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Steady State Assessment of the Grain Belt Express Clean Line HVDC Project

Prepared for

Grain Belt Express Clean Line LLC

Submitted by:
Nelson J. Bacalao, PhD., Senior Manager Consultant
Jack Henry, PE, Senior Staff Consultant
Linh Dinh, Staff Consultant
Satish Natti, PhD., Senior Consultant

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Siemens Industry, Inc.
Siemens Power Technologies International
400 State Street • P.O. Box 1058
Schenectady, New York 12301-1058 USA
Tel: +1 (518) 395-5000 • Fax: +1 (518) 346-2777
www.siemens.com/power-technologies

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Contents

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Executive Summary

Clean Line Energy Partners LLC is currently developing the Grain Belt Express Clean Line (GBX) Project (Project). The Project is planned to be a multi-terminal ±600 kV HVDC bi-pole line which will transport large amounts of new, renewable energy, primarily sourced from wind turbine generators (WTG). The wind will be independently developed within the Southwest Power Pool's (SPP) geographic footprint in and around the northwestern portion of Oklahoma and in the southwestern portion of Kansas. The power will then be transmitted via the Project approximately 700-750 miles to a location at or near the Palmyra Tap 345kV bus in the Ameren Missouri (AMMO in the MISO) and then on to the Sullivan 765kV substation in the American Electric Power (AEP in the PJM) power systems. The Project will have a planned delivery capability of 3,500MW as measured at the receiving ends of the HVDC line (500MW at Palmyra Tap and 3000MW at Sullivan).

The generation associated with the Project, for the purposes of this study, are direct-connect wind generators (WTG's) (i.e. the WTG's will be directly connected to the GBX HVDC Project substation at 345kV which is then directly connected to the Clark County 345kV substation). This interconnection approach assumes there will be minimal interaction with the SPP during normal conditions. For the purposes of the steady state analysis, the details of the direct-connect WTG's is a non-critical design piece, however for stability studies a level of detail is assumed that provides more specific information on the WTG collector system specifying how far away the WTG's are from the Project as well as the reasonable transmission means through which that generation will be delivered to the GBX HVDC substation. The agreed upon collector system model (for stability) is described in more detail in Section 7 of this report. From a steady state perspective, the important issue with respect to the collector system is that the losses and reactive needs of the Project and the collector system are covered to minimize the exchange of real and reactive power between the Project and SPP during normal conditions and to ensure the delivery of 3,500MW at the receiving ends (AMMO in the MISO and AEP in the PJM).

As stated above, the Project is being designed so that during normal operating conditions there is very little, if any, power (active and reactive) exchange with the SPP. However, following the loss of a pole, some of the power flowing on the Project will temporarily flow into the SPP system. The analysis focuses on this potential exchange of power during the contingent loss of one or both of the HVDC poles. In accordance with SPP Criteria 3.5, the objective of the steady state analysis is to determine any potential impacts that the project would introduce to the connecting system or the surrounding networks. The identified impacts herein are provided so that the Affected Parties can advise as to what actions may be necessary to resolve the conditions observed in the results.

A central focus of this analysis is the impact to the underlying systems during a single HVDC pole outage. This event is considered a N-1 (NERC Category B) event per the current NERC Transmission Planning performance requirements[1]. To further test the grid, contingencies are analyzed on the AC grid with the Project pole blocked thereby creating a N-1-1 contingency.

[1] Refer to Table I of NERC TPL-001-1 for definitions of various contingency categories. It should be noted that this document references the currently implemented NERC TPL standards and not the TPL-001-2 standard currently in the approval/implementation process. At this point, the proposed changes would not affect the validity of the analysis, but would change the categorization of the contingencies.

For the purpose of this analysis, N-1-1 contingencies involve the blocking of a single pole and the subsequent loss of an AC transmission element without intermediate re-dispatch or other corrective actions in the solution. It is important to note that the aforementioned N-1-1 events are more stringent than a NERC Category C event described in Table 1 of the NERC TPL Standards. According to the definition in the NERC standards, the planned/controlled interruption of load and/or interruption of firm transmission services are allowed as mitigation for a Category C contingency; however, no load shedding or other curtailments are implemented in this analysis. The results presented are the "raw" results of contingency events across the various scenarios which will help in understanding any potential mitigation that may need to be developed. For completeness, this study also considers the following other extreme contingencies:

- N-1-2 events created by a blocked pole coupled with a double contingency such as the loss of a double circuit section of the SPP Priority Projects or other double contingency defined and normally studied by the SPP and its members,

- N-2 event created by the loss of both HVDC poles (similar to NERC Category D in severity however, in this case, without allowing the interruption of firm transmission service or loss of load).

These events, as characterized by the NERC standards, would allow for system adjustments, such as allowing for phase shifter and transformer tap adjustments, to occur after the first event. Initially, this study does not make these adjustments. However, following a review of the results by the Affected Parties in the Plains and Eastern (P&E) Clean Line LLC study which incorporates most, if not all, the same contingencies as well as some of the same concerns, select contingencies were tested allowing phase shifter and transformer tap adjustments enabled to determine whether the observed conditions were resolved. While no phase shifter overloads were noted in the GBX study, phase shifters were allowed to adjust to be consistent with the efforts in the P&E study. This effort does indicate that allowing the system to adjust resolves problems noted at some transformers and also resolves a number of voltage issues.

The steady state analysis was conducted using the SPP 2011 Build-2 2017 light load, summer and winter peak cases, and the 2022 summer and winter peak cases. Updates to the cases were included before the final base cases were approved by Clean Line, the SPP, and all Affected Parties. The updates are described later in this report. Additionally, a sensitivity study was performed considering the wind generation dispatch in the SPP Near-Term Integrated Transmission Plan (ITP) Scenario 0[2] and Scenario 5[3] 2017 summer and winter peak and 2022 summer peak cases.

Table E-1 provides a summary of transmission facilities that were identified in the study as being affected by the Project. The table shows transmission elements that were observed with loading levels at or above 100% of the elements' emergency (Rate B) rating. The tables also indicate which case set (Build 2 or ITP) and modeled year the loading levels were

[2] The "Scenario Zero" model has the same dispatch as the MDWG models with the exception that generation that does not have a signed interconnection agreement and generation that does not have transmission service is also removed. The exception to this is in later years when generation load and interchange does not match, the shortfall is made up of units that are in-service.

[3] The "All Transactions" (Scenario 5) model is the same as the "Scenario Zero" model with the dispatch changed to include all transmission service sold with ERCOTN North to South, ERCOTE East to West, SPS importing and SPS exporting to the Lamar HVDC tie.

observed. Lastly, the tables indicate the contingency type that resulted in the observed loading.

- N-1: Loss of a single pole of the HVDC Project (no adjustments during the solution)
- N-1-1: Loss of a single pole of the HVDC Project coupled with a single contingency as defined by contingencies provided by the stakeholders (no adjustments during the solution)
- N-1-2: Loss of a single pole of the HVDC Project coupled with a double contingency as defined by contingencies provided by the stakeholders (no adjustments during the solution)

For the transmission elements observed at or above 100% of the elements emergency (Rate B) rating, the Affected Parties were consulted to provide input for mitigation of the conditions observed. In some cases, this involved allowing the adjustment of phase shifters and/or transformer tap settings. In other cases, upgrades and/or operational solutions are provided to finalize the analysis of the system.

The “raw” contingency results in Table E- 1 show the HARPER4-MILANTP4 138kV line was observed as overloaded for a N-1 event in the ITP 2017 cases. The N-1 contingency is particularly noteworthy in that it involves the loss of a single pole of the HVDC Project (without solution adjustments). The HARPER4-MILANTP4 138kV line is a part of the lower voltage path that serves to move power from west to east especially for the loss of one of the HVDC poles. However, it should also be noted that the N-1 overload is not present in the Build-2 cases until a more severe N-1-1 contingency is applied. Other overloads observed were captured resulting from N-1-1 and N-1-2 contingency conditions (without solution adjustments).

The proposed mitigation efforts, where they are applied, are simplistic in that reducing the direct-connected wind generation at the Project provides the desired relief. Details of the mitigation efforts are provided in the Mitigation Section of this report.

A screening of impacts of the Grain Belt Express project at the receiving end substations Sullivan and Palmyra Tap was conducted to identify potential impacts. This analysis does not replace the interconnection studies to be conducted by PJM and MISO respectively, but provides an advance view of potential reinforcements to be needed to accommodate the project. Contrary to SPP analysis where we concentrated on the situation when there is one pole out, this limited impact analysis considers the situation when both poles are in service and evaluate the impact of outages in the vicinity of the point of interconnection (POI). This study indicated that:

- Each 765/345 kV transformer connecting Sullivan 765 kV bus to Breed 345 kV bus would overload if the other transformer is out for all conditions in both Build2 and ITP Near-Term scenarios
- The 345 kV lines from Breed to Wheat and Casey would overload in Build2 Light Load conditions, when the Rockport to Jefferson 765 kV line trips

A sensitivity case of connecting the Project directly to the 345 kV network at Sullivan substation (opposed to 765 kV Sullivan bus via three transformers) was studied focusing on SPP side and Sullivan (AEP) side of the Project.

The sensitivity study (connecting the Project to 345 kV network at Sullivan) results with focus on SPP side are consistent with the results of the original study (connecting the Project to Sullivan 765 kV bus) and no additional overloads were observed. The following overloads are observed which were also observed in original study:

- The Harper – Milan Tap 138 kV line is overloaded in ITP Near-Term 2017 Summer Peak and Winter Peak scenarios for N-1 (pole outage) condition.

- The Spearville 345/230 kV transformer and Harper – Milan Tap 138 kV line are overloaded almost in all scenarios for N-1-1 conditions. Further, the Milan Tap – Clear Water 138 kV line was overloaded only in ITP 2017 Summer Peak 5 scenario.

The sensitivity study (connecting the Project to 345 kV network at Sullivan) with focus on the receiving end Sullivan (AEP) and Palmyra (MISO) side shows that the AEP 345 kV line Breed – Wheat overloads in Build2 Light Load conditions, for the trip of Rockport – Jefferson 765 kV line. This observation is inconsistent with N-1 overloads when both poles are in service as in the original study. This contingency did not converge for other loading scenarios, where the Rockport Plant was dispatched at close to full capacity. This contingency assessment and the proposed mitigation (tripping of one pole) are presented in the GBX Stability Assessment report.

Table E- 1 Summary of Impacted Facilities

Identification of the Worst Contingency Violations			Build 2					ITP0			ITP5		
Transmission Element	***FROM AREA***	***TO AREA***	***2017 Light***	***2017 Summer***	***2017 Winter***	***2022 Summer***	***2022 Winter***	***2017 Summer***	***2017 Winter***	***2022 Summer***	***2017 Summer***	***2017 Winter***	***2022 Summer***
300071 5CLINTN 161 300124 5HOLDEN 161 1	330 AECI	330 AECI		N-1-2									
334026 4GRIMES 138 334040 4WALDEN 138 1	351 EES	351 EES	N-1-1										
334058 4L558T485 138 334060 4MT.ZION 138 1	351 EES	351 EES	N-1-1										
336138 6FAIRVW 230 336190 6GYPSY 230 1	351 EES	351 EES		N-1-1									
336138 6FAIRVW 230 500510 MADISON6 230 1	351 EES	502 CLEC		N-1-1									
338813 5MIDWAY# 161 505460 BULL SH5 161 1	351 EES	515 SWPA		N-1-1		N-1-1		N-1-1		N-1-1	N-1-1		N-1-1
505502 TRUMAN 5 161 541314 NWARSAW5 161 1	515 SWPA	540 GMO											N-1-1
508090 WATLANT4 138 B$1894 WATLANT2 1.00 2	520 AEPW	520 AEPW											N-1-1
510877 FIXCT4 138 515055 MAUD 4 138 1	520 AEPW	524 OKGE				N-1-1							
530553 S HAYS 3 115 530562 HAYS 3 115 1	531 MIDW	531 MIDW		N-1-1	N-1-1	N-1-1	N-1-1				N-1-1		N-1-1
530592 SMOKYHL6 230 532873 SUMMIT 6 230 1	531 MIDW	531 MIDW										N-1-2	
531420 FLETCHR3 115 531448 HOLCOMB3 115 1	534 SUNC	534 SUNC				N-1-1							
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	534 SUNC	534 SUNC	N-1-2	N-1-1	N-1-1	N-1-1	N-1-1	N-1-1	N-1-2	N-1-2			
532765 HOYT 7 345 532766 JEC N 7 345 1	536 WERE	536 WERE									N-1-1		
532851 AUBURN 6 230 532852 JEC 6 230 1	536 WERE	536 WERE									N-1-1	N-1-1	N-1-1
532851 AUBURN 6 230 B$0430 AUBRN77X 1.00 1	536 WERE	536 WERE						N-1-1		N-1-1	N-1-1		N-1-1
533021 NEOSHO 4 138 B$1339 NEOSH2AX 1.00 1	536 WERE	536 WERE				N-1-1					N-1-1		N-1-1
533021 NEOSHO 4 138 B$1340 NEOSH2BX 1.00 1	536 WERE	536 WERE									N-1-1		
533021 NEOSHO 4 138 B$1341 NEOSH2CX 1.00 2	536 WERE	536 WERE									N-1-1		
533036 CLEARWT4 138 539675 MILANTP4 138 1	536 WERE	534 SUNC	N-1-2	N-1-2	N-1-1	N-1-2	N-1-1	N-1-2	N-1-2		N-1-1	N-1-1	N-1-2
533040 EVANS N4 138 533054 MAIZE 4 138 1	536 WERE	536 WERE									N-1-1		
533151 AUBURN 3 115 B$0430 AUBRN77X 1.00 1	536 WERE	536 WERE						N-1-1		N-1-1	N-1-1		N-1-1
533162 GOODYR 3 115 533166 INDIANH3 115 1	536 WERE	536 WERE						N-1-2	N-1-2		N-1-2	N-1-2	N-1-2
539668 HARPER 4 138 539675 MILANTP4 138 1	534 SUNC	534 SUNC	N-1-1	N-1-1	N-1-1	N-1-1	N-1-1	N-1-1	N-1-1	N-1-2	N-1	N-1	N-1-1
539671 FTDODGE3 115 539771 NFTDODG3 115 1	534 SUNC	534 SUNC	N-1-2	N-1-2		N-1-2							
539679 MULGREN6 230 539695 SPEARVL6 230 1	534 SUNC	534 SUNC		N-1-2		N-1-2		N-1-2			N-1-2		N-1-2
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	534 SUNC	534 SUNC	N-1-2	N-1-2	N-1-2	N-1-2			N-1-2			N-1-2	
539694 SPEARVL3 115 539771 NFTDODG3 115 1	534 SUNC	534 SUNC	N-1-2		N-1-2								
539694 SPEARVL3 115 B$1668 SPEARVL6 1.00 1	534 SUNC	534 SUNC			N-1-2								
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	534 SUNC	534 SUNC	N-1-2	N-1-1	N-1-1	N-1-1	N-1-2	N-1-1	N-1-2	N-1-2			
539695 SPEARVL6 230 B$1668 SPEARVL6 1.00 1	534 SUNC	534 SUNC			N-1-2								
541222 WSTELEC5 161 541224 LNGVW 5 161 1	540 GMO	540 GMO		N-1-1		N-1-1							N-1-1
547483 JOP389 5 161 B$1047 JOPLINSW 1.00 1	544 EMDE	544 EMDE				N-1-1							
640109 CHADRON7 115 640405 WAYSIDE7 115 1	640 NPPD	640 NPPD				N-1-1							
640234 HUMBOLT5 161 B$1596 S975 T4 1.00 1	645 OPPD	645 OPPD			N-1-2								
640267 MAXWELS7 115 640287 N.PLATT7 115 1	640 NPPD	640 NPPD				N-1-1							

Section

1

Introduction

The Clean Line Energy Partners LLC is currently developing the Grain Belt Express Clean Line Project (Project) which will use a multi-terminal HVDC technology to deliver wind generated electricity from southwestern Kansas and northwestern Oklahoma to serve load centers in AMMO and AEP. The Project is being developed as a ±600-kV HVDC overhead line interconnecting the SPP to the AMMO in the MISO and AEP in the PJM. The Project is expected to interconnect with AMMO at the Palmyra 345kV Tap Substation and with AEP at the Sullivan 765kV substation through a new 345kV substation and 3-765/345kV transformers.

The expected line lengths are approximately 530 miles to Palmyra Tap and 210 miles[4] from Palmyra Tap to Sullivan.

The Project is being designed so that during normal operating conditions there is minimal interchange between the Project and the SPP (i.e., the net active and reactive power exchanges are to be controlled at or near zero in the base case assumptions). Since the Project is currently expected to employ a "HVDC Classic" (Line Commutated Converter) technology, which consumes significant amounts of reactive power, it is presently proposed to install reactive compensation at the rectifier and inverter converter stations to provide reactive/voltage support and maintain VAR neutrality between the HVDC system and the interconnecting systems. The level of reactive compensation is modeled at approximately 60% of the nominal active power to be injected or extracted at all the converter stations of the GBX HVDC Project. The sizing and number of switched capacitor banks modeled is for study purposes only and does not reflects the final design requirements of the Project. More detailed studies will be performed by the technology vendor during final design and will yield a fine tuned reactive compensation design including size and number of switched banks, dynamic reactive equipment, and harmonic filtering to meet or exceed all interconnection requirements.

The 3,500MW delivery requirement implies that at the sending end of the Project there must be enough direct-connect wind turbine generation (WTG) to compensate for the losses of the WTG transmission system and collector as well as the HVDC links. For the steady state analysis, the collector detail is not critical to adequately capture the Project's impacts on the interconnected system. However, a more detailed collector system is necessary for the stability and short circuit analyses associated with the Project. The steady state analysis modeled the WTG capability generating at approximately 3,700MW in order to deliver 3,500 MW at the receiving ends (500MW into the AMMO and 3,000MW into the AEP). The WTG's are assumed to be type 3 and type 4 WTGs which are radially connected to the HVDC rectifier.

[4] Actual mileage will be dependent upon final routing.

In accordance with SPP Criteria 3.5, the objective of the steady state analysis is to determine any potential impacts that the project would introduce to the connecting system or the surrounding networks. The impacts identified are provided so that the Affected Parties are informed on potential impacts as well as any mitigation that may be required.

The results presented in this report are developed using the SPP 2011 series Build-2 2017 and 2022 data cases for the light load, summer and winter peak time frames. To complement these studies, a sensitivity of the results to the 2017 and 2022 ITP Near-Term (NT) cases Scenario 0 and Scenario 5 were analyzed. An extensive comparison between the ITP Near-Term and the Build 2 cases is provided.

The analysis is focused on the following conditions, which were selected to provide a comprehensive assessment of the GBX impact:

- N-1 contingencies (NERC's Category B), which due to the modeled zero interchange with the SPP, consists of only a single pole outage on the GBX.
- N-1-1 – Trip a single pole of the HVDC Project coincident with the single contingency defined by the SPP and Affected Parties without intermediate re-dispatch or other adjustments in the solution process (similar to Category C events prior any mitigation).
- N-1-2 – Trip a single pole of the HVDC Project coincident with the double contingency identified by the SPP and Affected Parties without intermediate re-dispatch or other adjustments in the solution process (similar to Category D events prior to mitigation). The loss of a double circuit of any of the SPP Priority Projects is a valid contingency in this definition.
- N-2 – Blocking both poles of the HVDC Project without intermediate re-dispatch or other adjustments in the solution process (similar to Category D prior mitigation)

The results of the contingency testing are provided in more detail in the following sections.

For selected contingencies, verification of potential impacts with subsequent adjustments was analyzed specifically targeting some observations on phase shifters and transformers resulting in transmission overloads and voltage violations. Allowing the phase shifters and transformer taps to adjust did resolve issues at specific locations. More specific details are presented in the analysis sections.

During the first stages of our analysis we identified certain Pre-Project contingency overloads that were potentially made worse by a GBX pole outage. In this case, in consultation with the affected parties, we identified planned upgrades as noted later in this report.

Finally, in the Mitigation Section of this report, proposed solutions are provided for those cases when a pole outage creates an overload in the system under otherwise normal conditions (N-1 event) or with a pre-exiting outage (N-1-1 event).

A limited system impact study at the receiving end of the GBX (Palmyra and Sullivan substations) was conducted for the case where two poles are in service and critical lines in the vicinity of the interconnection point trip.

