APPENDIX A CONNECTION ASSESSMENT

Gainford 165S Substation Upgrade
Project Number: 1412

The attached engineering study report has been prepared by a third party as part of the AESO Connection Process. The AESO has reviewed the report and the conclusions that it contains, and finds it acceptable for the purpose of assessing potential impacts of the Project on the transmission system.

After completing the studies for the Project, the ISD of the Project shifted from January 2017 to February 2019; in addition, the AESO corporate forecast has been updated from the 2014 Long-term Outlook to the 2016 Long-term Outlook. The shift in the ISD and the updated forecast do not materially impact the results of this connection assessment, and do not change the conclusions and recommendations contained in this report.

Information regarding the AESO Connection Process can be found at: http://www.aeso.ca/8602.html

Date: June 28, 2016

Function	Name	Company	Signature	Date
Senior Engineer	Roul Martin, P.Eng.	Alberta Electric System Operator	R. Martin	June 28, 2016
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ALTALINK
A BERKSHIRE HATHAWAY ENERGY COMPANY

Engineering Study Report

Gainford 165S Substation Upgrade

AESO Project Number: P1412

Revision: 0

Date: June 10, 2016

Role	Name	Date	Signature
Prepared:	For Carl Wang, P. Eng.	June 23, 2016	I. Rahim
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AltaLink APEGA Permit Number P-7862

June 23, 2016

Executive Summary

Project Overview

Trans Mountain Pipeline L.P. (TMPL) submitted a System Access Service Request (SASR) to the Alberta Electric System Operator (AESO) to supply electricity to a proposed industrial load addition in the Gainford area.

The SASR includes a request for a Rate DTS, Demand Transmission Service, contract capacity increase from 3.5 MW to 14.5 MW for the system access service provided at the existing Gainford 165S substation, and a request for transmission development (collectively, the Project). Specifically, TMPL requested an upgrade to the existing Gainford 165S substation to support the increased demand at the Gainford Pump Station for Kinder Morgan Canada's proposed Trans Mountain Expansion Project.

The scheduled in-service date for the Project is February 1, 2019.

This report details the system performance studies undertaken to assess the impact of the Project on the Alberta interconnected electric system (AIES).

Existing System

Geographically, the Project is located in the AESO planning area of Wabamun (Area 40), which is part of the AESO Edmonton Planning Region. The Wabamun area is surrounded by the Edmonton (Area 60), Athabasca/Lac La Biche (Area 27), Swan Hills (Area 26), Hinton/Edson (Area 29), Drayton Valley (Area 30), and Wetaskiwin (Area 31) planning areas.

From an electrical system perspective, there is a significant amount of base-load coal-fired generation in the Wabamun area. The transmission system is comprised of 500 kV, 240 kV, 138 kV and 69 kV facilities. The Wabamun area (Area 40) is connected to the rest of the AIES by:

- 500 kV transmission lines 1325L, 1202L and 1209L;
- 240 kV transmission lines 973L, 974L, 1043L, 903L, 190L, 905L, 922L, 926L, 919L, 989L, 1045L, 909L and 913L; and,
- 138 kV lines 834L, 744L, 799L, 672L, 723L, 452L, and 7L230.

The Gainford 165S substation has a T-tap connection onto the 138 kV transmission line 156L (Wabamun 19S – Entwistle 235S) through the 138 kV transmission line 156BL.

The existing constraints in the Edmonton Region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management*. Automatic protection schemes are also presently used to manage thermal and transient stability violations in the Edmonton Region.

Study Summary

Study Area for the Project

The study area for the project consists of the Wabamun area (Area 40). The study area also includes the transmission lines connecting the Wabamun planning area to neighboring planning areas. All transmission facilities within the study area were studied and monitored to assess the impact of the Project on the AIES, including any violations of the Reliability Criteria (as defined in Section 2.1.1).

Studies Performed for the Project

Power flow analysis was performed for the 2016-2017 winter peak (WP) and 2017 summer peak (SP) pre-Project and post-Project scenarios. Voltage stability analysis was performed for the 2016-2017 WP post-Project scenario.

Results of the pre-Project Studies

No Reliability Criteria violations were observed for any of the pre-Project study scenarios.

Connection alternatives examined for the Project

The AESO examined two transmission alternatives to meet TMPL's request for system access service:

> **Alternative 1:** Upgrade the existing Gainford 165S substation by adding a second 138/4.16 kV transformer, with a rating of 15/20/25 MVA, and other associated equipment. Alternative 1 would require upgrading the existing 138 kV bus and the existing 4.16 kV bus, to facilitate the connection of the existing and new transformers. In addition, the substation fence would need to be expanded to accommodate the second transformer.
>
> **Alternative 2:** Upgrade the existing Gainford 165S substation by replacing the existing 7.5/8.4 MVA, 138/4.16 kV transformer with a new 15/20/25 MVA, 138/4.16 kV transformer and adding other associated equipment. Alternative 2 would also require upgrading the existing 138 kV bus and the existing 4.16 kV bus, but fewer upgrades at both busses than necessary for Alternative 1, to facilitate the connection of the new transformer.

Connection alternatives selected for further examination

Alternative 2 was selected for further study. Alternative 1 involves additional transmission facilities and hence, additional cost compared to Alternative 2. Similar to Alternative 2, Alternative 1 requires upgrades to the existing 138 kV bus and the existing 4.16 kV bus; however, the scope of bus upgrades required for Alternative 1 would be greater than for Alternative 2. Further, Alternative 1 requires expansion of the substation fence to accommodate the second transformer. Therefore, Alternative 1 was not selected for further study.

Results of the post-Project studies

Similar to the pre-Project power flow scenarios, no thermal or voltage violations were observed for Category A conditions and Category B contingency conditions in any of the post-Project power flow scenarios. Voltage stability analysis was also performed. No violation of the voltage stability criteria was observed subsequent to the connection of the Project using Alternative 2.

Conclusions and Recommendation

Based on the study results, Alternative 2 is technically viable. The studies show that the connection of the Project using Alternative 2 would not adversely impact the performance of the AIES. Therefore, it is recommended to proceed with the Project using Alternative 2 as the preferred option to respond to TMPL's request for system access service.

Contents

Attachments

Attachment A Pre-Project Power Flow Diagrams (Scenarios 1 and 2)

Attachment B Post-Project Power Flow Diagrams (Scenarios 3 and 4)

Attachment C Alternative 2: Voltage Stability Diagrams (Scenario 3)

Figures

Tables

1. Introduction

This Customer Connection Engineering Study Report presents the results of the study conducted to assess the impact of the Project (as defined below) on the performance of the Alberta interconnected electric system (AIES).

1.1. Project

1.1.1. Project Overview

Trans Mountain Pipeline L.P. (TMPL) submitted a System Access Service Request (SASR) to the Alberta Electric System Operator (AESO) to supply electricity to a proposed industrial load addition in the Gainford area.

The SASR includes a request for a Rate DTS, Demand Transmission Service, contract capacity increase from 3.5 MW to 14.5 MW for the system access service provided at the existing Gainford 165S substation, and a request for transmission development (collectively, the Project). Specifically, TMPL requested an upgrade to the existing Gainford 165S substation to support the increased demand at the Gainford Pump Station for Kinder Morgan Canada's proposed Trans Mountain Expansion Project.

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

1.1.2. Load Component

The existing Rate DTS contract capacity for the system access service provided at the existing Gainford 165S substation is 3.5 MW. TMPL has requested a Rate DTS contract capacity increase to 14.5 MW.

The new load at the Gainford Pump Station consists of three 5000 HP induction motors. One Variable Frequency Drive (VFD) will be used to start the motors one at a time. In an emergency, the motors may be started across-the-line (without the VFD).

This connection assessment assumed a 0.9 lagging power factor (pf) for the load associated with the Project.

TMPL has not indicated plans for a future load increase requiring service from the Gainford 165S substation in the SASR.

1.1.3. Generation Component

There is no generation component associated with the Project.

1.2. Study Scope

1.2.1. Study Objectives

The objectives of the study are the following:

- Assess the impact of the Project on the performance of the AIES.
- Identify any violations of the relevant criteria, standards or requirements of the AESO, both before and after connection of the Project.
- Recommend mitigation measures, if required, to enable the reliable connection of the Project to the AIES.

1.2.2. Study Area

1.2.2.1. Study Area Description

Geographically, the Project is located in the AESO planning area of Wabamun (Area 40), which is part of the AESO Edmonton Planning Region. The Wabamun area is surrounded by the Edmonton (Area 60), Athabasca/Lac La Biche (Area 27), Swan Hills (Area 26), Hinton/Edson (Area 29), Drayton Valley (Area 30), and Wetaskiwin (Area 31) planning areas.

From an electrical system perspective, there is a significant amount of base-load coal-fired generation in the Wabamun area. The transmission system is comprised of 500 kV, 240 kV, 138 kV and 69 kV facilities. The Wabamun area (Area 40) is connected to the rest of the AIES by:

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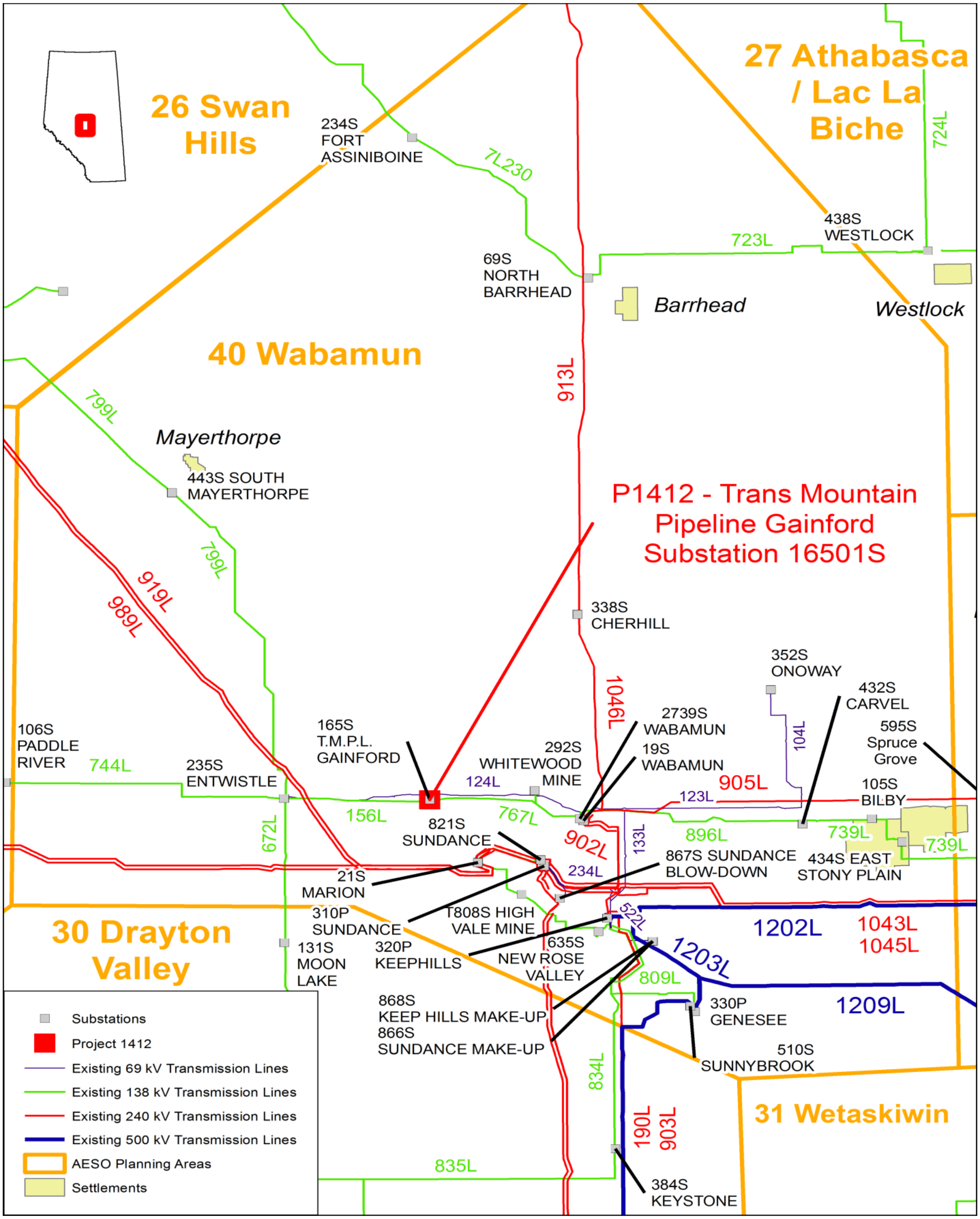
The Gainford 165S substation has a T-tap connection onto the 138 kV transmission line 156L (Wabamun 19S – Entwistle 235S) through the 138 kV transmission line 156BL.

The study area for the project consists of the Wabamun area (Area 40). The study area also includes the transmission lines connecting the Wabamun planning area to neighboring planning areas. All transmission facilities within the study area were studied and monitored to assess the impact of the Project on the AIES, including any violations of the Reliability Criteria (as defined in Section 2.1.1).

Figure 1-1 shows the existing transmission system in the study area.

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



1.2.2.2. Existing Constraints

The existing constraints in the Edmonton Region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (the TCM Rule). Automatic protection schemes are also presently used to manage thermal and transient stability violations in the Edmonton Region.

1.2.2.3. AESO Long-Term Transmission Plans (LTP)

The South and West of Edmonton Area Transmission Development[1] is included in all the study scenarios. There are no other system projects or projects included in the *AESO 2015 Long-term Transmission Plan* (2015 LTP)[2] that are planned to be developed in the vicinity of the Project location in the near term (by 2020).

Table 1.2-1: Summary of System Projects in the Vicinity of the Study Area

Project Number	Project Name	Project Area	In-Service Date
850	South and West of Edmonton Area Transmission Development	60	December 2017

1.2.3. Studies Performed

The following studies were performed for the pre-Project analysis:

- Power flow analysis (Category A conditions and Category B contingencies)

The following studies were performed for the post-Project analysis:

- Power flow analysis (Category A conditions and Category B contingencies)
- Voltage stability analysis (Category A conditions and Category B contingencies)

1.3. Report Overview

The Executive Summary provides a high-level summary of the study and its conclusions. Section 1 provides an introduction of the Project and describes the study scope. Section 2 describes the criteria, system data, and other study assumptions used in this study. Section 3 describes the methodology used for this study. Section 4 discusses the pre-Project assessment of the system. Section 5 presents all the connection alternatives examined. Section 6 provides a technical analysis of the post-Project system assessment for the alternative selected for further study. Section 7 presents any dependencies the Project may have on other AESO plans to

[1] The Alberta Utilities Commission approved the need for the South and West of Edmonton Area Transmission System Reinforcement on May 5, 2014 in Decision 2014-126 and Approval U2014-183.

[2] The 2015 LTP document is available on the AESO website.

expand or enhance the transmission system. Section 8 presents the conclusions and recommendations of this study.

2. Criteria, System Data, and Study Assumptions

2.1. Criteria, Standards, and Requirements

2.1.1. Transmission Planning Standards and Reliability Criteria

The Transmission Planning (TPL) Standards, which are included in the Alberta Reliability Standards, and the AESO's *Transmission Planning Criteria – Basis and Assumptions* (collectively, the Reliability Criteria)[3] were 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 as well as a summary of Category C5 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-AB-0, have referenced Applicable Ratings when specifying the required system performance under Category A and Category B events, respectively. For the purpose of applying the TPL standards to the studies documented in this report, Applicable Ratings are defined as follows:

- Seasonal continuous thermal rating of the line's loading limits.
- Highest specified loading limits for transformers.
- For Category A conditions: Voltage range under normal operating condition should follow the AESO Information Document ID# 2010-007RS. For the busses not listed in ID#2010-007RS, Table 2-1 in the Reliability Criteria applies.

[3] Filed under separate cover.

- For Category B conditions: The extreme voltage range values per Table 2-1 in the Reliability Criteria.
- Desired post-contingency voltage change limits for three defined post event timeframes as provided in Table 2.1-1.

Table 2.1-1: Post Contingency Voltage Deviation Guidelines

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 low voltage bus.	±10%	±7%	±5%

2.1.2. AESO Rules

AESO Information document ID# 2010-007RS, *General Operating Practices - Voltage Control*, which relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage*, was applied to establish system normal (i.e., pre-contingency) voltage profiles in the study area and its vicinity. The TCM Rule will be followed in setting up the study scenarios and assessment of the impact of the Project connection. In addition, due regard will be given to the AESO's Connection Study Requirements and the AESO's Generation and Load Interconnection Standard.

The Reliability Criteria is the basis for planning the AIES. The transmission system will normally be designed to meet or exceed the Reliability Criteria under credible worst-case loading and generation conditions.

2.2. Study Scenarios

Table 2.2-1 summarizes the study scenarios used for the connection assessment. This connection assessment will assume a 0.9 lagging power factor (pf) for the load associated with the Project. Scenarios 1 and 2 are the pre-Project scenarios for 2016-2017 WP and 2017 SP, respectively and Scenarios 3 and 4 are the post-Project scenarios for 2016-2017 WP and 2017 SP, respectively. A power factor of 0.9 lagging was used for the new Project load.

Table 2.2-1: List of the Connection Study Scenarios

Scenario	Year/Season Load	Condition	Project Load (MW)	Gainford 165S Load (MW)	System Generation Dispatch Conditions
1	2016-2017 WP	Pre-project	0	3.5	Merit-order based dispatch
2	2017 SP	Pre-Project	0	3.5	
3	2016-2017 WP	Post Project	11	14.5	
4	2017 SP	Post-Project	11	14.5	

2.3. Load and Generation Assumptions

2.3.1. Load Assumptions

The load forecasts used for this connection study are shown in Table 2.3-1 and are based on the *AESO 2012 Long-term Outlook Update* (2012 LTOU). In this study, the active power to reactive power ratio in the study scenarios was maintained when modifying the loads to comply with the forecast shown in Table 2.3-1.

Table 2.3-1: Forecast Area Load *(2012 LTOU at AIL Peak)*

Area or Region Name and Season	Forecast Peak Load (MW)	
	2016-2017 WP (MW)	2017 SP (MW)
Wabamun (Area 40)	229	193
Edmonton (Area 60)	1935	1815
Wetaskiwin (Area 31)	155	133
Alberta Internal Load (AIL) w/o Losses	12552	11607

2.3.2. Generation Assumptions

The generation conditions for this connection study are described in Table 2.3-2. Keephills Unit 3 is considered to be the critical generating unit for the purposes of the studies, and is assumed to be offline for the power flow and voltage stability analyses.

Table 2.3-2: Existing Local Generation (MW) in the Study Cases

Unit Name	Bus Number	Area	Pmax (MW)	2016-2017 WP Unit Net Generation[4] (MW)	2017 SP Unit Net Generation (MW)
Sundance 1	129	40	300	263	263
Sundance 2	338	40	300	263	263
Sundance 3A	130	40	395	336	336
Sundance 4A	342	40	430	379	379
Sundance 5A	345	40	435.4	367	367
Sundance 6A	350	40	425	373	373
Keephills 1	422	40	415	396	374
Keephills 2	424	40	415	388	372
Keephills 3	403	40	498	0	0

[4] Unit Net Generation refers to Gross Generating unit MW output less Unit Service Load.

Unit Name	Bus Number	Area	Pmax (MW)	2016-2017 WP Unit Net Generation[4] (MW)	2017 SP Unit Net Generation (MW)
Joffre 1	3354	35	158	66.2	55.2
Joffre 2	3355	35	163	68.1	36.6
Joffre 3	3357	35	133	54.8	50.2
Celanese 1	25402	60	6.6	0	0
Celanese 2	25402	60	6.6	0	0
Celanese 3	25402	60	6.6	0	0
Celanese 4	25401	60	6.6	0	0
Cloverbar G1	25516	60	43.9	45	37
Cloverbar G2	26516	60	100	96	86
Cloverbar G3	27516	60	100.8	96	86
Genesee 1	491	40	422	376	376
Genesee 2A	492	40	422	378	378
Genesee 3	490	40	527.4	434	434

2.3.3. Intertie Flow Assumptions

The Alberta-BC, Alberta-Montana, and Alberta-Saskatchewan intertie points are deemed to be too far away to have any material impact on the connection assessment for the Project. Therefore, the intertie assumptions are kept consistent with that in the corresponding AESO planning base cases and not adjusted in the study scenarios.

2.3.4. HVDC Power Order Assumptions

The flows in the Study Area are not significantly influenced by the AIES Western Alberta Transmission Line (WATL) and Eastern Alberta Transmission Line (EATL) HVDC facilities. Hence, the HVDC power order assumptions were kept consistent with that in the corresponding AESO planning base cases and not adjusted in the study scenarios.

2.4. System Projects

Table 2.4-1 lists the South and West of Edmonton Area Transmission Development subprojects that have been included in this study. Other than the South and West of Edmonton Area Transmission Development subprojects, no additional system projects were included in the study scenarios.

