Engineering Connection Assessment

P2969 Cadomin 983S Substation Upgrade

FortisAlberta Inc.

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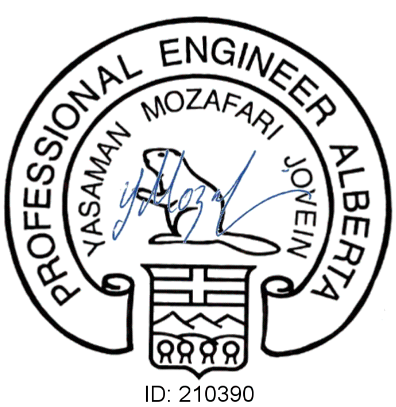
Role	Name	Date	Signature
Prepared	Adil Juma, P.Eng.		Adil Nizar Juma -- P. Eng. - APEGA Digitally signed by Adil Nizar Juma -- P. Eng. - APEGA Date: 2026.05.29 11:22:23 -06'00'
Reviewed	Yasaman Mozafari Jovein, P.Eng.		Yasaman Mozafari Jovein -- P. Eng. - APEGA Digitally signed by Yasaman Mozafari Jovein -- P. Eng. - APEGA Date: 2026.05.29 12:41:53 -06'00'
Approved	Peyman Ahmadi, P.Eng.		Peyman Ahmadi -- P. Eng. - APEGA Digitally signed by Peyman Ahmadi -- P. Eng. - APEGA Date: 2026.05.29 14:45:18 -06'00'



PERMIT TO PRACTICE
INDEPENDENT SYSTEM OPERATOR

RM SIGNATURE: Ahmadi

RM APEGA ID #: 196963

DATE: 2026-05-29

PERMIT NUMBER: P008200

The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

NOTE:

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

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

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Appendix A Engineering Connection Assessment Results

1 Introduction

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

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

1.1 Project Overview

FortisAlberta Inc. (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 industrial load growth in the Cadomin area.

The DFO's request includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of 1.8 MW, from 0.7 MW to 2.5 MW, for the system access service provided at the existing Cadomin 983S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested an enhancement to the existing Cadomin 983S substation. Details on the need for transmission enhancement are provided in the DFO's Distribution Deficiency Report (DDR). The DFO also requested that the DTS increase occur in stages, as shown in Table 1-1.

Table 1-1: DTS Staging Schedule

Requested Capacity	0.7 MW	1 MW	1.5 MW	2 MW	2.5 MW
Capacity Start Date	Existing	Jan 1, 2027	Jul 1, 2027	Sep 1, 2028	Sep 1, 2028

The scheduled in-service date (ISD) for the Project is September 1, 2028.

2 Assessment Scope

2.1 Objectives

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

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

2.2 Existing System

Geographically, the Project is located in the AESO planning area of Hinton/Edson (Area 29), which is part of the AESO's Central Planning Region. Hinton/Edson (Area 29) is surrounded by the planning areas of Grande Cache (Area 22), Fox Creek (Area 24) Swan Hills (Area 26), Wabamun (Area 40), Drayton Valley (Area 30), and Abraham Lake (Area 34).

From a transmission system perspective, Hinton/Edson (Area 29) consists of 138 kV, and 240 kV transmission systems. The Hinton/Edson area (Area 29) is connected to the Fox Creek area (Area 24) with one 138 kV transmission line 685L, the Wabamun area (Area 40) with one 138 kV transmission line 744L and two 240 kV transmission lines 973L and 974L, and the Drayton Valley area (Area 30) with one 138 kV transmission line 202L.

Existing constraints in the Central 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 consists of the AESO planning area of Hinton/Edson (Area 29), including the tie lines connecting this planning area to the rest of the AIES.

All transmission facilities within the Study Area will be studied and monitored for violations of the Reliability Criteria (defined in Section 3.1 of Appendix A – A1: Engineering Connection Assessment Scope).

3 Connection Alternatives

3.1 Overview

The AESO, in consultation with the TFO in the Study Area and the DFO, examined one transmission alternative[1] to meet the DFO'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 alternative that was examined for the Project.

Alternative 1 – Upgrade Cadomin 983S substation

This alternative includes the following developments:

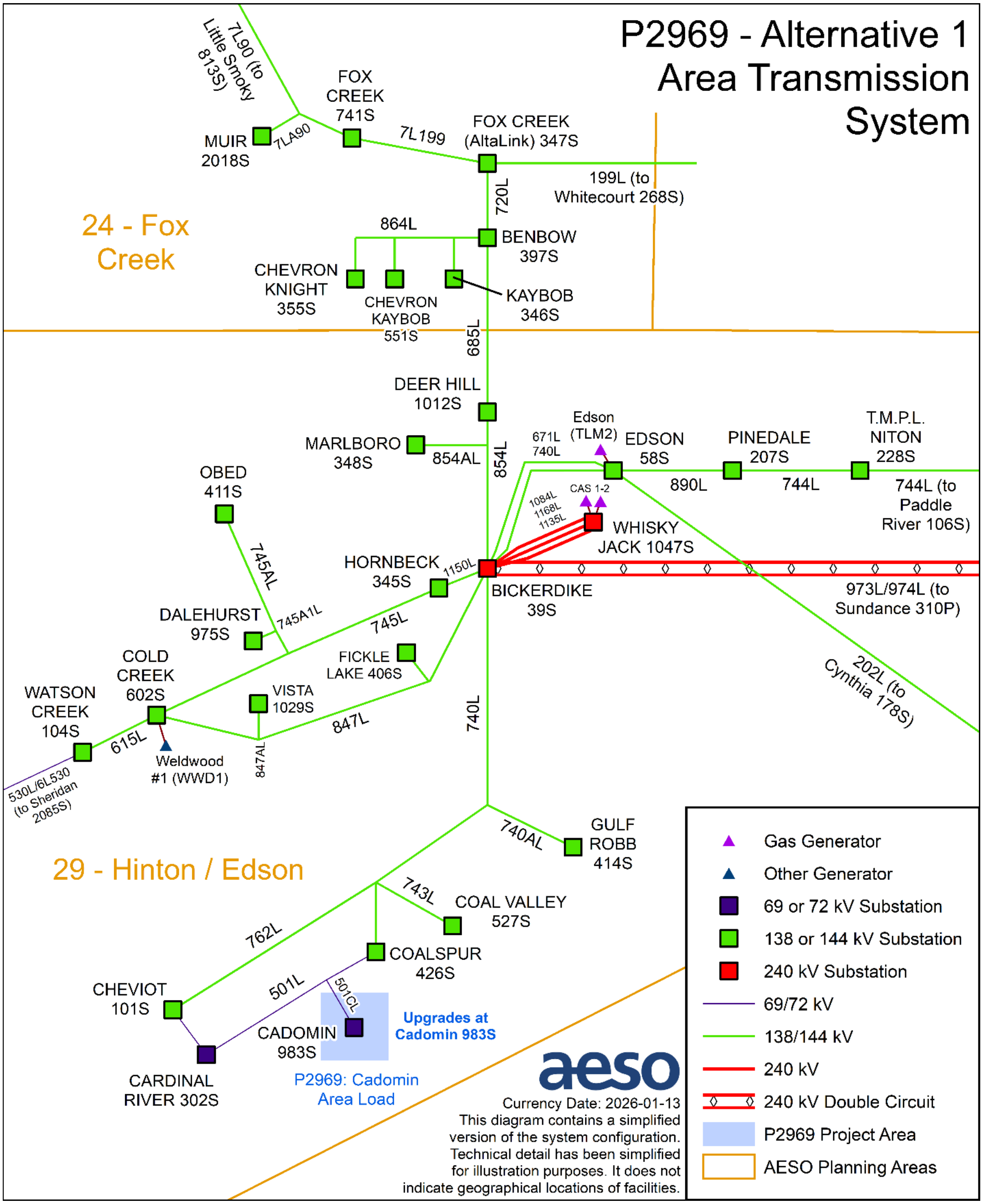
- Upgrade the existing Cadomin 983S substation, including replacement of the existing 69/25 kV 2.5 MVA transformer with a 69/25 kV transformer with a capacity of 5 MVA [2]; and
- Add or modify associated equipment as required for the above transmission developments.

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

[1] The DFO also examined and ruled out distribution system upgrades, as detailed in Section 5 of the Distribution Deficiency Report.

[2] The 5 MVA capacity is based on the DFO load staging schedule and load growth projection.

Figure 3-1: Connection Alternative 1



3.3 Connection Alternatives Selected for Further Study

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

4 Assessment Approach

4.1 Standards, Criteria and Assumptions

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

4.2 Studies Performed

The scheduled ISD for the Project is September 1, 2028. Studies were performed using scenarios for 2028 Summer Peak (SP) and 2028 Winter Peak (WP).

Short-circuit studies were performed using the 2028 WP Low Generation (LG) and 2033 WP scenario.

Table 4-1 lists the study scenarios. Post-Project scenarios reflect the requested Rate DTS contract capacity increase of 1.8 MW at the Cadomin 983S substation.

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	Project Load (MW)	Project Generation (MW)
Pre-Project					
1	2028 Summer Peak (SP)	Low Generation (LG)	2028 SP Pre-Project	0	0
2	2028 Winter Peak (WP)		2028 WP Pre-Project	0	0
Post-Project					
3	2028 SP	LG	2028 SP Post -Project	1.8	0
4	2028 WP	LG	2028 WP Post -Project	1.8	0
5	2033 WP	All generators in Study Area In-Service	2033 WP Post -Project	1.8	0

The AESO Planning Region load forecasts used for the connection studies were based on the AESO's *2023 Long-term Outlook* (2023 LTO). While the AESO has updated its regional forecasts since the connection studies were performed, the use of the current AESO forecast, the 2024 Long-term Outlook (2024 LTO) would not materially alter the connection study results or affect the conclusions and recommendations in this report.

4.2.1 Power Flow Studies

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

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

Power flow studies were performed for the 2028 Summer Peak, and 2028 Winter Peak pre-Project scenarios, and for 2028 Summer Peak, and 2028 Winter Peak 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 the 2028 Summer Peak, and 2028 Winter Peak post-Project scenarios.

4.2.3 Short-Circuit Current Level Studies

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

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

4.3 Mitigation Measure Development and Evaluation

No reliability criteria violations were identified as a result of this project's connection, and therefore no mitigation measures were developed.

[3] 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 Appendix A.

5 Interpretation of Results

5.1 Pre-Project Study Results

5.1.1 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.

5.1.2 Category B Conditions

No Reliability Criteria violations or voltage deviations beyond the limits listed in Table 3-1 of Appendix A – A1: Engineering Connection Assessment Scope (hereafter referred to as point of delivery (POD) bus voltage deviations) were observed under Category B conditions.

5.2 Post-Project Study Results

5.2.1 Category A Conditions

After upgrading the Cadomin Transformer to 5 MVA, 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.

5.2.2 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. The connection assessment identified no pre-Project and post-Project system performance issues.

The AESO recommends proceeding with the Project using Alternative 1 as the preferred alternative to respond to the DFO's request for system access service. Alternative 1 includes upgrading the existing Cadomin 983S substation, including replacement of the 69/25 kV 2.5 MVA transformer with a 69/25 kV 5 MVA transformer.

It is recommended that the 69/25 kV transformer at Cadomin 983S substation have a transformation capability of 5 MVA, based on the requested Rate DTS contract capacity increase, DFO load staging schedule and load growth projection.

Appendix A
Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

P2969 Cadomin Area Load

Fortis Alberta Inc.

Date: January 22, 2026

Version: Rev. 2

Prepared by AltaLink Management Ltd. for Alberta Electric System Operator (AESO)

Role	Name	Signature	Date
Author/Designer	Yuan Li, P.Eng.	Yuan Li	February 11, 2026
Engineering Reviewer	Joby Varghese, P.Eng.	Joby Varghese	February 11, 2026
Approver	Joby Varghese, P.Eng.	Joby Varghese	February 11, 2026

ENGINEERING STAMP	PERMIT TO PRACTICE STAMP
PROFESSIONAL ENGINEER ALBERTA Yuan Li YUAN LI ID 286065 LICENSED TO PRACTICE 2026-Feb-11	**PERMIT TO PRACTICE** **ALTALINK MANAGEMENT LTD** RM SIGNATURE: RM APEGA ID #: 87358 DATE: 2026-Feb-11 **PERMIT NUMBER: P007862** The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Revision	Description of Revision	By	Date
Rev.0	Initial submission	Yuan Li	Dec 2, 2025
Rev.1	Minor editorial updates	Yuan Li	Jan 14, 2026
Rev.2	Minor editorial updates	Yuan Li	Jan 22, 2026

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Attachment A1 Engineering Connection Assessment: Study Scope
Attachment A2 Pre-Project Power Flow Diagrams
Attachment A3 Post-Project Power Flow Diagrams
Attachment A4 Post-Project Voltage Stability Diagrams

1 Introduction

This report presents the results of the engineering studies that were completed by AltaLink LP (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 35.

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: 2028 Summer Peak Low Generation Pre-Project

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.

POD Bus Voltage Deviations

No 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: 2028 Winter Peak Low Generation Pre-Project

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.

