ENGINEERING CONNECTION ASSESSMENT

Engineering Connection Assessment

P2023 FortisAlberta Kananaskis Area Reliability

FortisAlberta Inc.

Date: September 21, 2018

Version: V1Final

Classification: Public

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NOTE:

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

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

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1 Introduction

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

Attached to this Engineering Connection Assessment are the results of the engineering studies (see Attachment A) and the scope and methodology used to perform the studies (see Attachment A1 to Attachment A). These attachments provide details regarding the technical criteria, assumptions, and methods for performing these engineering studies, and the results of the engineering studies.

1.1 Project Overview

FortisAlberta Inc. (FortisAlberta), 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 reliably serve load growth in the Kananaskis area.

The DFO's request includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of 4.6 MW, from 3.1 MW to 7.7 MW, for the system access service provided at the existing Mount Allan 115 substation, and a request for transmission development (collectively, the Project). Additional details supporting the DFO's request are provided in the DFO's Need for Development Kananaskis Area Upgrades (NFD) document[1] for the Project.

The scheduled in-service date (ISD) is November 1, 2019.

[1] FortisAlberta's *Need for Development Kananaskis Area Upgrades* is filed under a separate cover

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 Seebe (Area 44), which is part of the AESO South Planning Region. Seebe Area (Area 44) is surrounded by the planning areas of Abraham Lake (Area 34), Caroline (Area 38), Didsbury (Aea 39), Airdrie (Area 57), Calgary (Area 6) and High River (Area 46).

From a transmission system perspective, Seebe Area (Area 44) consists primarily of a 138 kV transmission system. Seebe Area (Area 44) is connected to Airdrie Area (Area 57) through the 138 kV transmission line 418L, to British Columbia (BC Hydro) through the 138 kV transmission line 777L and to Calgary Area (Area 6) through the 138 kV transmission lines 860L, 150L, and 3L.

Existing constraints in the South 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 Seebe (Area 44), including the tie lines connecting this planning area to the rest of the AIES. All transmission facilities within the Study Area will be studied and monitored for violations of the Reliability Criteria (defined in Section 3.1 of Attachment A1).

3 Connection Alternatives

3.1 Overview

The AESO, in consultation with the TFO in the Study Area and the DFO, examined five transmission alternatives to meet the DFO's request for system access service, as detailed in Section 3.2.[2] In addition to the alternatives considered by the AESO, the DFO identified one technically viable distribution alternative.[3]

The existing Mount Allan 115S substation includes two 138/25 kV transformers: T1 is a 6 MVA OLTC transformer that has been assessed by the TFO as nearing end of life and is normally de-energized, T2 is a 10 MVA OLTC transformer.

3.2 Connection Transmission Alternatives Examined

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

Alternative 1 – Upgrade the Mount Allan 115S substation, including adding a Voltage Regulator

This alternative includes the following developments:

- Upgrade the Mount Allan 115S substation, including adding one 25 kV voltage regulator with a minimum transformation capacity of 6 MVA, two 138 kV circuit breakers, and two 25 kV circuit breakers
- Add or modify associated equipment, as required for the above transmission developments

The DFO has advised that Alternative 1 would require the addition of 26 km of distribution feeders.

Alternative 2A – Upgrade the Mount Allan 115S substation, including adding a higher capacity transformer

This alternative includes the following developments:

- Discontinue from use for transmission purposes the existing 6 MVA transformer T1 at Mount Allan 115S substation
- Upgrade the existing Mount Allan 115S substation, including adding one 138/25 kV LTC transformer of higher capacity, two 138 kV circuit breakers, and two 25 kV circuit breakers

[2] These alternatives reflect more up to date engineering design than the alternatives identified in FortisAlberta's NFD.

[3] The distribution alternative identified by the DFO is described in Section 5.1 of FortisAlberta's *Need for Development Kananaskis Area Upgrades* (NFD).

- Add or modify associated equipment, as required for the above transmission developments

The DFO has advised that Alternative 2A would also require the addition of approximately 0.9 km of single-circuit underground distribution feeder.

Alternative 2B: Modify the Mount Allan 115S substation after Capital Maintenance

This alternative includes the following developments:

- Modify the Mount Allan 115S substation, including adding two 138 kV circuit breakers, and two 25 kV circuit breakers
- Add or modify associated equipment, as required for the above transmission developments

This alternative is dependent upon the execution of the scope proposed in the TFO's 2019-2021 General Tariff Application,[4] which would include:

- Discontinue from use for transmission purposes the existing 6 MVA transformer T1 at Mount Allan 115S substation
- Upgrade the existing Mount Allan 115S substation, including adding one 138/25 kV LTC 10 MVA transformer

The DFO has advised that Alternative 2B would also require the addition of approximately 0.9 km of single-circuit underground distribution feeder.

Alternative 3 – Upgrade the Pocaterra 48S substation, including adding a 138/25 kV transformer

This alternative includes the following developments:

- Upgrade the existing Pocaterra 48S substation, including adding one 138/25 kV LTC transformer, one 138 kV circuit breaker, and one 25 kV circuit breaker
- Add or modify associated equipment, as required for the above transmission developments.

The DFO has advised that Alternative 3 would also require upgrading approximately 31 km of three-phase distribution feeders.

Alternative 4 – Upgrade the Mount Allan 115S substation, including adding a 6 MVA LTC transformer

This alternative includes the following developments:

- Discontinue from use for transmission purposes the existing 6 MVA transformer T1 at Mount Allan 115S substation
- Upgrade the Mount Allan 115S substation, including adding one 138/25 kV 6 MVA LTC transformer, two 138 kV circuit breakers, and two 25 kV circuit breakers
- Add or modify associated equipment, as required for the above transmission developments

The DFO has advised that Alternative 4 would require the addition of 26 km of distribution feeders.

[4] The TFO's 2019-2021 General Tariff Application was registered with the Alberta Utilities Commission on August 23, 2018 in Proceeding 23848

3.3 Connection Transmission Alternatives Selected for Further Study

Alternative 2A was selected for further study.

3.4 Connection Transmission Alternatives Not Selected for Further Study

The TFO has advised that existing Mount Allen 115S substation transformer T1 is nearing end of life and is not suitable for long term continuous loading. Therefore Alternative 1 was not selected for further study.

The TFO has advised that Alternative 2B may not meet the DFO's requested ISD due to the dependency on execution of the scope proposed in the TFO's *2019-2021 General Tariff Application*. Therefore, Alternative 2B is not considered further.

Alternative 3 would involve increased overall development and hence, increased cost, compared to Alternative 2A. Therefore, Alternative 3 was not selected for further study.

Alternative 4 was not selected for further study because the TFO advised that the addition of a 6 MVA transformer would not be consistent with its current asset management and inventory practices.

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 November 1, 2019. Therefore, studies were performed using scenarios for 2019 Winter Peak (WP) and 2020 Summer Peak (SP).

Table 4-1 lists the study scenarios. Post-Project scenarios reflect the requested Rate DTS contract capacity increase of 4.6 MW at the Mount Allen 115S 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	2019 WP	Low local generation dispatch	2019 WP Pre-project	3.1	0
2	2020 SP	Low local generation dispatch	2020 SP Pre-project	3.1	0
Post-Project					
3	2019 WP	Low local generation dispatch	2019 WP Post-project	7.7	0
4	2020 SP	Low local generation dispatch	2020 SP Post-project	7.7	0

The AESO Planning Region load forecasts used for the connection studies were based on the AESO's 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.[5]

[5] 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.

Power flow studies were performed for 2019 WP and 2020 SP pre-Project scenarios, and for 2019 WP and 2020 SP 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 2019 WP post-Project scenario.

5 Interpretation of Results

The detailed study results are provided in Attachment A.

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.

5.1.2 Category B Conditions

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

5.2 Post-Project Study Results

5.2.1 Category A Conditions

No Reliability Criteria violations were observed under the Category A conditions for any of the post-Project scenarios.

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 2A is technically viable. The connection assessment did not identify any system performance issues in the pre-Project or post-Project scenarios.

Cost estimates prepared by the TFO and DFO indicate that Alternative 2A has a lower estimated total cost than the distribution alternative identified by the DFO.[6] While both Alternative 2A and the distribution alternative are technically viable, Alternative 2A is the preferred alternative based on total cost.

The AESO recommends proceeding with the Project using Alternative 2A as the preferred alternative to respond to the DFO's request for system access service.

Alternative 2A involves upgrading the Mount Allan 115S substation, including discontinuing from use for transmission purposes the existing 6 MVA transformer T1, and adding a 138/25 kV LTC transformer with higher capacity, two 138 kV circuit breakers, two 25 kV circuit breakers and associated equipment.

It is recommended that the proposed 138/25 kV LTC transformer at Mount Allan 115S substation have a minimum transformation capacity of 8.6 MVA to meet the DFO's requested Rate DTS contract capacity increase and the DFO's distribution system planning criteria for electrical load restoration.

[6] Cost estimates for the distribution alternative and Alternative 2 are provided under separate cover.

Attachment A: Engineering Connection Assessment: Study Results

Engineering Connection Assessment: Study Results

P2023 FortisAlberta Kananaskis Area Reliability

FortisAlberta Inc.

Date: September 20, 2018

Version: V2Final

Classification: Public

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1 Introduction

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

The power system network analysis tool that was used for the studies in this connection assessment was PSS/E version 33.

2 Pre-Project Study Results

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

2.1 Power Flow Studies

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

2.1.1 Scenario 1: 2019 Winter Peak Pre-Project

Category A Conditions

No Reliability Criteria (as defined in Section 3.1 of Attachment A1) 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 A conditions.

Category B Conditions

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

2.1.2 Scenario 2: 2020 Summer Peak Pre-Project

Category A Conditions

No Reliability Criteria (as defined in Section 3.1 of Attachment 2.2) violations were observed under Category A conditions.

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 studies and voltage stability studies. As described in Section 2 of Attachment 2.2, the post-Project studies were performed using Alternative 2A.

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: 2019 Winter Peak Post-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

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

3.1.2 Scenario 4: 2020 Summer Peak Post-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

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

3.2 Voltage Stability Studies

3.2.1 Scenario 3: 2019 Winter Peak Post-Project

Voltage stability analysis was performed for the 2019 WP Post Project scenario. The reference load level for the Study Area is 148.51 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 7.43 MW (0.05 x 148.51 MW = 7.43 MW), in order to meet the voltage stability criteria.

Table 3-1 provides the voltage stability study results under the Category A condition and for the five worst contingencies under Category B conditions. The voltage stability diagrams are provided in Attachment A4.

The voltage stability margin was met for all studied conditions.

Table 3-1: Voltage Stability Study Results for the 2019 WP Post Project Scenario

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	System Normal		180	Yes
84L	Rundle Plant 35S	Spray Plant 33S	150	Yes
29ST1	Cascade Plant 29S, 138/13.2 kV transformer T1		160	Yes
33ST1	Spray Plant 33S, 138/13.2 kV transformer T1		160	Yes
860L	Cochrane 291S	Bearspaw Plant 44S	165	Yes
3L	Springbank 272S	Sarcee 42S	165	Yes

.

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

Engineering Connection Assessment: Study Scope

P2023 FortisAlberta Kananaskis Area Reliability

FortisAlberta Inc.

Date: **September 20, 2018**

Version: **V2Final**

Classification: Public

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1 Introduction

This Study Scope provides an overview of the engineering studies to be completed by AltaLink Management Ltd. (the Studies Consultant) to assess the impact of the Project 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

FortisAlberta Inc. (FortisAlberta), 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 reliably serve existing load and load growth in the Kananaskis area.

The DFO's request includes a request for a Rate DTS*, Demand Transmission Service*, contract capacity increase of 4.6 MW, from 3.1 MW to 7.7 MW, for the system access service provided at the existing Mount Allan 115S substation and a request for transmission development (collectively, the Project).

The scheduled in-service date (ISD) for the Project is November 1, 2019.

The load components of the Project are listed in Table 1-1. There are no generation components for the Project.

Table 1-1: Project Load Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	3.1 MW at Mount Allan 115S
	Requested Rate DTS	An increase of 4.6 MW to 7.7 MW
	Type	Residential and commercial
	Motors (number and size)	No motor is greater than 500 hp
	Power factor	0.9 lagging
	Future load expansion plans	Not at this time

1.2 Existing System Overview

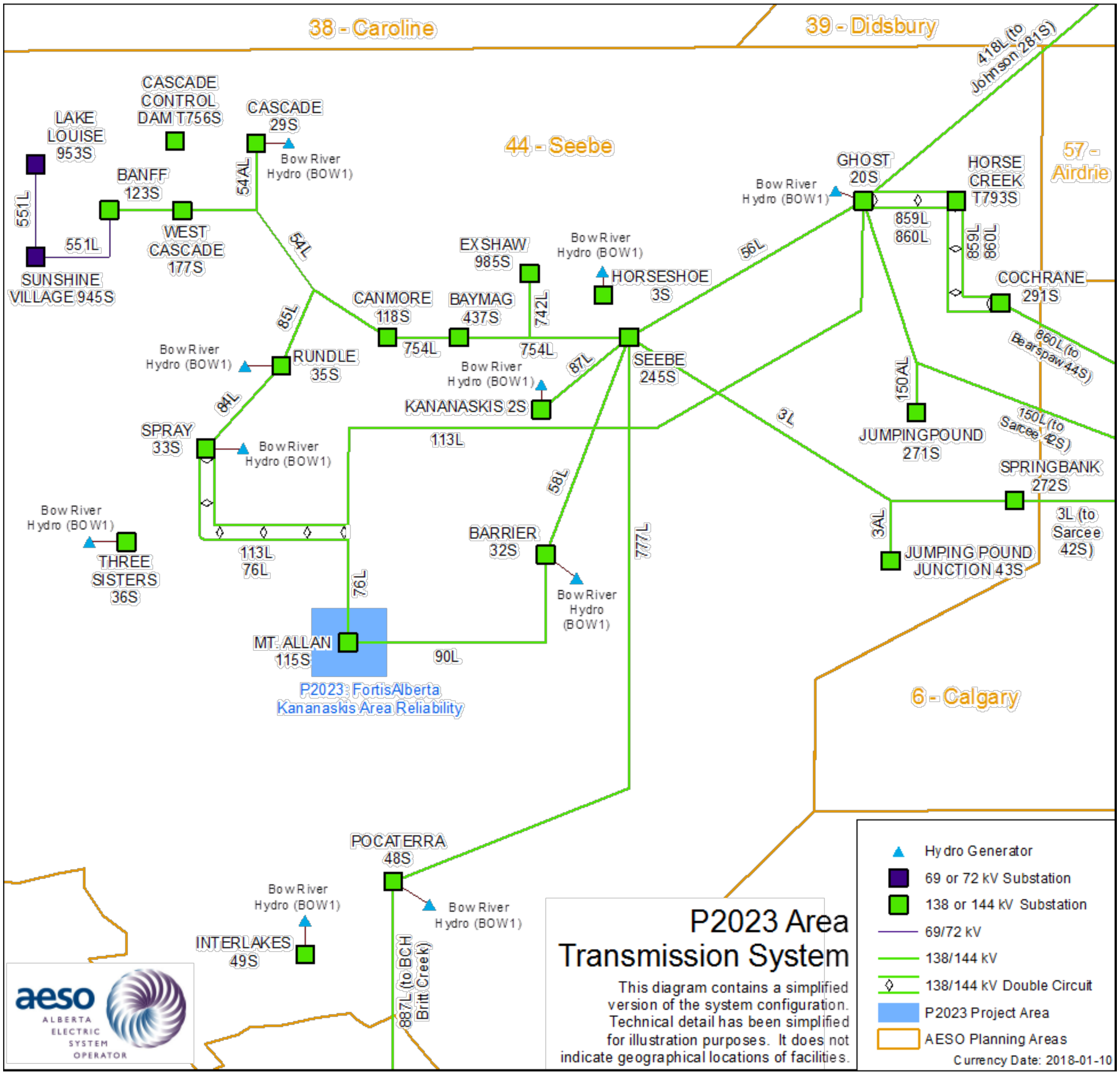
1.2.1 Study Area

Geographically, the Project is located in the AESO planning area of Seebe (Area 44), which is part of the AESO South Planning Region.

The Study Area consists of the AESO planning area Seebe (Area 44).

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

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



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).

The following existing RASs are used to manage constraints in the area:

- 45 - Ghost (T20S) and Seebe (T245S) Bow Hydro Islanding
- 102 - Bearspaw (T44S) Hydro Islanding Scheme
- 103 - Pocaterra (T48S) and Interlakes (49S) Hydro Islanding Scheme

2 Connection Alternative to be Studied

The following alternative will be studied:

2.1 Alternative 2A – Upgrade the existing Mount Allan 115S substation, including adding a higher capacity transformer

This alternative involves the following developments:

- Discontinue from use for transmission purposes the existing 6 MVA transformer T1 at Mount Allan 115S substation
- Upgrade the existing Mount Allan 115S substation, including adding one 138/25 kV LTC transformer of higher capacity, two 138 kV circuit breakers, and two 25 kV circuit breakers
- Add or modify associated equipment, as required for the above transmission developments

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.*
- 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 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 Sections 502.5 and 502.6 of the ISO rules as they relate to Generating Unit Technical and 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	2019 Winter Peak (WP)	Low local generation dispatch	2019 WP Pre-project	3.1	0
2	2020 Summer Peak (SP)	Low local generation dispatch	2020 SP Pre-project	3.1	0
Post-Project					
3	2019 WP	Low local generation dispatch	2019 WP Post-project	7.7	0
4	2020 SP	Low local generation dispatch	2020 SP Post-project	7.7	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 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 AESO Connection Queue.