Table 2.4-1: Summary of System Projects Included in the Study Scenarios

Project	Subproject	Subproject Name	In-Service Date

Project	Subproject	Subproject Name	In-Service Date
850	1	174L/780L 138 kV Transmission Line Renumbering	Dec 29, 2017
850	2	Cooking Lake 522S Substation	Dec 29, 2017
850	3	Saunders Lake 289S Substation and Transmission Lines	Dec 29, 2017
850	4	Nisku 149S Modifications	Dec 29, 2017
850	5	New 454L/455L 138 kV Transmission Line between Saunders Lake 289S and Nisku 149S	Dec 29, 2017
850	6	780L and 858L Transmission Line Modifications	Dec 29, 2017
850	7	Leduc 325S 138 kV 27 MVA Capacitor Bank	Dec 29, 2017
850	8	Wabamun 19S Open 133L Transmission Line	Dec 29, 2017
850	9	Lines salvage (910L-914L-780L-858L)	May 04, 2018
850	10	Telecomm Towers (Bardo 197S – Canmore 9285R)	Dec 29, 2017
850	11	New Harry Smith 367S Substation	Dec 31, 2017
850	12	Modifications at Acheson 305S	Dec 31, 2017
850	13	Lines 446L/453L between Harry Smith 367S and Acheson 305S	Dec 31, 2017
850	14	240 kV 1043L/1139L in-out at Harry Smith 367S	Dec 31, 2017
850	15	EPCOR P&C and Line Renumbering	Dec 31, 2017

2.5. Customer Connection Projects

The customer projects included in the study are shown in Table 2.5-1.

Table 2.5-1: Summary of Customer Connection Assumptions

Planning Area	Queue Position*	Planned In-Service Date	Project Name	Project #	Gen (MW)	Load (MW)	Included/Excluded from Studies
40	Energized	Sep. 2013	Fortis Onoway 352S Transformer Replacement	1210	0	0	Included
40	Energized	Nov. 2013	Cherhill 338S Transformer Addition	1223	0	0	Included
40	Energized	Sep. 2014	Enbridge Bernese 293S Substation	1358	0	22.0	Included

2.6. Facility Ratings and Shunt Elements

The Transmission Facility Owner (TFO) provided the ratings of the existing transmission lines (Table 2.6-1) and the existing transformers (
Table 2.6-2) in the Study Area.

Table 2.6-1: Summary of Transmission Line Ratings in the Study Area (*MVA on Voltage Class Base*)

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)		Short-term[5] Rating (MVA)	
			Summer	Winter	Summer	Winter
799L	Mayerthorpe 443S – Entwistle 235S	138	85	90	94	99
799L	South Mayerthorpe 443S – Sagitawah 77S	138	85	90	94	99
744L	Entwistle 235S – 106S Tap	138	75	79	83	87
156L	Entwistle 235S – Gainford 165S Tap	138	126	169	139	186
672L	Entwistle 235S – Moon Lake 131S	138	167	201	184	218
123L	Wabamun 19S – Onoway 352S	69	24CT[6]	24CT	36CT	36CT
133L	Wabamun 19S – 234L Junction	69	29	36	32	40
124L	Wabamun 19S – Wabamun 2739S	69	29	36	32	40
7L230	North Barrhead 69S – 888AL Tap	144	86	91	95	100
723L	North Barrhead 69S – 724L Tap	138	86	91	95	100
888AL	Fort Assiniboine 234S – 7L230 Junction	138	123	150	135	165
834L	Keystone 384S – Keephills 320P	138	158	191CT	174	213
973L	Bickerdike 39S – Sundance 310P	240	333CT	333CT	499CT	499CT
974L	Bickerdike 39S – Sundance 310P	240	333CT	333CT	499CT	499CT
512L	Sundance 310P – 521L Tap	69	22	27	24	30
512L	Sundance 821S – 521L Tap	69	22	27	24	30
767L	Sundance 310P – 767AL Tap	138	121	143CT	133	163
902L	Wabamun 19S – Sundance 310P	240	499	499CT	499	499CT
905L	Wabamun 19S – North Calder 37S	240	299	437	359	524
896L	Wabamun 19S – Carvel 432S	138	121	149	133	164
156L	Wabamun 19S – 156BL Tap	138	126	169	139	186

[5] When line loading in post Category B contingency is observed to exceed nominal rating and is less than the Short-term (emergency) rating, it is assumed that AESO and TFO operating practices can manage the constraint within the time requirements of TFO short time (emergency) rating.

[6] Limited by current transformer

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)		Short-term[5] Rating (MVA)	
			Summer	Winter	Summer	Winter
922L	Sundance 310P – Benalto 17S	240	466	499CT	499	499CT
926L	Sundance 310P – Benalto 17S	240	481	499CT	499	499CT
989L	Sundance 310P – Sagitawah 77S	240	489	599	587	648
919L	Sundance 310P – Sagitawah 77S	240	489	599	587	599
1046L	Sundance 310P – Cherhill 338S	240	337	407	404	488
1045L	Sundance 310P – Jasper 805S	240	481	581	577	697
909L	Sundance 310P – Dome 665S	240	481	581	577	697
913L	North Barrhead 69S – Cherhill 338S	240	337	407	404	488
9L913	North Barrhead 69S – Mitsue 732S	240	499CT	499CT	608	736
903L	Benalto 17S – Keephills 320P	240	448	499CT	499	499
190L	Benalto 17S – Keepthills 320P	240	466	499CT	499	499
1209L	Ellerslie 89S – Genesee 330P	500	2500	2500	3250	3250
1202L	Ellerslie 89S – Keephills 320P	500	2598CT	2598CT	3380	3464
522AL	Sundance 866S – Keephils Make-up 868S	69	29	36	32	40
522L	Keephills 320P – 133L Junction	69	22	27	24	30
767AL	Marion 21S – 767L Junction	69	85	90	94	99
739L	Stony Plain 434S – 739AL Tap	138	120	143CT	132	163
739L	Carvel 432S – 739AL Tap	138	120	148	132	163
744L	Niton 228S – 744AL Tap	138	75	79	83	87
767L	Keephills 320P – 767CL Tap	138	121	148	133	163
156BL	Gainford 165S – 156L Junction	138	121	149	133	164
739AL	Bilby 105S – 739L Junction	138	123	151	135	166
744AL	Paddle River 106S – 744L Junction	138	120	145	132	160

Table 2.6-2: Summary of Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
Wabamun 19S	T1	240/138	200
Sundance 310P	T1	240/138	168
Sundance 310P	T4	240/69	44.8

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
Keephills 320P	T6	500/240	1200
Keephills 320P	PS	240/240	600
Keephills 320P	T1	240/138	150
Genesee 330P	T1/T2	500/138	100

The Study Area does not include any shunt reactive devices.

2.7. Voltage Profile Assumptions

The AESO Voltage Control Practice ID # 2010-007RS is used to establish normal system (i.e., pre-contingency) voltage profiles for key area buses prior to commencing any studies. Table 2-1 of the Reliability Criteria applies for all the buses not included in the ID # 2010-007RS. These voltages were utilized to set the voltage profile in the study scenarios prior to conducting power flow analysis.

3. Study Methodology

3.1. Connection Studies Carried Out

The studies that were carried out for this connection assessment are identified in

Table 3.1-1:

Table 3.1-1: Summary of Studies Performed

Scenario and Condition		Project Load (MW)	System Conditions	Power Flow[7]	Voltage Stability
1	2016-2017 WP Pre-Project	3.5	Category A and Category B	Yes	No
2	2017 SP Pre-Project	3.5	Category A and Category B	Yes	No
3	2016-2017 WP Post-Project	14.5	Category A and Category B	Yes	Yes
4	2017 SP Post-Project	14.5	Category A and Category B	Yes	No

3.2. Power Flow Analysis

The purpose of the power flow analysis is to quantify any incremental violations in the study area after the Project is connected. Power flow analysis was completed for all study scenarios to identify thermal overloads or voltage violations as per the Reliability Criteria, and to identify any deviations from the desired limits in Table 2.1-1. Transformer tap and switched shunt reactive compensation devices such as shunt capacitors and reactors were locked and continuous shunt devices were enabled when performing Category B load flow analysis. This methodology was used for both the pre-Project and post-Project scenarios.

Point-of-Delivery (POD) low voltage bus deviations were also assessed by first locking all tap changers and shunt reactive devices to identify any post-transient voltage deviations above 10%. Second, tap changers were then allowed to adjust, while shunt reactive devices remained locked to determine if any voltage deviations above 7% would occur in the Study Area. Third, all taps and shunt reactive device controls were allowed to adjust and voltage deviations above 5% were reported for both the pre-Project and post-Project systems.

[7] The critical generator identified for this study is Keephills 3.

3.2.1. Contingencies Studied

For the power flow analysis, all transmission facilities in the study area were monitored for voltage criteria violations and thermal violations under Category A conditions and under Category B contingency conditions. Power flow analysis was conducted for all Category B contingencies (69 kV facilities and above) within the study area, including the tie lines connecting the study area to the surrounding planning areas.

3.3. Voltage Stability (PV) Analysis

The objective of the voltage stability analysis is to determine the ability of the network to maintain voltage stability at all the buses in the Study Area under normal and abnormal system conditions. The Power-Voltage (PV) curve is a representation of voltage change as a result of increased power transfer between two systems. The reported incremental transfers will be to the collapse point. As per the AESO requirements, no assessment based upon other criteria such as minimum voltage will be made at the PV minimum transfer. Voltage stability analysis for post-Project scenarios will be performed. For load connection projects, the load level modelled in the post-connection scenarios are either the same or higher than in pre-Project scenarios. Therefore, voltage stability analysis for pre-Project scenarios will only be performed if post-Project scenarios show voltage stability criteria violations.

The voltage stability analysis was 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 is required for the area modeled at a minimum of 105% of the reference load level for system normal conditions (Category A) and for single contingencies (Category B). For this standard, the reference load level is the maximum forecasted load for the Study Area.

Typically, voltage stability analysis is carried out assuming the worst case scenarios in terms of loading. Voltage stability analysis was performed by increasing the load in the Study Area and increasing the corresponding generation in the Wabamun (Area 40) and the Calgary (Area 6) planning areas.

3.3.1. Contingencies Studied

Voltage stability analysis was performed for the Category A condition and all Category B contingencies in the Study Area using the 2016-2017 WP post-Project scenario only.

4. Pre-Project System Assessment

4.1. Pre-Project Power Flow Analysis

4.1.1. Scenario 1: 2016-2017 Winter Peak

No Reliability Criteria violations were observed under Category A conditions or under Category B contingency conditions.

Refer to Attachment A for power flow diagrams and a list of the top five Category B contingencies resulting in the highest post-contingency thermal loading on the facilities in the Study Area.

4.1.2. Scenario 2: 2017 Summer Peak

No Reliability Criteria violations were observed under Category A conditions or under Category B contingency conditions.

Refer to Attachment A for power flow diagrams and a list of the top five Category B contingencies resulting in the highest post-contingency thermal loading on the facilities in the Study Area.

5. Connection Alternatives

5.1. Overview

The Gainford 165S substation is owned by TMPL and no other customer is supplied from this POD substation. Thus, only alternatives involving development at the Gainford 165S substation were examined in this engineering study report.

5.2. Connection Alternatives Identified

The AESO examined two transmission alternatives to meet TMPL's request for system access service:

Alternative 1: Upgrade the existing Gainford 165S substation by adding a second 138/4.16 kV transformer, with a rating of 15/20/25 MVA, and other associated equipment. Alternative 1 would require upgrading the existing 138 kV bus and the existing 4.16 kV bus, to facilitate the connection of the existing and new transformers. In addition, the substation fence would need to be expanded to accommodate the second transformer.

Alternative 2: Upgrade the existing Gainford 165S substation by replacing the existing 7.5/8.4 MVA, 138/4.16 kV transformer with a new 15/20/25 MVA, 138/4.16 kV transformer and adding other associated equipment. Alternative 2 would also require upgrading the existing 138 kV bus and the existing 4.16 kV bus, but fewer upgrades at both busses than necessary for Alternative 1, to facilitate the connection of the new transformer.

5.2.1. Connection Alternatives Selected for Further Studies

Alternative 2 was selected for further study.

5.2.2. Connection Alternatives Not Selected for Further Studies

Alternative 1 involves additional transmission facilities and hence, additional cost compared to Alternative 2. Similar to Alternative 2, Alternative 1 requires upgrades to the existing 138 kV bus and the existing 4.16 kV bus; however, the scope of bus upgrades required for Alternative 1 would be greater than for Alternative 2. Further, Alternative 1 requires expansion of the substation fence to accommodate the second transformer. Therefore, Alternative 1 was not selected for further study.

6. Technical Analysis of the Preferred Connection Alternative

6.1. Power Flow Analysis

The following is a summary of the power flow analysis results for Project.

6.1.1. Scenario 3: 2016-2017 Winter Peak

Similar to the 2016-2017 WP pre-Project scenario, no Reliability Criteria violations were observed under Category A conditions or under Category B contingency conditions.

Refer to Attachment B for power flow diagrams and a list of the top five Category B contingencies resulting in the highest post-contingency thermal loading on the facilities in the Study Area.

6.1.2. Scenario 4: 2017 Summer Peak

Similar to the 2017 SP pre-Project scenario, no Reliability Criteria violations were observed under Category A conditions or under Category B contingency conditions.

Refer to Attachment B for power flow diagrams and a list of the top five Category B contingencies resulting in the highest post-contingency thermal loading on the facilities in the Study Area.

6.2. Voltage Stability

Voltage stability analysis was performed using the 2016-2017 WP scenario (Scenario 3). The reference load level for the Study Area is 229 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load or 11.5 MW to meet the voltage stability criteria (0.05 x 229 MW = 11.5 MW). Table 6.2-1 summarizes the voltage stability results for Category A and the worst contingencies under Category B system conditions.

The voltage stability margin is met for all studied conditions.

The voltage stability diagrams are shown in Attachment C.

Table 6.2-1: Scenario 3: 2016-2017 WP– Voltage stability analysis results

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G	System Normal		720	Yes
452L	Stony Plain 434S	Harry Smith 367S	460	Yes
330P G3	Genesee 330P 500 kV	Genesee E330P 22 kV	560	Yes
69S T4	North Barrhead 69S 240/138 kV T4		580	Yes
1046L	Sundance 310P	Cherhill 338S	620	Yes
320P G1	Keephills 320P transformer G1		650	Yes
310P T5	Sundance 310P transformer T5		680	Yes

6.3. Mitigation Measures

No mitigation measures are needed for the Project as no Reliability Criteria violations were observed.

6.4. Conclusions

Based on the study results, Alternative 2 is technically viable. Power flow results indicate that there are no thermal criteria violations or voltage criteria violations prior to and after the Project. The voltage stability results confirm that the voltage stability margin of the study area meets the AESO requirement after the Project.

7. Project Dependencies

The Project is not dependent on other AESO plans to expand or enhance the transmission system or any other planned connection projects.

8. Summary and Conclusion

Project Overview

TMPL submitted a SASR to the AESO to supply electricity to a proposed industrial load addition in the Gainford area.

The SASR includes a request for a Rate DTS, Demand Transmission Service, contract capacity increase from 3.5 MW to 14.5 MW for the system access service provided at the existing Gainford 165S substation, and a request for transmission development. Specifically, TMPL requested an upgrade to the existing Gainford 165S substation to support the increased demand at the Gainford Pump Station for Kinder Morgan Canada's proposed Trans Mountain Expansion Project.

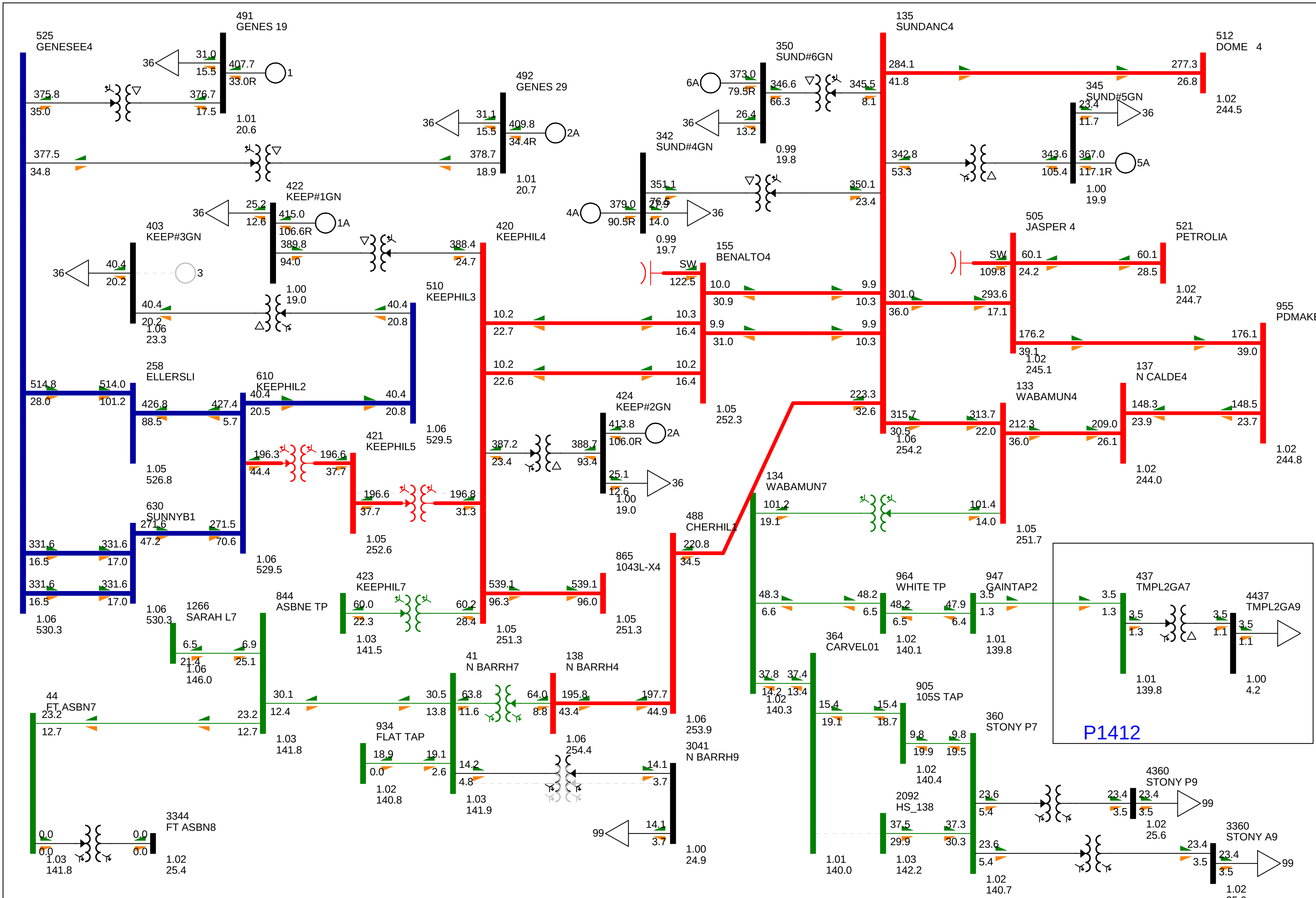
The scheduled in-service date for the Project is February 1, 2019.

Recommendation

Based on the study results, Alternative 2 is technically viable. The studies show that the connection of the Project using Alternative 2 would not adversely impact the performance of the AIES. Therefore, it is recommended to proceed with the Project using Alternative 2 as the preferred option to respond to the TMPL's request for system access service.