POD Bus Voltage Deviations

No 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 studies and transient 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.

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

Category A Conditions

Prior to upgrading the Cadomin 983S Transformer T1, thermal criteria violations were observed under Category A. After upgrading the Cadomin Transformer to 5 MVA, no reliability criteria violations were observed under Category A. For comparison purposes, the following N-0 results are presented for both pre- and post-upgrade conditions of the Cadomin 983S transformer.

Table 3-1: Comparison of Cadomin 983S Transformer Loading Results under Category A Conditions for Scenario 3

Location Details	Thermal Ratings (MVA)		Loading Results	
	Normal Rating	Emergency Rating	Power Flow[a] (MVA)	% Loading[b]
Cadomin 983S Transformer T1 (pre-upgrade)	*2.5*	*2.5*	*2.8*	*112%*
Cadomin 983S Transformer T2 (post-upgrade)	*5*	*5*	*2.8*	*56%*

Notes:

[a] Power flow (MVA) is current expressed as MVA (i.e., $S = \sqrt{3} \times V_{base} \times I_{actual}$)

[b] Reported as a percentage of the power flow (in MVA, i.e., $S = \sqrt{3} \times V_{base} \times I_{actual}$) relative to the transmission line's Normal Rating (also in MVA), as shown in the AESO's Study Scope.

Category B Conditions

No Reliability Criteria violations were observed under Category B conditions.

POD Bus Voltage Deviations

No POD bus voltage deviations were observed.

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

Category A Conditions

Prior to upgrading the Cadomin 983S Transformer T1, thermal criteria violations were observed under Category A. After upgrading the Cadomin Transformer to 5 MVA, no reliability criteria violations were observed under Category A. For comparison purposes, the following N-0 results are presented for both pre- and post-upgrade conditions of the Cadomin 983S transformer.

Table 3-2: Comparison of Cadomin 983S Transformer Loading Results under Category A Conditions for Scenario 4

Location Details	Thermal Ratings (MVA)		Loading Results	
	Normal Rating	Emergency Rating	Power Flow[a] (MVA)	% Loading[b]
Cadomin 983S Transformer T1 (pre-upgrade)	*2.5*	*2.5*	*2.8*	*112%*
Cadomin 983S Transformer T2 (post-upgrade)	*5*	*5*	*2.8*	*56%*

Notes:

[a] Power flow (MVA) is current expressed as MVA (i.e., $S = \sqrt{3} \times V_{base} \times I_{actual}$)

[b] Reported as a percentage of the power flow (in MVA, i.e., $S = \sqrt{3} \times V_{base} \times I_{actual}$) relative to the transmission line's Normal Rating (also in MVA), as shown in the AESO's Study Scope.

Category B Conditions

No Reliability Criteria violations were observed under Category B conditions.

POD Bus Voltage Deviations

No POD bus voltage deviations were observed.

3.2 Voltage Stability Studies

Voltage stability analysis was performed for the 2028 SP Low Generation Post-Project scenario. The voltage stability diagrams are provided in Attachment A4.

3.2.1 Scenario 3: 2028 Summer Peak Low Generation Post-Project

The reference load level for Hinton/Edson area (Area 29) is 121 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 106.4 MW (0.05 x 121 MW = 6.1 MW), to meet the voltage stability criteria.

Table 3-3 provides the voltage stability study results under the Category A condition and for the five worst contingencies under Category B conditions.

Table 3-3: Voltage Stability Study Results under Category B Conditions for Scenario 3

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		318.8	*Yes*
745L/745AL	Cold Creek 602S	Hornbeck 345S	213.8	*Yes*
345S_T1	Hornbeck 345S Transformer T1		255	*Yes*
58S_T1 or 58S_T2	Edson 58S Transformer T1 or T2		258.8	*Yes*
847L/847AL	Hornbeck 345S	Bickerdike 39S	262.5	*Yes*
P1756_T1	P1756 Transformer T1		277.5	*Yes*

3.2.2 Scenario 4: 2028 Winter Peak Low Generation Post-Project

Voltage stability analysis was performed for the 2028 WP Low Generation Post-Project scenario. The reference load level for Hinton/Edson area (Area 29) is 134 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 106.4 MW (0.05 x 134 MW = 6.7 MW), to meet the voltage stability criteria.

Table 3-3 provides the voltage stability study results under the Category A condition and for the five worst contingencies under Category B conditions.

Table 3-4: 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		408.8	Yes
745L/745AL	Cold Creek 602S	Hornbeck 345S	174.4	Yes
P1756_T1	P1756 Transformer T1		208.1	Yes
411S_T1	Edson 58S Transformer T1 or T2		210	Yes
58S_T1 or 58S_T2	Edson 58S Transformer T1 or T2		330	Yes
602S_T1_T2	Cold Creek 602S Transformer T1 or T2		337.5	Yes

4 Short Circuit Studies

4.1 Pre-Project Results

4.1.1 Scenario 2: 2028 WP LG Pre-Project

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)
Cadomin 983S	69	69.3	1.1	0.395441+0.675758j	0.8	0.58014+1.718966j
Coalspur 426S	69	69.5	2.1	0.07797+0.389697j	1.8	0.157856+0.625139j
	138	141.5	2.4	0.06737+0.165344j	1.6	0.152715+0.441102j
Chevoit 101S	69	71	1.4	0.132274+0.629314j	0.1	32.785702+0.37575j
	138	141.5	1.6	0.105261+0.253535j	1	0.256252+0.720518j

4.2 Post-Project Results

4.2.1 Scenario 4: 2028 WP LG Post-Project

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

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

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Cadomin 983S	69	68.3	1.1	0.395567+0.662952j	1.1	0.150995+0.743654j
Coalspur 426S	69	69.1	2.1	0.080012+0.387115j	1.9	0.123284+0.494735j
	138	141.1	2.4	0.067558+0.16472j	1.7	0.124213+0.379137j
Chevoit 101S	69	70.8	1.3	0.132491+0.628665j	0.1	32.785702+0.37575j
	138	141.1	1.6	0.105448+0.252907j	1	0.227608+0.658486j

[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.

4.2.2 Scenario 5: 2033 WP Post-Project

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

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

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Cadomin 983S	69	67.8	1.1	0.393774+0.657909j	1.1	0.151262+0.742052j
Coalspur 426S	69	68.6	2.1	0.078263+0.382151j	1.9	0.122831+0.488961j
	138	140.1	2.5	0.065755+0.159564j	1.7	0.123855+0.372132j
Chevoit 101S	69	70.4	1.3	0.12966+0.623898j	0.1	32.785702+0.37575j
	138	140.2	1.6	0.103548+0.247843j	1	0.227237+0.65145j

5 Mitigation Measure Development and Evaluation

No mitigation measures are required for this project as no reliability criteria violation were observed.

Attachment A1
Engineering Connection Assessment: Study Scope

Engineering Connection Assessment: Study Scope

P2969 Cadomin Area Load

Fortis Alberta Inc.

Date: Nov 3, 2025

Version: V1Final

Classification: Public

Company Name	Name and Credentials	Date	Signature
AltaLink Management Ltd. (Study Consultant)	Joby Varghese	12/17/2025	DocuSigned by: Joby Varghese FBB0E807591C4D9...
AESO	Nima Safari	1/7/2026	DocuSigned by: Nima Safari FDA585810A024D2...
Fortis Alberta Inc. (Distribution Facility Owner)	Ivan Chow	1/5/2026	Signed by: Ivan Chow D4CA73DF0B6749B...
AltaLink Management Ltd. (Transmission Facility Operator)	Michelle Lemieux	1/5/2026	Signed by: Michelle Lemieux F198601A2AC74D5...

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Attachment A: Transmission Planning Criteria – Basis and Assumptions

1 Introduction

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

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

1.1 Project Overview

Fortis Alberta Inc., 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 increase the contract capacity of one of their substations in Cadomin Area.

The DFO's request includes a request for a Rate DTS, Demand Transmission Service, contract capacity increase of 1.8 MW, from 0.7 MW to 2.5 MW, for the system access service provided at the existing Cadomin 983S Substation and a request for transmission development (collectively, the Project). Specifically, the DFO requested an enhancement to the existing Cadomin 983S substation. Details on the need for the enhancement can be found in the DFO's DDR.

The Project in-service date (ISD) used for the purpose of the studies is January 01, 2028.

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

There are no generation components of the Project.

Table 1-1: Project Load and Generation Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	0.7 MW at Cadomin 983S Substation
	Requested Rate DTS	1 MW, Jan 1, 2027 1.5 MW, Jul 1, 2027 2 MW, Jan 1, 2028 2.5 MW, Jul 1, 2028
	Type	Industrial Load
	Motors (number and size)	N/A
	Power factor	0.9
	Future load expansion plans	The DFO has indicated anticipated future load growth; however, the exact magnitude has yet to be determined.

Project Component	Description

1.2 Existing System Overview

1.2.1 Study Area

Geographically, the Project is located in the AESO planning area of Hinton/Edson (Area 29).

The Study Area consists of the AESO planning area of Hinton/Edson (Area 29), including the tie lines connecting these planning areas 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

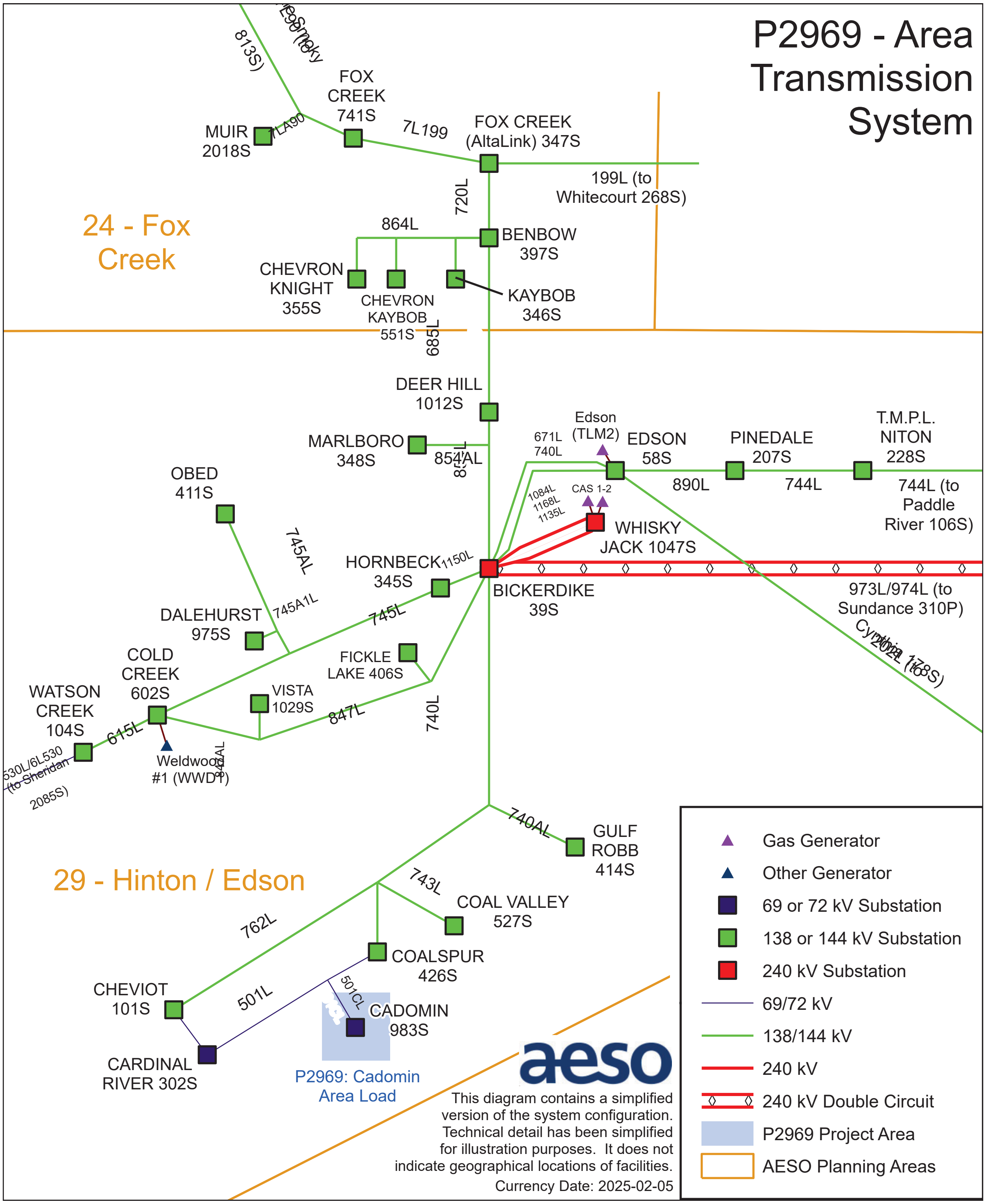
Existing constraints in the Study Area are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule).

