BAKKEN AREA LONG RANGE NETWORK LOAD SERVING TRANSMISSION STUDY

2012

Prepared By:
Basin Electric Power Cooperative
Transmission Services Division
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Bakken Area Long Range Transmission Study 2012

Executive Summary

The required facilities and approximate required in service dates are listed below. This scheduling is derived from the voltage stability results in Section 15 and Figure 15.2 in particular as well as the results in the steady state analysis. The analysis shows the need for sections of the 345kV additions to be placed in service prior to 2016. However the earliest the line or any section can be placed into service is likely 2016. Any transmission limitations will have to be made up by operating actions such as running generation, restricting transfers, or restricting load.

2013:

- Mandan-Dickinson-Belfield 230kV Line - increase rating to 398MVA conductor rating
- Bottineau area improvements are needed when area load exceeds 65MW (see Section 8.4)

2015:

- 2nd Dickinson 230/115kV transformer and eliminate 230kV bus outage issue

2016:

- AVS-Charlie Creek-Williston-Tioga 345kV Line
  - (also, address Williston 345kV breaker 292 failure outage)
  - The earliest the AVS-Williston-Tioga 345kV line can be placed in service is 2016
- Larson 230/115kV Substation
- Culbertson-Bainville 115kV Line (assumes Stateline-Bainville-Grenora 115kV in service)

2017:

- Williston 230kV bus capacitor addition, 3 x 80MVAR
- Reconductor Logan-Minot SW 115kV Line to increase rating to 180MVA
- Dawson 115kV bus, sectionalize main bus or implement UVLS

2018:

- Leland Olds-Logan-Tioga 345kV Line

2020:

- Addition of a 2nd Charlie Creek 345/115kV transformer or a 230/115kV transformer
- One of the following three options works well;
  - Additional Reactive Support, Dawson 115kV = 98MVAR, Maurine 115kV = 90MVAR, Hettinger 115kV = 75MVAR
  - Charlie Creek-Dawson 345kV Line
  - Or "230kV Build Out" which consists of upgrading the existing Williston-Fort Peck 115kV Line to 230kV operation, a new Williston-Richland-Dawson 230kV Line, and a new Charlie Creek-Richland 230kV Line.

1. Introduction

The Bakken Area is defined as the region of Western North Dakota and Eastern Montana that is impacted by the extraction of oil and natural gas. The electrical load in this area is forecasted to grow significantly in the next 10 years. This study will analyze the load growth impact to the electrical transmission system in the 5 to 10 year timeframe. The forecasted study area load in 2022 approaches 2200MW. Therefore the purpose of this study is to determine the facilities required to provide 2200MW of load serving capacity.

2. Study Area

The Bakken Study Area is identified in Figure 2.1.

CEII – Confidential Energy Infrastructure Information

Figure 2.1 – Bakken Study Area

The Bakken Study Area is defined by the cut set containing the following braches:

MAURINE4	230	TO	BISON 4	230
HESKET24	230	TO	DICKNSN4	230
COYOTE 7	115	TO	DICKSWH7	115
BEULAH 7	115	TO	HALIDAY7	115
ANTELOP3	345	TO	CHAR.CK3	345
LELANDO4	230	TO	LOGAN 4	230
GARRISN7	115	TO	MAX 7	115
RUGBY 7	115	TO	MALLARD7	115
BOTTNOJCTCP7	115	TO	DUNNING	115
SOURIS	115	TO	MALLARD	115
BDV 4	230	TO	TIOGA4 4	230

Preliminary analysis indicated a sub-area within the Bakken Study Area that may be load serving capacity limited. This area is called the Williston Load Pocket and is identified in Figure 2.2. Operating guides have been developed to monitor this area and direct the required mitigation actions.

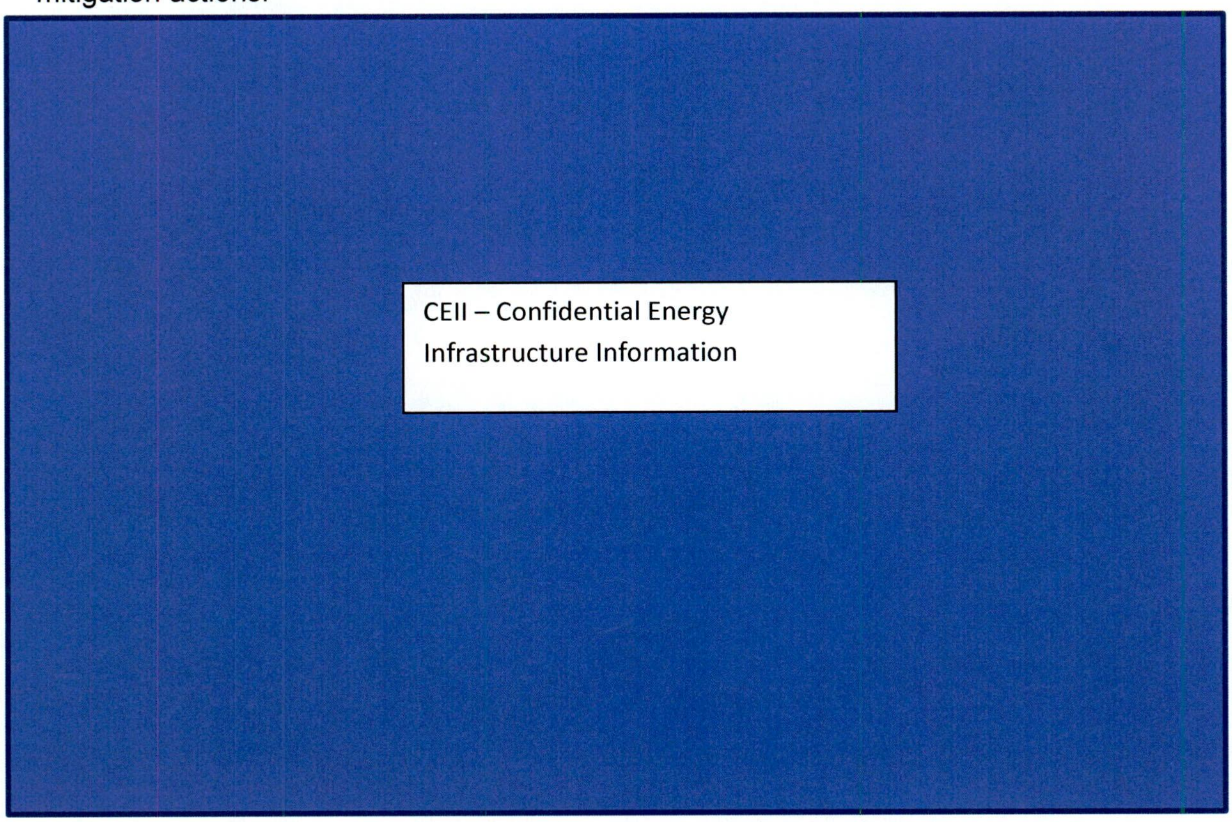

Figure 2.2 – Williston Load Pocket Area

The Williston load pocket is defined by the cut set containing the following braches:

Charlie Creek	230	To	Watford City	230
Richland	115	To	Fairview	115
Wolf Point	115	To	Poplar	115
Logan	115	To	Minot SW	115
Logan	230	To	Blaisdell	230
BDV 4	230	TO	TIOGA4 4	230

Total load in each of these areas will be monitored to help determine system load serving limits. In the powerflow cases the load located in the Williston Load Pocket will be assigned to Zone 50. The remaining load in the Bakken Study Area will be assigned to Zone 51. Therefore the total Bakken Study Area load is the sum of Zone 50 and 51 load.

All transmission facilities rated 69 kV and above located within the Bakken Study Area are monitored. Adjacent to the study area all 115kV and above facilities are monitored, except Sask Power where 230kV facilities are monitored.

3. Criteria

The following table provides the voltage criteria:

		Percent of Nominal			
		Normal Conditions		Emergency Conditions	
System	Facility	Max	Min	Max	Min
WAPA/Basin	All Buses	105%	95%	110%	90%
SP	All 230kV Buses	109%	95%	110%	85%
NSP	All Buses	105%	95%	105%	90%
OTP	>200 kV Buses	105%	97%	110%	92%
	115 kV Buses	107%	97%	110%	92%
OTHER	100 – 500 kV Buses	105%	95%	110%	90%

Table 3.1 – Voltage Criteria

The following table provides the facility loading criteria:

	Normal Condition Loading				Emergency Condition Loading			
System	Line	Station Equipment	Transformer	Duration	Line	Station Equipment	Transformer	Duration
WAPA/Basin	100%	100%	100%	Continuous	*	*	*	*
GRE	100%	100%	100%	Continuous	100%	100%	125%	30 Minutes
NSP	100%	100%	100%	Continuous	110%	This rating is based on the ANSI Standard	115% for Summer and 125% for Winter	Multiple Load cycles
OTP	100%	100%	100%	Continuous	110%	100%	125%	30 Minutes
OTHER	100%	100%	100%	Continuous	110%	110%	125%	30 Minutes

Table 3.2 – Loading Criteria

Regarding the WAPA and Basin Electric ratings, the normal and emergency rating values supplied with the MAPP power flow models should be used. The normal rating is the continuous rating unless noted (e.g. dynamic ratings could be an example where the normal rating is different from the continuous rating). The normal rating and emergency ratings are currently included as "Rate A" and "Rate C" respectively in the MAPP power flow models. The conductor rating is typically included as "Rate B" in the MAPP power flow models. Beginning with 2007 MRO models, "Rate B" is defined as the emergency rating and "Rate C" is defined as the conductor rating.

During the contingency analysis, for violations that meet the emergency condition criteria but violate the normal condition criteria, it will be demonstrated that system adjustments can mitigate to the normal condition criteria within the emergency adjustment time period.

4. Contingency List

The contingency definitions are provided in the MAPP Members Reliability Criteria Manual Table 1. A list of Category B, C, and D outages is provided in Appendix A. All category A and B contingencies within the Bakken Study Area will be run. A list of C1, C2, and C5 outages within the Bakken Study Area is be created by examining the area operating diagrams. Category C3 will be covered in the prior outage analysis which will be performed as a follow up analysis. Since this study consists of only a steady state analysis, Category C6-C9 delayed clearing is covered in the Category C1 and C2 normal clearing analysis.

There is an extensive Special Protection Scheme (SPS) in the study area that will initiate Miles City DC Tie (MCDC) runbacks. If MCDC is transferring power from east-west the SPS will limit the MCDC schedule to 20MW east-west. The following facilities are elements of the MCDC SPS;

<u>MCDC SPS Elements</u>
MCDC-Hettinger 230kV line
MCDC-Dawson 230kV Line
Dawson-Mandan 230kV Line
Belfield-Charlie Creek 345kV Line
AVS-Charlie Creek 345kV Line
Charlie Creek-Watford City 230kV Line
Charlie Creek 345/230kV Transformer

Therefore the outages of these elements will also be simulated with an automatic runback of MCDC to 20MW east-west.

5. Base Case

The original case is a 2017 winter peak (EQ-890-2017WIN-FINAL.sav) that was created as part of the 2012 MN TACT study. Refer to the "***MN TACT Region Third Annual 2012 Transmission Assessment For Period of 2012 to 2022"*** dated July 2012 for a detailed description of the base case construction. Several modifications are made to this case to create the base case for this analysis. An idev containing the code is available upon request.

Base Case Modifications:

1. Remove the proposed AVS-Charlie Creek-Williston-Tioga 345kV line from service as this study will identify improvements required in the study area.
2. Add WAPA, Basin, and MDU's spring 2012 load forecast for the 2017-18 winter peak condition. Then reduce loads by 50% in study area as preliminary analysis indicates the peak load case will not solve without the proposed AVS-Charlie Creek-Williston-Tioga 345kV line in service. Study area loads will be incrementally scaled upwards to determine limits.
3. Add 2nd McHenry 230/115kV transformer per the MNTAC report recommendation.
4. Remove extra Alexandria-Douglas County 115kV Line.
5. Remove Watford City 69kV bus, it is no longer in service.
6. Place Fargo SVC in service.
7. Add Barr Buttes and Strandahl 115kV Substations on the Williston-Grenora 115kV line and set the area MWE 115kV line ratings to 180MVA to reflect the 795mcm conductor rating.
8. Take wind generation in study area out of service as may not be in operation during a peak load scenario.
9. Update Logan-Tioga 230kV line rating to 319MVA continuous and 350MVA emergency.
10. Update Logan-Blaisdell-Tioga 230kV impedance.
11. Update AVS-Charlie Creek 345kV rating to 956MVA continuous and emergency.
12. Correct line impedance on Douglas Creek-Snake Creek 115kV line.

13. Lock several existing caps in service and shunts out of service, PSSE seems to have a solution glitch and will often not automatically switch shunts. Change large capacitor banks to type 2 if needed to help solution convergence.
14. Increase Leland Olds-Logan 230kV continuous and emergency rating to 450MVA continuous and emergency based on a 95F ambient temperature conductor rating.
15. Add proposed MDU capacitors at Dickinson Jct. 2 x 15 MVAR.
16. Reconfigure proposed Culbertson-Grenora 115kV line to Stateline-Grenora to reflect Upper Missouri G&T's current plan.
17. Take MDU and Basin peakers in the study area out of service and set Ft Peck generation at 34 MW total to reflect worst case dispatch. The system intact transmission solution should not rely on operation of peaking generation.
18. Open True Oil-Squaw Gap 115kV line, serve True Oil from Hay Butte.
19. Remove Squaw Gap proposed capacitor from service.
20. Update Logan-Minot SW 115kV line rating to 147MVA continuous and emergency based on a 95F ambient temperature conductor rating.
21. Increase Mandan-Dickinson-Belfield 230kV line rating to 334MVA based on Keystone XL report recommendation.
22. Upgrade Baker-Hettinger 230kV line rating to 394MVA based on structure raise and CT upgrade.
23. Update Garrison-Charlie Creek 115kV line rating to 140MVA continuous and emergency.
24. Update Richland-Williston 115kV line rating to 130MVA continuous and emergency.
25. Update Charlie Creek-Richland 115kV line rating to 130MVA continuous and 139MVA emergency.
26. Increase AVS unit #1 and #2 voltage control to 1.03 pu.
27. Move Blue Butte 115kV load to the Killdeer 115kV line.
28. Place both Groton peaking units in service. These units are out of the study area and placing them in service will provide a resource balance to the increased load in the Bakken area without affecting the transmission results.
29. Set RCDC to 0MW (normal operation will be moving excess Basin west side resources to east, therefore 0MW is a conservative assumption).
30. Set MCDC to 200MW east-west and change to load representation (DC model will block during low voltages and mask impacts).
31. Set B10T at 65MW south-north to reflect 50MW of service plus 15MW dead band (also check 165MW south-north).
32. Add proposed Williston 230/115kV 200MVA transformer #2. It will be in service in 2013.
33. Place proposed Pioneer #1 and Lonesome Creek #1 LM6000 generation in service in synchronous condenser mode.

These changes are added to the original case to create the base case for use in this study which is titled "d00-wp17aa-mod.sav".

Base case generation within the study area is provided in Table 5.1

BUS#	BUS NAME	STATUS	PGEN	QMAX	QMIN	PMAX	Zone
652219	MI CTYE8 57.000	Off	0	12	-5	26	51
652410	FTPECK3G 13.800	In Service	34	16	-22	34	51
652414	FTPECK4G 13.800	In Service	0	16	-22	34	51
652415	FTPECK5G 13.800	In Service	0	16	-22	34	51
659129	NBCS5 KLDR1G13.800	In Service	5.5	5.6	-2.9	7.5	51
659147	PIONEER GEN113.800	Sync Mode	0	53	-21	47	50
659148	LONESMCRKGN113.800	Sync Mode	0	53	-21	47	50
659194	NDPRAIRWND1W0.6900	Off	0	39.2	-58.4	115.5	51
659270	CULBERTSON1G13.800	Off	0	40	-10	120	50
659270	CULBERTSON1G13.800	In Service	5.5	5.6	-2.9	7.5	50
661032	GLENDCT7 115.00	Off	0	22	-8	42	51
661032	GLENDCT7 115.00	Off	0	29	-19	48	51
661055	LEWIS71G 13.800	In Service	50	20	-18	56	51
661307	DM WILWW 0.5750	Off	0	9.9	-14.5	30	51
661317	CDR HLLW 0.5750	Off	0	6.4	-9.5	19.5	51

Table 5.1 – Base Case Study Area Generation

Total Fort Peck generation is set at 34MW. Units at Fort Peck buses 652414 and 652415 are set in synchronous condenser mode to support local voltage.

A plot of the 2012 load forecast for the Bakken Study Area and the Williston Pocket is provided in Figure 5.1. This data includes Coop and MDU load. The base case is a 2017-2018 winter peak model. Therefore January 2018 represents the nominal 100% load level. The vertical axis represents the January forecast for each year.

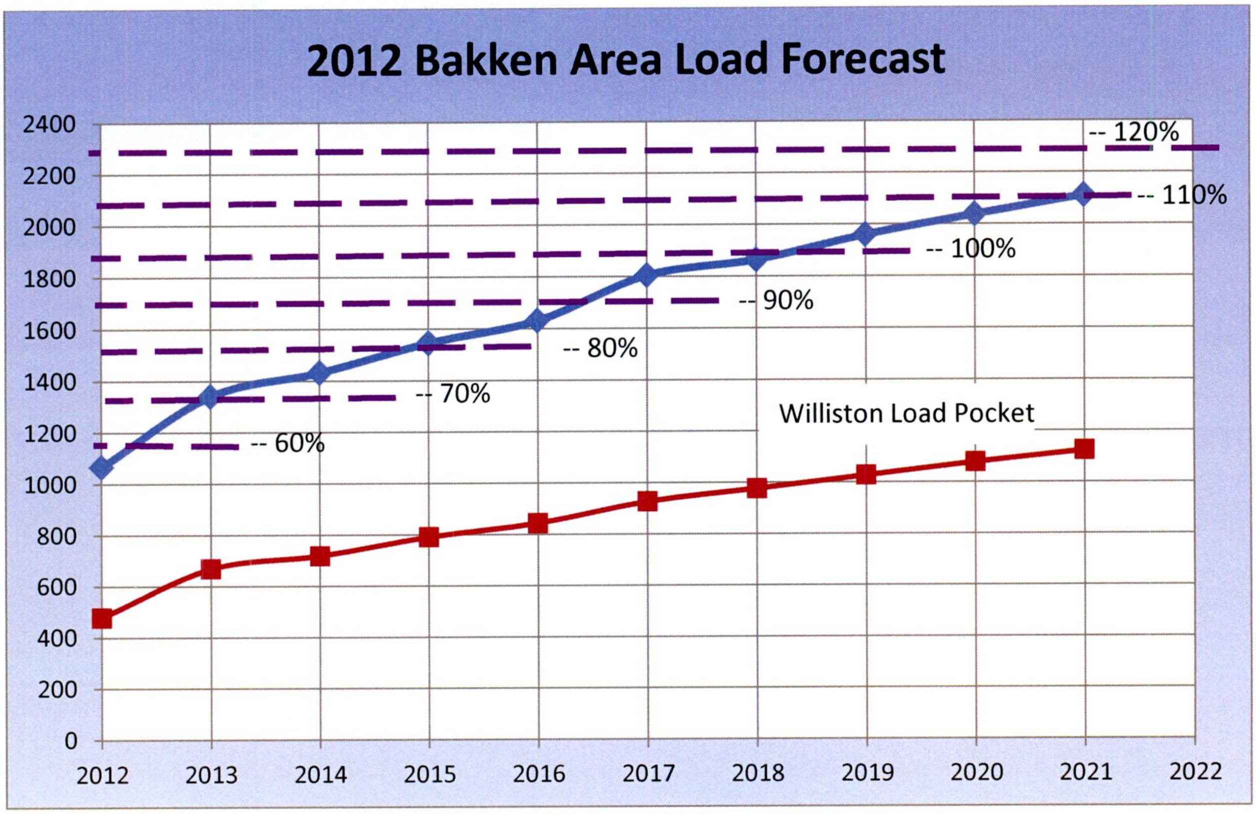

Figure 5.1 – Official 2012 Load Forecast

6. Procedure

The base case does not solve at its nominal load level with the proposed AVS-Charlie Creek-Williston-Tioga 345kV line removed from the case. Therefore load in Study Area (zones 50 and 51) will be scaled back in increments starting at 50% (using the scale command) and incremented upwards to 120%. Referring to the load forecast graph in Figure 5.1, the percent increment load levels are identified by the horizontal dashed lines. The required generation changes will be obtained by placing peaking generation outside the study area in service and then obtaining the remainder from the system swing machine. The contingency list will be run against each case to find limits for each transmission configuration. Transmission limits will be addressed by adding new facilities to the cases. The goal is to find a set of transmission additions that will results in a load serving limit of 2200MW, which corresponds to the 2022 peak load forecast.