Attachment A

Pre-Project Power Flow Diagrams (Scenarios 1 to 2)

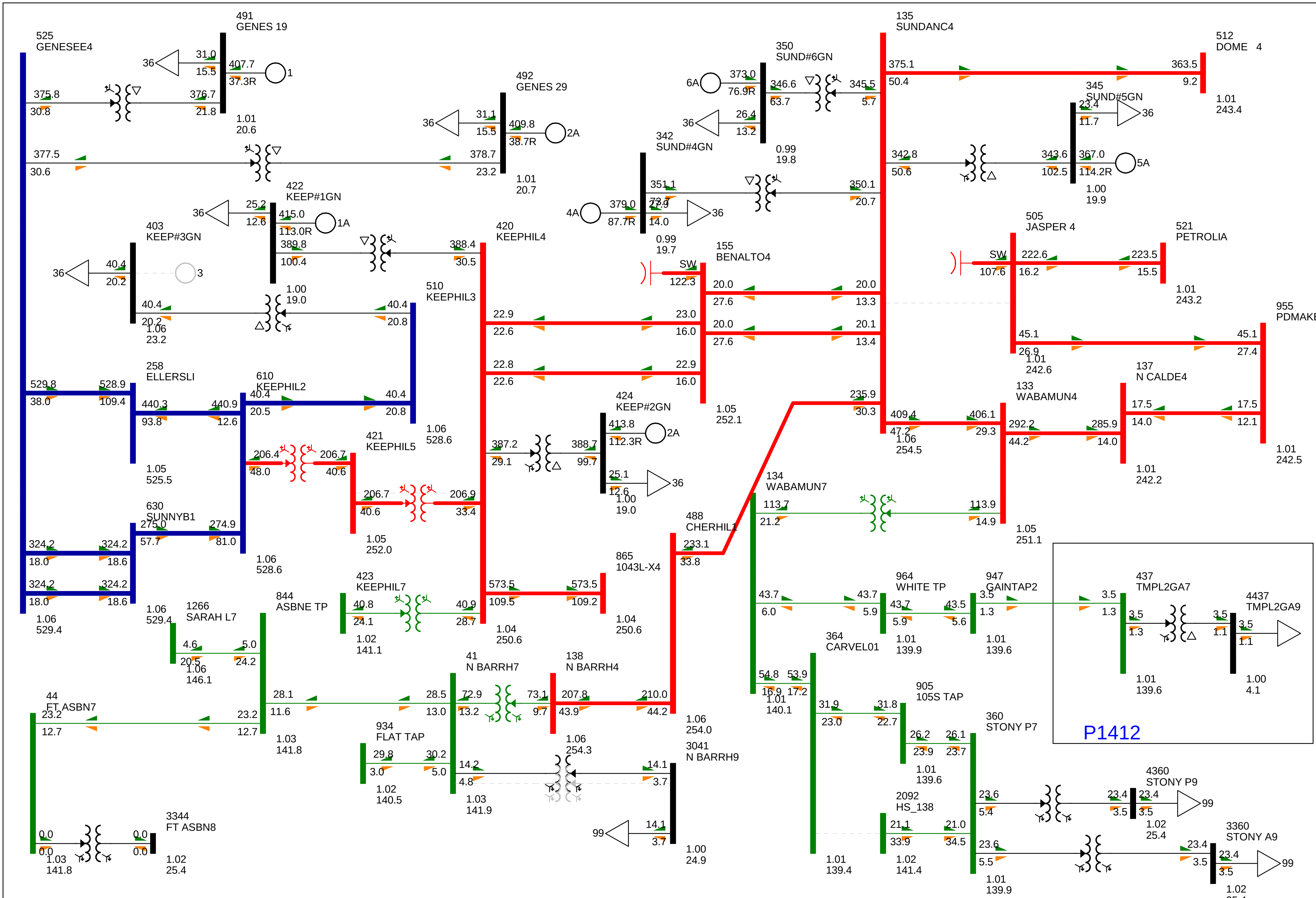


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 649.8 MW

FIGURE A1-SYSTEM NORMAL
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

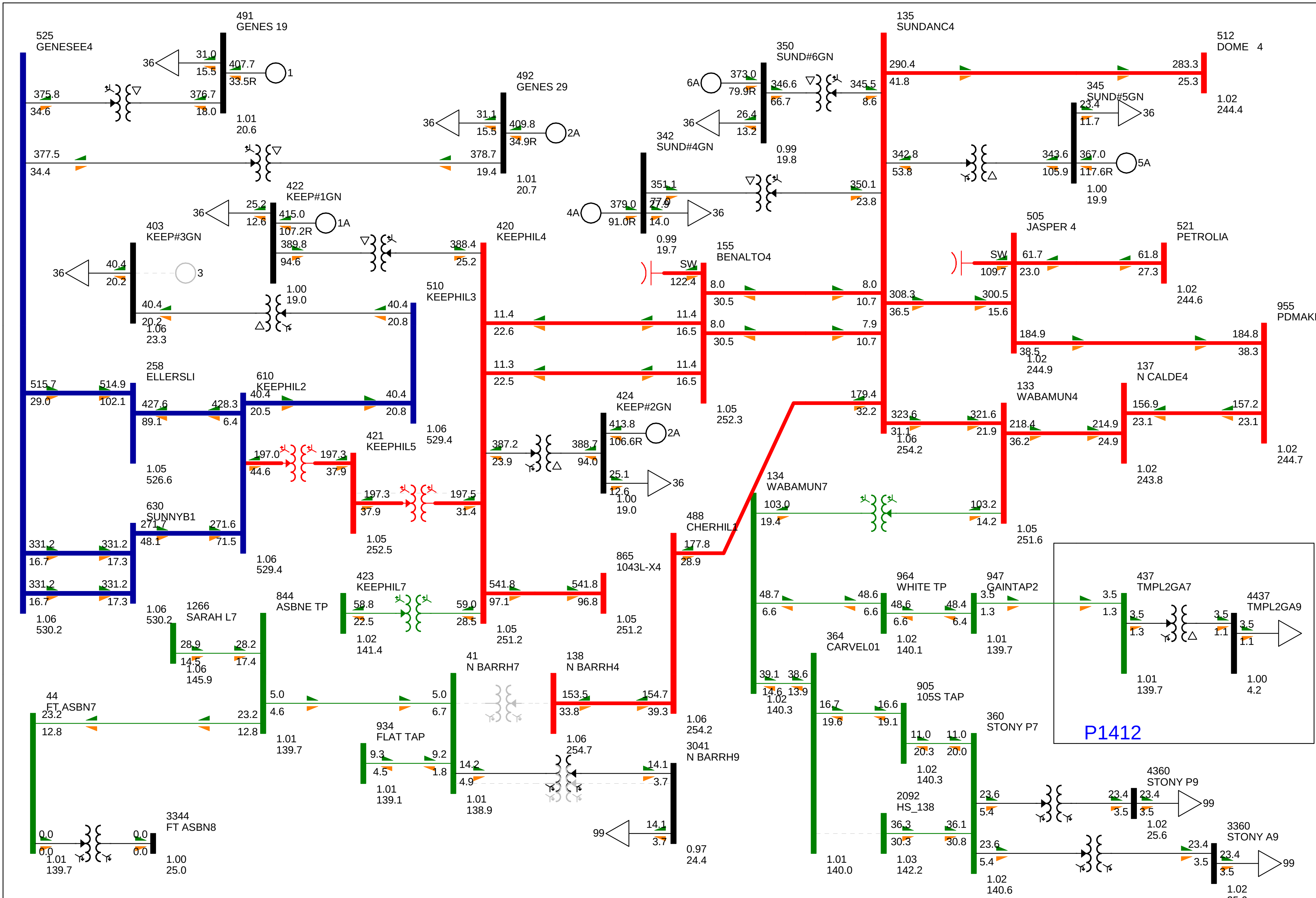


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 658.1 MW

FIGURE A2-CONTINGENCY 1045L(CONVERGED)
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

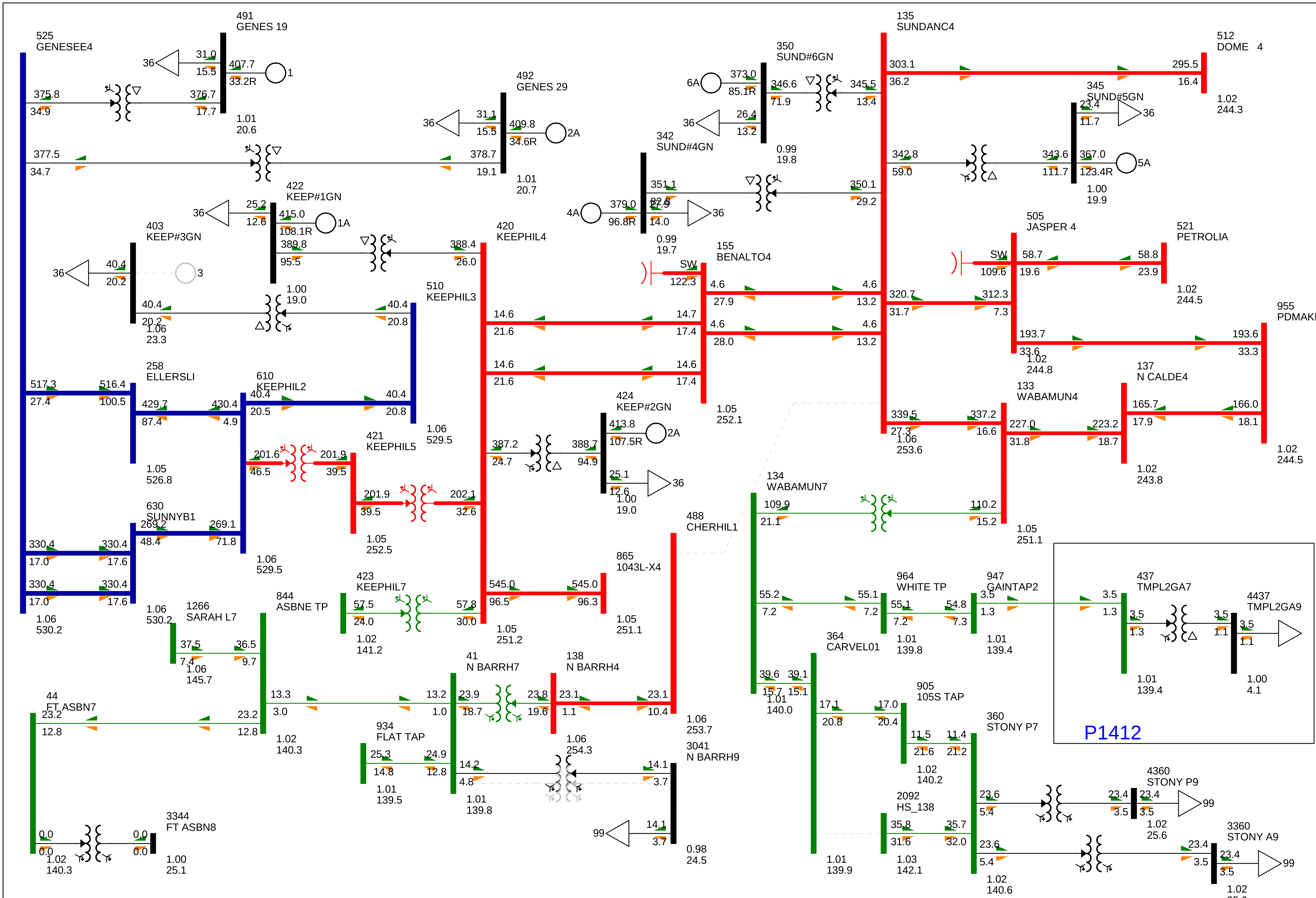


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 652.1 MW

FIGURE A3-CONTINGENCY N. BARRH T4(CONVERGED)
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

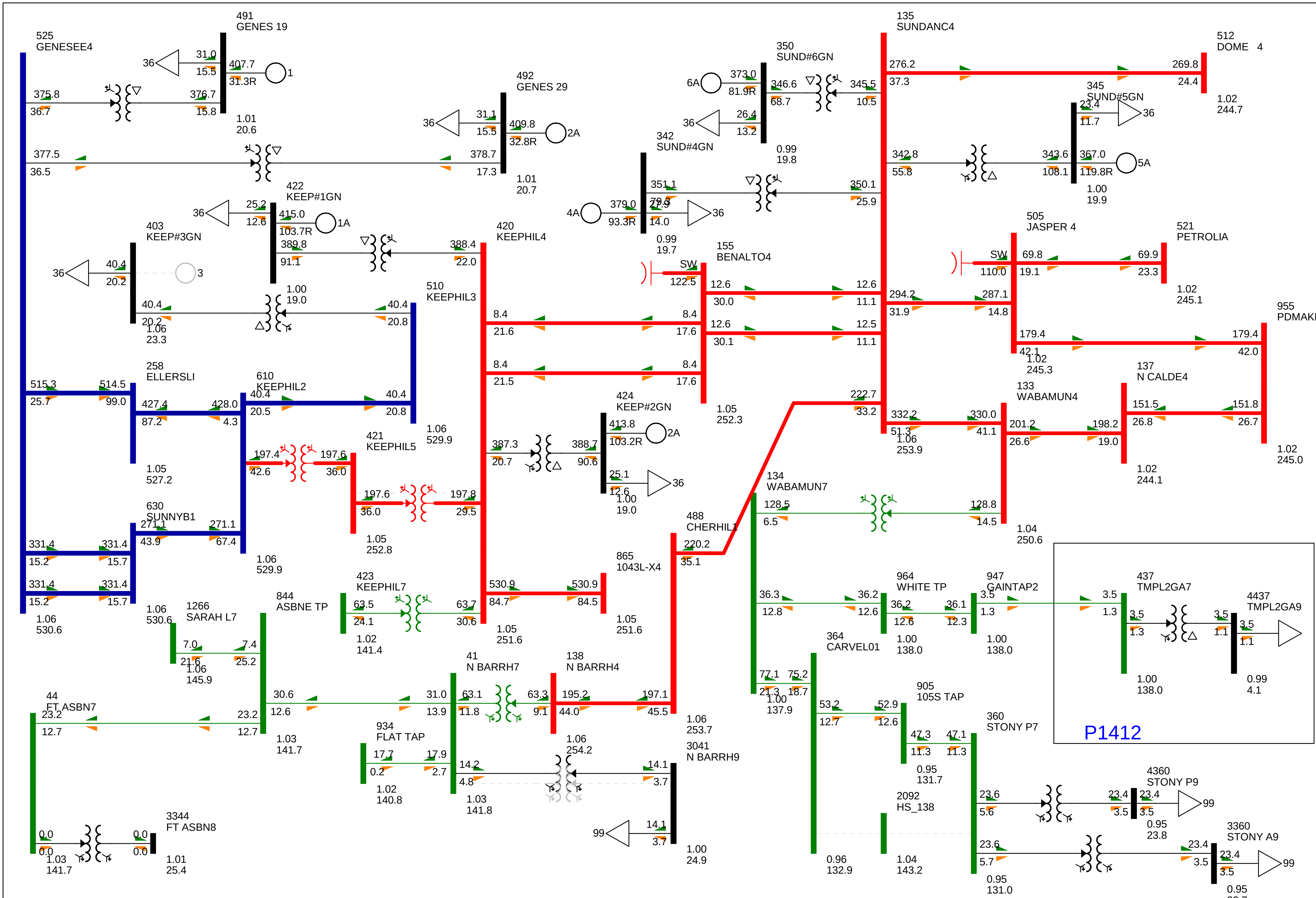


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 667.9 MW

FIGURE A4-CONTINGENCY 1046L(CONVERGED)
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

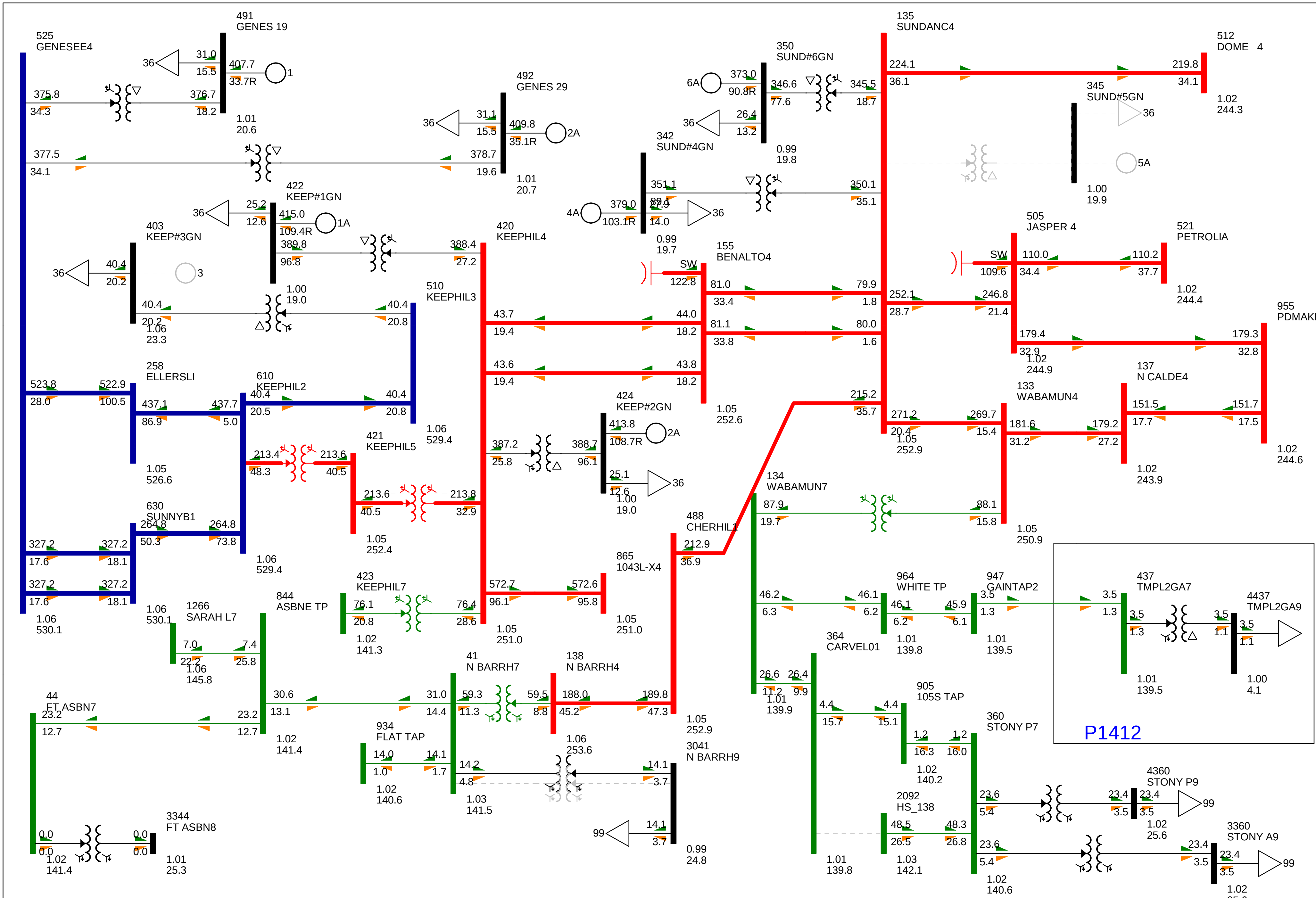


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 651.4 MW

FIGURE A5-CONTINGENCY 452L(CONVERGED)
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