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 163: Vista 1029S Under Voltage Mitigation Scheme
- RAS 185: 890L overload mitigation scheme
- RAS 186: T1 and T2 - 39S Bickerdike Overload Mitigation
- RAS 187: Any two 240 kV lines (1084L, 1135L and 1168L) contingency related mitigation
- RAS 188: 740L (Bickerdike to Edson) overload mitigation scheme
- RAS 189: 202L overload mitigation scheme
- RAS 190: 720L overload mitigation scheme

Figure 1-1: Transmission System in the Study Area



2 Connection Alternatives

The following alternative will be studied:

2.1 Alternative 1 – Upgrade Cadomin 983S substation

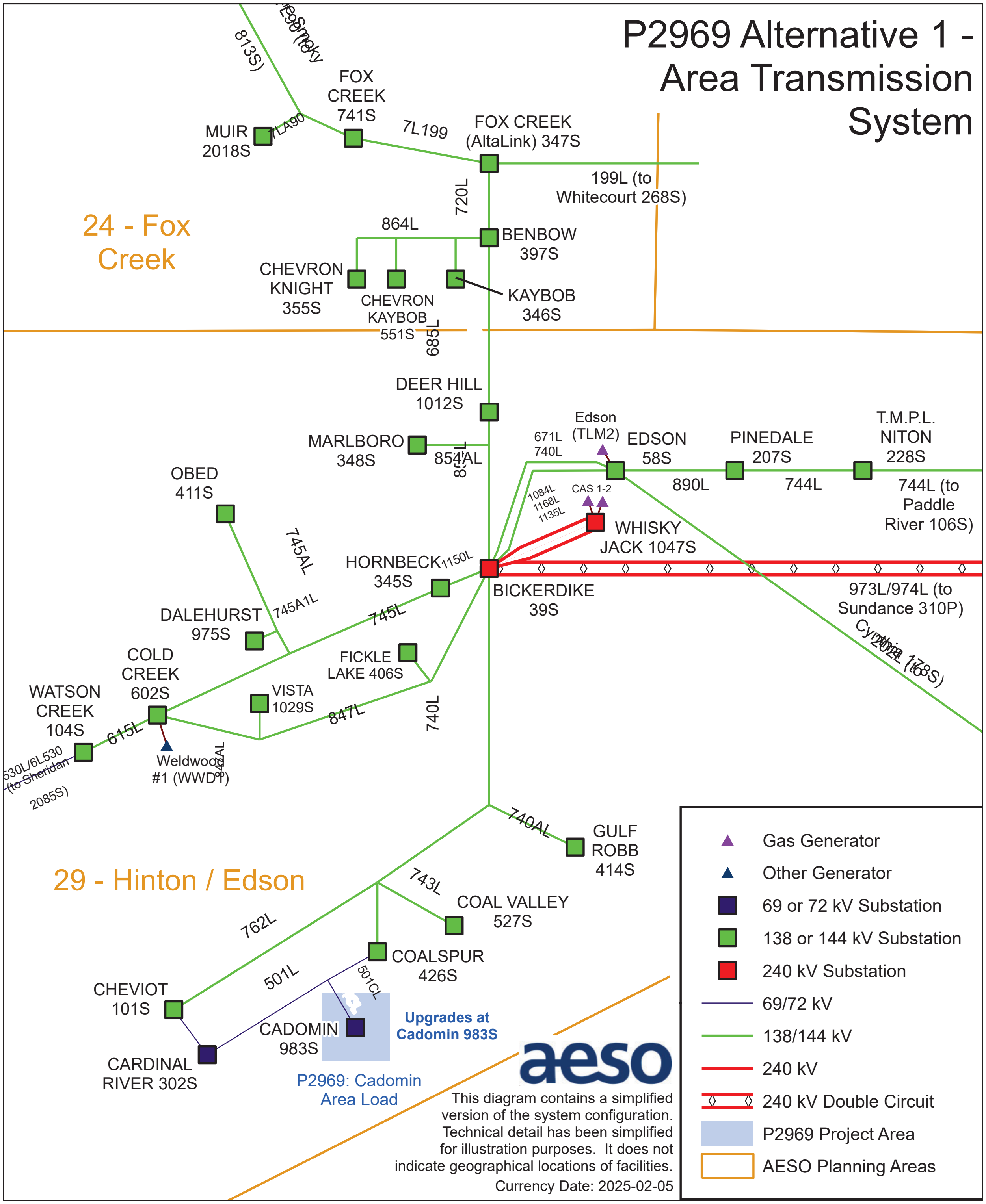
This alternative included the following developments:

- Upgrade the existing Cadomin 983S substation, including replacing the existing 69/25 kV2.5 MVA transformer with a 69/25 kV, 5 MVA transformer[1];
- Add or modify associated equipment as required for the above transmission developments.

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

[1] This is based on Fortis Alberta Inc. projects on load ramping schedule and load growth projection.

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, TPL-002-AB1-0, and TPL-003-AB-0, have referenced Applicable Ratings when specifying the required system performance under Category A and Category B. For the purpose of applying the TPL standards to the studies documented in this report, Applicable Ratings are defined as follows:

- Normal thermal rating of the line’s loading limits for each season;
- The highest specified loading limits for transformers;
- For Category A conditions: Voltage range under normal operating condition per AESO Information Document #2010-007RS, *General Operating Practices – Voltage Control* (ID #2010-007RS). For the busses not listed in ID #2010-007RS, Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions* applies;
- For Category B conditions: The extreme voltage range values per Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions; and*
- Desired post-contingency voltage deviation limits for three defined post-event timeframes as provided in Table 3-1.

Table 3-1: Post-Contingency Voltage Deviation Guidelines for Low Voltage Busses

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

3.2 ISO Rules and Information Documents

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

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

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

4 Scenarios and Assumptions

4.1 Scenarios

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

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

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	Project Load (MW)	Project Generation (MW)
Pre-Project					
1	2028 Summer Peak (SP)	Low Generation (LG)	2028 SP Pre-Project	0[a]	0
2	2028 Winter Peak (WP)	LG	2028 WP Pre-Project	0[a]	0
Post-Project					
3	2028 SP	LG	2028 SP Post-Project	1.8[a]	0
4	2028 WP	LG	2028 WP Post-Project	1.8[a]	0
5	2033 WP	All generators in Study Area In-Service	2033 WP Post-Project	1.8[a]	0

a: The total load at SS-54 shall be 0.7MW in the pre-project and 2.5MW in the post-project.

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 Central Planning Region peak based on the Preliminary Long-Term Outlook 2023 (2023 LTO)[2] with modifications to incorporate the latest forecast intelligence. For the post-Project studies, when the Study Area loads are

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

modified to align with the regional load forecast, the active power to reactive power ratio in the base case scenarios shall be maintained.

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

AESO Planning Region Name	Forecast Peak Load by Year/Season (MW)	
	2028 SP LG	2028 WP LG
Central	1,891	2,136
Hinton/Edson (Area 29)	121	134
AIES	11,249	11,988

Note:
[1] The Central Region comprises the following AESO planning areas: Vegreville (Area 56), Lloydminster (Area 13), Wainwright (Area 32), Provost (Area 37), Alliance/Battle River (Area 36), Hanna (Area 42), Red Deer (Area 35), Didsbury (Area 39), Caroline (Area 38), Drayton Valley (Area 30), Hinton/Edson (Area 29), Abraham Lake (Area 34), Cold Lake (Area 28).

IDEV 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 2023 LTO with modifications to incorporate the latest forecast intelligence. The generation assumptions for the studies will assume low generation dispatch conditions. Additional studies may be required in the event of changes to the AESO's corporate forecast.

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

CAS1 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 Generation Dispatch Conditions

Facility Name	Unit No.	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
					2028 SP LG	2028 WP LG
WWD1	1	4017	50	29	19	20
	2	4017		29	21	21
P1756	G1	2917	75	29	25	25

Facility Name	Unit No.	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
					2028 SP LG	2028 WP LG
P1756	G1	2917		29	25	25
P1756	G1	2917		29	25	25
TLM2	G1	13020	13	29	10	11.5
CAS1	G1	557014	450	29	0	478
CAS2	G2	558014	450	29	N-G[b]	N-G[b]

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. The HVDC power order assumptions for the studies will be set to minimize losses for the pre-Project and post-Project study scenarios.

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

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

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

4.2.7 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
740L	Bickerdike 39S-740AL tap	138	56	109	62	120
740L	740AL tap-743L	138	99	133	109	146
740L	743L-Coalspur 426S	138	99	133	109	146
762L	740L-Cheviot 101S	138	98	132	108	145
501L	Coalspure 426S-Cadomin Tap (501CL)	69	22	24	24	30
501CL	Cadomin Tap-Cadomin 983S	69	31	38	34	42

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)
Coalspur 426S	426ST2	138 /69	25
Cadomin 983S	983ST1	69/25	2.5
Bickerdike 39S	39ST1	240/138/13.8	269//56
Bickerdike 39S	39ST2	240/138/13.8	269//56

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)
Edson 58S	138	1	27	0	0
Cold Creek 602S	138	1	32.5	0	0

4.2.8 Protection Fault Clearing Times

4.2.9 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			Short Circuit
		Category			Category			Category A
		A	B	C5	A	B	C5	
Pre-Project								
1	2028 SP LG	X	X		X*	X*		
2	2028 WP LG	X	X		X*	X*		X
Post-Project								
3	2028 SP LG	X	X		X	X		
4	2028 WP LG	X	X		X	X		X
5	2033 WP							X

Note:
*Only required if post-project studies show potential voltage stability issues.

For the engineering studies, all transmission facilities 69kV and above, 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 Study Case Validation

The study will be conducted on the AIES system model using the AESO's planning base cases. The seasonal light/peak scenarios will be studied as required. The base cases will be modified by the AESO to include the corresponding load and generation forecast information. The resulting cases, or seed cases, along with the project IDEVs, will be provided by the AESO to the Studies Consultant. These cases are provided in PSS/E v34 and/or v33 format. Upon request, the AESO can provide RAW and SEQ files. Software used by the Studies Consultant must be able to read and write these file types. Manual adjustments may be required to ensure full alignment with the details outlined in this Study Scope, as described in the process outlined below. The AESO will provide guidance to the Studies Consultant with regard to the setup of the study cases should any questions arise.

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

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

2. The Studies Consultant applies the identified IDEVs to the seed cases to create the study cases. The Studies Consultant verifies and makes adjustments as required to ensure the study cases represent the assumptions outlined within the Study Scope.
3. Upon creating the study cases, all the study cases are forwarded to the AESO for approval.
4. The Studies Consultant proceeds with the required engineering studies only after the study cases are approved by the AESO.

5.2 Power Flow Studies

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

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

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

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

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

5.2.1 Contingencies to be Studied:

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

5.3 Voltage Stability Studies

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

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

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

Typically, voltage stability studies are carried out assuming the worst case scenarios in terms of loading. In this connection assessment, the voltage stability studies will be performed by increasing load in Hinton/Edson (Area 29) and increasing generation in Calgary (Area 6).

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

5.3.1 Contingencies to be Studied

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

5.4 Short-Circuit Current Level Studies

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

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

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

- Cadomin 983S
- Coalspur 426S
- Cardinal River 302S
- Chevoit 101S

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

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

6 Mitigation Measures

6.1 Development

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

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

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

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

6.2 Evaluation

6.2.1 Post-Mitigation Studies

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

6.2.2 Constraint Effective Factor Studies

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

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

7 Changes to Study Assumptions

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

Attachment A:
Transmission Planning Criteria – Basis and Assumptions

Transmission Planning Criteria – Basis and Assumptions

Date: July 9, 2019

Version: V1.2

Alberta Electric System Operator

Calgary Place, 2500, 330-5th Avenue SW Calgary, AB T2P 0L4

Phone: 403-539-2450 | Fax: 403-539-2949

www.aeso.ca

@theaeso

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 the *Alberta Reliability Standards* can be found on the AESO's website: 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	150
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	≥5%	Worst Case Scenario(8)
B	Bus Section	≥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	≥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

