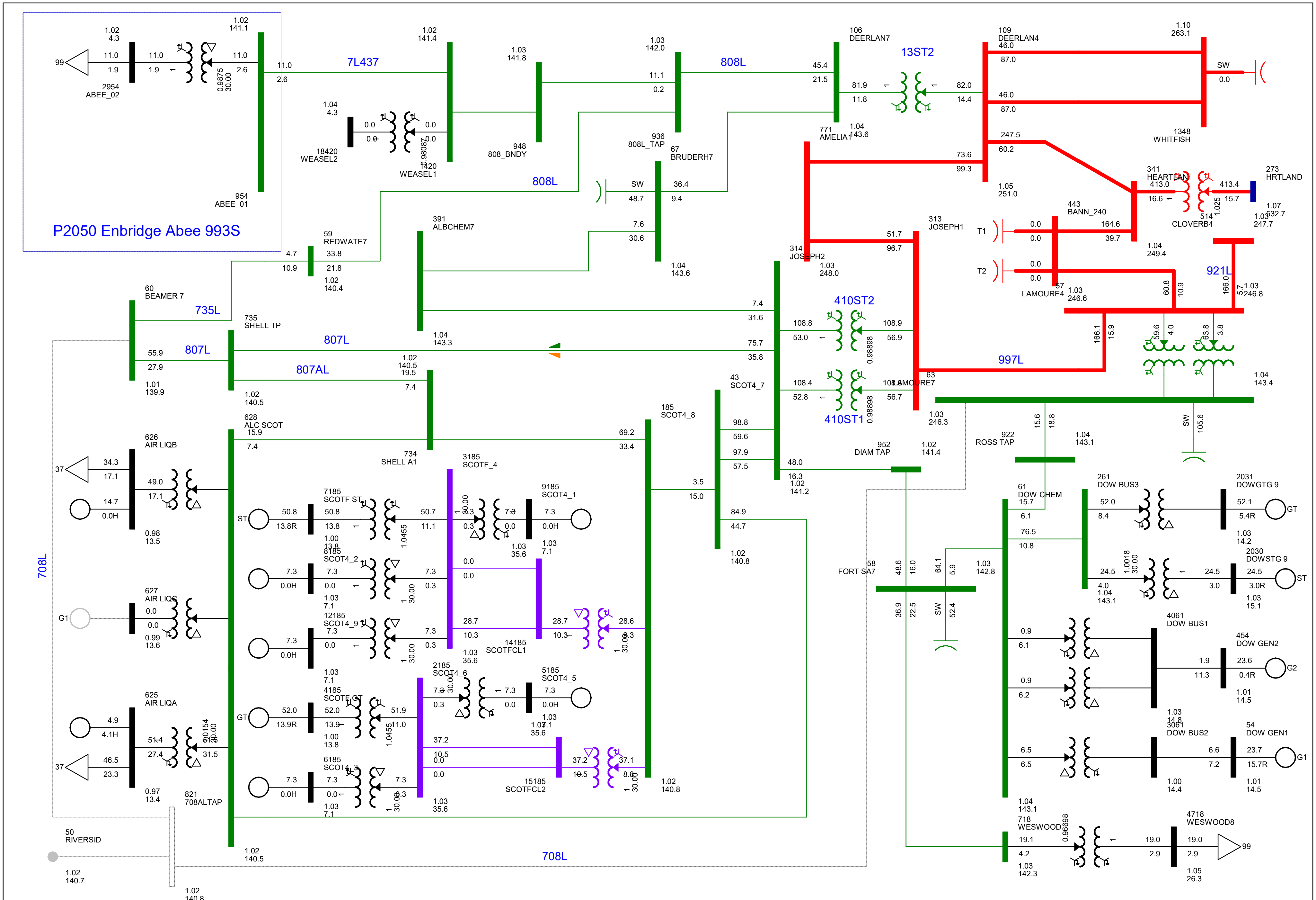


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-1
N-0: NORMAL OPERATION
WED, AUG 07 2019 10:49
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

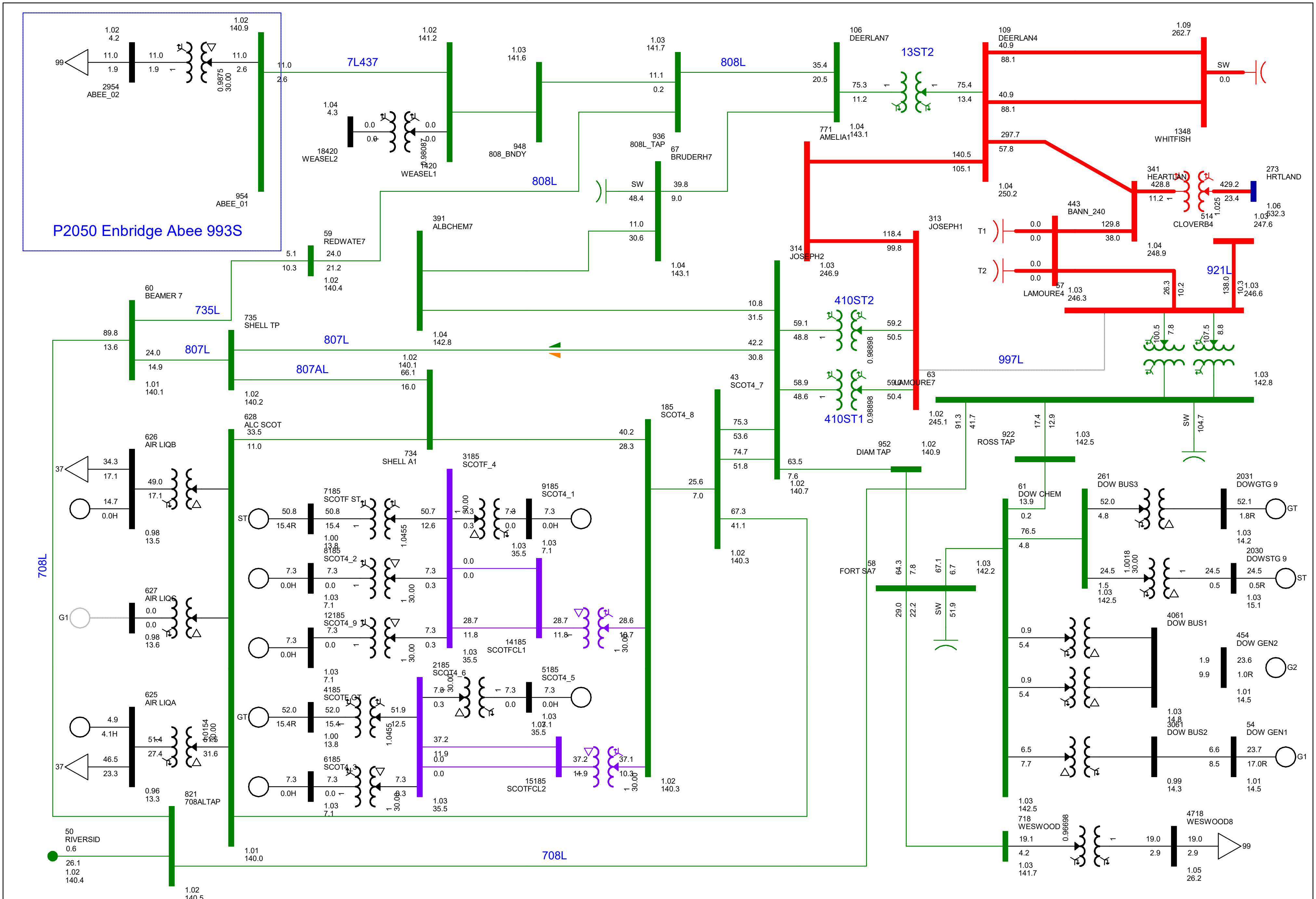


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-2
N-1: 708L LAMOUREUX 71S TO BEAMER 233S
WED, AUG 07 2019 10:50
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

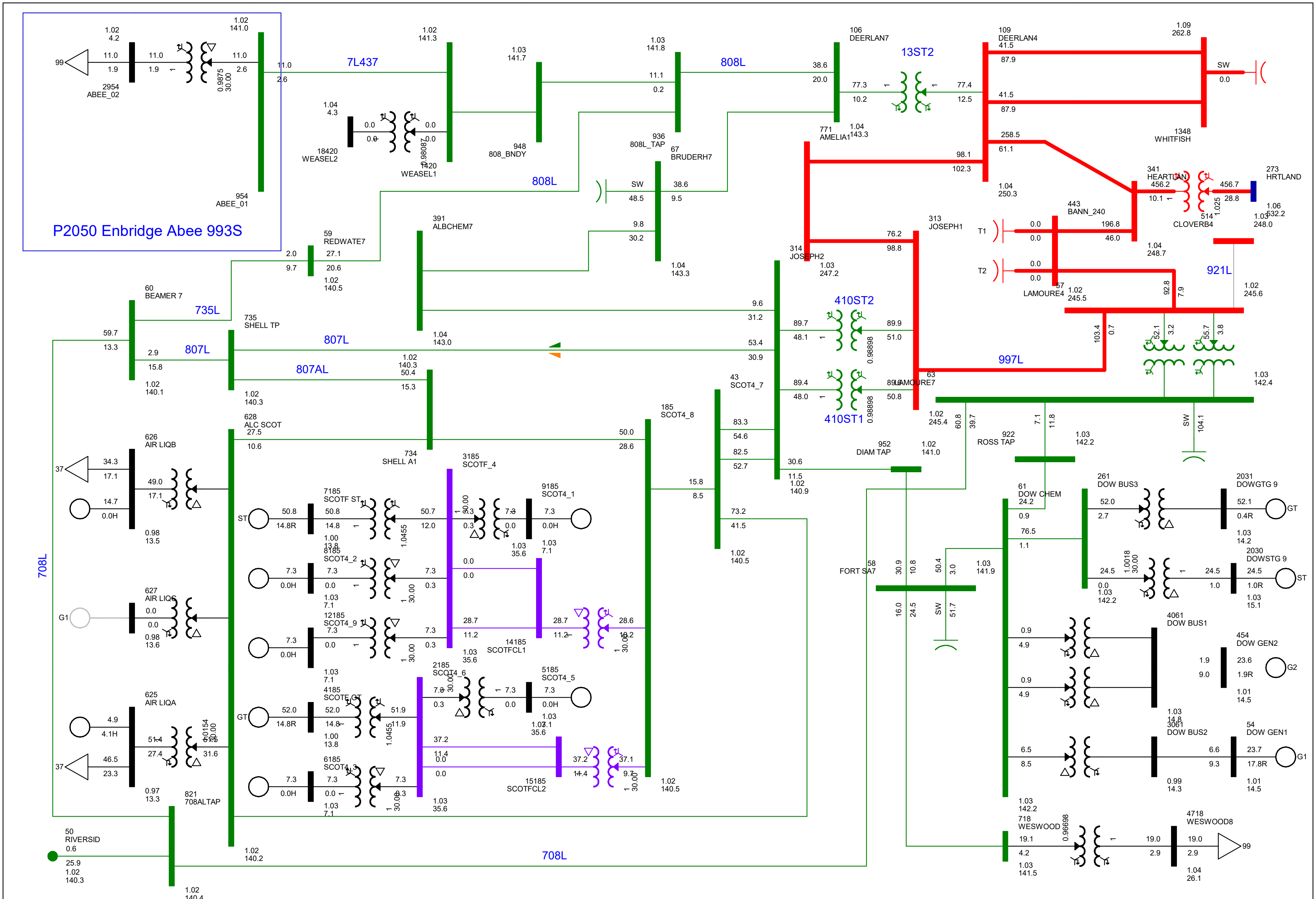


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-3
N-1: 997L JOSEPHBURG 410S TO LAMOUREUX 71S
WED, AUG 07 2019 10:50
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

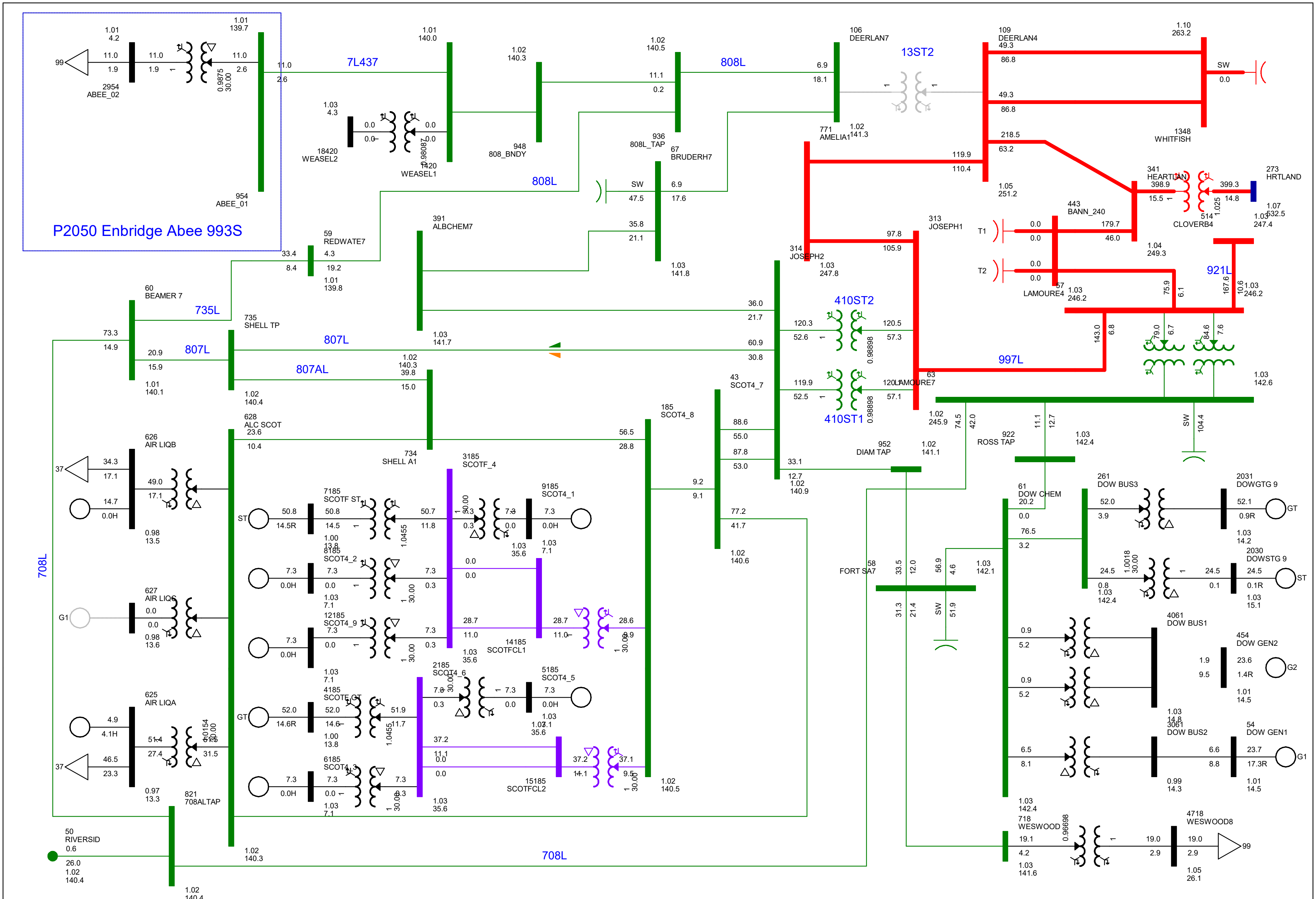


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-4
N-1: 921L LAMOUREUX 71S TO CLOVER BAR 987S
WED, AUG 07 2019 10:50
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