7. 50% Load Case: Study Area Load = 954MW, Williston Load Pocket = 513MW Date: ~ Before 2012

The base case load in zones 50 and 51 is scaled to 50%. The contingency list is run against the 50% case and no criteria violations were encountered at that load level.

8. 60% Load Case: Study Area Load = 1145MW, Williston Load Pocket = 616MW Date: 2012

The base case load in zones 50 and 51 is scaled to 60%. The 60% load case has low voltage violations in the Bottineau area. A summary of results is provided in Table 8.1. The Bottineau area is connected via a 115kV loop to Mallard or Towner Substations. The Bottineau area low voltages occur during outage of either end of the loop and are not significantly impacted by the performance of the network system. Therefore the Bottineau area can be studied independently from the rest of this analysis. Sections 8.1-8.4 contain the Bottineau area analysis.

Bus	Voltage PU	Contingency	Cat	Mitigation
RUTHVILLECP7115 DUNNING7 115 BOTTNO 7 115	0.851 0.879 0.892	Mallard-Ruthville 115kV line	B	Bottineau Analysis required
RUTHVILLECP7115 DUNNING7 115 BOTTNO 7 115	0.849 0.876 0.891	MALLARD#2115C1	C1	Bottineau Analysis required

Table 8.1 – 60% Load Case Voltage Violations

8.1. Bottineau Area System Analysis

A diagram of the Bottineau area is provided in Figure 8.1. The load forecast of busses within the Bottineau area is provided in Table 8.2.

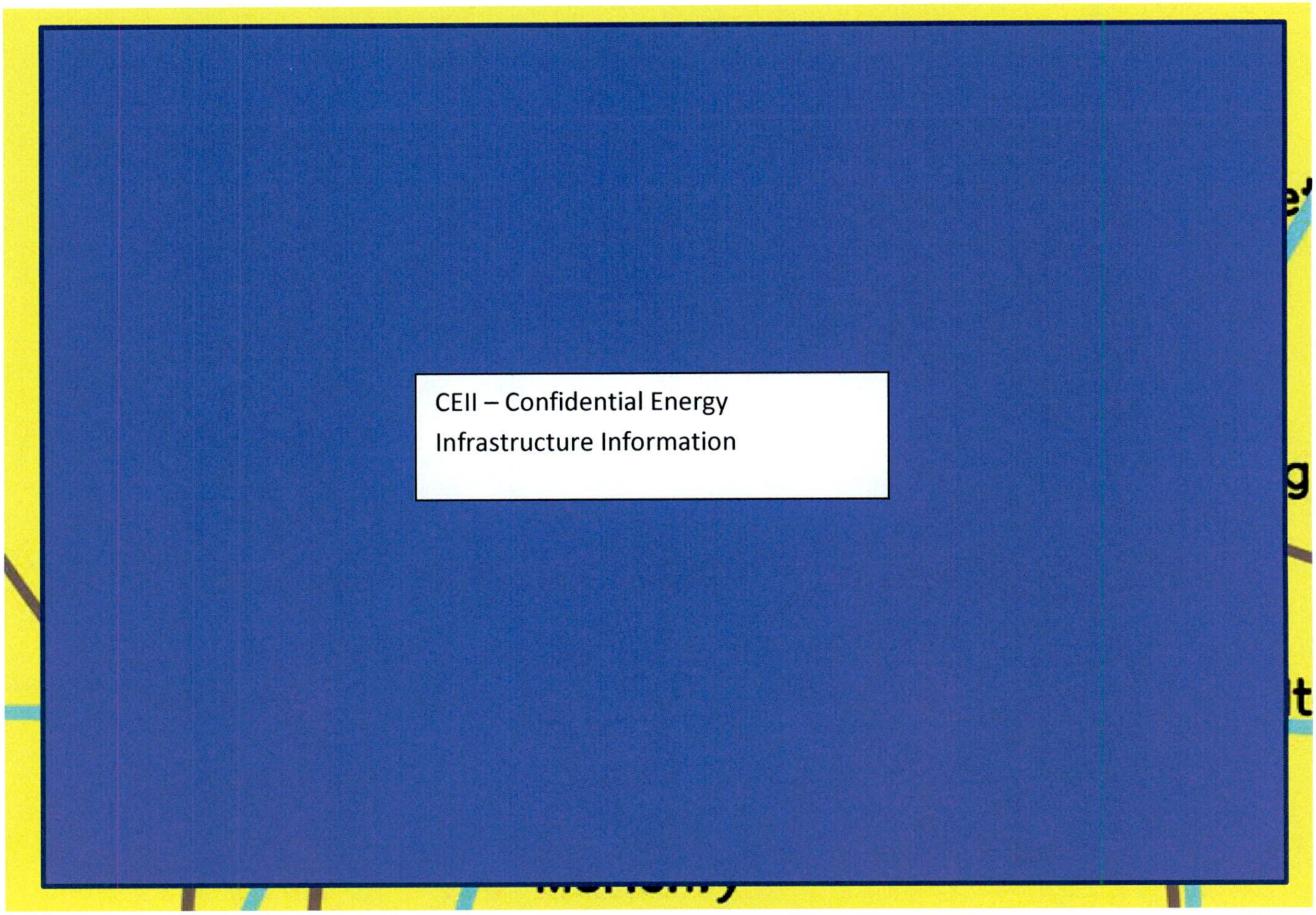

Figure 8.1 – Bottineau Area Transmission

In the 60% load case the Bottineau area has low voltage criteria violations during loss of the Mallard-Ruthville 115kV line or the Mallard 115kV Bus #2 category C outage. Figure 8.2 is a one line diagram of the Mallard-Ruthville 115kV line outage condition. With that outage the large amount of load left connected radial to Towner causes decay in voltage along the line. The Towner 115kV voltage is acceptable. Therefore the voltage problem is local to the Bottineau area. This issue could be cleared by UVLS, but this analysis will determine the facilities required to serve the load without the use of UVLS.

Bottineau Area Load

Bus	60% Load MW/MVAR	2018 Winter Peak Load MW/MVAR	120% Load MW/MVAR	Capacitor MVAR
Ruthville 115	20.1 / 6.3	33.5 / 10.5	40.2/12.6	
Dunning 115	14.0 / 4.1	23.3 / 6.9	27.9/8.3	2 x 10
Whitby 115	25.7 / 8.0	42.8 / 13.4	51.3/16.0	1 x 10
Bottineau 115	3.5 / 1.1	5.8 / 2.0	7.0/2.4	
Bottineau Jct 115	5.2 / 1.6	8.7 / 2.7	10.4/3.2	
TOTAL	68.5 / 21.1	114.1 / 35.5	136.7/42.5	3 x 10

Table 8.2

The results for the 60% load case are displayed on the one line in Figure 8.2. The Dunning and Whitby capacitors are conceptual and are not sufficient to support the 60% load case.

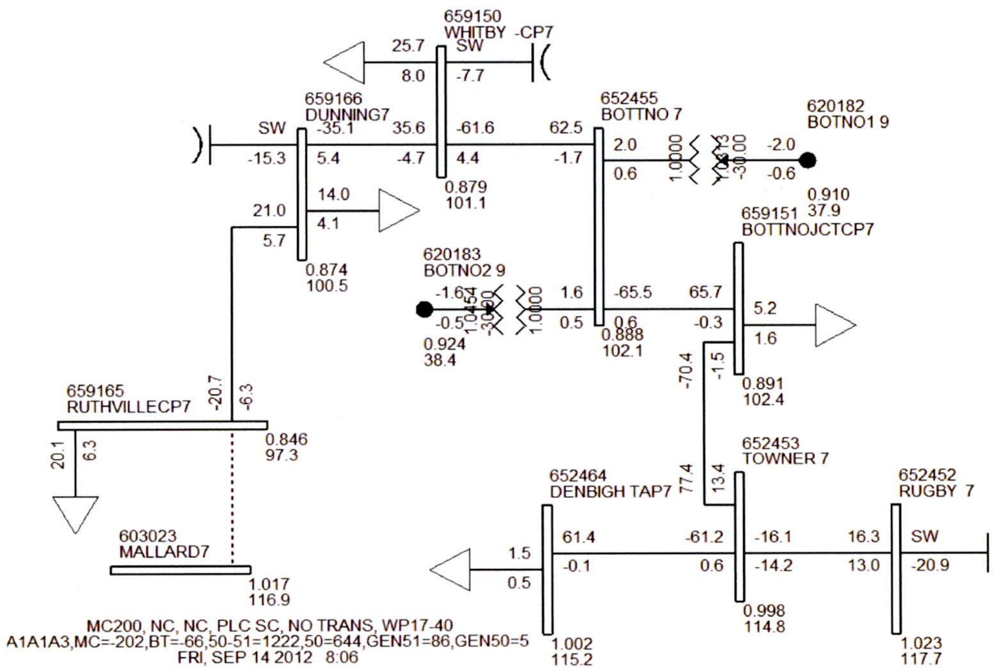

Figure 8.2

Using the 100% load case, a fictitious VAR source is connected to the Ruthville 115kV bus to determine the reactive support required to hold a 1.0 pu voltage during the Mallard-Ruthville 115kV line outage. The case did not solve with infinite reactive support at Ruthville. A VAR source was placed at Bottineau instead. The results are displayed in Figure 8.3, 92.5MVAR is required to maintain 1.0 pu voltage at Bottineau. This is an unreasonable amount of VAR support; therefore additional transmission lines into the area are analyzed.

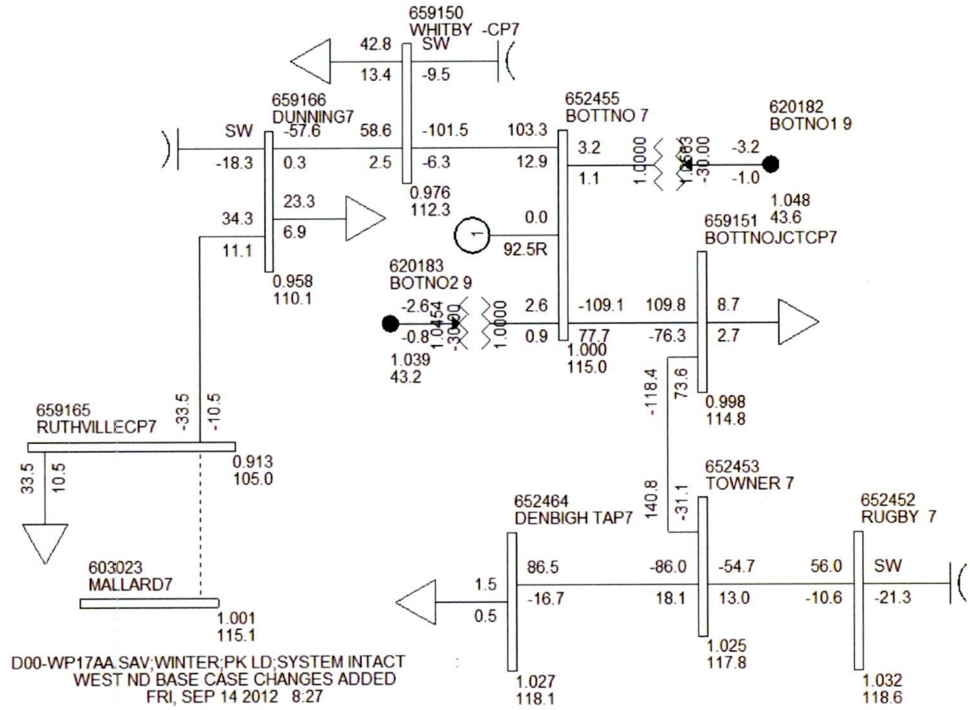

Figure 8.3

8.2. Bottineau Area Transmission Addition Alternatives

The following options will be considered to support the Bottineau area 115kV transmission loop.

1. Logan-Ruthville 115kV line:

Name:	Logan-Ruthville 115kV line
Length:	25 miles
Conductor:	795mcm Mallard, 915A, 182MVA
Impedance:	R=0.02204 X=0.14308 B=0.01873
Spacing:	A=40,-8 B=40,8 C=40,24

2. Logan-Dunning 115kV line:

Name:	Logan-Dunning 115kV line
Length:	60 miles
Conductor:	795mcm Mallard, 915A, 182MVA
Impedance:	R= 0.05266 X= 0.34269 B= 0.04499
Spacing:	A=40,-8 B=40,8 C=40,24

3. Logan-Dunning 115kV line & 30MVAR Caps at Whitby:

Name:	Logan-Dunning 115kV line
Length:	60 miles
Conductor:	795mcm Mallard, 915A, 182MVA
Impedance:	R= 0.05266 X= 0.34269 B= 0.04499
Spacing:	A=40,-8 B=40,8 C=40,24

Plus total of 30MVAR (3 x10) capacitor banks at Whitby 115kV Bus

4. Logan-Whitby 115kV line:

Name:	Logan-Whitby 115kV line
Length:	85 miles
Conductor:	795mcm Mallard, 915A, 182MVA
Impedance:	R= 0.07421 X= 0.48425 B= 0.06382
Spacing:	A=40,-8 B=40,8 C=40,24

5. Logan-Whitby 230kV line:

Name:	Logan-Whitby 230kV line
Length:	85 miles
Conductor:	1272mcm Bittern, 1155A, 460MVA
Impedance:	R= 0.01208 X= 0.12049 B= 0.25552
Spacing:	A=56,-11 B=66,10 C=76,-11

8.3. Bottineau Area Results

PV curves are created for each alternative and provided on Figure 8.4. The 2018 winter peak Ruthville to Bottineau area total load forecast is 114MW. The 120% load forecast in the area is 136.7MW. Therefore the alternative should be able to accommodate at least 114MW (preferably 136.7MW) and maintain voltage at 0.90 pu which is the low voltage criteria for the buses in that area.

The base case limit is approximately 65MW. It is limited by the Mallard-Ruthville 115kV outage and voltage at the Ruthville 115kV bus.

Alternative #2, the Logan-Dunning 115kV line addition has a load serving capacity of approximately 114MW which is exactly at criteria. It is limited by the Mallard-Ruthville 115kV outage and voltage at the Ruthville 115kV bus.

Alternative #3, the Logan-Dunning 115kV line addition plus a total of 30MVAR of capacitors at Whitby has a load serving capacity of approximately 123MW which provides 9MW of margin at 100% load but is below the 120% load level. It is limited by the Mallard-Ruthville 115kV outage and voltage at the Ruthville 115kV bus.

Alternative #5, the Logan-Whitby 230kV line addition has a load serving capacity of approximately 160MW which provides 46MW of margin at 100% load and 24MW of margin at the 120% load level. It is limited by the outage of the new 230kV line and voltage at the Ruthville 115kV bus.

The other alternatives are not acceptable as their limits are below the 100% load serving capacity requirement.

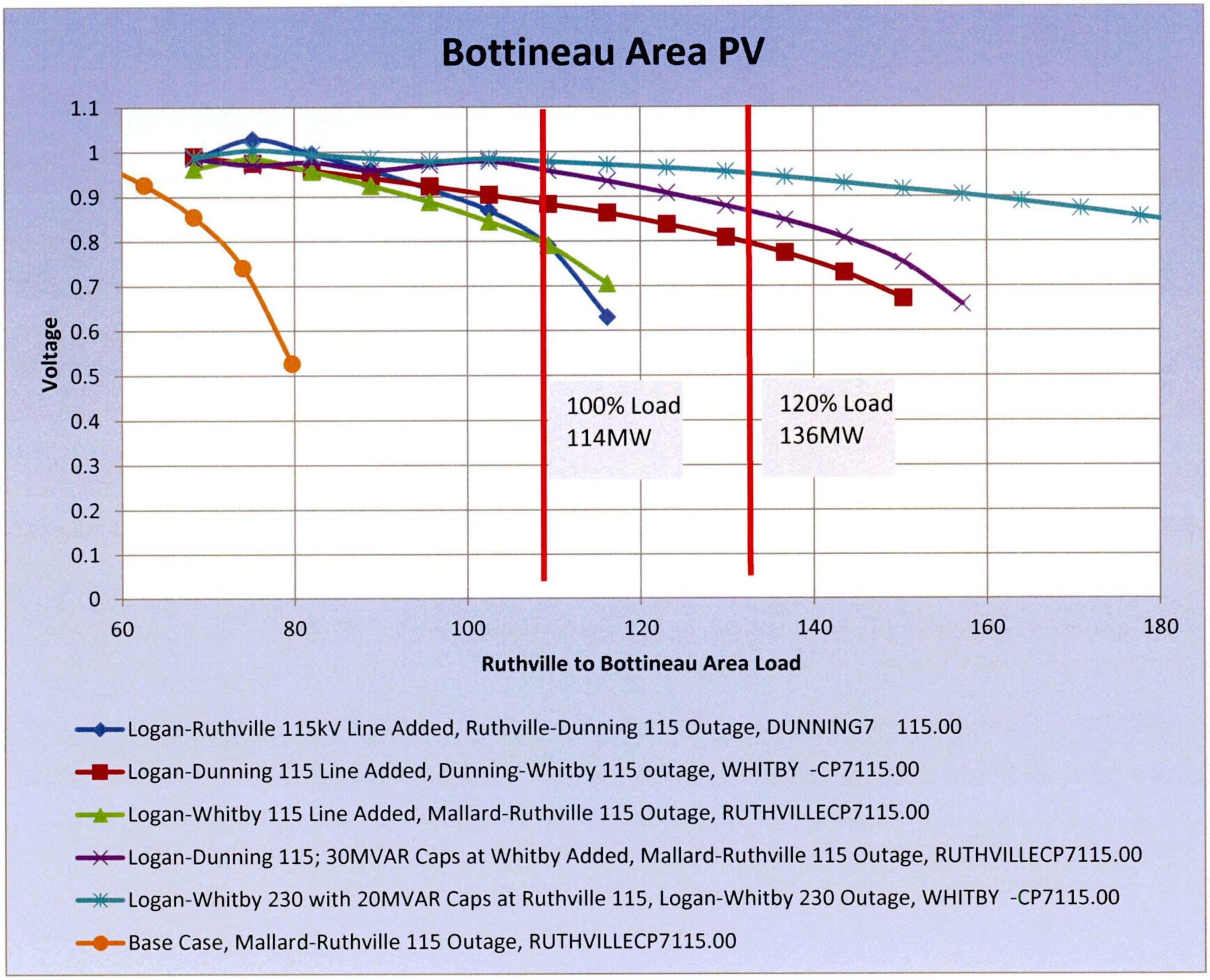

Figure 8.4

8.4. Bottineau Area Recommendation

Alternative #5, a 230kV line from Logan to Whitby plus 20MVAR capacitors at Ruthville provides the maximum load serving criteria in the Bottineau area. Therefore it will be added to the base case and placed in service for the remainder of this analysis to eliminate the Bottineau area criteria violations. The Logan-Dunning 115kV line addition with 30MVAR capacitors at Whitby would suffice if the system was only being designed for the 100% load level case. A UVLS would also be effective as a temporary measure until the transmission improvements are in service. These additions would be required should the load on the Bottineau 115kV loop exceed 65MW.

9. 70% Load Case: Study Area Load = 1336MW, Williston Load Pocket = 719MW Date: 2013

In this section the zone 50/51 load is scaled to 70% of base case load level. The improvements described in Section 8 are added to the case. The contingency list is run and a summary of the results is provided in Tables 9.1 and 9.2. The major limiter of the 70% load case is loss of the Charlie Creek-Watford city 230kV line with RCDC ramp to 20MW E-W which results in low voltage and an overload of the Richland-Fairview 115kV line. This outage opens the west side of the 230kV loop, severs the connection to the 345kV system, and leaves the large Watford City load connected radial to Williston. A reduction of Watford City load to 50MW as an SPS clears the low voltage violations; however the Richland-Fairview 115kV line remains slightly overloaded. A parallel 345kV line, Charlie Creek-Williston, is added to the case. The analysis of the 345kV line addition is provided in sections 9.1-9.2.

Outage of the Charlie Creek 345/115kV transformer causes low voltage on the area 115kV system. This could be solved with capacitor banks or shifting load from Blue Butte back to Watford City. However at higher load levels the outage of the transformer will cause the Beulah-Charlie Creek 115kV line to overload. Therefore the solution could be a 2nd transformer or upgrade of the 115kV line rating. Also, other transmission additions may affect the performance of this area. Therefore this issue will be rolled forward and the solution determined at a higher load level.