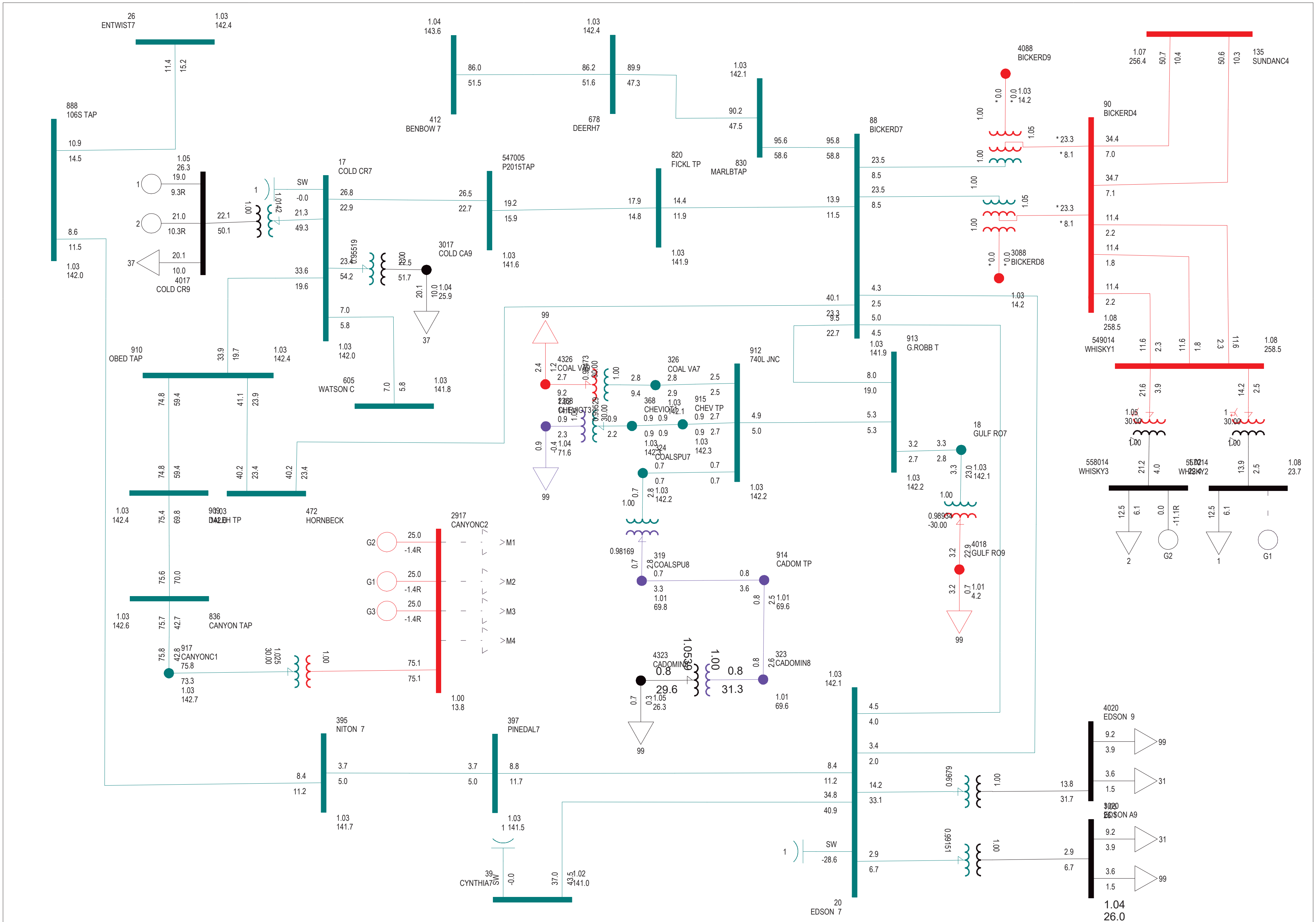
Table 2-4: Stuck Breaker Clearing Times for Lines

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-Project Power Flow Diagrams



P2969 Cadomin Area Load

P2969 PRE-CONNECTION (2028SP)- DIAGRAM A-1
N-0: NORMAL OPERATION
THU, JUN 12 2025 13:15
New Diagram

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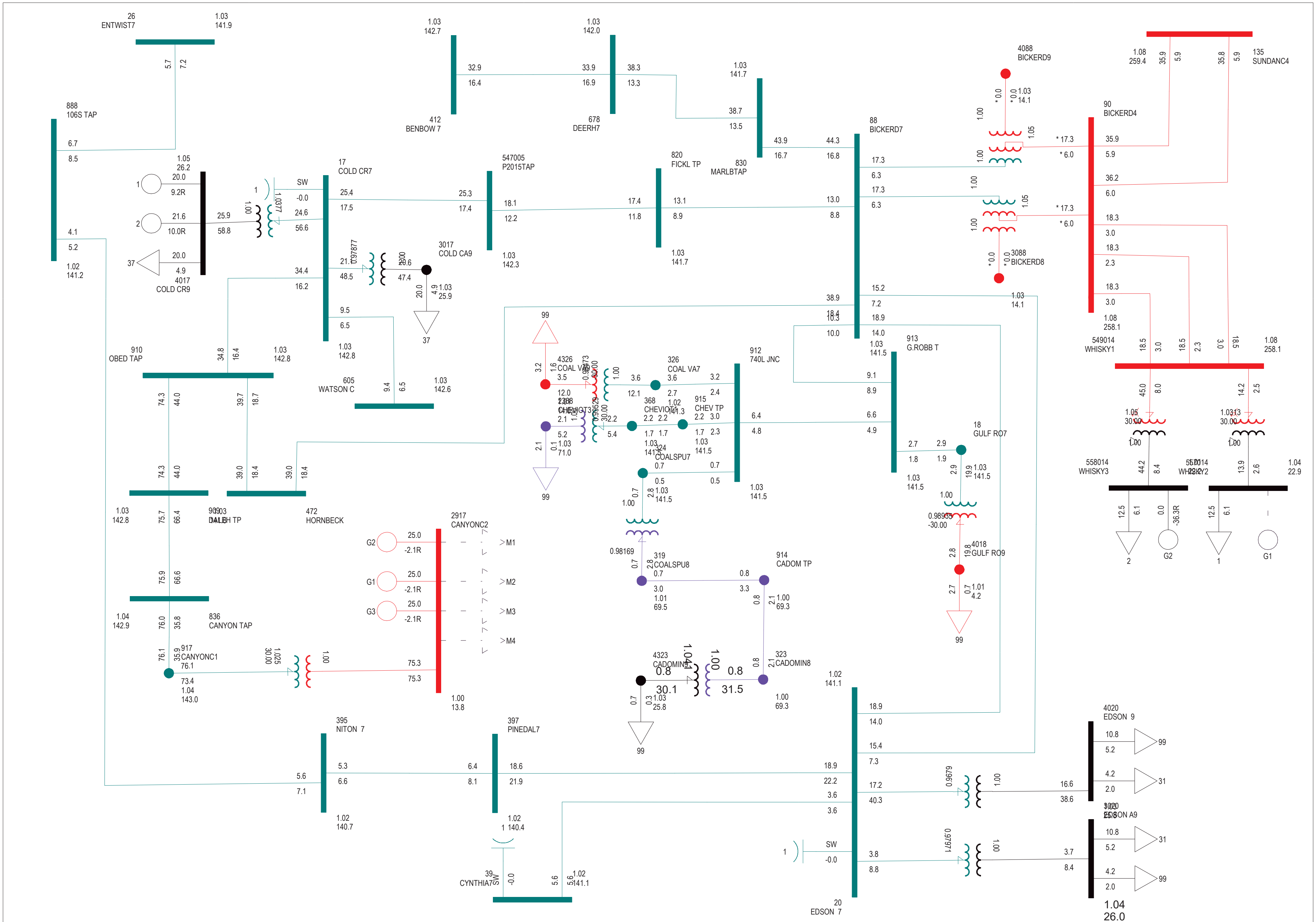
1

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
100.0%RATE1
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

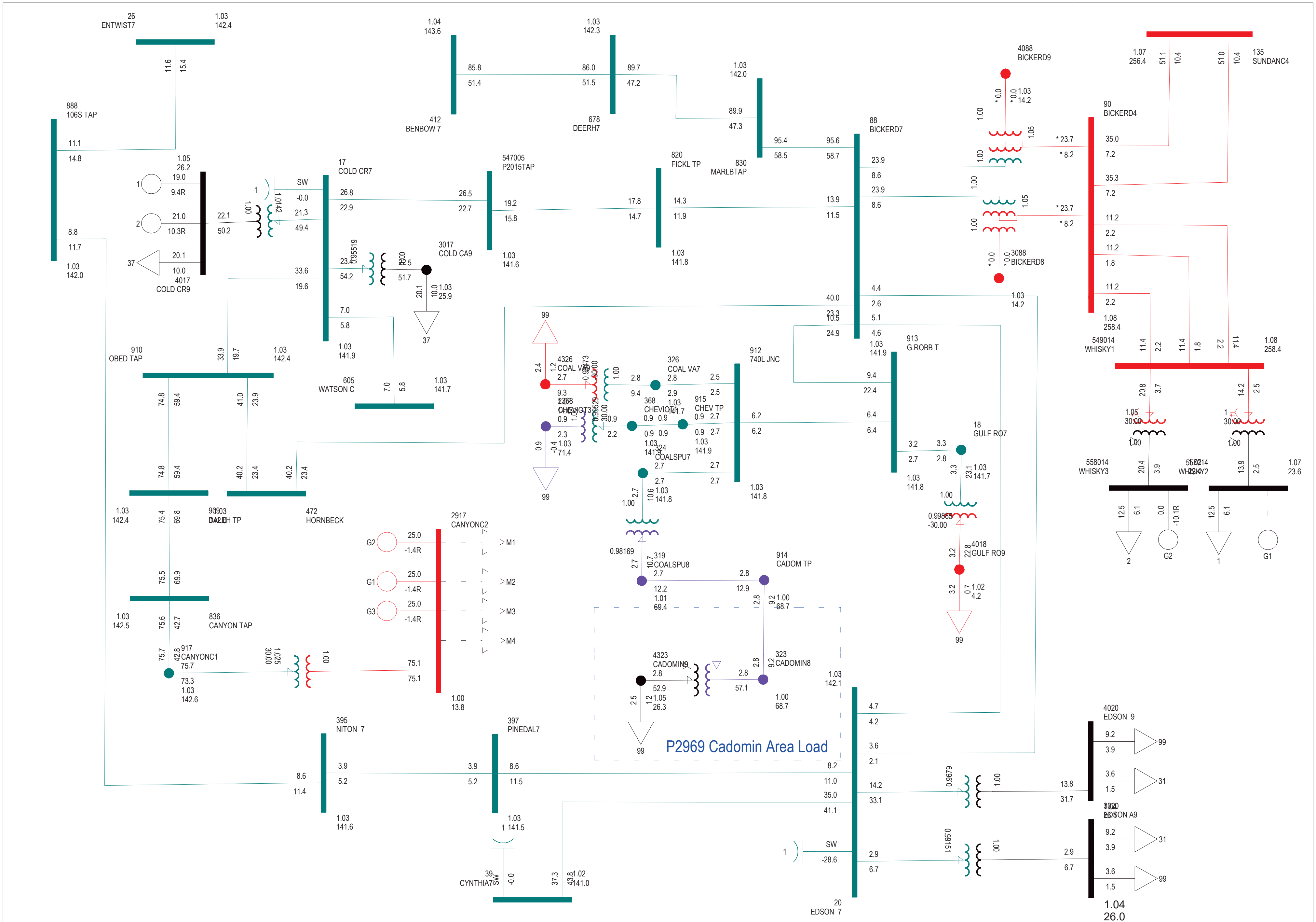


P2969 Cadomin Area Load

P2969 PRE-CONNECTION (2028WP)- DIAGRAM A-2
N-0: NORMAL OPERATION
THU, JUN 12 2025 13:16
New Diagram

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
100.0%RATE2
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment A3
Post-Project Power Flow Diagrams

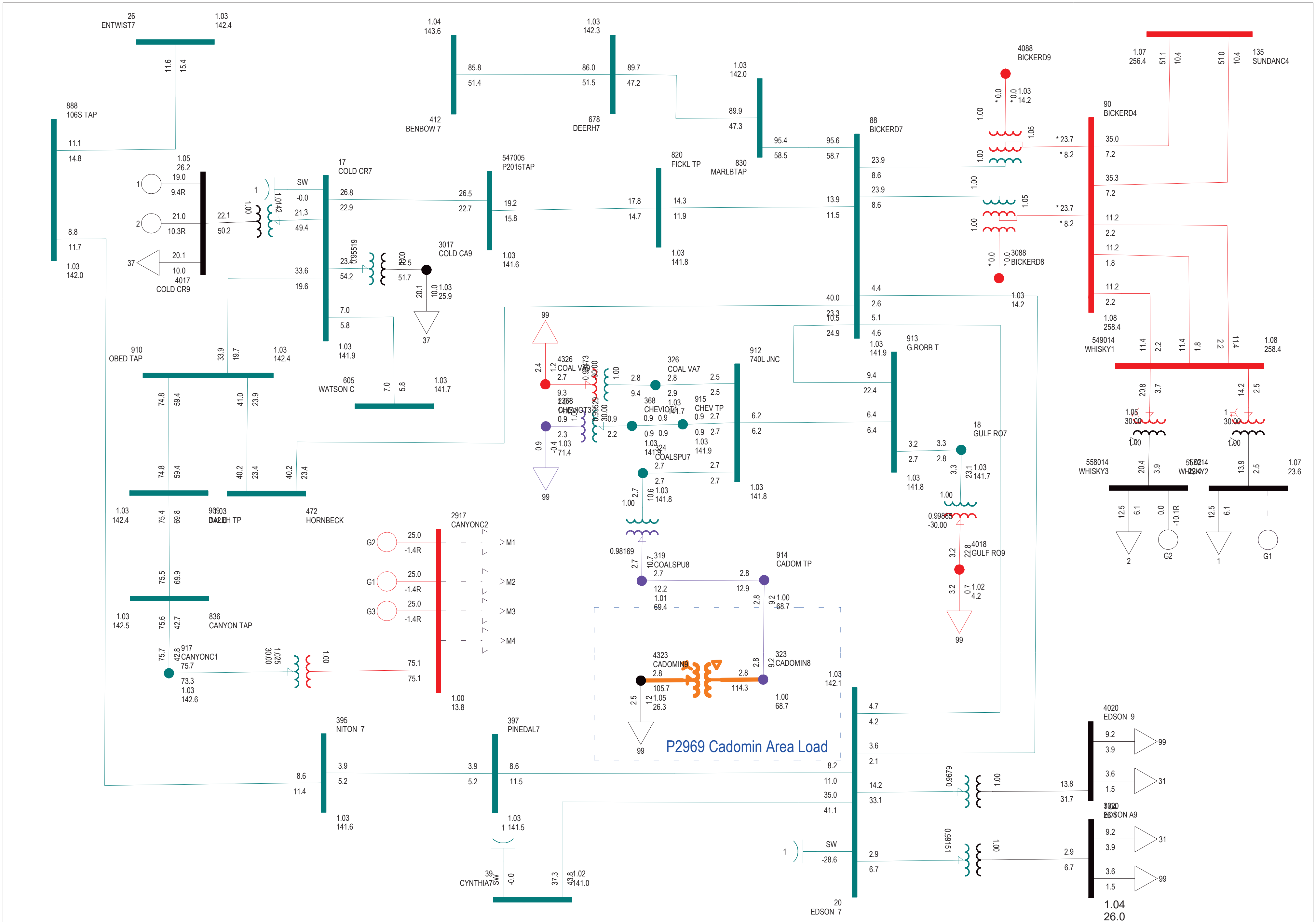


P2969 Cadomin Area Load

P2969 POST-CONNECTION (2028SP)- DIAGRAM B-1
N-0: NORMAL OPERATION (POST-UPGRADE)
THU, JUN 12 2025 13:19
New Diagram

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
100.0%RATE1
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