A sensitivity case of connecting the Project to 345 kV network at Sullivan is studied and the corresponding results are discussed.

The rest of the report is organized in the following sections to present the details of the study:

Section 2: Base Case Development

Section 3: Study Methodology

Section 4: Base Contingency Analysis

Section 5: ITP Near-Term Contingency Analysis.

Section 6: Voltage Assessment

Section 7: Short Circuit Analysis

Section 8: Mitigation

Section 9: Impacts at the Receiving End

Section 10: 345 kV Connection at Sullivan Area

Section 11: Summary of Observations

Appendices

Section

2

Base Case Development

The SPP 2011 Build 2 Base Cases were provided by SPP in PSS®E version 30.3.3. These cases were used as the Base Case for the evaluation of the Project's impact. Analysis was also conducted using the SPP 2012 ITP Near-Term Cases as sensitivity.

The following Build 2 Base Cases (published in 2011) were used to assess the impact of the Grain Belt Express HVDC Project:

- 2017 Light Load
- 2017 Summer Peak
- 2017 Winter Peak
- 2022 Summer Peak
- 2022 Winter Peak

Additionally the following ITP Near-Term[5] cases (developed in 2012) were considered in the analysis:

- 2017 Summer Peak Scenario 0[6]
- 2017 Summer Peak Scenario 5[7]
- 2017 Winter Peak Scenario 0
- 2017 Winter Peak Scenario 5
- 2022 Summer Peak Scenario 0
- 2022 Summer Peak Scenario 5

The following discussion reviews the generation and topology information and changes necessary to model the base cases and the Project cases.

[5] These cases correspond to the results presented in the 2012 ITP near term report dated January 9, 2012

[6] The "Scenario Zero" model has the same dispatch as the MDWG models with the exception that generation that does not have a signed interconnection agreement and generation that does not have transmission service is also removed. The exception to this is in later years when generation load and interchange does not match, the shortfall is made up of units that are in-service.

[7] The "All Transactions" (Scenario 5) model is the same as the "Scenario Zero" model with the dispatch changed to include all transmission service sold with ERCOTN North to South, ERCOTE East to West, SPS importing and SPS exporting to the Lamar HVDC tie.

2.1 SPP Generation

No modifications were made to the generation levels in the cases with the exception of the addition of the Project's WTG generation (direct-connected) described below. Thus the SPP generation levels are those included in the corresponding cases provided for the various years.

2.1.1 Build 2 SPP Generation

The following tables summarize the generation profile in each of the identified areas that can be potentially affected by the project, including multiple SPP areas, Entergy (EES), and the Associated Electric Cooperative (AECI). The areas most impacted by the Project are shaded blue in the following tables. These areas include:

- 534 SUNC (also SECI) – Sunflower Electric Cooperative
- 531 MIDW – Midwest Energy
- 536 WERE – Westar
- 526 SPS – Southwestern Public Service Company
- 525 WFEC – Western Farmers Electric Cooperative
- 524 OKGE – Oklahoma Gas & Electric Company
- 520 AEPW – AEP West

Other areas impacted by the Project are shown with no highlight for SPP and yellow for outside SPP. These "other" areas are not as impacted by the Project as the above entities. The areas impact and identification is further discussed in the Methodology Section of the report.

The information provided in the generation tables is provided to display the dispatch in each of the areas represented. The information is broken down further by our estimation of how much of the generation in each of the areas can be attributed to wind turbine generation (WTG). The generation levels in the SPP are unchanged from the base case to the Project case. The generation needed to send across the HVDC lines to the AMMO and AEP is accomplished by adding WTG's directly connected to the HVDC Project. Generation in the AMMO and AEP were reduced by 500MW and 3,000MW, respectively, to allow for the new multi-terminal HVDC tie. The generation models for the AEP and AMMO are acceptable; however, each respective region is expected to coordinate their own impact studies to determine the impact of the Project in their region. The SPP contingency studies obviously impact the AMMO and AEP; however, the impact is only noted at the interfaces in this study.

The information provided in the generation tables is derived from the reviewed information and while we believe it is accurate, there may be some discrepancies in the amount of wind shown modeled in each of the areas. The information is provided for informational purposes only in that the generation in the cases was not changed except for the generation in the AMMO and AEP regions that were scaled down as indicated above.

Table 2-1 shows the generation totals by area for the 2017 Summer Peak Build 2 Case. In this table we observe that the amount of WTG is dispatched at fairly low levels except for the Kansas City Power & Light (KCPL), which is dispatched close to 78% of the maximum capacity. On average the WTG is dispatched at 12% of its maximum in this case and it is less than 1% of the total generation.

Table 2-1: 2017 Summer Peak Build 2 Generation Totals by Affected Area

		2017 Summer Peak Build 2			
		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax
534	SUNC	1,118	2,029	89	759
531	MIDW	135	408	33	261
536	WERE	6,489	7,740	46	150
526	SPS	6,615	8,589	63	994
525	WFEC	1,305	2,673	22	539
524	OKGE	6,961	9,306	99	1,141
520	AEPW	10,117	16,799	23	388
541	KCPL	4,495	5,336	240	308
540	GMO	1,184	2,028	0	170
545	INDN	202	288	0	0
515	SWPA	1,996	2,564	0	122
502	CLEC	3,663	4,617	0	0
503	LAFA	168	465	0	0
504	LEPA	123	211	0	0
523	GRDA	1,217	1,532	0	0
527	OMPA	196	197	0	0
542	KACY	580	961	0	0
544	EMDE	1,106	1,460	0	0
546	SPRM	879	1,060	0	0
640	NPPD	2,907	4,687	22	345
645	OPPD	3,249	3,781	12	60
351	EES	29,083	42,202	0	0
330	AECI	4,538	5,622	0	0
	Total	**88,326**	**124,555**	**650**	**5,237**

Table 2-2 shows the generation at the affected areas for the 2017 Winter Peak Build 2 case. Here we note that the WTG was dispatched at a lower level than the case above and in average 11% of the maximum.

Table 2-2: 2017 Winter Peak Build 2 Generation Totals by Affected Area

		2017 Winter Peak Build 2			
		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax
534	SUNC	815	2,029	116	439
531	MIDW	136	408	87	261
536	WERE	5,096	7,740	0	0
526	SPS	4,820	8,618	123	834
525	WFEC	1,524	2,673	8	200
524	OKGE	4,701	9,306	10	1,141
520	AEPW	7,940	16,960	15	388
541	KCPL	3,452	5,316	0	308
540	GMO	819	2,028	0	170
545	INDN	100	288	0	0
515	SWPA	1,864	2,564	0	122
502	CLEC	3,306	4,617	0	0
503	LAFA	36	465	0	0
504	LEPA	72	211	0	0
523	GRDA	1,033	1,532	0	0
527	OMPA	81	197	0	0
542	KACY	410	862	0	0
544	EMDE	754	1,598	0	0
546	SPRM	590	1,060	0	0
640	NPPD	2,961	4,687	77	345
645	OPPD	2,406	3,817	21	60
351	EES	23,733	42,202	0	0
330	AECI	3,997	5,814	0	0
	Total	**70,645**	**124,992**	**457**	**4,268**

Table 2-3 shows the generation totals for the 2017 Light Load Build 2. Here we note slightly higher wind component that the winter case but still less than that in the summer peak case; 14% average dispatch.

Table 2-3: 2017 Light Load Build 2 Generation Totals by Affected Area

		Light Load Build 2			
		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax
534	SUNC	652	2,029	102	439
531	MIDW	85	408	75	261
536	WERE	5,070	7,740	0	0
526	SPS	3,330	8,578	123	834
525	WFEC	1,264	2,673	37	200
524	OKGE	2,419	9,306	123	1,141
520	AEPW	2,858	16,799	23	388
541	KCPL	2,375	5,336	0	308
540	GMO	285	2,028	0	170
545	INDN	0	288	0	0
515	SWPA	999	2,564	0	122
502	CLEC	1,800	4,617	0	0
503	LAFA	54	465	0	0
504	LEPA	85	211	0	0
523	GRDA	727	1,532	0	0
527	OMPA	107	197	0	0
542	KACY	236	961	0	0
544	EMDE	98	1,460	0	0
546	SPRM	257	1,060	0	0
640	NPPD	1,484	4,687	77	345
645	OPPD	1,154	3,813	21	60
351	EES	19,334	42,202	0	0
330	AECI	1,181	5,622	0	0
	Total	**45,856**	**124,576**	**582**	**4,268**

Table 2-4 shows the generation totals by area for the Build 2, 2022 Summer Peak case. In this case the WTG generation dispatch is 17% of the maximum.

Table 2-4 2022 Summer Peak Build 2 Generation Totals by Affected Area

		2022 Summer Peak Build 2			
		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax
534	SUNC	1,304	2,029	78	439
531	MIDW	136	408	33	261
536	WERE	6,744	7,740	0	0
526	SPS	7,424	8,605	47	834
525	WFEC	1,536	2,673	8	200
524	OKGE	7,389	9,306	99	1,141
520	AEPW	10,706	16,799	73	388
541	KCPL	4,788	5,342	240	308
540	GMO	1,343	2,028	60	170
545	INDN	216	288	0	0
515	SWPA	2,031	2,564	52	122
502	CLEC	3,609	4,617	0	0
503	LAFA	310	465	0	0
504	LEPA	128	211	0	0
523	GRDA	1,315	1,532	0	0
527	OMPA	248	197	0	0
542	KACY	594	961	0	0
544	EMDE	1,203	1,460	0	0
546	SPRM	998	1,160	0	0
640	NPPD	3,123	4,687	22	345
645	OPPD	3,506	3,990	12	60
351	EES	30,260	42,202	0	0
330	AECI	4,930	5,622	0	0
	Total	**93,843**	**124,886**	**724**	**4,268**

Finally, Table 2-5 shows the generation totals by area for the 2022 Winter Peak Build 2 case.

Table 2-5: 2022 Winter Peak Build 2 Generation Totals by Affected Area

		2022 Winter Peak Build 2			
		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax
534	SUNC	802	2,029	189	649
531	MIDW	138	408	87	261
536	WERE	5,361	7,740	0	0
526	SPS	5,370	8,638	171	994
525	WFEC	1,526	2,673	42	314
524	OKGE	5,038	9,306	10	1,141
520	AEPW	8,410	16,799	23	388
541	KCPL	3,635	5,336	0	308
540	GMO	941	2,028	0	170
545	INDN	87	288	0	0
515	SWPA	2,009	2,564	49	122
502	CLEC	3,347	4,617	0	0
503	LAFA	59	465	0	0
504	LEPA	75	211	0	0
523	GRDA	1,124	1,532	0	0
527	OMPA	80	197	0	0
542	KACY	414	862	0	0
544	EMDE	846	1,460	0	0
546	SPRM	662	1,164	0	0
640	NPPD	3,175	4,687	77	345
645	OPPD	2,609	4,026	21	60
351	EES	23,737	42,202	0	0
330	AECI	4,354	5,814	0	0
	Total	**73,802**	**125,046**	**669**	**4,752**

2.1.2 ITP Scenario 0 Generation

Table 2-6 to Table 2-8 summarize the generation levels within the SPP region with a breakout of the dispatched wind generation for each of the most affected areas as well as for other affected areas within SPP and affected external areas for the ITP Scenario 0 cases. The Build 2 cases are also shown in each table for comparison.

As can be observed, the total wind generation dispatch is similar between Scenario 0 and that of the Build 2 cases. However, as will be seen in Section 5, there are slightly different impacts which can be attributed to differences in the overall generation dispatch. Again, as in the Build 2 cases, the generation in the SPP is unchanged with the addition of the Project.

This information is provided to indicate of how much wind is modeled in the cases and give an idea of where the greatest levels of wind are modeled (on an area basis). In all of these cases the level of WTG with respect of the installed generation is very similar between the Build 2 and the ITP Scenario 0 cases.

Table 2-6: 2017 Summer Peak ITP Scenario 0 vs. Build 2 Generation

		2017 Summer Peak Build 2				2017 Summer Peak S0			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	1,118	2,029	89	759	1,150	2,002	161	849
531	MIDW	135	408	33	261	125	392	33	261
536	WERE	6,489	7,740	46	150	6,049	8,002	55	386
526	SPS	6,615	8,589	63	994	6,227	8,637	56	994
525	WFEC	1,305	2,673	22	539	1,292	2,373	22	539
524	OKGE	6,961	9,306	99	1,141	6,990	9,506	50	1,341
520	AEPW	10,117	16,799	23	388	10,343	16,799	23	388
541	KCPL	4,495	5,336	240	308	4,410	5,463	50	308
540	GMO	1,184	2,028	0	170	1,331	2,028	119	170
545	INDN	202	288	0	0	202	288	0	0
515	SWPA	1,996	2,564	0	122	1,978	2,564	0	122
502	CLEC	3,663	4,617	0	0	3,660	4,617	0	0
503	LAFA	168	465	0	0	167	465	0	0
504	LEPA	123	211	0	0	123	211	0	0
523	GRDA	1,217	1,532	0	0	1,386	1,591	0	0
527	OMPA	196	197	0	0	186	197	0	0
542	KACY	580	961	0	0	580	961	0	0
544	EMDE	1,106	1,460	0	0	1,082	1,460	0	0
546	SPRM	879	1,060	0	0	880	1,060	0	0
640	NPPD	2,907	4,687	22	345	2,746	4,565	19	386
645	OPPD	3,249	3,781	12	60	3,066	3,607	12	60
351	EES	29,083	42,202	0	0	29,027	42,473	0	0
330	AECI	4,538	5,622	0	0	4,572	5,601	0	0
	Total	**88,326**	**124,555**	**650**	**5,237**	**87,570**	**124,860**	**600**	**5,805**

Table 2-7: 2017 Winter Peak ITP Scenario 0 vs. Build 2 Generation

		2017 Winter Peak Build 2				2017 Winter Peak S0			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	815	2,029	116	439	811	2,002	224	850
531	MIDW	136	408	87	261	96	392	87	261
536	WERE	5,096	7,740	0	0	4,352	8,002	69	386
526	SPS	4,820	8,618	123	834	4,435	8,666	96	834
525	WFEC	1,524	2,673	8	200	1,156	2,373	48	380
524	OKGE	4,701	9,306	10	1,141	4,739	9,506	6	1,341
520	AEPW	7,940	16,960	15	388	8,166	16,960	15	388
541	KCPL	3,452	5,316	0	308	3,494	5,443	0	308
540	GMO	819	2,028	0	170	820	2,028	49	170
545	INDN	100	288	0	0	79	288	0	0
515	SWPA	1,864	2,564	0	122	1,846	2,564	0	122
502	CLEC	3,306	4,617	0	0	3,306	4,617	0	0
503	LAFA	36	465	0	0	35	465	0	0
504	LEPA	72	211	0	0	72	211	0	0
523	GRDA	1,033	1,532	0	0	1,190	1,591	0	0
527	OMPA	81	197	0	0	32	197	0	0
542	KACY	410	862	0	0	410	862	0	0
544	EMDE	754	1,598	0	0	755	1,598	0	0
546	SPRM	590	1,060	0	0	591	1,060	0	0
640	NPPD	2,961	4,687	77	345	2,789	4,565	70	386
645	OPPD	2,406	3,817	21	60	2,250	3,648	21	60
351	EES	23,733	42,202	0	0	25,901	42,473	0	0
330	AECI	3,997	5,814	0	0	4,029	5,793	0	0
	Total	**70,645**	**124,992**	**457**	**4,268**	**71,353**	**125,302**	**685**	**5,487**

Table 2-8: 2022 Summer Peak ITP Scenario 0 versus Build 2 Generation

		2022 Summer Peak Build 2				2022 Summer Peak S0			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	1,304	2,029	78	439	1,191	2,002	163	850
531	MIDW	136	408	33	261	128	392	33	261
536	WERE	6,744	7,740	0	0	6,314	8,002	58	386
526	SPS	7,424	8,605	47	834	6,339	8,653	56	994
525	WFEC	1,536	2,673	8	200	1,517	2,373	78	539
524	OKGE	7,389	9,306	99	1,141	7,488	9,506	61	1,341
520	AEPW	10,706	16,799	73	388	11,244	16,799	23	388
541	KCPL	4,788	5,342	240	308	4,807	5,469	240	308
540	GMO	1,343	2,028	60	170	1,540	2,028	164	170
545	INDN	216	288	0	0	216	288	0	0
515	SWPA	2,031	2,564	52	122	2,014	2,564	51	122
502	CLEC	3,609	4,617	0	0	3,607	4,617	0	0
503	LAFA	310	465	0	0	309	465	0	0
504	LEPA	128	211	0	0	128	211	0	0
523	GRDA	1,315	1,532	0	0	1,467	1,591	0	0
527	OMPA	248	197	0	0	185	197	0	0
542	KACY	594	961	0	0	595	961	0	0
544	EMDE	1,203	1,460	0	0	1,234	1,460	0	0
546	SPRM	998	1,160	0	0	1,016	1,160	0	0
640	NPPD	3,123	4,687	22	345	3,037	4,565	19	386
645	OPPD	3,506	3,990	12	60	3,337	3,607	12	60
351	EES	30,260	42,202	0	0	30,070	42,473	0	0
330	AECI	4,930	5,622	0	0	4,955	5,601	0	0
	Total	**93,843**	**124,886**	**724**	**4,268**	**92,738**	**124,982**	**960**	**5,806**

2.1.3 ITP Scenario 5 Generation

Table 2-9 to Table 2-11 summarize the generation levels within the SPP region with a breakout of the dispatched wind generation for each of the most affected areas as well as for SPP at-large within the ITP Scenario 5 cases. The Build 2 cases are also shown in each table for comparison. It can be observed that Scenario 5 has significantly more WTG dispatched than in the Build 2 or Scenario 0 cases and, as presented in Section 7, there is a greater impact due to the generation profile changes. On average the WTG is dispatched between 62% (17 Winter Case) to 73% (2022 Summer Peak Case) of its maximum in the Scenario 5 cases.