Bus	Voltage PU	Contingency	Cat	Mitigation
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115	0.900 0.900 0.888	CHAR.CK3_345/115	B	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case
WILISTN7 115 WILISTN4 230 + Many More	0.841 0.857	Charlie Creek-Watford City 230 with MCDC ramp to 20MW	B	Reducing Watford City load to 50MW as an SPS enabled a solution with no voltage criteria violations
KILDEER7 115 HALIDAY7 115 CHAR.CK7 115 BLUEBUTT 115	0.848 0.882 0.849 0.834	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW	C2	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case

Table 9.1 – 70% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
RICHLND7 - FAIRVIEW 7 115	130	122.5	Charlie Creek-Watford City 230 with MCDC ramp to 20MW	B	This is a valid limit
RICHLND7 - FAIRVIEW 7 115	130	107.5	Charlie Creek-Watford City 230 with MCDC ramp to 20MW and reduction of Watford City load to 50MW	B	This is a valid limit
LOGAN 7 - SWMINOT CP7115	147	118.1	Logan-Blaisdell 230	B	This is a valid limit
BTHOLD 7 - SWMINOT CP7115	147	102.4			
DICKNSN4 - BELFELD4 230	334	100.0	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW	C2	Increase line rating to 398MVA summer conductor rating

Table 9.2 – 70% Load Case Thermal Loading Violations

9.1. 345kV Line Characteristics

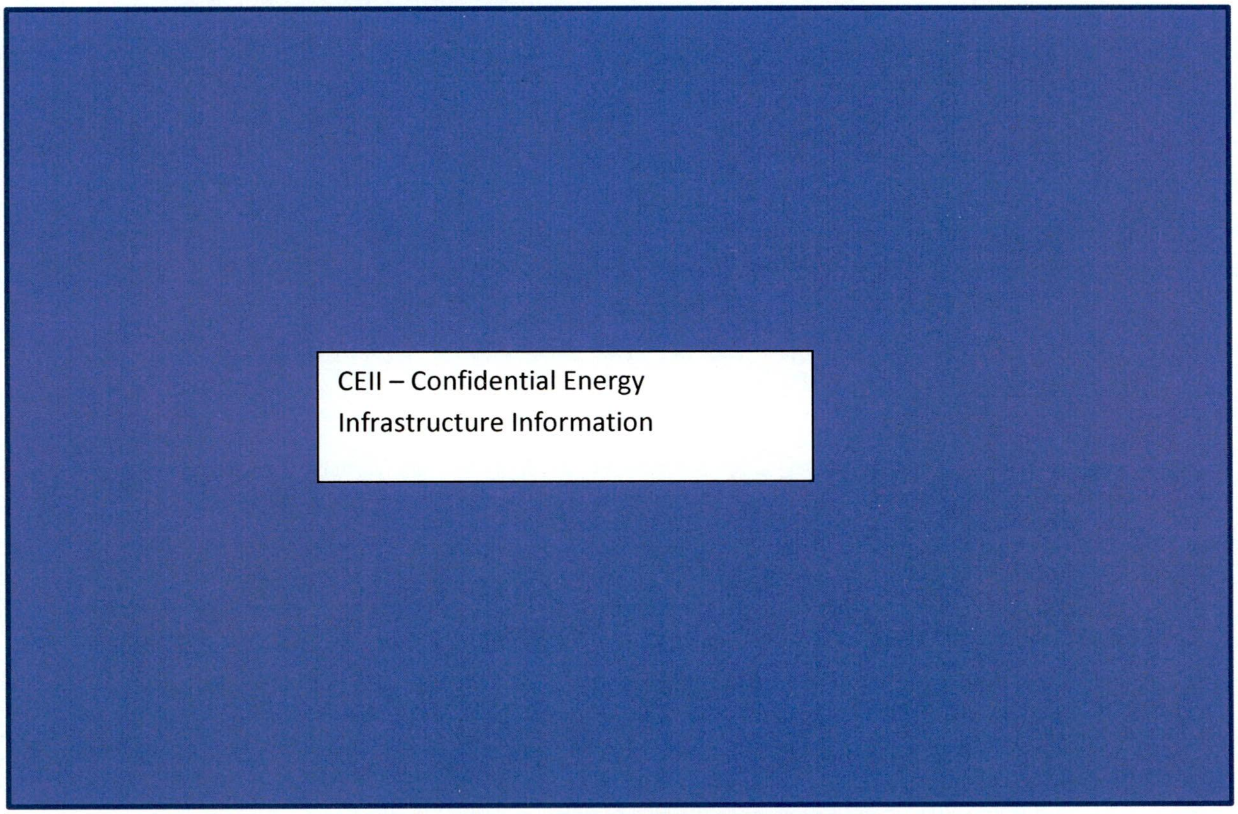

Figure 9.1 – Charlie Creek – Williston 345k Line

A Charlie Creek-Williston 345kV line will be added to the case to mitigate the problems associated with the low voltages and overload caused by the loss of the Charlie Creek-Watford City 230kV line. The location is provided on the map in Figure 9.1. Basin Electric is proposing to use single steel pole towers and single conductor for new 345kV lines. Single pole self supporting towers are proposed to reduce the footprint of the towers which minimizes the land use impact. The towers have the following configuration.

	Position		
Phase	X (ft)	Y (ft)	Sag (ft)
A	-14	92	37.8
B	16	79.5	37.8
C	-14	67	37.8
GR1	-6	115	10
GR2	6	115	10

Single conductor is proposed for the ease of maintenance, lower icing loads, and hardware compatibility with other existing 345kV lines. The 345kV line will have the following characteristics.

Name:	Charlie Creek-Williston 345KV line
Length:	71 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R= 0.00253328 X= 0.044496 B= 0.48599

9.2. 70% Load Case: Charlie Creek-Williston 345V Line Results

The results with the Charlie Creek-Williston 345V line added to the 70% load case are provided in Tables 9.3 and 9.4. The criteria violations associated with the outage of the Charlie Creek-Watford City 230kV line are mitigated. The remaining violations are not limiting.

Bus	Voltage PU	Contingency	Cat	Mitigation
KILDEER7 115 HALIDAY7 115 CHAR.CK7 115 BLUEBUTT 115	0.863 0.895 0.865 0.850	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR 345/115 trans	C2	Consider UVLS for C2 outages, capacitor banks, or 2nd CCR 345/115 transformer

Table 9.3 – 70% Load Case Voltage Violations
Charlie Creek-Williston 345V Line

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
DICKNSN4 - BELFELD4 230 DICKNSN4 - MANDAN 230	334 334	102.7 100.3	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW	C2	Increase line rating to 398MVA summer conductor rating

Table 9.4 – 70% Load Case Thermal Loading Violations
Charlie Creek-Williston 345V Line

10. 80% Load Case: Study Area Load = 1527MW, Williston Load Pocket = 822MW Date: 2015

In this section the zone 50/51 load is scaled to 80% of base case load level. The Charlie Creek-Williston 345V line, described in Section 9, is added to the case. The contingency list is run and a summary of the results is provided in Tables 10.1 and 10.2.

10.1. 80% Load Case Initial Results

Outage of the Dickinson 230/115kV transformer causes low voltage, either alone or as part of the breaker failure outage. This is in spite of a 30MVAR capacitor bank added at the DICKSWH7 115kV bus in the base case. Also the transformer loads to 109.5% of its continuous rating for loss of the Coyote-Dickinson 115kV Line. Therefore a 2nd Dickinson 230/115kV transformer will be added. It will be modeled as a copy of the existing unit.

Bus	Voltage PU	Contingency	Cat	Mitigation
DKSN-ND7 115 DICKSWH7 115 DICKNTH7 115	0.879 0.885 0.877	DICKNSN4_230/115	B	Consider a 2nd Dickinson 230/115 Transformer
KILDEER7 115 CHAR.CK7 115 R.RIDER7 115 BLUEBUTT 115	0.871 0.872 0.893 0.856	CHAR.CK3_345/115	B	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case
POPLAR 7 115	0.895	WOLFPT 7 - POPLAR 7_115	B	Consider reactive support
CLBRTSN7 115	0.897	WILISTN7 - CLBRTSN7_115	B	Consider reactive support
Not Solved		AVS-Charlie Creek 345 with MCDC ramp to 20MW E-W	B	This is a valid limit
DKSN-ND7 115 DICKSWH7 115 DICKNTH7 115	0.882 0.890 0.881	DICKINSON230C1	C1	Consider a 2nd Dickinson 230/115 Transformer and reconfigure 230 bus to eliminate C1 outage
Not Solved		Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR 345/115 trans	C2	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case
Not Solved		Charlie Creek 345 3696 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR-Will 345	C2	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case

Table 10.1 – 80% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
Logan-Minot SW 115	147	111.0	Logan-Blaisdell 230	B	
Dickinson 230/115	100	109.5	Coyote-Dickinson 115	B	Emergency rating = 125%, a 2nd transformer to fix voltage issues would mitigate this issue as well
ANTELOP3- CHAR.CK3 345	956	101.7	Leland Olds 230 Bus	C1	Upgrade terminal equipment. Summer conductor rating is 1135MVA

Table 10.2 – 80% Load Case Thermal Loading Violations

10.2. 80% Load Case Transmission Addition Results

An AVS-Charlie Creek 345kV #2 line will be added to the case to mitigate the problems associated with the loss of the AVS-Charlie Creek 345kV #1 line. The line is modeled with the following characteristics;

Name:	AVS-Charlie Creek #2 345kV line
Length:	66 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R= 0.00235714 X= 0.041382 B= 0.45165

The addition of this line segment to the previous case will create a new AVS-Charlie Creek-Williston 345kV line. The location is shown in Figure 10.1. The AVS-Charlie Creek-Williston 345V line is added to this case and the contingency list is run. A summary of results is provided in Tables 10.3 and 10.4.

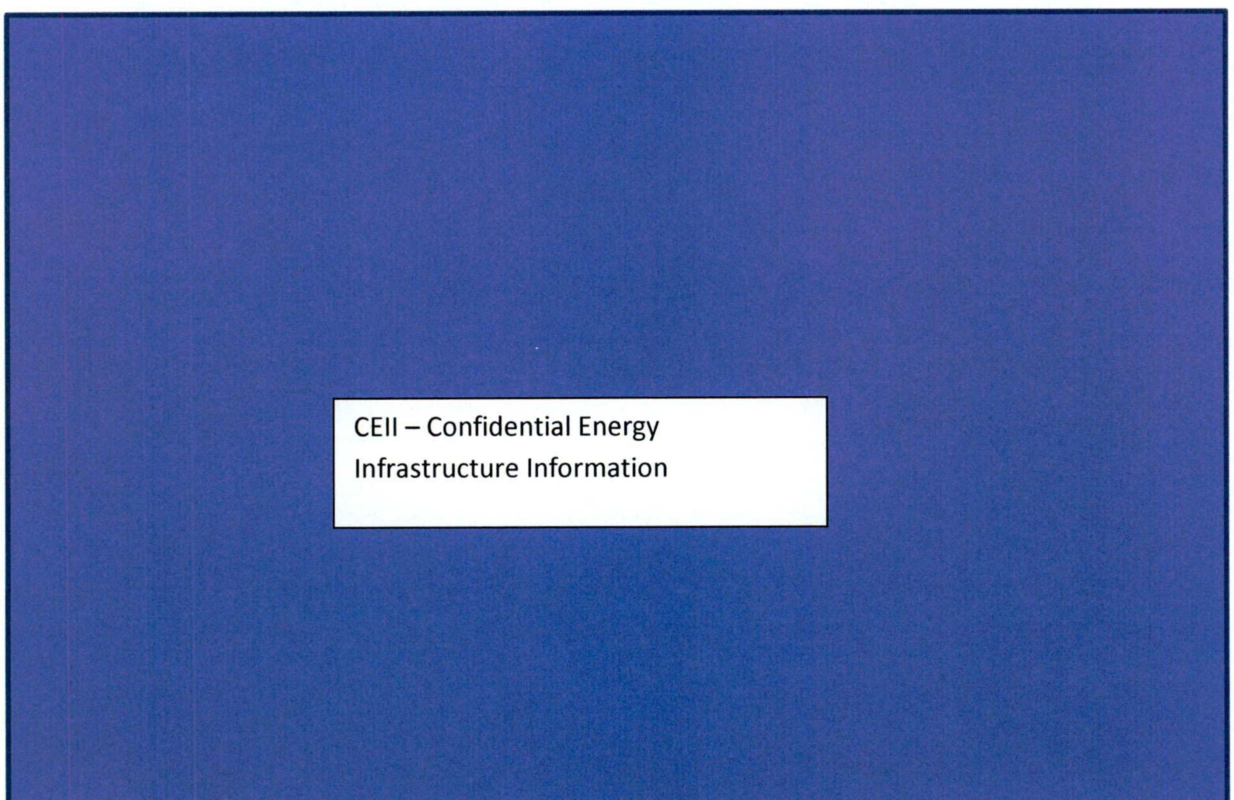

Figure 10.1: AVS-Charlie Creek–Williston 345k Line

The AVS-Charlie Creek-Williston 345kV line addition eliminates the violation associated with the loss of the AVS-Charlie Creek #1 345kV line. The voltage profile is improved enough to eliminate the Culbertson area low voltage violations as well. The violations associated with the Dickinson 230/115 transformer remain. Therefore a 2nd Dickinson

230/115 transformer should be considered. Also, the Dickinson 230kV bus should be configured to eliminate the bus or breaker failure outage issue.

Bus	Voltage PU	Contingency	Cat	Mitigation
DKSN-ND7 115 DICKNTH7 115	0.902 0.901	DICKNSN4_230/115	B	Consider a 2nd Dickinson 230/115 Transformer
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115	0.890 0.891 0.875	CHAR.CK3_345/115	B	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case
DKSN-ND7 115 DICKSWH7 115 DICKNTH7 115	0.878 0.887 0.878	DICKINSON230C1	C1	Consider a 2nd Dickinson 230/115 Transformer and reconfigure 230 bus to eliminate C1 outage
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115	0.893 0.894 0.878	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR 345/115 trans	C2	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case

Table 10.3 – 80% Load Case Voltage Violations
AVS-Charlie Creek-Williston 345V line

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
Dickinson 230/115	100	112.4	Coyote-Dickinson 115	B	Emergency rating = 125%, a 2nd transformer to fix voltage issues would mitigate this issue as well

Table 10.4 – 80% Load Case Thermal Loading Violations
AVS-Charlie Creek-Williston 345V line

11. 90% Load Case: Study Area Load = 1718MW, Williston Load Pocket = 925MW Date: 2016

The zone 50/51 load is scaled to 90% of the base case level. The AVS-Charlie Creek-Williston 345kV line as described in sections 9 and 10 is added to the case.

11.1. 90% Load Case Initial Results

In spite of the 345kV line addition the 90% load case has a poor system intact voltage profile. A voltage heat map of the Bakken area is provided in Figure 11.1. There are numerous outages that result in low voltage criteria violations as well. A summary of results is provided in Tables 11.1 and 11.2.

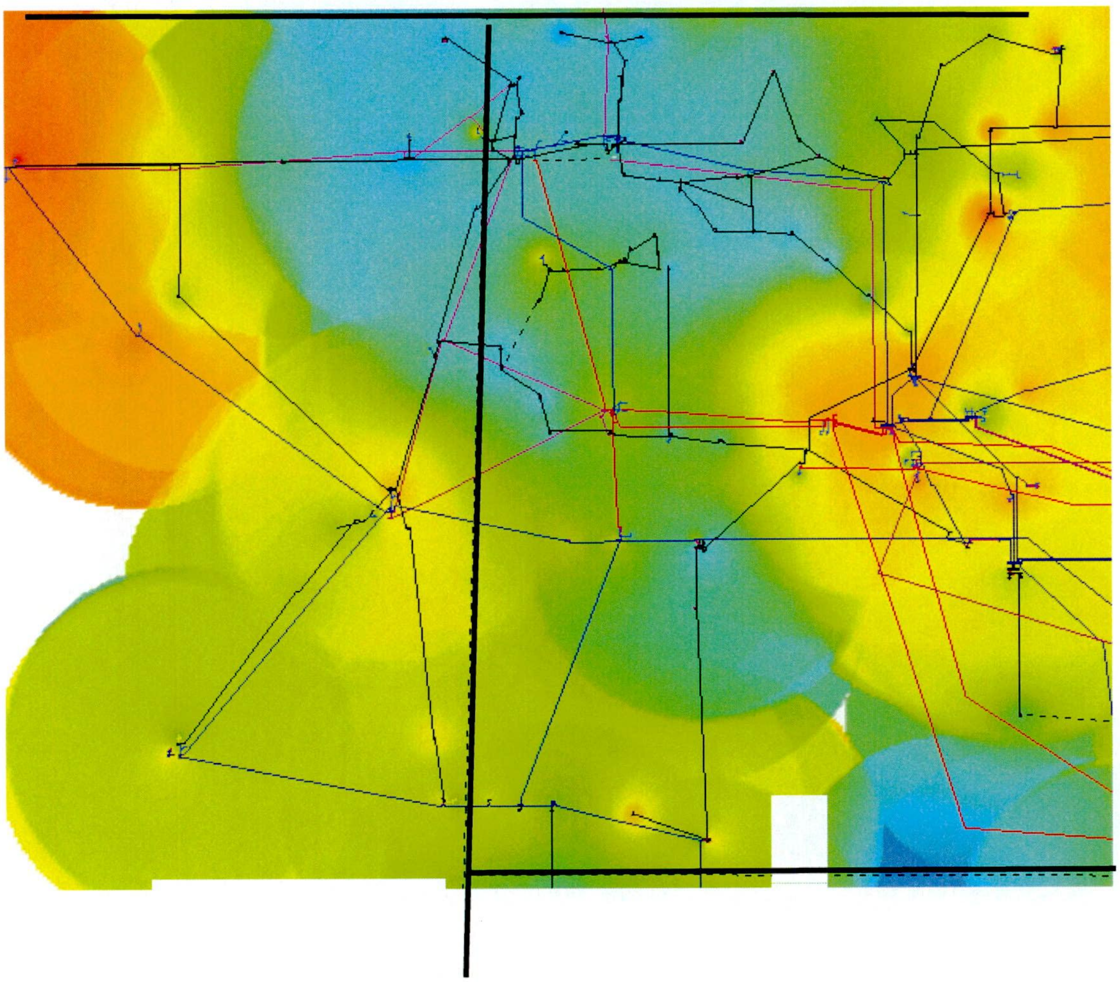

Figure 11.1: 90% Load System Intact Voltage Profile (Scale = 0.9 to 1.1 pu voltage)

Bus	Voltage PU	Contingency	Cat	Mitigation
LARSON 7115 LIGNITE -BD7115 CROSBY -BD7115	0.955 0.951 0.940	System Intact	A	This is a valid limit
WILISTN7 115 GRENORA7 115 CROSBY -BD7115 + others	0.893 0.865 0.862	Charlie Creek-Williston 345	B	This is a valid limit
GRENORA7 115 CROSBY -BD7115 + others	0.883 0.878	Charlie Creek-Williston 345 with MCDC ramp to 20MW E-W	B	This is a valid limit
WILISTN7 115 GRENORA7 115 + others	0.897 0.873	Williston-Williston 230	B	This is a valid limit
GRENORA7 115 + others	0.880	Williston 345/230	B	This is a valid limit
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115 + Others	0.836 0.837 0.817	CHAR.CK3_345/115	B	This could be solved with a 2[nd] transformer or capacitor banks, to be determined at higher load level case
POPLAR 7 115 CLBRTSN7 115	0.860 0.875	Wolf Point-Poplar 115	B	A Culberston-Bainville 115kV Line addition will mitigate
BLUEBUTT 115 KILDEER7 115	0.883 0.899	KILDEER7_115 - CHAR.CK7_115	B	2 x 10MVAR caps at Killdeer and Blue Butte will mitigate
CLBRTSN7_115	0.838	WILISTN7_115 - CLBRTSN7_115	**B**	A Culberston-Bainville 115kV Line addition will mitigate
PLNTYWD7 115	0.896	MONT_ STRNDAHL-MW7_115	B	A Culberston-Bainville 115kV Line addition will mitigate
DKSN-ND7 115 DICKSWH7 115 DICKNTH7 115	0.819 0.828 0.817	DICKINSON230C1	C1	The proposed 2[nd] Dickinson transformer should include upgraded bus arrangement to mitigate
POPLAR 7 115 CLBRTSN7 115	0.861 0.877	Wolf Point 115 C1	C1	A Culberston-Bainville 115kV Line addition will mitigate
DGLASCRK-CP7115 SNAKECRKPMP7115 ROSEGLEN-CP7115 MAKOTI -CP7115	0.895 0.896 0.894 0.899	Garrison-Max 115 and Garrison-Snake Creek 115 Double Circuit	C5	Additions associated with higher load level cases will mitigate
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115 + Others	0.839 0.840 0.821	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR 345/115 trans	C2	2 x 10MVAR caps at Killdeer and Blue Butte will mitigate
WILISTN7 115 GRENORA7 115 CROSBY -BD7115 + others	0.878 0.847 0.846	Charlie Creek 345 3696 breaker fail with MCDC ramp to 20MW, trips AVS-CCR #1 and CCR-Watford 230	C2	This is a valid limit
GRENORA7 115 STRNDAHL-MW7115 LARSON 7115 + Others	0.879 0.885 0.892	Williston 345 196 breaker, trips CCR-Williston 345 and Williston 345/230	C2	This is a valid limit
GRENORA7 115 STRNDAHL-MW7115 LARSON 7115 + Others	0.879 0.885 0.892	Williston 345 292 breaker, trips CCR-Williston 345 and Williston-Tioga 345	C2	This is a valid limit