4.2.3 Load Assumptions

The load forecast to be used for the studies is shown in Table 4-2 and is based on the AESO's 2017 Long-term Outlook (2017 LTO)[1] at the AESO South Planning Region peak. For the studies, when loads for the Alberta Internal Load (AIL) are modified to align with the load forecast in the 2017 LTO, the active power to reactive power ratio in the base case scenarios will be maintained.

Table 4-2: Forecast Area Peak Load (2017 LTO at AESO South Planning Region Peak)

AESO Planning Area or Region Name	Forecast Peak Load by Year/Season (MW)	
	2019 WP	2020 SP
South Planning Region[a]	1359	1397

Note:
[a] The South Region comprises the following AESO planning areas: [4, 43, 44, 45, 46, 47, 48, 49, 52, 53, 54 and 55]

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 2017 LTO. The generation assumptions for the studies will assume low local generation dispatch. Additional studies may be required in the event of changes to the AESO's corporate forecast.

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

Bow River Hydro (Barrier 32S) Generator 1 is considered to be out of service to represent the N-G[b] condition for all studies.

Table 4-3: Non-Renewable Generation Dispatch Conditions

Generator Facility	Unit No.	Bus No.	Pmax (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) per Scenario	
					2019 WP	2020 SP
Bow River Hydro (SPRAY 33S)	1	174	97	44	14.4	11.2
	2A	190				
Bow River Hydro (THREE SISTERS 36S)	1	381	3.6	44	0	0
Bow River Hydro (KANANASKIS 2S)	1	196	19	44	4.6	5.6
	2	196				
	3	196				
Bow River Hydro (POCATERRA 48S)	1	214	13	44	0	0

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

Generator Facility	Unit No.	Bus No.	Pmax (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) per Scenario	
					2019 WP	2020 SP
Bow River Hydro (RUNDLE 35S)	1	479	48	44	3.8	2
	2	197				
Bow River Hydro (GHOST 20S)	1	3181	58	44	6.1	12.2
	2	181				
	3	181				
	4A	181				
Bow River Hydro (HORSESHOE 3S)	1	172	16	44	0	5.8
	2	172				
	3	172				
	4	172				
Bow River Hydro (INTERLAKES 49S)	1	377	5	44	0	0
Bow River Hydro (BARRIER 32S)	1	222	11	44	0	0
Bow River Hydro (BEARSPAW PLANT 44S)	1	183	16	44	0	0
Bow River Hydro (CASCADE 29S)	1	176	34	44	4.3	0

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 flows are assumed to be the same as in the AESO planning base cases 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 are assumed to be the same as in the AESO planning base cases and will not be adjusted for the studies.

4.2.7 Transmission Facility Ratings

AltaLink provided the thermal ratings assumptions for the existing transmission lines in the Study Area. Table 4-4 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 4-4: 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
90L	Mount Allan 115S – Barrier 32S	138	81	111	89	122
76L	Mount Allan 115S – Spray 33S	138	113	120	124	132
58L	Barrier 32S – Seebe 245S	138	105	120	116	151
87L	Seebe 245S – Kananaskis 2S	138	98	132	108	145
56L	Seebe 245S – Ghost 20S	138	108	114	119	125
113L	Spray 33S – Ghost 20S	138	120	120	120	120
777L	Pocaterra 48S – Seebe 245S	138	96	115	96	115
754L	Seebe 245S – 742L Tap Point	138	112	120	123	152
3L	Seebe 245S – 3AL Tap Point	138	118	146	130	161
3L	3AL Tap Point – Springbank 272S	138	118	146	130	161
3L	Springbank 272S – Sarcee 42S	138	97	111	107	122
3AL	3AL Tap Point – Jumping Pound 271S	138	99	133	109	146
150L	Ghost 20S – 150AL Tap Point	138	143	172	157	186
150L	150AL Tap Point – Sarcee 42S	138	173	250	190	275
150AL	Jumping Pound 271S – 150AL Tap Point	138	98	132	108	145
887L/2741L	Pocaterra 48S – Britt Creek 978S	138	72	72	108	108
742L	742L Tap Point – Exshaw 985S	138	85	90	94	99
754L	Canmore 118S – Bay Mag 437S	138	94	135	103	149
754L	742L Tap Point – Bay Mag 437S	138	153	189	168	208
859L/860L	Ghost 20S – Horse Creek T793S	138	120	143	120	143
860L	Cochrane 291S – Bearspaw Plant 44S	138	108	139	119	153
433L	Horse Creek 793S – Cochrane 291S	138	121	148	133	163
54L	Banff 123S – West Cascade 177S	138	143	172	163	186
54L	West Cascade 177S – 54AL Tap Point	138	143	172	171	186
54AL	Cascade 29S – 54AL Tap Point	138	130	160	143	176
54L	54AL Tap Point – 85L Tap Point	138	129	158	142	174
85L	Rundle 35S – 85L Tap Point	138	96	96	133	143
84L	Rundle 35S – Spray 33S	138	98	132	108	145
54L	Canmore 118S – 85L Tap Point	138	153	189	168	208

AltaLink provided the details of the substation transformers in the Study Area. The key transformers in the Study Area are shown in Table 4-5.

Table 4-5: Summary of Key Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	Transformer Rating (MVA)
Mount Allan 115S	T1	138/25	6
	T2	138/25	10
Seebe 245S	T2	138/25	25

AltaLink provided the details of the shunt elements in the Study Area. The key shunt elements in the Study Area are shown in Table 4-6.

Table 4-6: 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)
Canmore 118S	138	1x24.55	24.55	-	-

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

5.1 Engineering Studies

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

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

Scenario No. and Name		Power Flow		Voltage Stability	
		Category		Category	
		A	B	A	B
1	2019 WP	X	X		
2	2020 SP	X	X		
3	2019 WP	X	X	X	X
4	2020 SP	X	X		

For the engineering studies, all transmission facilities 69 kV 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).

5.2 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 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.

5.2.1 Contingencies to be Studied

Power flow studies will be performed for the Category A and all Category B contingencies 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 The AESO planning area Seebe (Area 44) and increasing generation in Northeast Region, Northwest Region and Edmonton Region.

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.

Attachment B: 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

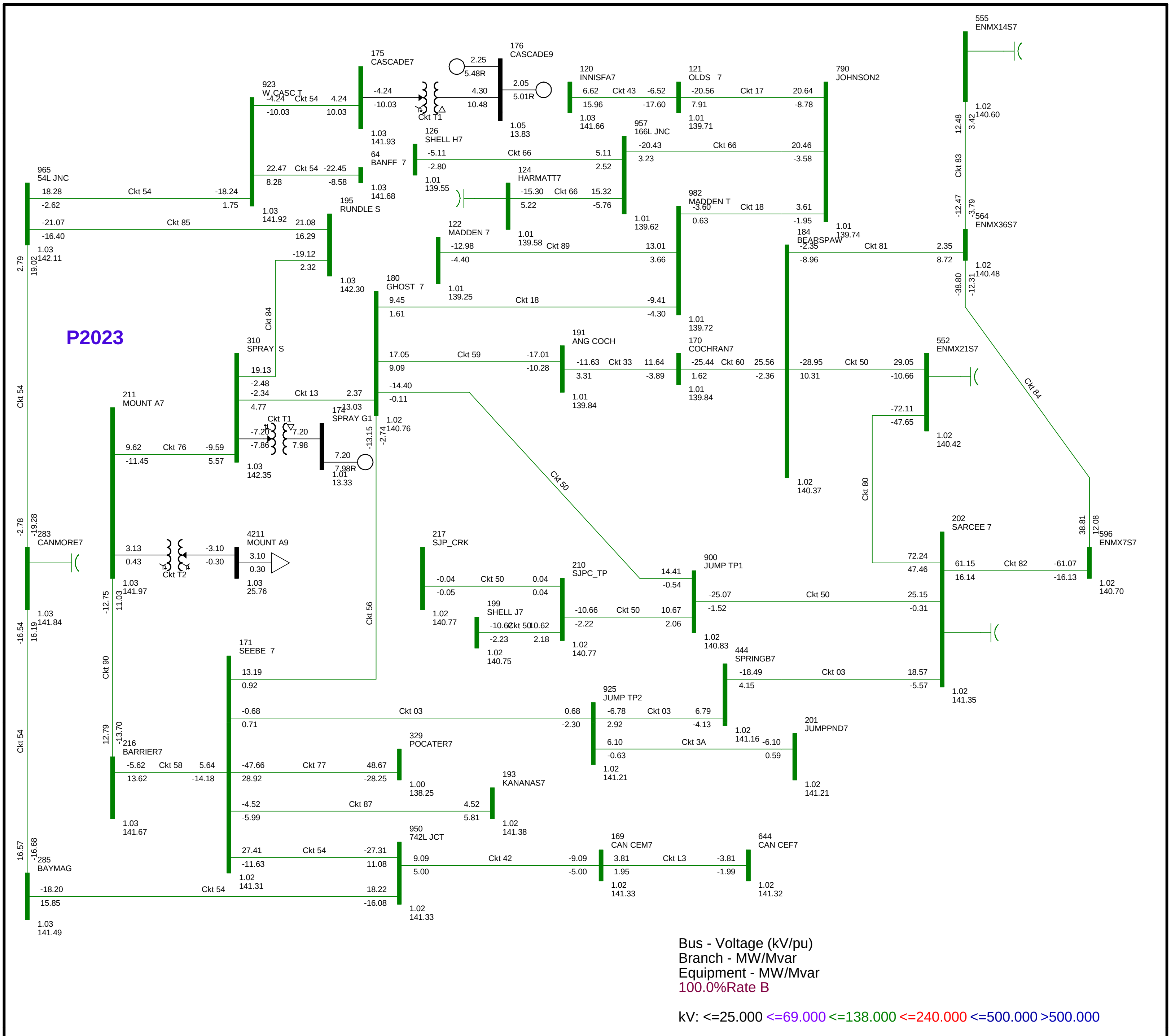

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FIGURE A2-1-N-0: NORMAL OPERATION
2019 WINTER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

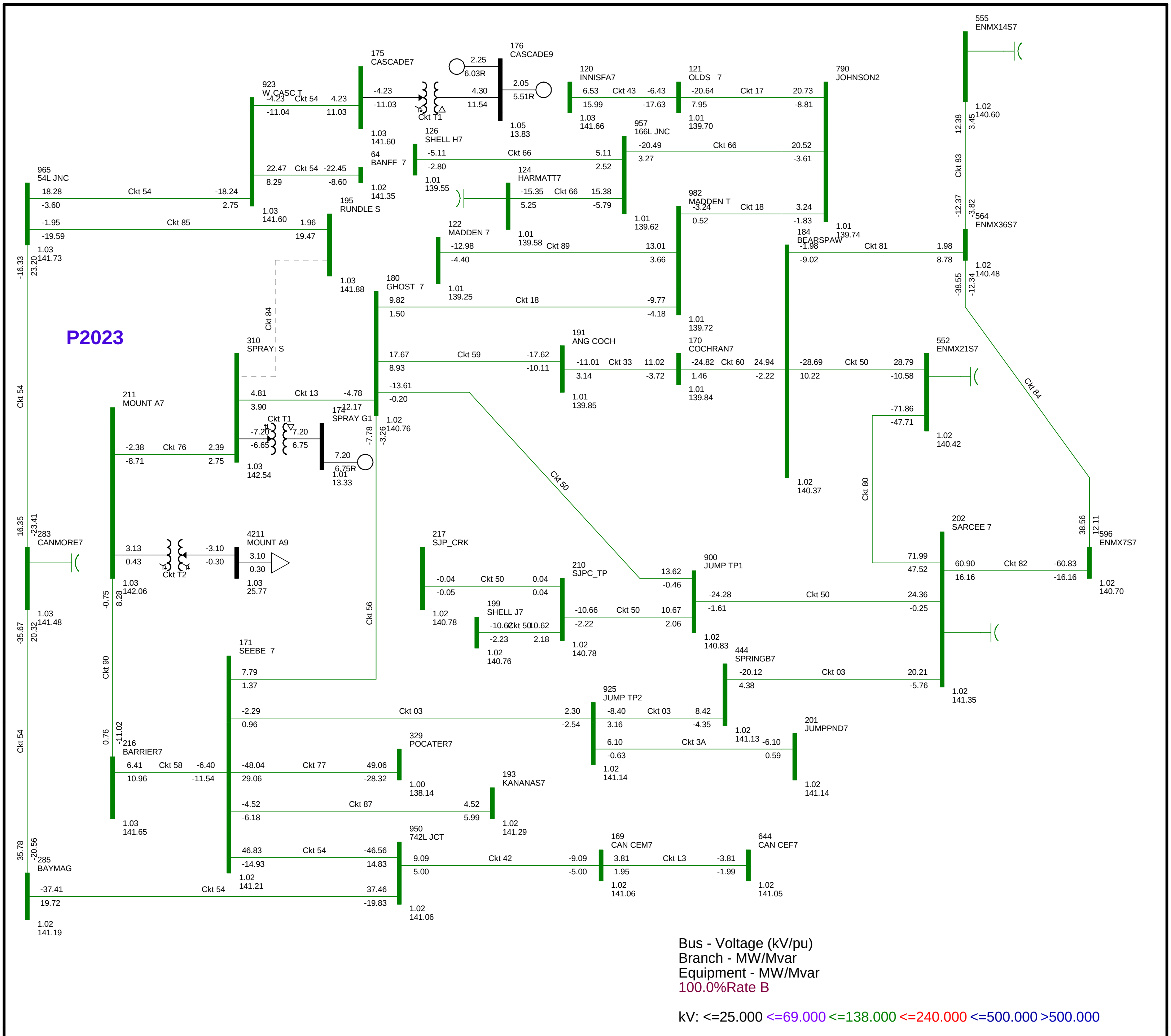

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FIGURE A2-2 N-1: 84L (RUNDLE PLANT 35S TO SPRAY PLANT 33S)
2019 WINTER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

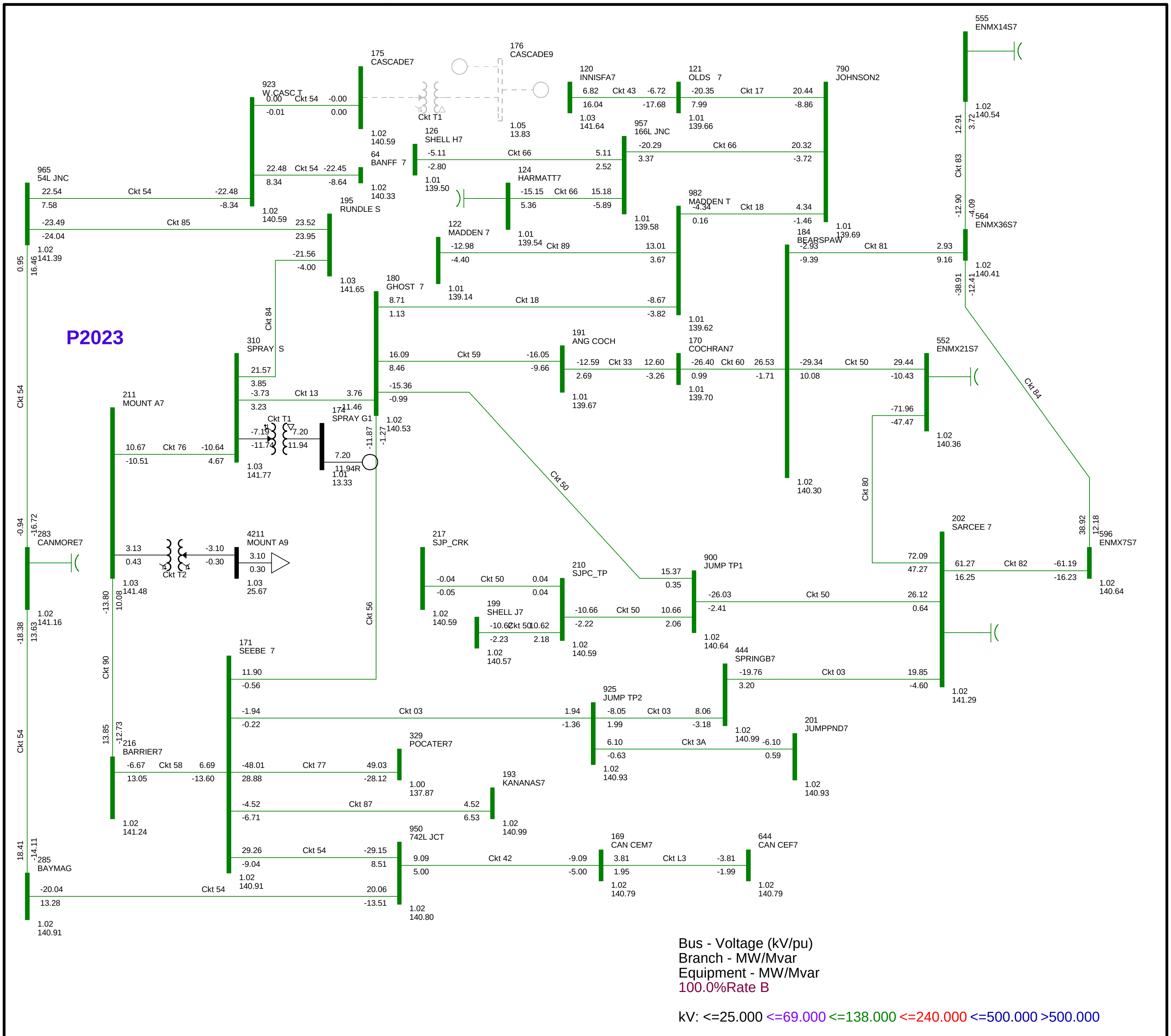

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FIGURE A2-3 N-1: CASCADE PLANT 29S 138/13.2 KV TRANSFORMER T1
2019 WINTER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