Table 2-9: 2017 Summer Peak ITP Scenario 5 vs. Build 2 Generation

		2017 Summer Peak Build 2				2017 Summer Peak S5			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	1,118	2,029	89	759	1,754	2,002	728	850
531	MIDW	135	408	33	261	277	392	200	261
536	WERE	6,489	7,740	46	150	6,413	8,002	360	386
526	SPS	6,615	8,589	63	994	6,741	8,637	366	834
525	WFEC	1,305	2,673	22	539	1,808	2,373	355	380
524	OKGE	6,961	9,306	99	1,141	7,648	9,506	723	1,341
520	AEPW	10,117	16,799	23	388	10,594	16,799	247	388
541	KCPL	4,495	5,336	240	308	4,761	5,463	188	308
540	GMO	1,184	2,028	0	170	1,172	2,028	49	170
545	INDN	202	288	0	0	186	288	0	0
515	SWPA	1,996	2,564	0	122	1,941	2,564	0	122
502	CLEC	3,663	4,617	0	0	3,705	4,617	0	0
503	LAFA	168	465	0	0	167	465	0	0
504	LEPA	123	211	0	0	123	211	0	0
523	GRDA	1,217	1,532	0	0	1,183	1,591	0	0
527	OMPA	196	197	0	0	145	197	0	0
542	KACY	580	961	0	0	552	961	0	0
544	EMDE	1,106	1,460	0	0	914	1,460	0	0
546	SPRM	879	1,060	0	0	795	1,060	0	0
640	NPPD	2,907	4,687	22	345	3,093	4,565	384	386
645	OPPD	3,249	3,781	12	60	3,195	3,607	60	60
351	EES	29,083	42,202	0	0	28,980	42,473	0	0
330	AECI	4,538	5,622	0	0	4,363	5,601	0	0
	Total	**88,326**	**124,555**	**650**	**5,237**	**90,510**	**124,860**	**3,660**	**5,487**

Table 2-10: 2017 Winter Peak ITP Scenario 5 vs. Build 2 Generation

		2017 Winter Peak Build 2				2017 Winter Peak S5			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	815	2,029	116	439	1,378	2,002	706	850
531	MIDW	136	408	87	261	203	392	195	261
536	WERE	5,096	7,740	0	0	4,521	8,002	352	386
526	SPS	4,820	8,618	123	834	4,855	8,666	366	834
525	WFEC	1,524	2,673	8	200	1,677	2,373	355	380
524	OKGE	4,701	9,306	10	1,141	5,387	9,506	723	1,341
520	AEPW	7,940	16,960	15	388	8,320	16,960	239	388
541	KCPL	3,452	5,316	0	308	3,839	5,443	0	308
540	GMO	819	2,028	0	170	660	2,028	14	170
545	INDN	100	288	0	0	63	288	0	0
515	SWPA	1,864	2,564	0	122	1,806	2,564	0	122
502	CLEC	3,306	4,617	0	0	3,354	4,617	0	0
503	LAFA	36	465	0	0	35	465	0	0
504	LEPA	72	211	0	0	72	211	0	0
523	GRDA	1,033	1,532	0	0	977	1,591	0	0
527	OMPA	81	197	0	0	3	197	0	0
542	KACY	410	862	0	0	404	862	0	0
544	EMDE	754	1,598	0	0	854	1,598	0	0
546	SPRM	590	1,060	0	0	498	1,060	0	0
640	NPPD	2,961	4,687	77	345	3,142	4,565	384	386
645	OPPD	2,406	3,817	21	60	2,386	3,648	60	60
351	EES	23,733	42,202	0	0	25,447	42,473	0	0
330	AECI	3,997	5,814	0	0	3,816	5,793	0	0
	Total	**70,645**	**124,992**	**457**	**4,268**	**73,694**	**125,302**	**3,394**	**5,487**

Table 2-11: 2022 Summer Peak ITP Scenario 5 vs. Build 2 Generation

		2022 Summer Peak Build 2				2022 Summer Peak S5			
		Total		Wind		Total		Wind	
Area		Pgen	Pmax	Pgen	Pmax	Pgen	Pmax	Pgen	Pmax
534	SUNC	1,304	2,029	78	439	1,764	2,002	729	850
531	MIDW	136	408	33	261	281	392	200	261
536	WERE	6,744	7,740	0	0	6,795	8,002	363	386
526	SPS	7,424	8,605	47	834	6,810	8,653	526	994
525	WFEC	1,536	2,673	8	200	1,969	2,373	530	539
524	OKGE	7,389	9,306	99	1,141	8,130	9,506	723	1,341
520	AEPW	10,706	16,799	73	388	11,479	16,799	247	388
541	KCPL	4,788	5,342	240	308	5,108	5,469	308	308
540	GMO	1,343	2,028	60	170	1,387	2,028	129	170
545	INDN	216	288	0	0	200	288	0	0
515	SWPA	2,031	2,564	52	122	1,978	2,564	50	122
502	CLEC	3,609	4,617	0	0	3,653	4,617	0	0
503	LAFA	310	465	0	0	309	465	0	0
504	LEPA	128	211	0	0	128	211	0	0
523	GRDA	1,315	1,532	0	0	1,283	1,591	0	0
527	OMPA	248	197	0	0	186	197	0	0
542	KACY	594	961	0	0	566	961	0	0
544	EMDE	1,203	1,460	0	0	1,078	1,460	0	0
546	SPRM	998	1,160	0	0	936	1,160	0	0
640	NPPD	3,123	4,687	22	345	3,382	4,565	384	386
645	OPPD	3,506	3,990	12	60	3,461	3,607	60	60
351	EES	30,260	42,202	0	0	30,004	42,473	0	0
330	AECI	4,930	5,622	0	0	4,751	5,601	0	0
	Total	**93,843**	**124,886**	**724**	**4,268**	**95,637**	**124,982**	**4,250**	**5,806**

2.2 Topology Changes to the 2011 Build 2 Cases

The SPP 2011 Build 2 cases were reviewed in detail with SPP and all Affected Parties and the topology within the cases was deemed accurate for the study once the changes described in the following sections were incorporated.

2.2.1 Update to the SPP Priority Projects

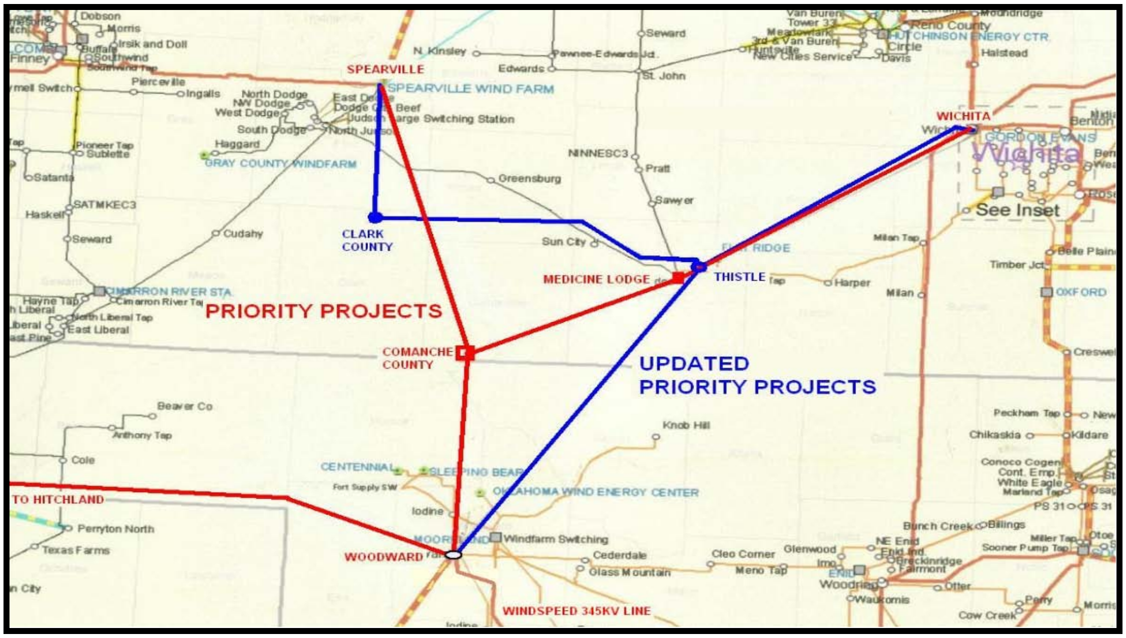
ITC Great Plains, provided updates for the SPP Priority Projects connecting the Spearville 345 kV substation to the Wichita 345 kV substation as well as the circuit to the south connecting to the Woodward 345 kV substation. These projects were updated to reflect the following interconnections:

- Spearville-Clark County-Thistle-Wichita 345 kV double circuit line
- Thistle-Woodward 345 kV double circuit line

These changes effectively replace the modeled Comanche County and Medicine Lodge substations with the Clarke County and Thistle substations as shown in Figure 2-1.

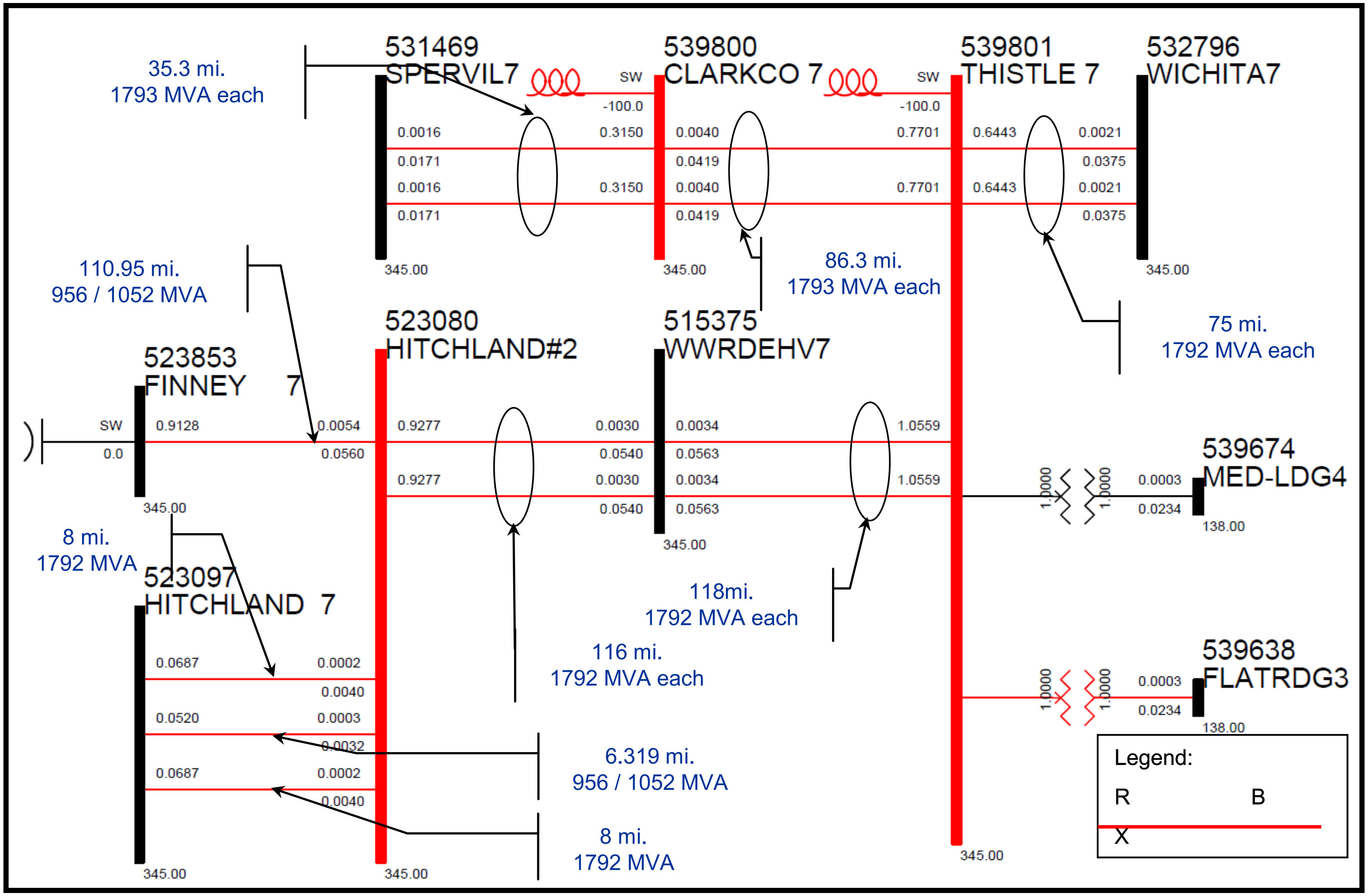
In Figure 2-1, the red lines indicate the original topology while the blue lines indicate the modified topology. (Note that the lines are not indicative of proposed or final routing, but merely representative of electrical system topology).

Figure 2-1 SPP 2011 Build 2 Case Update with Priority Projects



ITP Great Plains also provided the corresponding impedances and lengths for the updated topology. The data is shown in Figure 2-2 below.

Figure 2-2: Priority Project Updates - Line Parameters



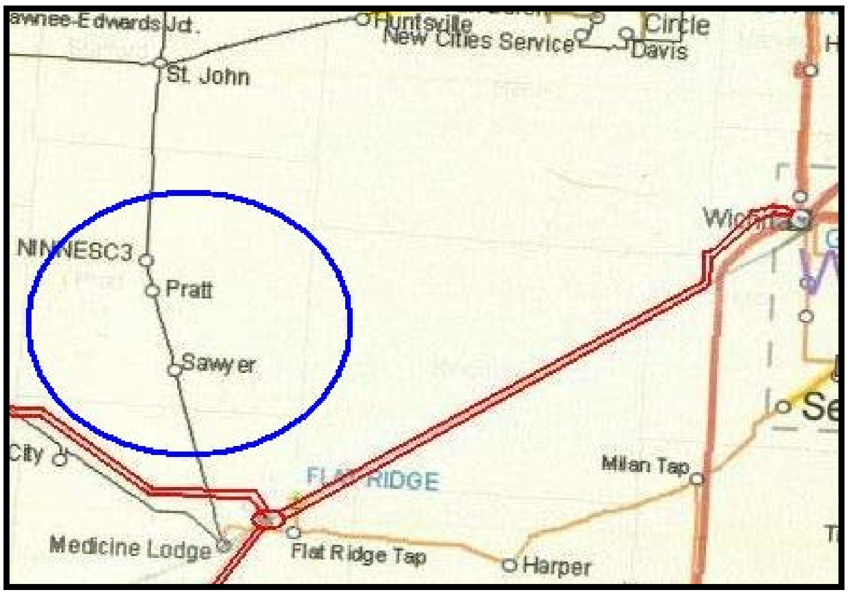
2.2.2 Additional Updates to the Build 2 Topology

The GBX study follows and benefits from the Clean Line Plains & Eastern HVDC (PE) study in that a number of relevant Pre-Project contingency overloads (i.e. contingencies that were made worse by the project by more than 5%) were identified and resolutions determined for all of them during the P&E study. These relevant Pre-Project contingency overloads are directly applicable to the GBX study and for completeness the resolutions are summarized below.

2.2.2.1 Sawyer-River Road-Pratt 115kV line

A recurring overload was identified within the analysis on Sunflower Electric's (SUNC) 115 kV lines connecting SAWYER 3 (539649) to RVROAD (539651) to PRATT 3 (539687). During stakeholder review of these overloads SUNC informed Siemens PTI that the ratings of these lines had been increased from 79.7 MVA to 202.2 MVA. This rating change resulted in no further overloads of this circuit. A map of the area is given in Figure 2-3.

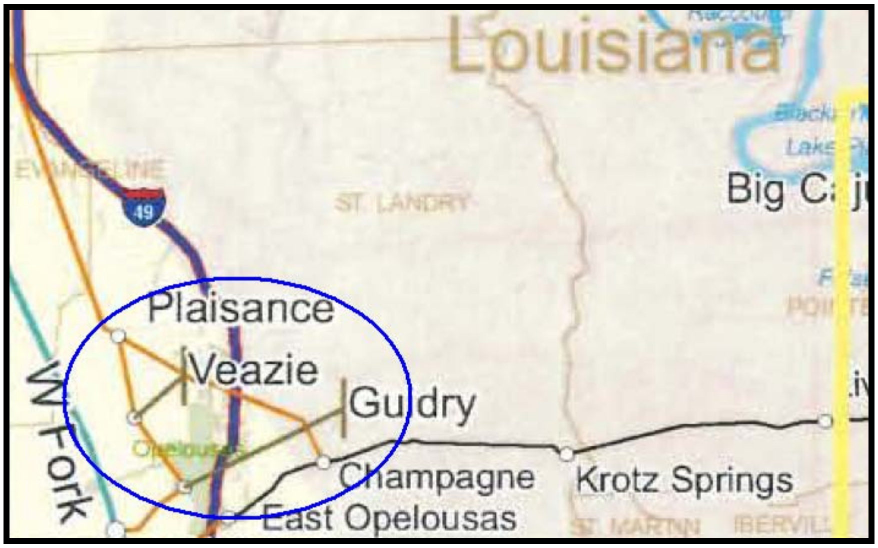
Figure 2-3 Sawyer - River Road - Pratt 115kV Line



2.2.2.2 Champagne-Plaisance 138kV line

The Champagne-Plaisance 138kV line (Entergy area) experienced significant contingency overloads under all the cases analyzed. Entergy issued upgrade information increasing the rating from 191 MVA to 287 MVA resolving the overloads. A map of the area is given in Figure 2-4.

Figure 2-4 Champagne-Plaisance 138kV Line



2.2.2.3 Leland Olds 345kV transformers

The Leland Olds 345kV transformers in WAPA were overloaded under contingency conditions in all the cases evaluated. WAPA provided an upgrade that replaces the existing 250 MVA transformer with a 600 MVA three-winding transformer resolving the overloads observed.

2.2.2.4 Meadowlark-Tower 33 115kV line

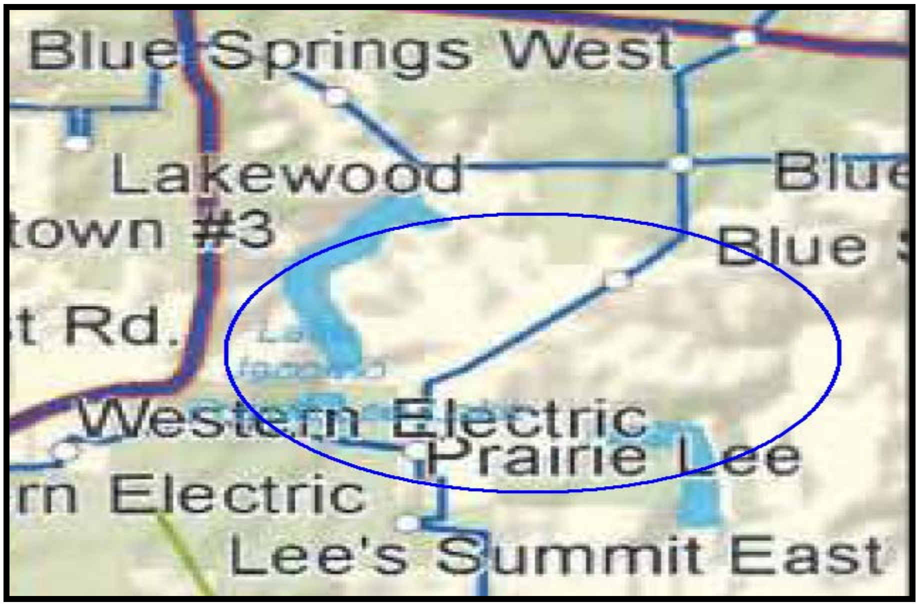
The Meadowlark-Tower 33 115kV line was overloaded by the outage of a parallel element under all cases. SPP indicated the contingency was invalid thus the overload was ignored in the study. A map of the area is given in Figure 2-5.

Figure 2-5 Meadowlark - Tower 33 115kV Line

2.2.2.5 Prairie Lee-Blue Spring South 161kV line

The Prairie Lee-Blue Spring South 161kV line was overloaded during contingency in the 2022 Summer Peak case. SPP provided an upgrade that increased the rating from 224 MVA to 558 MVA resolving the overload. A map of the area is given in Figure 2-6.

Figure 2-6 Prairie Lee - Blue Springs South 161kV Line



2.2.2.6 TSE-East 61st Street 138kV line

The TSE-East 61st Street 138kV line was overloaded in the 2017 Summer Peak case under contingency. The contingency resulting in the overload was determined to be invalid by the SPP therefore the overload was ignored in the study. A map of the area is given in Figure 2-7.

Figure 2-7 TSE - East 61st Street 138kV Line

2.2.2.7 Victory Hill 230/115kV transformers

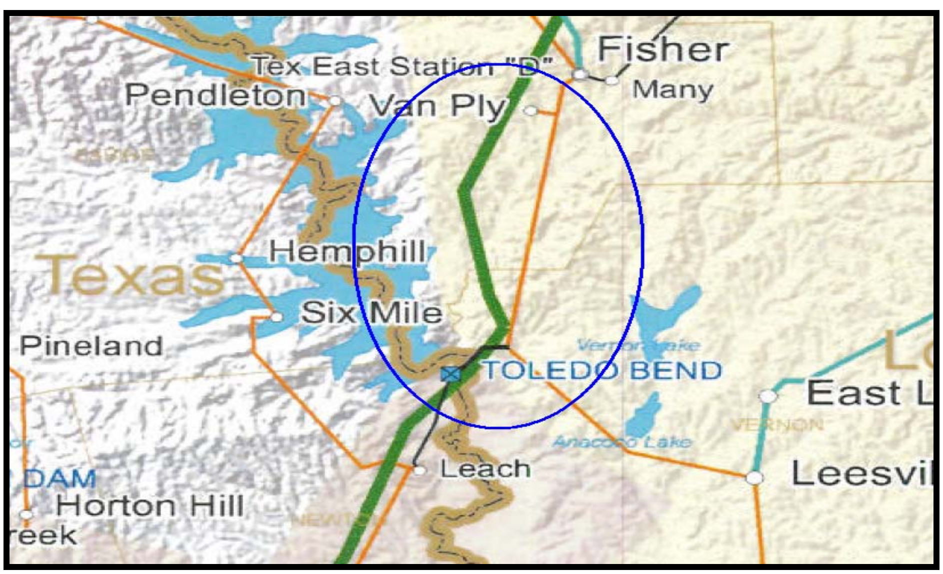
The Victory Hill 230/115kV transformers observed significant increases in contingency loadings in all the cases evaluated. SPP indicated there was an operational solution resolving the overloads. Procedure 2 of the SPP Operating Guides addresses the issue by reducing the generation at Laramie River and across the DC ties to reduce the loading to acceptable operating limits. A map of the area is given in Figure 2-8.