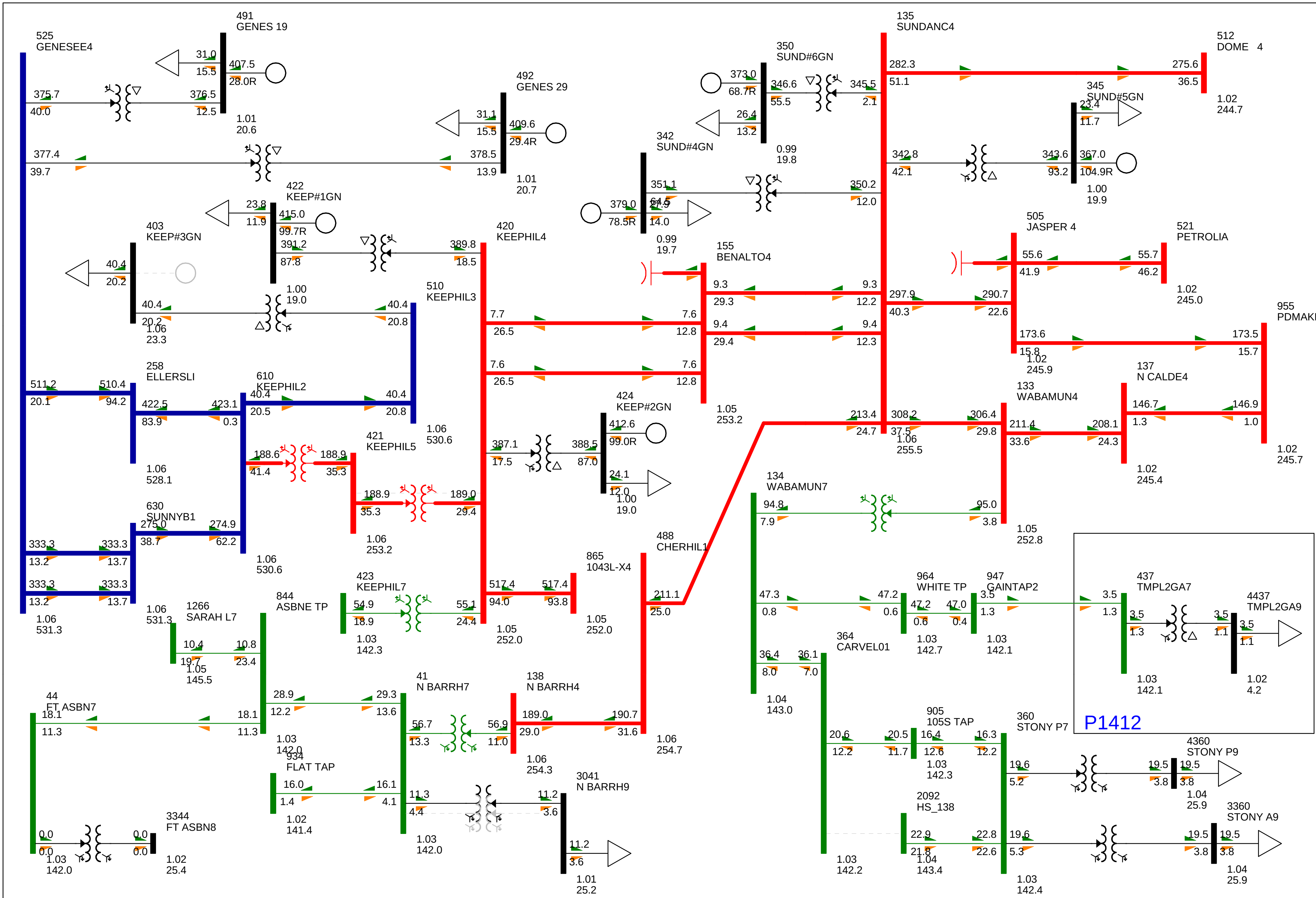


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 1034.6 MW

FIGURE A6-CTG N-1 (SUNDANCE 5A XFMR T5)(CONVERGED)
2016-17 WINTER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

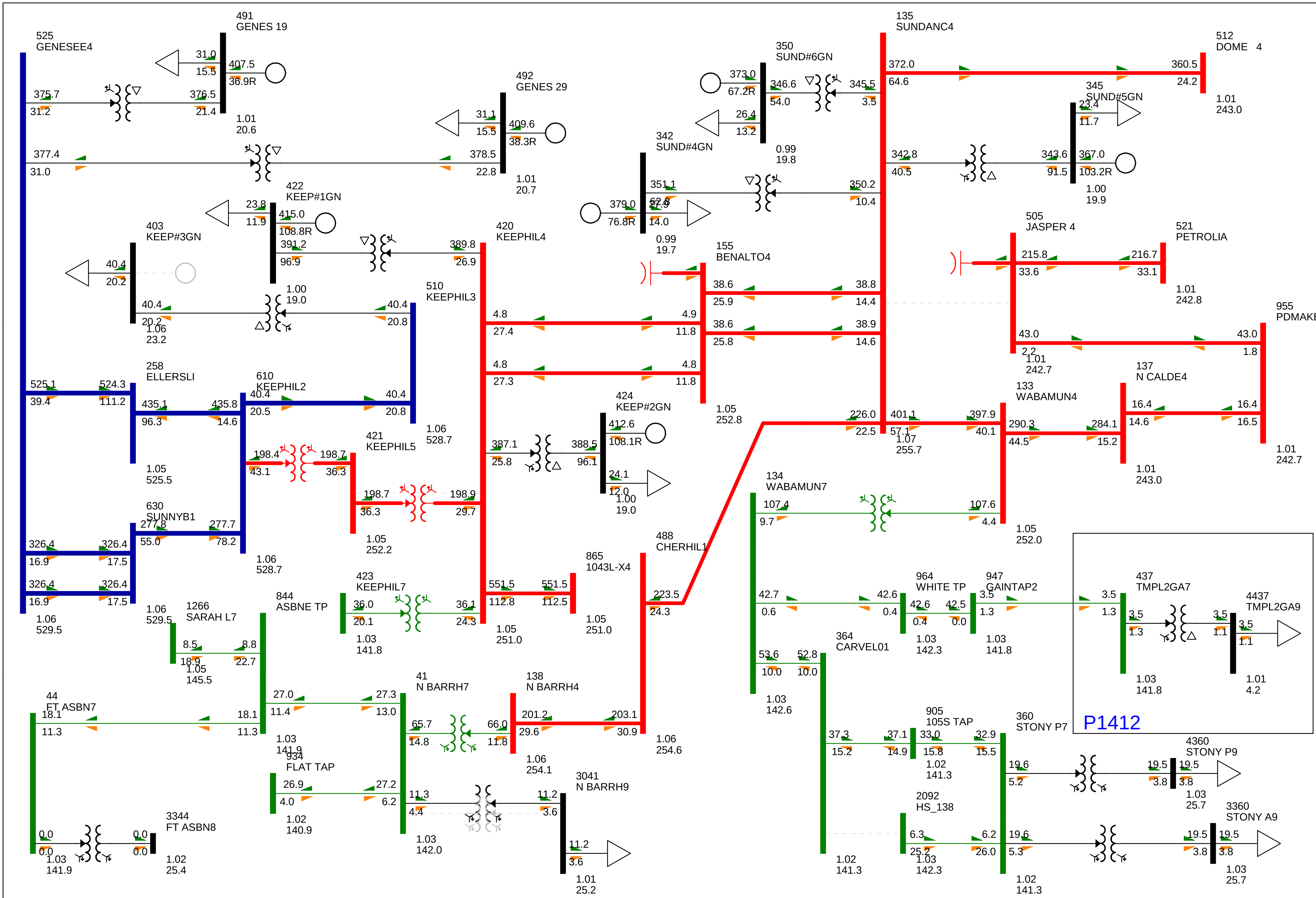


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 560.7 MW

FIGURE A7-SYSTEM NORMAL
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

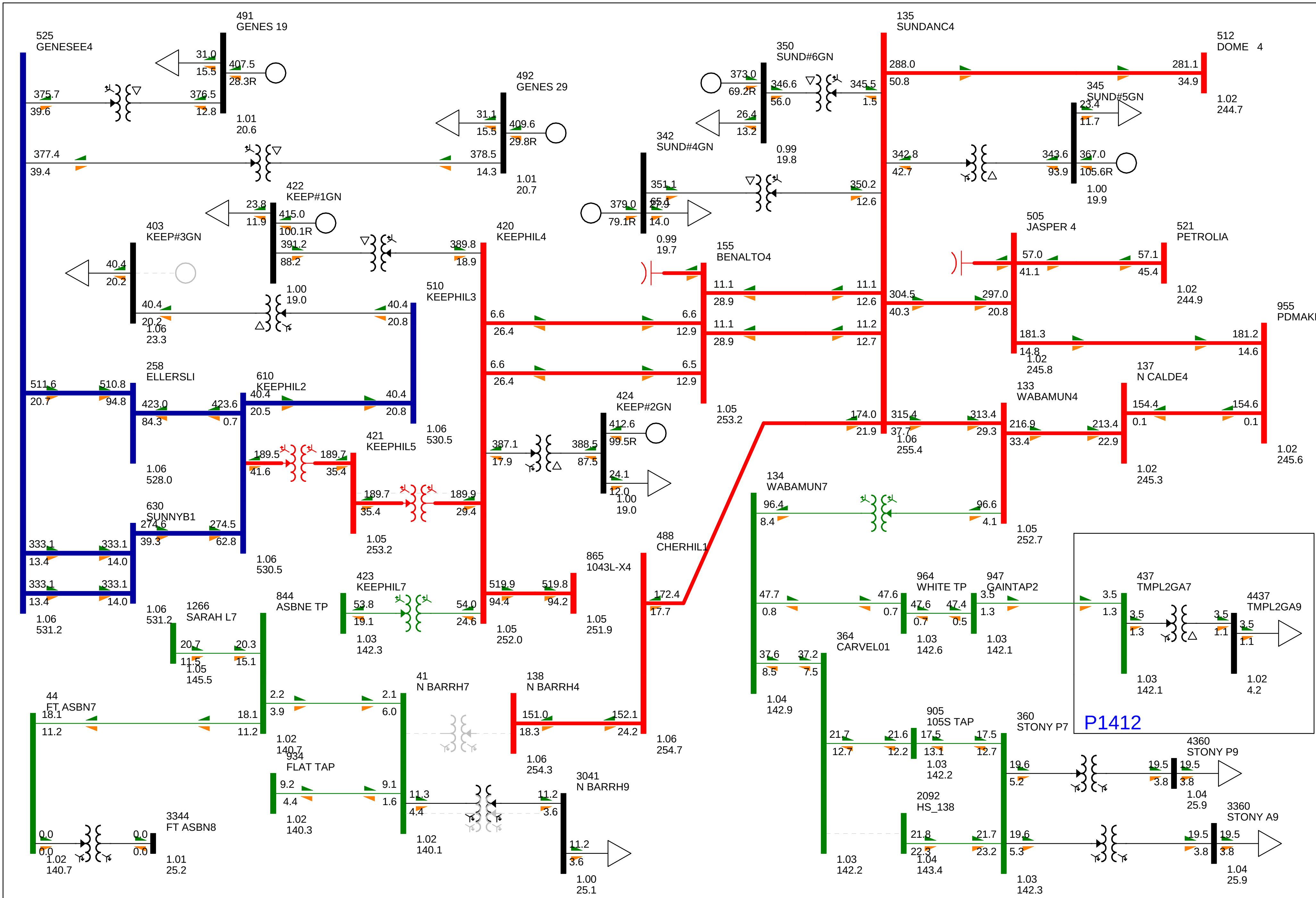


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 569.5 MW

FIGURE A8-CONTINGENCY 1045L(CONVERGED)
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

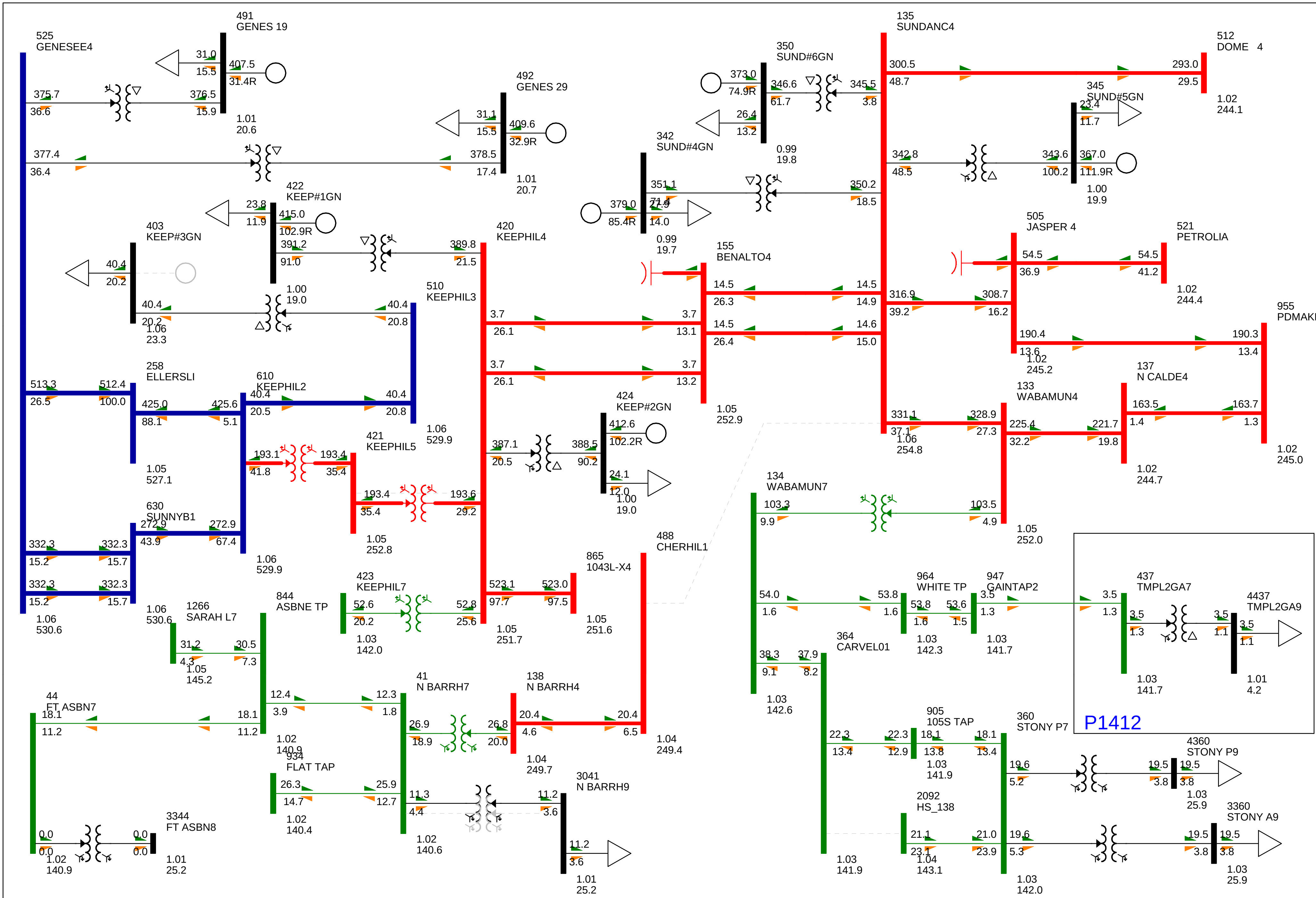


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 562.2 MW

FIGURE A9-CONTINGENCY N. BARRH T4(CONVERGED)
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

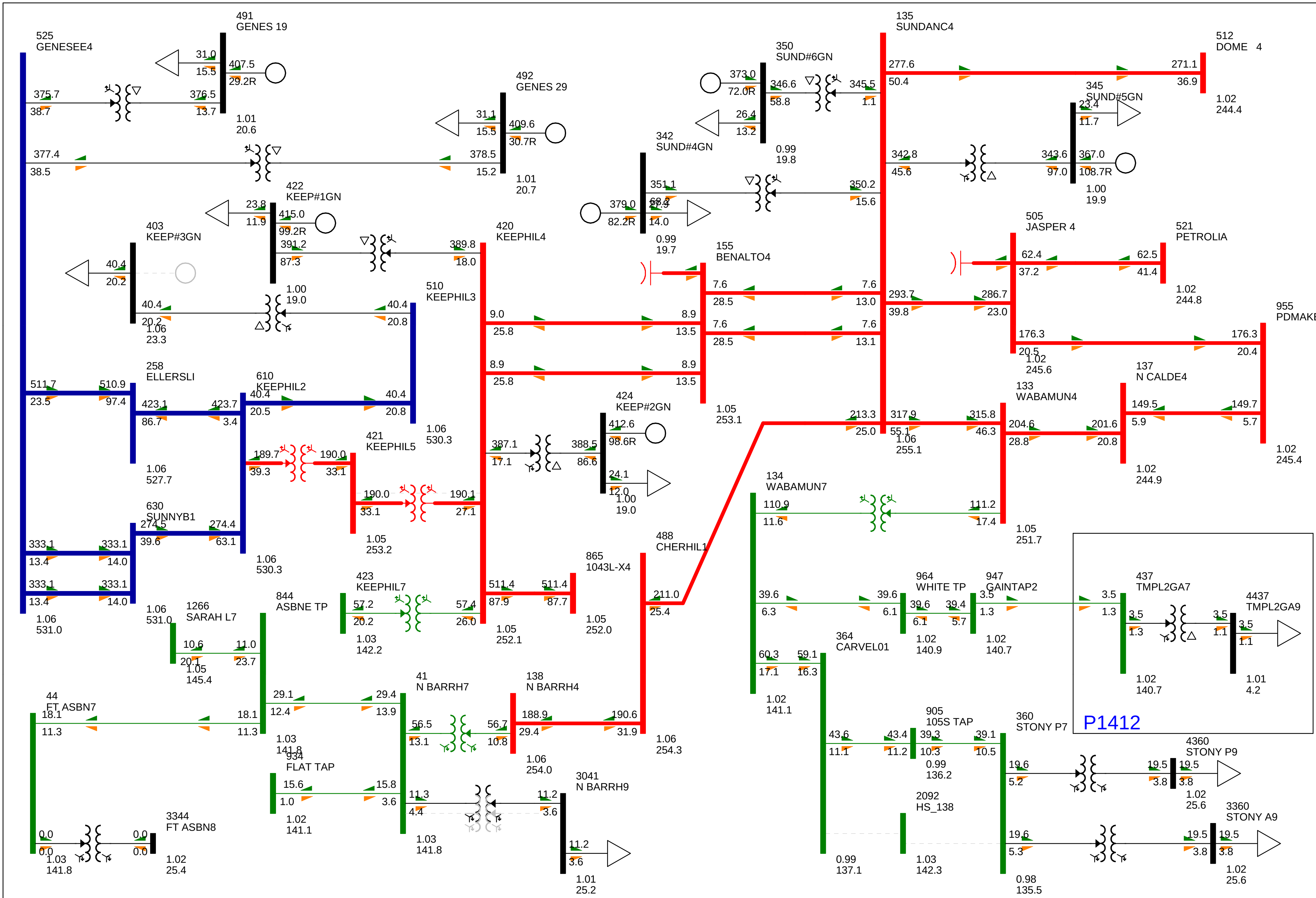


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 576.9 MW

FIGURE A10-CONTINGENCY 1046L(CONVERGED)
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

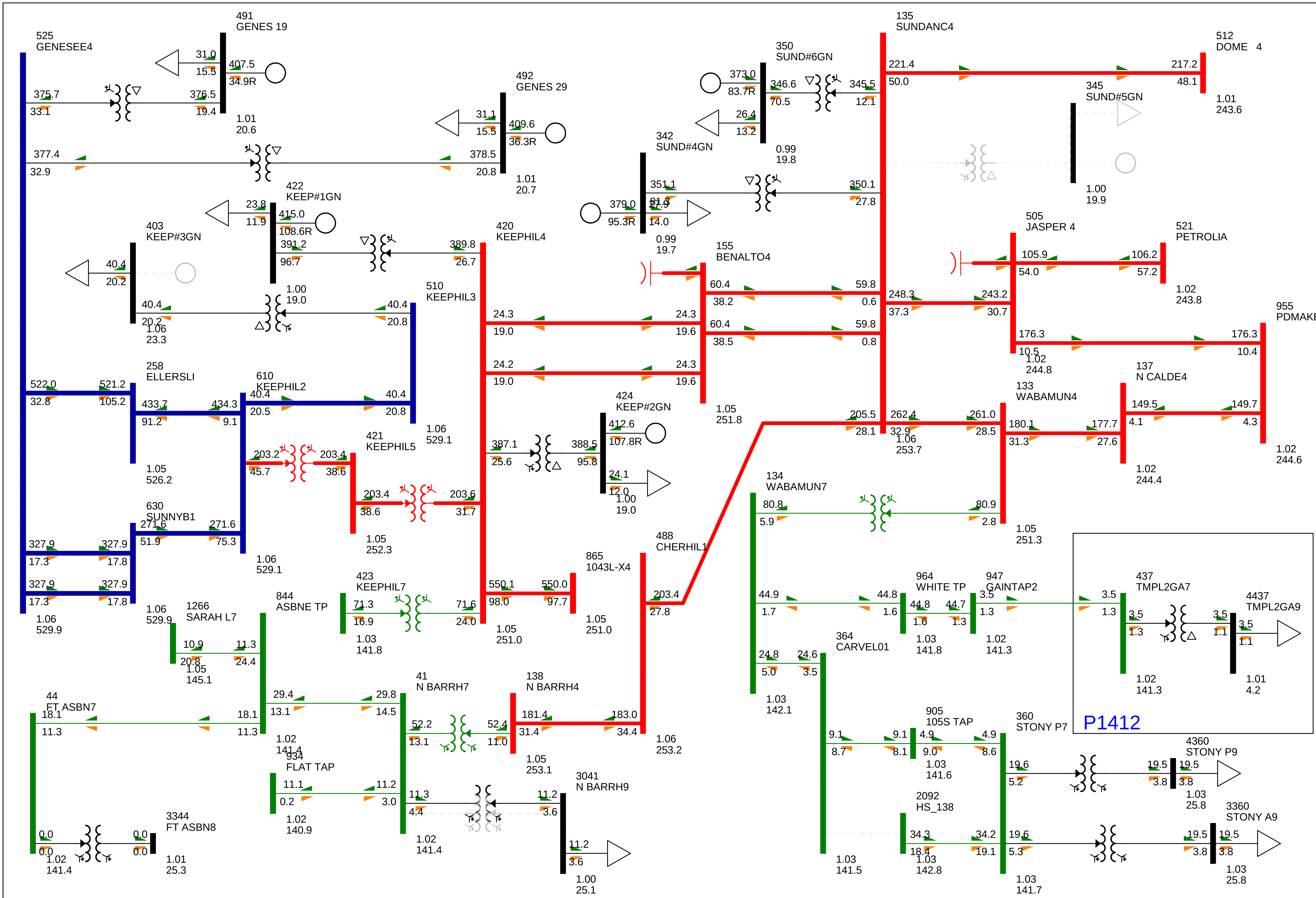
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 562.1 MW

FIGURE A11-CONTINGENCY 452L(CONVERGED)
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014