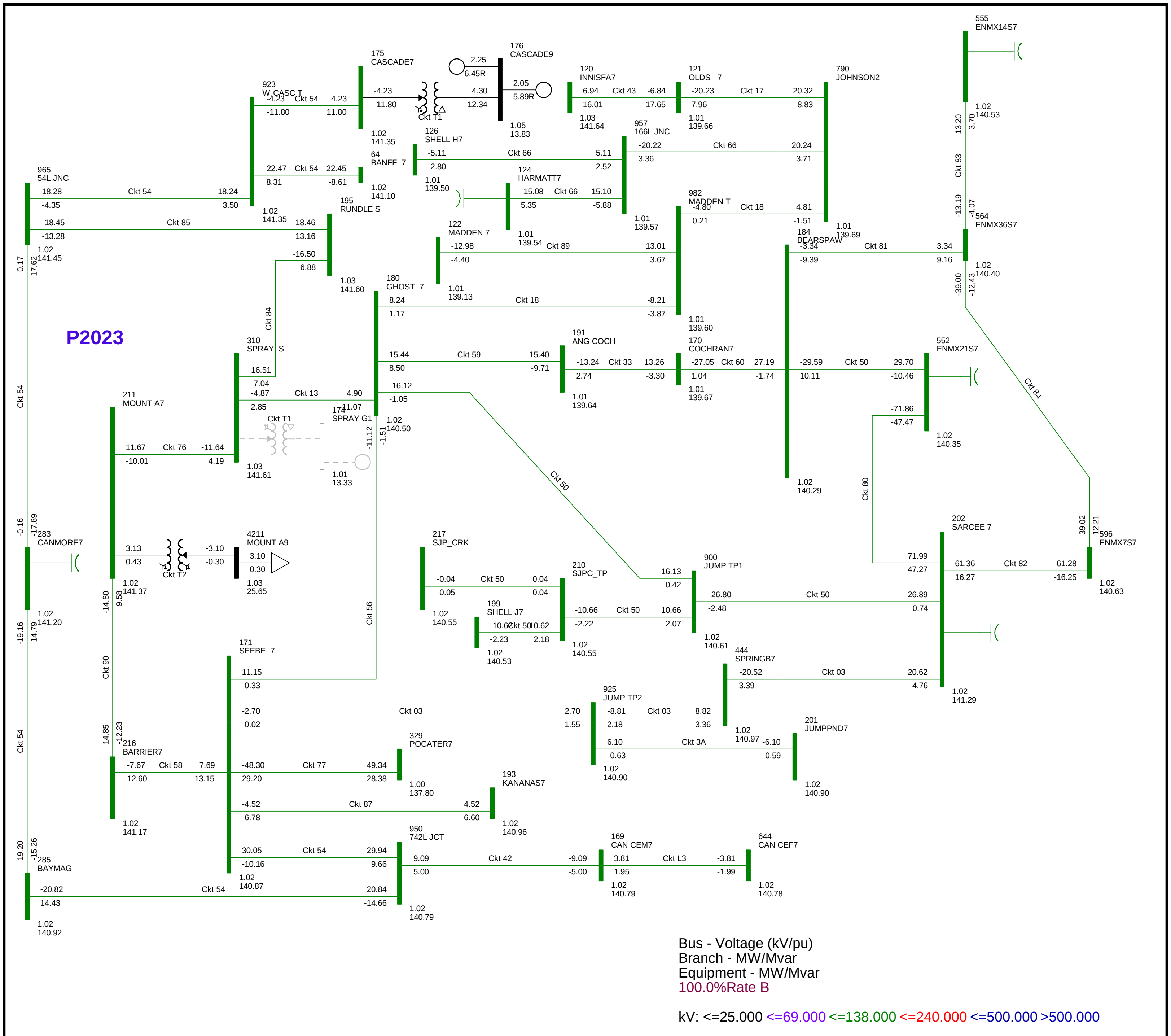

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FIGURE A2-4 N-1: SPRAY PLANT 33S 138/13.2 KV TRANSFORMER T1
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PRINTED ON THURSDAY 20. SEPTEMBER 2018

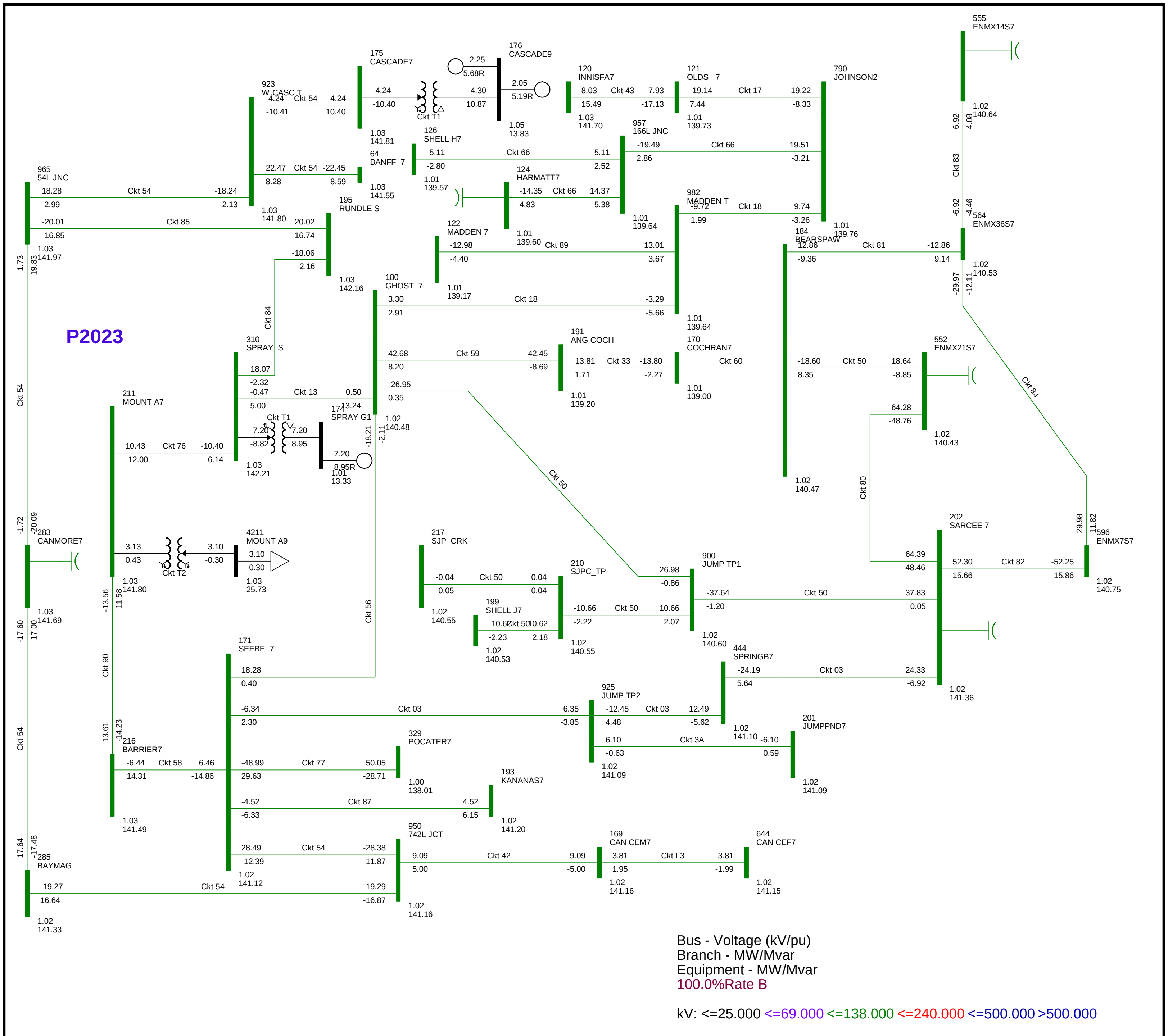

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FIGURE A2-5 N-1: 860L (COCHRANE 291S TO BEARSPAW PLANT 44S)
2019 WINTER PEAK (PRE-CONNECTION)
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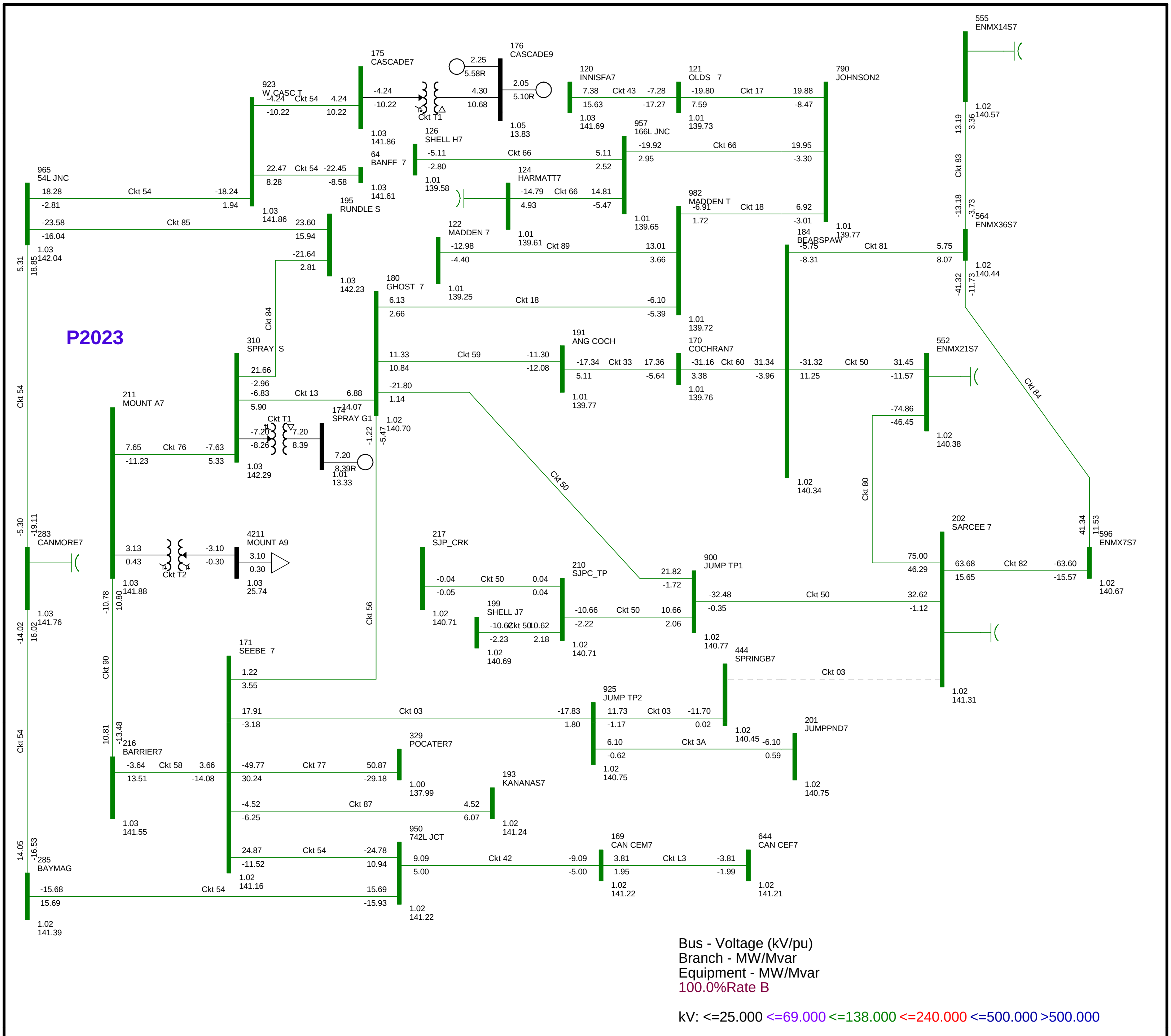

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FIGURE A2-6 N-1: 3L (SPRINGBANK 272S TO SARCEE 42S)
2019 WINTER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

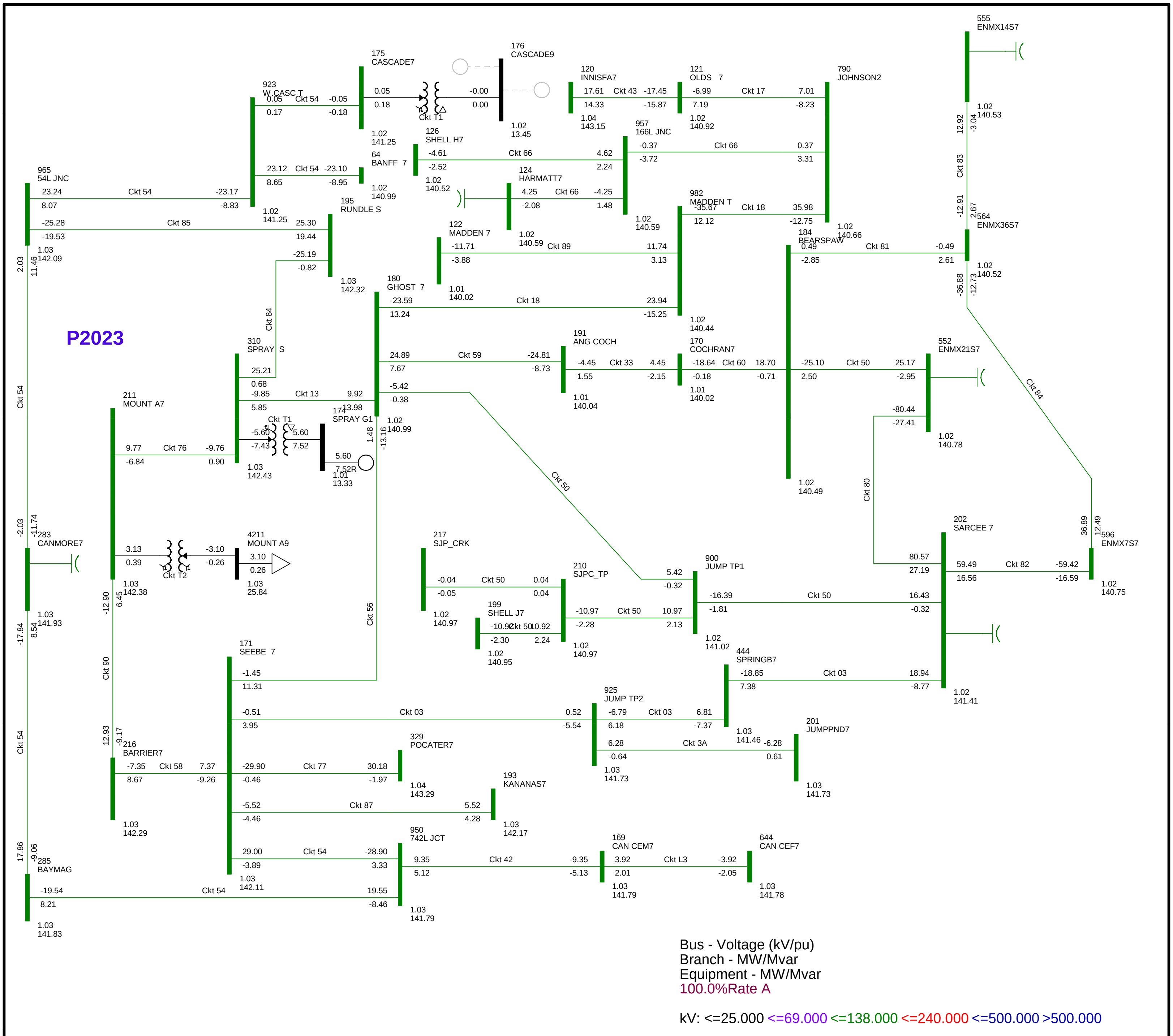

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FIGURE A2-7-N-0: NORMAL OPERATION
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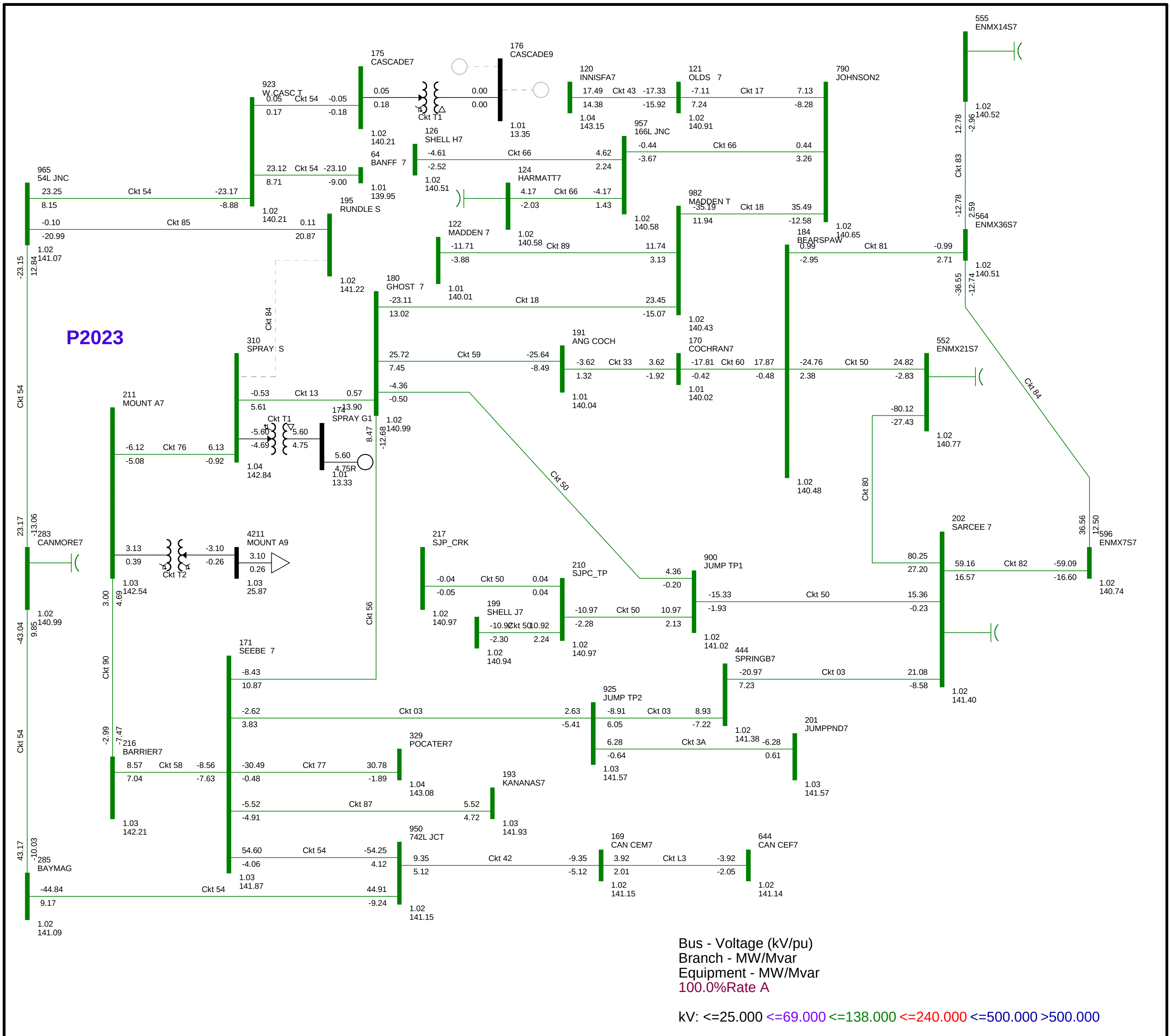