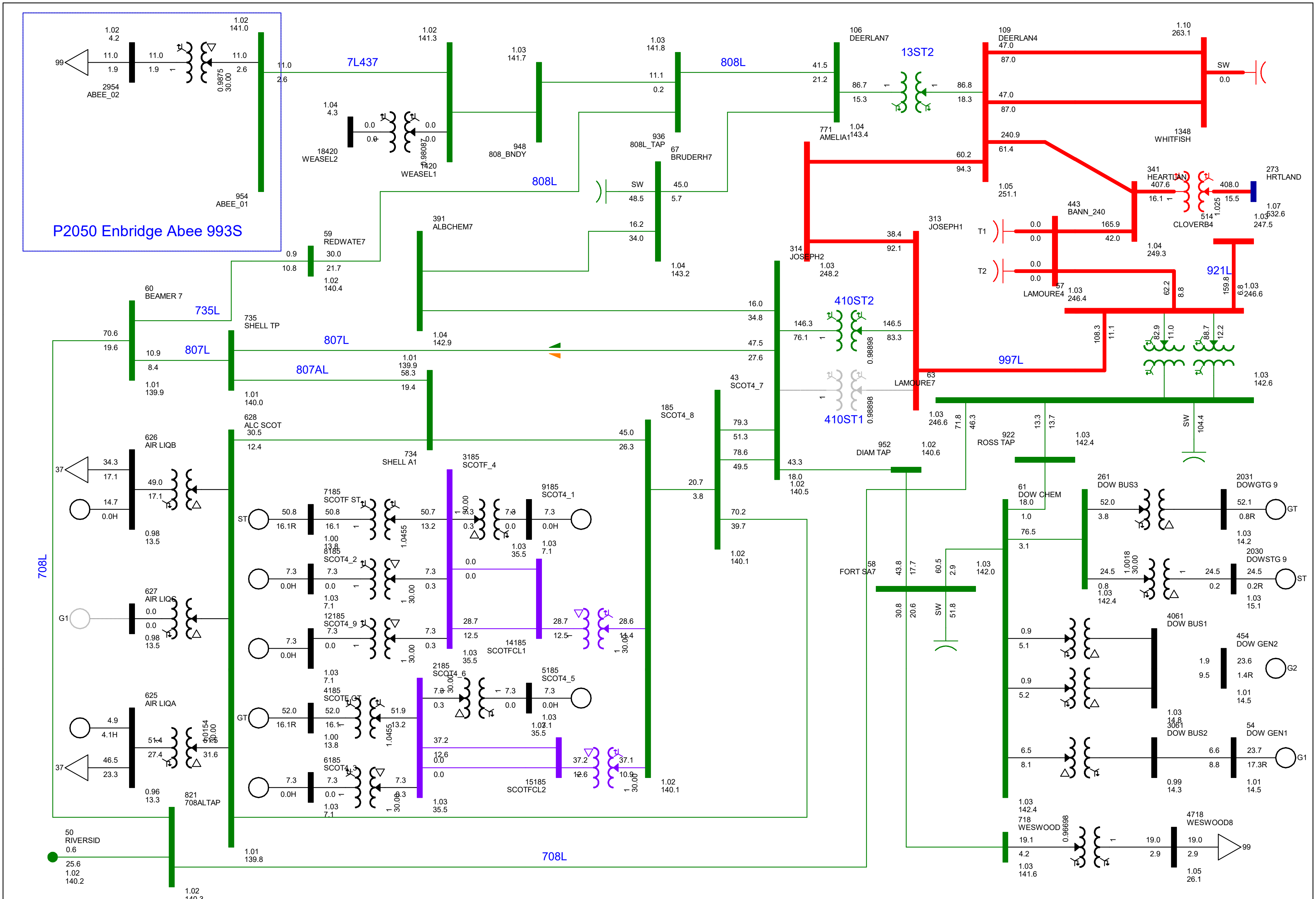


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-5
N-1: 13ST2 DEERLAND 13S TRANSFORMER
WED, AUG 07 2019 10:51
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

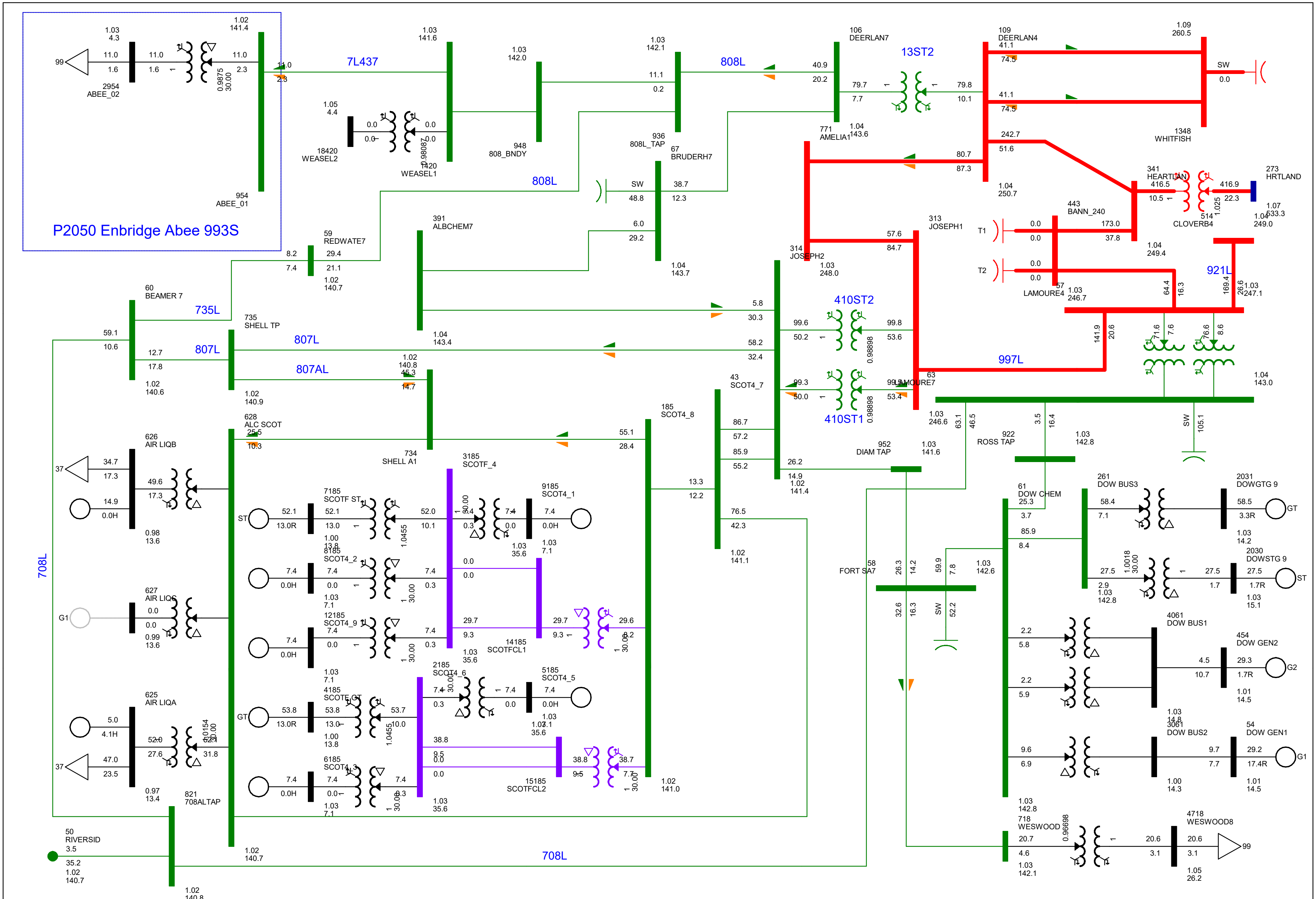


Enbridge Abee 993S Upgrade (P2050)

2022 SP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-6
N-1: 410ST1 JOSEPHBURG 410S TRANSFORMER
WED, AUG 07 2019 10:51
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

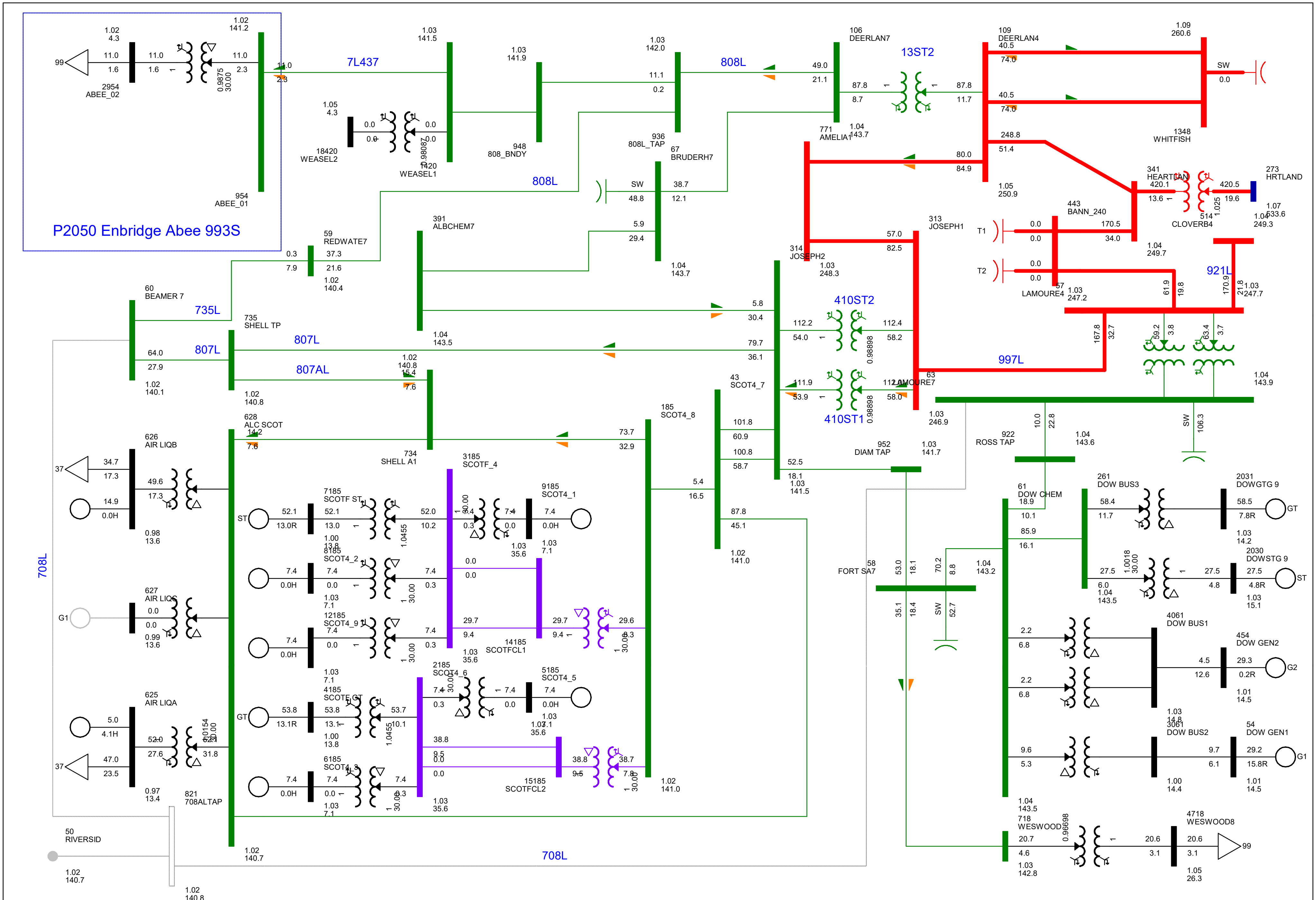


Enbridge Abee 993S Upgrade (P2050)