Gainford Substation 165S Facility Upgrade

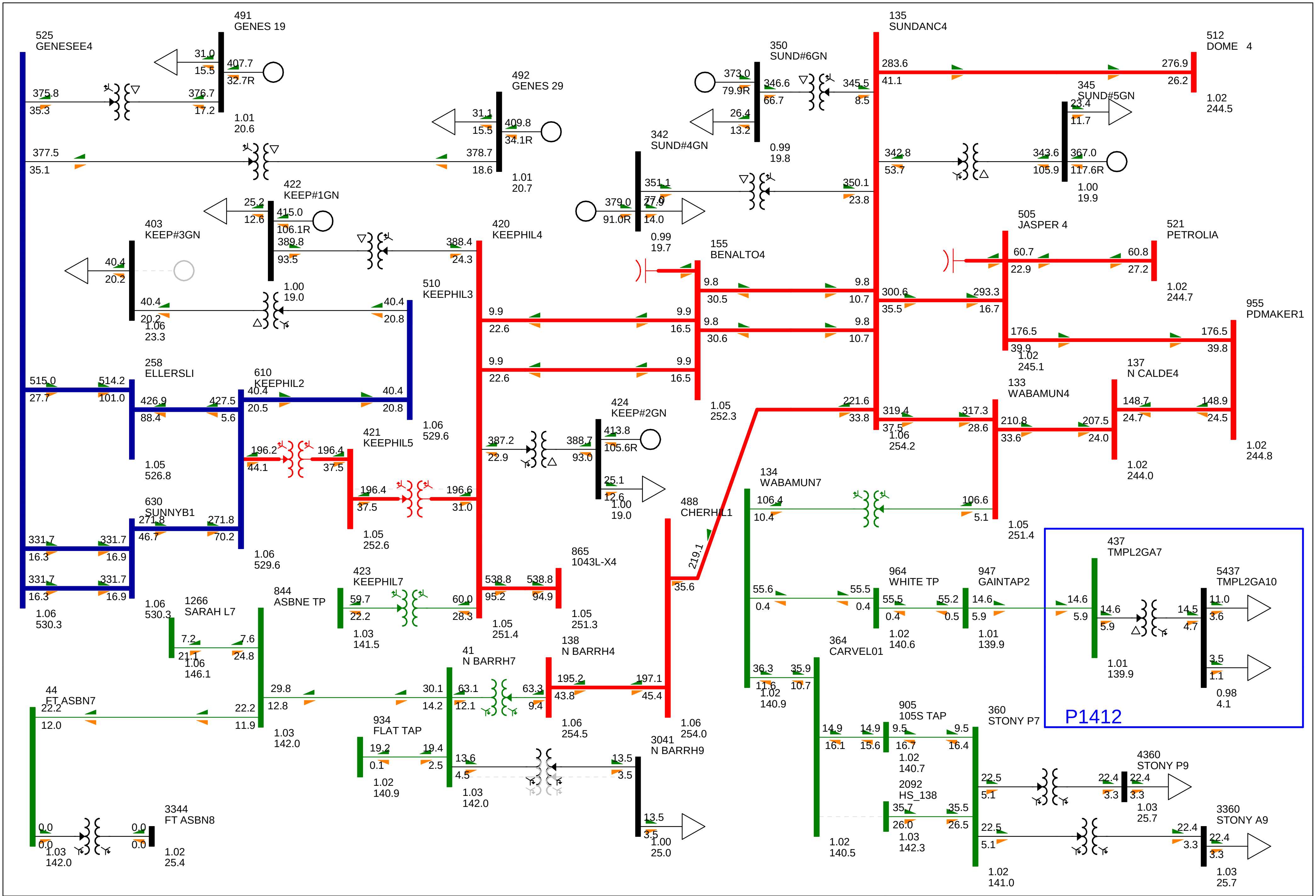
SK Tie (Import): -0.1 MW BC and MATL (Import): 941.9 MW

FIGURE A12-CTG N-1 (SUNDANCE 5A XFMR T5)(CONVERGED)
2017 SUMMER PEAK PRE-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment B

Post-Project Power Flow Diagrams (Scenarios 3 to 4)

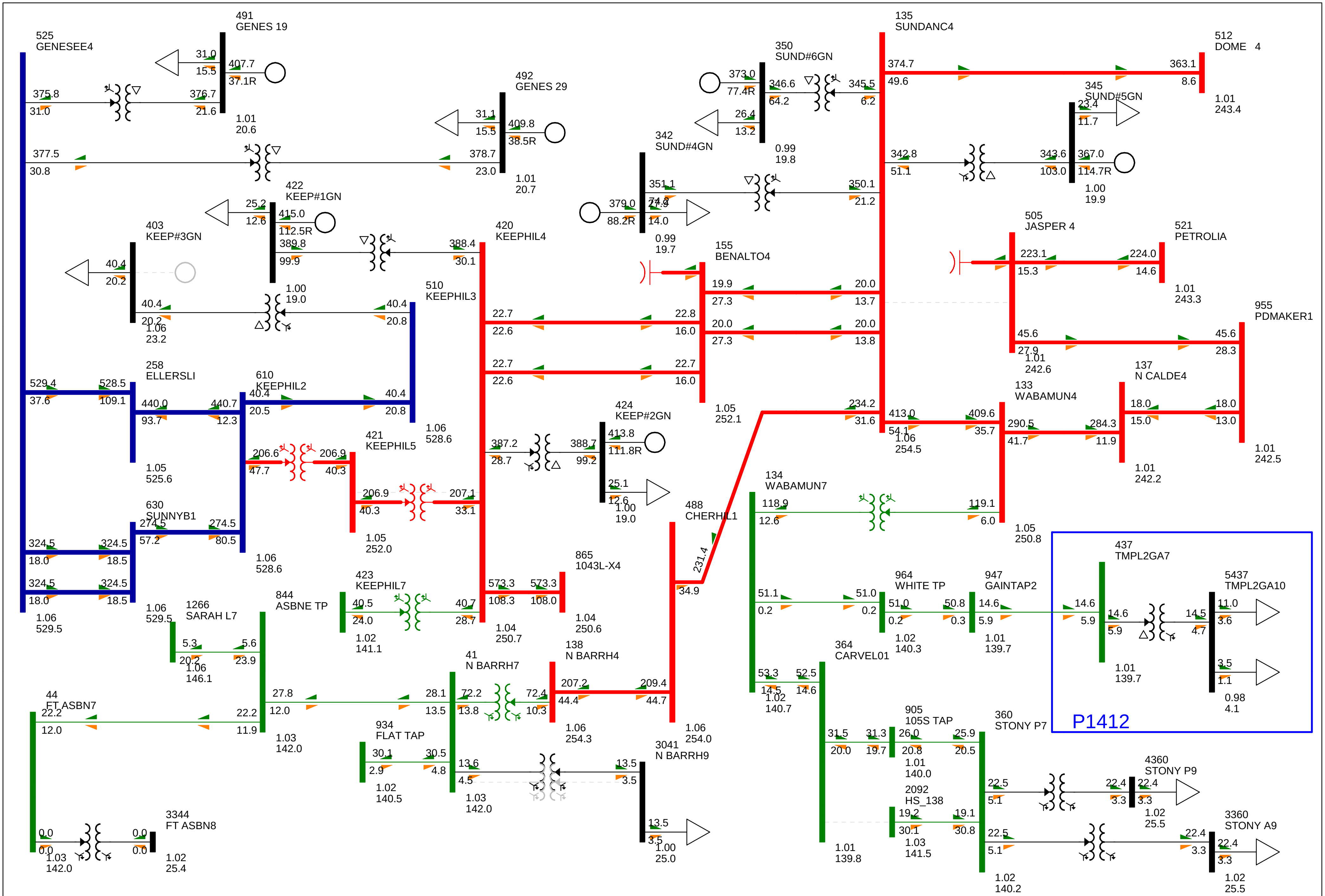


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 532.2 MW

FIGURE B1-SYSTEM NORMAL
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

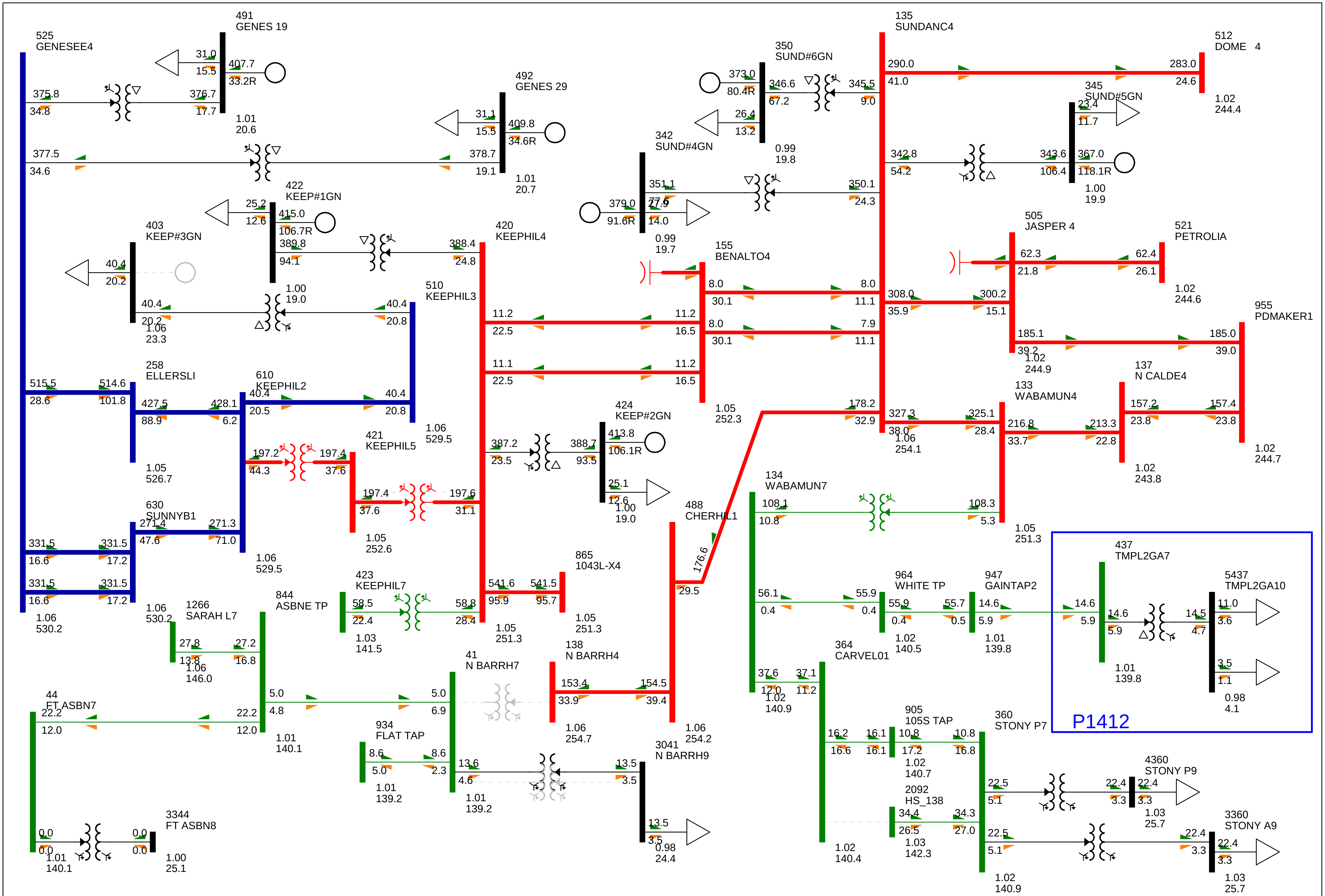


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 540.6 MW

FIGURE B2-CONTINGENCY 1045L(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

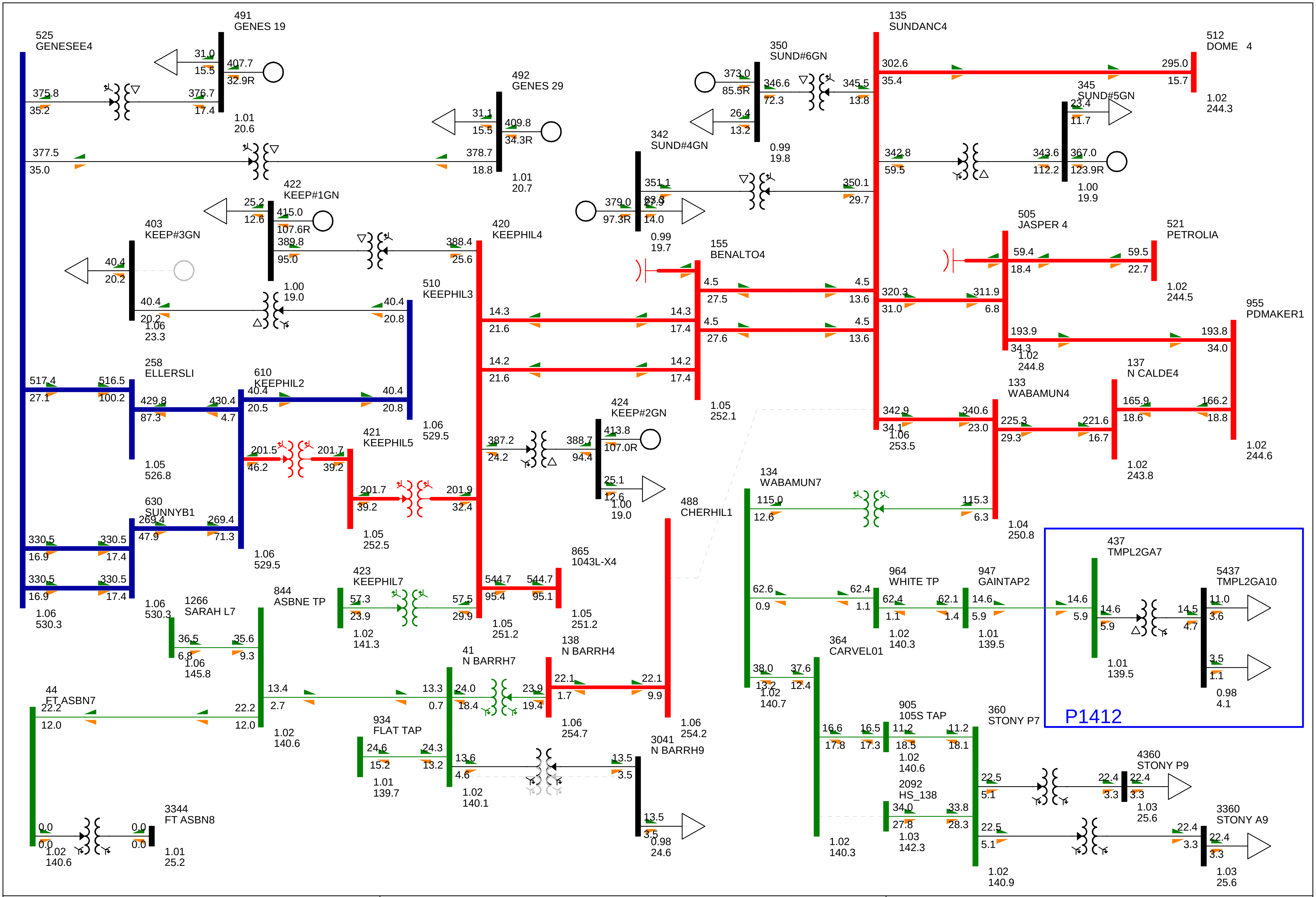


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 534.5 MW

FIGURE B3-CONTINGENCY N. BARRH T4(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

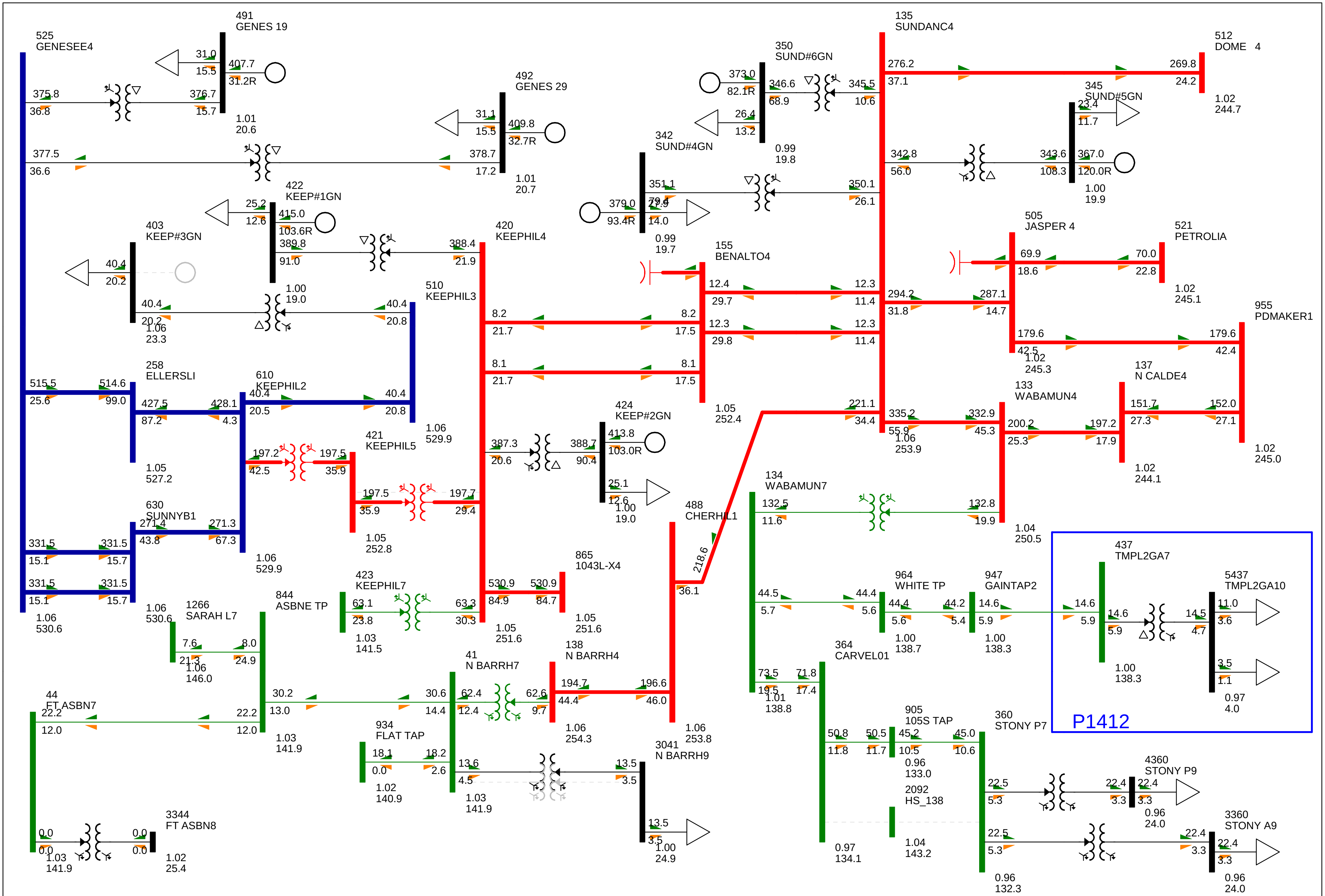


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 549.7 MW

FIGURE B4-CONTINGENCY 1046L(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