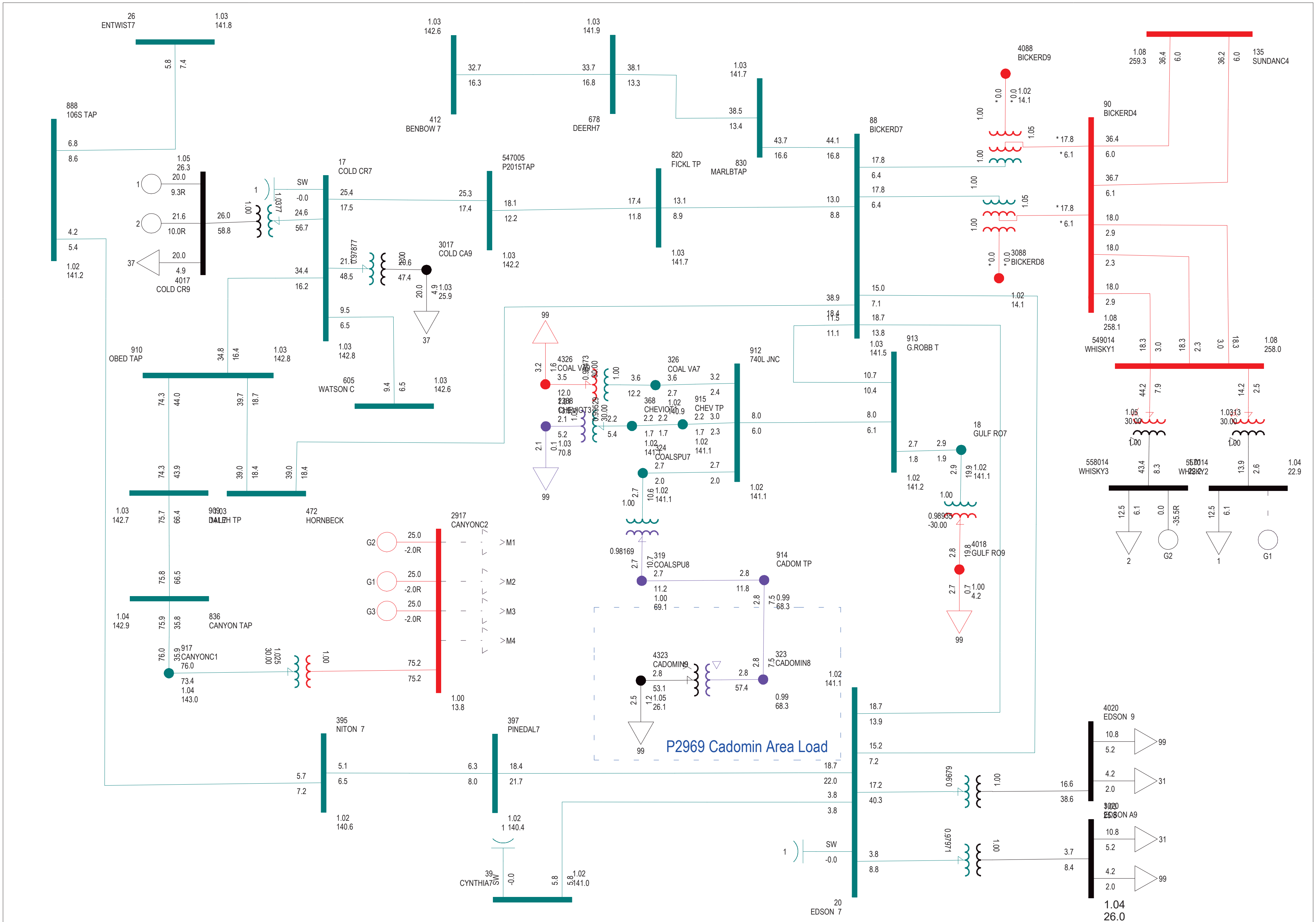
1



P2969 Cadomin Area Load

P2969 POST-CONNECTION (2028SP)- DIAGRAM B-2
N-0: NORMAL OPERATION (PRE-UPGRADE)
THU, JUN 12 2025 13:19
New Diagram

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
100.0%RATE1
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

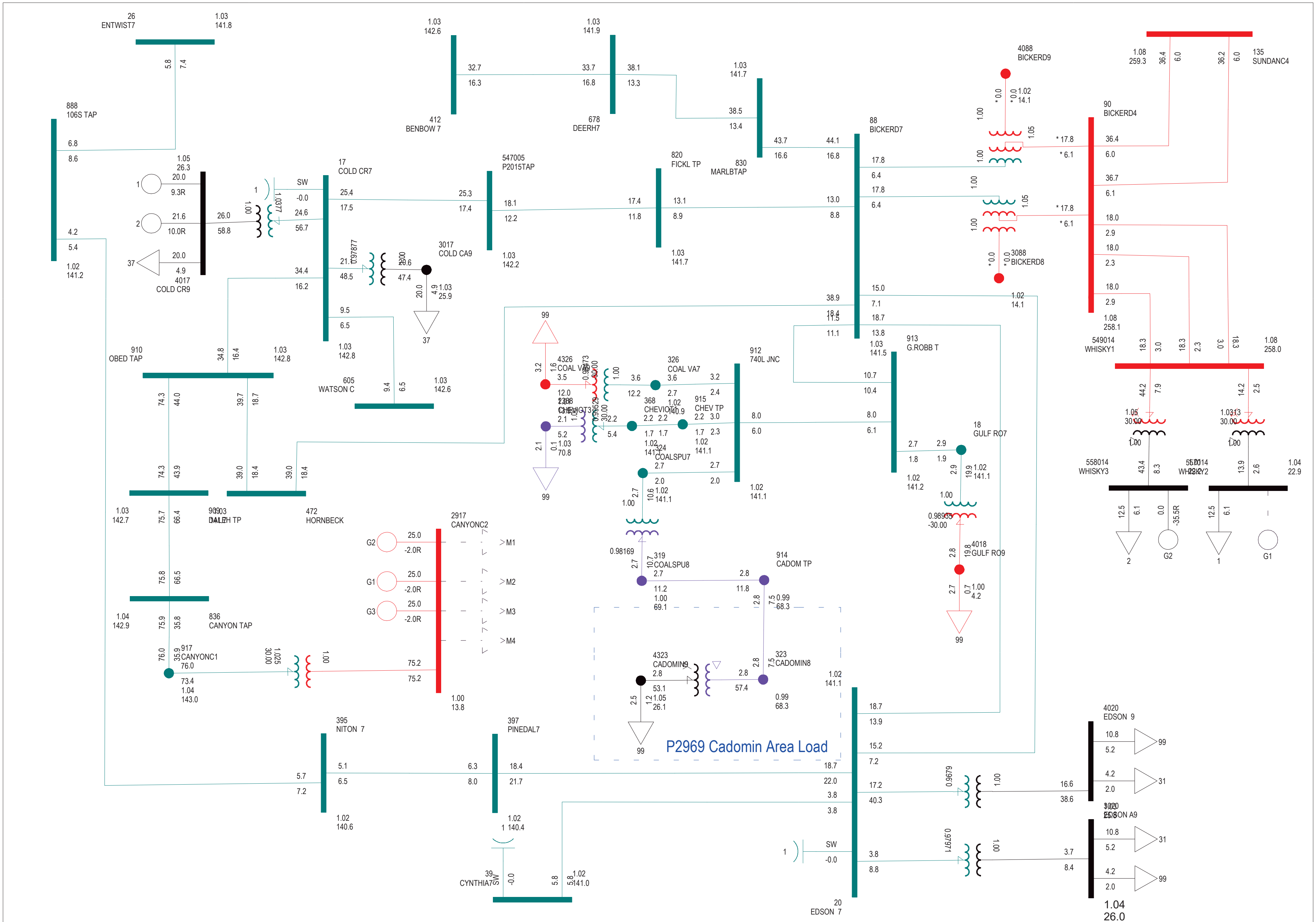


P2969 Cadomin Area Load

P2969 POST-CONNECTION (2028WP)- DIAGRAM B-3
N-0: NORMAL OPERATION (POST-UPGRADE)
THU, JUN 12 2025 13:19
New Diagram

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
100.0%RATE2
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