GRENORA7 115 STRNDAHL-MW7115 LARSON 7115 + Others	0.887 0.893 0.898	Williston 345 192 breaker, trips CCR-Tioga 345 and Williston 345/230	C2	This is a valid limit

Table 11.1 – 90% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
WATFORD4 - CHAR.CK4 230	431.8	104.5	Charlie Creek-Williston 345	B	Emergency rating = 121.8%
WILISTN7- WILLISTON MW7115 STATELINE- WILLISTON MW7115	120 120	141.3 130.8	WILISTN7_115 - MONT_115	B	This is a valid limit
WILISTN7_115 - MONT_115	159	105.8	WILISTN7- WILLISTON MW7115	B	This is a valid limit
SOURIS 7 - VELVA TAP 115	118.5	109.0	Leland Olds-Logan 230	B	Emergency rating = 110%
LOGAN 7 - SWMINOT CP7115	147	110.6	Logan-Blasdell 230	B	This is a valid limit
WATFORD4 - CHAR.CK4 230	431.8	103	Williston 345 196 breaker, trips CCR-Williston 345 and Williston 345/230	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	103	Williston 345 292 breaker, trips CCR-Williston 345 and Williston-Tioga 345	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	102.7	Williston 345 192 breaker, trips CCR-Tioga 345 and Williston 345/230	C2	Emergency rating = 121.8%

Table 11.2 – 90% Load Case Thermal Loading Violations

11.2. 90% Load Case Transmission Additions

A Williston-Tioga 345kV line addition helps relieve the low voltages listed in Table 11.1. The addition of this section combined with the additions identified in sections 9 and 10 create an AVS-Charlie Creek-Williston-Tioga 345kV line. A voltage heat map with the Williston-Tioga 345kV line is provided in Figure 11.2. A comparison of the heat map in Figure 11.1 with the heat map in Figure 11.2 demonstrates the effect of the Williston-Tioga 345kV line. These additions will create a 345kV path into the center of the load growth area. The location is shown in Figure 11.3. The line is modeled with the following characteristics;

Name:	Williston-Tioga 345kV line
Length:	58 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R= 0.00207437 X= 0.036392 B= 0.39679

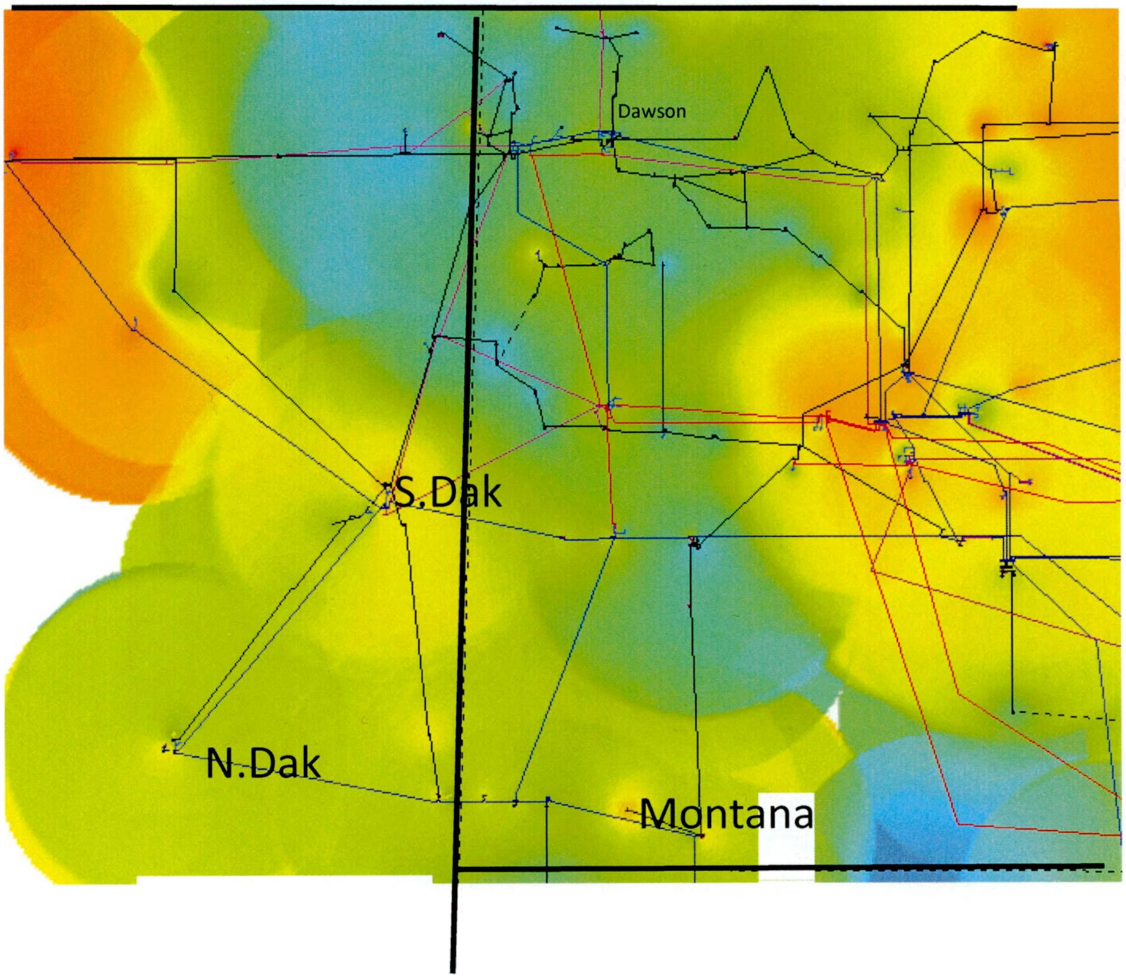

Figure 11.2: 90% Load System Intact Voltage Profile
Addition of Williston-Tioga 345kV Line
(Scale = 0.9 to 1.1 pu voltage)

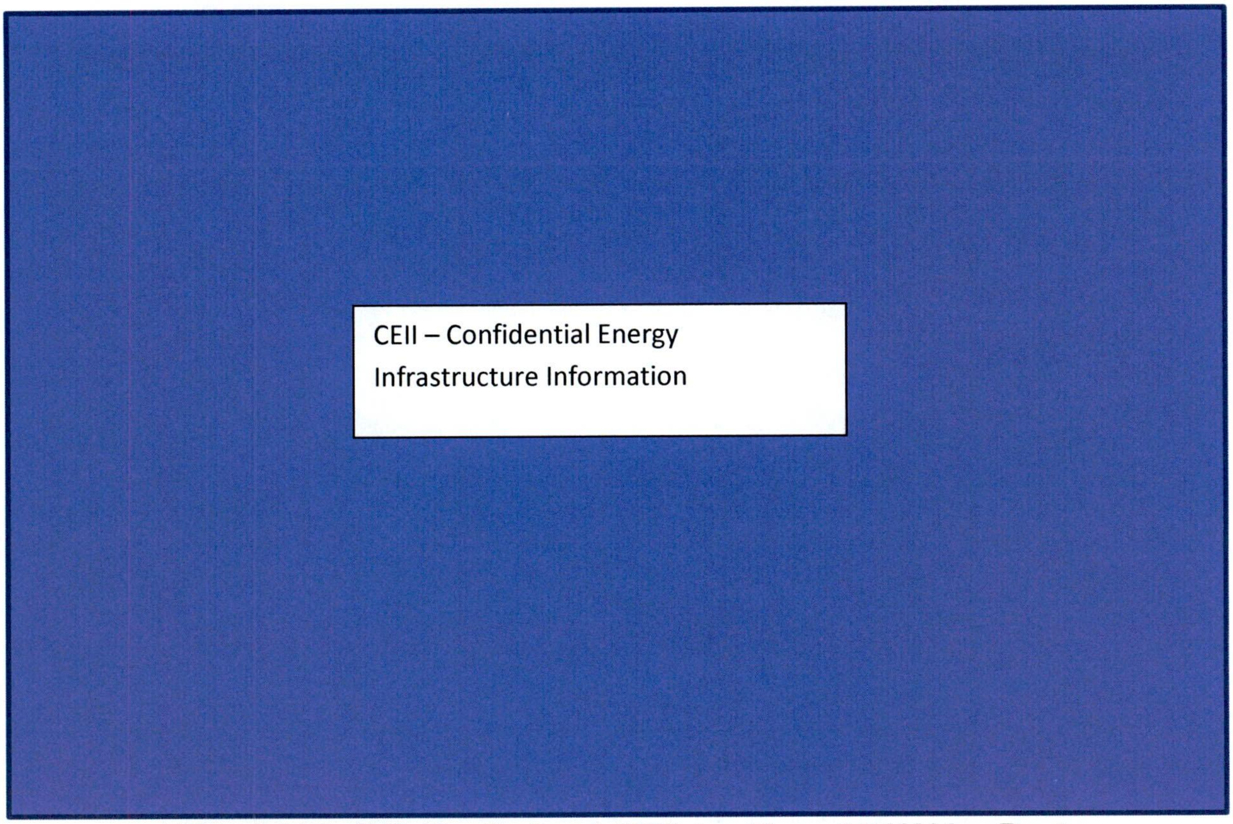

Figure 11.3: AVS-Charlie Creek-Williston-Tioga 345kV Line Route

Basin Electric members are constructing an extensive 115kV load serving system in the Bakken area. A portion is shown as the dashed lines in Figure 11.4.

The proposed Larson Substation will be a 230/115kV delivery and will serve the Crosby and Lignite 115kV Substations. These Substations are connected to Tioga in the base case. The long distance of the 115kV connection to Tioga causes a large voltage drop. These buses are listed in Table 11.1 as low voltage violations. The addition of the Larson Substation will eliminate the long 115kV connection and help mitigate the voltage problems. Larson 230/115 Substation will be modeled by tapping the Tioga-Boundary Dam 230kV line at its midpoint and connecting to the Larson 115kV Substation which is already in the base case. The Larson-Neset 115kV line is opened.

The Stateline Substation has been recently placed in service and the 115kV lines to Williston are either in service or under construction. Also Upper Missouri recently announced their intention of building a Stateline-Bainville-Grenora 115kV line. This line will provide a delivery to the Bainville Substation and also a 2nd connection to Grenora which will help support the voltage. This line was added to the original base case as described in Section 5.

Bainville and Culbertson are located relatively close together. A new 115kV line from Culbertson to Bainville would provide another outlet to Culbertson and help with low voltages which are shown occurring for adjacent line outages as shown in Table 10.1. The line is modeled with the following characteristics;

Culbertson-Bainville 115kV Line:
15 miles, Drake Conductor, R=0.01336, X=0.08962, B=0.01079, Rating=120MVA

In Table 11.3 there are minor low voltage violations for loss of the Charlie Creek 345/115kV transformer (either as a category B or part of a category C) or loss of the Charlie Creek-Killdeer 115kV line. The addition of 20MVAR (2 x 10) capacitors at Killdeer and Blue Butte 115kV buses mitigates the low voltage violations.

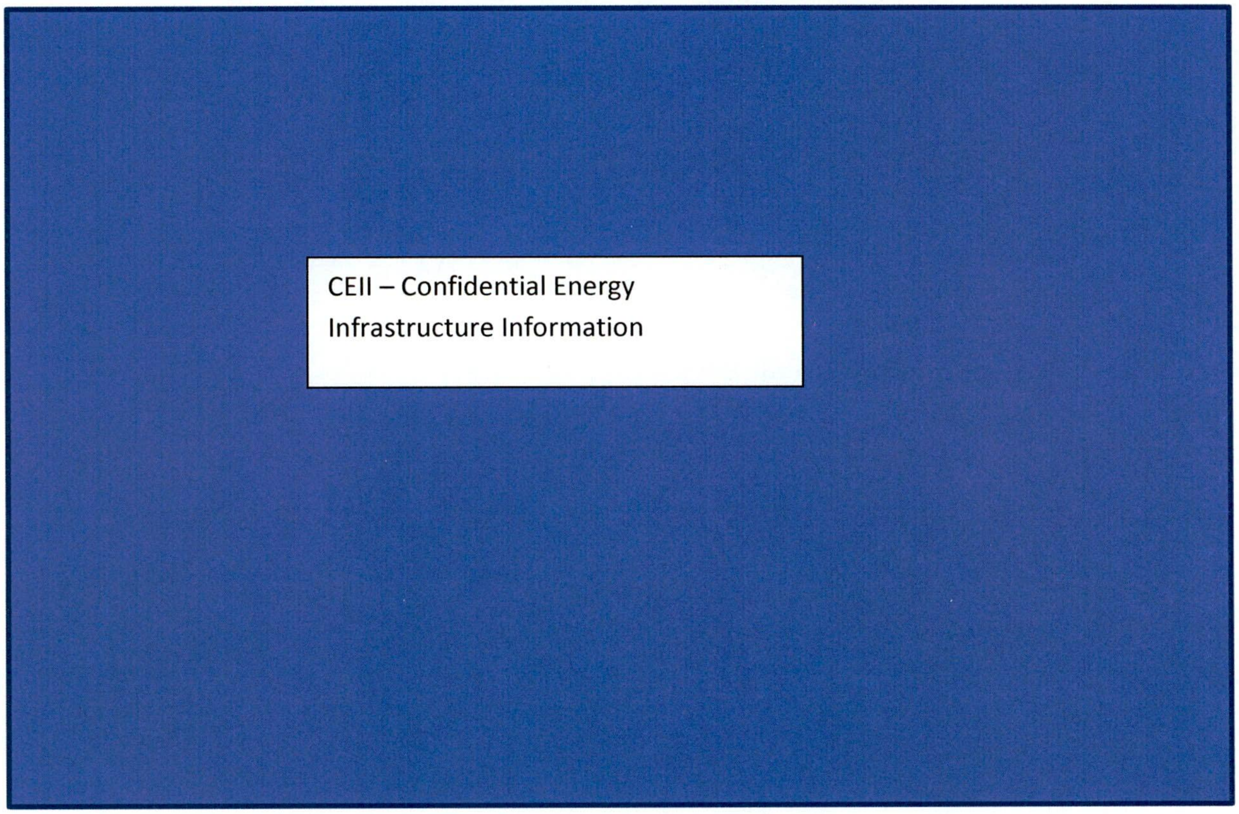

Figure 11.4: Larson and Stateline/Bainville Areas

11.3. 90% Load Case Transmission Additions Results

The additions listed in Section 11.2 are added to the case and the contingency list is run. The summary of results is provided in Tables 11.3 and 11.4. There are no limiting criteria violations.

Bus	Voltage PU	Contingency	Cat	Mitigation
GRENORA7 115 STRNDAHL-MW7115	0.896 0.899	Williston 345 292 breaker, trips CCR-Williston 345 and Williston-	C2	Modify breaker arrangement

+ Others		Tioga 345		

Table 11.3 – 90% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
WILISTN7- WILLISTON MW7115 STATELINE- WILLISTON MW7115	120 120	127.9 117.3	WILISTN7_115 - MONT_115	B	Ensure these proposed lines are built with adequate capacity
WATFORD4 - CHAR.CK4 230	431.8	101.9	Charlie Creek-Williston 345	B	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	100.2	Williston 345 196 breaker, trips CCR-Williston 345 and Williston 345/230	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	100.4	Williston 345 292 breaker, trips CCR-Williston 345 and Williston-Tioga 345	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	101.3	Williston 345 192 breaker, trips CCR-Tioga 345 and Williston 345/230	C2	Emergency rating = 121.8%

Table 11.4 – 90% Load Case Thermal Loading Violations

12. 100% Load Case: Study Area Load = 1909MW, Williston Load Pocket = 1028MW
Date: 2018

12.1. 100% Load Case Initial Results

The 100% load case is not scaled as the loads are the original base case values. The transmission additions described in Section 11.2 are added to this case, including the AVS-Charlie Creek-Williston-Tioga 345kV line. In spite of the addition of the 345kV line, due to the increase in load from the 90% case the system intact voltage profile is poor across the entire study area. A heat map of the system intact voltage is provided in Figure 12.1. A summary of voltage results is provided in Table 12.1. There are numerous outages that do not solve.

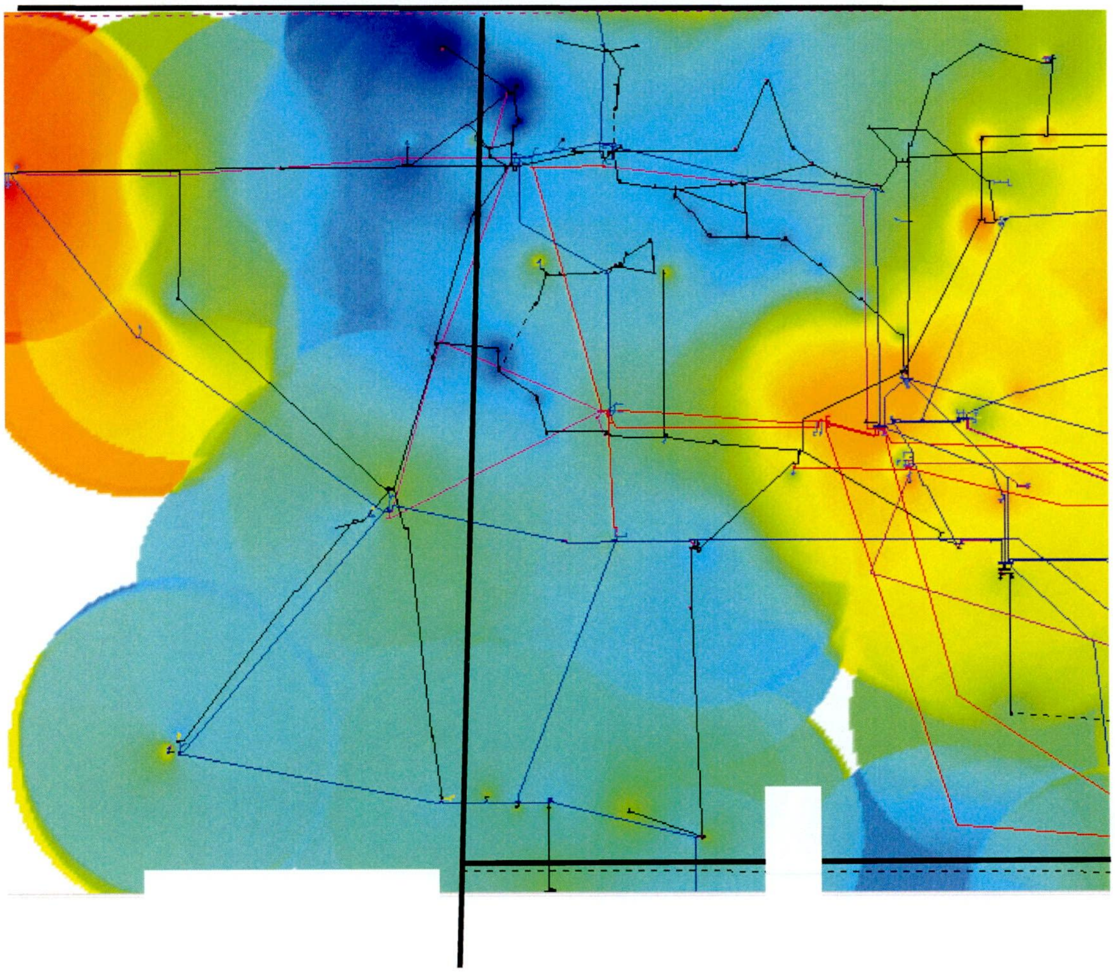

Figure 12.1: 100% Load System Intact Voltage Profile
(Scale = 0.9 to 1.1 pu voltage)

Bus	Voltage PU	Contingency	Cat	Mitigation
WILISTN7 115 SQUAWGP7 115 DICKNTH7 115 PLNTYWD7 115 + Others	0.950 0.935 0.947 0.909	System Intact	A	Valid Limit

Not Solved		CHAR.CK3-WILLISTON 345	B	Valid Limit
Not Solved		WILLISTON – TIOGA 345	B	Valid Limit
Not Solved		WILLISTON - WILISTN4 230	B	Valid Limit
Not Solved		+ plus many more outages	B & C	Valid Limit

Table 12.1 – 100% Load Case Voltage Violations

12.2. 100% Load Case Transmission Additions

The case is short of reactive power. To determine the amount of required compensation large VAR source is connected to the Williston 230kV bus. It is modeled as a type 2 capacitor bank and set to hold various voltages for both system intact and outages. A summary of results in provided on the graph in Figure 12.2. At the 100% load level with 1909MW in the study area approximately 140MVAR's injected at Williston is required to maintain a 1.02 pu system intact voltage. Approximately 210MVAR's is required to maintain 1.00 pu voltage at Williston during the Charlie Creek-Williston 345kV line outage. Based on these results a shunt capacitor injection of 240MVAR will be tested. This will be modeled as 3 x 80MVA banks. 80MVAR provides a 3% system intact voltage step change when switched at Williston. The voltage heat map is provided in Figure 12.3. Comparing Figure 12.3 to 12.1 demonstrates the voltage profile improvement provided by the capacitors.