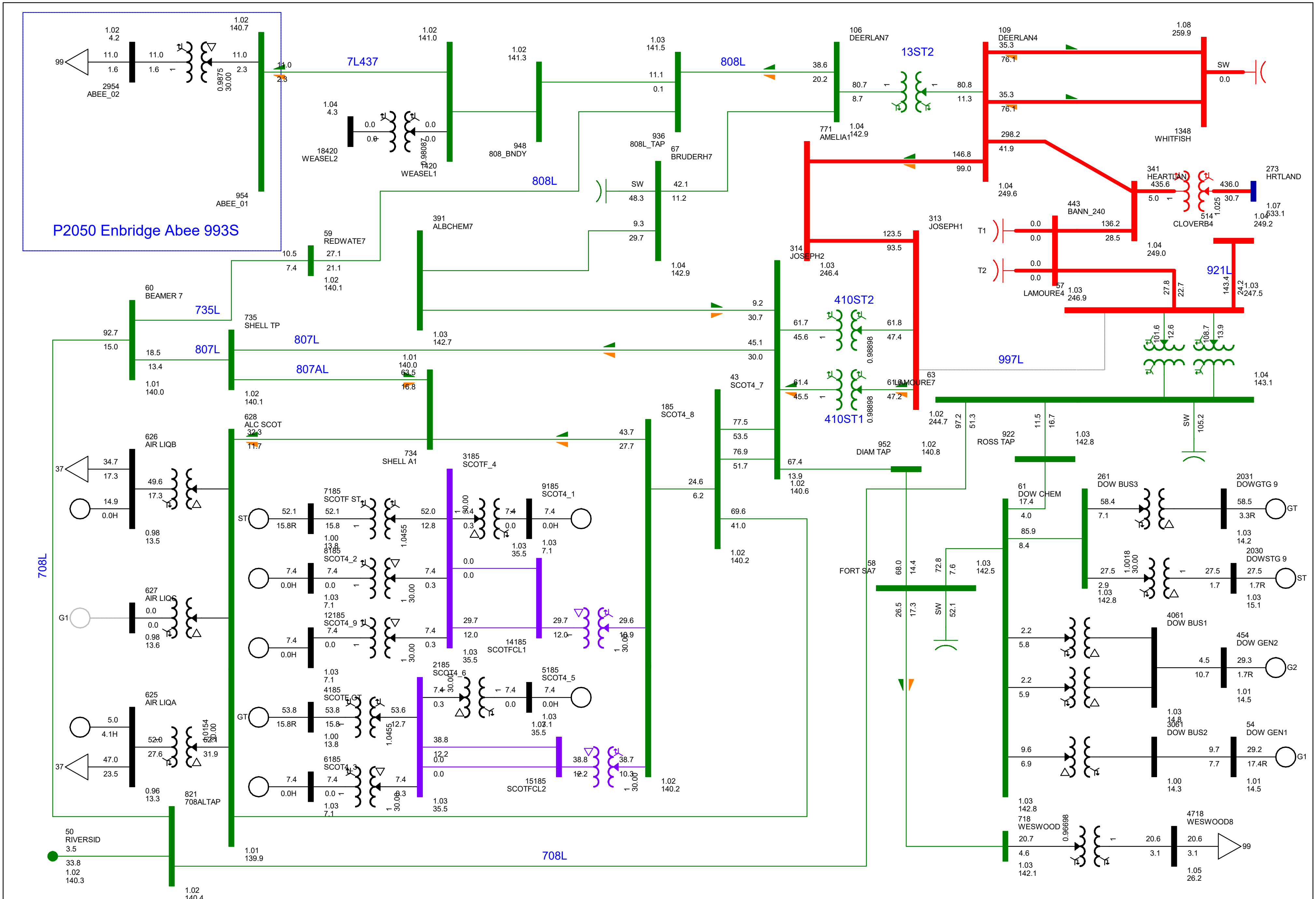
2021 WP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-7
N-0: NORMAL OPERATION
WED, AUG 07 2019 10:53
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Enbridge Abee 993S Upgrade (P2050) **2021 WP Pre-Project**	P2050 PRE-CONNECTION - DIAGRAM A2-8 N-1: 708L LAMOUREUX 71S TO BEAMER 233S WED, AUG 07 2019 10:53 Fort Saskatchewan Study Area	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.100OV 0.890UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

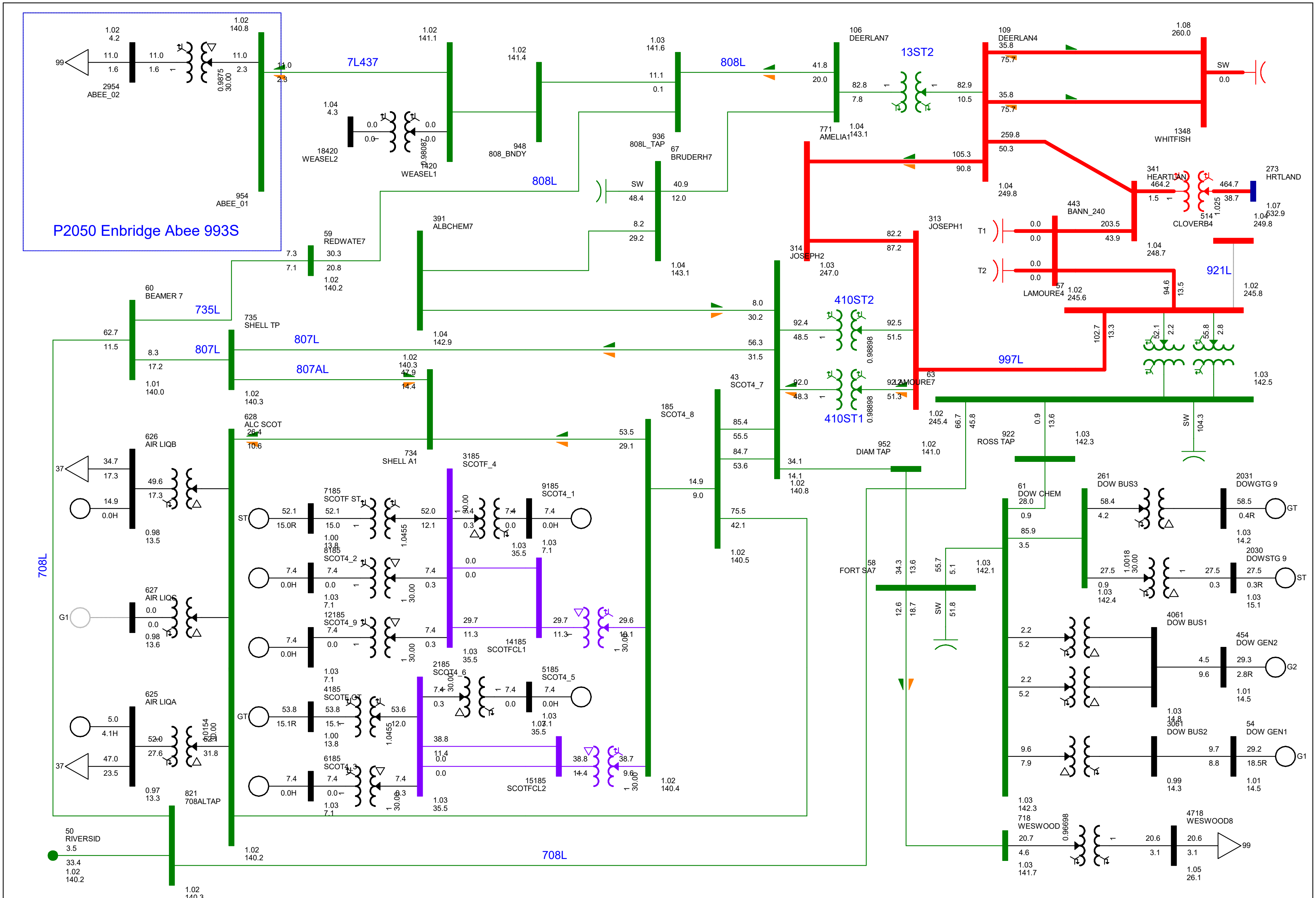


Enbridge Abee 993S Upgrade (P2050)

2021 WP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-9
N-1: 997L JOSEPHBURG 410S TO LAMOUREUX 71S
WED, AUG 07 2019 10:53
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

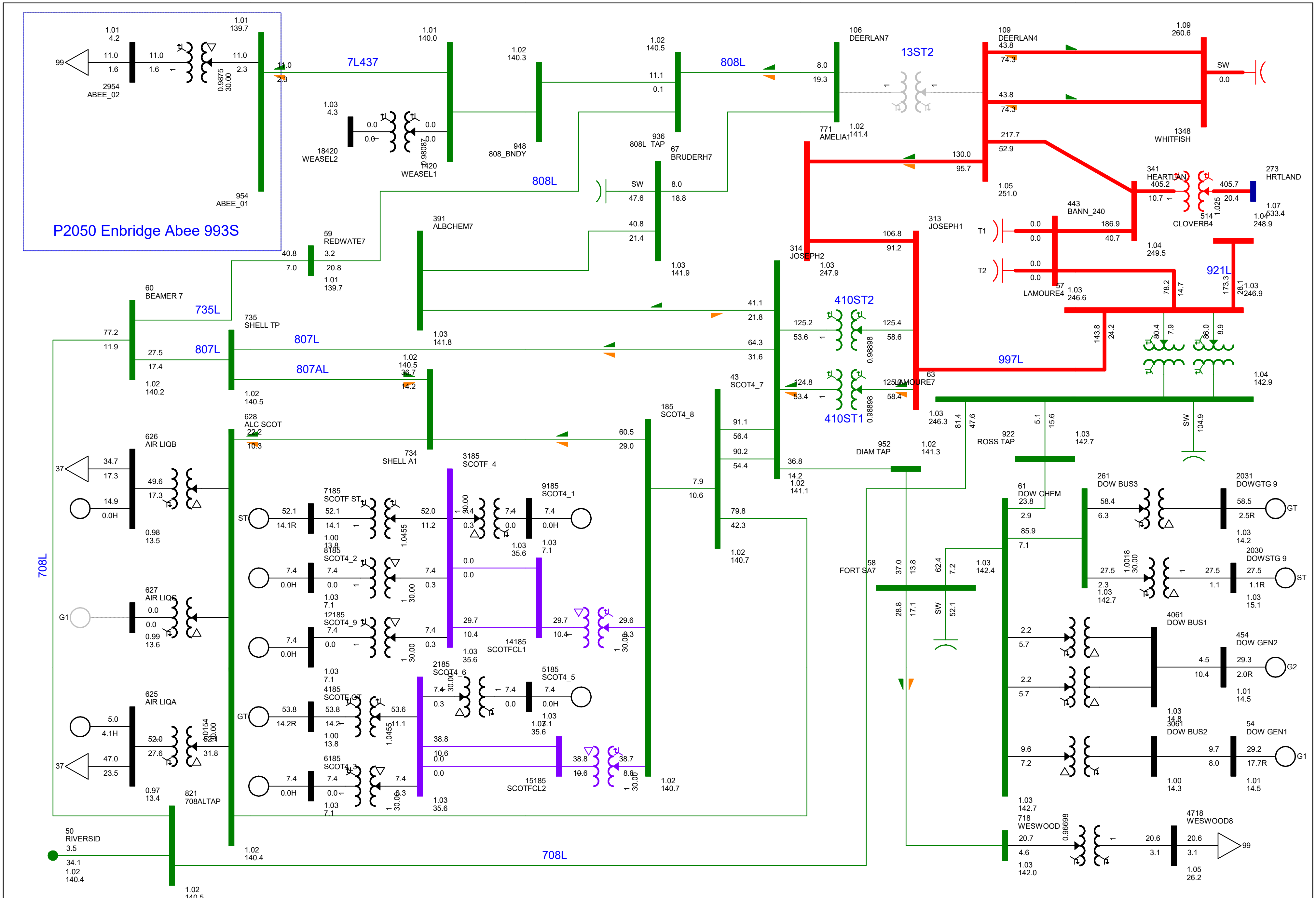


Enbridge Abee 993S Upgrade (P2050)

2021 WP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-10
N-1: 921L LAMOUREUX 71S TO CLOVER BAR 987S
WED, AUG 07 2019 10:54
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

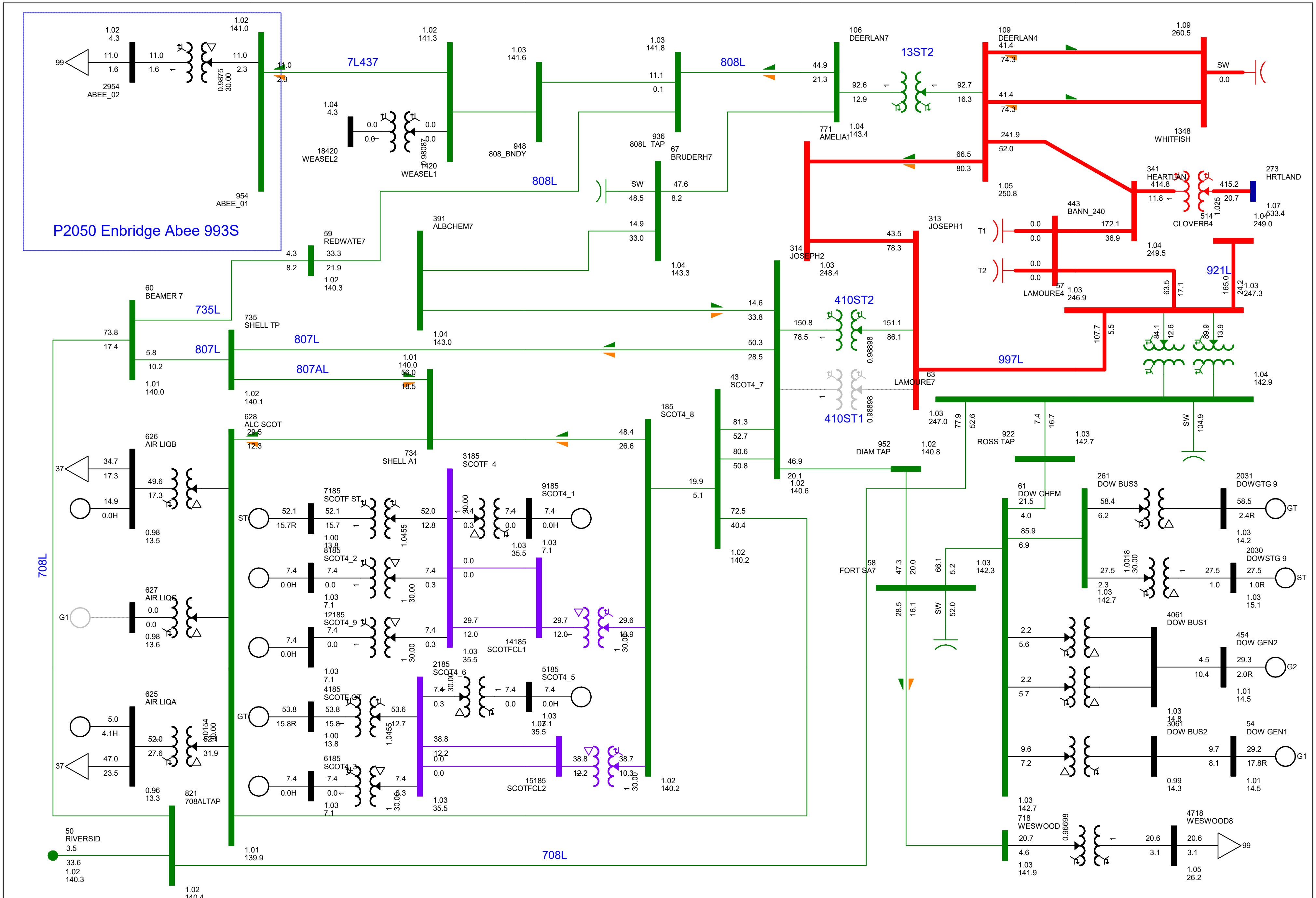


Enbridge Abee 993S Upgrade (P2050)

2021 WP Pre-Project

P2050 PRE-CONNECTION - DIAGRAM A2-11
N-1: 13ST2 DEERLAND 13S TRANSFORMER
WED, AUG 07 2019 10:54
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Enbridge Abee 993S Upgrade (P2050) 2021 WP Pre-Project	P2050 PRE-CONNECTION - DIAGRAM A2-12 N-1: 410ST1 JOSEPHBURG 410S TRANSFORMER WED, AUG 07 2019 10:54 Fort Saskatchewan Study Area	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.100OV 0.890UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