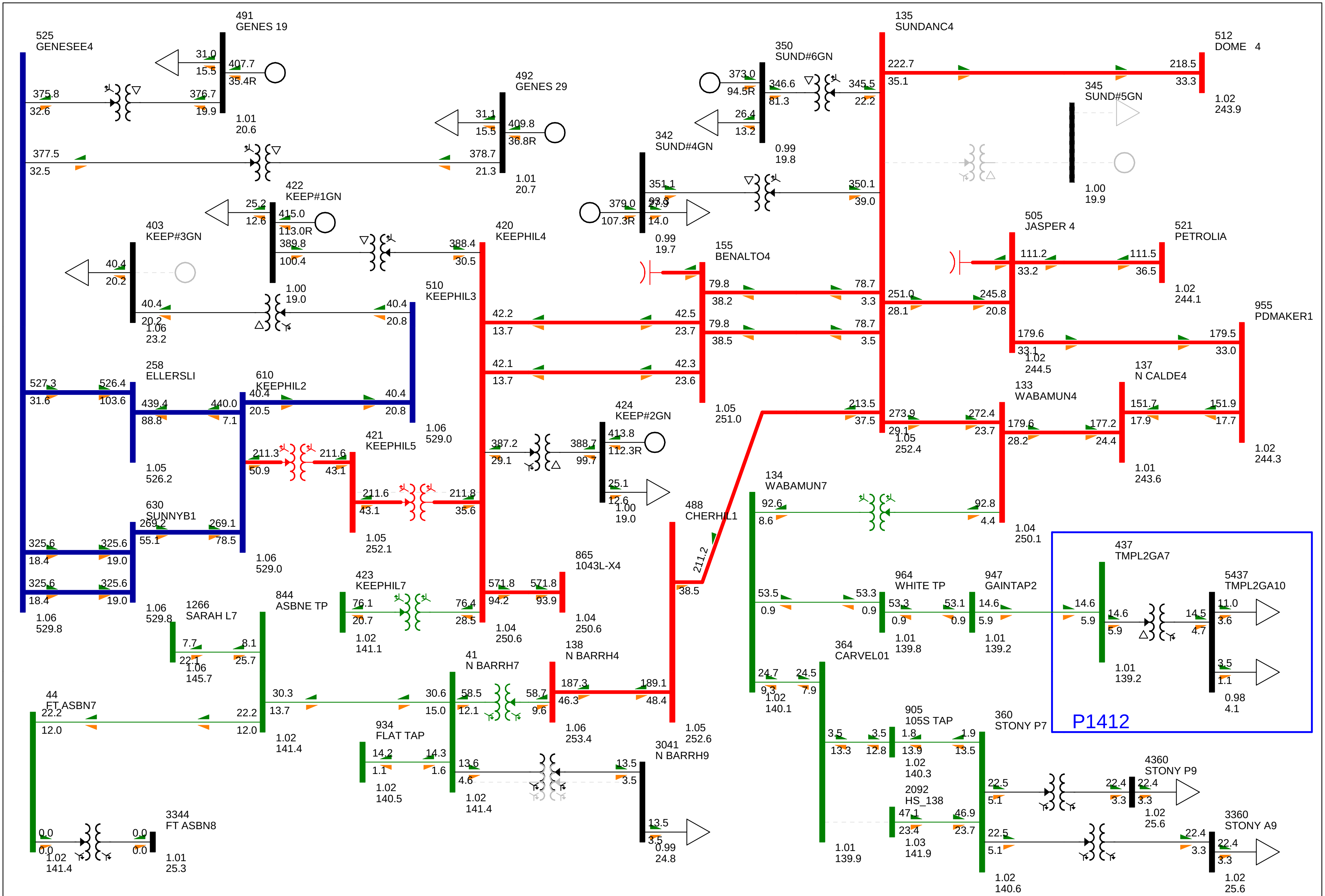


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 533.6 MW

FIGURE B5-CONTINGENCY 452L(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

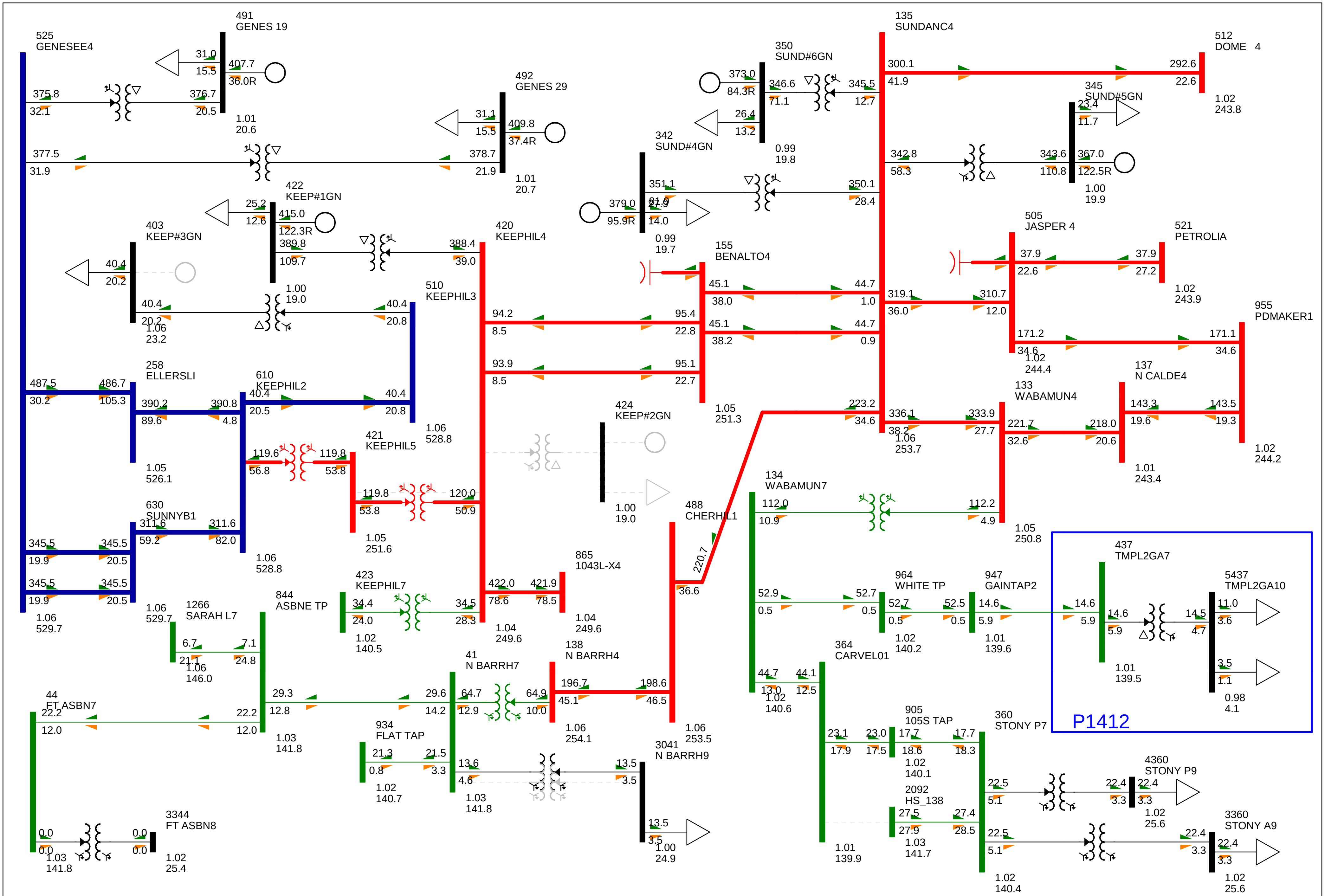


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 917.0 MW

FIGURE B6-CTG N-1 (SUNDANCE 5A XFMR T5)(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

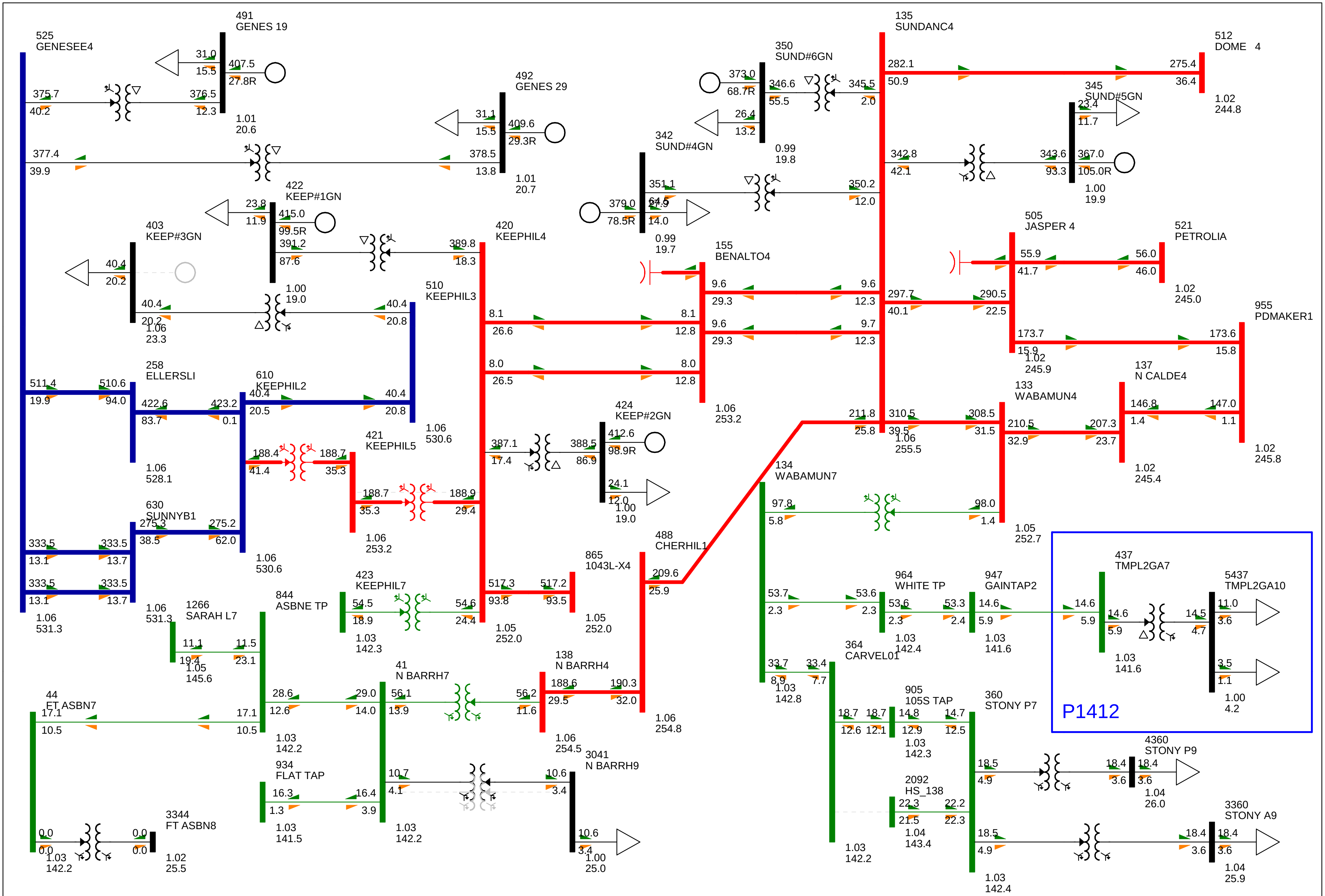


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 973.0 MW

FIGURE B7-CTG N-1 (KEEPHILLS #2 XFMR G2)(CONVERGED)
2016-17 WINTER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

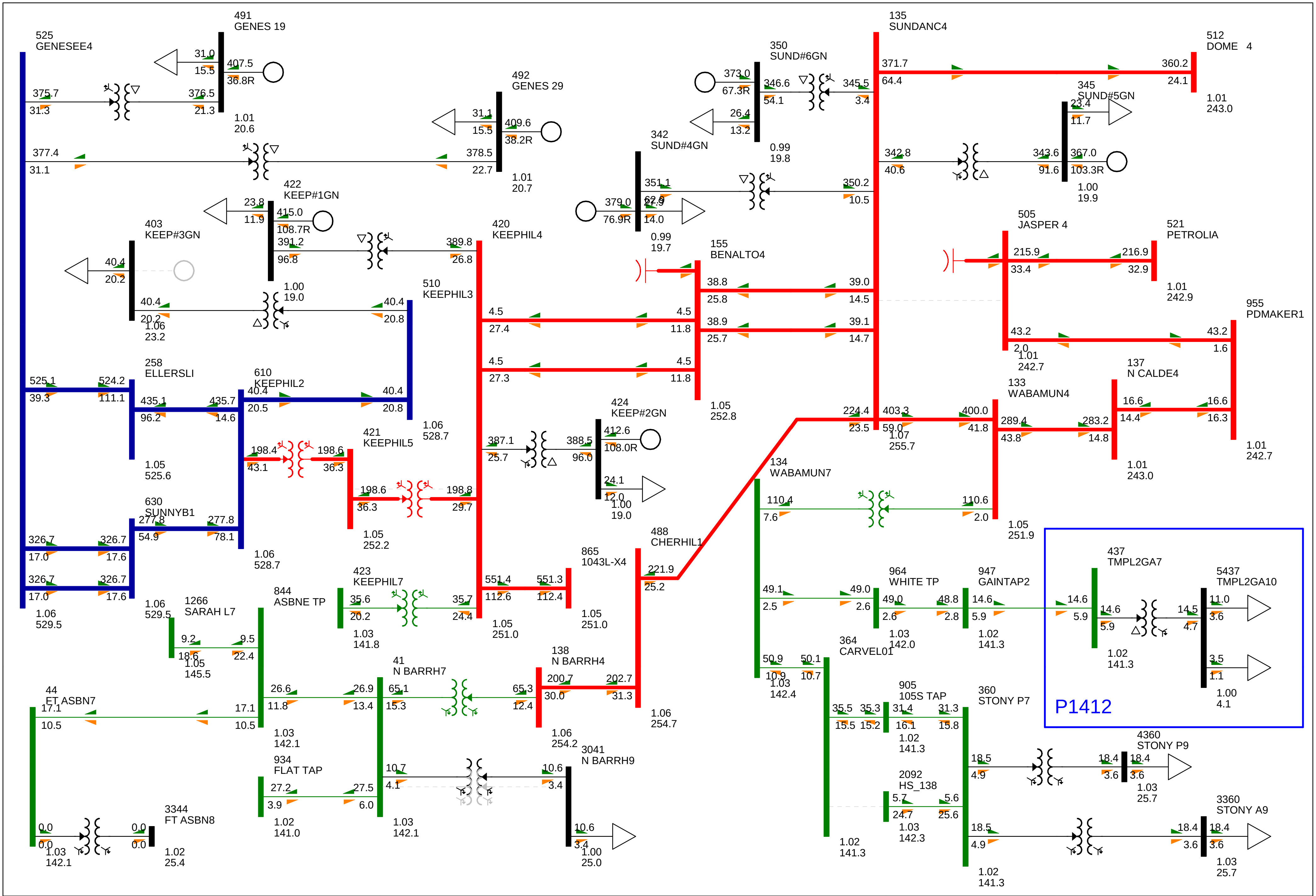


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 556.7 MW

FIGURE B8-SYSTEM NORMAL
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

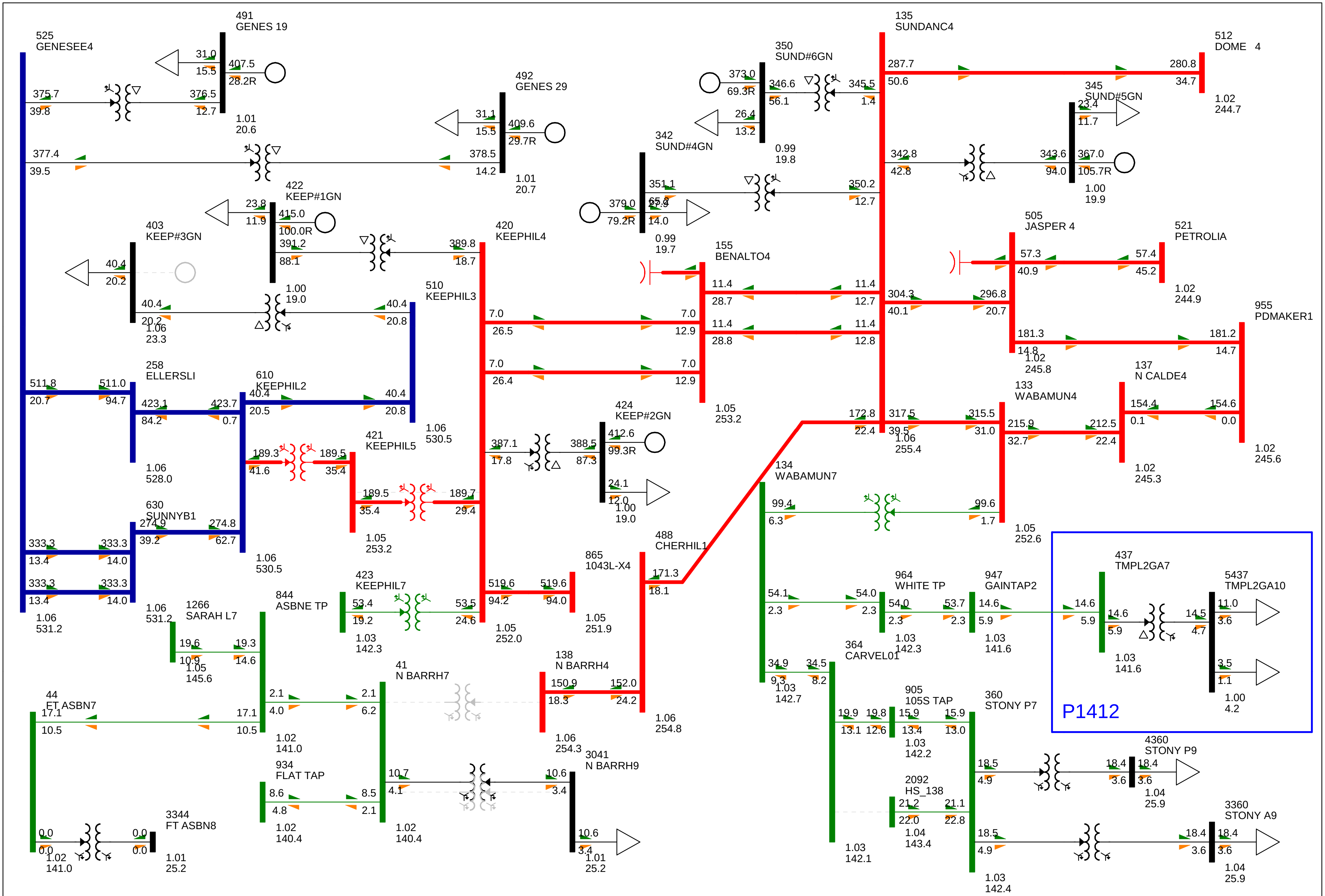


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW   BC and MATL (Import): 565.4 MW

FIGURE B9-CONTINGENCY 1045L(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

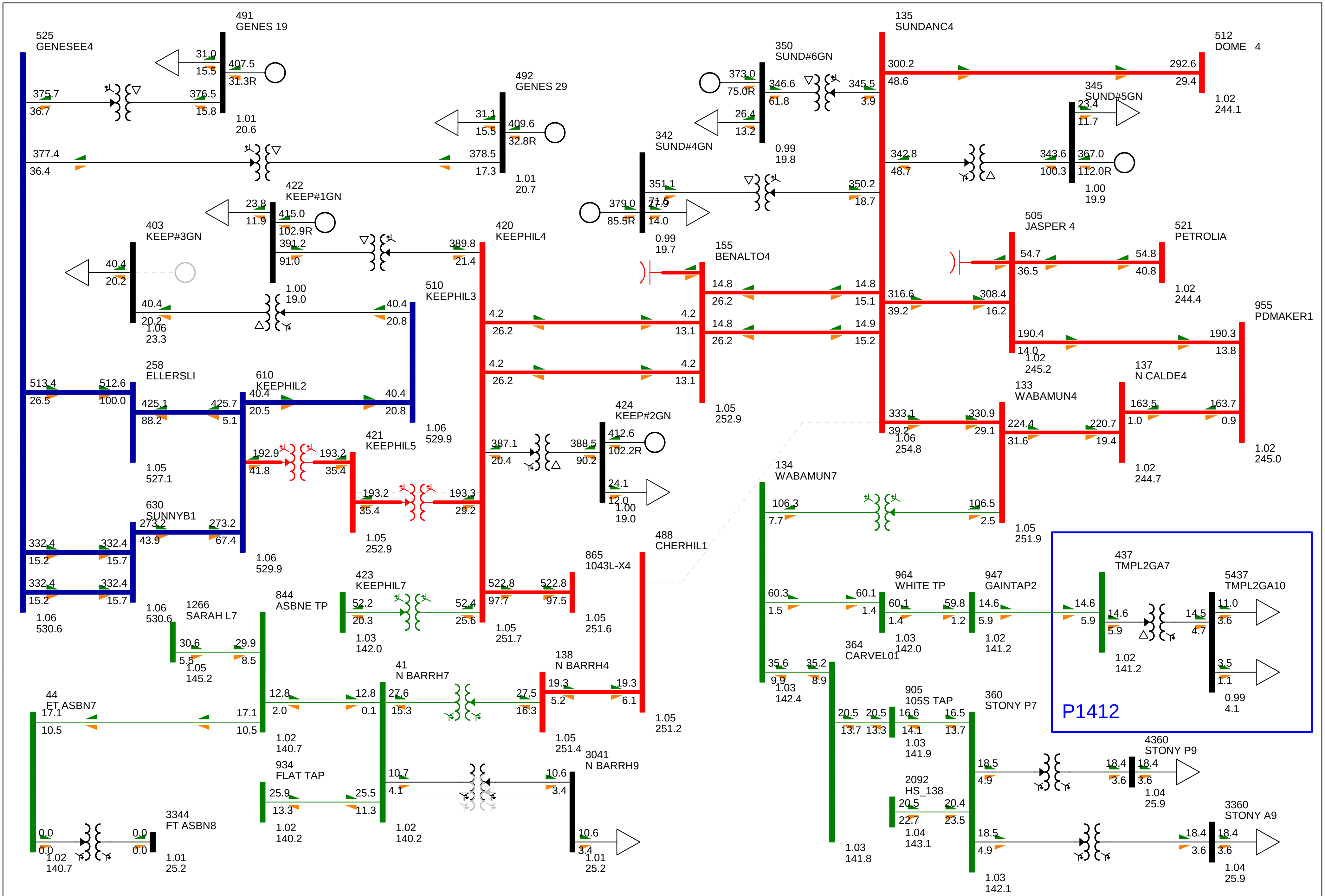


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 558.0 MW

FIGURE B10-CONTINGENCY N. BARRH T4(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