Figure 2-8 Victory Hill

2.2.2.8 Toledo-Van Ply 138kV line

The Toledo-Van Ply 138kV line (Entergy) overloaded during contingency conditions. Entergy indicated that its Horizon Plan, Project 11-ETI-014-HZ will upgrade the line rating from 143 MVA to 339 MVA eliminating the overload condition. A map of the area is given in Figure 2-9.

Figure 2-9 Toledo - Van Ply138kV line

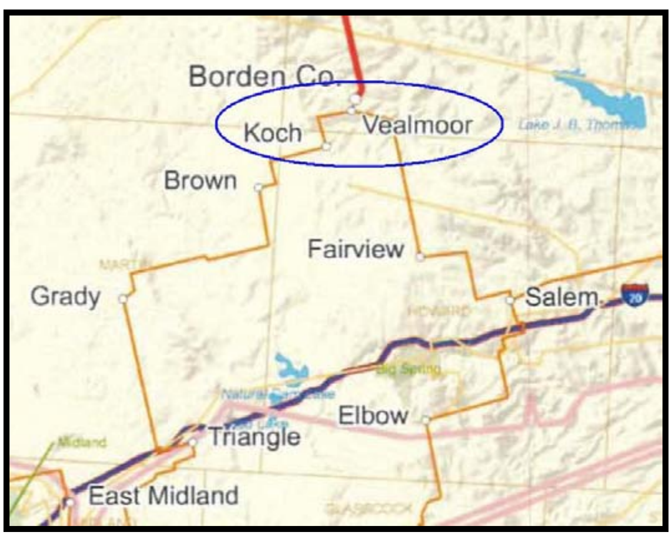


2.2.2.9 CAPROCK facilities moving to the ERCOT

The SPP has indicated that a portion of the SPP system owned by CAPROCK that will be moving into the ERCOT system. SPP is aware of problems that are noted in the studies; specifically, the loss of either of two sources (GARNDALE or VEALMOOR) into the CAPROCK territory results in low voltages and overloads of the remaining supply. This issue is slated for solution when the facilities are moved into ERCOT. A map of the area is given in Figure 2-10 and Figure 2-11.

Figure 2-10 Garndale

Figure 2-11 Vealmoor

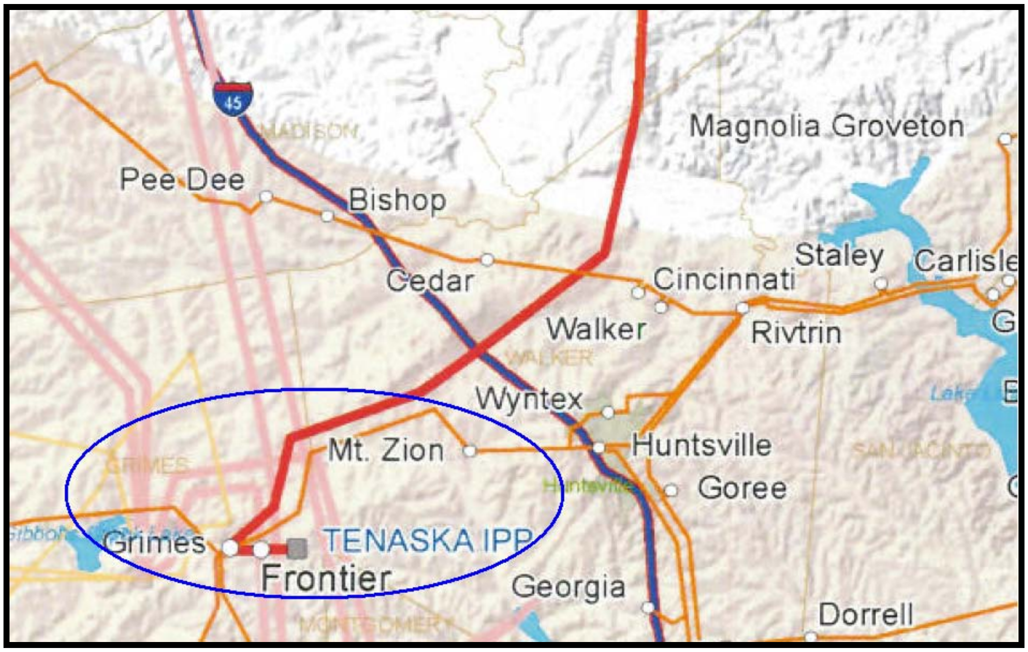


2.2.2.10 Grimes-Mt Zion 138kV line

The Grimes-Mt Zion 138kV line was observed to overload under contingency. Entergy indicated its Horizon Plan Project 11-ETI-014-HZ will upgrade the line together with the

Toledo-Van Ply 138kV line raising the rating from 206 MVA to 339 MVA eliminating the overload. A map of the area is given in Figure 2-12.

Figure 2-12 Grimes - Mt Zion 138kV Line



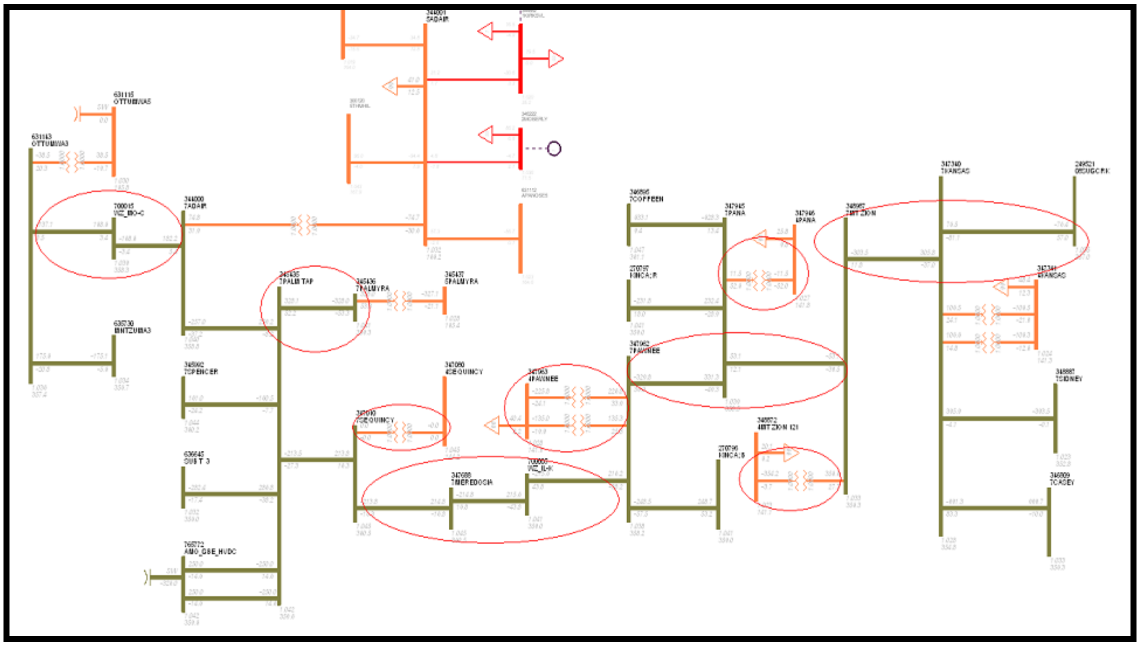
2.2.2.11 MISO Multi-Value Projects (MVP)

When connecting the Project into the MISO system we observed overloads in the vicinity of Palmyra Tap. Further investigation identified a number of committed MISO Multi Value Projects (MVP) that resolved the overloads observed. The projects that resolved the overloads were:

- Ottumva – MO wind zone – Adair 345kV lines
- Adair 345/161kV transformer
- Palmyra Tap – Palmyra 345kV line
- Quincy – Meredosia – WZ IL – Pawnee – Pana – Mt Zion – Kansas – Sugar Creek 345kV lines
- 345/138kV transformers at Quincy (1), Pawnee (2), Pana (1) and Mt Zion (1)

Figure 2-13 shows the additions on a one-line of the area. It is important to note that not all the MISO MVPs were added to the cases.

Figure 2-13 MISO MVP's



2.3 Topology Changes to the 2011 ITP Cases

The ITP Near-Term cases already contained the updated system topology for the Priority Projects so the changes required were limited to introducing the new Hitchland-2 substation, the Project and the adjustments indicated Section 2.2.2, above.

Additionally, during the course of the study of the ITP Near-Term cases, the 115kV line from SHELDON7 to FOLSM&PHIL7 was found to be overloaded during contingency conditions. Further investigation indicated that the rating of this line was only 43 MVA and it was parallel to another SHELDON7 to FOLSM&PHIL7 115kV line with a rating of 240MVA. This was obviously a mistake that was confirmed with SPP and the line was taken out of service within the models.

2.4 GBX Modeling Assumptions

The Project was incorporated in the Build 2 cases and ITP cases by:

a) Connecting the western converter station to the Clark County 345 kV substation in SPP.
b) In AMMO the converter was connected to an existing Palmyra Tap (bus number 345435) station and
c) In PJM to Sullivan 765 kV (bus number 243210) via a short lines and 345/765 kV transformers at the converter station.

Figure 2-14 below shows the approximate location of the terminals; line route not shown.

At the time the cases were developed this was the best information available for the connection to the AMMO and AEP, although this maybe further adjusted as the respective interconnection procedure advances.   However the impact in SPP system of these adjustments are expected to be negligible.

Figure 2-14 GBX HVDC Project Illustration to Palmyra Sullivan

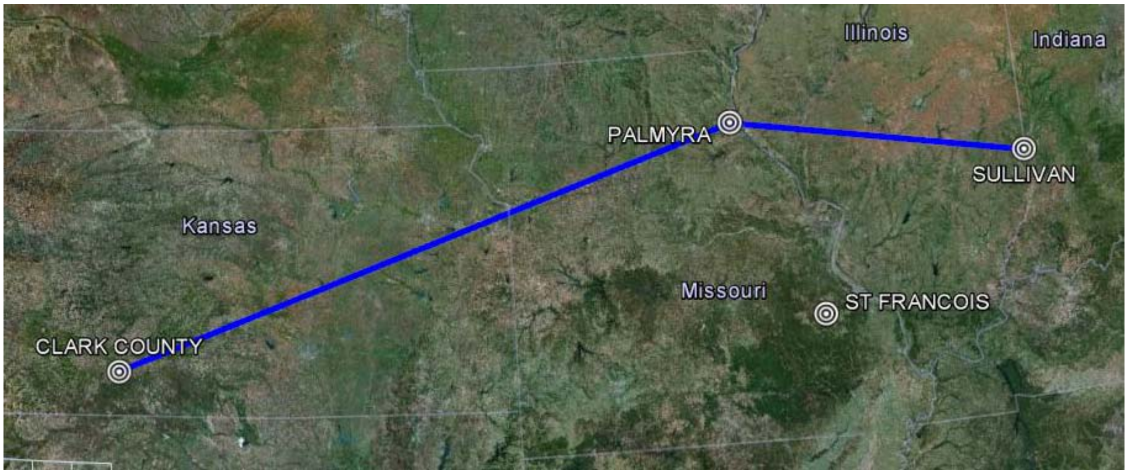
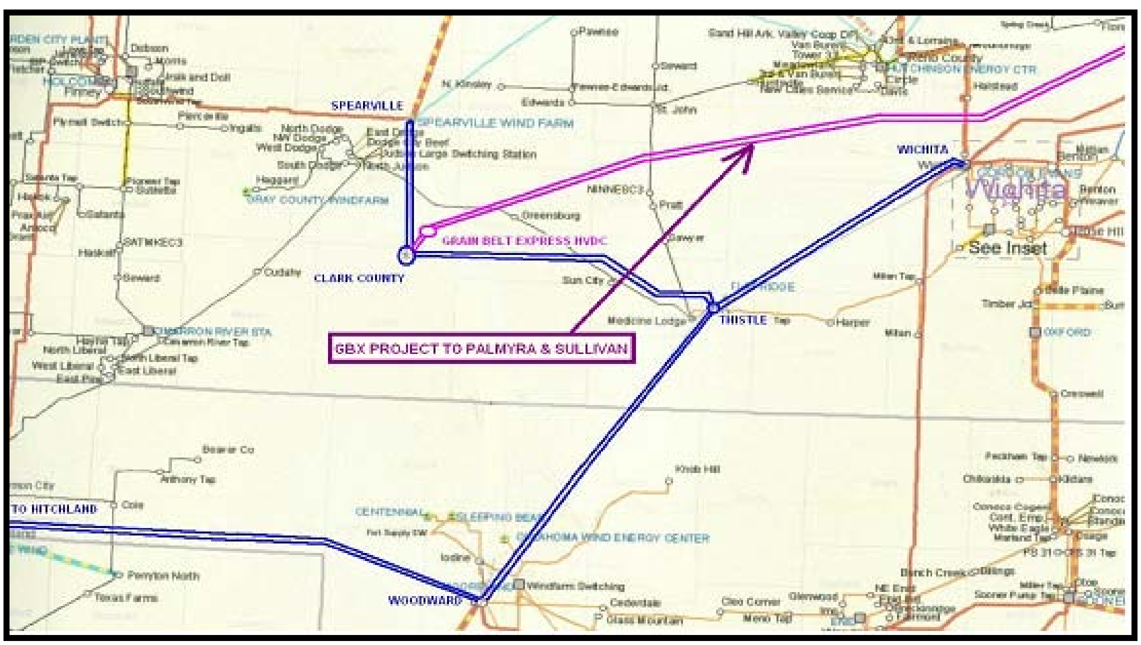


Figure 2-15 shows an overview of the interconnection of the SPP terminal to the Clark County Substation. The map is for illustrative purposes only and does not represent or imply a proposed route.

Figure 2-15: GBX HVDC Interconnection at Clark County



Reactive compensation was added at all ends of the three-terminal HVDCs.

The reactive power compensations at both the Clark County and Sullivan is at 2,100 MVARs for each substation (5x420 MVARs), this is approximately 54% of the maximum active power at Clark County and 66% at Sullivan.

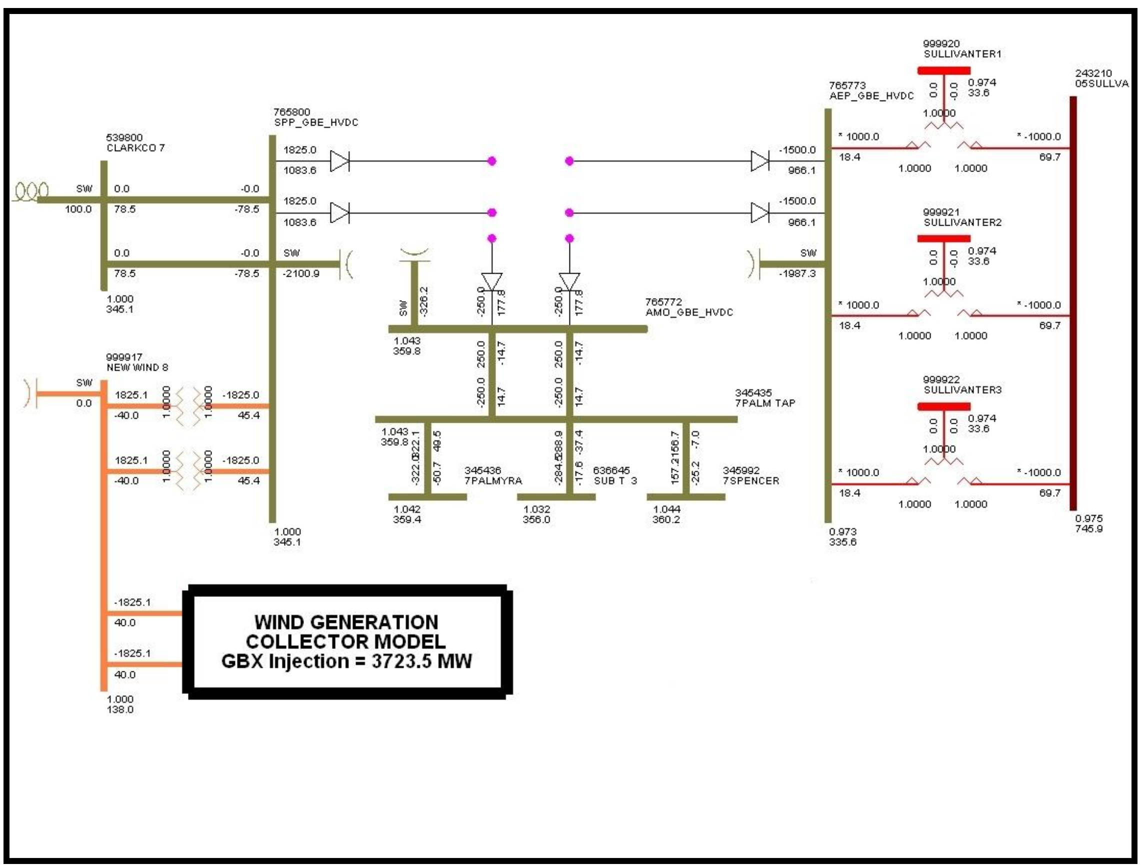
A reactive power compensation of 400 MVAR (4x100 MVARs) was placed at the Palmyra Tap to accommodate the import of 500 MW; 80% of the injected active power.

The reactive compensation at Palmyra Tap is greater than the typical expected values due to the nature of the multi-terminal operation modeled that in the case of the smaller inverter at Palmyra was found to consume about 71% of the injected active power. In the case of Sullivan the greater compensation serves the dual purpose of allowing the injection of the entire 3,500 MW into PJM or provide for the slightly higher reactive compensation needs when multi-terminal operation is in place (64% of the reactive power.)

It is anticipated that part of this compensation will be provided by Synchronous Condensers during the stability evaluations.

Figure 2-16 shows the Project's connections with and flows between the SPP system in the 2017 Summer Peak case. In this figure, we note that the project's interconnected WTG is dispatched at 3,723 MW and it is connected radially to the converter station (SPP_GBE_HVDC). There is zero active power exchange and approximately 157 MVAR is imported from SPP.

Figure 2-16 2017 Summer Peak Project Connections



In the figure above, we note that there is a relatively small reactive power exchange between SPP and the Project. This reactive power exchange is due to voltages at nearby 345kV buses (e.g. Woodward, Thistle and Holcomb) which are slightly above 1.0 pu and as the convertor voltage is maintained 1.0 pu there is some absorption of reactive power.

Table 2-12 shows the parameters used for modeling the HVDC link (only one pole is shown, the second pole is identical but reverse voltage). In this table we observe that the HVDC link is rated 600kV.