ATTACHMENT: A3

Post - Connection: Power Flow Analysis

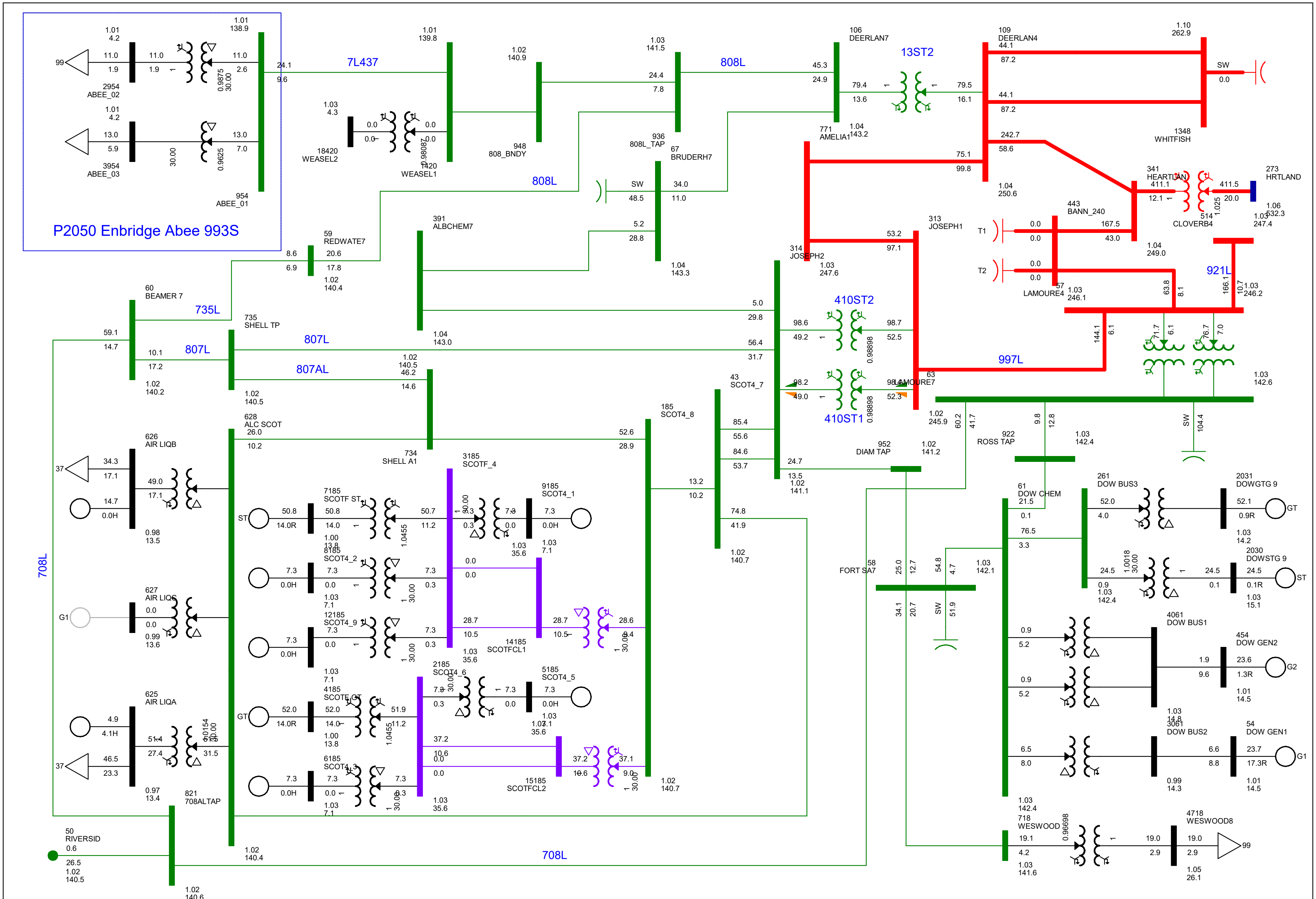
After P2050

Table 1: Summary of System Performance (Element Loading) Scenario 3: 2022 SP Post-Project

Contingency	Thermal Overloads	Overload %	Figure in Attachment A3
N-0: Normal Operation	*None*	--	*A3-1*
708L (Beamer 233S - Lamoureux 71S)	*None*	--	*A3-2*
997L (Josephburg 410S - Lamoureux 71S)	*None*	--	*A3-3*
921L (Lamoureux 71S - Clover Bar 987S)	*None*	--	*A3-4*
13ST2 (Deerland 13S 240/138 kV transformer T2)	*None*	--	*A3-5*
410ST1 (Josephburg 410S 240/138 kV transformer T1)	*None*	--	*A3-6*

Table 2: Summary of System Performance (Element Loading) Scenario 4: 2021 WP Post-Project

Contingency	Thermal Overloads	Overload %	Figure in Attachment A3
N-0: Normal Operation	*None*	--	*A3-7*
708L (Beamer 233S - Lamoureux 71S)	*None*	--	*A3-8*
997L (Josephburg 410S - Lamoureux 71S)	*None*	--	*A3-9*
921L (Lamoureux 71S - Clover Bar 987S)	*None*	--	*A3-10*
13ST2 (Deerland 13S 240/138 kV transformer T2)	*None*	--	*A3-11*
410ST1 (Josephburg 410S 240/138 kV transformer T1)	*None*	--	*A3-12*

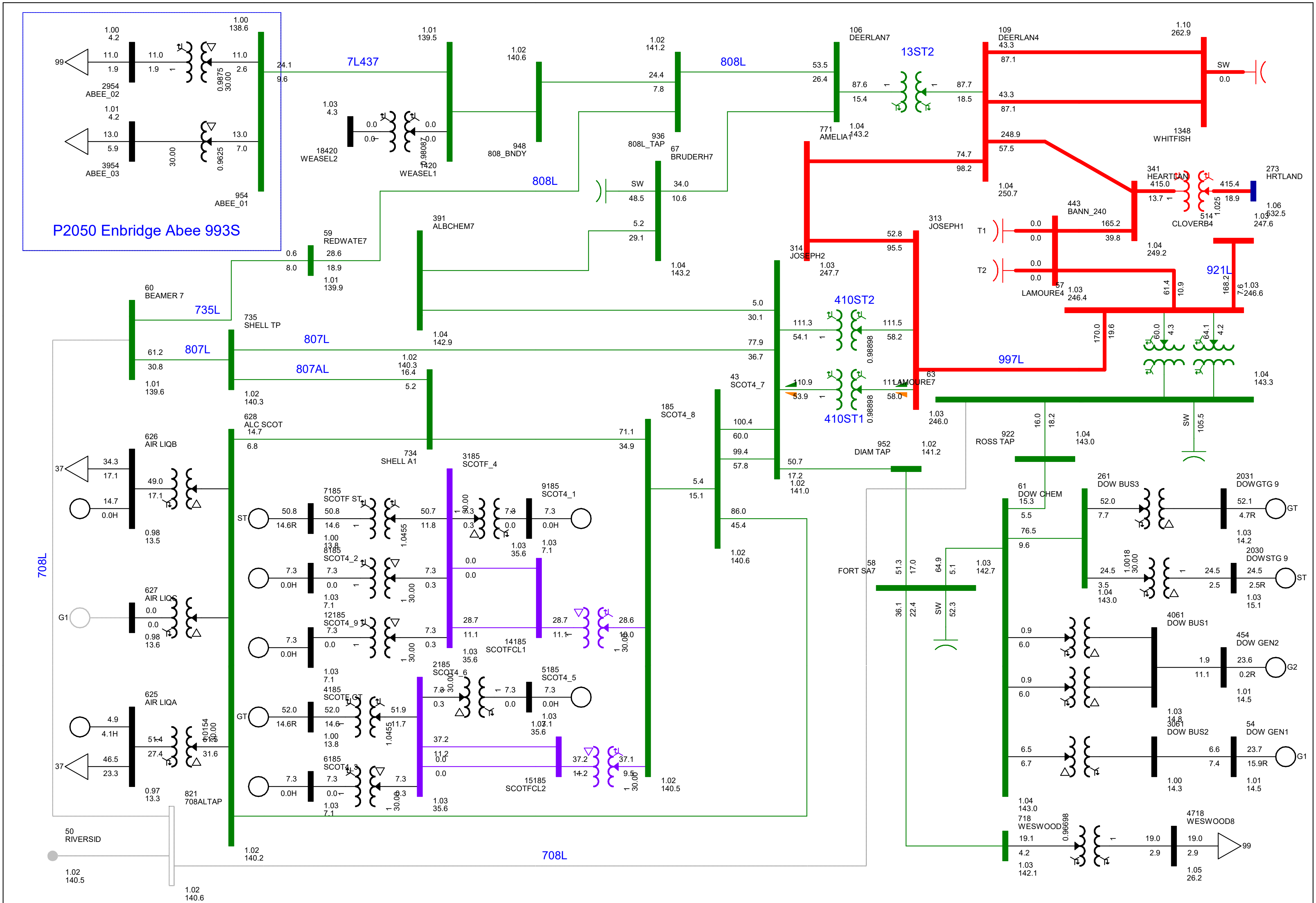


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-1
N-0: NORMAL OPERATION
WED, AUG 07 2019 10:55
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

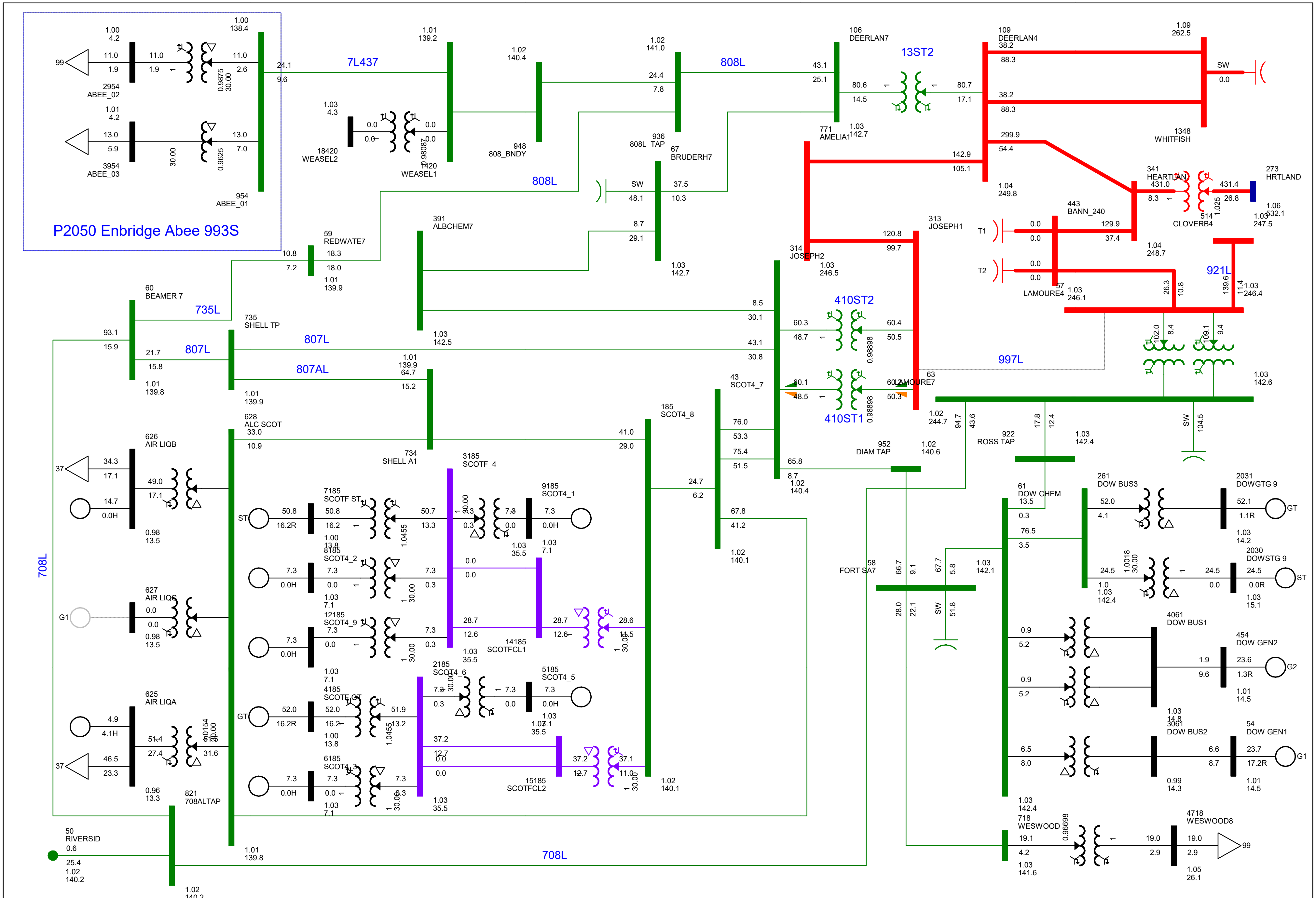


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-2
N-1: 708L LAMOUREUX 71S TO BEAMER 233S
WED, AUG 07 2019 10:56
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