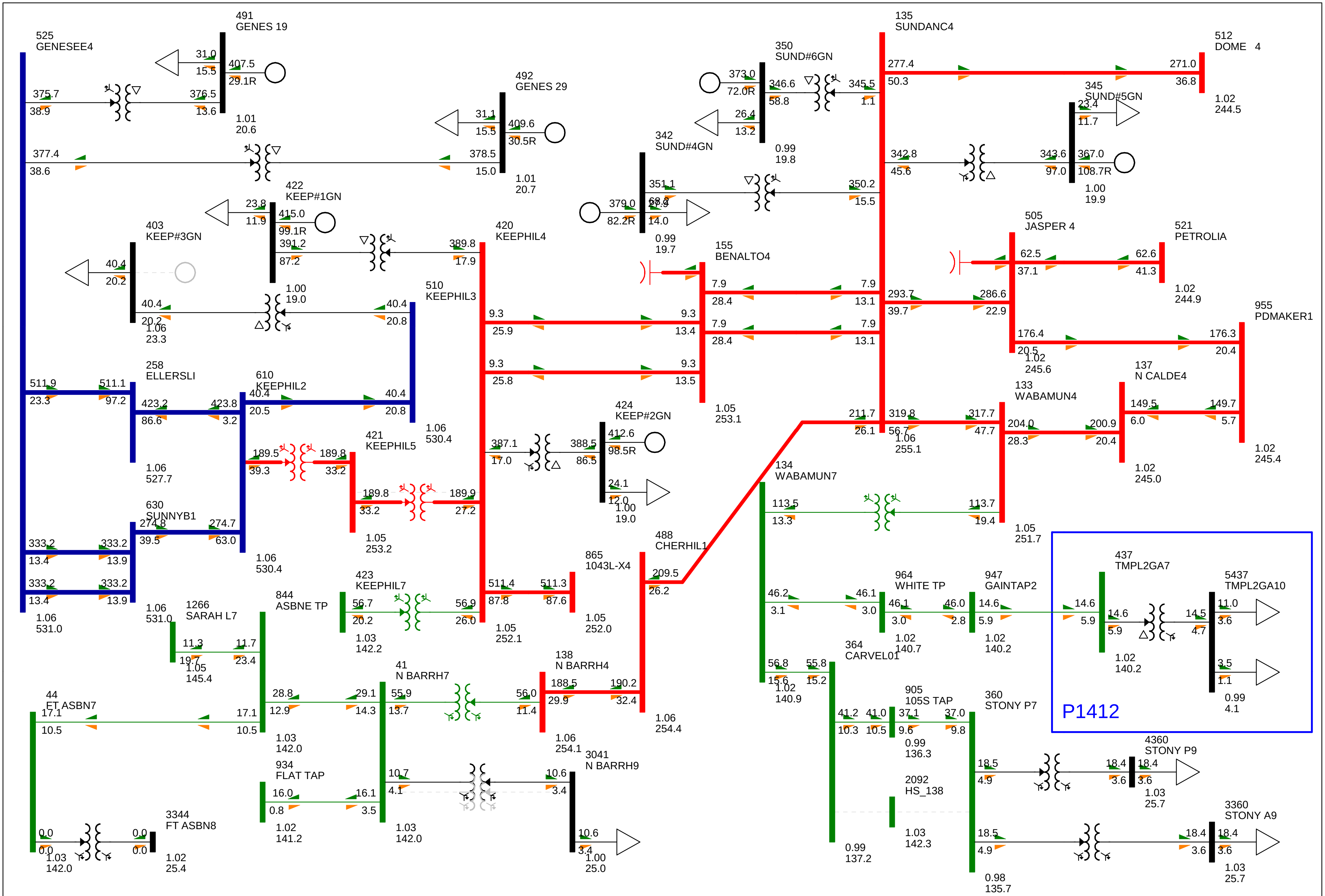


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 572.5 MW

FIGURE B11-CONTINGENCY 1046L(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

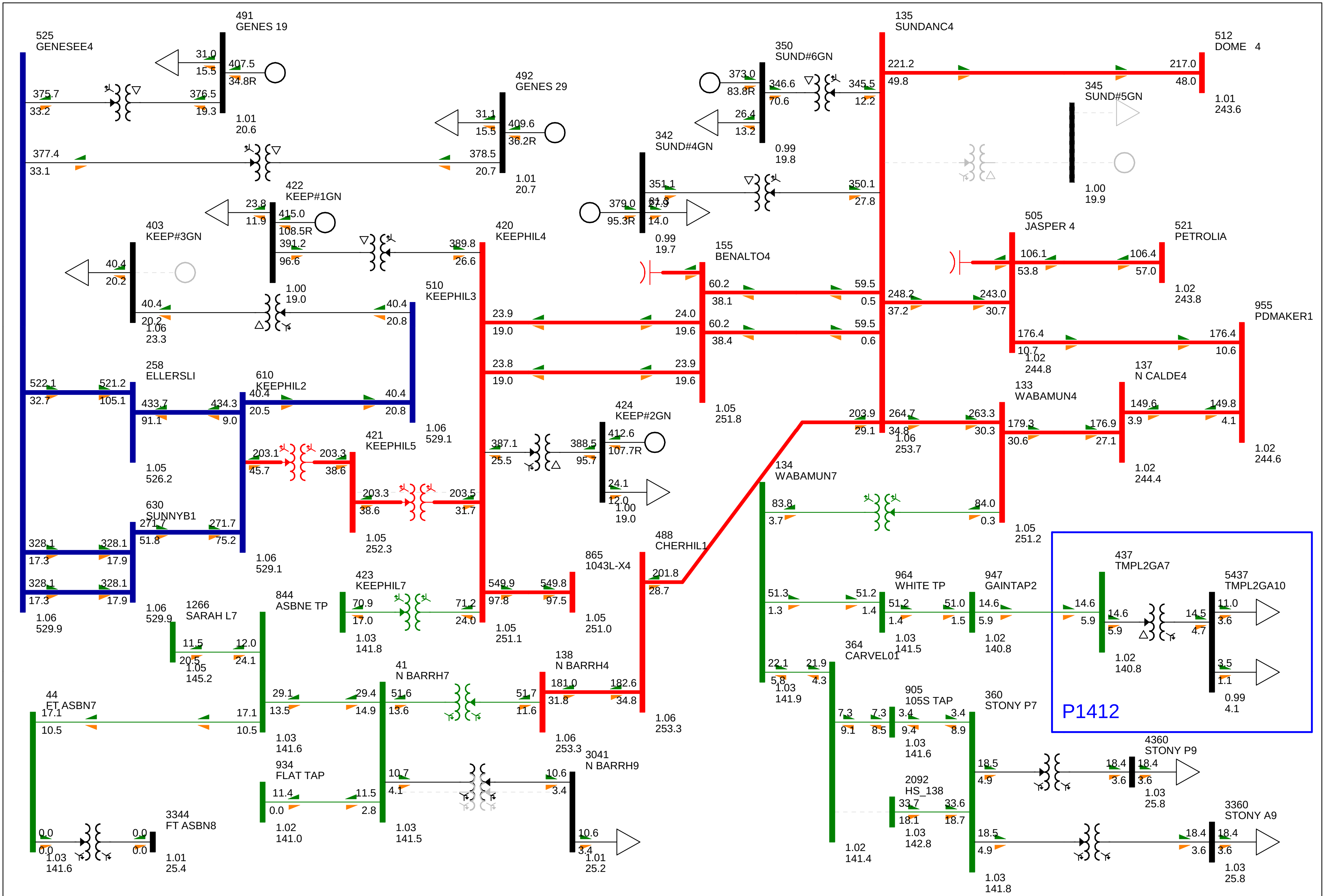


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 558.0 MW

FIGURE B12-CONTINGENCY 452L(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

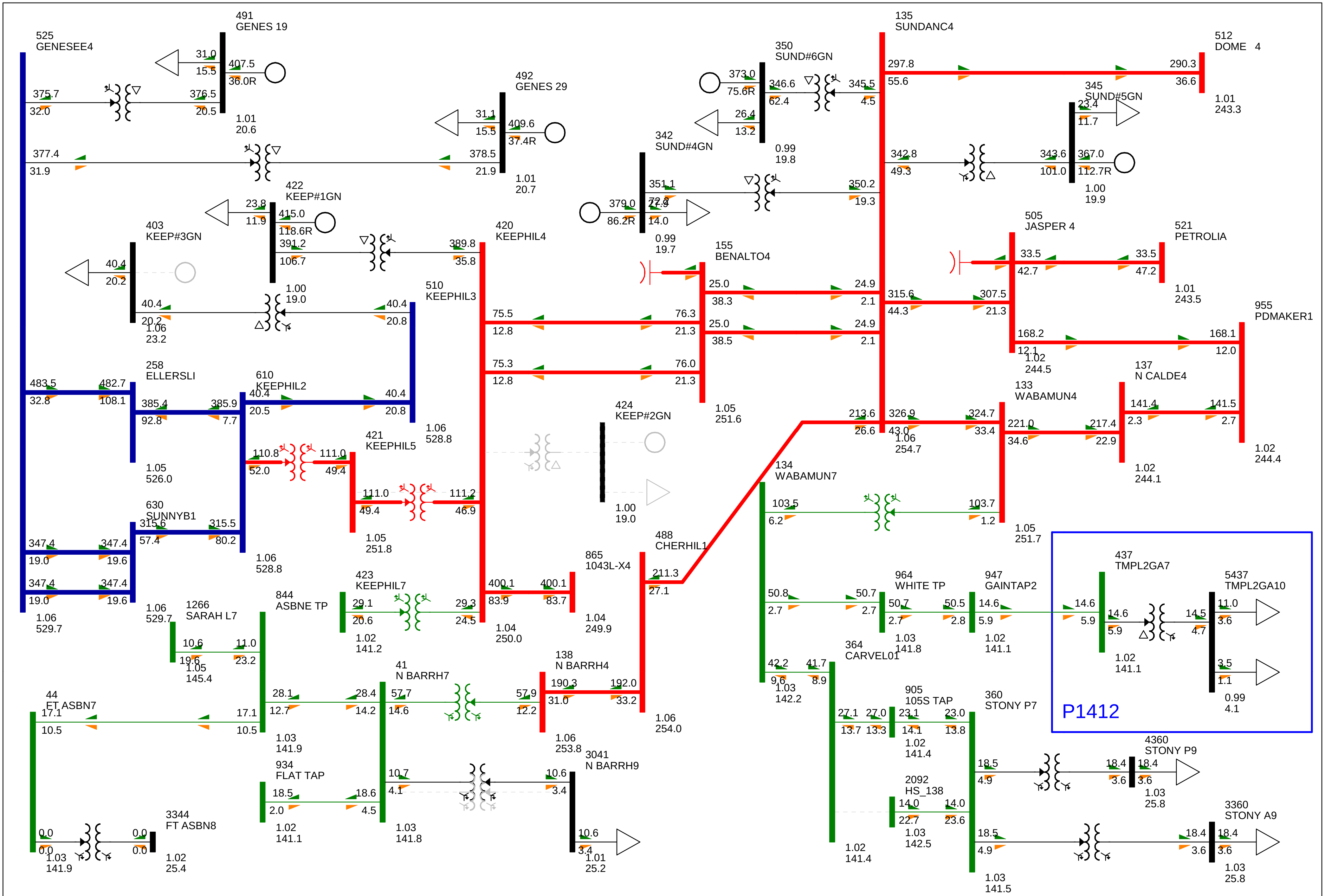


Gainford Substation 165S Facility Upgrade

SK Tie (Import): -0.1 MW BC and MATL (Import): 937.5 MW

FIGURE B13-CTG N-1 (SUNDANCE 5A XFMR T5)(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Gainford Substation 165S Facility Upgrade

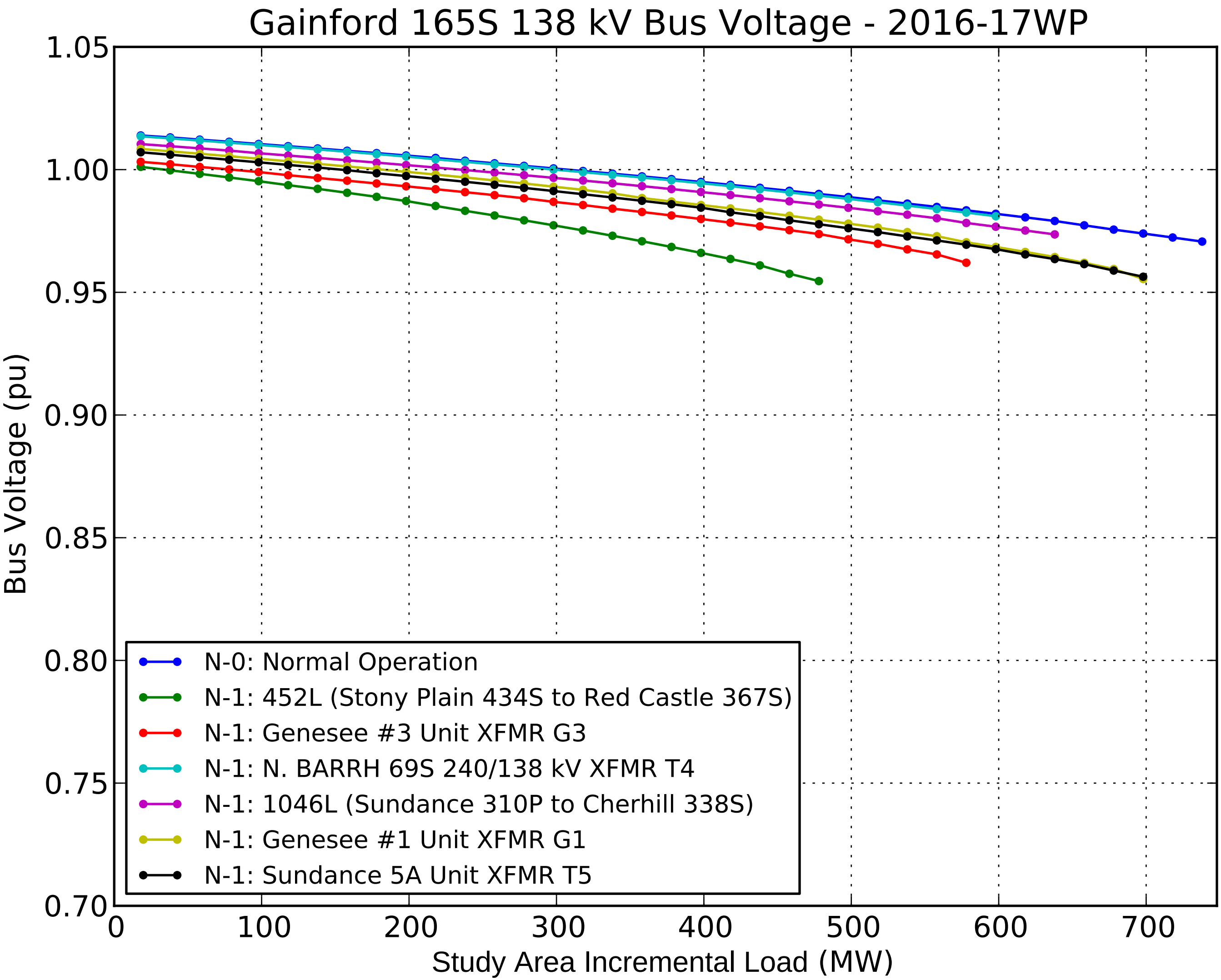
SK Tie (Import): -0.1 MW BC and MATL (Import): 993.9 MW

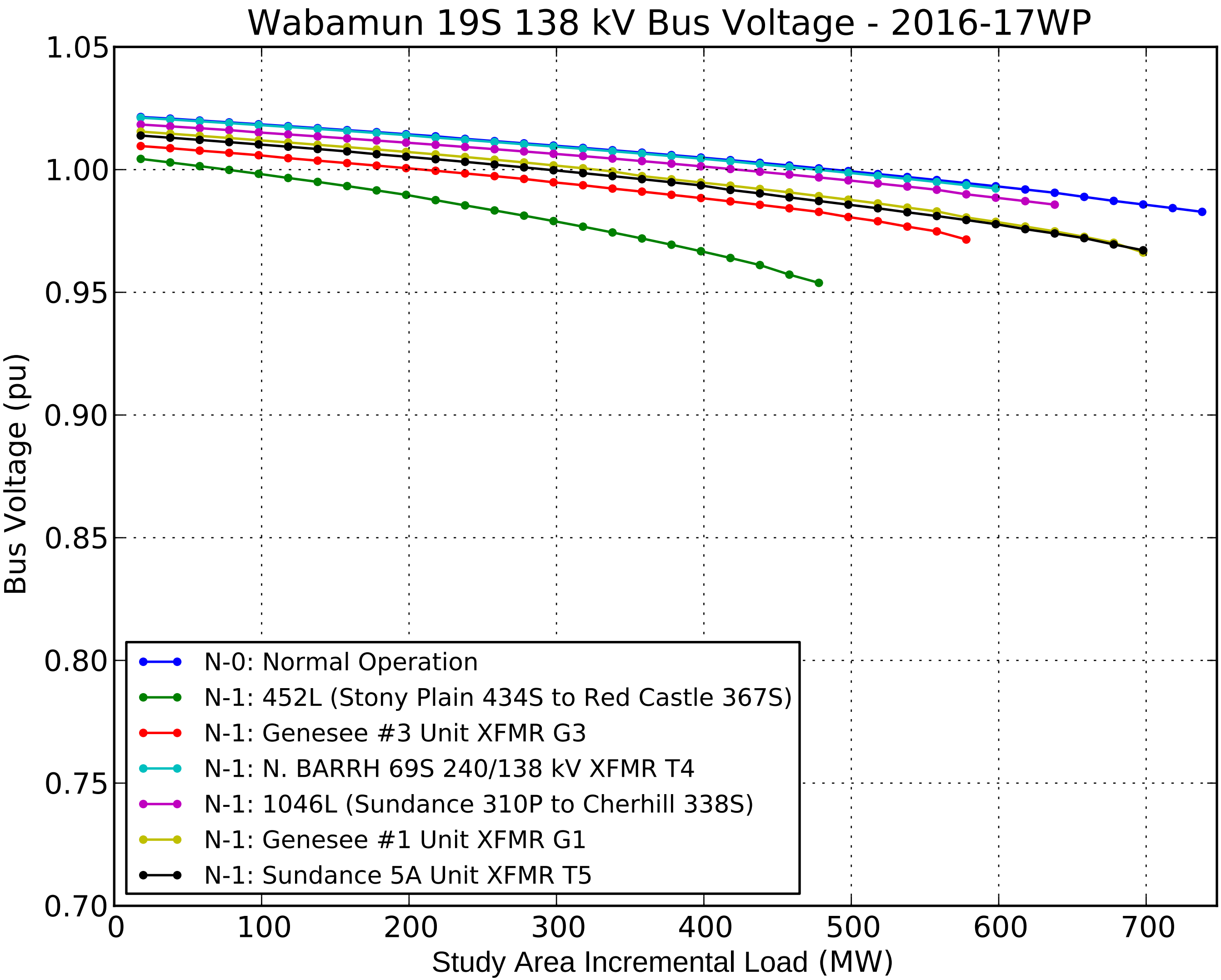
FIGURE B14-CTG N-1 (KEEPHILLS #2 XFMR G2)(CONVERGED)
2017 SUMMER PEAK POST-DEVELOPMENT
PRINTED ON TUESDAY 21. JANUARY 2014