1

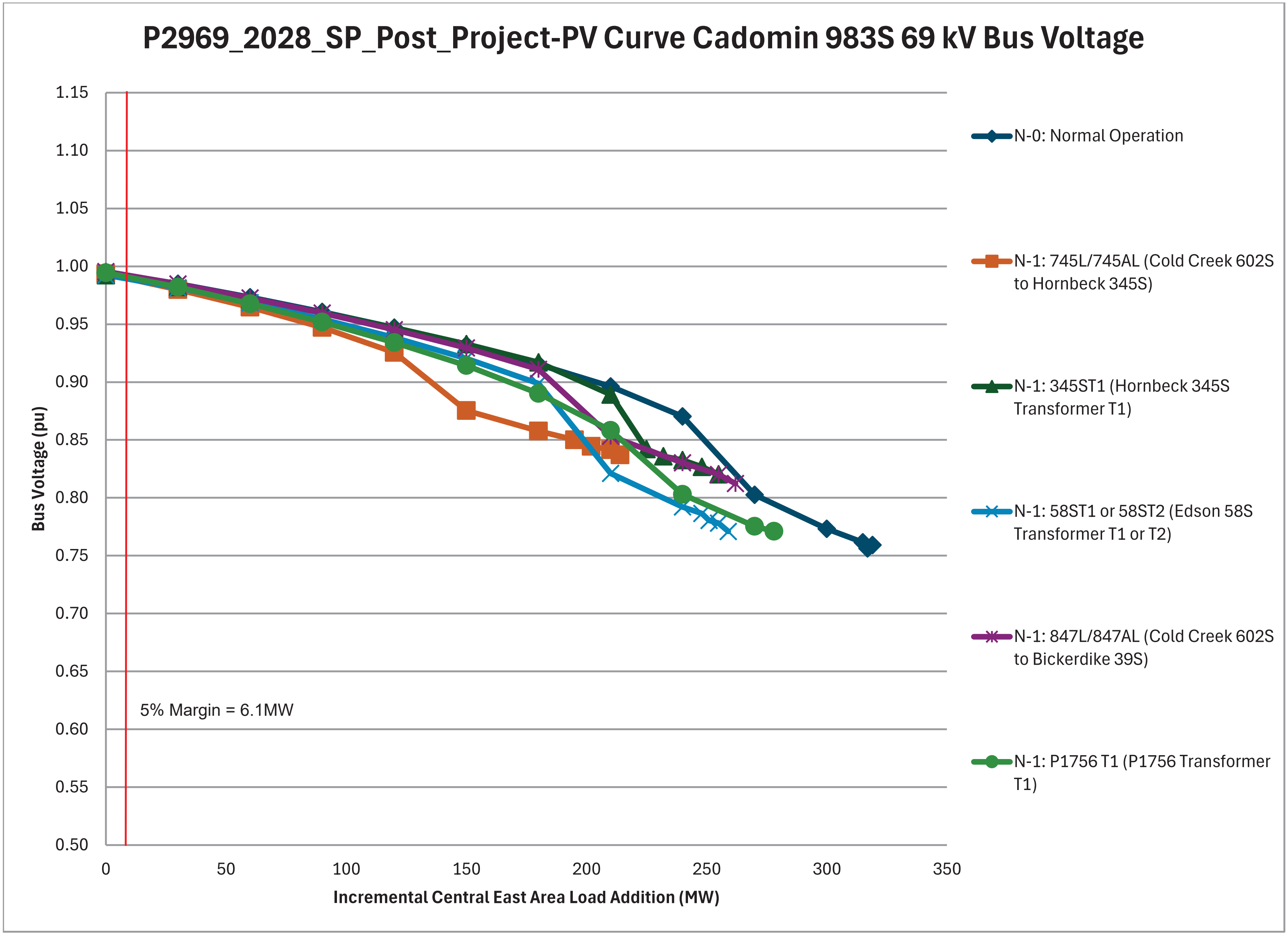


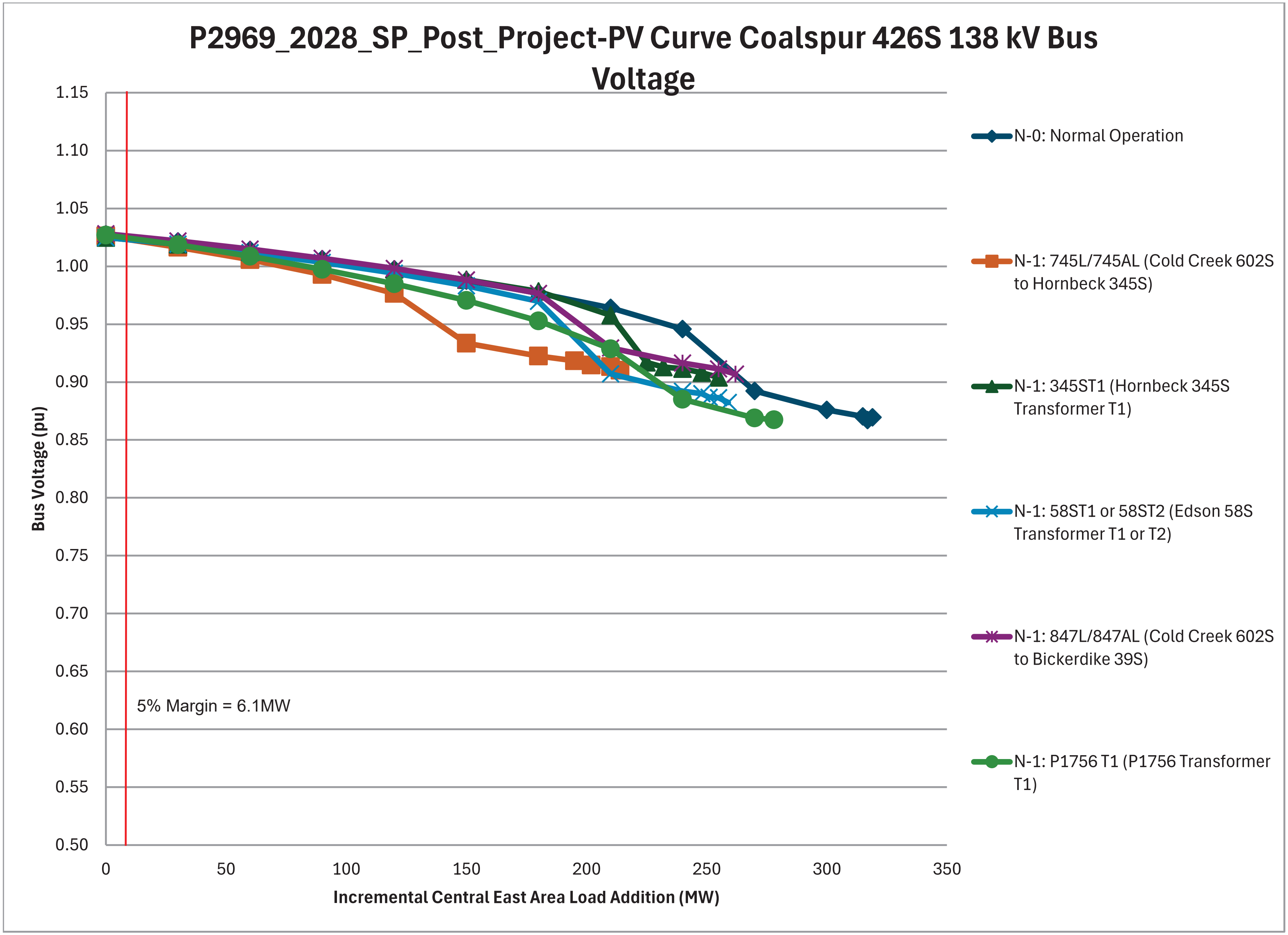
P2969 Cadomin Area Load

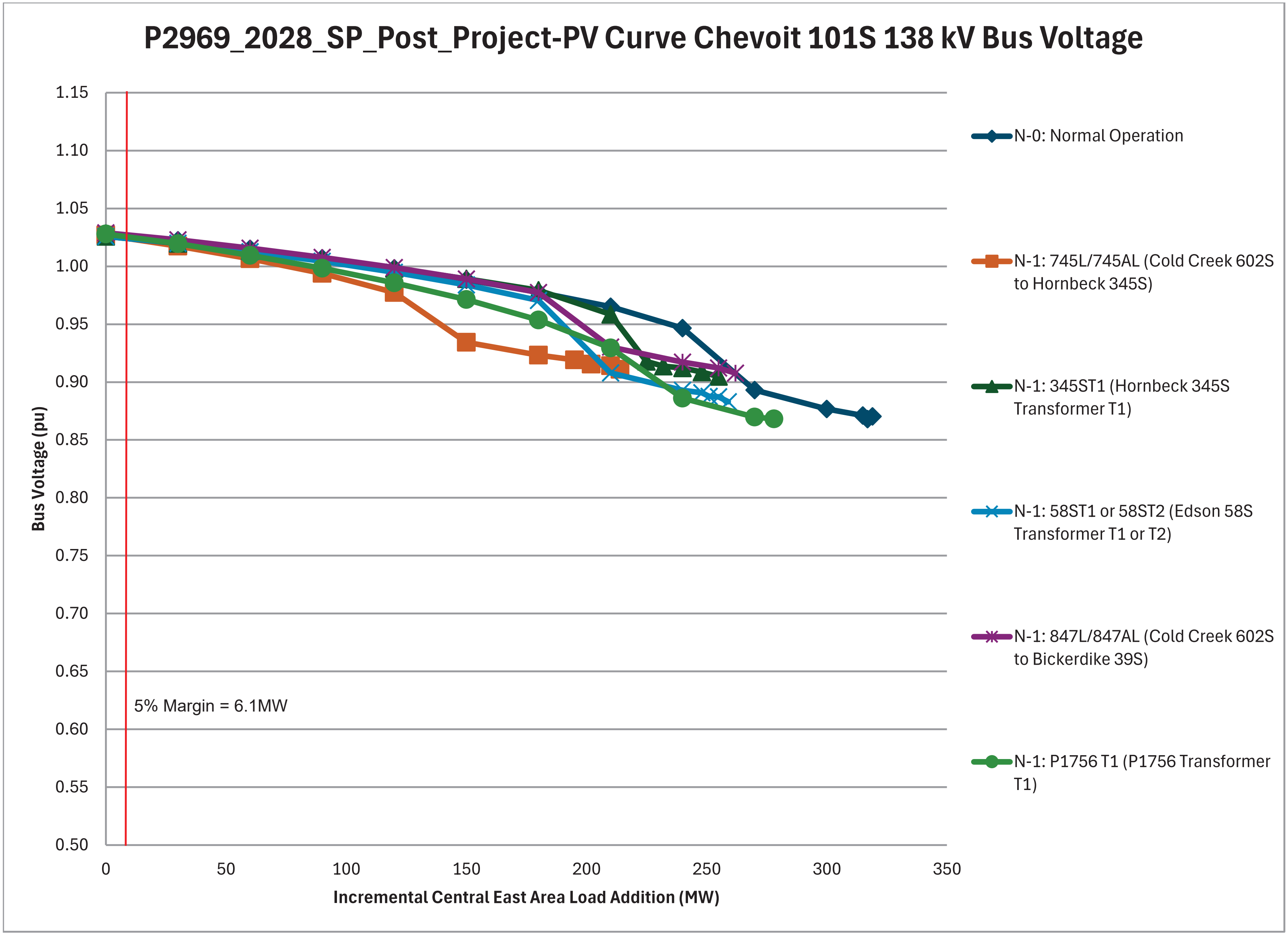
P2969 POST-CONNECTION (2028WP)- DIAGRAM B-4
N-0: NORMAL OPERATION (PRE-UPGRADE)
THU, JUN 12 2025 13:19
New Diagram

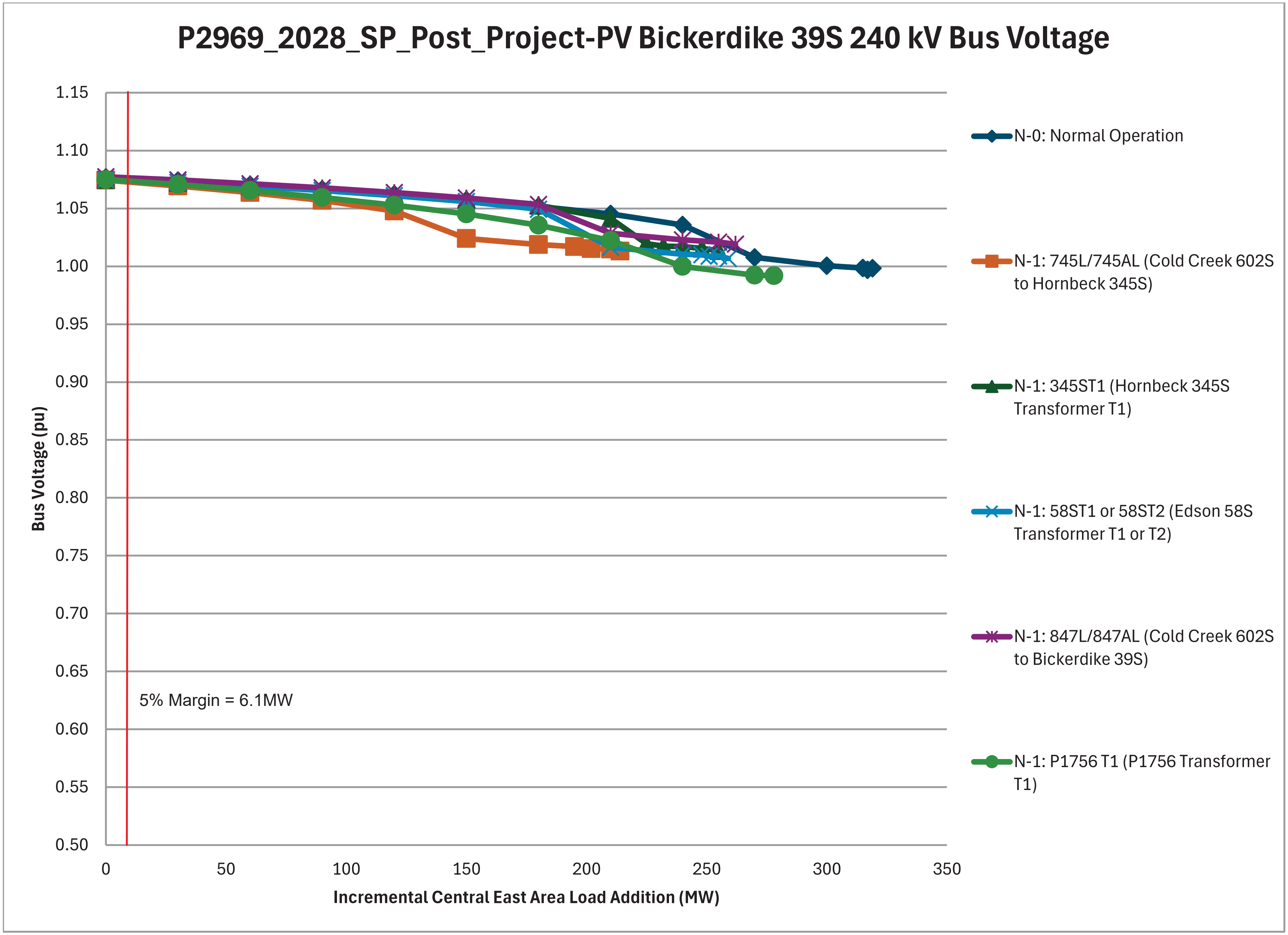
Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
100.0%RATE2
1.100OV 0.900UV
kV: >0.000 <=13.800 <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