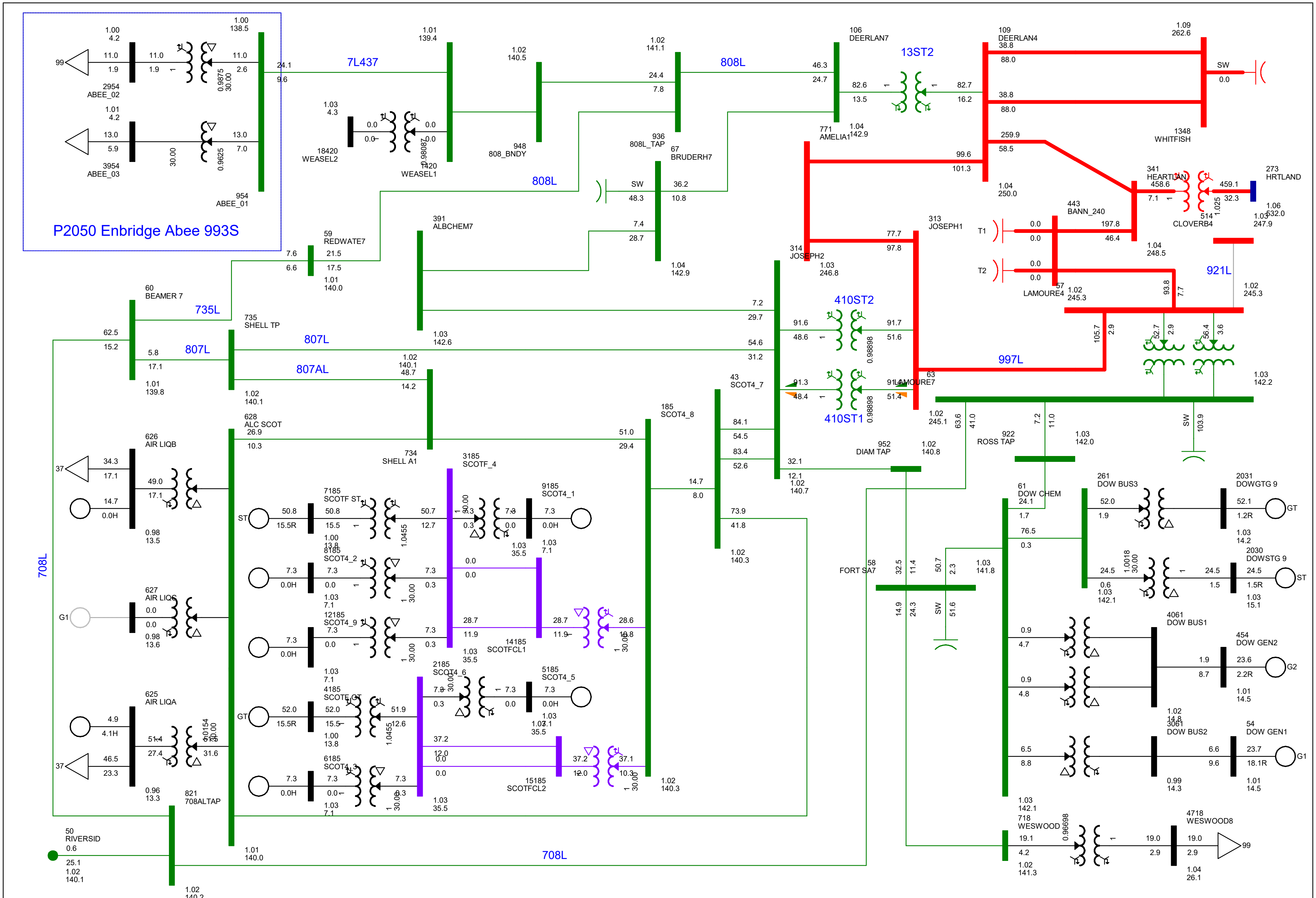


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-3
N-1: 997L JOSEPHBURG 410S TO LAMOUREUX 71S
WED, AUG 07 2019 10:56
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

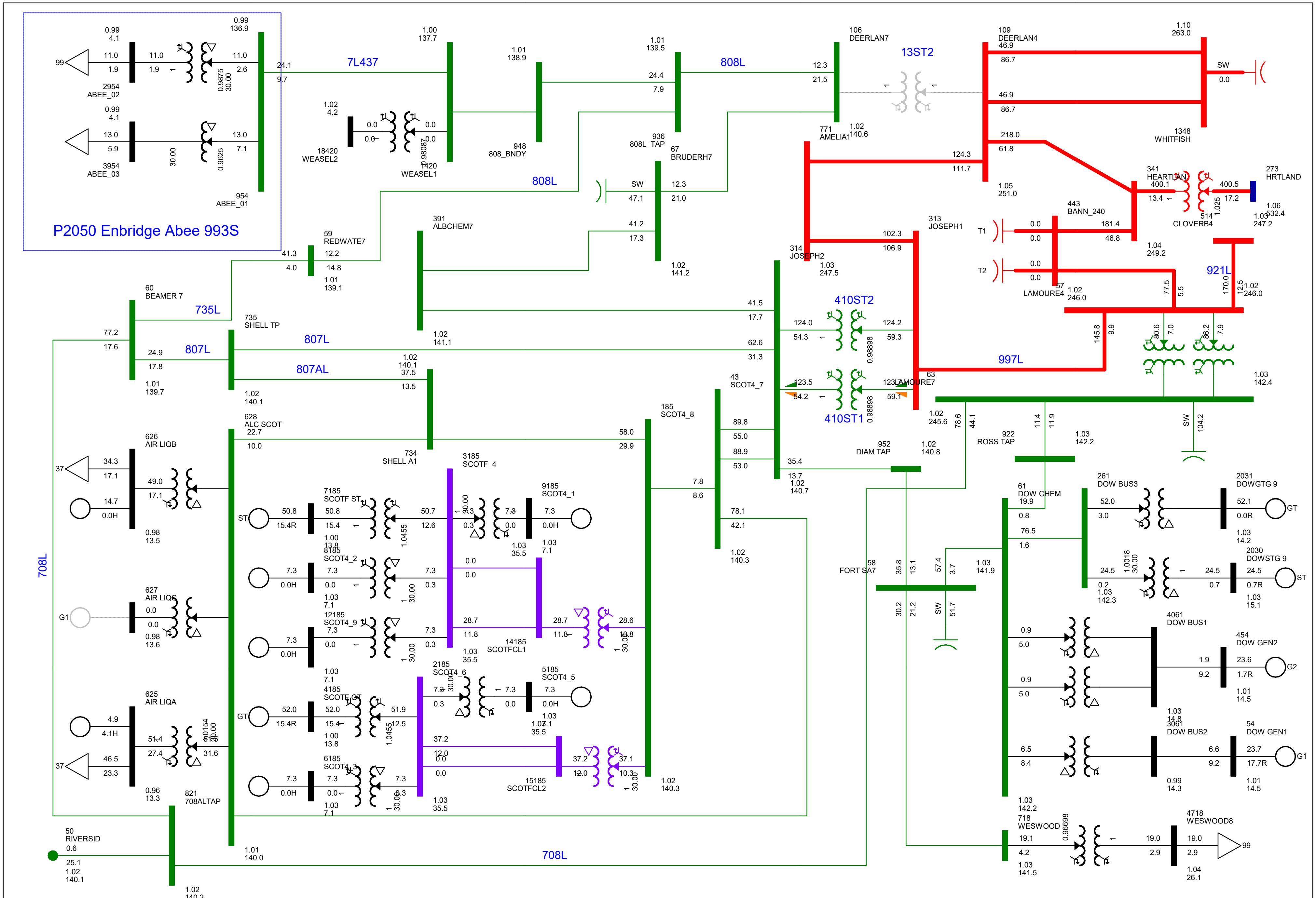


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-4
N-1: 921L LAMOUREUX 71S TO CLOVER BAR 987S
WED, AUG 07 2019 10:56
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

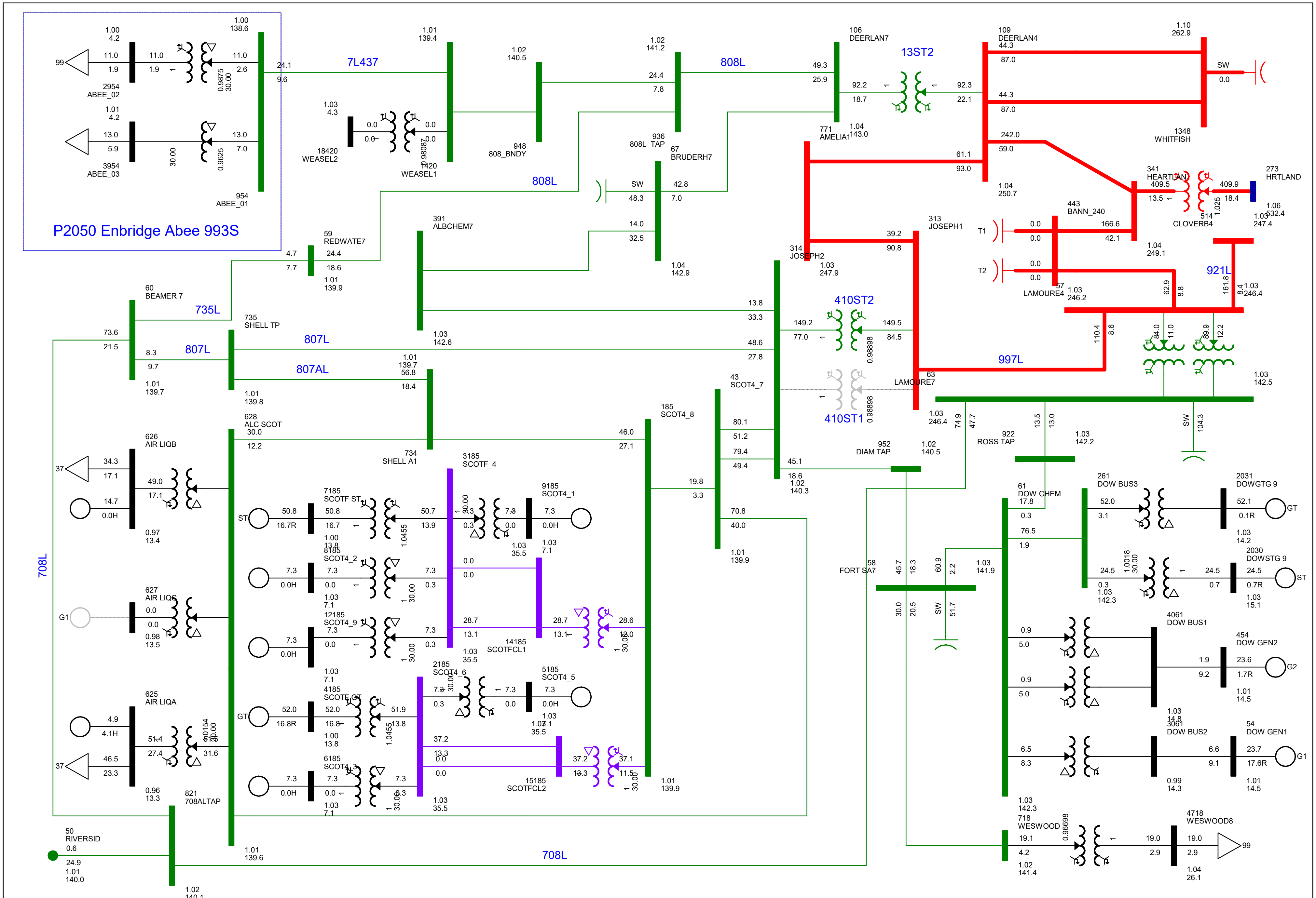


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-5
N-1: 13ST2 DEERLAND 13S TRANSFORMER
WED, AUG 07 2019 10:57
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

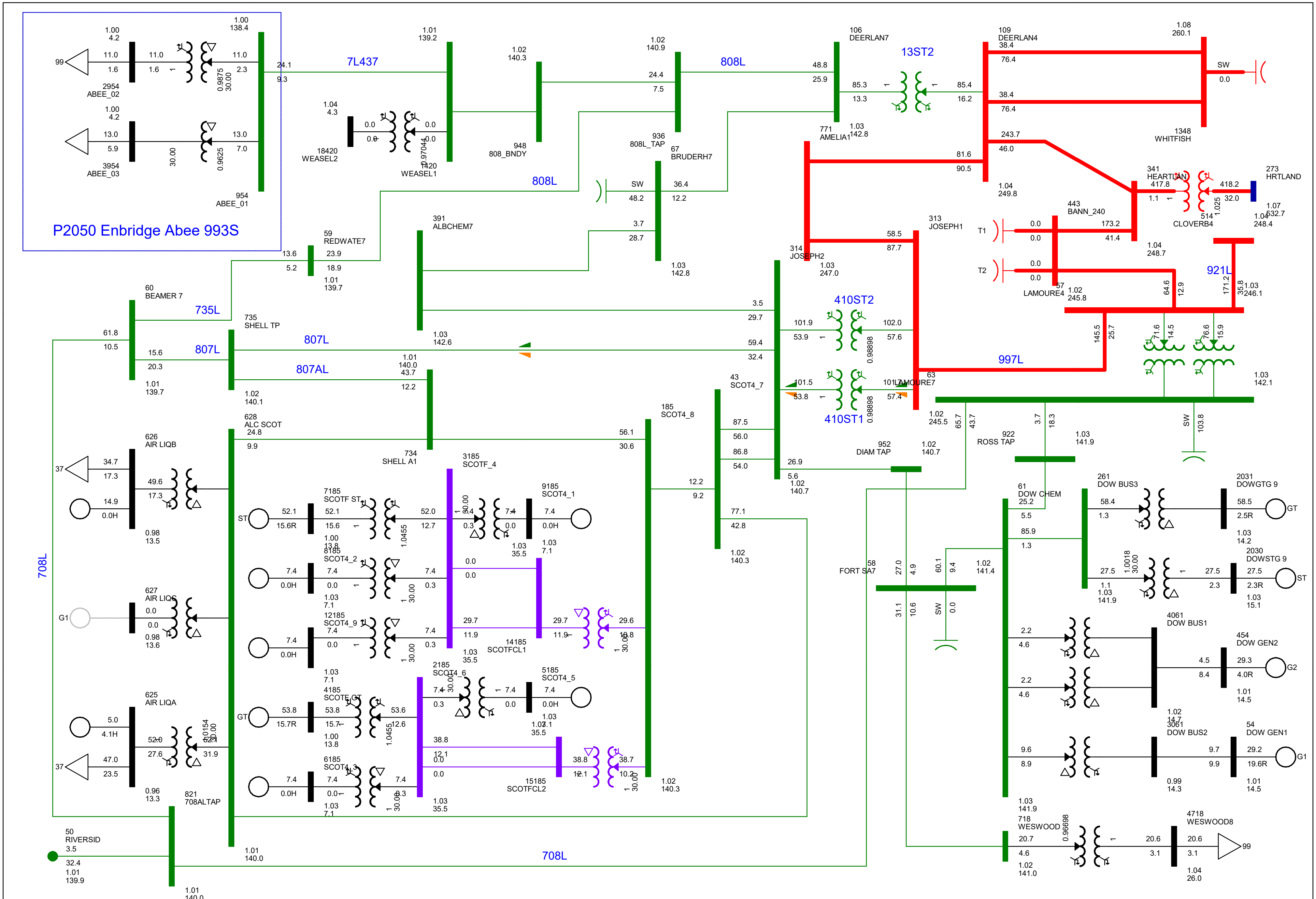


Enbridge Abee 993S Upgrade (P2050)

2022 SP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-6
N-1: 410ST1 JOSEPHBURG 410S TRANSFORMER
WED, AUG 07 2019 10:57
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