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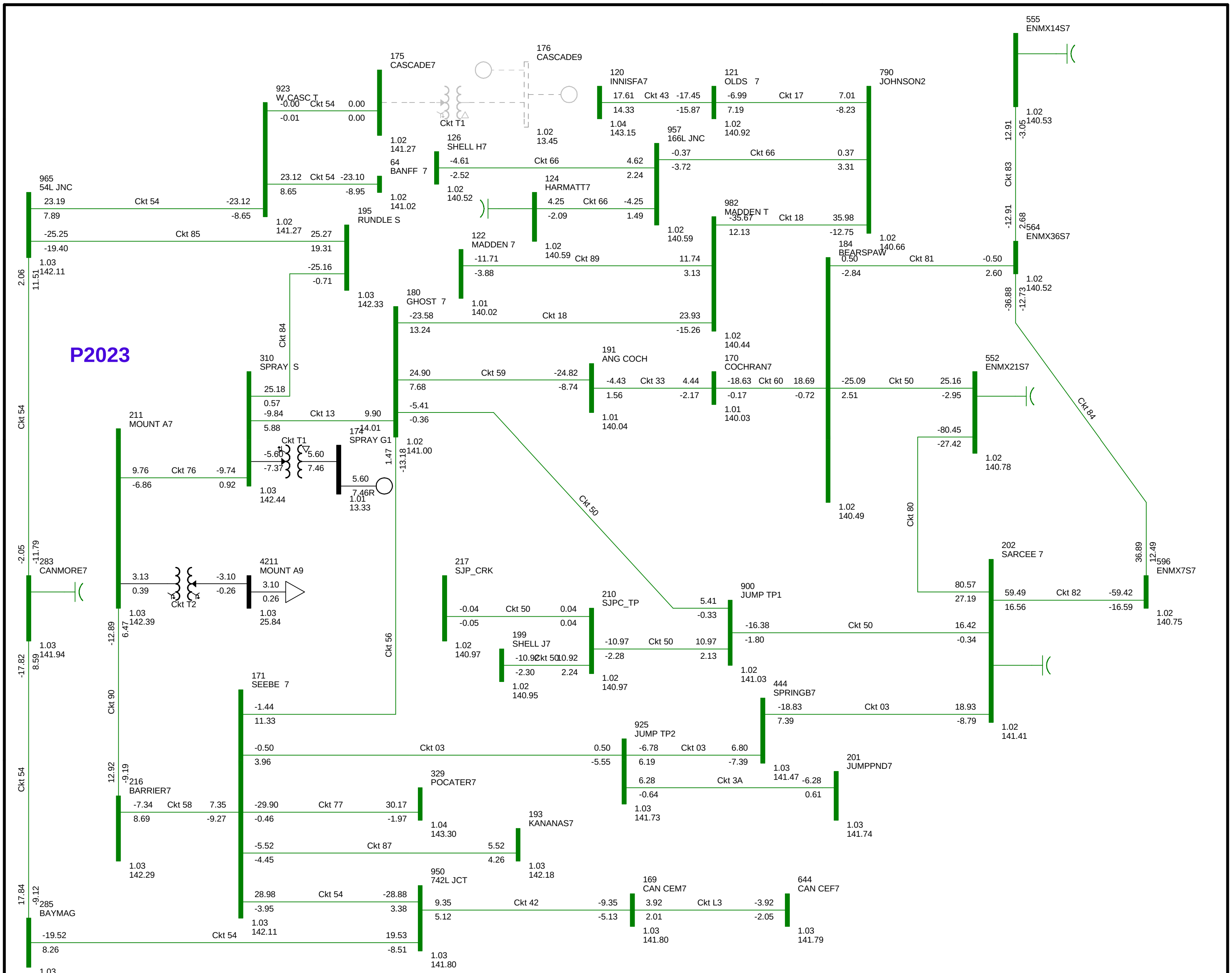
FIGURE A2-8 N-1: 84L (RUNDLE PLANT 35S TO SPRAY PLANT 33S)
2020 SUMMER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018



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

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

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FIGURE A2-9 N-1: CASCADE PLANT 29S 138/13.2 KV TRANSFORMER T1
2020 SUMMER PEAK (PRE-CONNECTION)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

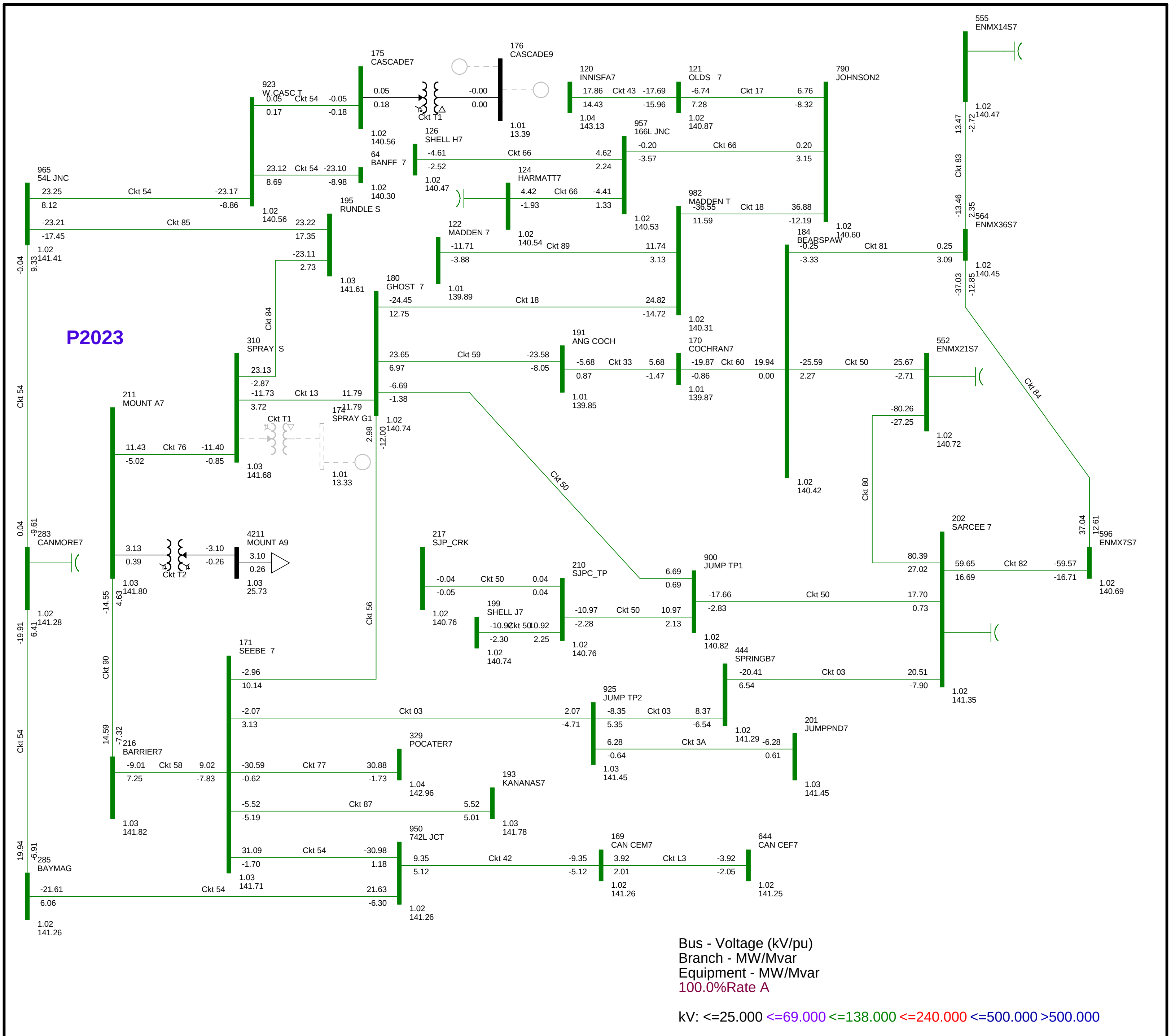

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FIGURE A2-10 N-1: SPRAY PLANT 33S 138/13.2 KV TRANSFORMER T1
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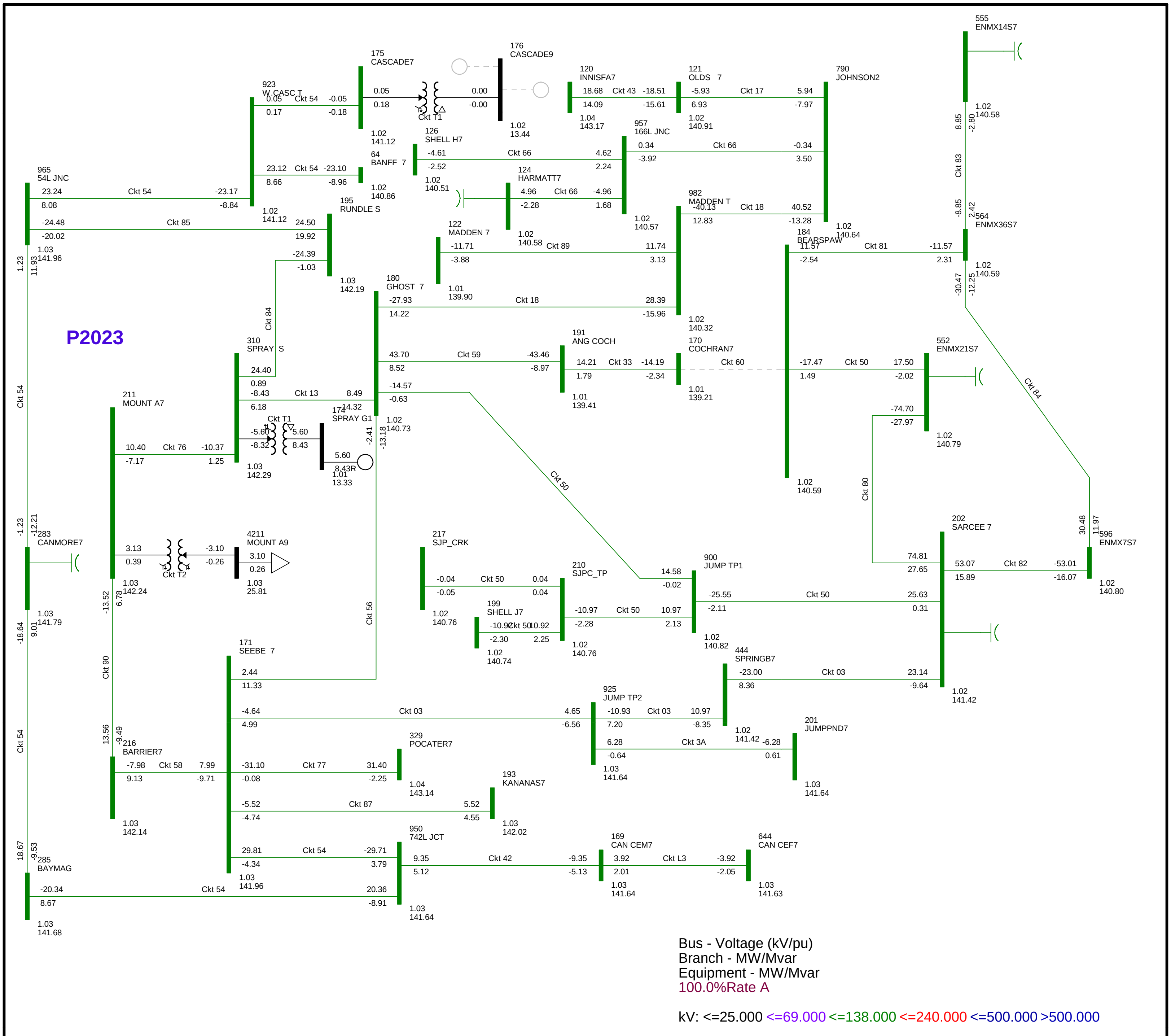

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FIGURE A2-11 N-1: 860L (COCHRANE 291S TO BEARSPAW PLANT 44S)
2020 SUMMER PEAK (PRE-CONNECTION)
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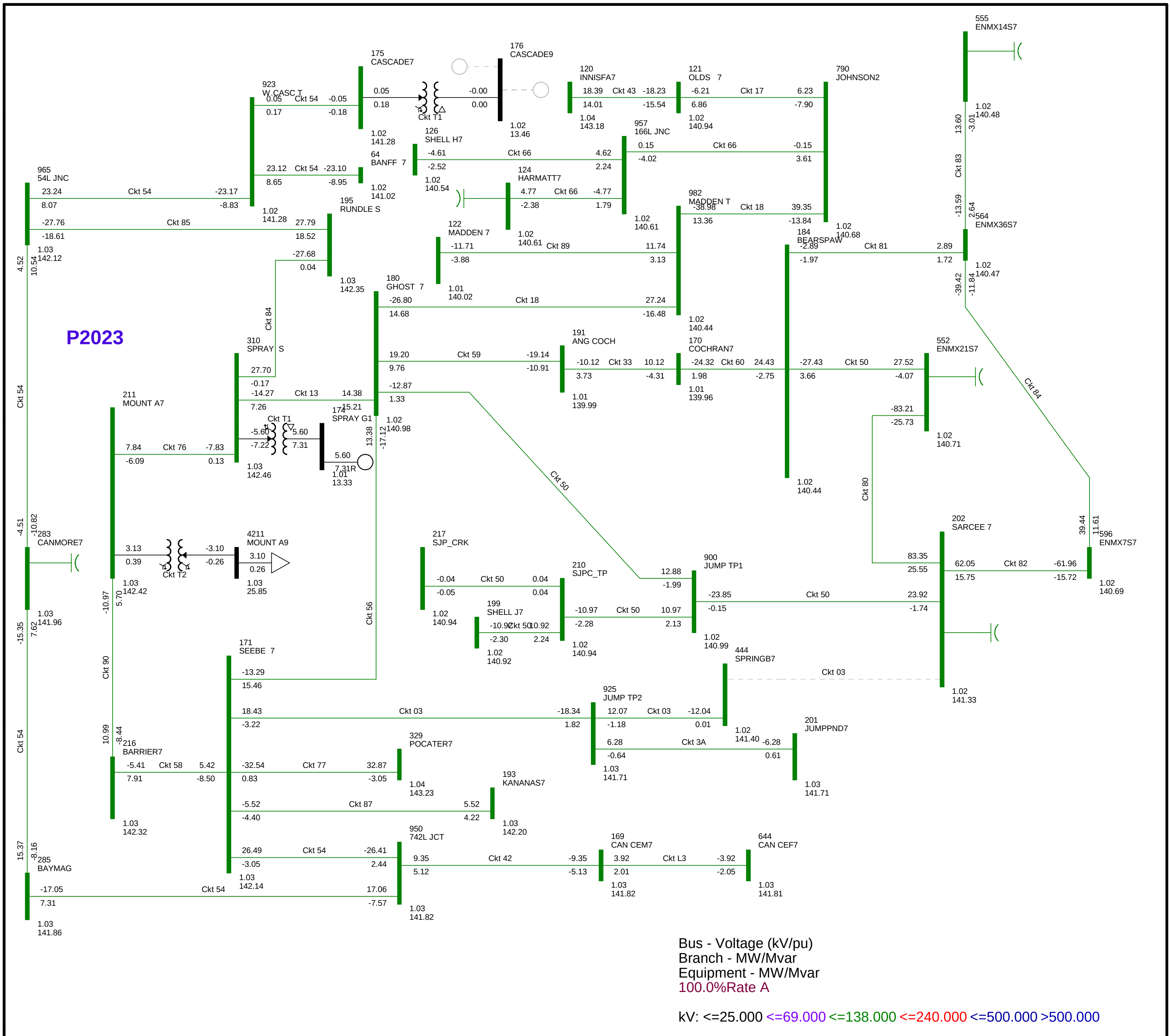