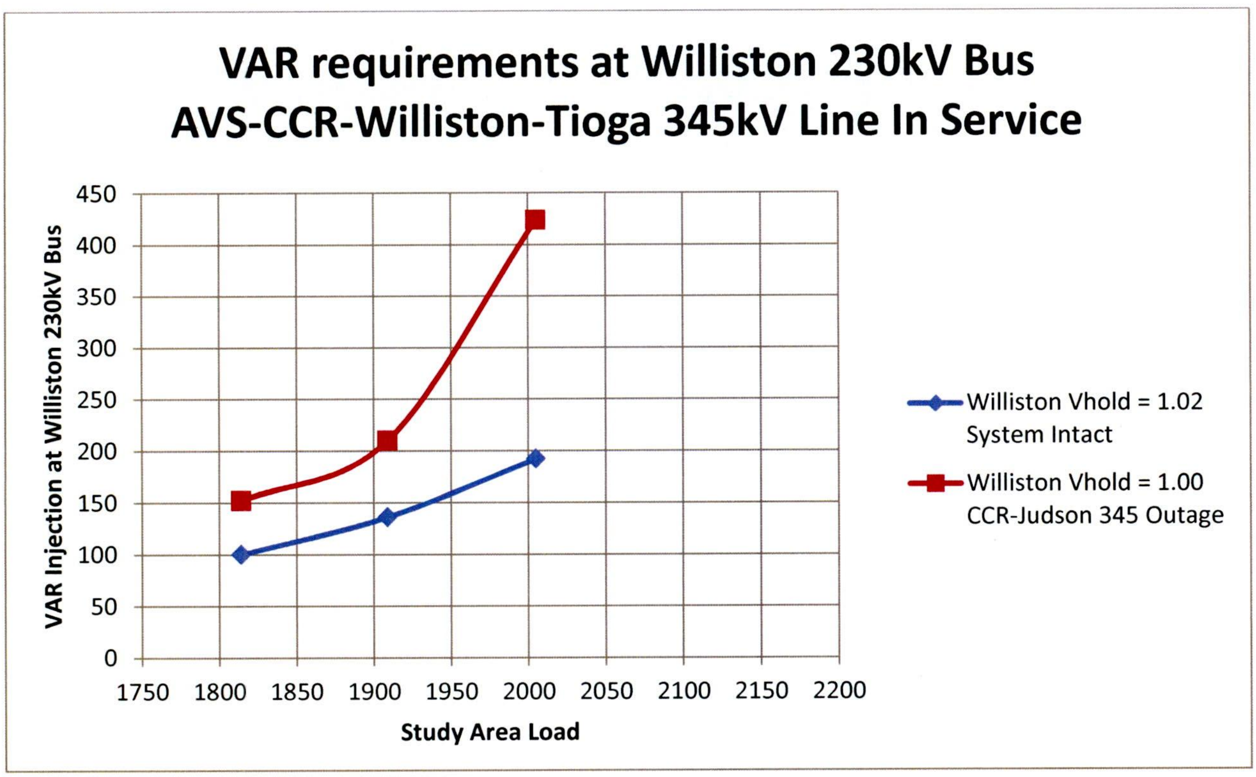

Figure 12.2 – Williston VAR Requirements as a Function of Load

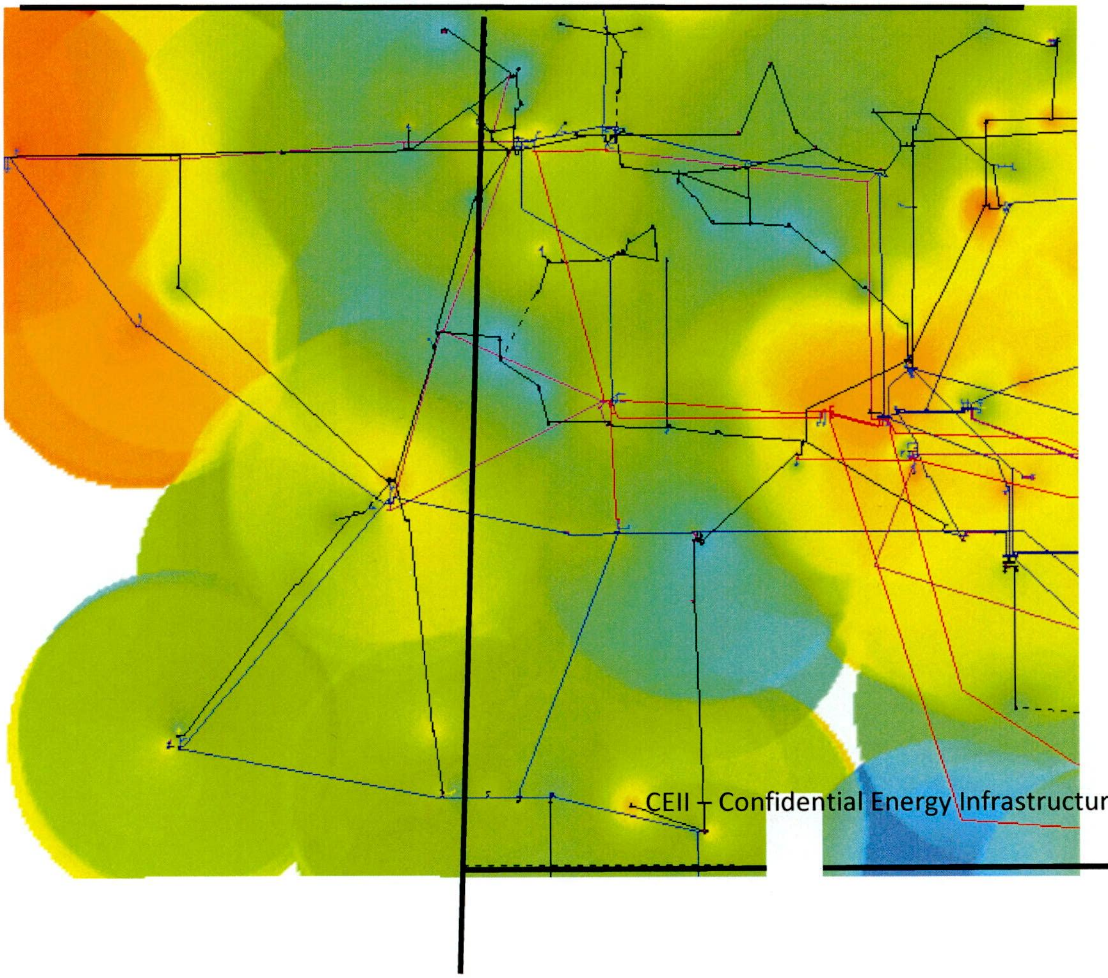

Figure 12.3: 100% Load System Intact Voltage Profile
240MVAR Capacitors Added At Williston 230KV Bus
(Scale = 0.9 to 1.1 pu voltage)

12.3. 100% Load Case Transmission Addition Results

The 240MVAR capacitor facility is added to the Williston 230kV bus as described in Section 12.2. It is successfully meets the VAR requirement needs of the case and eliminates the low voltage violations listed in Table 12.1. A summary of results is provided in Tables 12.2 and 12.3.

The Logan-Minot SW 115kV line loads to 110.6% of its 147MVA rating for loss of the Logan-Blaisdel 230kV line. This may be a valid limitation as the 147MVA rating is equal to the summer conductor rating. This line is less than 10 miles in length; therefore addition of a second line or a reconductor of the existing line would mitigate this overload.

Bus	Voltage PU	Contingency	Cat	Mitigation

Charlie Creek 115	0.894	Charlie Creek 345/115	B	This could be solved with a 2nd transformer or capacitor banks, to be determined at higher load level case
Not Solved		Dawson 115 Bus	C1	Consider UVLS

Table 12.2 – 100% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
Charlie Creek-Watford 230	431.8	114.2	Charlie Creek-Williston 345	B	Emergency rating = 121.8%
Williston-Williston 115	120	140.4	Williston-Mont 115	B	Ensure these proposed lines are built with adequate capacity
Williston-Stateline 115	120	128.6	Williston-Mont 115	B	Ensure these proposed lines are built with adequate capacity
Williston-Mont 115	159	108 100.9	Williston-Williston 115 Stateline-Williston 115	B B	Ensure these proposed lines are built with adequate capacity
LOGAN 7 - SWMINOT CP7115	147	110.6	Logan-Blasdell 230	B	This may be a valid limit, consider reconductor or 2nd line
WATFORD4 - CHAR.CK4 230	431.8	106.2	Charlie Creek 345 3696 breaker fail with MCDC ramp to 20MW, trips AVS-CCR #1 and CCR-Watford 230	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	112.4	Williston 345 196 breaker, trips CCR-Williston 345 and Williston 345/230	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	112.8	Williston 345 292 breaker, trips CCR-Williston 345 and Williston-Tioga 345	C2	Emergency rating = 121.8%
WATFORD4 - CHAR.CK4 230	431.8	112.4	Williston 345 192 breaker, trips CCR-Tioga 345 and Williston 345/230	C2	Emergency rating = 121.8%

Table 12.3 – 100% Load Case Thermal Loading Violations

13. 110% Load Case: Study Area Load = 2100MW, Williston Load Pocket = 1131MW Date: 2021

13.1. 110% Load Case Initial Results

The transmission additions described in Section 12 are added to this case, including the AVS-Charlie Creek-Williston-Tioga 345kV line and the 240MVAR capacitor facility at Williston. In spite of the addition of the 345kV line and the capacitor banks, the system intact voltage profile is poor across the entire study area and numerous outages do not solve.

A voltage profile heat map is provided in Figure 13.1. The heat map shows decay in profile in the southwestern portion of the study area. Problems associated with outages in this area are mitigated with the Miles City DC SPS. The remainder of the outages that do not solve are in the eastern portion of the study area.

A summary of results is provided in Table 13.1 which includes a listing of some of the unsolved outages.

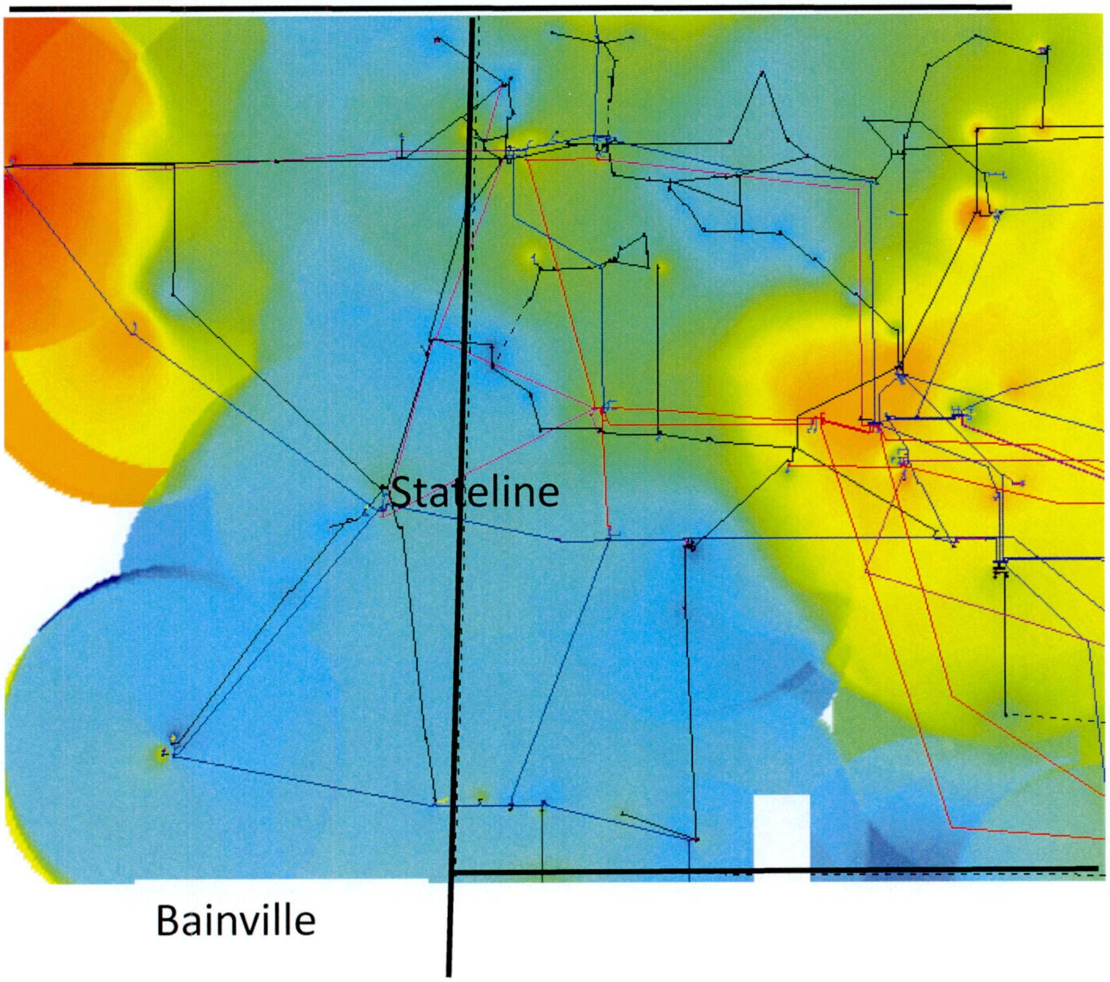

Figure 13.1: 110% Load System Intact Voltage Profile
(Scale = 0.9 to 1.1 pu voltage)

Bus	Voltage PU	Contingency	Cat	Mitigation
DKSN-ND7 115 DICKNTH7 115 KOCH 7 115 MI CTYE7 115	0.940 0.936 0.944 0.947	System Intact	A	
Not Solved		L.Olds-Logan 230 Logan-Blaisdell 230 Blaisdell-Tioga 230 Logan-SW Minot 115 Souris-Velva 115 Williston-Fairview 115 Williston-Culbertson 115 Garrison-Snake Creek 115 + Others	B	

Table 13.1 – 110% Load Case Voltage Violations
(Due to the large number of unsolved outages, the complete table is not shown)

13.2. 110% Load Case Transmission Additions

The majority of the outages in the 110% case that do not solve are located in the eastern or northern part of the study area. Therefore a Leland Olds-Logan-Tioga 345kV line will be tested. This line will complete the 345kV loop around the study area. The location is shown on Figure 13.3. The line will consist of a Leland Olds-Logan section and a Logan-Tioga section. The Logan terminal will contain a 345/230kV 400MVA transformer to allow the line to support the Logan area 230kV system. The line is modeled with the following characteristics;

Name:	Leland Olds-Logan 345kV line
Length:	90 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R=0.00319, X= 0.05629, B= 0.61566

Name:	Logan-Tioga 345kV line
Length:	90 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R=0.00319, X= 0.05629, B= 0.61566

13.3. 110% Load Case Transmission Additions Results

The system intact voltage profile heat map is provided in Figure 13.2. Comparing Figure 13.2 to 13.1 demonstrates the voltage profile improvement provided by the Leland Olds-Logan-Tioga 345kV line. A summary of results is provided in Tables 13.2 and 13.3. The system intact voltage is good except for a pocket of relatively weak voltage in the Dickinson 115kV area. The network performance is good. There are some low voltage and overloads resulting from outages of the 115kV system serving the Grenora area and the outage of the Charlie Creek 345/115kV transformer. A second Charlie Creek 345/115kV transformer or a 230/115kV transformer should be considered. This does not affect the regional network and should be looked into as a follow up analysis.

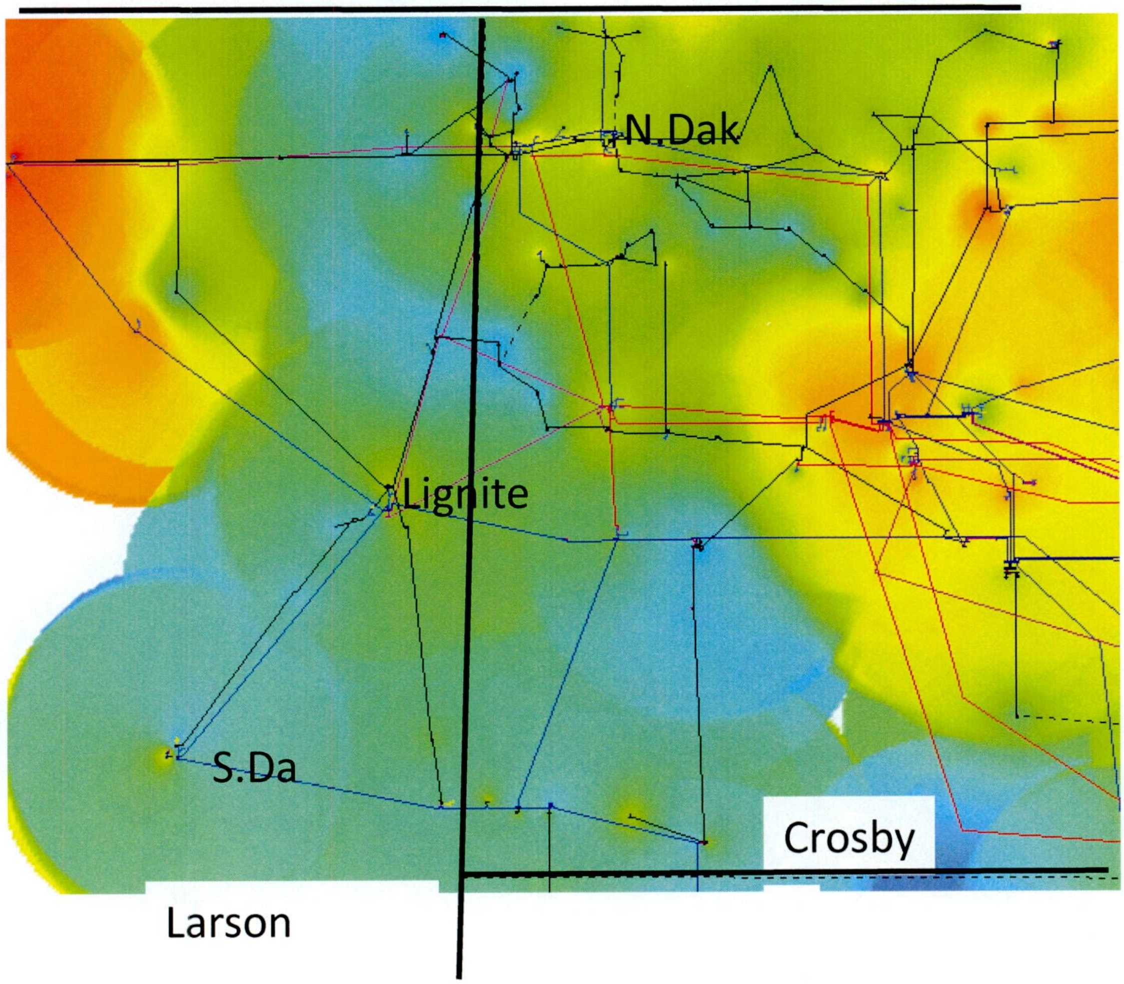

Figure 13.2: 110% Load System Intact Voltage Profile
Leland Olds-Logan-Tioga 345KV Line Added
(Scale = 0.9 to 1.1 pu voltage)