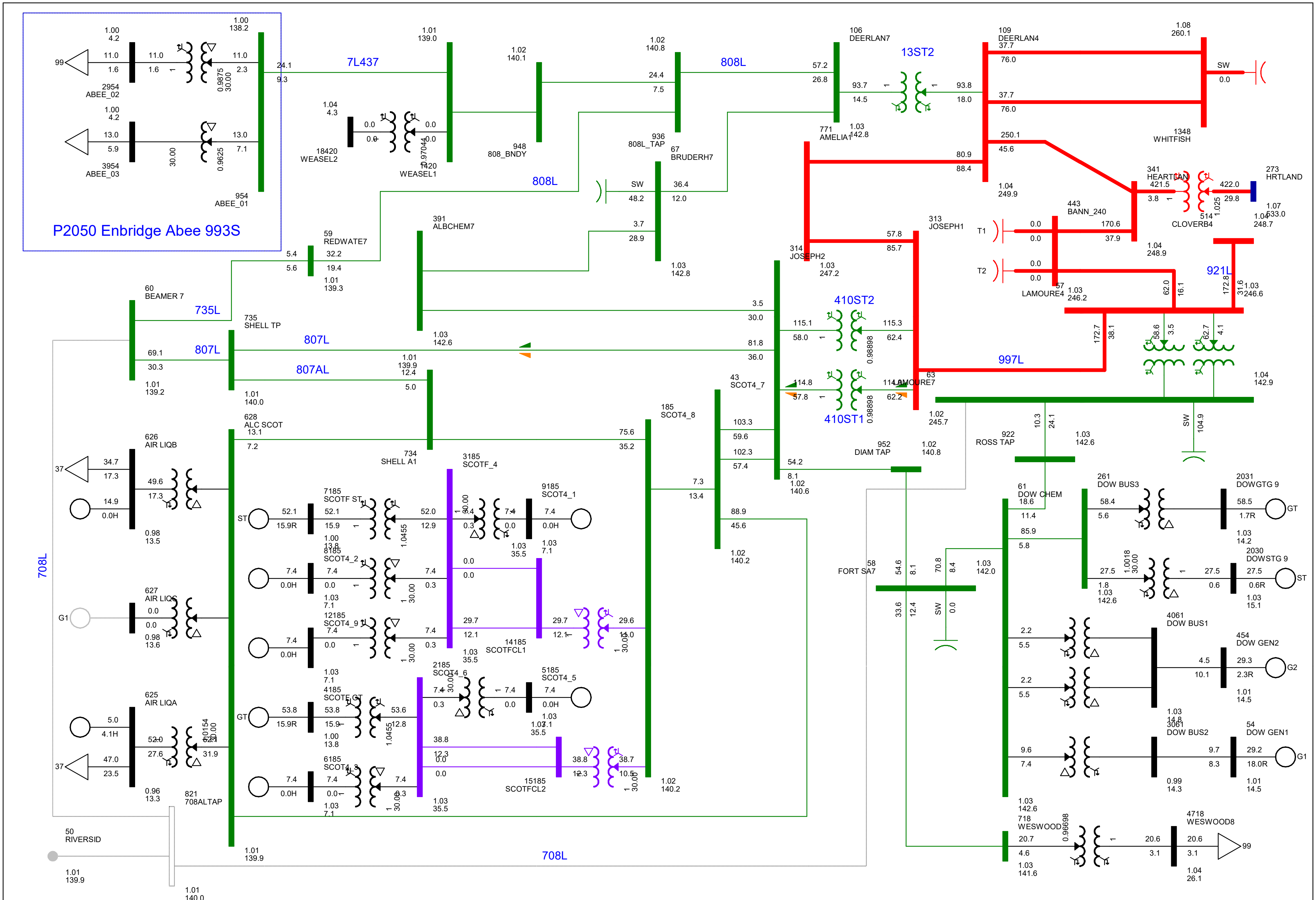


Enbridge Abee 993S Upgrade (P2050)

2021 WP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-7
N-0: NORMAL OPERATION
WED, AUG 07 2019 10:58
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

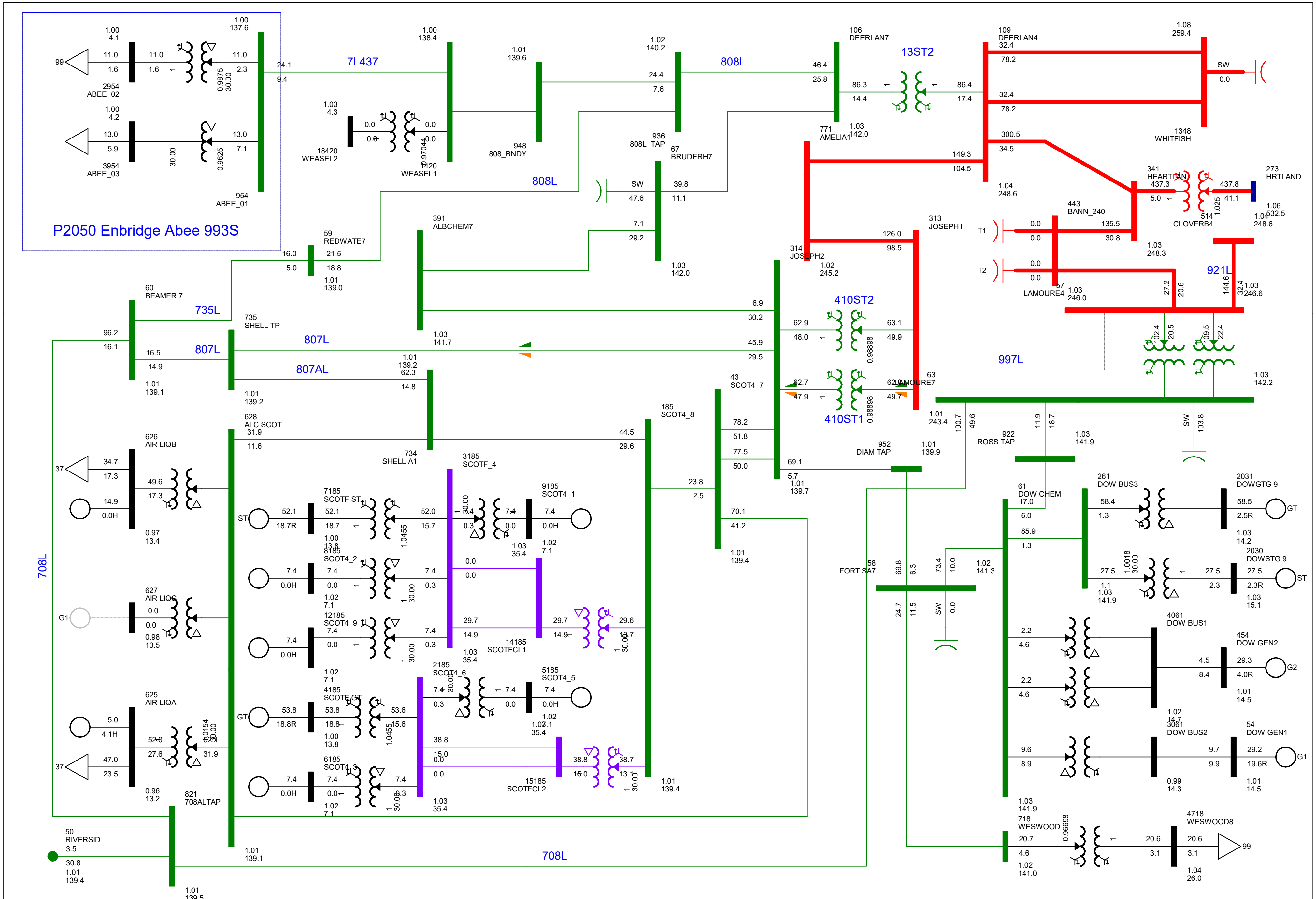


Enbridge Abee 993S Upgrade (P2050)

2021 WP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-8
N-1: 708L LAMOUREUX 71S TO BEAMER 233S
WED, AUG 07 2019 10:58
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

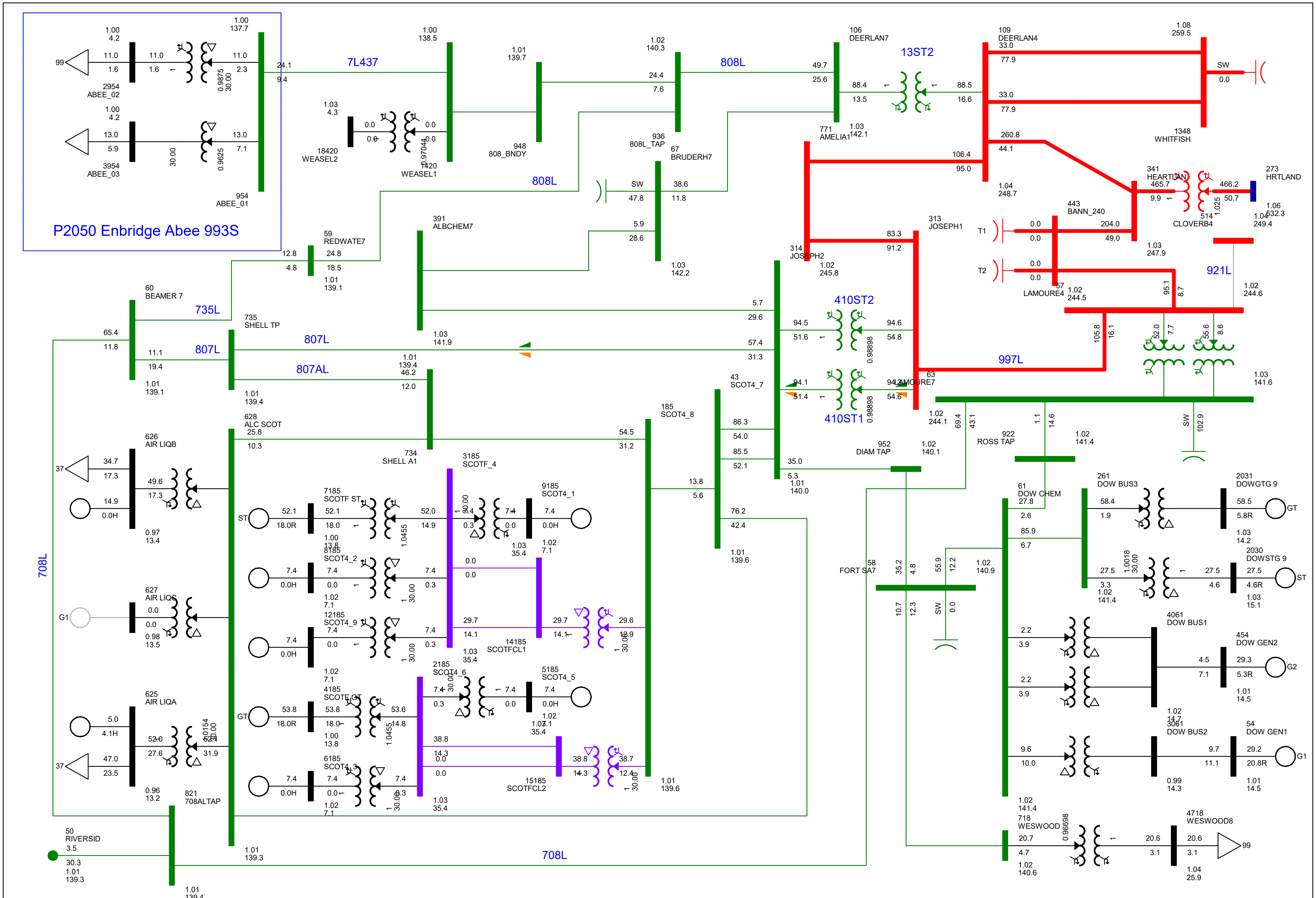


Enbridge Abee 993S Upgrade (P2050)

2021 WP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-9
N-1: 997L JOSEPHBURG 410S TO LAMOUREUX 71S
WED, AUG 07 2019 10:59
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

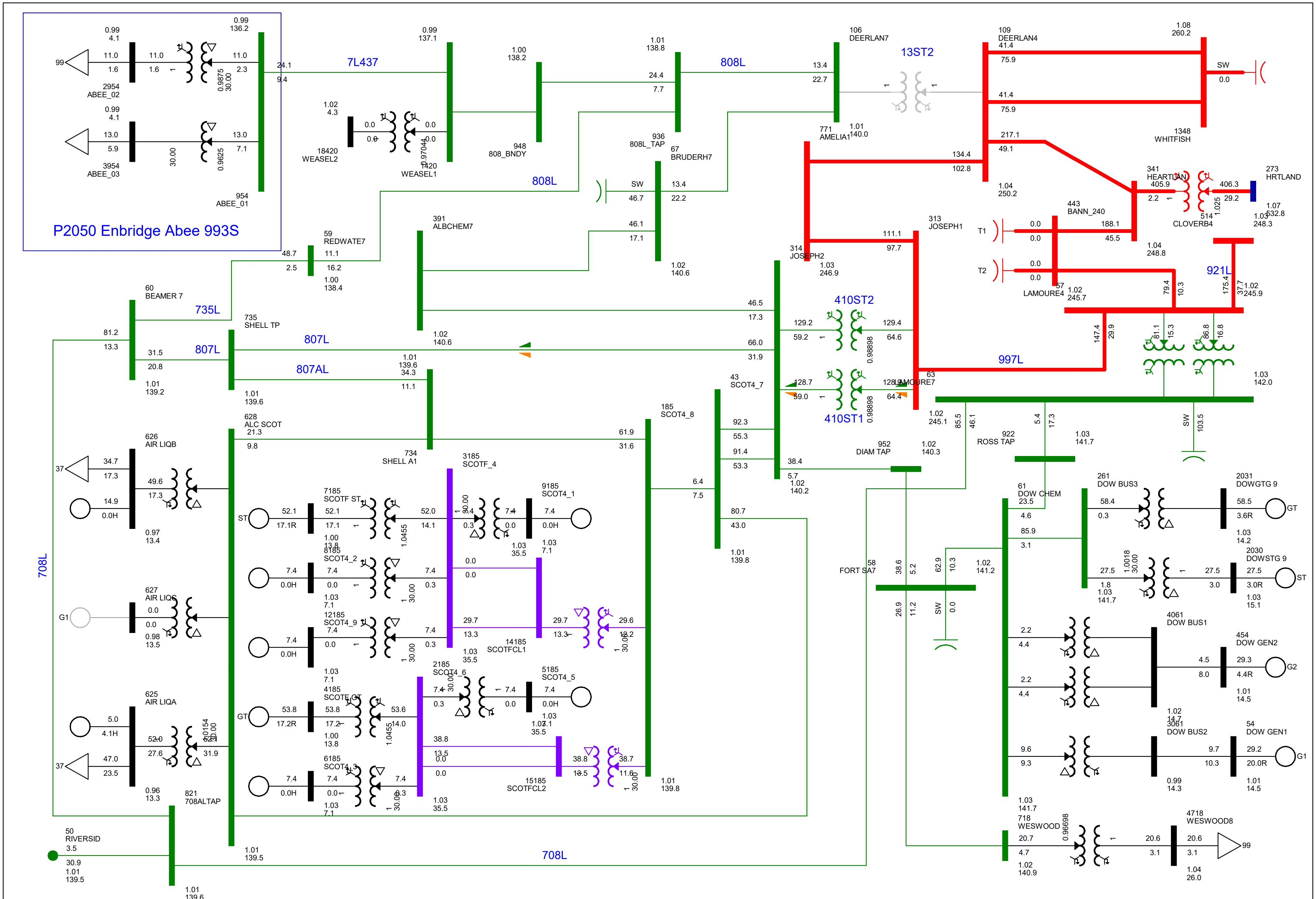


Enbridge Abee 993S Upgrade (P2050)