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FIGURE A2-12 N-1: 3L (SPRINGBANK 272S TO SARCEE 42S)
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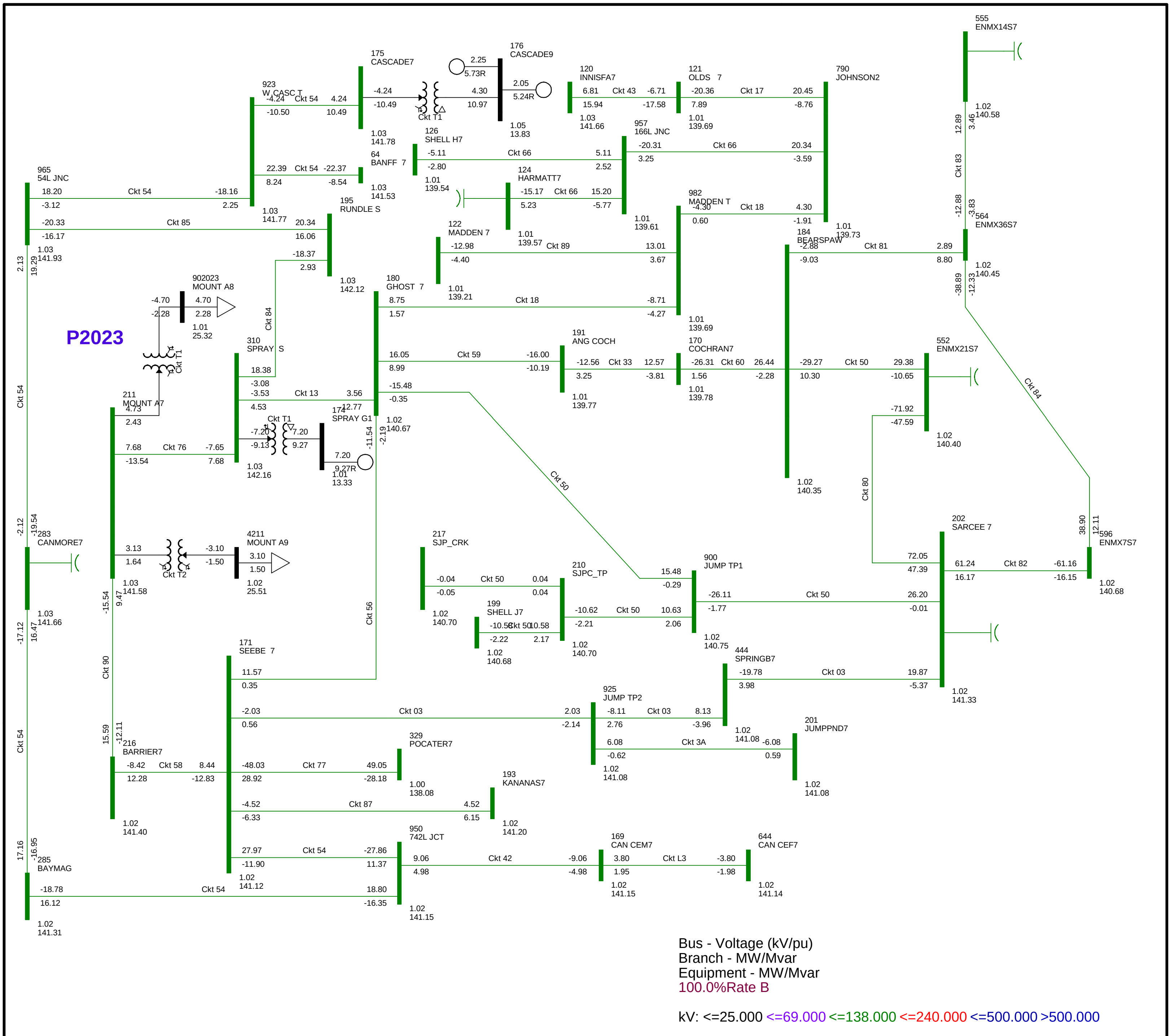

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FIGURE A3-1-N-0: NORMAL OPERATION
2019 WINTER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

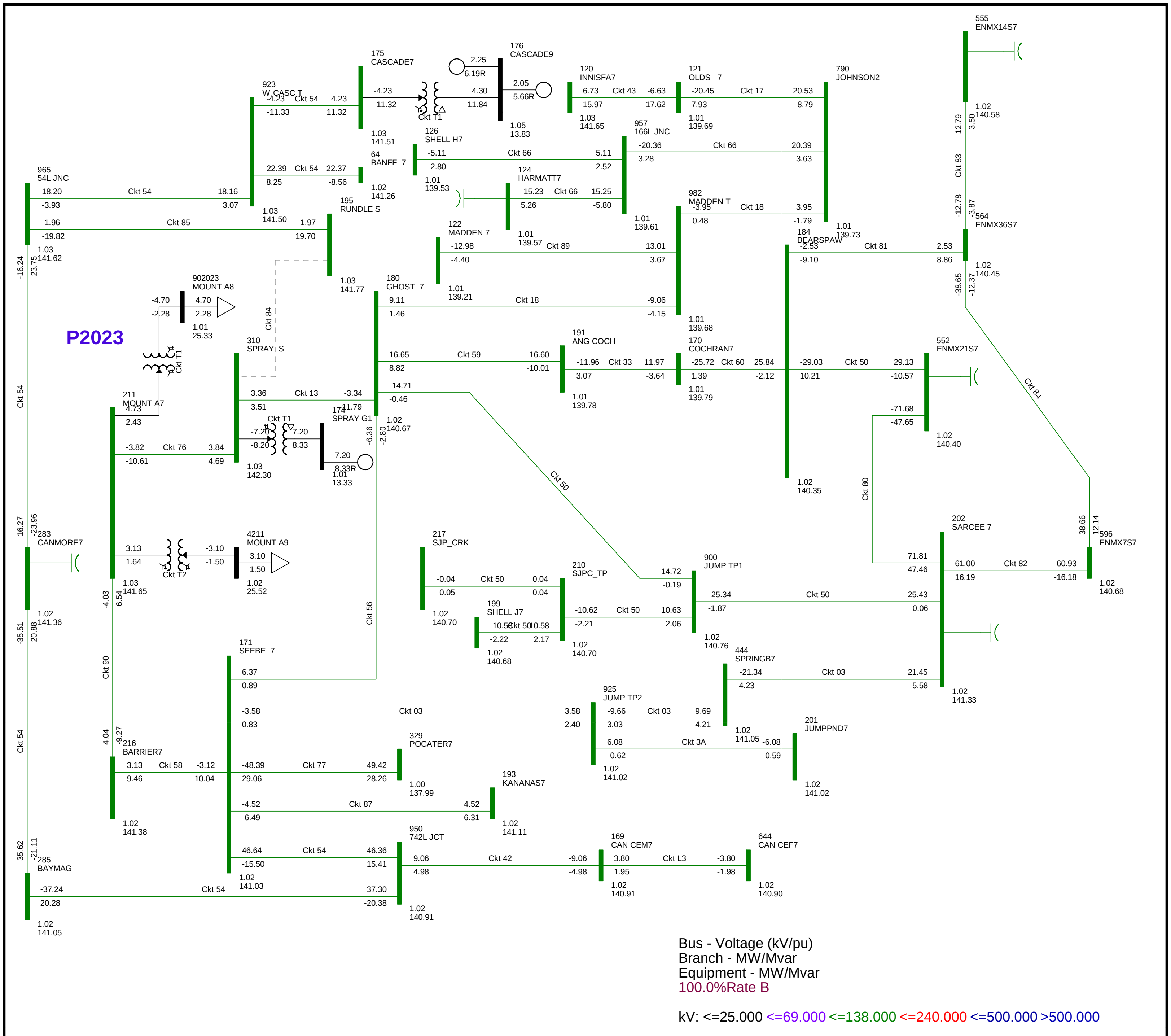

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FIGURE A3-2 N-1: 84L (RUNDLE PLANT 35S TO SPRAY PLANT 33S)
2019 WINTER PEAK (POST-A2)
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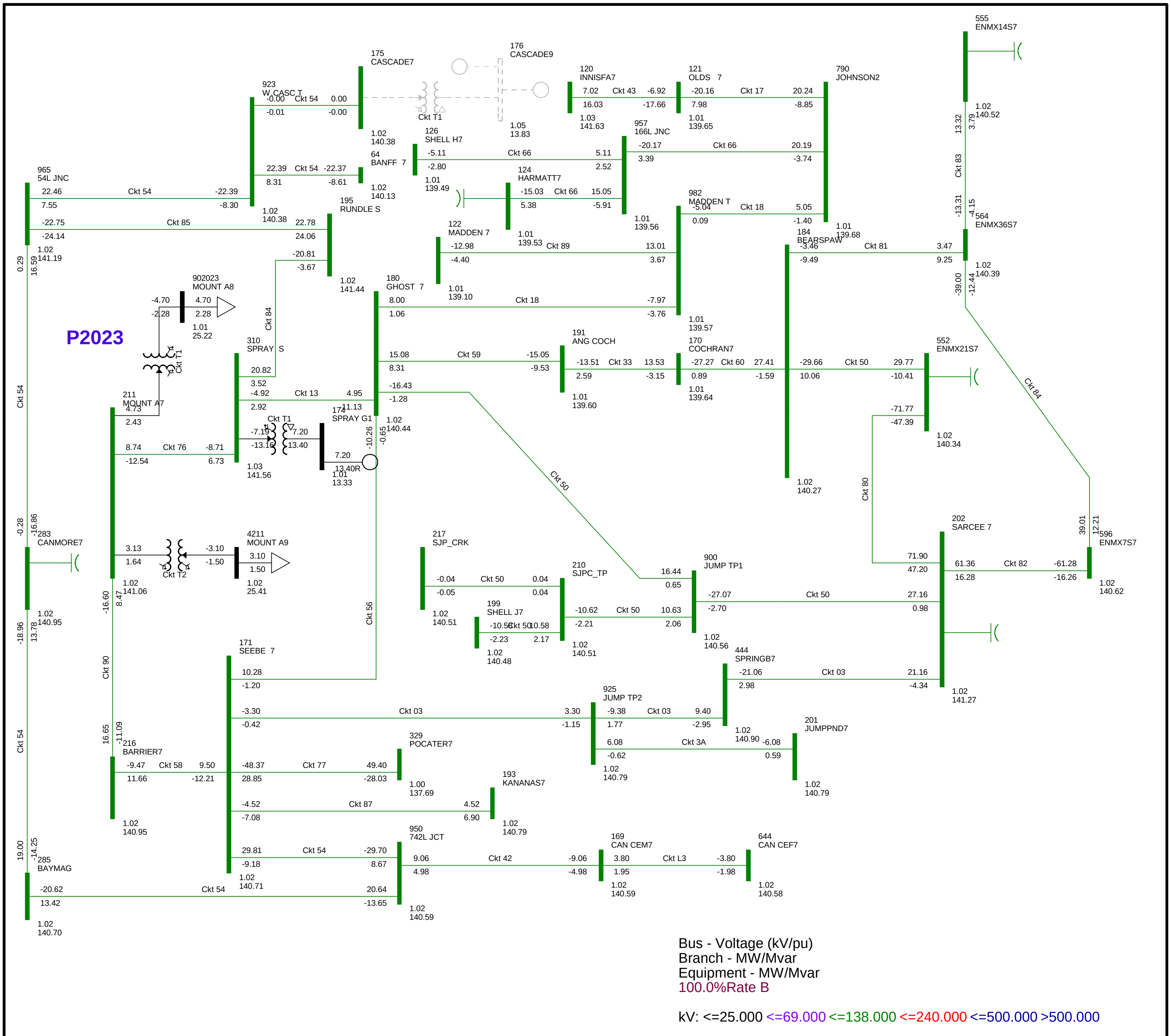

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FIGURE A3-3 N-1: CASCADE PLANT 29S 138/13.2 KV TRANSFORMER T1
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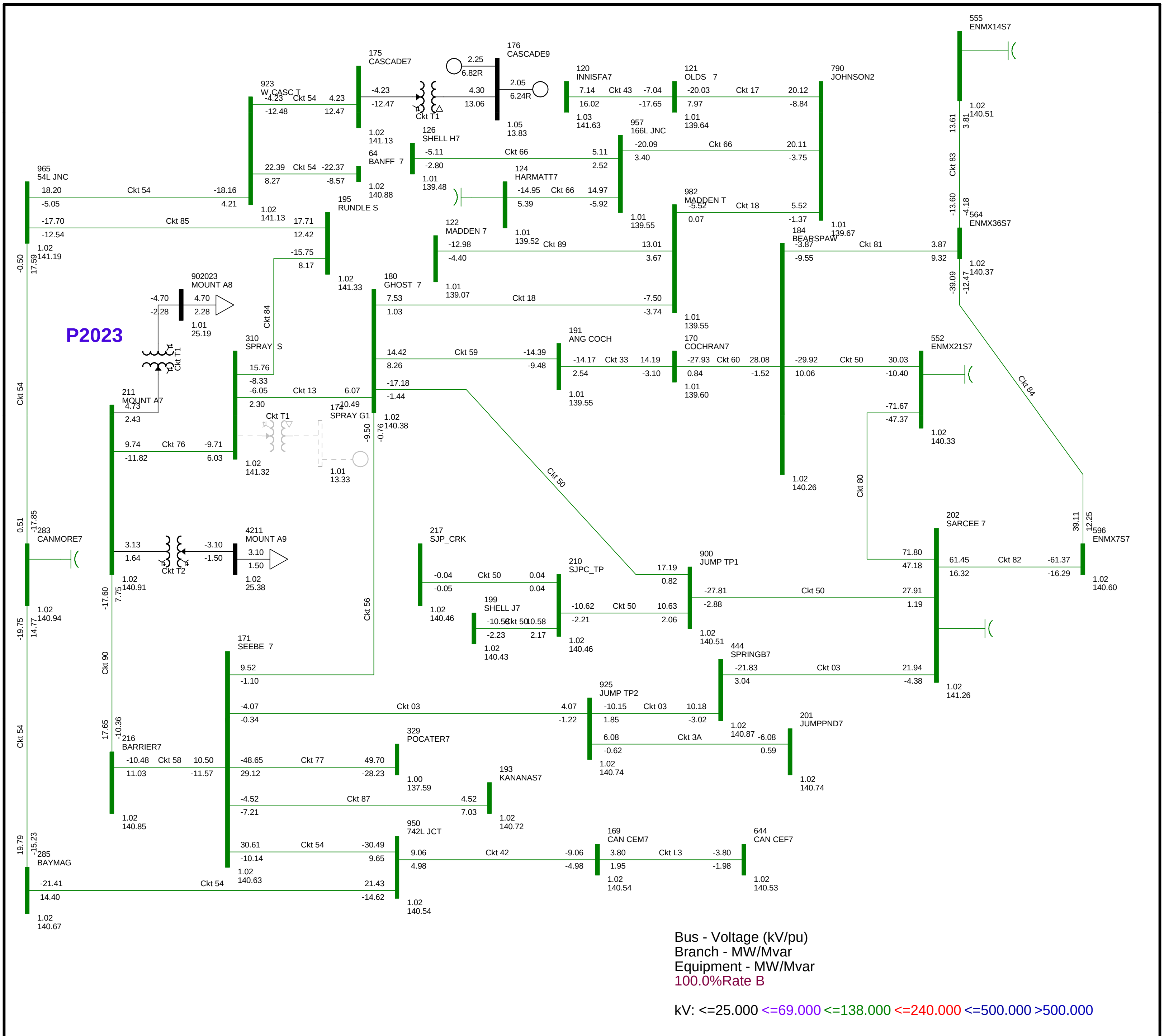