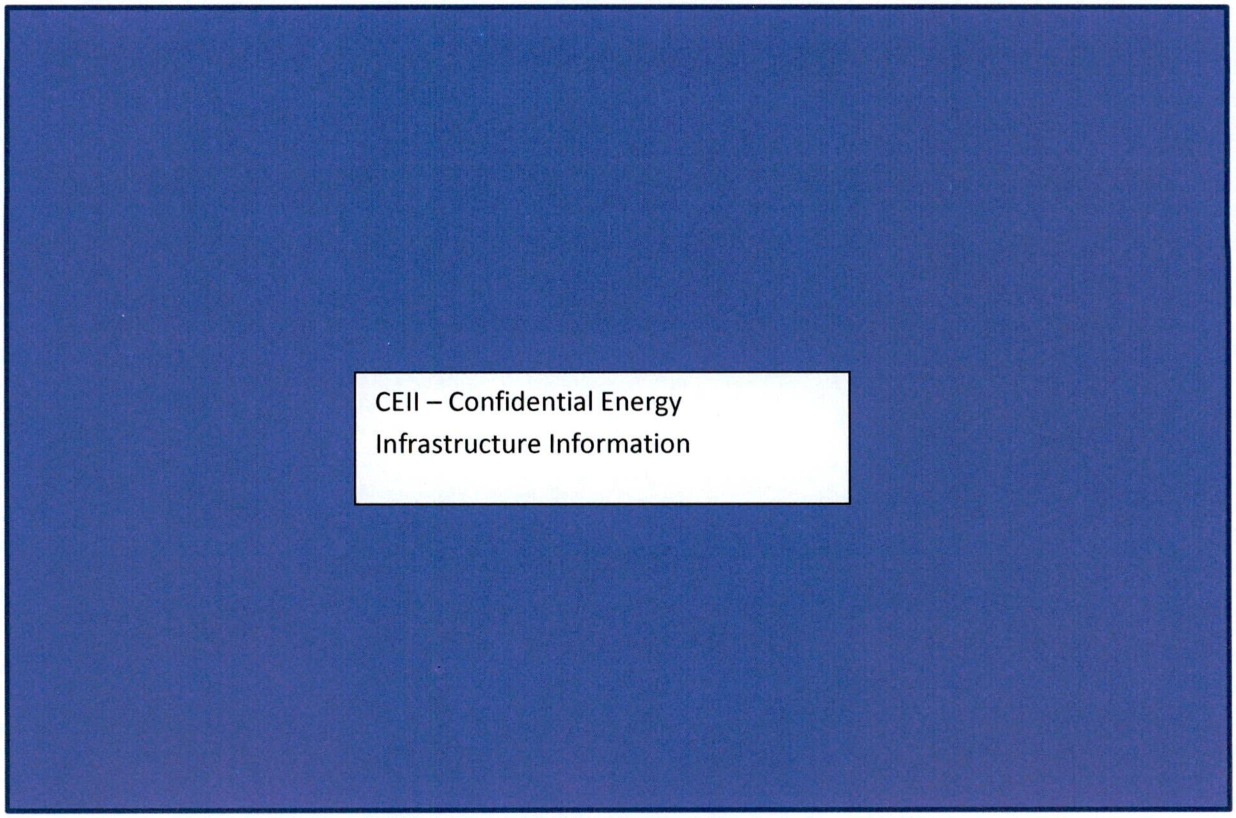

Figure 13.3: Leland Olds-Logan-Tioga 345kV line

Bus	Voltage PU	Contingency	Cat	Mitigation
DKSN-ND7 115	0.957	System Intact	A	Technically not a violation, but a weak voltage
CHAR.CK7 115 KILDEER7 115 SQUAWGP7 115 R.RIDER7 115	0.836 0.875 0.885 0.855	Charlie Creek 345/115 Transformer	B	A 2nd transformer would mitigate low voltages associated with the outage as well as the overload noted in Table 13.3
DAWSONC4 230 FALLON 7 115 + many others	0.862 0.825	Dawson-Coal Hill 230	B	Initiating MCDC runback to 20MW E-W will mitigate
FALLON 7 115	0.862	Dawson – O'Fallon 115	B	Consider adding outage to MCDC SPS
FAIRVIEW 7 115	0.884	Williston-Fairview 115	B	Consider adding caps at Squaw Gap as recommended in Keystone XL study
PLNTYWD7 115 GRENORA7 115	0.866 0.876	Bainville-Grenora 115	B	Consider additional 115kV lines into area as noted in Table 13.3
Not Solved		Dawson 115 Bus	C1	Consider modifying bus arrangement or adding UVLS
KILDEER7 115 CHAR.CK7 115 BLUEBUTT 115 + Others	0.868 0.861 0.878	Charlie Creek 345 3896 breaker fail with MCDC ramp to 20MW, trips AVS-CCR and CCR 345/115 trans	C2	A 2nd transformer would mitigate low voltages associated with the outage as well as the overload noted in Table 13.3

Table 13.2 – 110% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
Beulah-Haliday 115	140	102.1	Charlie Creek 345/115 Transformer	B	This is a valid limit. A 2nd transformer would mitigate the overload as well as mitigate low

					voltages associated with the outage, or else consider raising the line rating
Williston-Judson 115	120	160.9	Williston-Mont 115	B	This is a 192MVA flow. Consider additional 115kV lines into area
Williston-Stateline 115	120	147.7	Williston-Mont 115	B	This is a 176MVA flow. Consider additional 115kV lines into area
Williston-Mont 115	159	123.5 115.4	Williston-Judson 115 Stateline-Williston 115	B B	This is a 195MVA flow. Consider additional 115kV lines into area

Table 13.3 – 110% Load Case Thermal Loading Violations

14. 120% Load Case: Study Area Load = 2291MW, Williston Load Pocket = 1235MW Date: ~2022

14.1. 120% Load Case Initial Results

The zone 50/51 load is scaled to 120% of the base case level. This study area load in this case is 2291MW, slightly higher than the goal of 2200MW. Therefore the transmission solution identified for this case will complete this analysis. The 345kV loop as described in section 13.2 is added to the case. In spite of the 345kV addition the 120% load case has an extremely poor system intact voltage profile due to the increase in load from the previous case. The system intact case is near or in voltage collapse as many bus voltages are less than 0.70 pu. A sample of bus voltages is provided in Table 14.1. Figure 14.1 is a heat map of system intact voltages. It shows the voltage profile in the study area. The dark black lines are the Montana, North Dakota, and South Dakota state boundaries. The Bakken Area voltage is poor, but the voltage decay occurs mainly in Montana around the Dawson, Miles City, and Baker areas.

Bus	Voltage PU	Contingency	Cat	Mitigation
MI CTYE4 230	0.684	System Intact	A	
CIRCLE 7 115	0.584			
WOLFPT 7 115	0.684			
FAIRVIEW 7 115	0.736			
BAKER 7 115	0.533			
+ Many Others				

Table 14.1 – 120% Load Case Voltage Violations

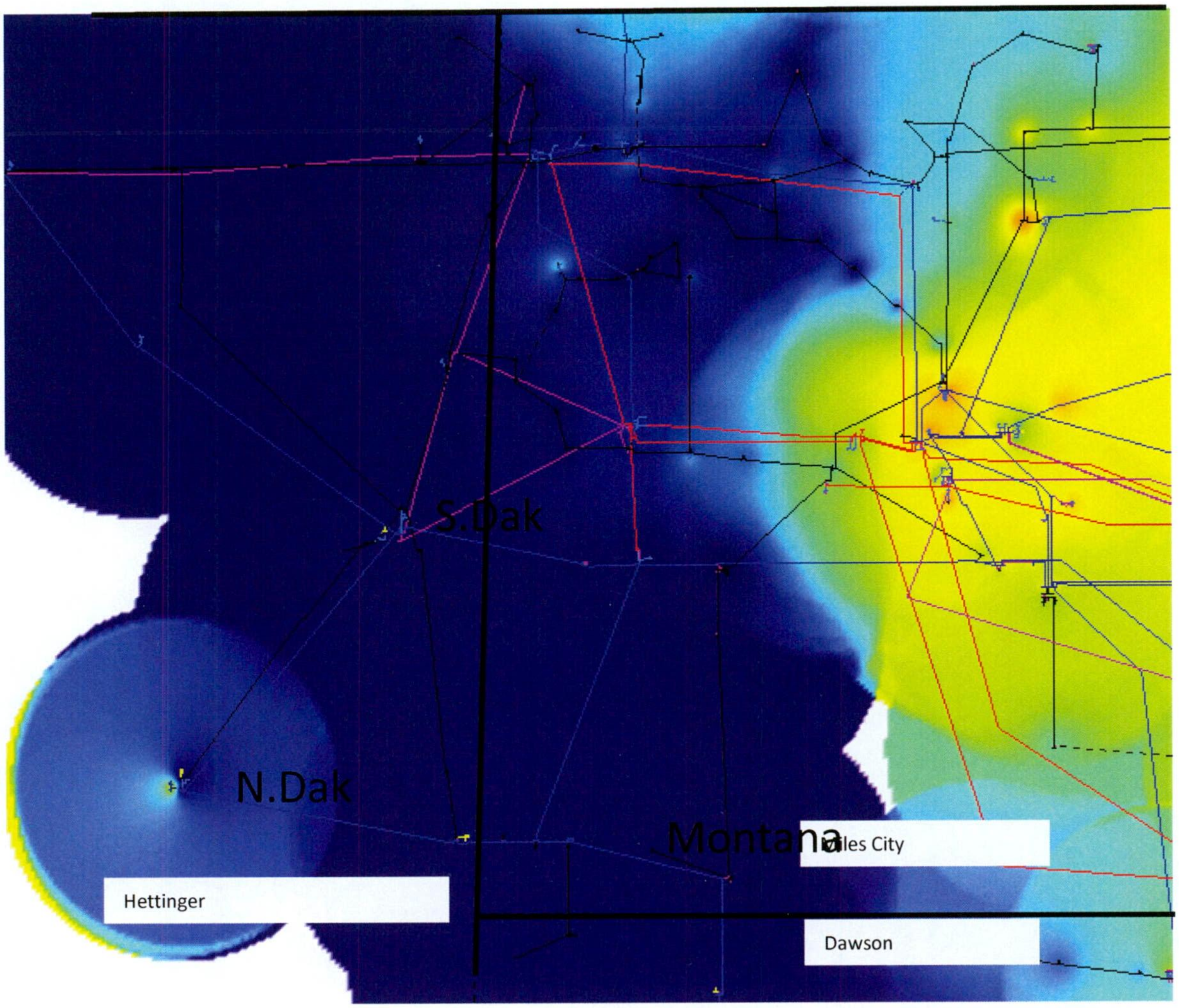

Figure 14.1: West North Dakota, East Montana System Intact Voltage Profile (Scale = 0.9 to 1.1 pu voltage)

14.2. 120% Load Case Transmission Additions

14.2.1. Charlie Creek-Dawson 345kV Line Addition Alternative

In order to support the system in eastern Montana a Charlie Creek-Dawson 345kV line is added to the 120% load case. The line will include a 345/230kV 400MVA transformer at Dawson. The line is modeled with the following characteristics;

Name:	Charlie Creek-Dawson 345V line
Length:	100 miles
Conductor:	2306mcm Joree, 3390A, 2025MVA
Impedance:	R= 0.00353 X= 0.06246 B= 0.68455

A diagram showing the location of the line is provided in Figure 14.2. A system intact voltage profile heat map is provided in Figure 14.3. The voltage profile is plotted with a scale of 0.90 to 1.1 pu. Compared to Figure 14.1, the line addition significantly improves the area system intact voltage profile.

A summary of results is provided in Tables 14.1 and 14.2. There are several minor criteria violations related to local issues and not overall network performance. The voltage profile is poor in the Grenora and Blaisdell 115kV systems. Also there are overloads on the 115kV path from Williston to Grenora.

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Figure 14.2: Charlie Creek-Dawson 345kV Line

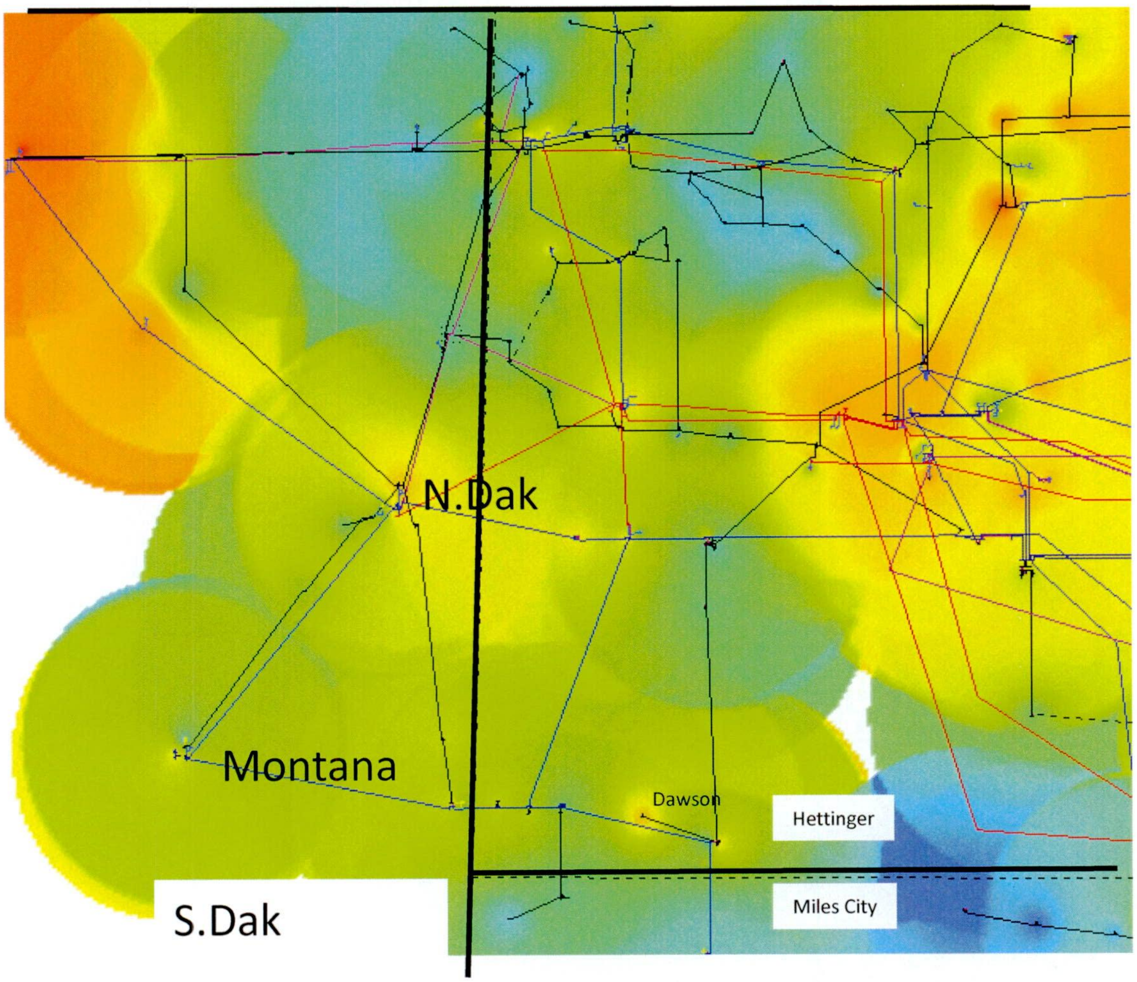

Figure 14.3: West North Dakota, East Montana System Intact Voltage Profile Charlie Creek-Dawson 345kV Line Added (Scale = 0.9 to 1.1 pu voltage)

Bus	Voltage PU	Contingency	Cat	Mitigation
PLNTYWD7 115 GRENORA7 115	0.884 0.874	Bainville-Grenora 115	B	Additional voltage support needed at Grenora
Not Solved	0.0	Charlie Creek-Dawson 345	B	MCDC 20MW Runback SPS will enable case to solve with no violations
CIRCLE 7 115 KPS12-CR7 115	0.899 0.896	Dawson-Circle 115	B	Additional voltage support needed at Circle
GRENORA7 115 PLNTYWD7 115	0.855 0.863	MONT-STRNDAHL-MW7_115	B	Additional voltage support needed at Grenora
RBNSNLAK-MW7115	0.891	BELDEN -MW – RBNSNLAK 115	B	Additional voltage support needed on the 115kV system between Logan and Tioga
STANLEY7 115	0.879	STANLEY7- TIOGA4 7_115	B	Additional voltage support needed on the 115kV system between Logan and Tioga
Not Solved	0.0	Dawson 115 Bus	C1	Consider modifying bus arrangement or adding UVLS

ROSEGLEN-CP7115 DGLASCRK-CP7115	0.898 0.898	Garrison-Snake Creek 115 & Garrison-Max 115 Double Ckt	C5	Additional voltage support needed on the 115kV system between Logan and Tioga

Table 14.1 – 120% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
WILISTN7 - JUDSON MW7115	180	109.5	WILISTN7- MONT_115	B	Consider another 115kV line into the area.
WILISTN7- MONT_115	159	126.0	WILISTN7 - JUDSON MW7115	B	Consider another 115kV line into the area.
WILLISTON 230/115 #2 WILLISTON 230/115 #1	200 200	170.5 170.5	WILLISTON 230/115 #1 WILLISTON 230/115 #2	B	Consider another 230/115 transformation in the area
LOGAN 7 - SWMINOT CP7115	147	100.8	Logan-Blaisdell 230	B	Consider a 2nd Logan-Minot SW 115kV line
WILISTN7 115 - MONT 115	159	117.1	STATELINEMW7 - JUDSON 115	B	Consider another 115kV line into the area.
LOGAN 7 - SWMINOT CP7115	147	106	BLAISDELL 230/115	B	Consider a 2nd Logan-Minot SW 115kV line

Table 14.2 – 120% Load Case Thermal Loading Violations

14.2.2. Charlie Creek-Richland, Williston-Richland-Dawson, and Williston-Wolf Point 230kV Addition Alternative

As an alternative to the Charlie Creek-Dawson 345kV line analyzed in Section 14.2.1, a 230kV build out plan is studied. Refer to the map provide in Figure 14.4. The 230kV build out consists of upgrading the existing Williston-Fort Peck 115kV line to 230kV operation, a new Williston-Richland-Dawson 230kV line, and a new Charlie Creek-Richland 230kV line. The Williston-Fort Peck upgrade has been in progress for several years. The majority of the transmission line has been upgraded to 230kV insulation. The major effort would be the upgrading of numerous taps on the line to 230kV operation.

The new line segments have the following characteristics;

CCR-Richland 230kV line:

Name:	CCR-Richland 230kV line
Length:	66 miles
Conductor:	1272mcm Bittern, 1155A, 460MVA
Impedance:	R= 0.00944 X= 0.09374 B= 0.19870
Spacing:	A=56,-11 B=66,10 C=76,-11

Williston-Richland 230kV line:

Name:	Williston-Richland 230kV line
Length:	50 miles
Conductor:	1272mcm Bittern, 1155A, 460MVA
Impedance:	R= 0.00717 X= 0.07111 B= 0.15043
Spacing:	A=56,-11 B=66,10 C=76,-11

Dawson-Richland 230kV line:

Name:	Dawson-Richland 230kV line
Length:	50 miles
Conductor:	1272mcm Bittern, 1155A, 460MVA
Impedance:	R= 0.00717 X= 0.07111 B= 0.15043
Spacing:	A=56,-11 B=66,10 C=76,-11

A system intact voltage profile heat map is provided in Figure 14.5. The voltage profile is plotted with a scale of 0.90 to 1.1 pu. Compared to Figure 14.1, the line addition significantly improves the area system intact voltage profile. The voltage profile is very similar to the Charlie Creek-Dawson 345kV line alternative described in Section 14.2.1.

A summary of results is provided in Tables 14.3 and 14.4. There are several minor criteria violations related to local issue and not overall network performance. There are several minor criteria violations related to local issues and not overall network performance. The voltage profile is poor in the Grenora and Blaisdell 115kV systems. Also there are overloads on the 115kV path from Williston to Grenora. The results indicate that system performance at the 120% load level is similar to the Charlie Creek-Dawson 345kV line alternative described in Section 14.2.1.