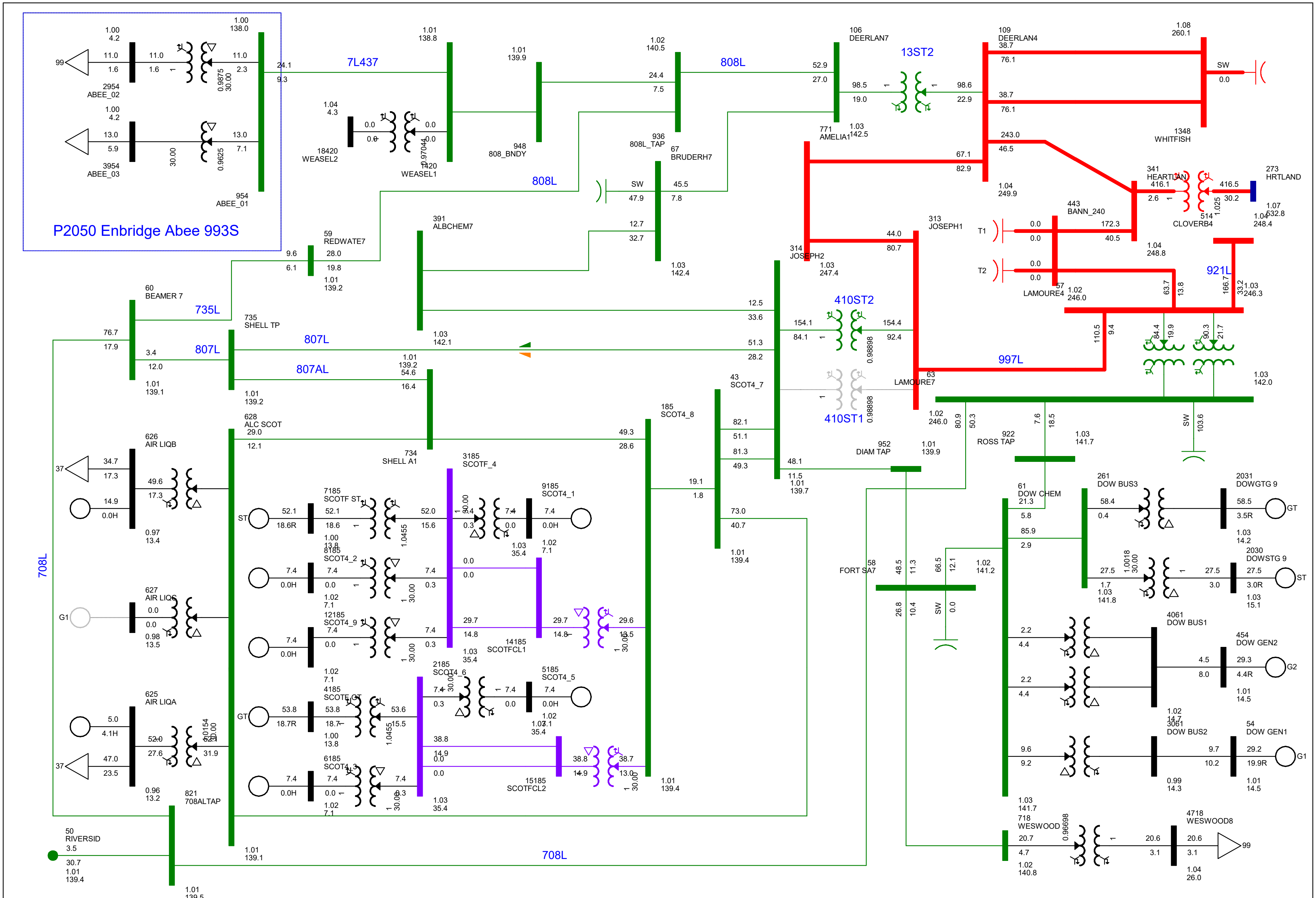
2021 WP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-10
N-1: 921L LAMOUREUX 71S TO CLOVER BAR 987S
WED, AUG 07 2019 10:59
Fort Saskatchewan Study Area

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Enbridge Abee 993S Upgrade (P2050) **2021 WP Post-Project**	P2050 PRE-CONNECTION - DIAGRAM A3-11 N-1: 13ST2 DEERLAND 13S TRANSFORMER WED, AUG 07 2019 10:59 Fort Saskatchewan Study Area	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%Rate B 1.100OV 0.890UV kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Enbridge Abee 993S Upgrade (P2050)

2021 WP Post-Project

P2050 PRE-CONNECTION - DIAGRAM A3-12
N-1: 410ST1 JOSEPHBURG 410S TRANSFORMER
WED, AUG 07 2019 10:59
Fort Saskatchewan Study Area

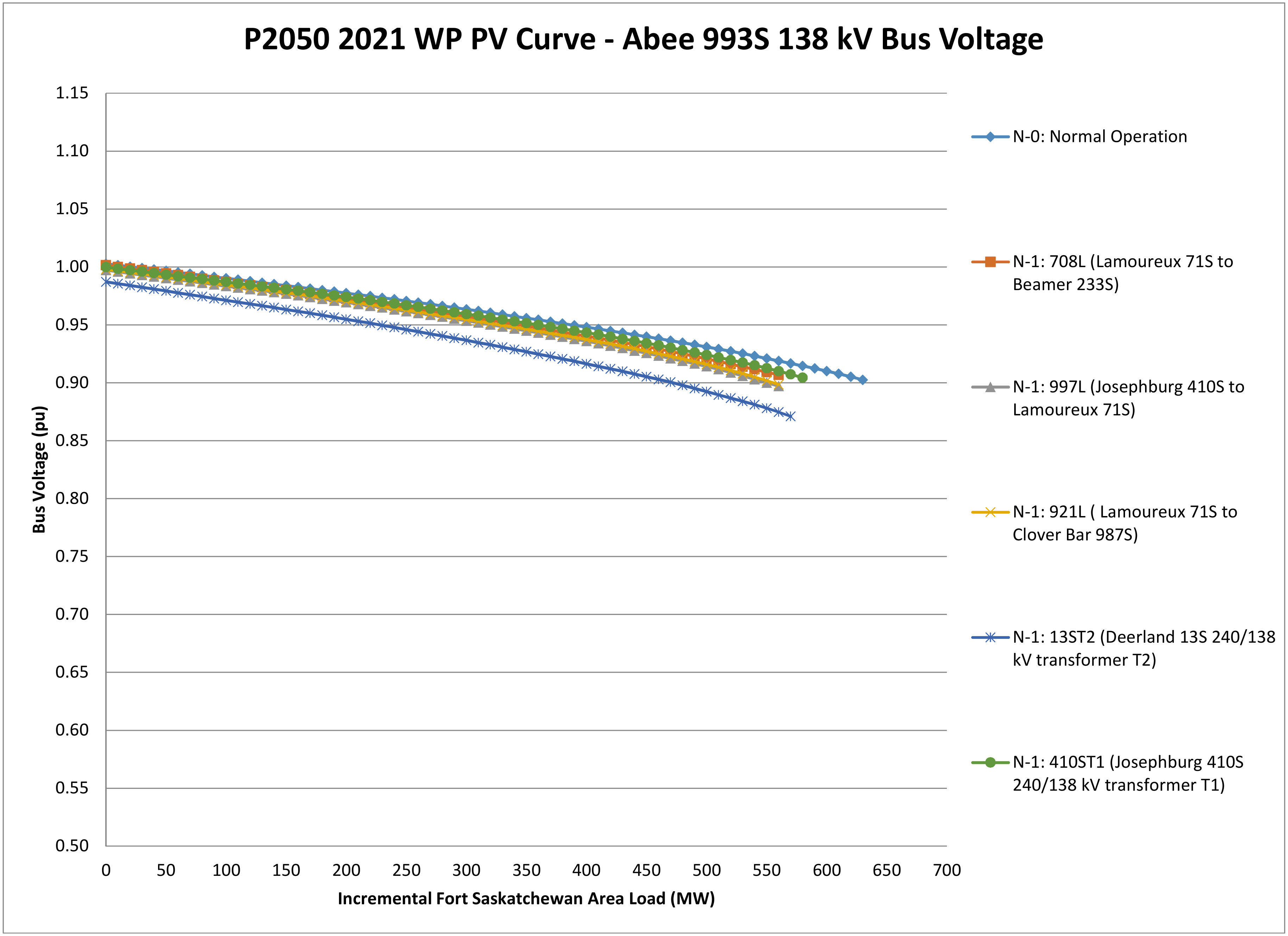
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.100OV 0.890UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