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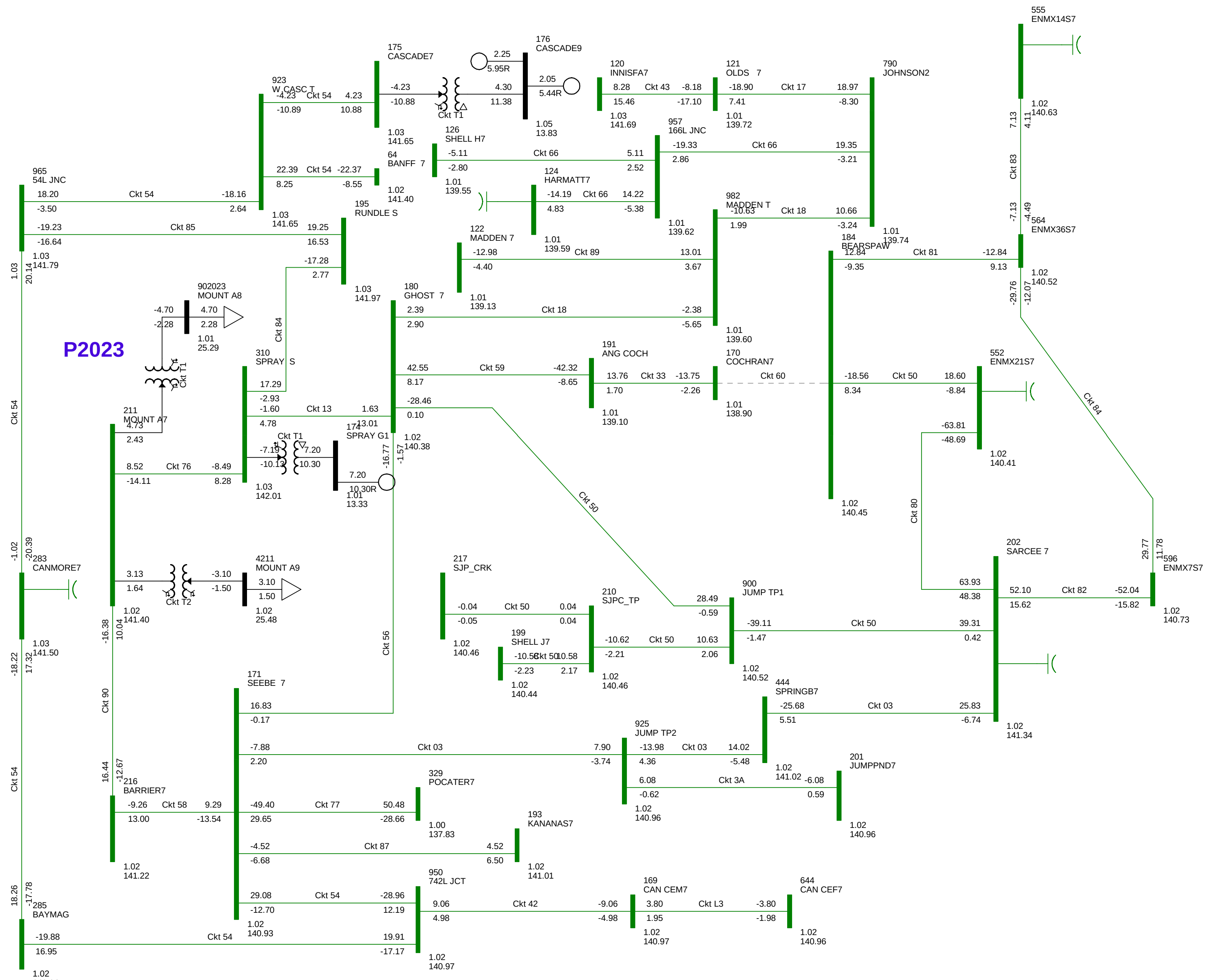
FIGURE A3-4 N-1: SPRAY PLANT 33S 138/13.2 KV TRANSFORMER T1
2019 WINTER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

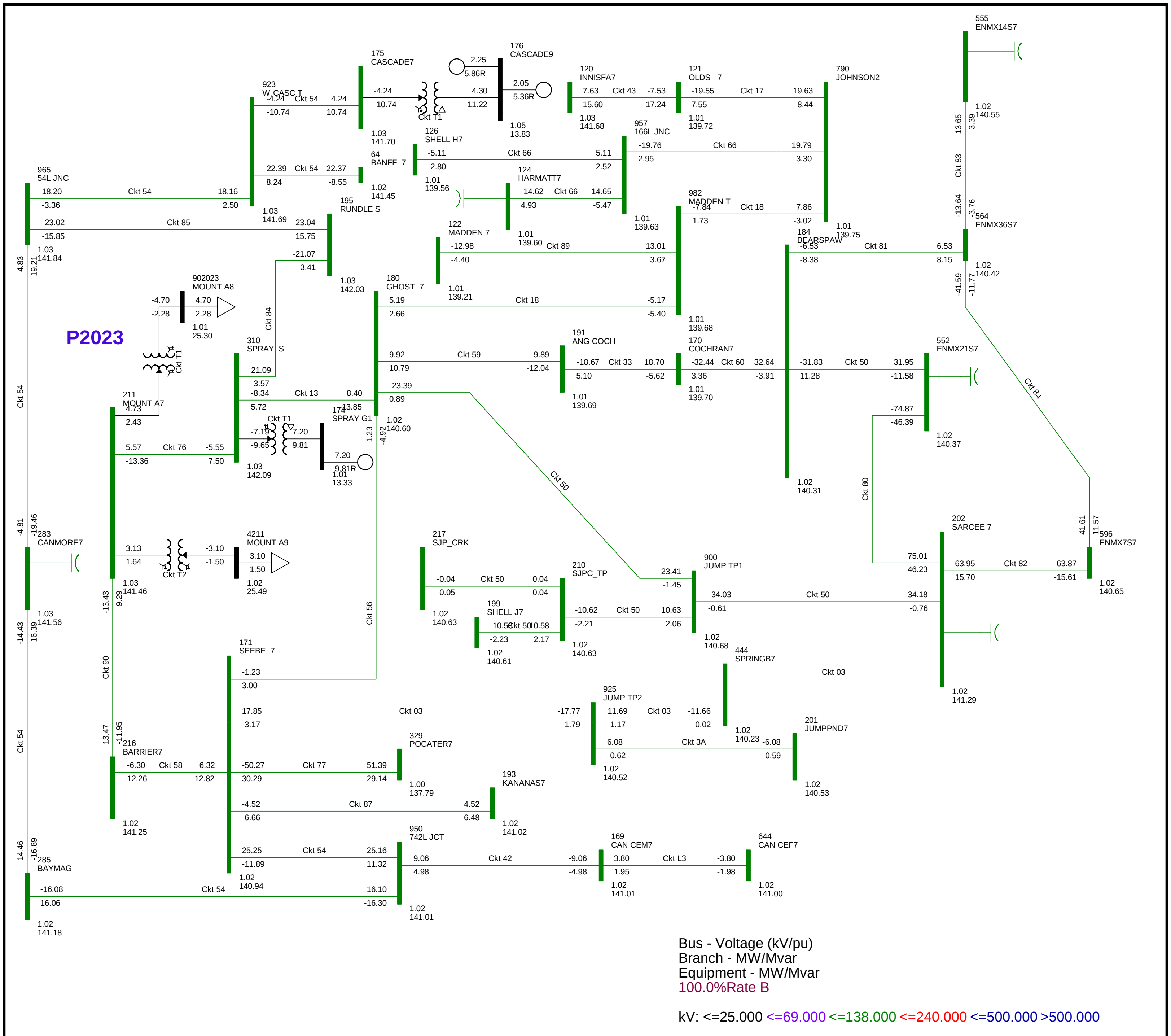


Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B

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

P2023 - Kananaskis Area Reliability

FIGURE A3-5 N-1: 860L (COCHRANE 291S TO BEARSPAW PLANT 44S)
2019 WINTER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018



P2023 - Kananaskis Area Reliability

FIGURE A3-6 N-1: 3L (SPRINGBANK 272S TO SARCEE 42S)
2019 WINTER PEAK (POST-A2)
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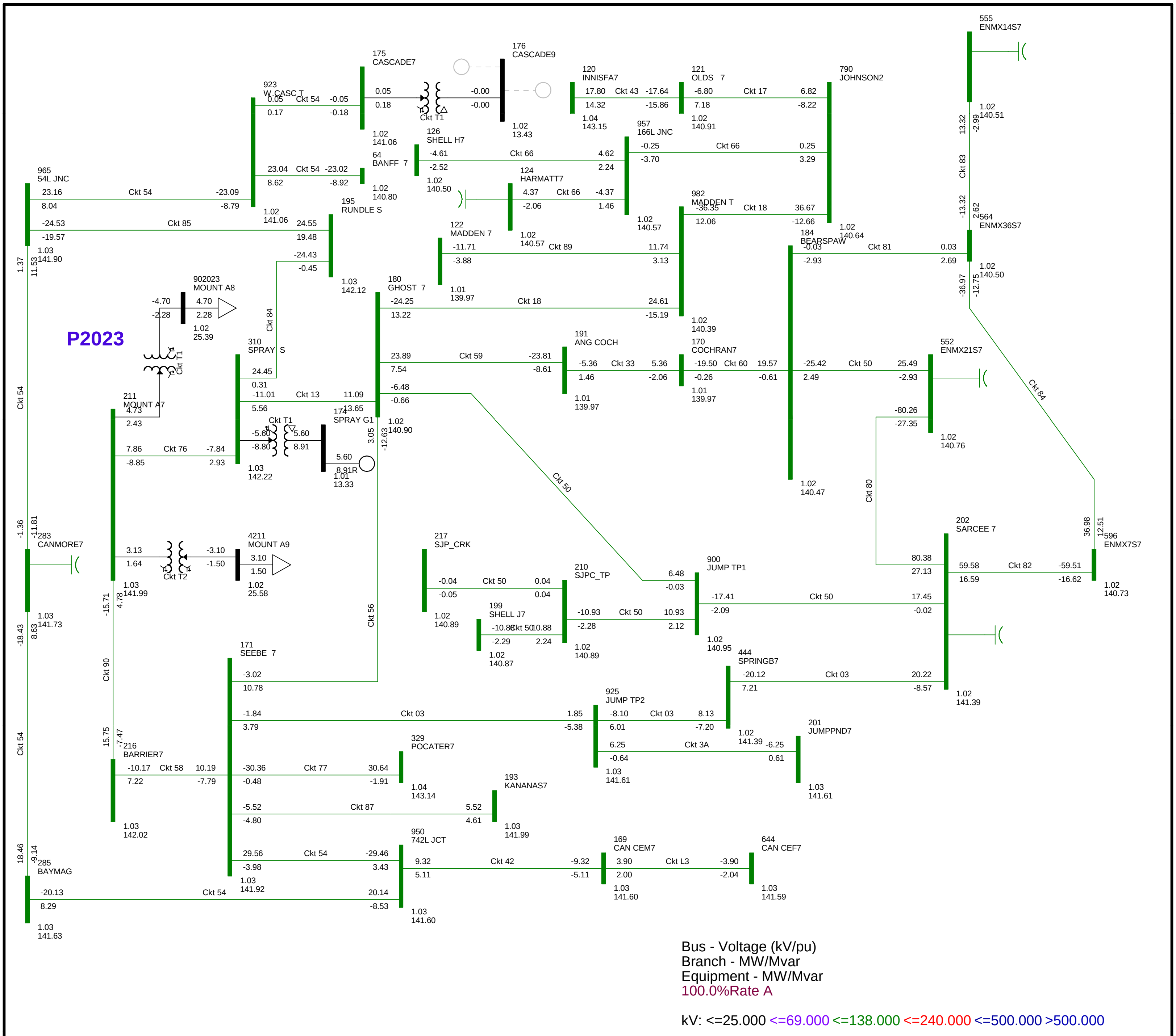

P2023 - Kananaskis Area Reliability

FIGURE A3-7-N-0: NORMAL OPERATION
2020 SUMMER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