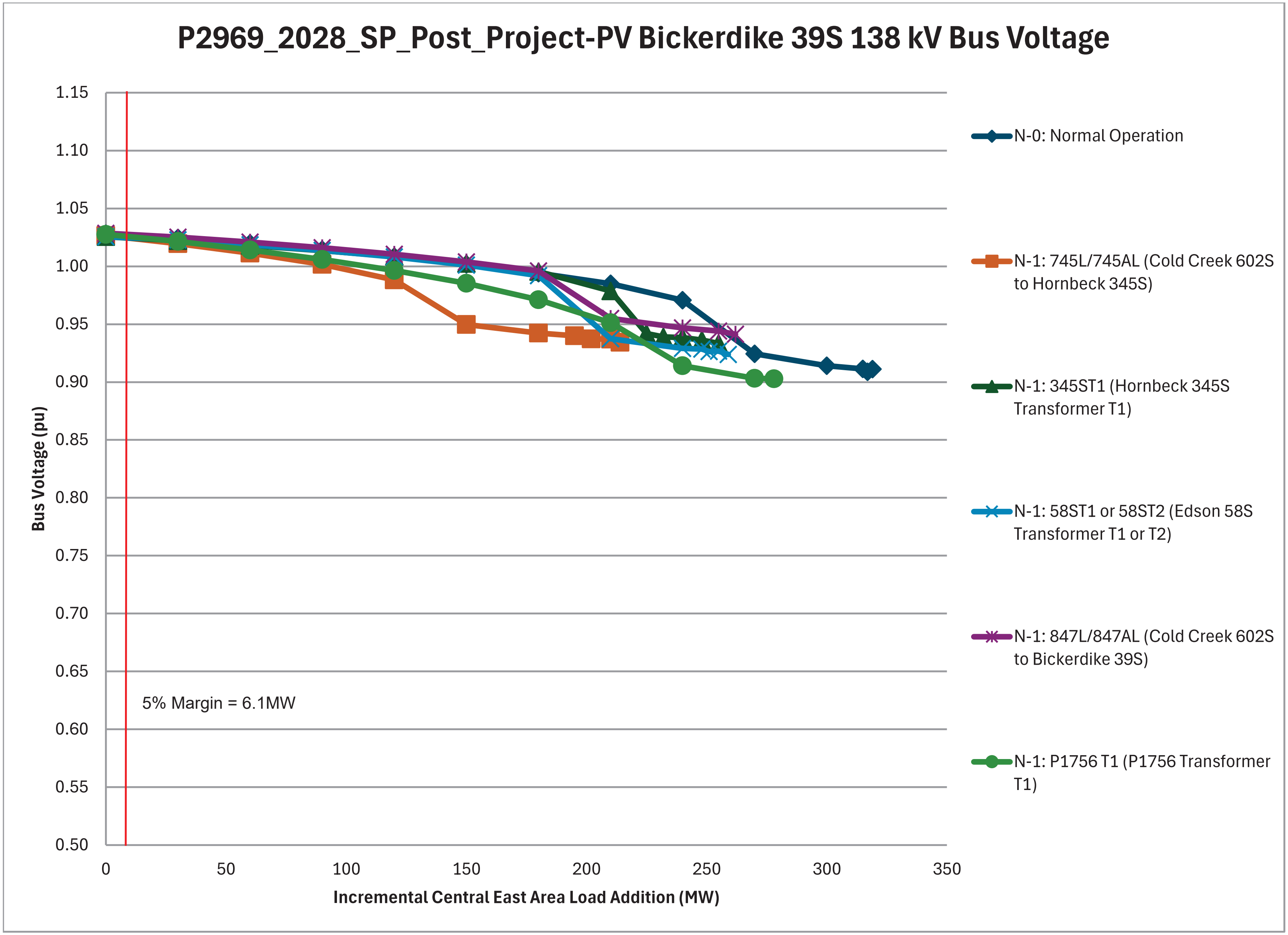
Attachment A4
Post-Project Voltage Stability Diagrams

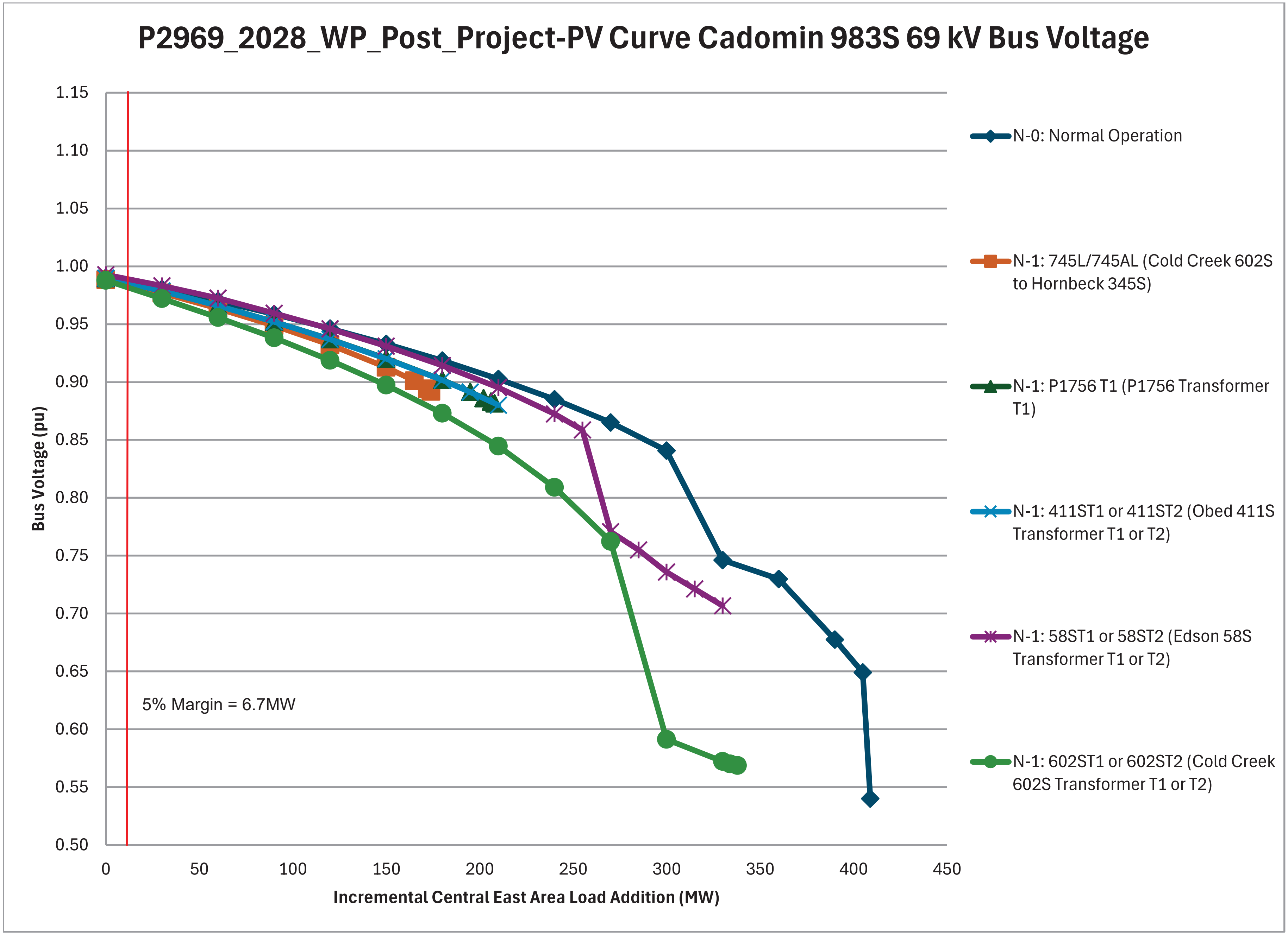

P2969_2028_SP_Post_Project-PV Curve Cadomin 983S 69 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
Incremental Central East Area Load Addition (MW)
5% Margin = 6.1MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: 345ST1 (Hornbeck 345S Transformer T1)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 847L/847AL (Cold Creek 602S to Bickerdike 39S)
N-1: P1756 T1 (P1756 Transformer T1)

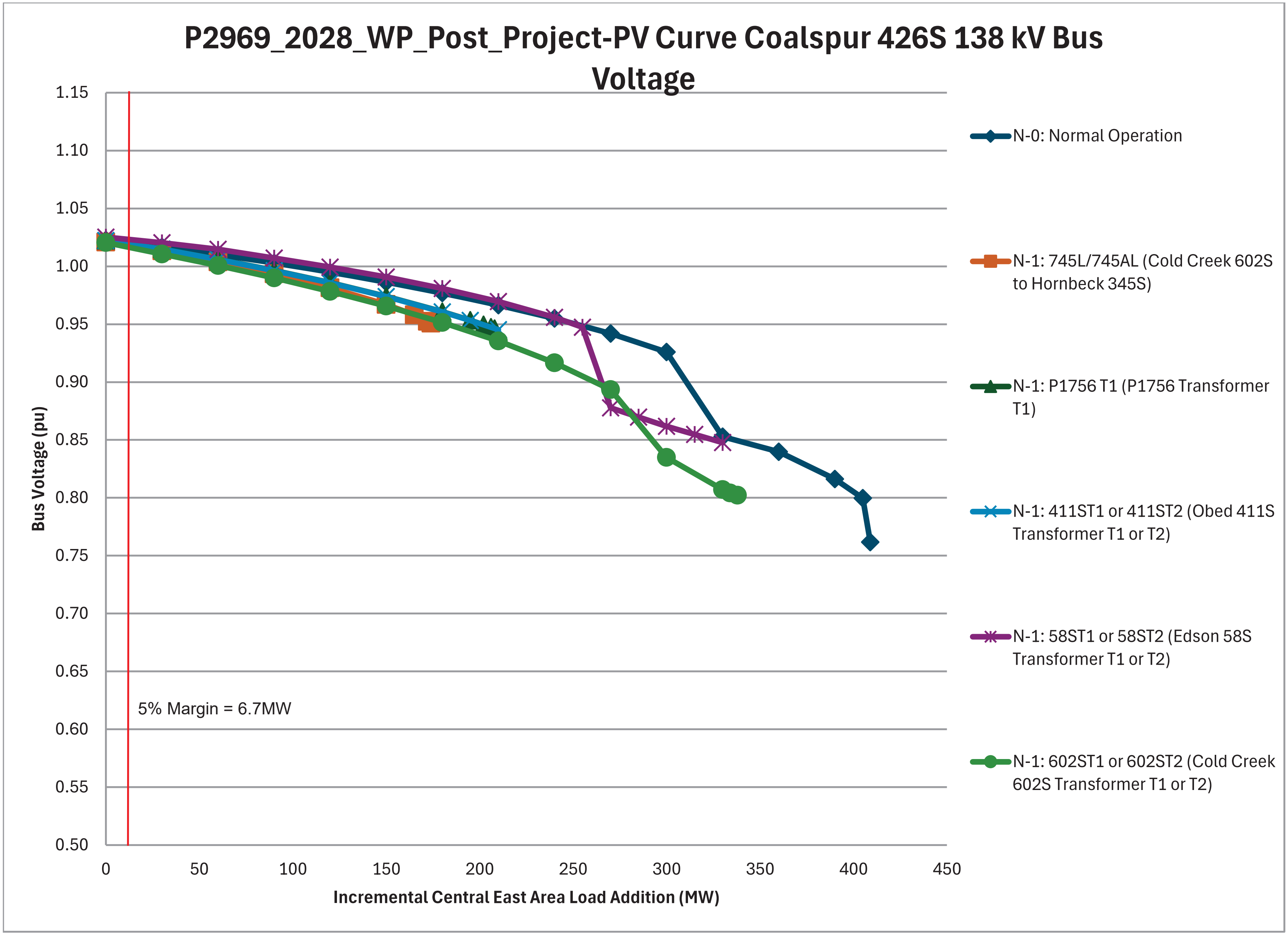

P2969_2028_SP_Post_Project-PV Curve Coalspur 426S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
Incremental Central East Area Load Addition (MW)
5% Margin = 6.1MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: 345ST1 (Hornbeck 345S Transformer T1)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 847L/847AL (Cold Creek 602S to Bickerdike 39S)
N-1: P1756 T1 (P1756 Transformer T1)