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Figure 14.4: Charlie Creek-Richland, Williston-Richland-Dawson, and Williston-Ft Peck 230kV Addition Alternative

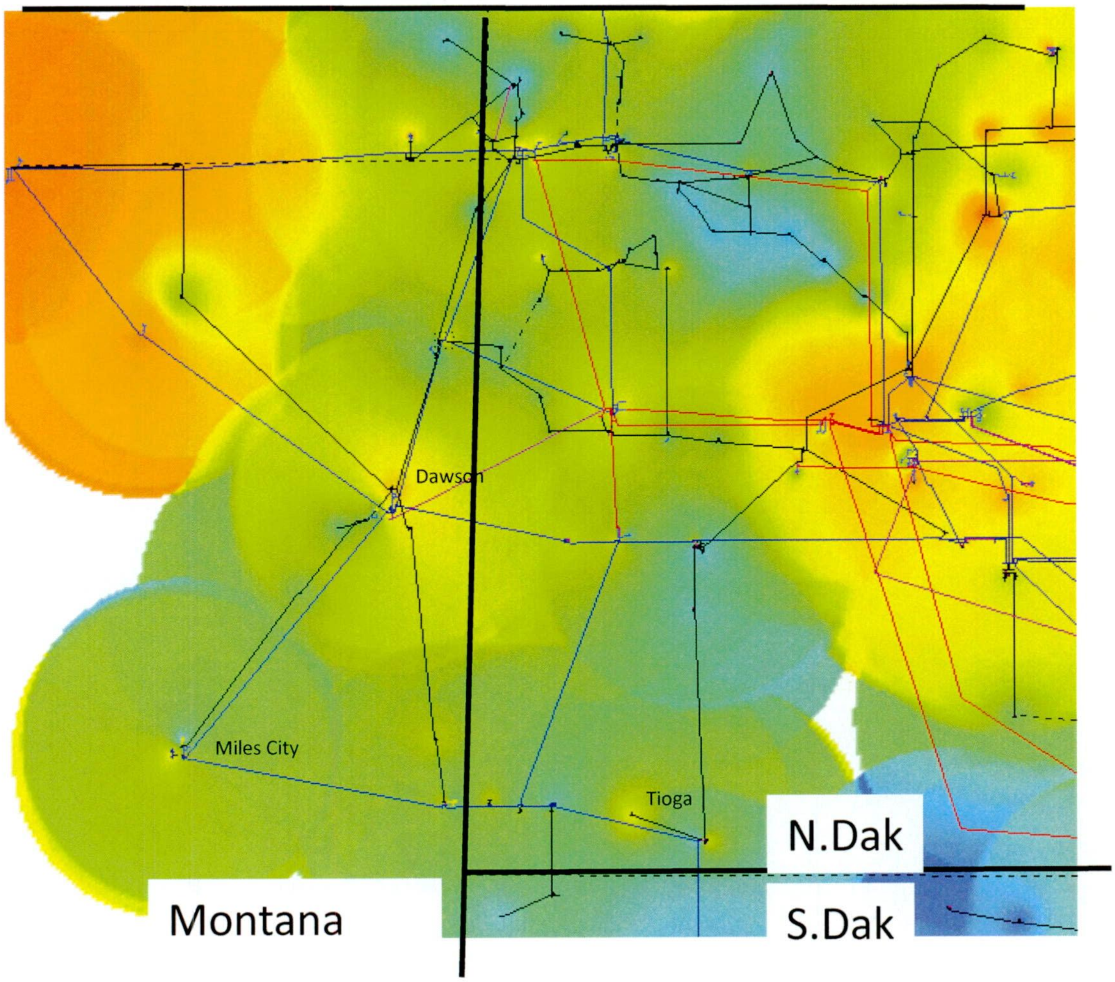

Figure 14.5: West North Dakota, East Montana System Intact Voltage Profile Charlie Creek-Richland, Williston-Richland-Dawson, and Williston-Ft Peck 230kV Addition Alternative (Scale = 0.9 to 1.1 pu voltage)

Bus	Voltage PU	Contingency	Cat	Mitigation
PLNTYWD7 115 GRENORA7 115	0.898 0.887	Bainville-Grenora 115	B	Additional voltage support needed at Grenora
FALLON 115 KPS13-OF7 115	0.892 0.883	Dawson-Fallon115	B	Additional voltage support needed at O'Fallon
RBNSNLAK-MW7115	0.891	BELDEN -MW – RBNSNLAK 115	B	Additional voltage support needed on the 115kV system between Logan and Tioga
STANLEY7 115	0.879	STANLEY7- TIOGA4 7_115	B	Additional voltage support needed on the 115kV system between Logan and Tioga
Not Solved	0.0	Dawson 115 Bus	C1	Consider modifying bus arrangement of adding UVLS
ROSEGLEN-CP7115 DGLASCRK-CP7115	0.898 0.898	Garrison-Snake Creek 115 & Garrison-Max 115 Double Ckt	C5	Additional voltage support needed on the 115kV system between Logan and Tioga

Table 14.3 – 120% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
LOGAN 7 - SWMINOT CP7115	147	100.8	Logan-Blaisdell 230	B	Consider a 2nd Logan-Minot SW 115kV line
WILISTN7 115 - MONT 115	159	117.1	STATELINEMW7 - JUDSON 115	B	Consider another 115kV line into the area.
LOGAN 7 - SWMINOT CP7115	147	105.9	BLAISDELL 230/115	B	Consider a 2nd Logan-Minot SW 115kV line

Table 14.4 – 120% Load Case Thermal Loading Violations

14.2.3. Additional Reactive Support Alternative

The voltage profile map provided in Figure 14.1 demonstrates an extremely poor voltage profile in the western and southern portions of the study area. Also there is heavy power flow on the 230kV line from New Underwood to Hettinger that is causing low voltage in the southern portion of the study area. Preliminary analysis indicates that additional reactive support at Dawson, Maurine, and Hettinger is helpful and may be an alternative to the transmission line additions options described in Sections 14.2.1 and 14.2.2.

The Dawson 115kV bus presently has 36MVARS (2 x 18) and the Hettinger 115kV bus has 30MVAR (2 x 15) of capacitors. There are 30MVARS (2 x 15) of capacitors proposed at the Maurine 115kV bus as part of the Keystone XL project. The 120% case described in section 14.1 will be studied. The most severe category B outages are loss of the proposed Charlie Creek-Williston 345kV line, the proposed Leland Olds-Logan 345kV line, or the existing Maurine-Bison 230kV line. These lines will be individually taken out of service and the resulting MVAR output of the Dawson, Hettinger, and Maurine capacitor banks will be monitored. The highest MVAR output at each site is used in the contingency analysis to size the proposed capacitor banks.

	MVAR Injection		
Outage	Dawson 115	Hettinger 115	Maurine 115
CCR-Williston 345kV	57	45	73
L.Olds-Logan 345kV	60	50	81
Maurine-Bison 230kV	88	68	0

Table 14.5 – MVAR Requirements

The 115kV capacitor banks in this area are typically sized in 15MVAR increments. Adding these increments in amounts to provide at least the total required MVAR listed in Table 14.5 results in the additions described below.

Location	Existing	Proposed		Total
Dawson 115kV	38MVAR	60MVAR (4 x 15)	=	98MVAR
Maurine 115kV	30MVAR	60MVAR (4 x 15)	=	90MVAR
Hettinger 115kV	30MVAR	45MVAR (3 x 15)	=	75MVAR

These capacitors are added to the 120% load case and the contingency analysis is run.

A system intact voltage profile heat map is provided in Figure 14.6. The voltage profile is plotted with a scale of 0.90 to 1.1 pu. Compared to Figure 14.1, the line addition significantly improves the area system intact voltage profile. The voltage profile is very similar to the line addition alternatives described in Section 14.2.1 and 14.2.2.

A summary of results is provided in Tables 14.6 and 14.7. There are several minor criteria violations related to local issue and not overall network performance. The results indicate that system performance at the 120% load level is similar to the line addition alternatives described in Section 14.2.1 and 14.2.2.

There are three pockets of poor voltage, the Grenora/Plentywood area, the 115kV system south of Blaisdell, and the Dawson 115kV area. The Blaisdel area low voltage could be mitigated by additional capacitor support. The Grenora area would benefit from additional capacitor support, but there are also 115kV line overloads reported in Table 14.7. Also the Williston 230/115kV transformers are reported as a system intact overload. Therefore further study is required to determine if additional 230/115kV support from another location such as Larson or Wheelock would mitigate the transformer and line overloads and the Grenora area low voltages. The Dawson 115kV area low voltages occur at Circle and O'Fallon for loss of the 115kV lines connecting to Dawson and could be mitigated with additional capacitors.

Bus	Voltage PU	Contingency	Cat	Mitigation
GRENORA7 115 ENEWTWN -MW7115 MAKOTI -CP7115	0.957 0.957 0.954	System Intact	A	Additional voltage support needed on the 115kV system between Logan and Tioga and also the Grenora area
GRENORA7 115 FLATLAKE-SH7115 PLNTYWD7 115	0.857 0.848 0.866	BAINVILLE- GRENORA7_115	B	Additional voltage support needed on the Grenora area 115kV system
CIRCLE 7 115	0.875	CIRCLE115-DAWSONC7_115	B	Additional voltage support needed at Circle 115kV bus
FALLON 7 115 MI CTYE7 115	0.833 0.896	DAWSONC-FALLON115	B	Additional voltage support needed at O'Fallon 115kV bus
GLENDCT7 115 BAKER 7 115	0.818 0.879	DAWSONC-GLENDCT115	B	Additional voltage support needed at Glendive 115kV bus
ROSEGLEN-CP7115 DGLASCRK-CP7115	0.889 0.890	GARRISN7-SNAKECRK115	B	Additional voltage support needed on the Blaisdell area 115kV system
GRENORA7 115 PLNTYWD7 115	0.832 0.838	MONT - STRNDAHL115	B	Additional voltage support needed on the Grenora area 115kV system
RBNSNLAK-MW7115 FINSTAD -MW7115	0.883 0.891	BELDEN-RBNSNLAK115	B	Additional voltage support needed on the Blaisdell area 115kV system
STANLEY7 115	0.870	STANLEY7115-TIOGA4115	B	Additional voltage support needed on the Stanley/Kenmare area 115kV system
ENEWTWN -MW7115	0.893	BLAISDELL 230/115	B	Additional voltage support needed on the Blaisdell area 115kV system

Table 14.6 – 120% Load Case Voltage Violations

Circuit	Rating	% Loading	Contingency	Cat	Mitigation
Williston 230/115 #1 Williston 230/115 #2	200 200	107.5 107.5	System Intact	A	Consider another 230/115kV connection into the system
BAKER 230/115	100	121.7	DAWSONC7-GLENDCT7_115	B	Consider a 2nd transformer
WILISTN7-JUDSON115 STATELINEMW7115 - JUDSON MW7115	180 180	119.4 109.6	WILISTN7 - MONT_115	B	Consider another 115kV line into the area.
WILISTN7 - MONT_115	159	136.7	WILISTN7_115 - JUDSON	B	Consider another 115kV line into the area.
LOGAN - SWMINOT CP7115	108	147	BLAISDELL 230/115	B	Consider a 2nd transformer

Table 14.7 – 120% Load Case Thermal Loading Violations

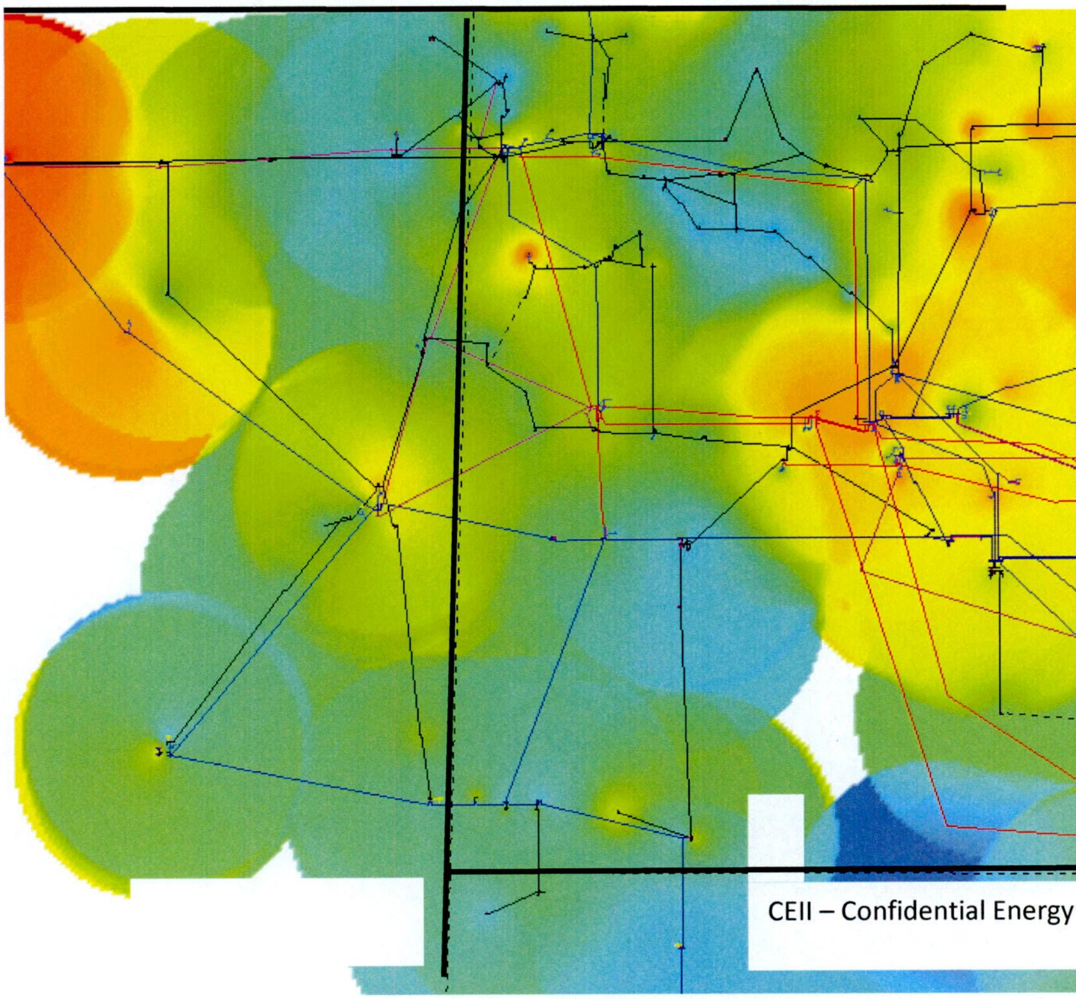

Figure 14.6: West North Dakota, East Montana System Intact Voltage Profile
Additional Reactive Support Alternative
(Scale = 0.9 to 1.1 pu voltage)

15. Voltage Stability Results

The voltage stability analysis consists of PV curves created for each of the major additions described in the previous sections. The procedure to create the PV curves by scaling the load in the entire Bakken Study Area. The following outages are each studied; Charlie Creek-Williston 345kV Line, Charlie Creek-Watford 230KV Line, Leland Olds-Logan 230KV Line, and Leland Olds-Logan 345KV Line. The curves are plotted on Figure 15.1 and a summary of results are provided in Table 15.1.

Figure 15.2 plots the voltage stability limits onto the Bakken area load forecast with the anticipated in service dates of each addition. The graph of the limits with the load forecasts provides a time line of when each addition should be placed in service.

Transmission Additions	Nose Point MW	Limit with 5% Margin MW
Base Case	1552	1474
AVS-CCR-Williston-Tioga 345KV Line	1823	1731
AVS-CCR-Williston-Tioga 345KV Line 240MVAR Caps at Williston	1980	1881
345KV Loop 240MVAR Caps at Williston	2113	2007
345KV Loop 240MVAR Caps at Williston 230KV MT Build Out	2397	2277
345KV Loop 240MVAR Caps at Williston CCR-Dawson 345kV Line	2387	2267
345KV Loop 240MVAR Caps at Williston Additional Caps at Dawson, Hettinger, and Maurine	2376	2257

Table 15.1 – PV Analysis Results Summary

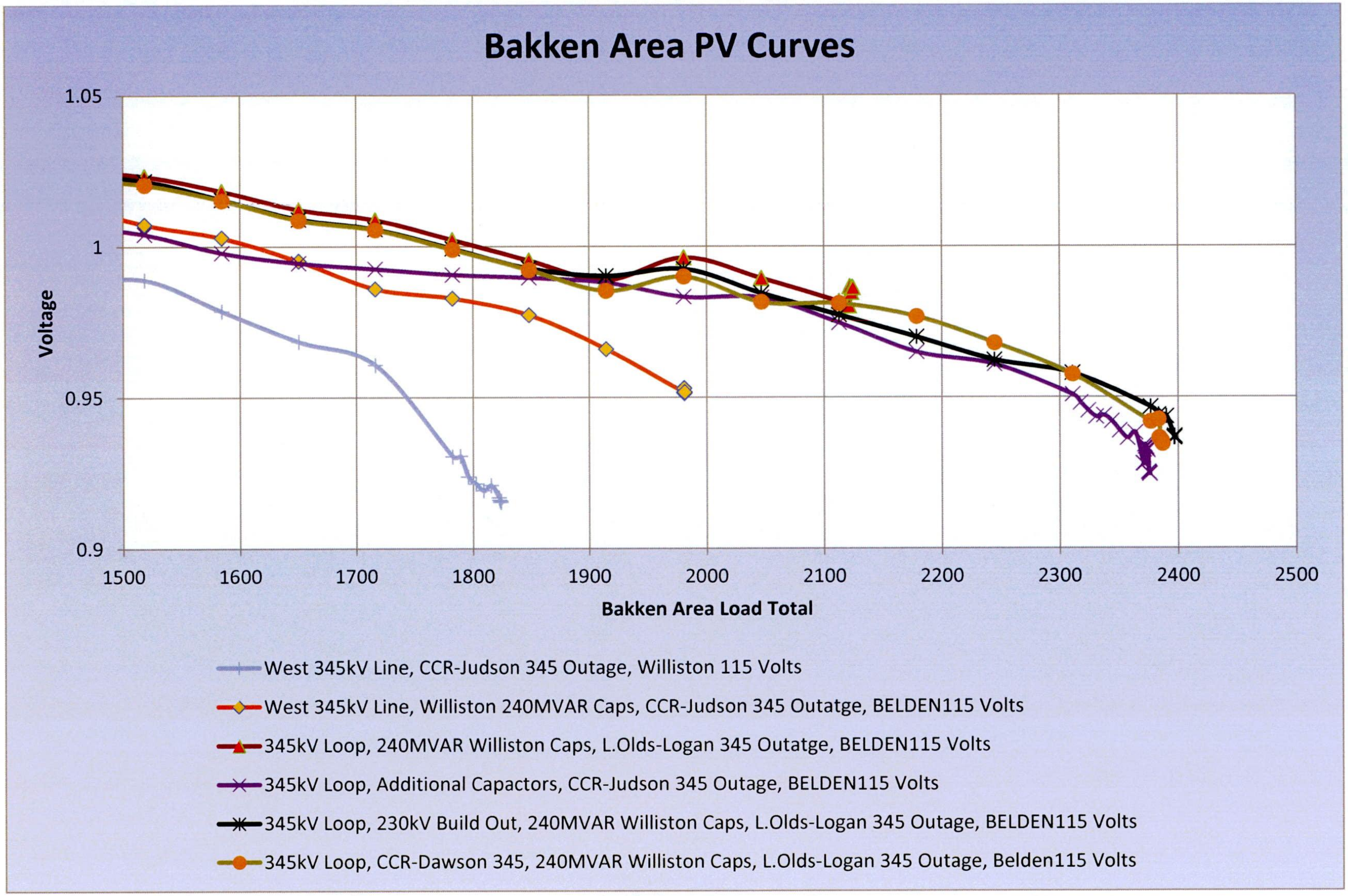
Bakken Area PV Curves
1.05
1
0.95
0.9
Voltage
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
Bakken Area Load Total
West 345kV Line, CCR-Judson 345 Outage, Williston 115 Volts
West 345kV Line, Williston 240MVAR Caps, CCR-Judson 345 Outatge, BELDEN115 Volts
345kV Loop, 240MVAR Williston Caps, L.Olds-Logan 345 Outatge, BELDEN115 Volts
345kV Loop, Additional Capactors, CCR-Judson 345 Outage, BELDEN115 Volts
345kV Loop, 230kV Build Out, 240MVAR Williston Caps, L.Olds-Logan 345 Outage, BELDEN115 Volts
345kV Loop, CCR-Dawson 345, 240MVAR Williston Caps, L.Olds-Logan 345 Outage, Belden115 Volts