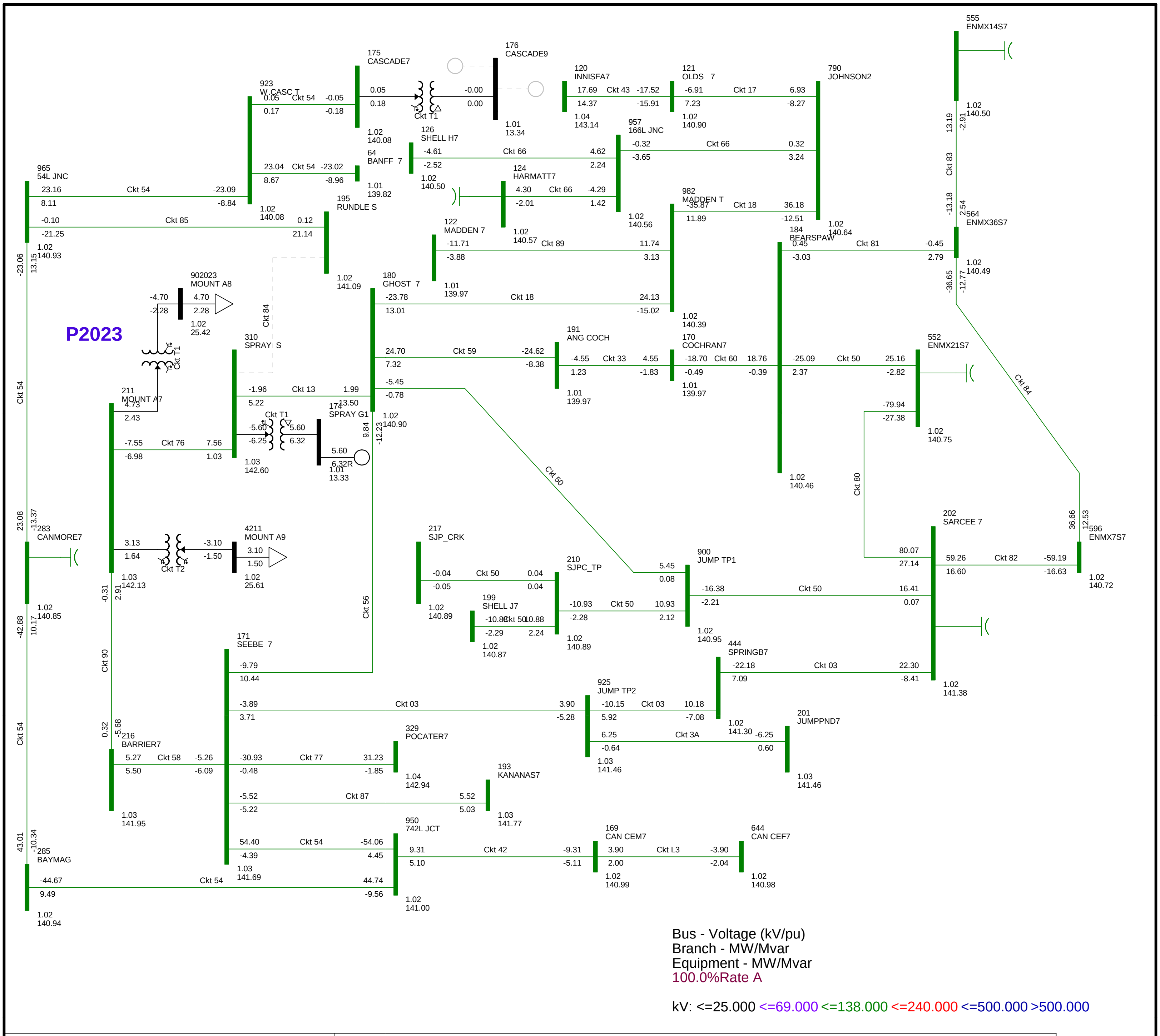

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FIGURE A3-8 N-1: 84L (RUNDLE PLANT 35S TO SPRAY PLANT 33S)
2020 SUMMER PEAK (POST-A2)
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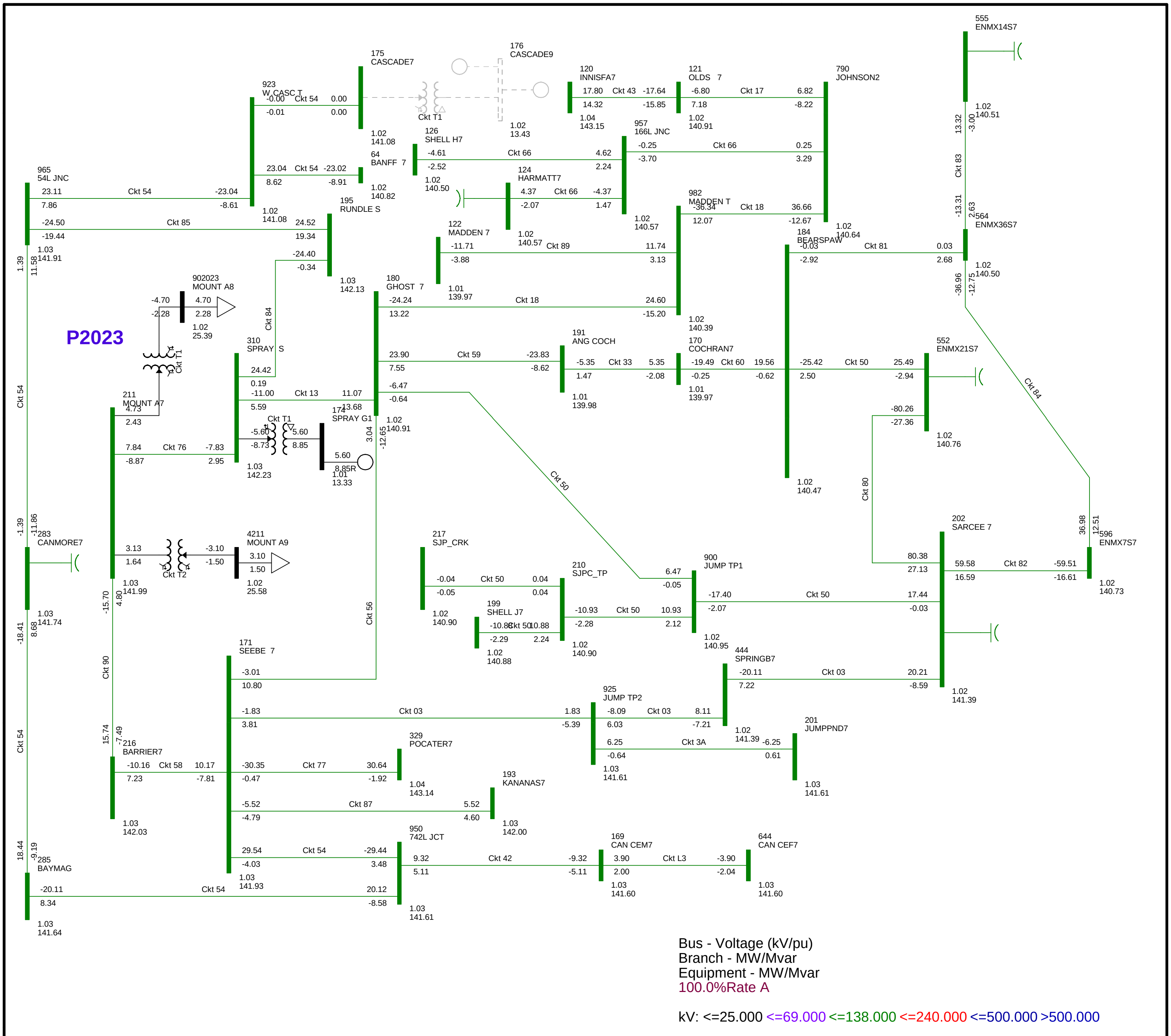
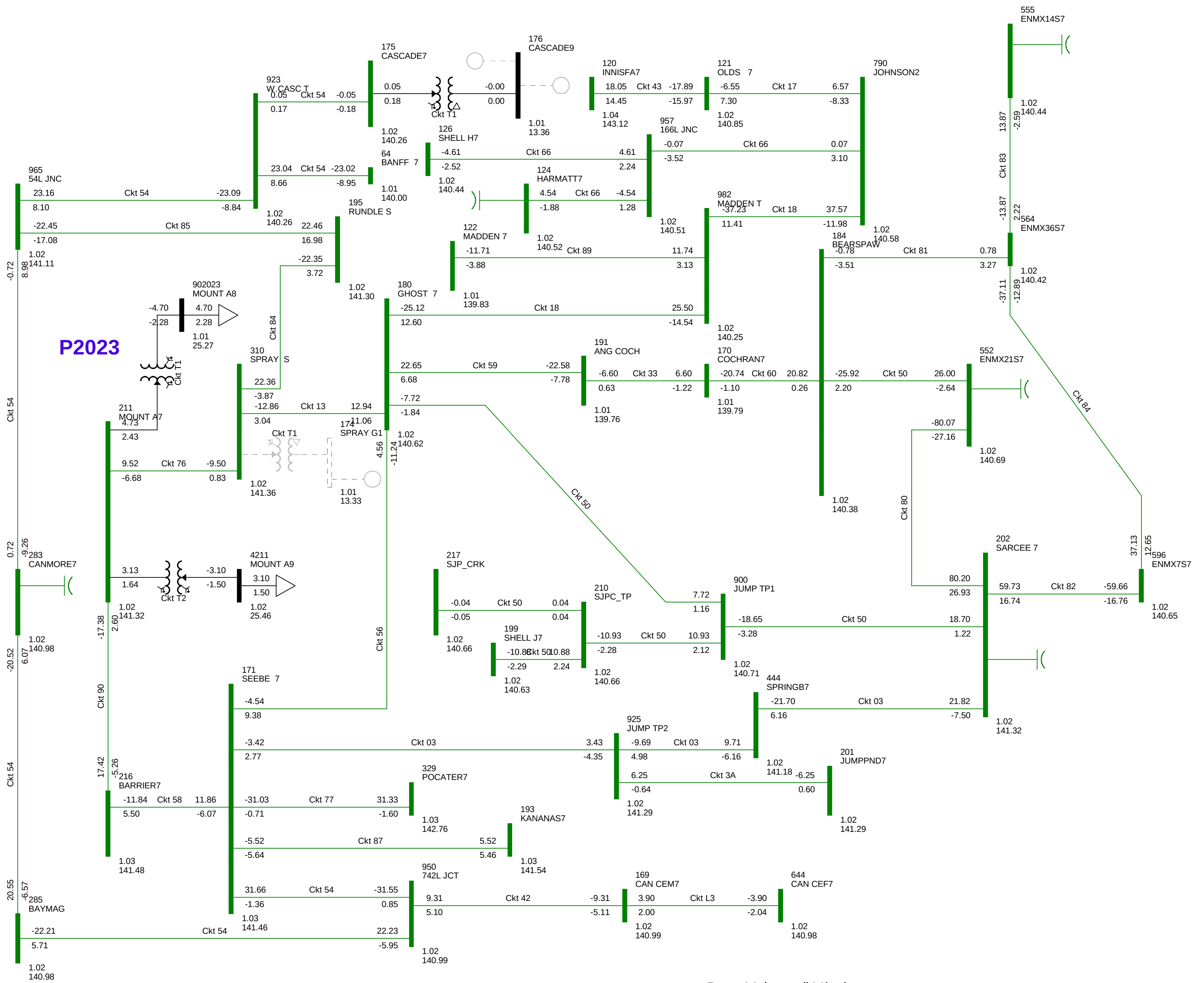


P2023 - Kananaskis Area Reliability

FIGURE A3-9 N-1: CASCADE PLANT 29S 138/13.2 KV TRANSFORMER T1
2020 SUMMER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

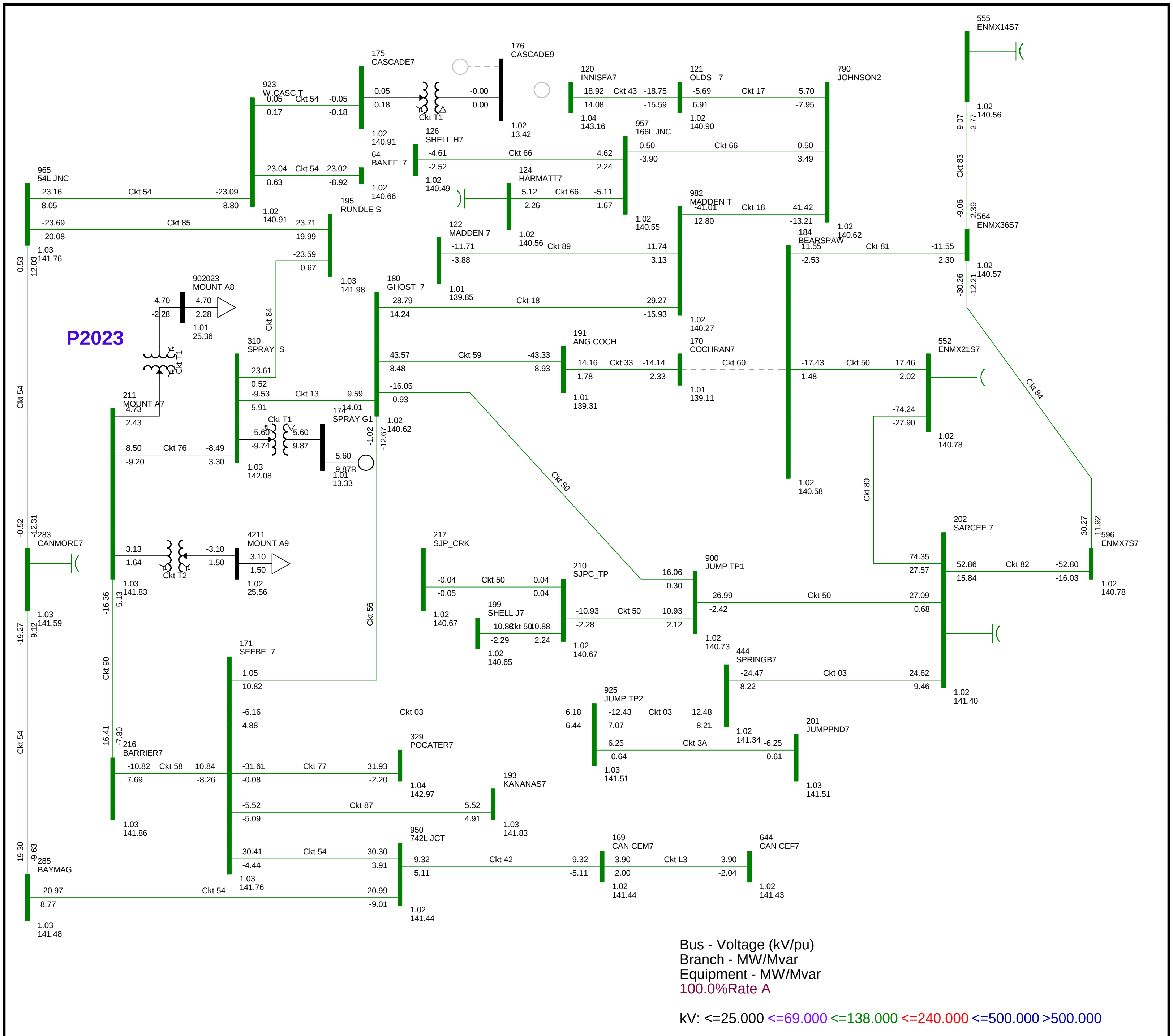


Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A

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

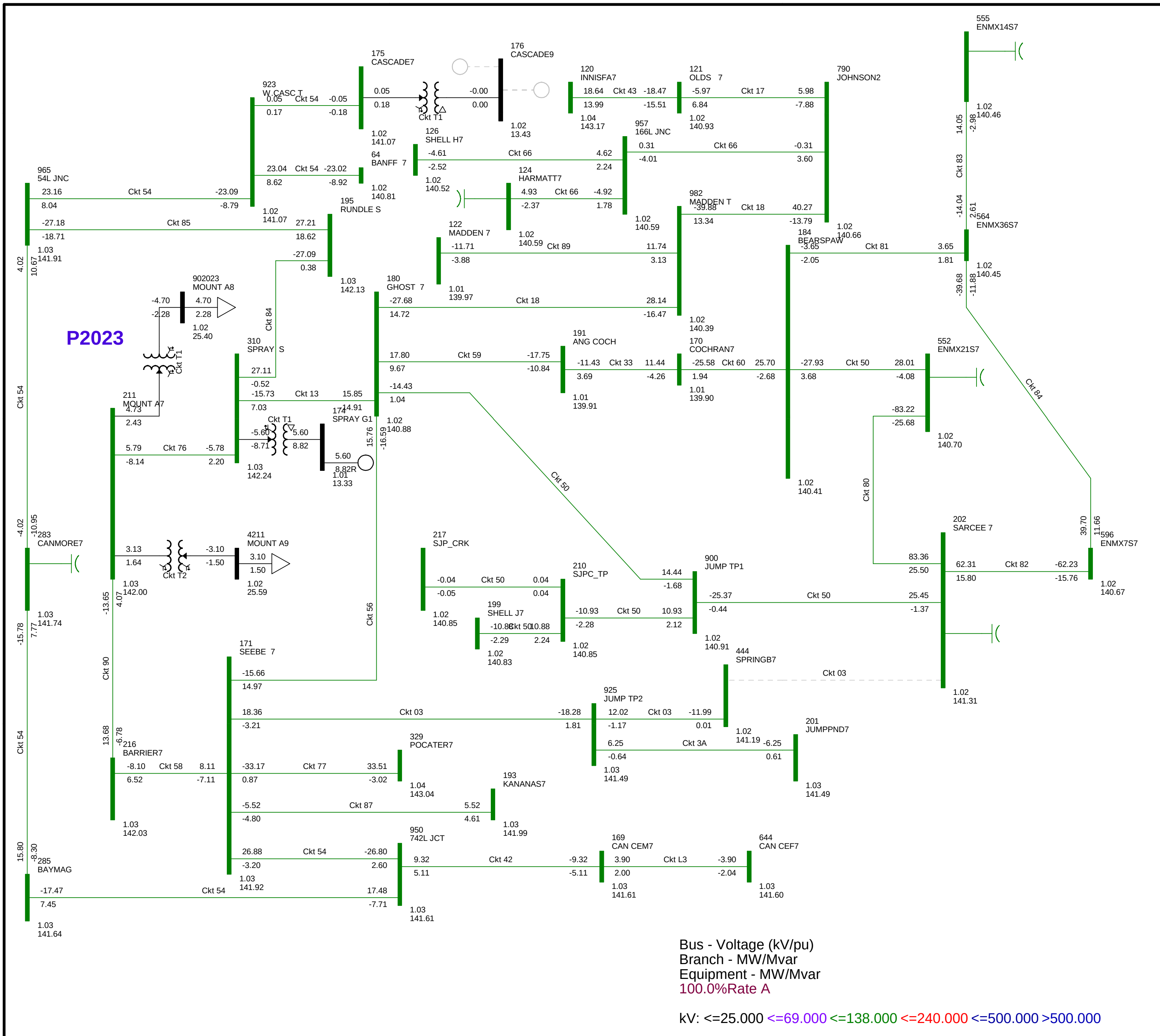
P2023 - Kananaskis Area Reliability

FIGURE A3-10 N-1: SPRAY PLANT 33S 138/13.2 KV TRANSFORMER T1
2020 SUMMER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018



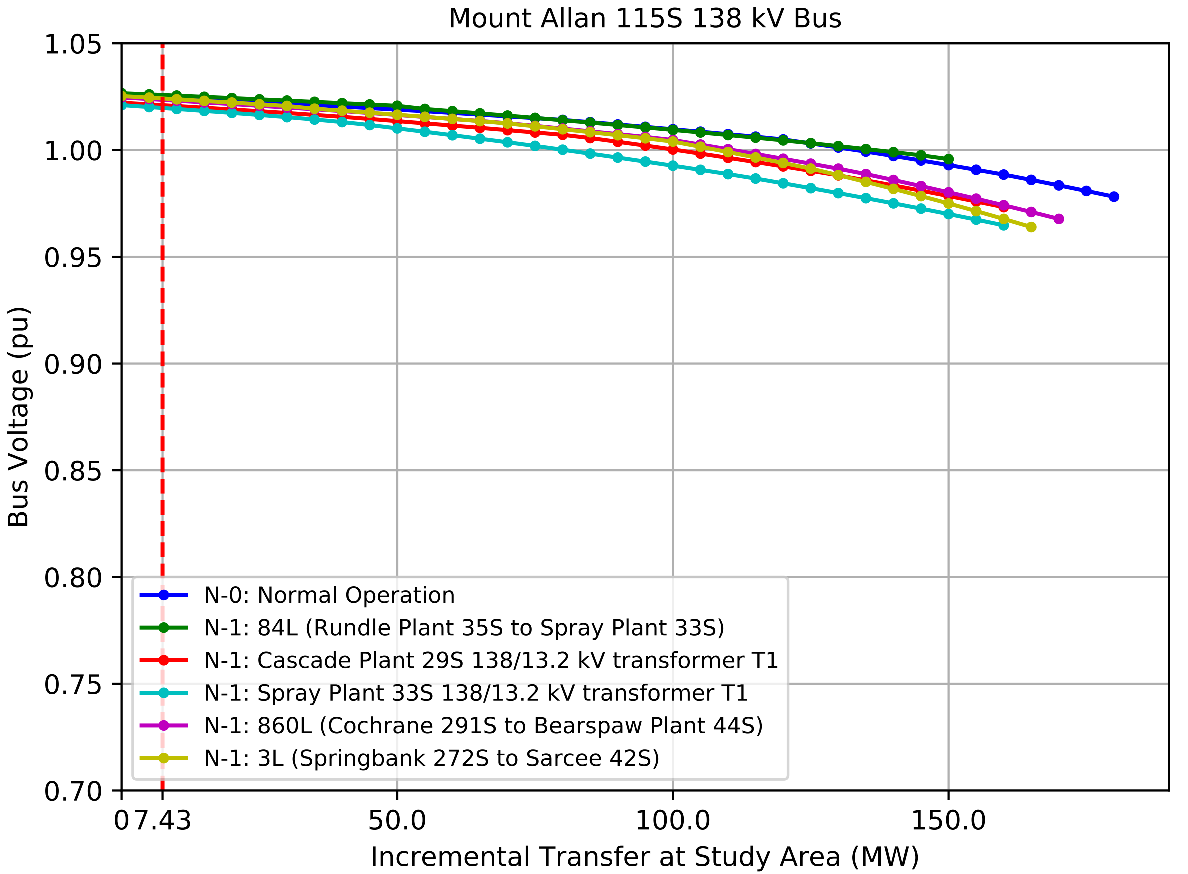
P2023 - Kananaskis Area Reliability

FIGURE A3-11 N-1: 860L (COCHRANE 291S TO BEARSPAW PLANT 44S)
2020 SUMMER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