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

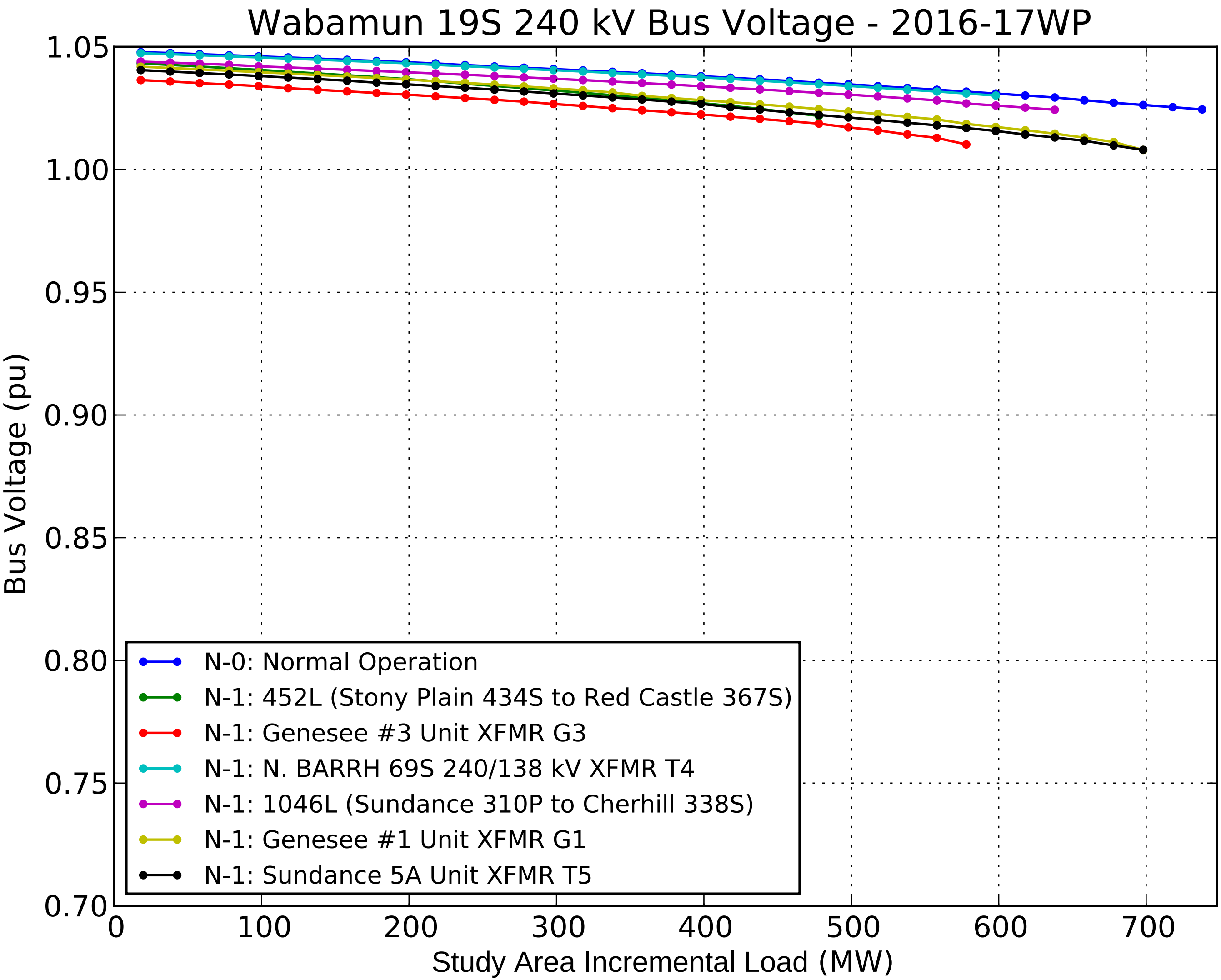
Attachment C

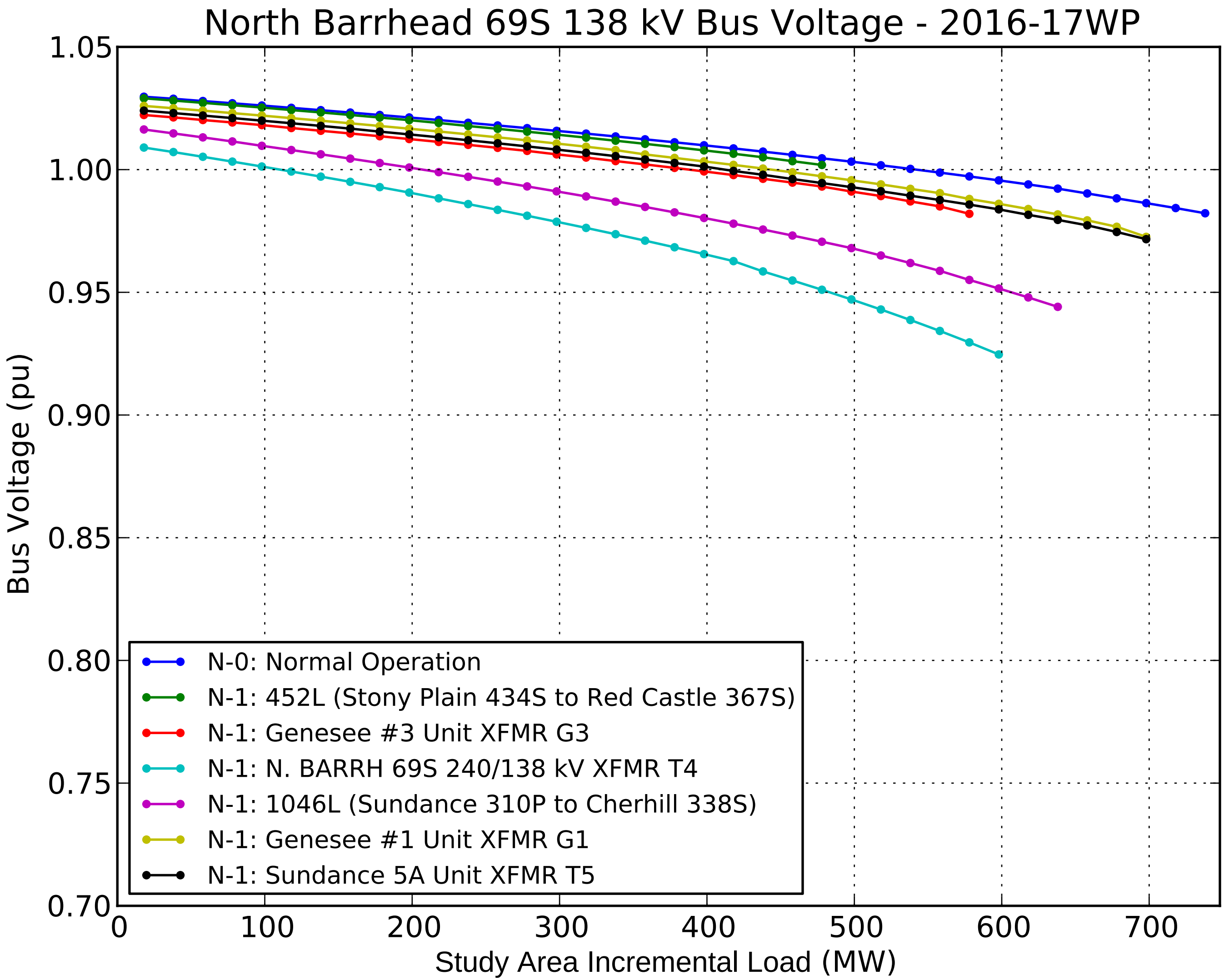
Post-Project Voltage Stability Diagrams (Scenarios 3)

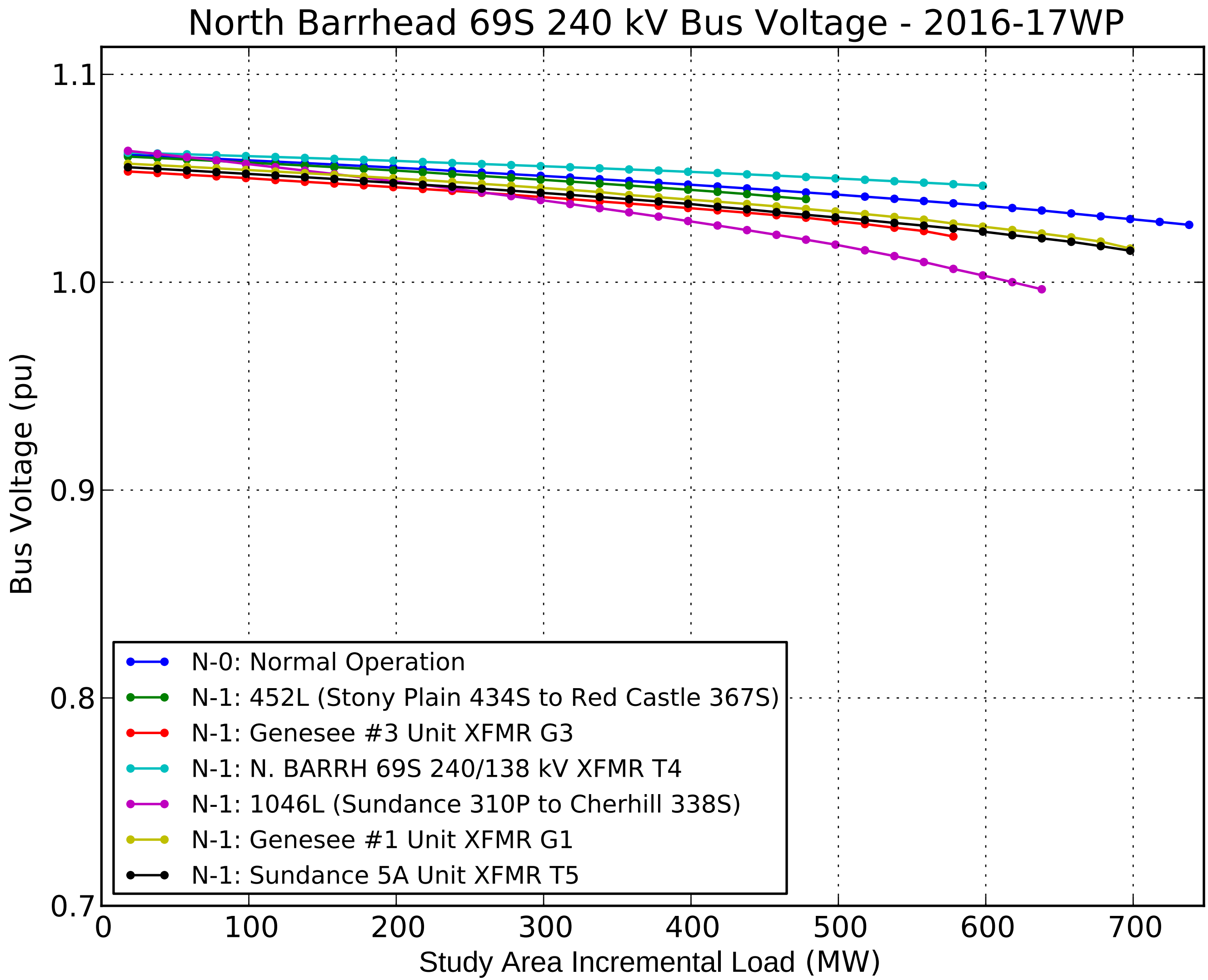

Gainford 165S 138 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
Study Area Incremental Load (MW)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5

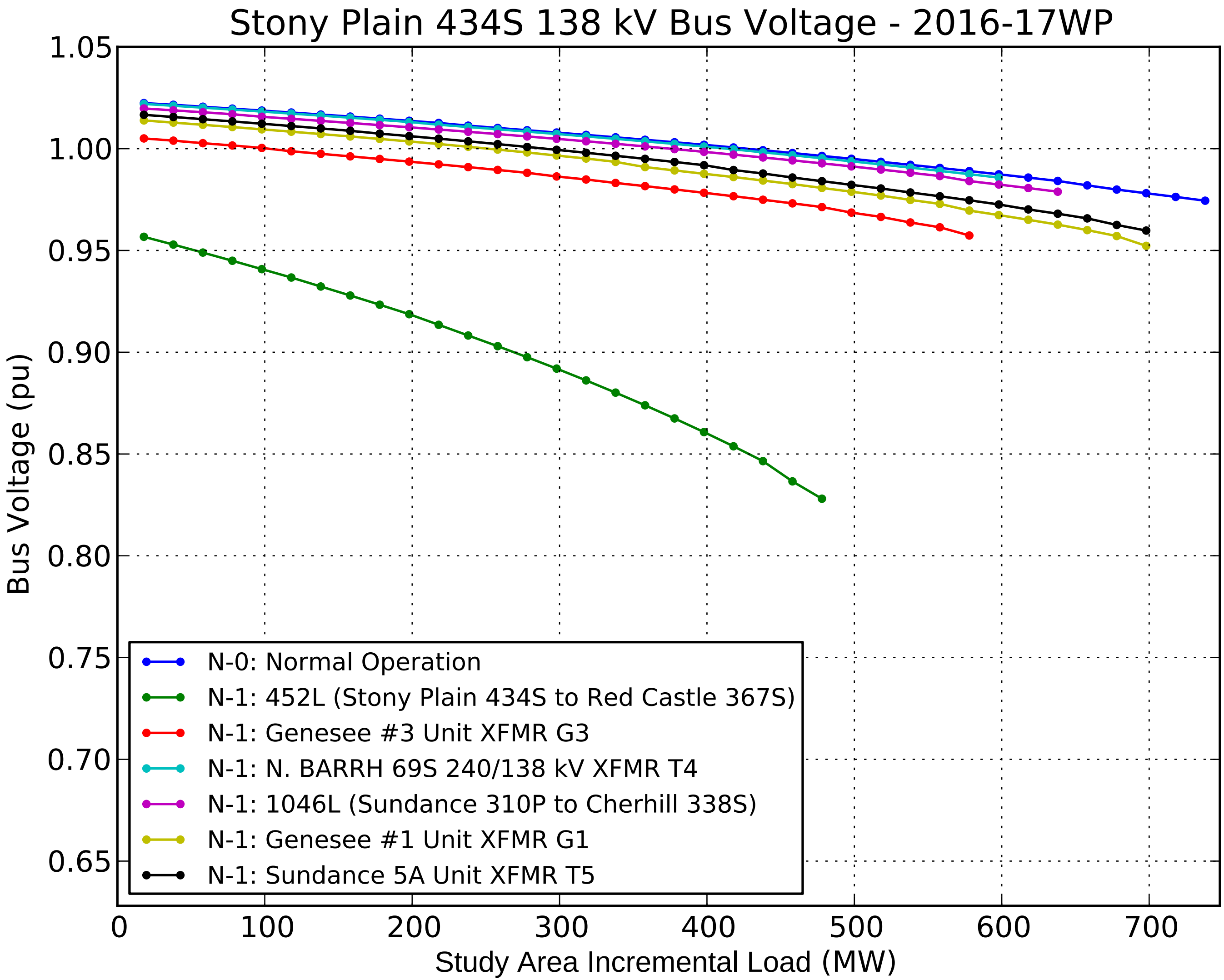


Wabamun 19S 138 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5

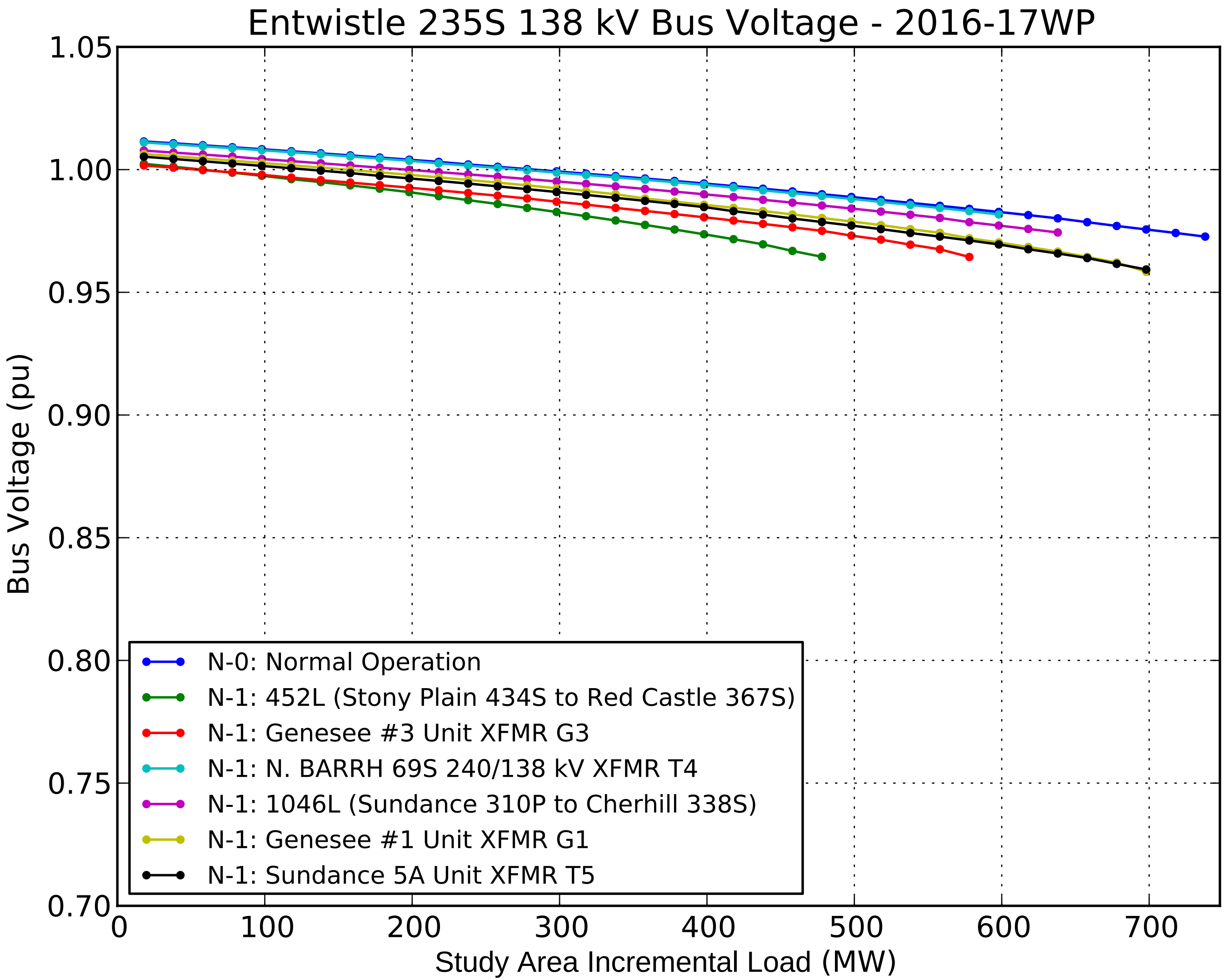

Wabamun 19S 240 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5


North Barrhead 69S 138 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5

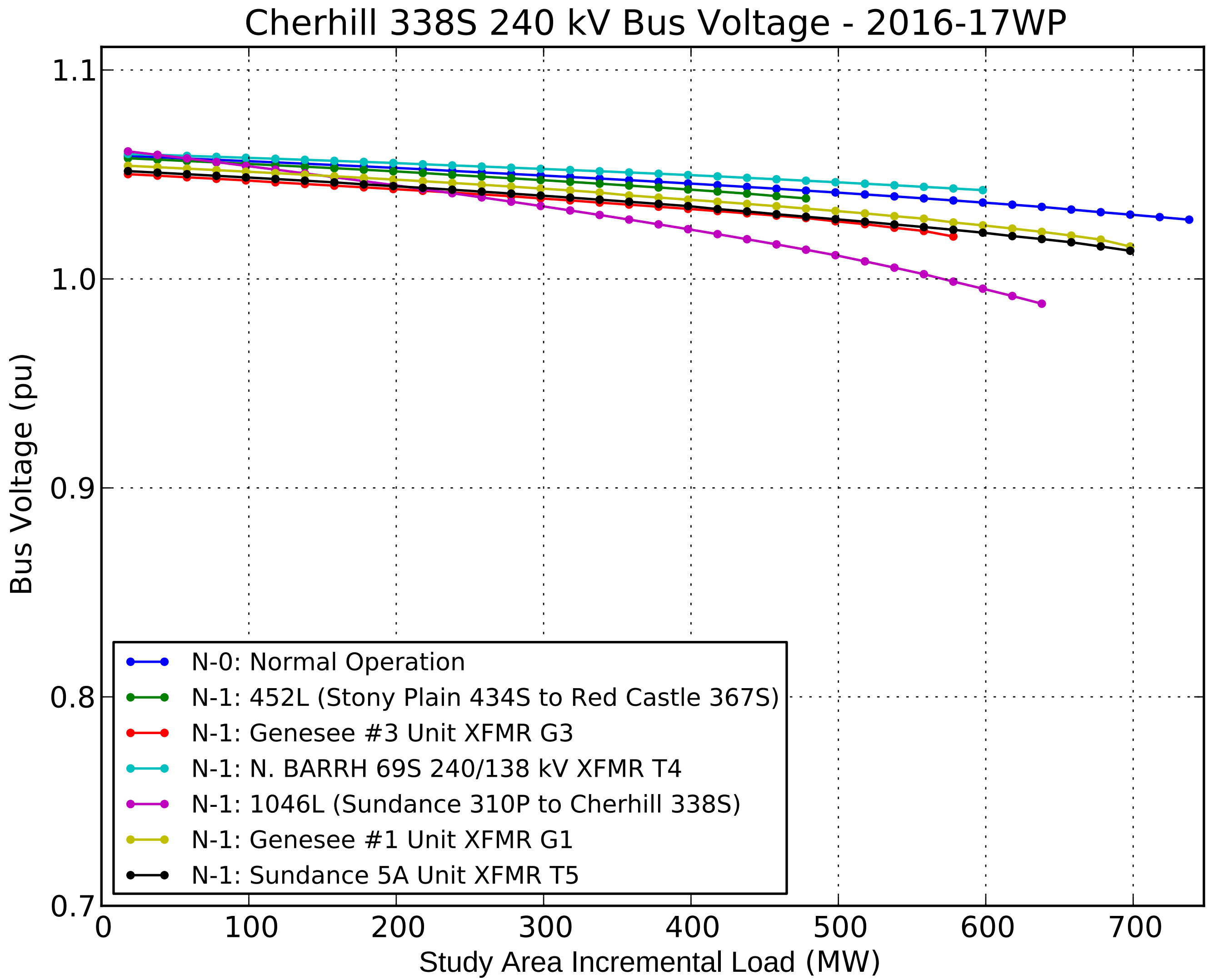

North Barrhead 69S 240 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.1
1.0
0.9
0.8
0.7
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5



Stony Plain 434S 138 kV Bus Voltage - 2016-17WP
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
Bus Voltage (pu)
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5



Entwistle 235S 138 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5


Cherhill 338S 240 kV Bus Voltage - 2016-17WP
Bus Voltage (pu)
1.1
1.0
0.9
0.8
0.7
0
100
200
300
400
500
600
700
Study Area Incremental Load (MW)
N-0: Normal Operation
N-1: 452L (Stony Plain 434S to Red Castle 367S)
N-1: Genesee #3 Unit XFMR G3
N-1: N. BARRH 69S 240/138 kV XFMR T4
N-1: 1046L (Sundance 310P to Cherhill 338S)
N-1: Genesee #1 Unit XFMR G1
N-1: Sundance 5A Unit XFMR T5