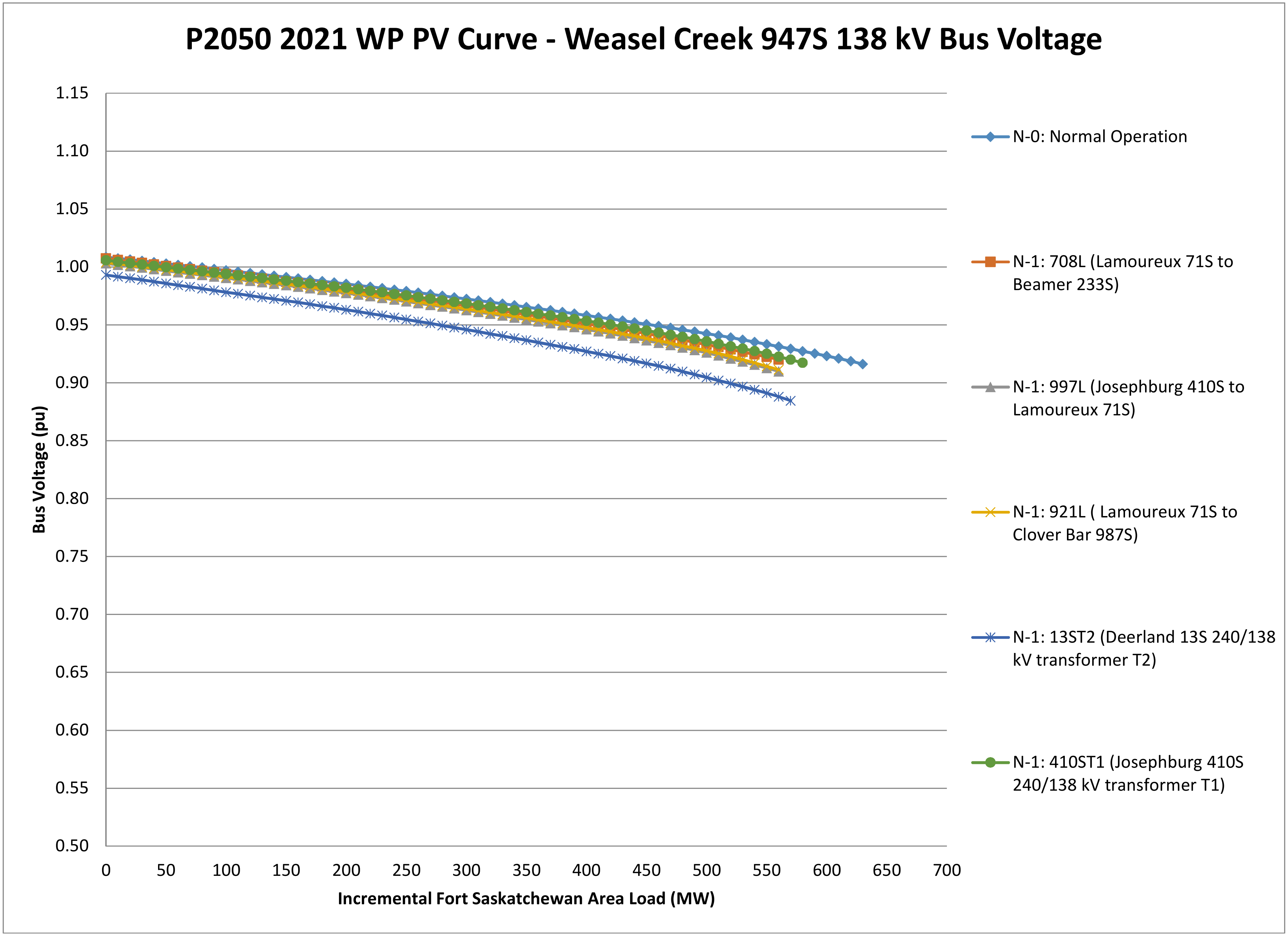
Attachment A4

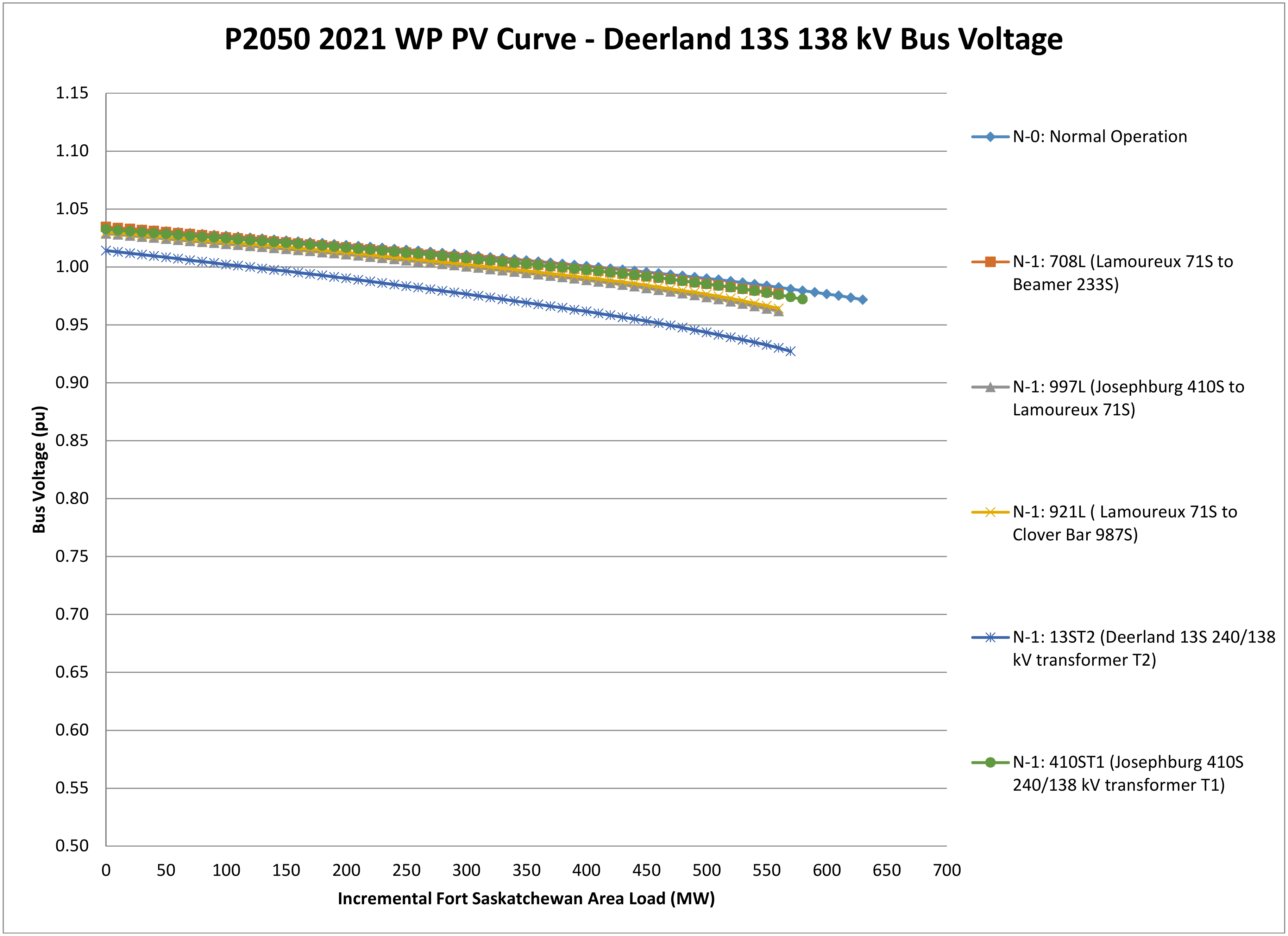
Voltage Stability

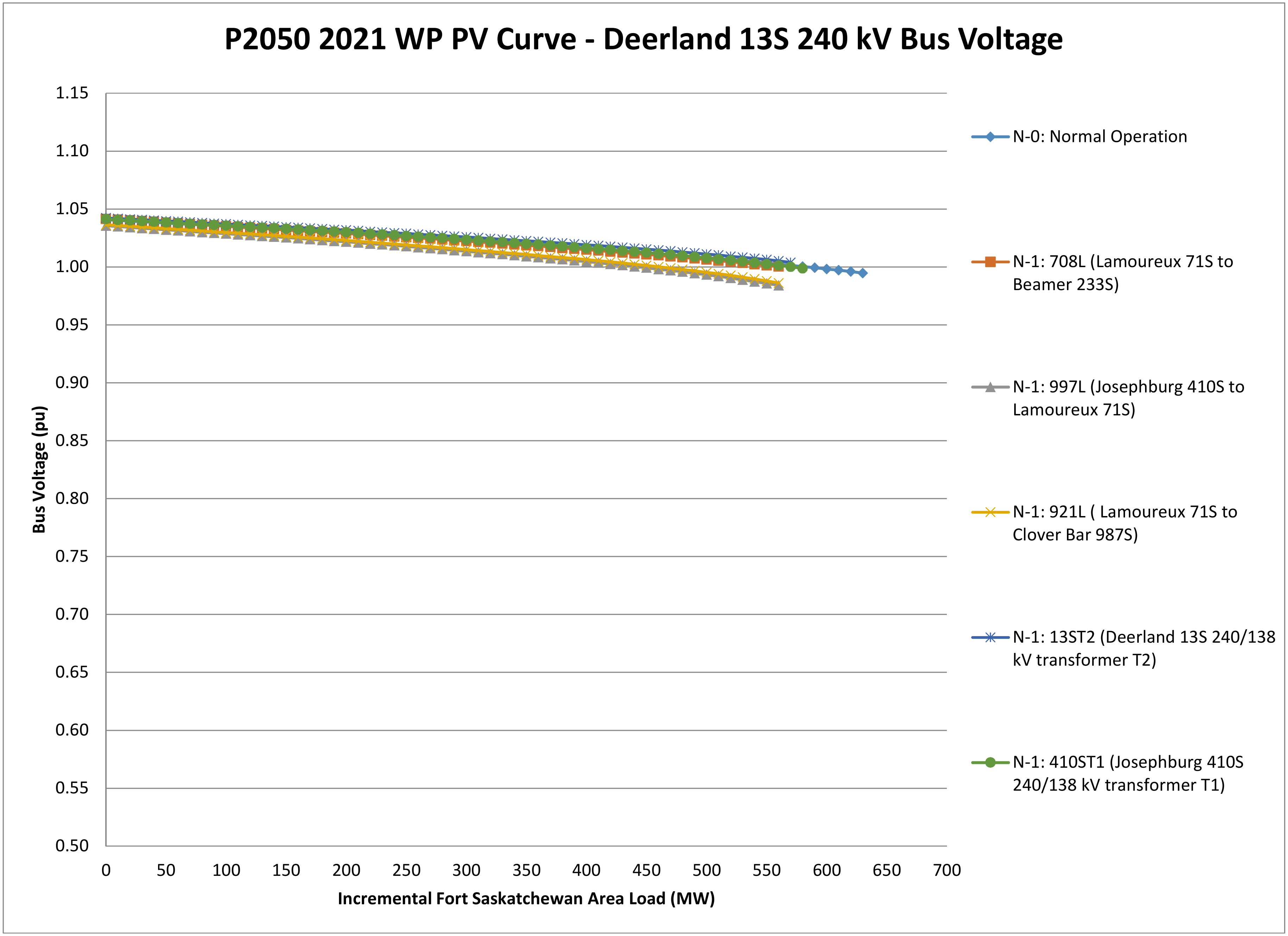
Table 1: Voltage Stability Study Results for Scenario 4: 2021 WP Post-Project

Studied Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets 105% transfer criteria
Category A	System Normal		*630*	*Yes*
708L	Beamer 233S	Lamoureux 71S	*560*	*Yes*
997L	Josephburg 410S	Lamoureux 71S	*560*	*Yes*
921L	Lamoureux 71S	Clover Bar 987S	*560*	*Yes*
13ST2	Deerland 13S 240/138 kV transformer T2		*580*	*Yes*
410ST1	Josephburg 410S 240/138 kV transformer T1		*580*	*Yes*

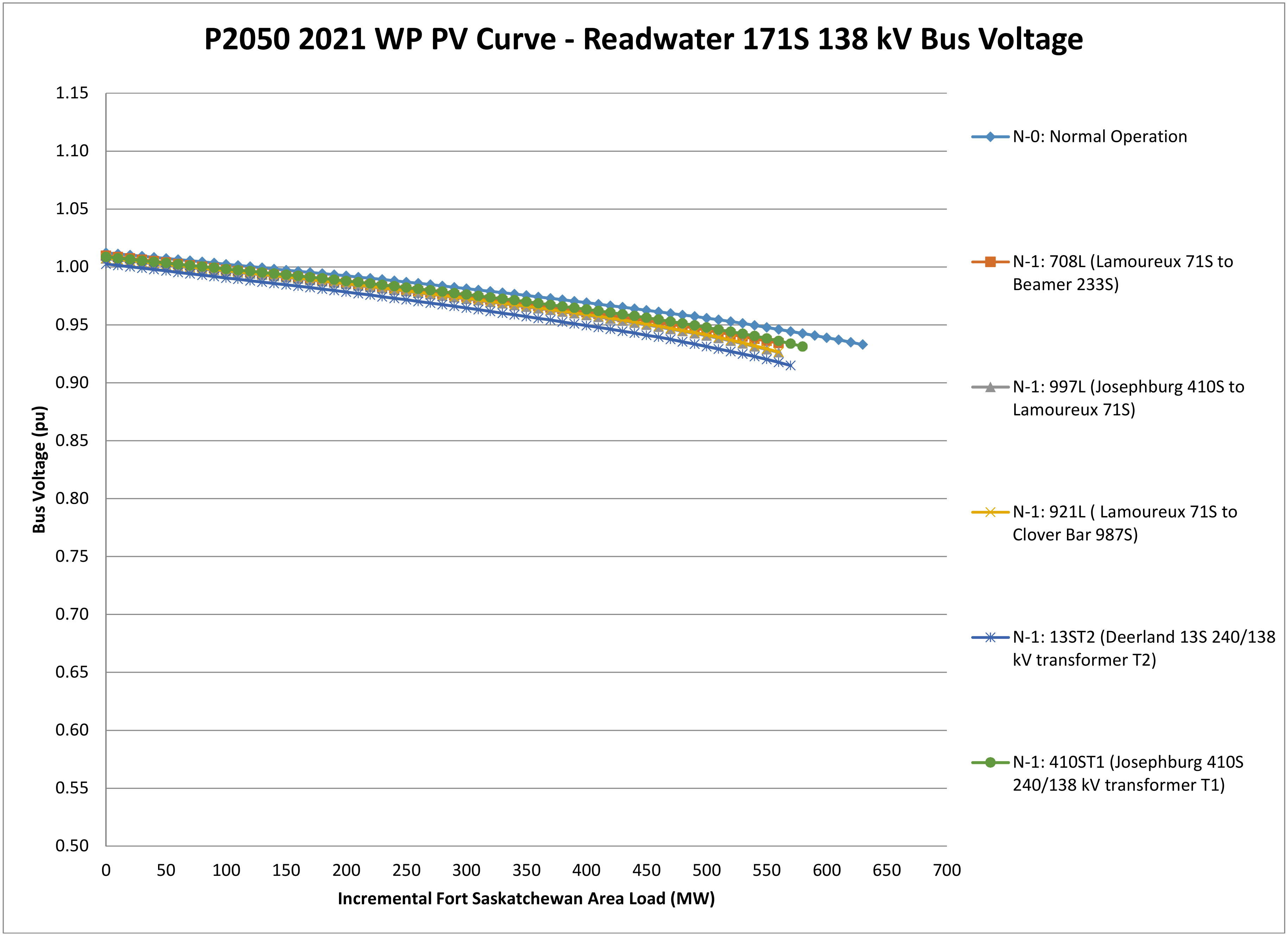

P2050 2021 WP PV Curve - Abee 993S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)

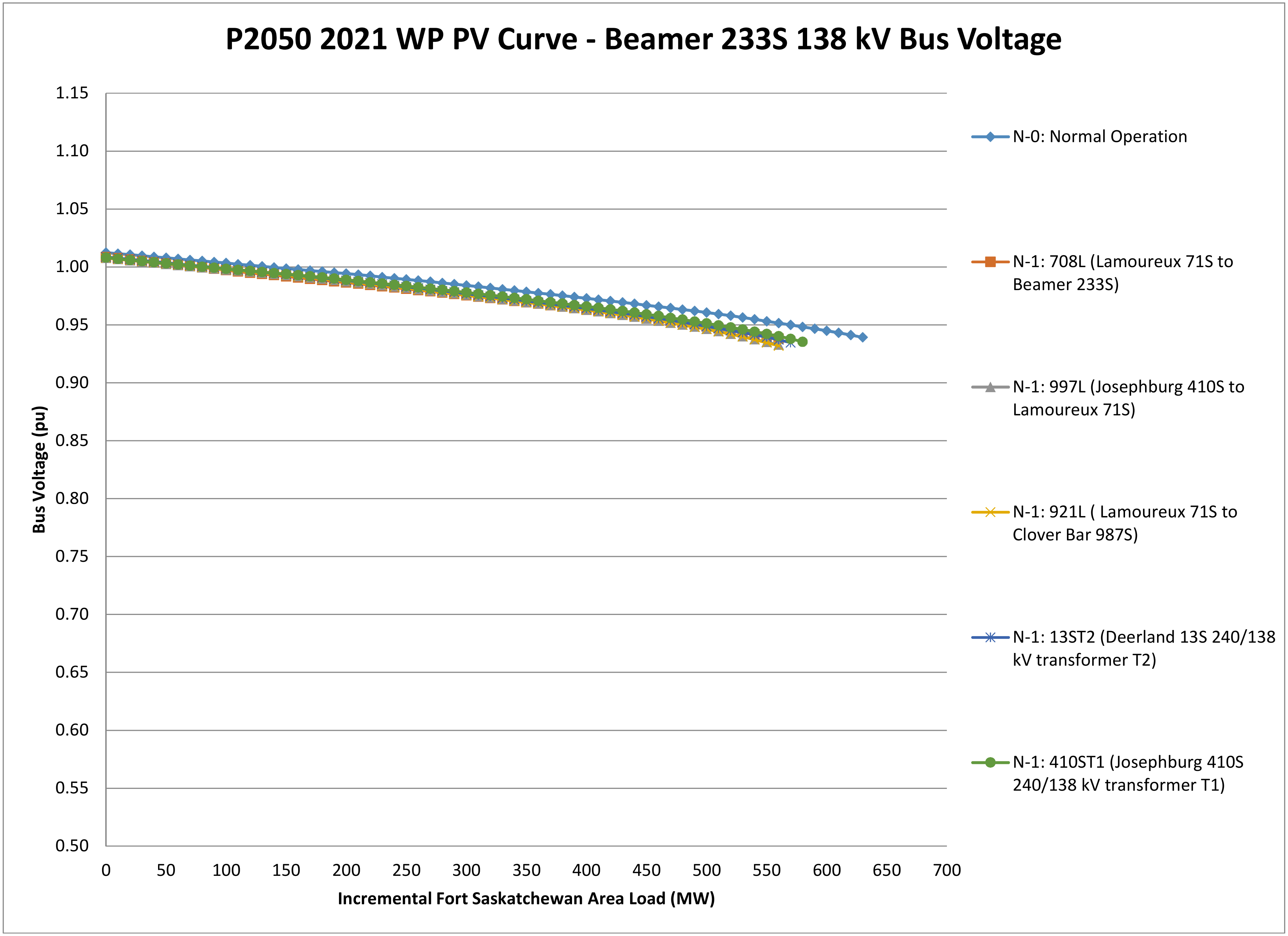

P2050 2021 WP PV Curve - Weasel Creek 947S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)


P2050 2021 WP PV Curve - Deerland 13S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)



P2050 2021 WP PV Curve - Deerland 13S 240 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)


P2050 2021 WP PV Curve - Readwater 171S 138 kV Bus Voltage
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Bus Voltage (pu)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)


P2050 2021 WP PV Curve - Beamer 233S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Incremental Fort Saskatchewan Area Load (MW)
N-0: Normal Operation
N-1: 708L (Lamoureux 71S to Beamer 233S)
N-1: 997L (Josephburg 410S to Lamoureux 71S)
N-1: 921L (Lamoureux 71S to Clover Bar 987S)
N-1: 13ST2 (Deerland 13S 240/138 kV transformer T2)
N-1: 410ST1 (Josephburg 410S 240/138 kV transformer T1)