Figure 15.1

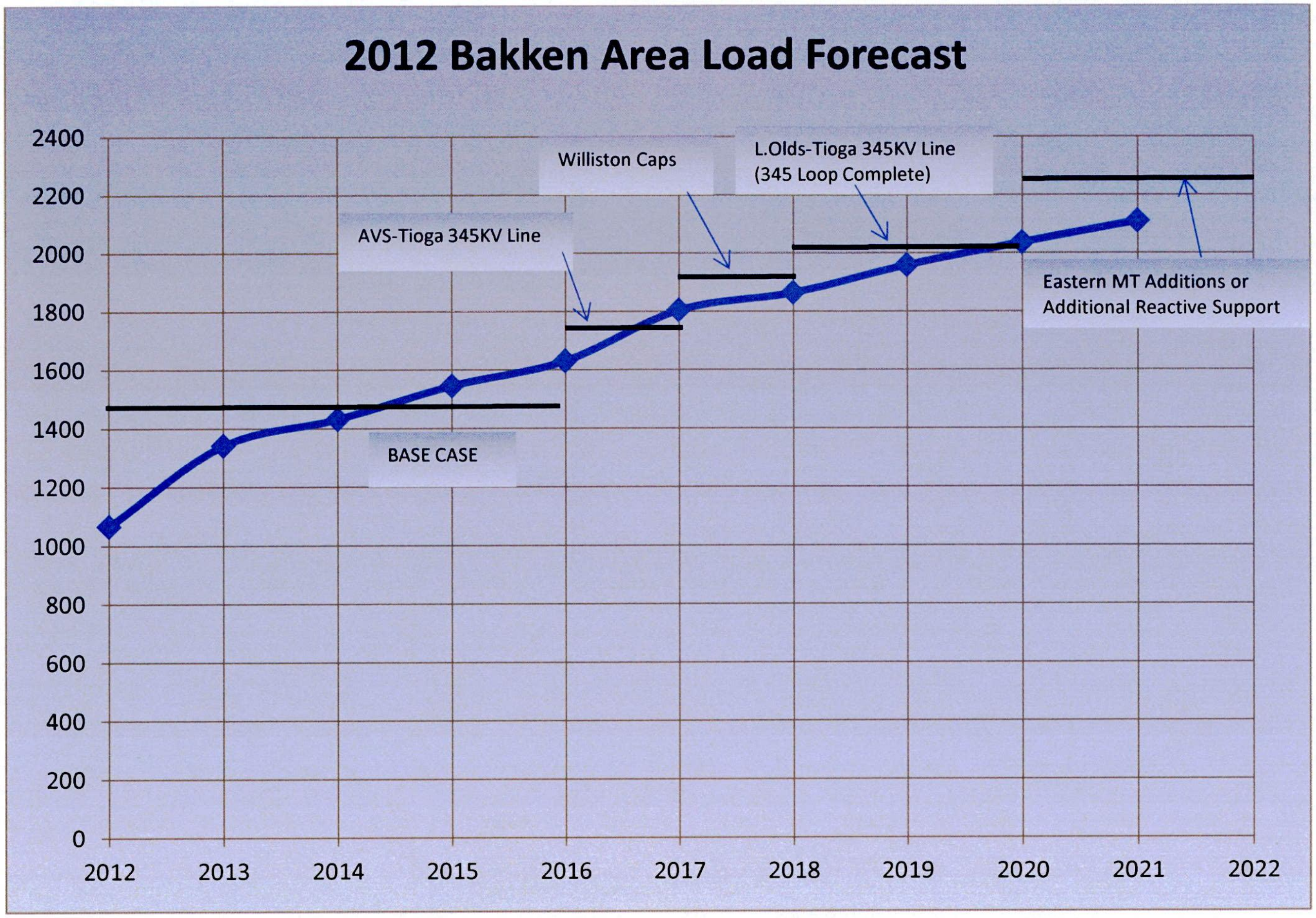

Figure 15.2: Voltage Stability Limits (5% Margin) and Load Forecast

16. Summary of Results

The required facilities and approximate required in service dates are listed below. This scheduling is derived from the voltage stability results in Section 15 and Figure 15.2 in particular as well as the results in the steady state analysis. The analysis shows the need for sections of the 345kV additions to be placed in service prior to 2016. However the earliest the line or any section can be placed into service is likely 2016. Any transmission limitations will have to be made up by operating actions such as running generation, restricting transfers, or restricting load.

2013:

- Mandan-Dickinson-Belfield 230kV Line - increase rating to 398MVA conductor rating
- Bottineau area improvements are needed when area load exceeds 65MW (see Section 8.4)

2015:

- 2nd Dickinson 230/115kV transformer and eliminate 230kV bus outage issue

2016:

- AVS-Charlie Creek-Williston-Tioga 345kV Line
  - (also, address Williston 345kV breaker 292 failure outage)
  - The earliest the AVS-Williston-Tioga 345kV line can be placed in service is 2016
- Larson 230/115kV Substation
- Culbertson-Bainville 115kV Line (assumes Stateline-Bainville-Grenora 115kV in service)

2017:

- Williston 230kV bus capacitor addition, 3 x 80MVAR
- Reconductor Logan-Minot SW 115kV Line to increase rating to 180MVA
- Dawson 115kV bus, sectionalize main bus or implement UVLS

2018:

- Leland Olds-Logan-Tioga 345kV Line

2020:

- Addition of a 2nd Charlie Creek 345/115kV transformer or a 230/115kV transformer
- One of the following three options works well;
  - Additional Reactive Support, Dawson 115kV = 98MVAR, Maurine 115kV = 90MVAR, Hettinger 115kV = 75MVAR
  - Charlie Creek-Dawson 345kV Line
  - Or "230kV Build Out" which consists of upgrading the existing Williston-Fort Peck 115kV Line to 230kV operation, a new Williston-Richland-Dawson 230kV Line, and a new Charlie Creek-Richland 230kV Line.

Appendix A: Outage List

1	LOGAN_345 - LELANDO3_345
2	LOGAN_345 - LOGAN 4_230
3	LOGAN_345 - TANDE 3_345
4	LOG-TIOGA 345 CAPS ON
5	BDV 4_230 - LARSON_230
6	TIOGA4 4_230 - LARSON_230
7	LARSON_230 - LARSON 7_115
8	CHAR.CK3_345 - JUDSON 3_345
9	CR-JUD 345 CAPS ON
10	CCR-JUD 345, (SOL)
11	CCR-JUD 345, MCDC=20
12	JUDSON 3_345 - TANDE
13	TANDE 4_230 - NESET 4_23
14	JUDSON 4_230 - WILISTN4_23
15	JUDSON 345/230 TRANS
16	JUD-WIL 230 CAPS ON
17	JUD-WIL 230 (SOL)
18	BLAISDELL 7_115 - BTHOLD 7_115
19	BISMARK4_230 - WARD 4_230
20	BISMARK4_230 - JAMESTN4_230
21	BAINVILLE_115 - GRENORA7_115
22	MAKOTI -CP7_115 - ROSEGLEN-CP
23	BAINVILLE_115-STATELINEMW7_115
24	DAWSON_345 - CHAR.CK3_345
25	CCR-DAWSON345 (SOL)
26	CCR-DAWSON345 MCDC20 (SOL)
27	DAWSON_345 - JUDSON 3_345
28	BAINVILLE_115 - CLBRTSN7_115
29	BISMARK4_230 - WASHBRN4_230
30	WHITBY_230 - LOGAN 4_230
31	BISMARK4_230 - HILKEN 4_230
32	LOGAN 7_115 - WHITBY -CP7_115
33	BISMARK4_230 - WEBER 4_230
34	BISMARK4_230 - GLENHAM4_230
35	CLBRTSN7_115 - GRENORA7_115
36	WATFORD4_230 - WATFORD7_115
37	FTPECK 4_230 - FTPECK 7_115
38	DICKNSN4_230 - DKSN-ND7_115
39	BELFELD4_230 - BELFIELDY_345
40	BELFELD4_230 - BELFIELD 7_115
41	GARRISN4_230 - GARRISN7_115
42	BASIN 7_115 - BASIN TY_230
43	LOGAN 7_115 - LOGAN TY_230
44	CHAR.CK7_115 - CHARCKTY_345
45	MANDAN 4_230 - MANDAN 7_115
46	LEWIS71G_14 - LEWIS 7_115
47	LEWIS&CLARK GEN
48	LOGAN 7_115 - RUTHVILLECP7_11
49	MERRCRT4_230 - MERRICRTCL 9_35
50	REDRIVR7_115 - NOTFOUND
51	SOURIS 7_115 - MALLARD7_115
52	SOURIS 7_115 - VELVA TAP_115
53	MALLARD7_115 - NELSON 7_115
54	MALLARD7_115 - RUGBY 7_115
55	MALLARD7_115 - LOGAN 7_115
56	MALLARD7_115 - RUTHVILLECP7_11
57	GRE-STANTON4_230 - ELANDO4_230
58	JAMESTN3_345 - CENTER 3_345
59	RUGBY 4_230 - GLENBOR4_230
60	WAYSIDE4_230 - NUNDRWD4_230
61	WAYSIDE4_230 - STEGALL4_230
62	COALHILL4_230 - DAWSONC4_230
63	C.HILL-DAWSON230 (SOL)
64	C.HILL-DAWSON230 MCDC=20(SOL)
65	COALHILL4_230 - FTPECK 4_230
66	C.HILL-FT.PECK230 (SOL)
67	C.HILL-FT.PECK230 MCDC=20(SOL)
68	WATFORD4_230 - WILISTN4_230
69	WATFORD4_230 - CHAR.CK4_230
70	WATF-CCR 230, MCDC=20
71	WATF-CCR 230, MCDC=20 SOL
72	WATF-CCR 230, MCDC=20, LD=75
73	WATF-CCR 230, MCDC=20, LD=50
74	ROLLA 7_115 - AGATE 7_115
75	WILISTN4_230 - WHEELOCK 4_23
76	CIRCLE 7_115 - DAWSONC7_115
77	CIRCLE 7_115 - WOLFPT 7_115
78	MI CTYW4_230 - MT WEST4_230
79	DAWSONC4_230 - MI CTYE4_230
80	DAWSON-MCDC 230, MCDC=20
81	DAWSONC4_230 - MEDORA 4_230
82	DAWSON-MEDORA 230, MCDC=20
83	DAWSONC7_115 - FALLON 7_115
84	DAWSON-FALLON115 (SOL)
85	DAWSONC7_115 - GLENDCT7_115
86	DAWSON-GLENDCT7115 (SOL)
87	DAWSONC7_115 - LEWIS 7_115
88	FTPECK 7_115 - WOLFPT 7_115
89	FTPECK 7_115 - WOLFPT 7_115
90	WATFORD7_115 - CHRRYCRK-MK7_115
91	WATFORD7_115 - GARDENCK-MK7_115
92	WATFORD7_115 - BLUBTETP-MK7_115
93	WOLFPT 7_115 - POPLAR 7_115
94	MI CTYE4_230 - BAKER 4_230

95	MC-BAKER 230, MCDC=20
96	MEDORA 4_230 - BELFELD4_230
97	MEDORA-BELFIELD 230, MCDC=20
98	DICKNSN4_230 - BELFELD4_230
99	DKSN-BELFIELD 230, MCDC=20
100	DICKNSN4_230 - MANDAN 4_230
101	DKSN-ND7_115 - DICKSWH7_115
102	DKSN-ND7_115 - N ENGLN7_115
103	KILDEER7_115 - HALIDAY7_115
104	KILDEER7_115 - CHAR.CK7_115
105	WILISTN7_115 - FAIRVIEW 7_115
106	WILISTN7_115 - MONT_115
107	WILISTN7_115 - JUDSON MW7_115
108	WILISTN7_115 - TRENTON -LY7_115
109	WILISTN7_115 - CLBRTSN7_115
110	WIL-CULB 115 (SOL)
111	WILISTN7_115 - TIOGA7 7_115
112	HALIDAY7_115 - BEULAH 7_115
113	BELFELD3_345 - CHAR.CK3_345
114	BELFIELD-CCR 345, MCDC=20
115	BELFELD4_230 - RHAME 4_230
116	BELFIELD-RHAME 230, MCDC=20
117	NELSON 7_115 - MAX 7_115
118	NELSON 7_115 - NDPRAIRWND 7_115
119	GARRISN4_230 - JAMESTN4_230
120	GARRISN4_230 - HILKEN 4_230
121	GARRISN4_230 - LELANDO4_230
122	GARRISN7_115 - MAX 7_115
123	GARRISN7_115 - SNAKECRKPMP7_115
124	GAR-S.CREEK 115 CAPS,
125	GARRISN7_115 - VOLTAIR7_115
126	GARRISN7_115 - BEULAH 7_115
127	PLEASANT LK7_115 - LEEDS 7_115
128	PLEASANT LK7_115 - RUGBY 7_115
129	LEEDS 7_115 - PENN 7_115
130	RICHLND7_115 - FAIRVIEW 7_115
131	RICHLND7_115 - KOCH 7_115
132	RICHLND7_115 - LEWIS 7_115
133	RUGBY 7_115 - TOWNER 7_115
134	RUGBY 7_115 - RUGBCPC7_115
135	TOWNER 7_115 - DENBIGH TAP7_115
136	TOWNER 7_115 - BOTTNOJCTCP7_115
137	BOTTNO 7_115 - BOTTNOJCTCP7_115
138	WASHBRN4_230 - LELANDO4_230
139	BISON 4_230 - MAURINE4_230
140	BISON 4_230 - HETINGR4_230
141	NUNDRWD4_230 - PHILTAP4_230
142	NUNDRWD4_230 - MAURINE4_230
143	NUNDRWD7_115 - WICKSVL7_115
144	ANTELOP3_345 - LELANDO3_345
145	ANTELOP3_345 - LELANDO3_345
146	ANTELOP3_345 - BRDLAND3_345
147	ANTELOP3_345 - CHAR.CK3_345
148	ANT-CCR 345, MCDC=20
149	ANT-CCR 345, MCDC=20 (SOL)
150	LELANDO3_345 - GROTON 3_345
151	LELANDO4_230 - LOGAN 4_230
152	LO-LOG 230 CAPS ON
153	LO-LOG 230 (SOL)
154	LOGAN 4_230 - BLAISDELL 4_2
155	LOG-BLAIS 230 CAPS ON
156	LOG-BLAIS 230 (SOL)
157	NESET 4_230 - TIOGA4 4_230
158	NESET 7_115 - PVALLEY -MW7_115
159	NESET 7_115 - HESS GAS-MW7_115
160	NESET 7_115 - HESS GAS-MW7_115
161	NESET 7_115 - LINDAHLS-MW7_115
162	NESET 7_115 - TIOGA4 7_115
163	BLAISDELL 4_230 - TIOGA4 4_2
164	BLAISDELL 7_115 - PALERMO -M
165	GRENORA7_115 - STRNDAHL-MW7_115
166	GRENORA7_115 - FLATLAKE-SH7_115
167	GRENORA7_115 - PLNTYWD7_115
168	THORNE CP7_115 - ROLETTE7_115
169	LOGAN 7_115 - SWMINOT CP7_115
170	RUTHVILLECP7_115 - DUNNING7_115
171	BALTA 7_115 - RUGBYNP7_115
172	RUGBYNP7_115 - RUGBCPC7_115
173	KOCH 7_115 - SQUAWGP7_115
174	BICNTNL7_115 - R.RIDER7_115
175	BICNTNL7_115 - SQUAWGP7_115
176	CHAR.CK7_115 - R.RIDER7_115
177	SQUAWGP7_115 - TRUEOIL -MK7_115
178	BTHOLD 7_115 - SWMINOT CP7_115
179	BTHOLD 7_115 - KENASTON 7_115
180	LTLMISS4_230 - RHAME 4_230
181	L.MISS-RHAME 230, MCDC=20
182	LTLMISS4_230 - BAKER 4_230
183	L.MISS-BAKER 230, MCDC=20
184	RHAME 4_230 - BOWMAN 4_230
185	CLBRTSONGEN7_115 - CLBRTSN7_115
186	KENASTON 7_115 - KENMARE7_115
187	MONT_115 - STRNDAHL-MW7_115
188	MONT_115 - STATELINEMW7_115
189	WHEELOCK 4_230 - TIOGA4 4_2
190	LARSON 7_115 - NORMANLK-B
191	LARSON 7_115 - LIGNITE -B
192	LARSON 7_115 - CROSBY -B

193 PVALLEY -MW7_115 - ROSS -M
194 PVALLEY -MW7_115 - HESS GAS-M
195 ROSS -MW7_115 - BELDEN -M
196 BELDEN -MW7_115 - RBNSNLAK-M
197 BELDEN -MW7_115 - STANLEY -M
198 RBNSNLAK-MW7_115 - FINSTAD -M
199 FINSTAD -MW7_115 - ENEWTWN -M
200 ENEWTWN -MW7_115 - PARSHALL-M
201 LINDAHLS-MW7_115 - SIMPSON -M
202 LINDAHLS-MW7_115 - NORMANLK-B
203 PALERMO -MW7_115 - STANLEY -M
204 STANLEY -MW7_115 - LOSTWOOD-M
205 STATELINEMW7_115 - JUDSON M
206 CHRRYCRK-MK7_115 - ARNEGARD-M
207 ARNEGARD-MK7_115 - HAYBUTTE-M
208 HAYBUTTE-MK7_115 - TRUEOIL -M
209 GARDENCK-MK7_115 - BANKS -M
210 BANKS -MK7_115 - SWENSON -M
211 SWENSON -MK7_115 - KEENE -M
212 KEENE -MK7_115 - BLUBTETP-M
213 BAKER 7_115 - CABINCR7_115
214 BEULAH 7_115 - COYOTE 7_115
215 BEULAH 7_115 - MANDAN 7_115
216 BOWMAN 4_230 - HETINGR4_230
217 BOWMAN-HETTINGER 230, MCDC=20
218 CLBRTSN7_115 - POPLAR 7_115
219 COYOTE 7_115 - DICKSWH7_115
220 DICKSWH7_115 - DICKNTH7_115
221 HETINGR7_115 - GASCOYN7_115
222 HETINGR7_115 - N ENGLN7_115
223 KENMARE7_115 - STANLEY7_115
224 MANDAN 7_115 - MANDANW7_115
225 MANDANS7_115 - MANDANW7_115
226 MANDANS7_115 - MIDWAY 7_115
227 STANLEY7_115 - TIOGA4 7_115
228 TIOGA4 4_230 - BDV 4_230
229 TIOGA4 7_115 - TIOGA7 7_115
230 RUGBY 4_230 - RUGBOTP7_115
231 WAYSIDE7_115 - WAYSIDE4_230
232 WILISTN4_230 - WILISTN7_115
233 DAWSONC4_230 - DAWSONC7_115
234 FALLON 7_115 - FALLON 8_69
235 MI CTYE4_230 - MI CTYE7_115
236 BELFELD3_345 - BELFELD4_230
237 LELANDO3_345 - LELANDO4_230
238 LELANDO3_345 - LELANDO4_230
239 BRDLAND3_345 - BRDLAND4_230
240 BRDLAND3_345 - BRDLAND4_230
241 NESET 4_230 - NESET 7_115
242 BLAISDELL 4_230 - BLAISDELL
243 CHAR.CK3_345 - CHAR.CK4_230
244 CHAR.CK3_345 - CHAR.CK4_230
245 WHEELOCK 4_230 - WHEELOCK
246 BAKER 4_230 - BAKER 7_115
247 COYOTE 3_345 - COYOTE 7_115
248 HESKETT4_230 - HESKETT7_115
249 HETINGR4_230 - HETINGR7_115
250 TIOGA4 4_230 - TIOGA4 7_115
251 WISHEK 4_230 - WISHEK 7_115
252 LO230 BUS
253 LO230 BUS;MC=20
254 CULBERTSON
255 LEWIS&CLARK (SOL)
256 DICKINSON230C1
257 DICKINSON115C1
258 DAWSON230C1
259 RUBGY115C1
260 RICH115C1
261 LEWIS115C1
262 WILLISTN115C1
263 GARRISON115C1
264 MALLARD#1115C1
265 MALLARD#2115C1
266 BEULAH115C1
267 CCR115C1
268 M.CITY115C1
269 DAWSON115C1(SOL)
270 W.POINT115C1
271 CCR345C2A(3896)
272 CCR345C2B
273 CCR345C2C
274 CCR345C2D(4096)
275 CCR345C2E(3696)
276 WIL345C2A(196)
277 WIL345C2A(292)
278 WIL345C2A(192)
279 WNDBEF1282C2
280 WNDBEF1282C2MOD
281 WNDBEF1286C2
282 WNDBEF1482C2
283 FTPECK230C2
284 WMT4MC582C2
285 WMT4MC382C2
286 WND4GA982C2
287 WND4GAX82C1
288 WND4GA882C2
289 WND4GA782C2
290 WND4GA182C2

291 WND4GA682C2
292 WND4RHA786C2
293 MND4HETBF.C2
294 MMT4BK.BF.C2
295 GAR-SC&GAR-MAX115