Table 2-12 Multi-Terminal HVDC Model – Converter and Line Data

Line Name	Control Mode	Number of Converters	Number of DC Bus	Number of DC Link	Vcmode (kV)	+ pole inverter AC bus	- pole inverter AC bus
1	Power	3	6	6	300	765773	0
2	Power	3	6	6	300	765773	0

Converter Number	Bus Number	Bus Name	Pole (Pos/Neg)	Min (deg)	Max (deg)	Setval (deg)	Nb
1	765800	SPP_GBE_HVDC345.00	1	5	24	1825	1
2	765772	AMO_GBE_HVDC345.00	1	15	25	-250	1
3	765773	AEP_GBE_HVDC345.00	1	15	25	600	1

Converter Number	Ebase (kV)	Rc (ohms)	Xc (ohms)	Transformer Ratio (pu)	Tap (pu)	Tap Min (pu)	Tap Max (pu)	Tap Step (pu)	Margin (pu)	Participation factor
1	345	0	26.31	1.572	1	0.85	1.15	0.00625	0	1
2	345	0	185	1.552	1.01875	0.85	1.15	0.00625	0	1
3	345	0	30	1.5344	0.96875	0.85	1.15	0.00625	0	1

DC Bus Number	DC Bus Name	Converter Bus	Area Num	Zone Num	Owner Num	RG (ohms)	DC Bus Second
1	DC_RECT	765800	26	260	1	9999	0
2	DC_RECT_P	None	26	260	1	9999	0
3	DC_INV2_P	None	40	404	1	9999	0
4	DC_INV1	765772	40	404	1	9999	0
5	DC_INV2	765773	40	404	1	9999	0
6	DC_INV1_P	None	26	260	1	9999	0

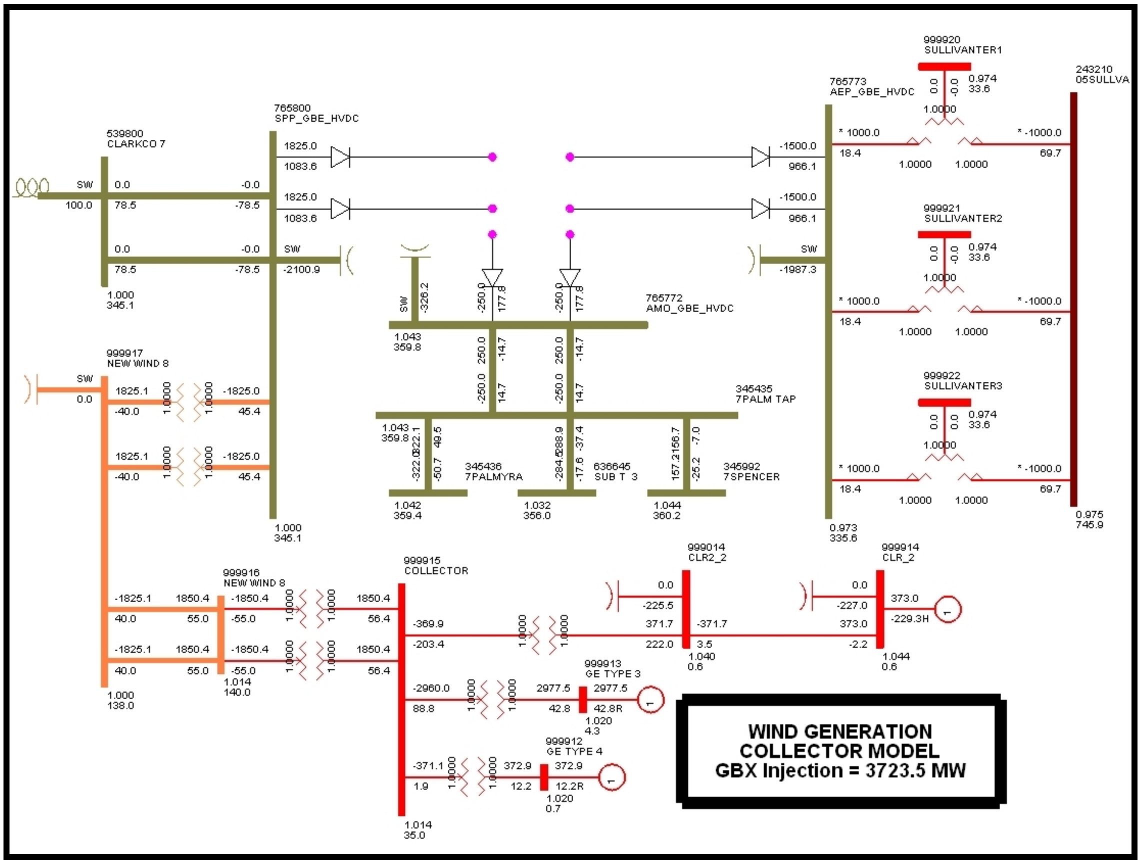
DC Link	From DC Bus	From DC Name	To DC Bus	To DC Name	Id	Metered	Rdc (ohms)	LDC Mh
1	1	DC_RECT	2	DC_RECT_P	1	1	0.02	500
2	2	DC_RECT_P	6	DC_INV1_P	1	1	8.73	0
3	6	DC_INV1_P	3	DC_INV2_P	1	1	2.8	0
4	3	DC_INV2_P	4	DC_INV1	1	1	0.02	500
5	3	DC_INV2_P	5	DC_INV2	1	1	0.02	500
6	6	DC_INV1_P	4	DC_INV1	1	1	0.02	500

2.4.1 Collector System Model (Steady State)

A very simplified collector system was modeled for the steady state study as the objective of the study is focused around the external impacts of the Project's associated generation flowing in the underlying system during contingencies. The steady-state model was constructed considering three representative groups of wind turbine generation connected via a 600V/34.5kV step up transformer to a Collector substation where the voltage was elevated to 138kV. From this substation, two short equivalent lines connect to the rectifier.

This equivalent representation of the collector circuit is shown in Figure 2-17. The collector system for the stability study is far more advanced looking at expected locations for wind sites relative to the proposed HVDC rectifier site. The stability collector model will be further described in the Short Circuit Section of the report. This expanded collector model employs 345kV lines to wind locations as far as 40 miles from the HVDC rectifier station and a collector system to accommodate type 3 and type 4 wind turbines.

Figure 2-17: GBX HVDC Project Addition & WTG Model (For Steady-State Purposes Only)



Section

3

Study Methodology

3.1 Affected Parties

The Affected Parties are those transmission owners whose facilities are affected by the presence of the project; that is the owners of those facilities whose loading changes appreciably when the Project is in service with respect to the case when the Project does not exist.

We present below an overview of the procedure employed to provide a deterministic way to determine the facilities affected by the project and ultimately who the Affected Parties are.

This procedure was structured to be as inclusive as possible and it included, as a potentially affected party, not only the owners of facilities that could overload due to the project, but also the owner of facilities that see a significant change of loading (e.g. greater than 5% of the facility's rating). This procedure insured that all potentially affected parties under the various topologies and dispatches considered are directly involved in the study and the formulation of key modeling assumptions.

The potentially affected parties list is divided into the following groups:

- All Areas in the SPP footprint (SPP Area)
- Areas which are part of the Southeast Electric Reliability Corporation (SERC) footprint, located between SPP and the project delivery points.
- Areas that as part of Midwest Reliability Organization (MRO), located between SPP and the project delivery points.
- Selected but extensive MISO Areas located between SPP and the project delivery points.

The initial selection of affected parties was done when the project was expected to be terminated at the Saint Francois substation in AMMO. However, as the project progressed the delivery point was extended to AEP in the PJM. Thus, at that time AEP (Area 205) was added to the affected party list. However, as PJM does not have an interface (seam) with SPP and an independent interconnection request will be conducted in that interconnection, no further affected parties were identified.

Table 3-1 to Table 3-5 below show the definition of areas and area numbers as in the PSS®E Load flow case.

Table 3-1 SPP Balancing Authority Areas

SPP Balancing Authority Areas		
Area No.	PSS NAME	AREANAME
520	AEPW	American Electric Power West
545	INDN	City of Independence, MO (Independence Power & Light)
503	LAFA	City of Lafayette, Louisiana (BA & RC)
546	SPRM	City Utilities of Springfield, MO
502	CELE	CLECO Power, LLC (BA & RC)
544	EMDE	Empire District Electric
523	GRDA	Grand River Dam Authority
542	KACY	Kansas City Board of Public Utilities
541	KACP	Kansas City Power & Light
504	LEPA	Louisiana Energy & Power Authority
539	MKEC	Mid-Kansas Electric Company
531	MIDW	Midwest Energy
540	MIPU/GMO	Missouri Public Service/GMO
524	OKGE	OG&E Electric Services
527	OMPA	Oklahoma Municipal Power Authority
515	SWPA	Southwestern Power Administration
526	SPS	Southwestern Public Service
534	SUNC	Sunflower Electric
536	WERE	Westar Energy
525	WFEC	Western Farmers Electric Cooperative

Table 3-2 SPP Reliability Coordinator Areas

SPP Reliability Coordinator Areas		
Area No.	PSS Name	Area Name
331	BCA	Batesville Control Area (SPP RC)
335	CONWAY	CECD, LLC – Conway (SPP RC)
334	WESTMEMP	CECD, LLC - West Memphis (SPP RC)
336	BUBA	City of Benton, AR (SPP RC)
360	CWLP	City Water, Light & Power – Springfield, IL (SPP RC)
339	DENL	DECA, LLC - North Little Rock (SPP RC)
338	DERS	DECA, LLC – Ruston (SPP RC)
337	PUPP	Union Power Partners, LLC (SPP RC)

Table 3-3 SERC Areas

SERC Areas		
Area No.	**PSS Name**	**Area Name**
330	**AECI**	Associated Electric Cooperative, Inc
362	**EEI**	Electric Energy, Inc

Table 3-4 MRO Areas

MRO Areas		
Area No.	**PSS Name**	**Area Name**
640	**NPPD**	Nebraska Public Power District
645	**OPPD**	Omaha Public Power District
650	**LES**	Lincoln Electric System
652	**WAPA**	Western Area Power Administration

Table 3-5 MISO Areas

MISO Areas		
Area No.	**PSS Name**	**Area Name**
202	**FE**	FirstEnergy Corporation
207	**HE**	Hoosier Energy Rural Electric Cooperative
208	**DEM**	Duke Energy Business Services
210	**SIGE**	Southern Indiana Gas & Electric (Vectren)
216	**IPL**	Indianapolis Power & Light
217	**NIPS**	Northern Indiana Public Service Company
218	**METC**	Michigan Electric Transmission Company
219	**ITCT**	International Transmission Company
295	**WEC**	Wisconsin Electric Power Company
314	**BREC**	Big Rivers Electric Corporation
333	**CWLD**	City of Columbia. Missouri Water & Light Department
356	**AMMO**	Ameren Missouri
357	**AMIL**	Ameren Illinois.
360	**CWLP**	City Water, Light & Power (Springfield, Illinois)
361	**SIPC**	Southern Illinois Power Cooperative
600	**XEL**	Xcel Energy
608	**MP**	Minnesota Power
613	**SMMPA**	Southern Minnesota Municipal Power Agency
615	**GRE**	Great River Energy
620	**OTP**	Otter Tail Power Company

MISO Areas		
Area No.	**PSS Name**	**Area Name**
627	**ALTW**	Alliant Energy
633	**MPW**	Muscatine Power and Water
635	**MEC**	MidAmerican Electric Company
661	**MDU**	Montana-Dakota Utilities Company
680	**DPC**	Dairyland Power Cooperative
694	**ALTE**	Alliant Energy
696	**WPS**	Wisconsin Public Service
697	**MGE**	Madison Gas & Electric
698	**UPPC**	Upper Peninsula Power Cooperative

3.1.1 Affected Parties Impact Criteria

All 100kV and above rated facilities in the case were monitored and the facilities loading was checked against Rate A. Note that rating A was selected for the calculation of loading to make the list as inclusive as possible although for contingency Rate B is generally used.

The affected facilities are divided based on three criteria (1, 2 and 3) based on the severity of the impact due to the project. An affected facility will be those facilities that meet one of the following criteria:

Criteria 1: Those facilities that are loaded to greater than or equal to 100% in the Post-Project Case but are loaded less than or equal to 100% in the Pre-Project Case. These parties and facilities are considered the most affected by the inclusion of the project.

Criteria 2: Those facilities loaded to greater than or equal to 100% in both the Post- and Pre-Project Cases. This list of facilities is divided into two sub-groups:

- Criteria 2.1 - Those facilities that have a Transfer Distribution Factor (TDF) greater than or equal to 3% (calculated based on a transfer of 1825 MW)
- Criteria 2.2 - Those facilities that have a TDF of less than 3% but there is an increase in MVA flow greater than or equal to 5% from Pre-Project to Post-Project Case (Based on Rate A).

Criteria 3: Those facilities loaded to less than 100% in both the Post- and Pre-Project Cases. The facilities are divided into two groups:

- Criteria 3.1 - Those facilities that have a Transfer Distribution Factor (TDF) greater than or equal to 3% (calculated based on transfer level of 1825 MW)

- Criteria 3.2 - Those facilities that have a TDF of less than 3% but there is an increase in MVA flow greater than or equal to 5% from Pre-Project to Post-Project Case (Based on Rate A).

The facilities falling in these criteria would not necessarily overload due to the presence of the project, however, as the project has the potential of a significant impact in the flows, the facilities falling under this criteria (either in terms of TDF or % increase in loading) makes the element significant.

3.1.2 Affected Parties

The affected parties were identified by monitoring the facilities that fall into any of the criteria above when a pole is lost. This analysis was conducted using linear DC approximation to appropriately capture the expected delta change. Table 3-6 and Table 3-7 show the results of this study and the selected parties.

Table 3-6: SPP Potentially Affected Parties

		Number of Affected Facilities					
		Criteria 1	Criteria 2		Criteria 3		
Area	Name	1	2.1	2.2	3.1	3.2	Total
536 WERE	Westar Energy	0	0	0	12	54	66
539 MKEC	Mid-Kansas Electric Company	0	0	0	5	41	46
534 SUNC	Sunflower Electric	0	0	0	10	16	26
540 MIPU/GMO	Missouri Public Service / GMO	0	0	1	11	14	26
520 AEPW	American Electric Power West	1	0	0	6	18	25
524 OKGE	OG+E Electric Services	0	0	0	2	21	23
541 KACP	Kansas City Power & Light	0	0	0	4	16	20
525 WFEC	Western Farmers Electric Cooperative	0	0	0	2	14	16
531 MIDW	Midwest Energy	0	0	0	4	11	15
526 SPS	Southwestern Public Service	0	0	0	1	8	9
544 EMDE	Empire District Electric	0	0	0	0	8	8
515 SWPA	Southwestern Power Administration	0	0	0	0	5	5
546 SPRM	City Utilities of Springfield, MO	0	0	0	0	3	3
523 GRDA	Grand River Dam Authority	0	0	0	1	0	1
545 INDN	Independence Power & Light	0	0	0	0	1	1

Table 3-7: Non-SPP Potentially Affected Parties

		Number of Affected Facilities					
		Criteria 1	Criteria 2		Criteria 3		Total
Area	Name	1	2.1	2.2	3.1	3.2	
627 ALTW	Alliant Energy W	1	0	2	9	168	**180**
330 AECI	Associated Electric Cooperative, Inc	1	0	0	5	169	**175**
635 MEC	MidAmerican Electric Company	0	0	0	21	109	**130**
600 XEL	Xcel Energy	2	0	1	37	83	**123**
356 AMMO	Ameren	2	0	0	37	67	**106**
652 WAPA	Western Area Power Administration	0	0	1	5	64	**70**
652 WAPA	Western Area Power Administration	0	0	1	5	64	**70**
640 NPPD	Nebraska Public Power District	0	0	0	9	60	**69**
694 ALTE	Alliant Energy E	0	0	0	8	45	**53**
680 DPC	Dairyland Power Cooperative	0	0	0	0	50	**50**
615 GRE	Great River Energy	1	0	1	0	37	**39**
645 OPPD	Omaha Public Power District	0	0	0	5	22	**27**
217 NIPS	Northern Indiana Public Service Company	0	0	0	9	12	**21**
218 METC	Michigan Electric Transmission Company	0	0	0	0	16	**16**
698 UPPC	Upper Peninsula Power Cooperative	2	0	0	0	13	**15**
361 SIPC	Southern Illinois Power Cooperative	0	0	0	0	9	**9**
620 OTP	Otter Tail Power Company	0	0	0	0	6	**6**
360 CWLP	City of Springfield Water, Light & Power	0	0	0	0	5	**5**
633 MPW	Muscatine Power & Water	0	0	0	0	5	**5**
207 HE	Hoosier Energy Rural Electric Cooperative	0	0	0	0	3	**3**
208 DEM	Duke Energy Business Services	1	0	0	0	2	**3**
333 CWLD	City of Columbia Water & Light Department	0	0	0	0	3	**3**
608 MP	Minnesota Power	0	0	0	0	3	**3**
362 EEI	Electric Energy, Inc	0	0	0	0	3	**3**
650 LES	Lincoln Electric System	0	0	0	1	0	**1**

The parties noted were contacted to participate as an Ad Hoc Stakeholder group which, as mentioned previously, was expanded to include AEP and also included the parties affected by the P&E project, due to the simultaneous nature of both studies.

3.2 Contingency Development

3.2.1 Contingency Definitions

An initial screening of all potentially Affected Parties was performed by evaluating the change in flows on all lines as previously described.

Contingency lists and the associated subsystem and monitored element files were requested of all identified Affected Parties and were provided by the following organizations:

- Southwest Power Pool (SPP)
- Southwestern Public Service Company (SPS/XCEL)
- Columbia, MO Water & Light (CWLD)
- Kansas City Power & Light (KCPL)
- KCP&L Greater Missouri Operations (GMO)
- Associated Electric Cooperative (AECI)

Appendix C contains the resultant subsystem, monitored element, and contingency files from the combination of the received information.

3.2.2 Contingency Reduction

When all supplied contingencies were combined and overlapping contingencies were eliminated, the final contingency set consisted of over 10,000 contingencies. In order to reduce the number of contingencies to include only those that would be relevant to the study, a “DC Load Flow” contingency analysis was performed on a Pre-Project and Post-Project[8] cases.

A comparison was performed between the Pre and Post Project and cases by evaluating the change in flows in all monitored elements. A contingency was retained for detailed AC analysis if, for the given contingency, one of the following were true:

a) A monitored element became overloaded in the Post-Project Case and it was not overloaded for the same contingency in the Pre-Project case, regardless of the change in loading.

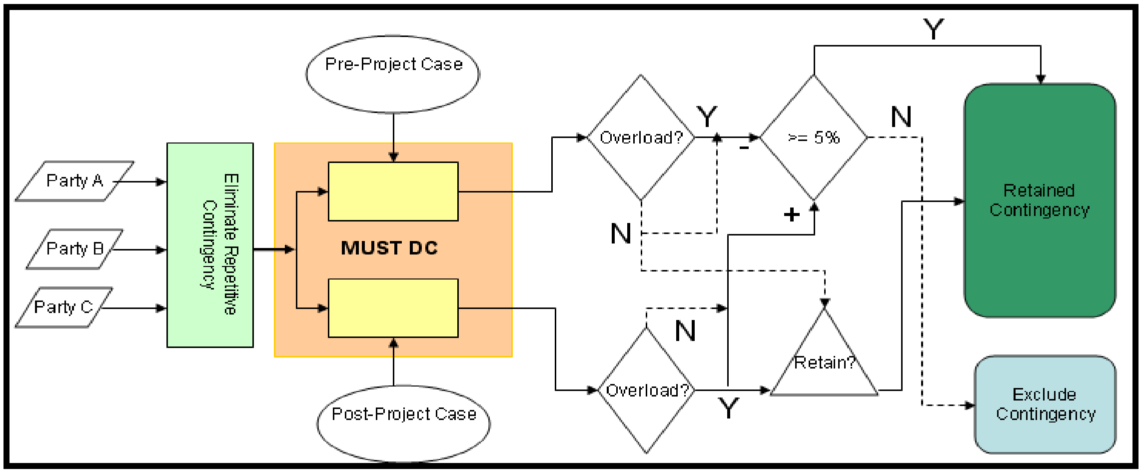
b) A monitored element was overloaded in both the Post-Project and Pre-Project cases for the same contingency and the monitored facility’s flow increased by 5% or more of the facilities’ rating from the Pre-Project and Post-Project conditions.

c) A monitored element was not overloaded in both the Pre-Project and Post-Project cases; however, a change in flow of more than 5% from the Pre-Project was recorded.

Figure 3-1 shows a flow chart of this contingency screening process.

[8] “Post-Project” refers to the case in which the Project is in service, but one pole has been tripped and approximately 1750 MW is being injected into the Clark County substation from the radially connected wind.

Figure 3-1: Contingency Reduction Process



In the special case that an element became overloaded by multiple contingencies, the worst contingency was selected and a more detailed investigation was conducted. In the case that the worst contingency was an N-2 situation, the worst N-1 contingency was also added to the contingency list.

Finally, all double circuit contingencies for the SPP Priority Projects were added to the contingency list.

From the original list of over 10,000 contingencies, the screening procedure reduced the final contingency list to 315 relevant/critical contingencies. This list was provided to the Affected Parties for review and discussion. Consensus was reached that the reduced contingency list would be adequate to ensure a robust study was conducted.

3.3 Monitored Elements

The list of monitored elements submitted by all parties was kept intact. This list basically consisted of all facilities rated 69 kV and above within all of SPP and other areas in SERC identified as affected.

3.4 Impact Assessment of the HVDC Project

Thermal and voltage impact assessments were conducted to investigate if the project would create facility overloads or voltage deviations that do not exist for that system topology in the given case absent the Project.

3.4.1 Thermal Assessment

Using the cases provided by SPP, thermal assessments were conducted using PSS®MUST version 10.2. The case topologies were modified as described in Section 2. Subsystem (*.sub) and monitored element (*.mon) files that were provided by the Affected Parties, and the reduced contingency (*.con) list, were also employed in these assessments.