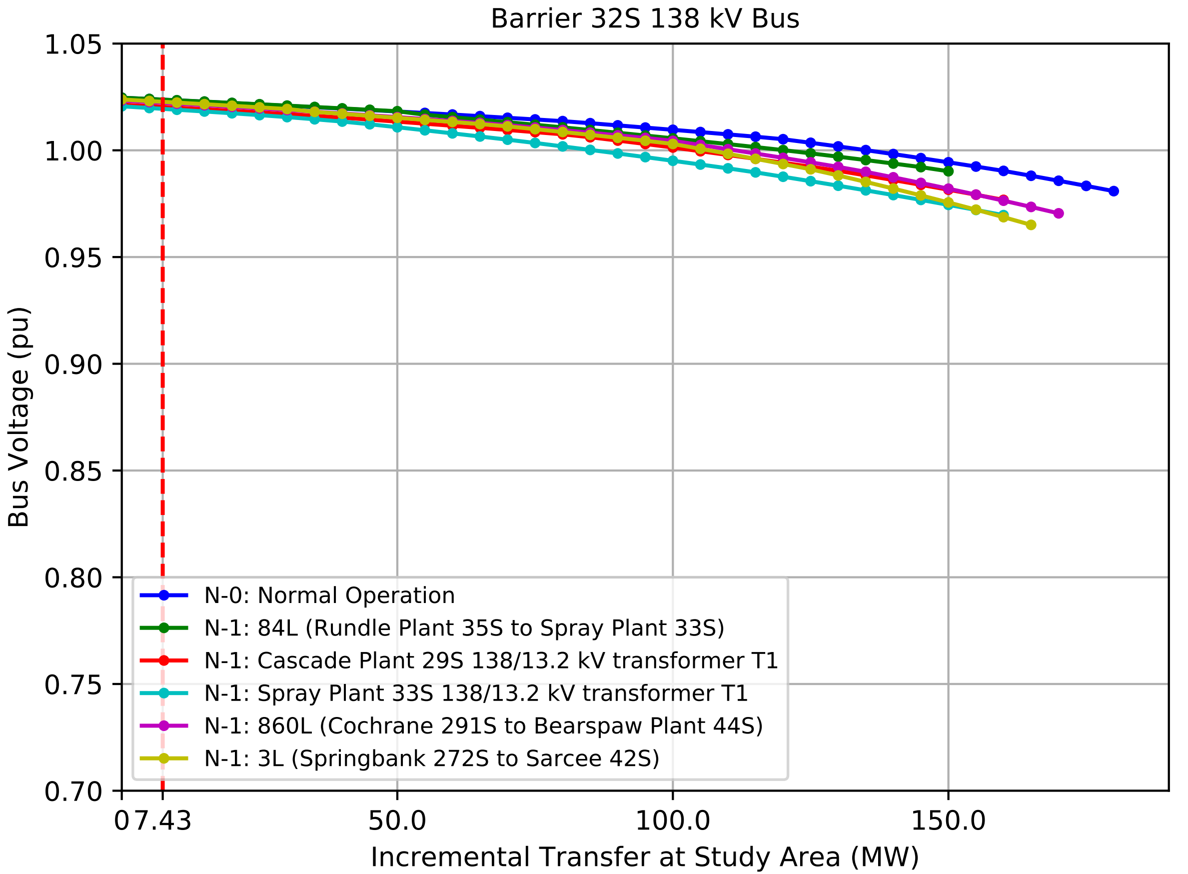


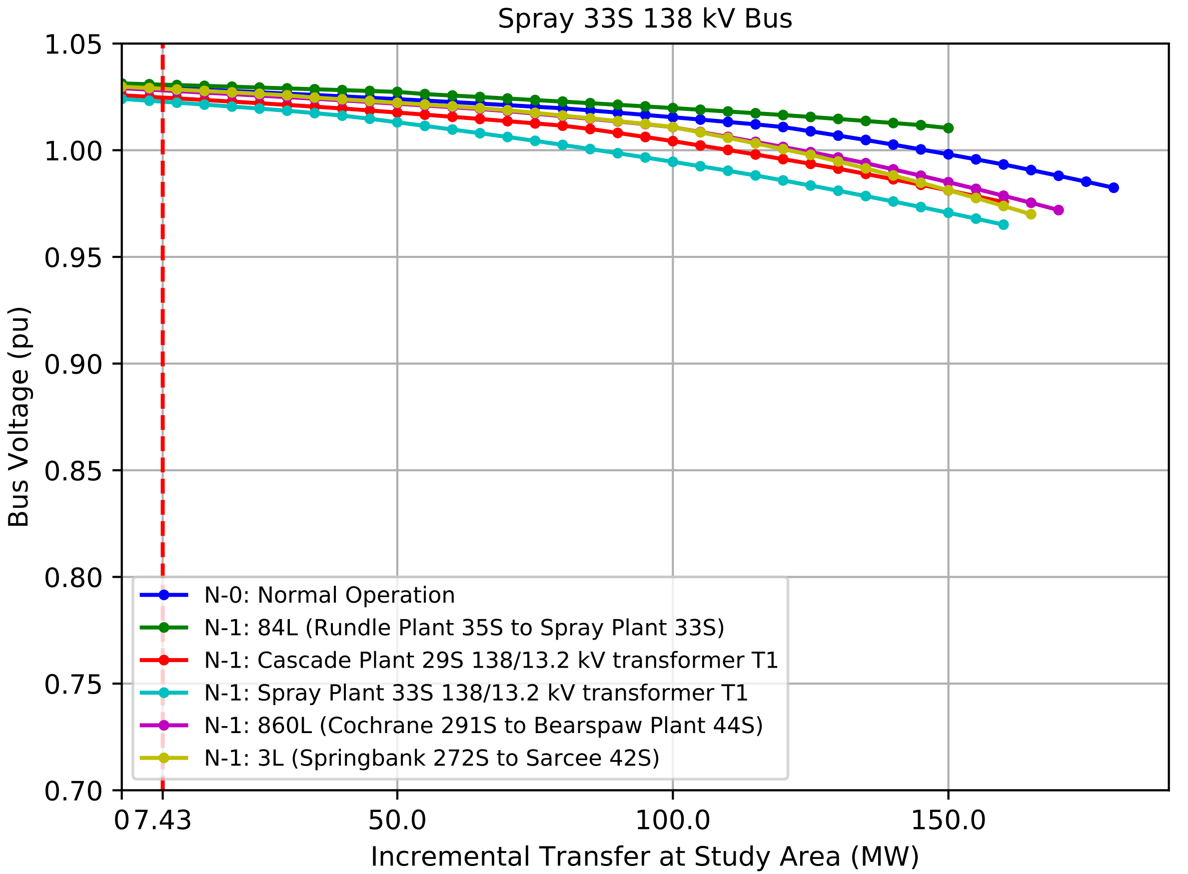
P2023 - Kananaskis Area Reliability

FIGURE A3-12 N-1: 3L (SPRINGBANK 272S TO SARCEE 42S)
2020 SUMMER PEAK (POST-A2)
PRINTED ON THURSDAY 20. SEPTEMBER 2018

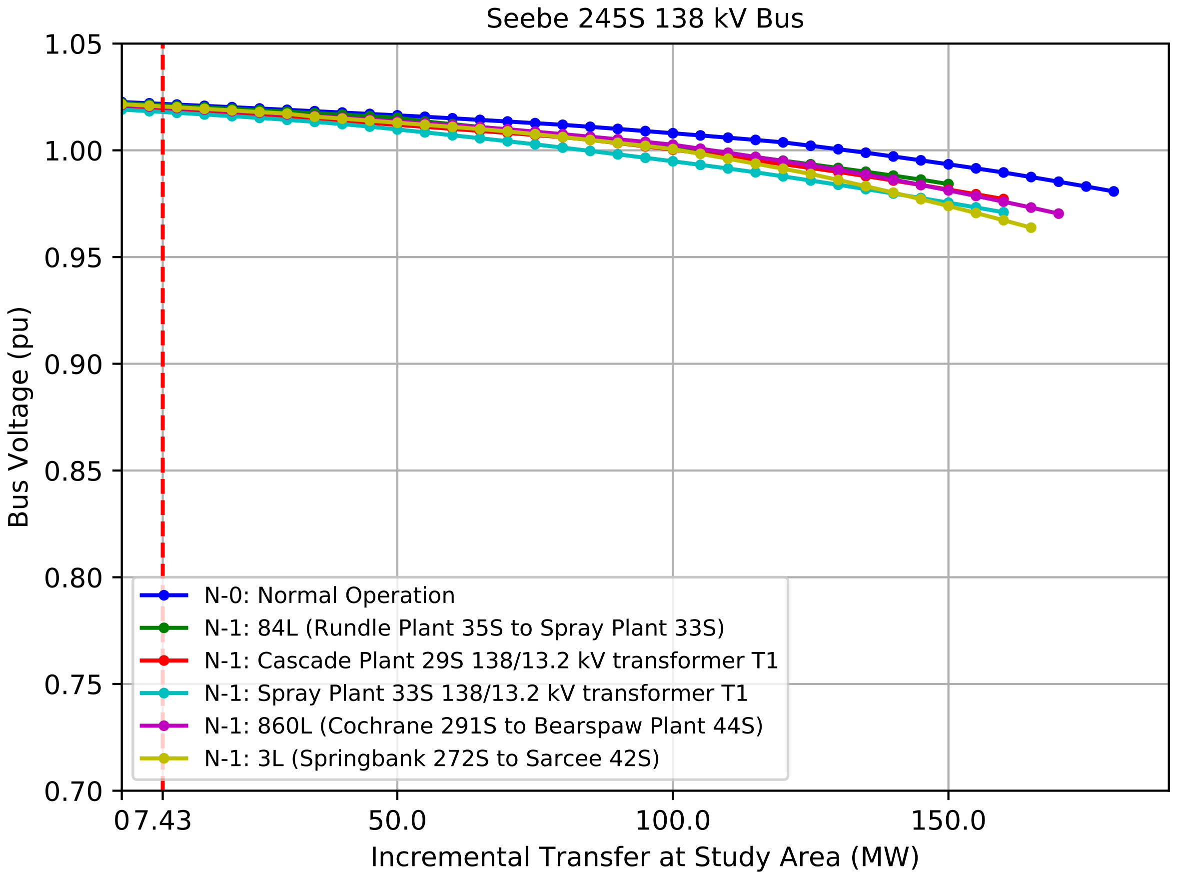


Mount Allan 115S 138 kV Bus
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
07.43
50.0
100.0
150.0
Incremental Transfer at Study Area (MW)
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)

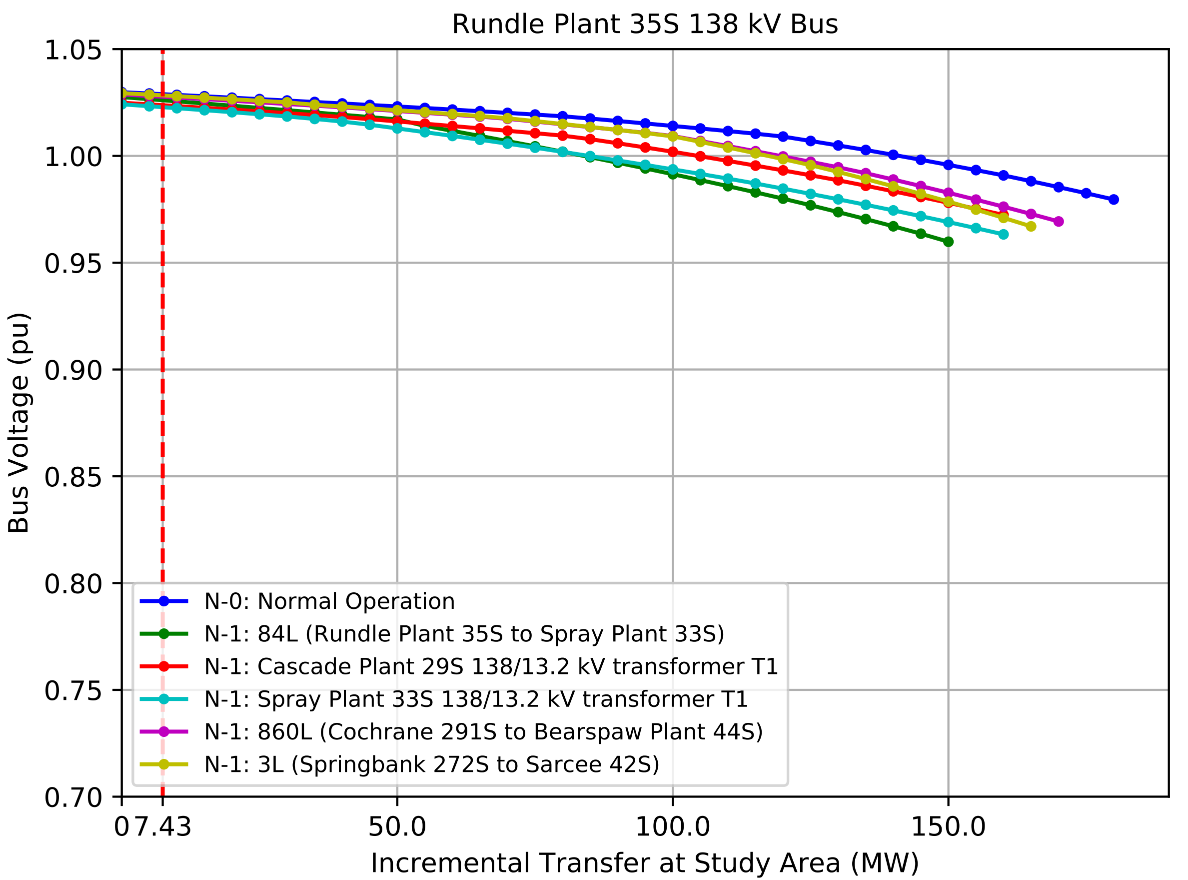

Barrier 32S 138 kV Bus
Bus Voltage (pu)
Incremental Transfer at Study Area (MW)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
07.43
50.0
100.0
150.0
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)

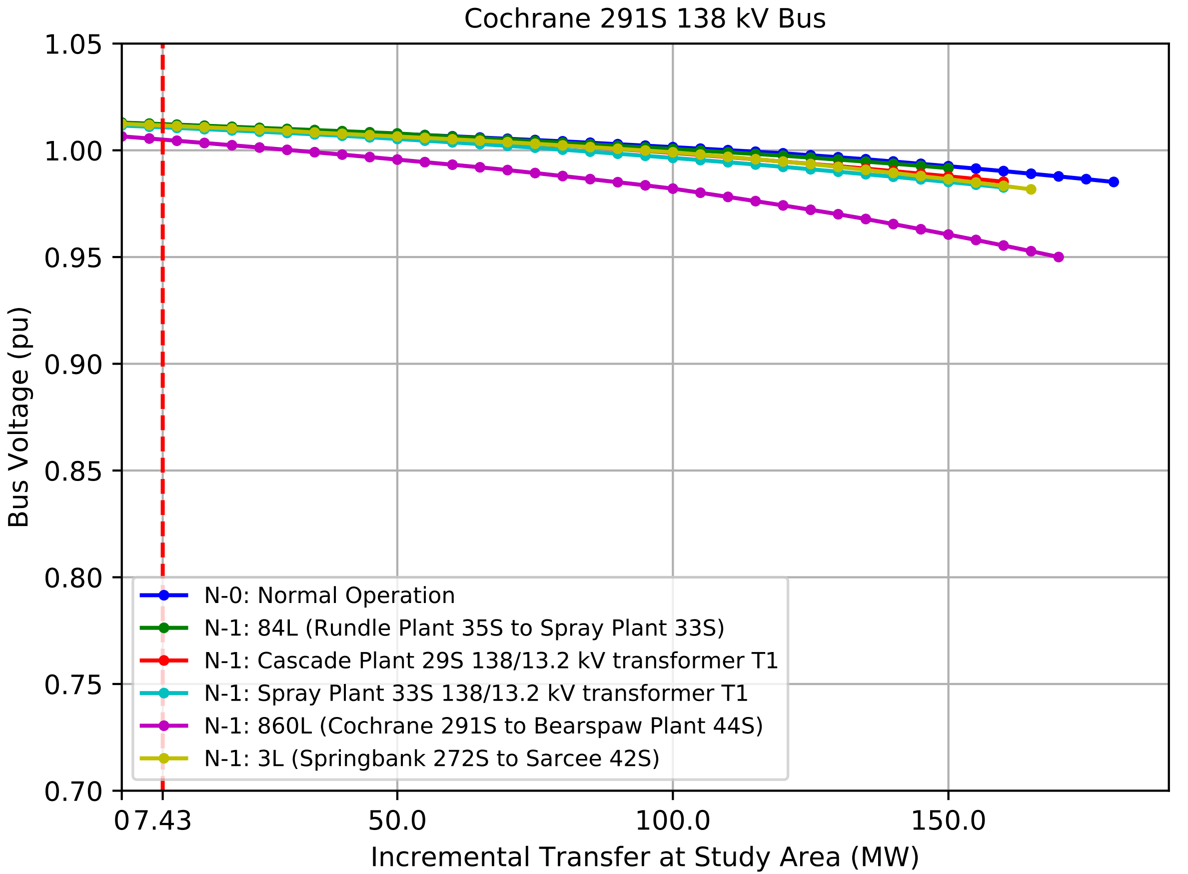


Spray 33S 138 kV Bus
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Bus Voltage (pu)
07.43
50.0
100.0
150.0
Incremental Transfer at Study Area (MW)
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)



Seebe 245S 138 kV Bus
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Bus Voltage (pu)
07.43
50.0
100.0
150.0
Incremental Transfer at Study Area (MW)
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)


Rundle Plant 35S 138 kV Bus
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Bus Voltage (pu)
07.43
50.0
100.0
150.0
Incremental Transfer at Study Area (MW)
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)



Cochrane 291S 138 kV Bus
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Bus Voltage (pu)
07.43
50.0
100.0
150.0
Incremental Transfer at Study Area (MW)
N-0: Normal Operation
N-1: 84L (Rundle Plant 35S to Spray Plant 33S)
N-1: Cascade Plant 29S 138/13.2 kV transformer T1
N-1: Spray Plant 33S 138/13.2 kV transformer T1
N-1: 860L (Cochrane 291S to Bearspaw Plant 44S)
N-1: 3L (Springbank 272S to Sarcee 42S)

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