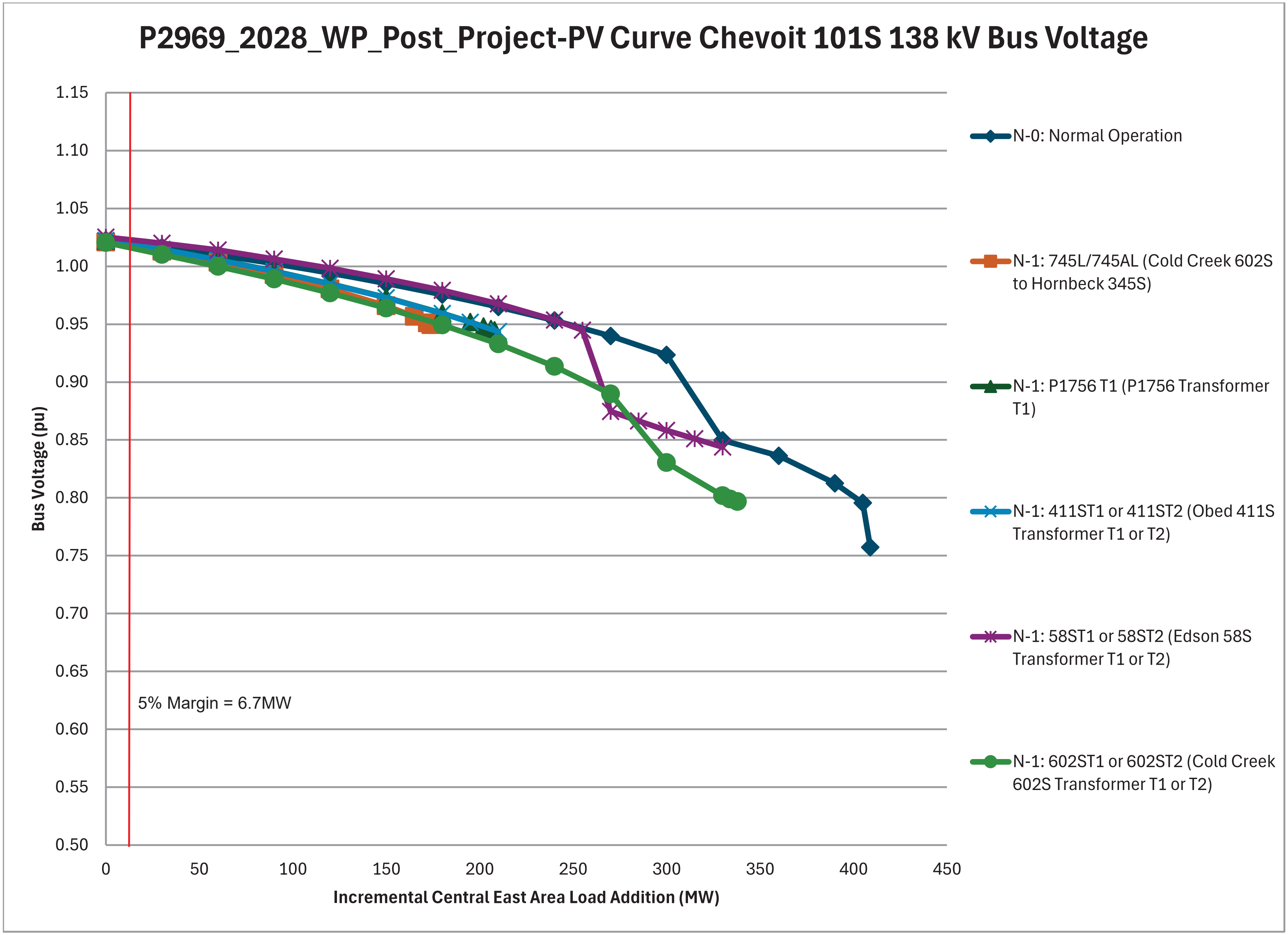

P2969_2028_SP_Post_Project-PV Curve Chevoit 101S 138 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
Incremental Central East Area Load Addition (MW)
5% Margin = 6.1MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: 345ST1 (Hornbeck 345S Transformer T1)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 847L/847AL (Cold Creek 602S to Bickerdike 39S)
N-1: P1756 T1 (P1756 Transformer T1)

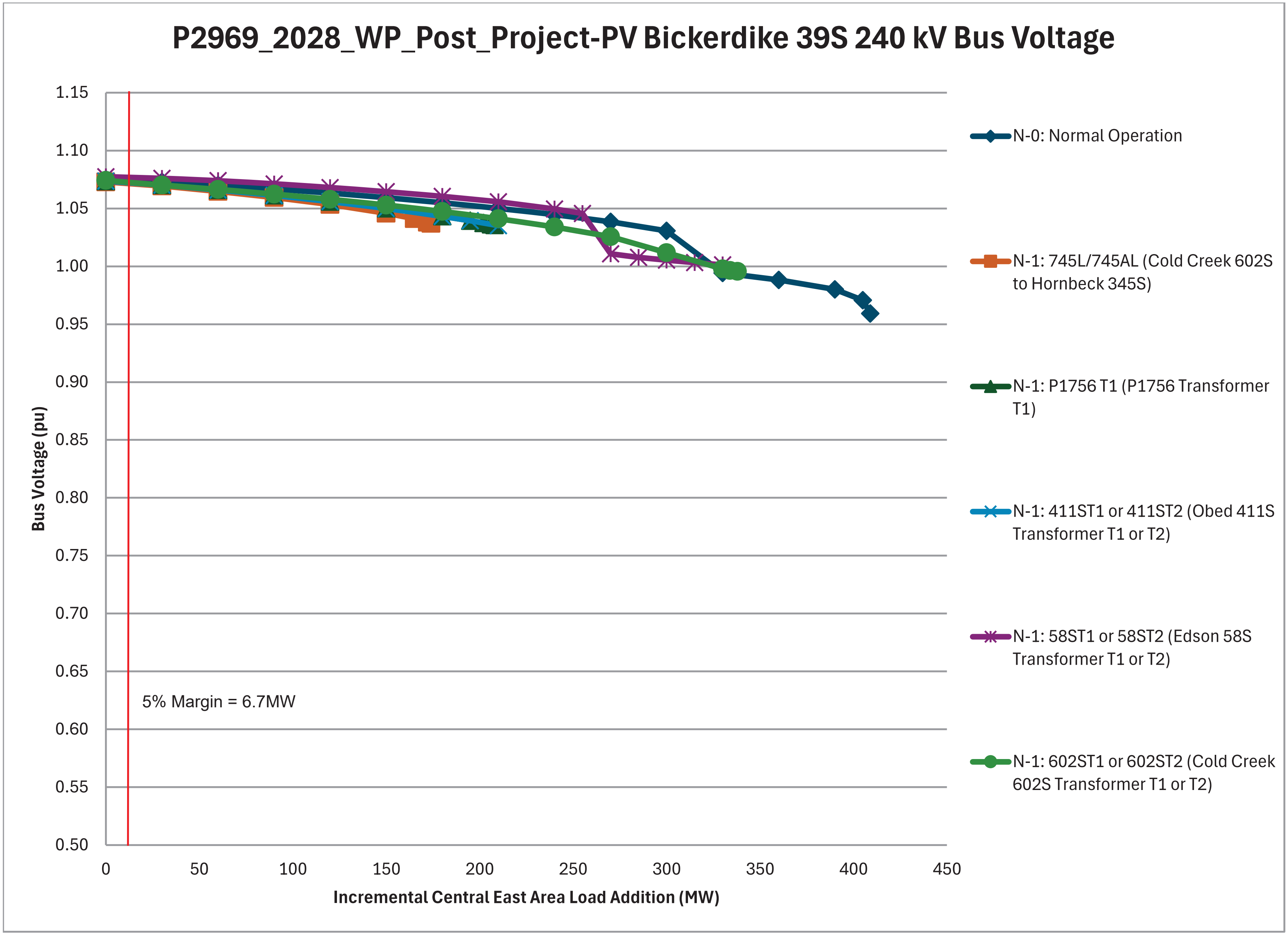

P2969_2028_SP_Post_Project-PV Bickerdike 39S 240 kV Bus Voltage
Bus Voltage (pu)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0
50
100
150
200
250
300
350
Incremental Central East Area Load Addition (MW)
5% Margin = 6.1MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: 345ST1 (Hornbeck 345S Transformer T1)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 847L/847AL (Cold Creek 602S to Bickerdike 39S)
N-1: P1756 T1 (P1756 Transformer T1)

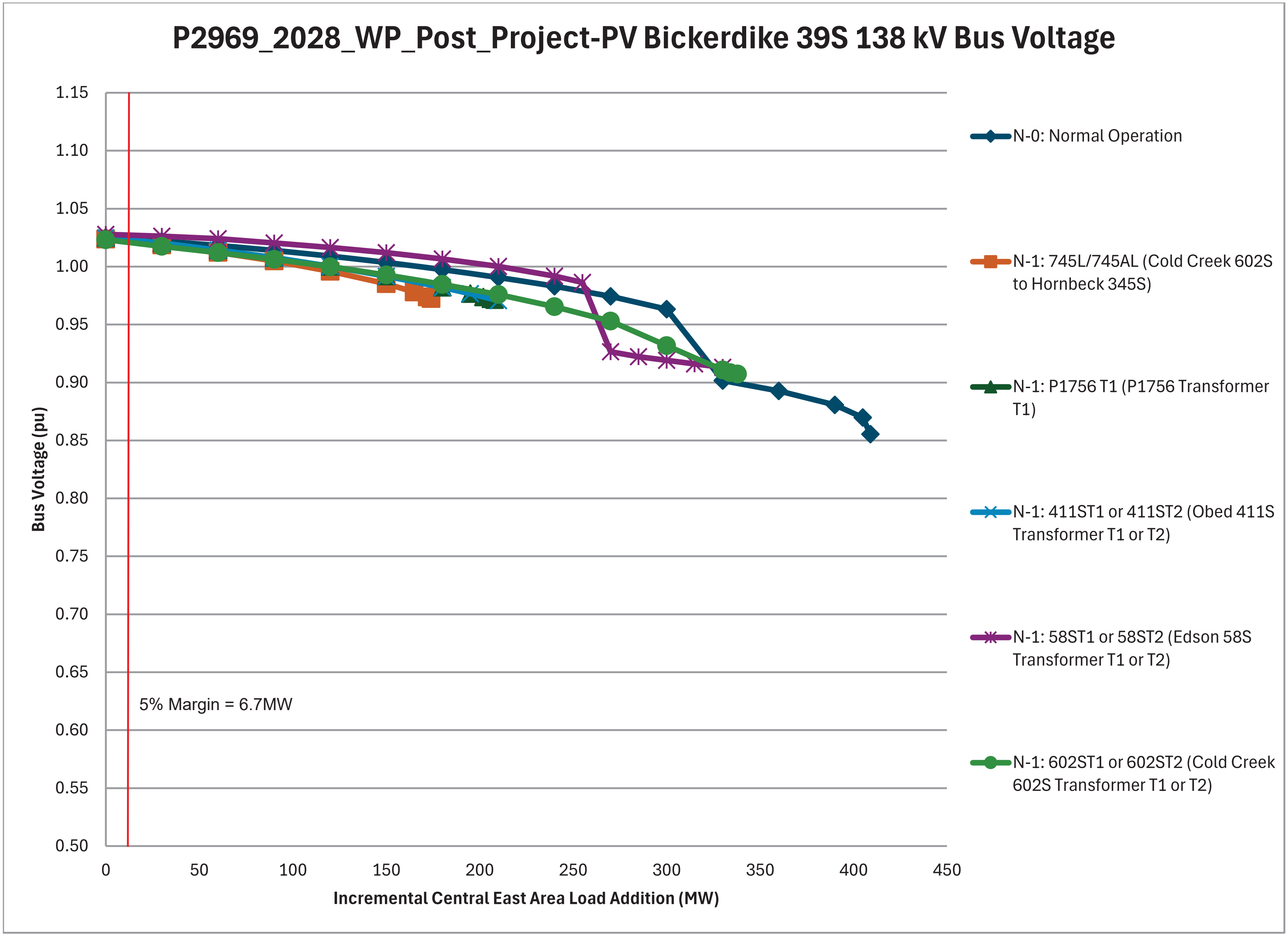

P2969_2028_SP_Post_Project-PV Bickerdike 39S 138 kV Bus Voltage
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Bus Voltage (pu)
0
50
100
150
200
250
300
350
Incremental Central East Area Load Addition (MW)
5% Margin = 6.1MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: 345ST1 (Hornbeck 345S Transformer T1)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 847L/847AL (Cold Creek 602S to Bickerdike 39S)
N-1: P1756 T1 (P1756 Transformer T1)


P2969_2028_WP_Post_Project-PV Curve Cadomin 983S 69 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)
5% Margin = 6.7MW
0
50
100
150
200
250
300
350
400
450
Incremental Central East Area Load Addition (MW)
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: P1756 T1 (P1756 Transformer T1)
N-1: 411ST1 or 411ST2 (Obed 411S Transformer T1 or T2)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 602ST1 or 602ST2 (Cold Creek 602S Transformer T1 or T2)


P2969_2028_WP_Post_Project-PV Curve Coalspur 426S 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
Incremental Central East Area Load Addition (MW)
5% Margin = 6.7MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: P1756 T1 (P1756 Transformer T1)
N-1: 411ST1 or 411ST2 (Obed 411S Transformer T1 or T2)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 602ST1 or 602ST2 (Cold Creek 602S Transformer T1 or T2)


P2969_2028_WP_Post_Project-PV Curve Chevoit 101S 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
Incremental Central East Area Load Addition (MW)
5% Margin = 6.7MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: P1756 T1 (P1756 Transformer T1)
N-1: 411ST1 or 411ST2 (Obed 411S Transformer T1 or T2)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 602ST1 or 602ST2 (Cold Creek 602S Transformer T1 or T2)


P2969_2028_WP_Post_Project-PV Bickerdike 39S 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
Incremental Central East Area Load Addition (MW)
5% Margin = 6.7MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: P1756 T1 (P1756 Transformer T1)
N-1: 411ST1 or 411ST2 (Obed 411S Transformer T1 or T2)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 602ST1 or 602ST2 (Cold Creek 602S Transformer T1 or T2)


P2969_2028_WP_Post_Project-PV Bickerdike 39S 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
Incremental Central East Area Load Addition (MW)
5% Margin = 6.7MW
N-0: Normal Operation
N-1: 745L/745AL (Cold Creek 602S to Hornbeck 345S)
N-1: P1756 T1 (P1756 Transformer T1)
N-1: 411ST1 or 411ST2 (Obed 411S Transformer T1 or T2)
N-1: 58ST1 or 58ST2 (Edson 58S Transformer T1 or T2)
N-1: 602ST1 or 602ST2 (Cold Creek 602S Transformer T1 or T2)