No detailed Pre-Project assessment was conducted as this was fully documented in the Plains and Easter Steady State Report, however we checked that there were no Pre-Project contingency overloads that would be made worse by the GBX and thus mitigation was needed to be identified.

3.4.2 Voltage Assessment

Voltage assessment was conducted only for the N-1 condition (single pole DC outage of the Project) for all the years and scenarios considered. Per SPP's voltage operation guideline, it is considered that the bus/substation is in an acceptable condition if the bus/substation voltage is within the range of 0.9 p.u.-1.05 p.u., following a contingency[9]. For impact analysis, it is assumed that if a bus is within the specified range in the base case and the bus voltage deviates from this range due to the loss of a HVDC pole, then this is recognized as the Project introducing voltage deviations to the system that would need to be mitigated.

3.4.3 ITP vs. Build 2 Considerations Analysis

Analysis was conducted to evaluate what impact the GBX HVDC Project would have on the system under different dispatches and, in particular, those dispatches reflected in the ITP Near-Term Scenario 0 and Scenario 5 cases.

This analysis was conducted using the Build 2 results as a reference. An investigation was carried out- with emphasis on those post-contingency violations which can be observed in the ITP-NT cases but not in the Build 2 cases.

[9] Southwest Power Pool Criteria, January 30, 2012, Criteria 3.0, 3.3 Coordinated Planning, Sufficient reactive capacity shall be planned within the SPP electric system at appropriate places to maintain transmission system voltages 60 kV and above within plus or minus 5% of nominal voltage on all buses under normal conditions and plus 5% or minus 10% of nominal voltage on load serving buses under single contingency conditions.

Section

4

Base Contingency Analysis

In this section, thermal violations caused by the Project under the Build 2 Cases are presented. All results correspond to cases where the Pre-Project contingency loading is under 100% and loading of the same circuit is at or above 100% in a Post-Project case. Recall that no relevant Pre-Project contingency overloads remained unsolved.

The analysis presented provides the results of single pole outages (N-1), single pole outages coupled concurrent with a single contingency (N-1-1), a single pole outage concurrent with a double contingency (N-1-2), and finally the loss of both poles of the HVDC Project (N-2).

The contingency analysis was conducted without network adjustments in the solution; i.e. not allowing phase shifters or transformer taps to move.

Sensitivity to delivering 3,500MW directly to Sullivan versus 3,000MW to Sullivan and 500MW to Palmyra Tap was also conducted. This analysis did not produce additional situations of concern and, in general, the differences observed within SPP were on the order of 1%, with the higher loading levels observed in the case delivering 3,500MW to Sullivan.

The following results correspond to Post-Project Contingency Analysis with 3,000MW delivered to Sullivan and 500MW delivered to Palmyra Tap.

4.1 Post-Project 2017 Summer Peak Case

4.1.1 Post-Project 2017 Summer Peak Single Pole Outage (N-1)

The loss of a single pole of the Project does not result in any overloads.

4.1.2 Post-Project 2017 Summer Peak N-1-1 and N-1-2 Contingencies

Table 4-1 shows the N-1-1 overloads where we note that the most severe overloading occurs on the 345/230kV transformer at Spearville substation for the outage of Post Rock-Spearville 345kV line, as shown in Figure 4-1. This element has an increase in loading between Pre-Project and Post-Project conditions equal to over 72% of its 336 MVA rating, resulting in a 16% overload.

This transformer will also appear as affected on 2017 Winter Peak, 2022 Summer Peak, and 2022 Winter Peak conditions and ITP-NT Scenario 0 and the figure below provides insight on this overload as part of GBX generation goes back to Spearville, where one of the outlets at this substation is lost.

Figure 4-1 Situation for outage of line Spearville to Post Rock 345 kV

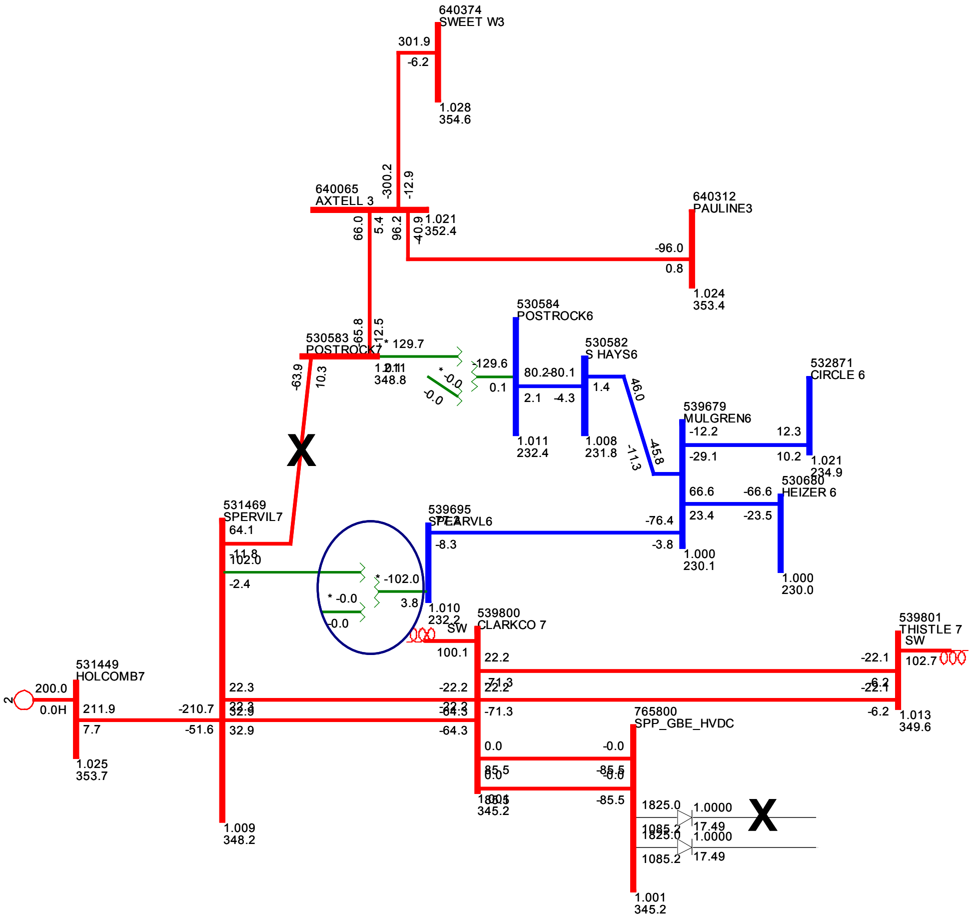


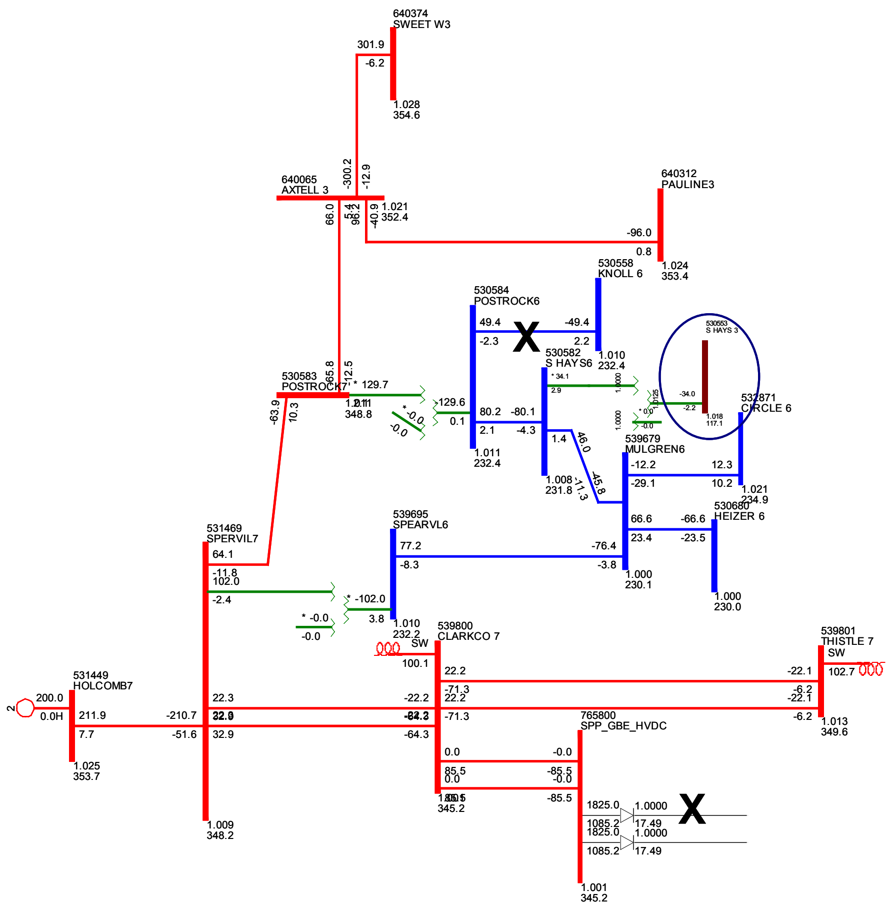
Table 4-1 Post-Project 2017 Summer Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	116.2	44.0	72.2	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	116.2	31.0	85.2	534 SUNC	534 SUNC
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	530558 KNOLL 6 230 530584 POSTROCK6 230 1	109.4	91.1	18.3	531 MIDW	531 MIDW
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	338138 5MORFLD 161 338142 5ISES-1 161 1	107.0	87.0	20.0	351 EES	515 SWPA
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	104.7	23.0	81.7	534 SUNC	534 SUNC
336138 6FAIRVW 230 336190 6GYPSY 230 1	LN	303204 6FRNSTL 230 336060 6SORR 2 230 1	100.7	98.3	2.4	351 EES	351 EES
336138 6FAIRVW 230 500510 MADISON6 230 1	LN	303204 6FRNSTL 230 336060 6SORR 2 230 1	100.2	97.8	2.4	351 EES	502 CLEC
541222 WSTELEC5 161 541224 LNGVW 5 161 1	LN	541218 GRNWD 5 161 541233 LEESUM 5 161 1	100.2	94.2	6.0	540 GMO	540 GMO

There is an 18% increase in loading in the 115 kV line Hays to S Hays when the 230 kV line to Knoll to Post Rock is out and a GBX pole outage occurs.

The reason for this overload can be observed in Figure 4-2 below as part of GBX generation flows at 230 kV towards Post Rock where the outage of the line to Knoll forces part of this flow to 115 kV creating the overload.

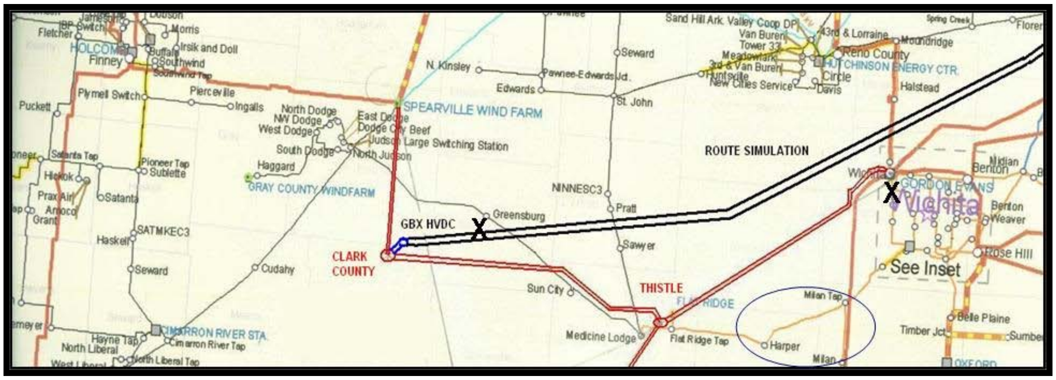
Figure 4-2 Situation for outage of line Post Rock to Knoll 230 kV



The overload on the Harper-Milan Tap 138kV will also be observed throughout the analysis. This line is experiences significant increase in loading from Pre-Project to Post-Project conditions, when there is one (or two) poles out of service.

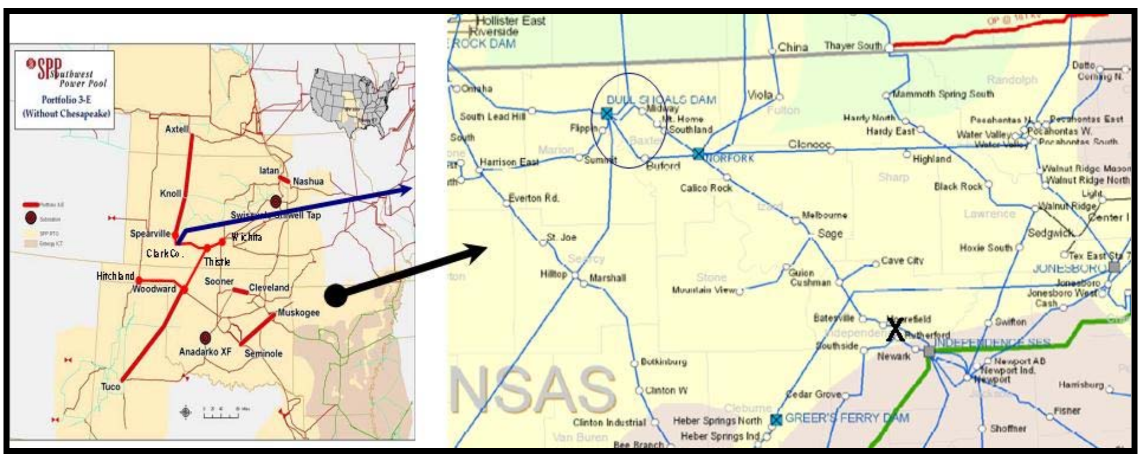
In Figure 4-3, we note that this 138 kV line is very close to the 345 kV lines connected to the project and largely parallels the lines out of Thistle; thus the increase in flow is expected under N-1, N-1-1, N-1-2 or N-2 contingency occurs.

Figure 4-3 2017SP: GBX Single Pole Outage + Evans N-S 138kV Line Outage



The Midway-Bull Shoals 161kV line is relatively remote from the injection point (Clark County) but the line is in the flow path to the AMMO and AEP. The line experienced a 20% increase in loading with the GBX pole outage for the loss of the Moorefield-Independence SES 161kV line. The approximate location of the impacted elements is shown in Figure 4-4.

Figure 4-4 2017SP: MIDWAY-BULL SHOALS 161kV Line (Entergy-SWPA)



The Gypsy-Fairview-Madisonville 230kV line (Entergy) and the WSTELEC5-LNGVW 5 161kV line (GMO) were overload when there is a GBX pole outage coupled with outages close to these transmission elements. In these cases, the Pre-Project loading was between 94% and 98% loading, indicating an already stressed situation. The relative locations of the transmission elements are shown in Figure 4-5 and Figure 4-6 which confirms that these elements are remote and the problem is largely a local issue.

Figure 4-5 2017SP: GYPSY-FAIRVIEW-MADISONVILLE 230kV Line (Entergy)

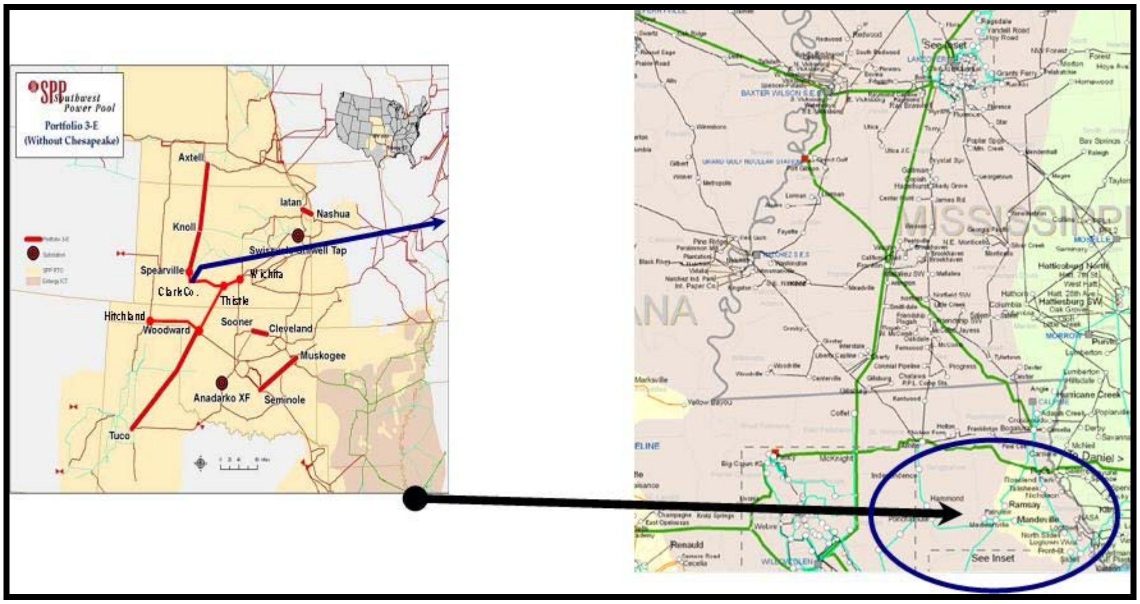


Figure 4-6 2017SP: WSTELEC5-LNGVW 5 161kV Line (GMO)

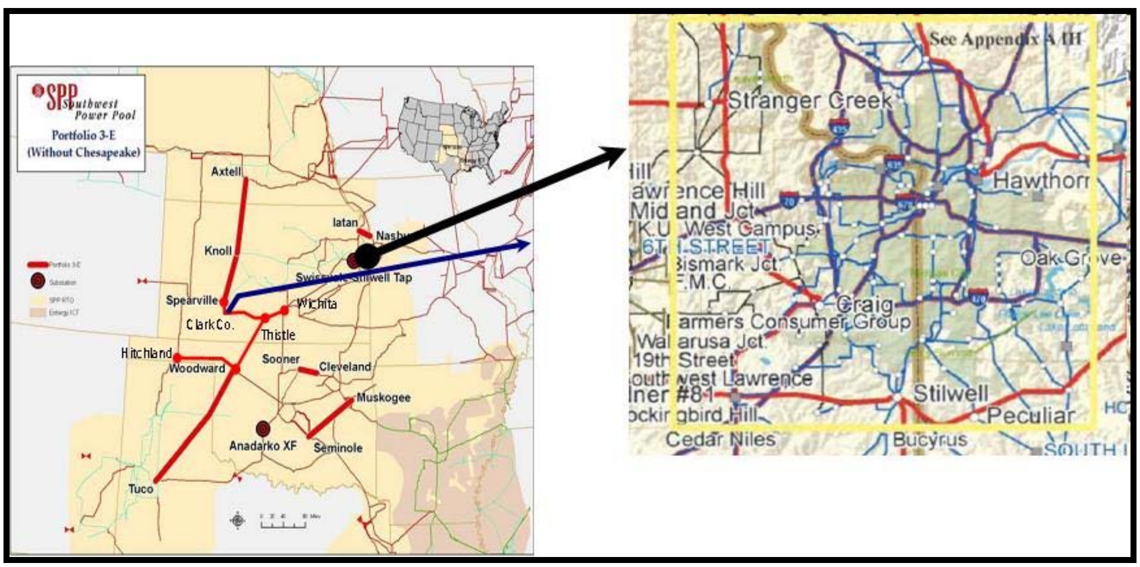


Table 4-2 shows the results for N-1-2 scenarios. As noted before, outages of the Priority Projects have most of the impact and this impact occurs in facilities already identified (Harper to Milan Tap 138kV line and Spearville 345/230 kV transformer).

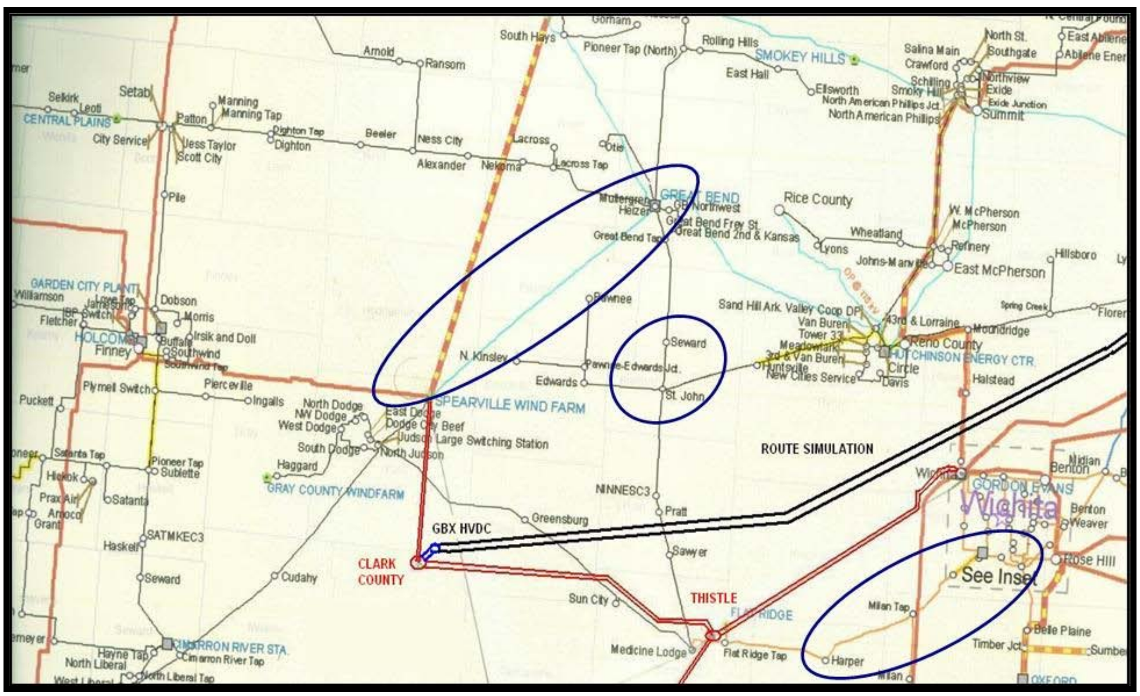
Table 4-2 Post-Project 2017 Summer Peak N-1-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	162.0	23.0	139.0	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	155.1	44.0	111.1	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	155.1	31.0	124.1	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	130.2	15.0	115.2	536 WERE	534 SUNC
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	108.4	23.0	85.4	534 SUNC	534 SUNC
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	102.2	14.0	88.2	534 SUNC	534 SUNC
300071 5CLINTN 161 300124 5HOLDEN 161 1	LN	AI-OG4A	100.1	99.4	0.7	330 AECI	330 AECI

The loss of one pole at the Project with the subsequent loss of the Clark County-Thistle or Wichita-Thistle 345kV double circuit lines diverts a significant amount of power to the underlying transmission grid, overloading transmission elements between Spearville and Wichita, as shown in Figure 4-7 below.

There is one contingency in the AECI territory that is listed in Table 4-2 where the affected line is loaded very close to 100% on a Pre-Project basis. The change in loading is less than any of the determinants used to define affected elements; the delta loading is less than 1% and the OTDF is 0.07%. Therefore, this overload is reported but not considered a result of the Project.

Figure 4-7 2017SP: N-1-2 & N-2 Contingency Analysis Reference Map



4.1.3 Post-Project 2017 Summer Peak Double Pole Outage (N-2)

Table 4-3 presents the results for the bi-pole outage (Category D Event per the currently NERC Standards).

Additional overloads due to large changes in flow from Pre-Project to Post-Project conditions occur in elements that were already identified as affected in previous sections of this report. For example, identified overloads include the Harper-Milan Tap-Clearwater 138 kV line and the Spearville 345/230 kV transformer. The location of these elements is also shown in Figure 4-7 referenced in the N-1-2 results.

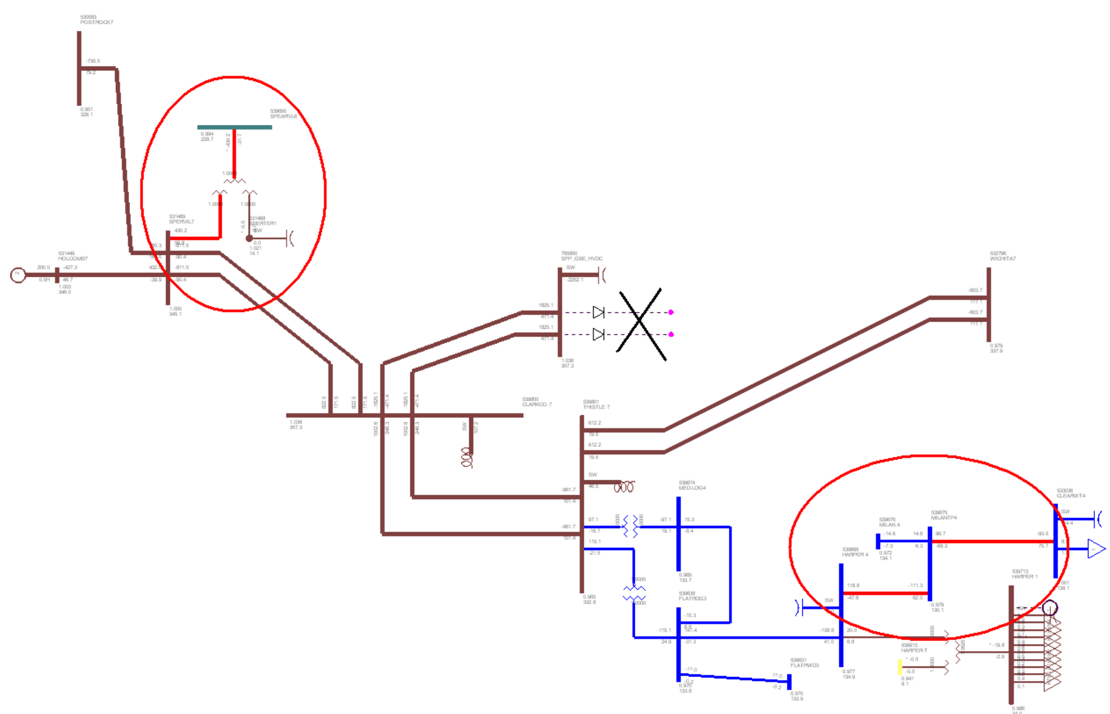
Table 4-3 Post Project 2017 Summer Peak N-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	137.2	27.0	110.2	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	131.7	33.0	98.7	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	131.7	33.0	98.7	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	110.0	14.0	96.0	536 WERE	534 SUNC

With respect of this contingency it should be noted that, as outlined in the introduction, the Grain Belt Express line will transmit wind energy, thus it will operate at multiple outputs levels and we are assuming here that the outage happens when the transfer is maximized (as a worse case). A double pole outage at full load would result in an injection of about 3,700 MW of power into the SPP system before disconnecting any WTG.

Figure 4-8 below shows the areas overloaded from the loss of both poles. Noting the injection of the power at Clark County, the power moves initially on the 345kV Priority Projects and then onto the underlying grid.

Figure 4-8 Post Project 2017 Summer Peak Double Pole Project Outage



4.2 Post Project 2017 Winter Peak Case

4.2.1 Post-Project 2017 Winter Peak Single Pole Outage (N-1)

The loss of a single pole on the Project does not create any additional overloads in the system compared to the Pre-Project case.

4.2.2 Post-Project 2017 Winter Peak N-1-1 and N-1-2 Contingencies

Under N-1-1 conditions, i.e. loss of a pole concurrent with other contingencies, there are a number of circuits loaded beyond their ratings, as shown in Table 4-4. As identified for the Summer Peak conditions, the loss of the Post Rock-Spearville 345kV line overloads the Spearville 345/230 kV transformer. Similarly, the loss of the Evans North-Evans South 138kV line loads the Harper-Milan Tap-Clearwater 138 kV line beyond its ratings. These overloads are expected as noted before.

Table 4-4 Post Project 2017 Winter Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	132.6	79.1	53.5	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	115.1	44.0	71.1	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	115.1	42.0	73.1	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	105.7	59.9	45.8	536 WERE	534 SUNC
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	3Wnd: OPEN KNOLL T1 1	103.4	89.7	13.7	531 MIDW	531 MIDW

Table 4-5 shows the results for N-1-2 conditions; loss of a pole concurrent with a double outage in the network. As before, we note that under these conditions the entire loss of the Priority Projects between Clark County and Thistle or Wichita and Thistle results in overloads in the area. In particular, the loss of the Wichita-Thistle 345kV double circuit or the loss of the Clark County-Thistle 345kV double circuit lines results in overloading conditions on the Spearville 345/230kV transformer and also introduces overloads in the underlying 138 kV system by diverting approximately 670 MW which would normally flow from Thistle to Wichita on the 345kV lines and re-routing it through the 138kV network where it impacts the Harper-Milan Tap-Clearwater 138kV (noted before) line and the Seward-St John 115kV line.

Another overload occurs on a transformer in OPPD's territory. However, this element was close to its limit (99.4%) under Pre-Project conditions and the single pole DC brings it to overload due to slight (2.5%) flow increase. Moreover, the OTDF for the affected element is 0.09% (less than 0.5% threshold), thus we are of the opinion that it can be ignored for the purposes of the Project.

Table 4-5 Post Project 2017 Winter Peak N-1-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	187.5	79.1	108.4	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	162.5	44.0	118.5	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	162.5	42.0	120.5	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	154.9	59.9	95.0	536 WERE	534 SUNC
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	110.0	24.0	86.0	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1668 SPEARVL6 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	103.3	42.0	61.3	534 SUNC	534 SUNC
539694 SPEARVL3 115 B$1668 SPEARVL6 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	101.9	61.9	40.0	534 SUNC	534 SUNC
B$1596 S975 T4 1.00 640234 HUMBOLT5 161 1	TR	S1263T1 AUTO	101.9	99.4	2.5	645 OPPD	645 OPPD

4.2.3 Post-Project 2017 Winter Peak Double Pole Outage (N-2)

With regard to a bi-pole outage, the only observed overloads are the Harper-Milan Tap-Clearwater 138 kV line and the Spearville 345/230 kV transformer. These overloads are seen repetitively over many cases.

Table 4-6 Post Project 2017 Winter Peak N-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	152.4	79.1	73.3	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	135.5	44.0	91.5	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	135.5	42.0	93.5	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	122.9	59.9	63.0	536 WERE	534 SUNC

4.3 Post-Project 2017 Light Load Case

4.3.1 Post-Project 2017 Light Load Single Pole Outage (N-1)

The loss of a single pole DC outage on the Project does not create any additional overloads in the system for the 2017 Light Load Case when compared to the Pre-project case.

4.3.2 Post-Project 2017 Light Load N-1-1 and N-1-2 Contingencies

The loss of a single pole in conjunction with a contingency outage results in an overload on the Harper-Milan Tap 138kV line, as shown in Table 4-7. This overload was noted before and expected as the loss of the Wichita-Thistle 345kV line combined with the loss of a GBX pole routes the power from the Project to the east through the area.

Table 4-7 Post-Project 2017 Light Load N-1-1 Branch Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
334058 4L558T485 138 334060 4MT.ZION 138 1	LN	334325 8HARTBRG 500 337368 8MTOLIV 500 1	105.4	98.2	7.2	351 EES	351 EES
334026 4GRIMES 138 334040 4WALDEN 138 1	LN	334325 8HARTBRG 500 337368 8MTOLIV 500 1	104.7	98.0	6.7	351 EES	351 EES
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 1	103.8	50.4	53.4	534 SUNC	534 SUNC

The overloads noted in Entergy territory (EES) may be alleviated with the upgrade of the Grimes-Mt. Zion 138kV line. Note that the Pre-Project contingency loading on these lines is close to 100%.

Table 4-8 shows the impact of some double circuit contingencies following the single pole outage (i.e. N-1-2 condition). In this case, the loss of a double circuit line between Wichita and Thistle or Clark County and Thistle leads to overloads on the underlying grid as power from the Project is shifted to the 230 and 138 kV systems.

In particular, as noted before, the loss impacts the Harper-Milan Tap-Clearwater 138kV circuit, Spearville transformers and 115 kV system. These overloads again are not unexpected in that the underlying system is carrying the power diverted due to the 345kV double circuit outage.

Table 4-8 Post-Project 2017 Light Load N-1-2 Branch Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	170.1	50.4	119.7	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	141.3	26.0	115.3	536 WERE	534 SUNC
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	137.2	17.0	120.2	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	137.2	17.0	120.2	534 SUNC	534 SUNC
539671 FTDODGE3 115 539771 NFTDODG3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	111.2	57.0	54.2	534 SUNC	534 SUNC
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	110.6	26.0	84.6	534 SUNC	534 SUNC
539694 SPEARVL3 115 539771 NFTDODG3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	104.9	50.0	54.9	534 SUNC	534 SUNC

4.3.3 Post-Project 2017 Light Load Double Pole Outage (N-2)

As mentioned above, the total loss of the Project is a Category D contingency per the current NERC standards and is presented here for completeness.

As noted, under this condition, all the project power is being diverted to the underlying 345kV, 230kV and 138kV grid resulting in the noted overloads, as shown in Table 4-9. In particular we note in this case the overload of the line Woodward to Windfarm 138 kV, which had not appeared before.

Table 4-9 Post-Project 2017 Light Load N-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	137.8	50.4	87.4	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	111.7	17.0	94.7	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	111.7	50.4	61.3	536 WERE	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	111.7	17.0	94.7	534 SUNC	534 SUNC
514785 WOODWRD4 138 515785 WINDFRM4 138 1	LN	GBX DOUBLE POLE OUTAGE	103.3	46.0	57.3	524 OKGE	524 OKGE

4.4 Post-Project 2022 Summer Peak Case

4.4.1 Post-Project 2022 Summer Peak Single Pole Outage (N-1)

The loss of a single pole on the Project does not create any additional overloads in the system compared to the Pre-Project case.

4.4.2 Post-Project 2022 Summer Peak N-1-1 and N-1-2 Contingencies

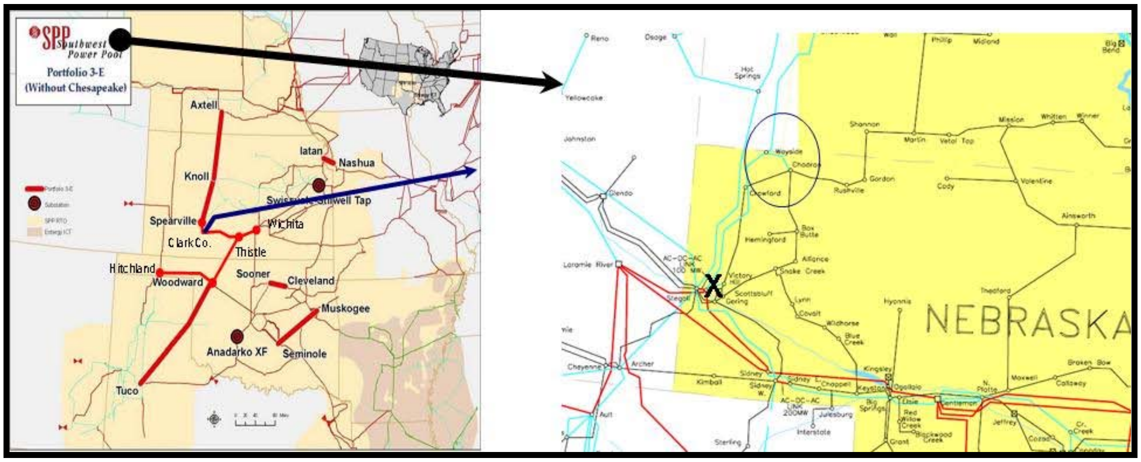
There are a number of N-1-1 overloads presented in Table 4-10 below. The most noticeable overloads were observed on the Spearville 345/230 kV transformer, the Harper-Milan Tap 138kV line and on the Hays-South Hays 115kV line, for the same conditions observed in the 2017 summer case.

Table 4-10 Post-Project 2022 Summer Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	530558 KNOLL 6 230 530584 POSTROCK6 230 1	114.1	91.1	23.0	531 MIDW	531 MIDW
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	112.5	56.8	55.7	534 SUNC	534 SUNC
640109 CHADRON7 115 640405 WAYSIDE7 115 1	LN	640396 VICTRYH4 230 652573 STEGALL4 230 1	106.8	88.5	18.3	640 NPPD	640 NPPD
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	106.5	36.1	70.4	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	530583 POSTROCK7 345 531469 SPERVIL7 345 1	106.5	33.9	72.6	534 SUNC	534 SUNC
541222 WSTELEC5 161 541224 LNGVW 5 161 1	LN	541218 GRNWD 5 161 541233 LEESUM 5 161 1	105.1	99.1	6.0	540 GMO	540 GMO
533021 NEOSHO 4 138 B$1342 NEOSH2AX 1.00 1	TR	3Wnd: OPEN NEC3 GSU 1	103.7	99.2	4.5	536 WERE	536 WERE
547483 JOP389 5 161 B$1047 JOPLINSW 1.00 1	TR	547472 TIP292 5 161 547483 JOP389 5 161 1	103.5	86.4	17.1	544 EMDE	544 EMDE
640267 MAXWELS7 115 640287 N.PLATT7 115 1	LN	3Wnd: OPEN B$0653 CR.CREEK T1 1	102.6	90.2	12.4	640 NPPD	640 NPPD
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	338138 5MORFLD 161 338142 5ISES-1 161 1	101.3	88.9	12.4	351 EES	515 SWPA
510877 FIXCT4 138 515055 MAUD 4 138 1	LN	3Wnd: OPEN MAUD1 1	100.6	92.2	8.4	520 AEPW	524 OKGE
531420 FLETCHR3 115 531448 HOLCOMB3 115 1	LN	531393 PLYMELL3 115 531448 HOLCOMB3 115 1	100.6	97.2	3.4	534 SUNC	534 SUNC

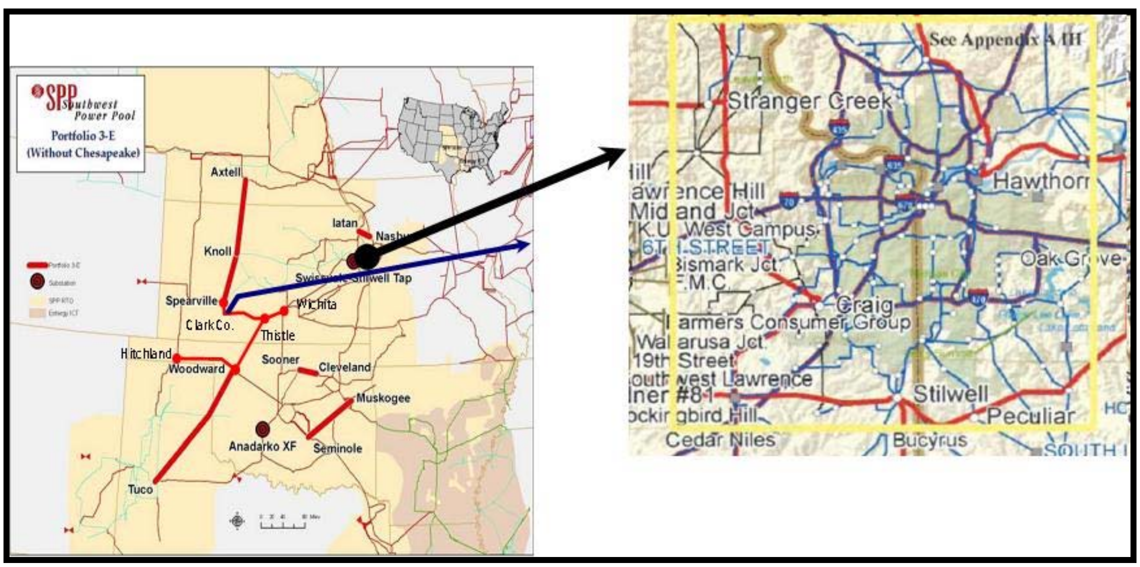
The CHADRON7-WAYSIDE7 115kV line (NPPD) in the northwestern part of the SPP experienced an 18% increase in loading from Pre-Project conditions for the loss of the Victory Hill-Stegall 230kV line. The loading may be related to the loading experienced on the Victory Hill transformers which is resolved by an operational solution involving the Laramie River injection. Also, this overload could be eliminated if the Rate C of this line (176 MVA) was considered – the line's normal rating (Rate A) and emergency rating (Rate B) are the same. A map of the area is shown in Figure 4-9.

Figure 4-9 Post Project 2022 Summer Peak - Chadron-Wayside 230kV Line Overload



The WSTELEC5-LNGVW 5 161kV line overload is Pre-Project loaded to 99% in this case and although the increase in loading is about 6% due to the pole outage, this condition will probably need to be addressed independently of the GBX. Figure 4-10 below shows the location of this line with respect of the Project.

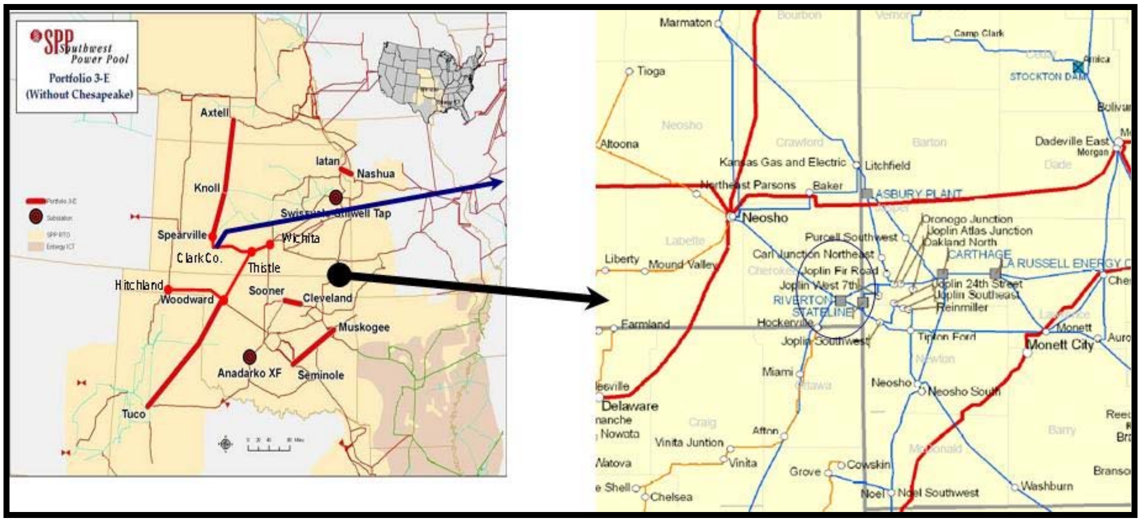
Figure 4-10 Post-Project 2022 Summer Peak - WSTELEC5-LNGVW5 161kV Line (GMO)



The 138/69KV transformer at NEOSHO 4 (WERE) is in a similar situation with Pre-Project loading at 99.2% and a Post-Project increase of only 4.5%. Thus, it will probably be addressed independently of the Project. This overload also appears later in this study in the 2017 ITP Scenario 5.

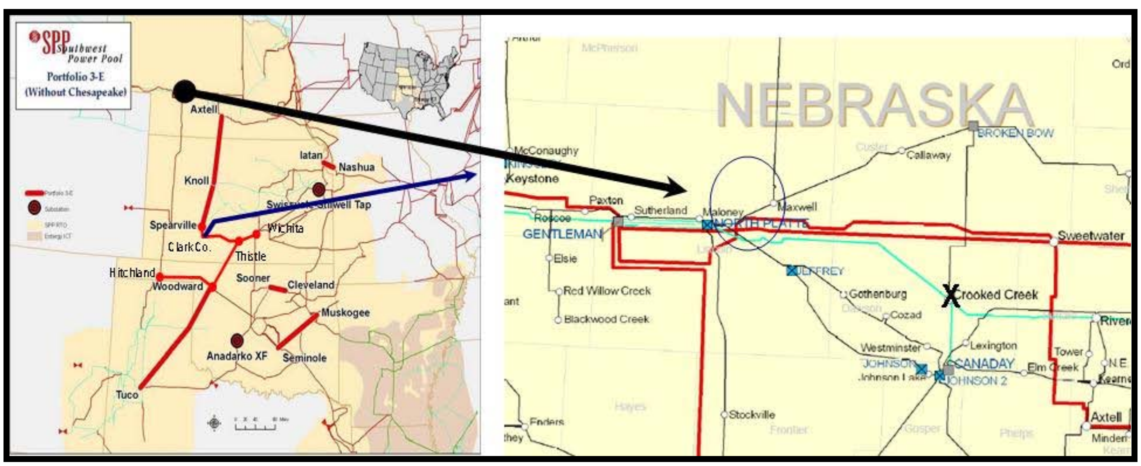
The Joplin 161/69kV transformer (EMDE) experienced a 17% increase in loading with a GBX pole outage coupled with the loss of the TIP292 5-JOP389 5 161kV line. The transformer is loaded at 86% in the Pre-Project case and is in the path that the incremental power is expected to take following flow the loss of a pole at the Project. A map of the area is shown in Figure 4-11.

Figure 4-11 Post Project 2022 Summer Peak - Joplin 161/69kV Transformer



The MAXWELS7-N.PLATT7 115kV line observed a 12% increase in loading from Pre-Project conditions when the Crooked Creek 230/115kV transformer is out. The line was 90% loaded in the Pre-Project case and is located north of the path of the Project's flow. A map of the area is shown in Figure 4-12.

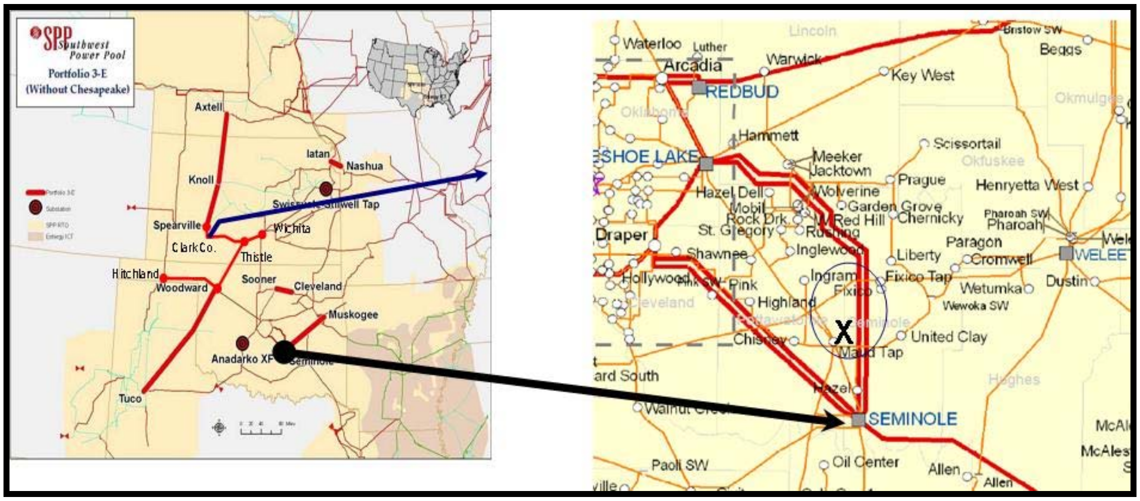
Figure 4-12 Post Project 2022 Summer Peak – MAXWELS-N PLATT 115kV Line



As in the 2017 Summer Peak analysis, the Midway-Bull Shoals 161kV line was observed overloaded during N-1-1 conditions. The Midway-Bull Shoals 161kV line is relatively remote from the injection point (Clark County) but the line is in the flow path to the AMMO and AEP. The line experienced a 12% increase in loading with the GBX pole outage and the loss of the Moorefield-Independence SES 161kV line (see Figure 4-4.)

The FIXCT4-MAUD4 138kV line experienced an 8% increase in loading when a transformer at the MAUD4 substation is lost. The line is loaded to 92% of its emergency rating in the Pre-Project case and is in the path of the Project's flow to the east when a pole at the Project is lost. A map of the area is shown in Figure 4-13.

Figure 4-13 Post Project 2022 Summer Peak – FIXCT-MAUD 138kV Line



The Fletcher-Holcomb 115kV line overloads with the loss of the Plymell-Holcomb 115kV line when a pole at the Project is lost. The Pre-Project loading was observed to be 97%. The Post-Project loading was recorded at 100.6%. The increase in loading is 3.6% thus overload can be considered largely independent of the Project.

Table 4-11 shows the results for a single HVDC pole outage followed by a double circuit outage (N-1-2). As noted before, outages of the Priority Projects have most of the impact and this impact occurs in facilities already identified (i.e. Harper-Milan Tap 138kV line, Spearville 345/230 kV transformer, and Seward-St John 115kV line).

Table 4-11: Post-Project 2022 Summer Peak N-1-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	175.3	56.8	118.5	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	151.0	36.1	114.9	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	151.0	33.9	117.1	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	141.7	35.5	106.2	536 WERE	534 SUNC
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	117.6	16.0	101.6	534 SUNC	534 SUNC
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	110.4	31.5	78.9	534 SUNC	534 SUNC

4.4.3 Post-Project 2022 Summer Peak Double Pole Outage (N-2)

Table 4-12 presents the results with a double HVDC pole outage (Category D Event per the NERC Standards). Similar observations, as have been discussed in previous results can be made here. The injection of power of approximately 3,700 MW due to the loss of the entire HVDC converter would cause some circuits to operate beyond their normal thermal limits. All of the overloaded elements were identified in previous cases.

Table 4-12: Post-Project 2022 Summer Peak N-2

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	144.6	56.8	87.8	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	121.8	39.0	82.8	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	121.8	36.0	85.8	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	116.4	6.0	110.4	536 WERE	534 SUNC

4.5 Post-Project 2022 Winter Peak Case

4.5.1 Post-Project 2022 Winter Peak Single Pole Outage (N-1)

The loss of a single pole on the Project does not create any additional overloads in the system compared to the Pre-Project case for 2022 Winter Peak.

4.5.2 Post-Project 2022 Winter Peak N-1-1 and N-1-2 Contingencies

Table 4-13 shows the results for the Post-Project 2022 Winter Peak conditions. The previously identified overloads of the Harper-Milan Tap-Clearwater 138kV line and the Hays-South Hays 115kV line are also observed in this analysis.

Table 4-13: Post-Project 2022 Winter Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	128.9	75.7	53.2	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL	TR	530583 POSTROCK7 345 531469 SPERVIL7	109.2	31.0	78.2	534 SUNC	534 SUNC
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	3Wnd: OPEN KNOLL T1 1	107.4	94.7	12.7	531 MIDW	531 MIDW
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	102.4	56.8	45.6	536 WERE	534 SUNC

Table 4-14 below shows the results for the N-1-2 conditions (Pole out followed by a double contingency) and we observe the same results as in the previous cases for the outage of the same Priority Projects.

Table 4-14: Post-Project 2022 Winter Peak N-1-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	174.3	75.7	98.6	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	155.4	31.0	47.4	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	155.4	59.9	47.4	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	143.6	56.8	86.8	536 WERE	534 SUNC

4.5.3 Post-Project 2022 Winter Peak Double Pole Outage (N-2)

Table 4-15 shows the overloads for a double HVDC pole outage (Category D event). All overloads noted have already been identified in previous cases.

Table 4-15: Post-Project 2022 Winter Peak N-2 Violations

** From bus ** ** To bus ** CKT	TYPE	Contingency Description	Loading%	Pre-Proj Loading%	Δ	From Area	To Area
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	145.6	75.7	69.9	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	129.7	31.0	21.7	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	129.7	59.9	21.7	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	117.1	56.8	60.3	536 WERE	534 SUNC

Section

5

Comparison of ITP Near-Term and Build 2 Cases

As mentioned in the introduction and in compliance with SPP Criteria 3.5 (i.e., to study "all applicable Scenario Cases[10]") an evaluation was performed using the ITP Near-Term Scenario 0 and Scenario 5 cases for study years 2017 and 2022. These cases were identified as relevant for this study by the Affected Parties and SPP.

This section presents the results of this sensitivity and focused on a comparison of the contingency analysis results of the ITP cases to those of the Build 2.

5.1 General Observations with respect of Pre-Project and Post-Project increases

During the analysis, we have consistently noted the change in flow in the affected elements between the Pre-Project and Post-Project cases (the Delta Loading.) When considering the ITP conditions we realized that while in general the deltas are very similar between the ITP and the Build 2 cases and would be identical if the problem were linear. However, in some cases the Delta Loading was significantly different. Further investigation identified two conditions when this can occur:

- There is change in flow direction on the affected element between Pre-Project and Post-Project in one of the cases (ITP or Build 2) that is not present in the other. In this case, for the delta loading to be similar it should have been calculated by adding the loading for comparison purposes; but we elected not to as this would wrongly state the impact. For example, this situation happened on the Spearville 345/230 kV transformers.

- For comparison with Pre-Project conditions, we took the worse loading observed in the element and this generally corresponded to the same contingency on both ITP and Build 2 cases. However, for some conditions and facilities (e.g. lines Harper to Milan Tap), the worse contingency loading happened for a different contingency between the cases. Thus, as the Delta is heavily influenced by the topology, they do not match.

[10] Appendix 11 indicates, under Technical Study Requirements, point 3: "A review of impacts shall utilize all applicable Scenario Cases developed by the SPP extending to the planning horizon year."

5.2 ITP Scenario 0: 2017 Summer Peak

The tables below show the results of the contingency analysis performed for the 2017 Summer Peak ITP Scenario 0, as described in Section 2.1.2 (2017SP0) versus the Build 2 cases. The results presented include N-1 (single pole outage), N-1-1 (single pole concurrent with a contingency), and N-1-2 (single pole concurrent with a double contingency) events. The results for this ITP Scenario 0 for N-2 (bi-pole outage) are also presented.

5.2.1 ITP Scenario 0: 2017 Summer Peak with Single HVDC Pole Outage (N-1)

The loss of a single pole on the Project does not create overloads in the system.

5.2.2 ITP Scenario 0: 2017 Summer Peak with N-1-1 and N-1-2 Contingencies

Table 5-1 shows the results of the comparison for those facilities that resulted in overloads in the ITP Scenario 0 together with the corresponding results for the Build 2 Case.

As observed, there are certain contingencies that produce Pre-Project overloads for the ITP cases and in this case we present those that the GBX resulted in an increase in loading greater than 5%, as a reference.

We observe that in most cases the same elements identified in the Build 2 appear as overloaded in the ITP cases with the exception of the Auburn transformers which are affected by an outage in the vicinity of the JEC. We note, however, that this is a pre-existing condition probability due to the way the dispatch in the ITP case was set up and possibly can be ignored.

Table 5-1: 2017SP0 vs. 2017 Build 2 N-1-1

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Project Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4 138 1	533040 EVANS N4 138 533041 EVANS S4 138 1	*112.2*	*58.3*	53.9	104.7	50.0	54.7
532851 AUBURN 6 230 B$0430 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	*110.3*	*103.5*	6.8			
533151 AUBURN 3 115 B$0430 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	*109.1*	*103.5*	5.6			
338813 5MIDWAY# 161 505460 BULL SH5 161 1	338138 5MORFLD 161 338142 5ISES-1 161 1	*106.5*	*91.9*	14.6	107.0	87.0	20.0
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	530583 POSTROCK7 345 531469 SPERVIL7 345	*100.6*	*27.5*	73.1	116.2	39.0	77.2
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	530583 POSTROCK7 345 531469 SPERVIL7 345	*100.6*	*14.5*	86.1	116.2	36.0	80.2

Table 5-2: 2017SP0 vs. 2017 Build 2 N-1-2

			ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	CONT	Post-Project Loading%	Pre-Project Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	N-1-2	*145.1*	*58.3*	86.8	162	23	139
531469 SPERVIL7 345 B$1665 SPEARVL	539800 CLARKCO 7 345 539801 THISTLE 7	N-1-2	*139.4*	*27.5*	111.9	155.1	32	123.1
539695 SPEARVL6 230 B$1665 SPEARVL	539800 CLARKCO 7 345 539801 THISTLE 7	N-1-2	*139.4*	*14.5*	124.9	155.1	32	123.1
533036 CLEARWT4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	N-1-2	*115.5*	*39.0*	76.5	130.2	6	124.2
533162 GOODYR 3 115 533166 INDIANH3	WRTOD400	N-1-2	*105.6*	*80.8*	24.8	70.7	45	25.7
539679 MULGREN6 230 539695 SPEARVL6	539800 CLARKCO 7 345 539801 THISTLE 7	N-1-2	*101.6*	*17.1*	84.5	108.4	23	85.4

Table 5-2 above presents the results for N-1-2 conditions (pole outage followed by a double contingency.) In this case, the only additional contingency is the double contingency identified as WRT0D400 that results in overload of the GOODYR-INDIANH 115kV line (Kansas City area). This contingency corresponds to the simultaneous outage of:

- HOYT 7-JEC N 7 345kV line
- QUINTON3-29 GAGE3 115kV line
- S GAGEE3-UNDERPS3 #1 115kV line
- S GAGEE3- UNDERPS3 #2 115kV line

This contingency definition is a combination of a contingent loss of element and the associated operating procedure to alleviate overloads in the WERE region.

Table 5-3 shows the situation for a bi- pole DC outage under ITP Scenario 0. There were no overloads that were not already found in the Build 2 analysis.

Table 5-3: 2017 SP0 N-2 Conditions

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	130.1	58.3	71.8	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	117.6	44.0	73.6	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	117.6	31.0	86.6	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	103.6	15.0	88.6	536 WERE	534 SUNC

5.3 ITP Scenario 5: 2017 Summer Peak

The tables below show the results of the contingency analysis performed for the 2017 Summer Peak ITP Near-Term Scenario 5, as described in Section 2.1.3 (2017SP5), versus the Build 2 cases. The results are presented through the Conditions described above and include N-1 (single pole DC outage), N-1-1, and N-1-2 contingencies. The results for N-2 (double HVDC pole outage) are also presented.

5.3.1 ITP Scenario 5: 2017 Summer Peak with Single HVDC Pole Outage (N-1)

The loss of a single pole DC outage on the Project overloaded the Harper-Milan Tap 138kV line, as shown in Table 5-4. The line was lightly loaded in the Build 2 case and this is an important finding as this is one of the few overloads observed that can be attributed only to the outage of the GBX pole.

Table 5-4 2017SP5 vs 2017SP Build 2 (N-1)

			ITP			Build 2		
** From bus ** ** To bus ** CKT	Type	Contingency Description	GBE Loading%	Pre-Proj Loading%	Δ	GBE Loading%	Pre-Proj Loading%	Δ
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX POLE OUTAGE	103.1	79.6	23.5	47.8	23.0	24.8

5.3.2 ITP Scenario 5: 2017 Summer Peak with N-1-1 and N-1-2 Contingencies

Table 5-5 shows the results of the comparison for those facilities that resulted in overloads in the ITP Scenario 5.

We note, that as before, there are some pre-project overloads that are made worse by the GBX by more than 5% associated with the JEC. Also we observe that there is an overload at a transformer branch at NEOSHO (AECI), but this is probably a local issue as it is initiated by the trip of a GSU Transformer.

In general the contingency loadings occur in mostly the same elements as before, but with higher loadings than in the Scenario 0. Also we observe another, possible relevant overload that occurs at the Hays 115 kV line for the trip of the Knoll transformer.

Table 5-5: 2017SP5 vs. 2017 SP Build 2, N-1-1

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Project Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	134.5	79.6	54.9	104.7	49.0	55.7
338813 5MIDWAY# 161 505460 BULL SH5	338138 5MORFLD 161 338142 5ISES-1	116.9	105.5	11.4	107	87	20
532851 AUBURN 6 230 B$0430 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	115.4	109.0	6.4	78.1	71.5	6.6
533151 AUBURN 3 115 B$0430 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	114.2	107.8	6.4	78.1	71.5	6.6
532851 AUBURN 6 230 532852 JEC 6	532765 HOYT 7 345 532766 JEC N 7	108.8	97.0	11.8	93.8	82.3	11.5
533021 NEOSHO 4 138 B$1341 NEOSH2CX	3Wnd: OPEN NEC3 GSU 1	107.9	101.5	6.4	99.9	95.2	4.7
533021 NEOSHO 4 138 B$1340 NEOSH2BX	3Wnd: OPEN NEC3 GSU 1	107.8	101.5	6.3	99.8	95.1	4.7
533036 CLEARWT4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	106.0	57.9	48.1	72.3	23.0	49.3
533021 NEOSHO 4 138 B$1339 NEOSH2AX	3Wnd: OPEN NEC3 GSU 1	105.9	99.7	6.2	98.1	93.4	4.7
533040 EVANS N4 138 533054 MAIZE 4	533040 EVANS N4 138 533041 EVANS S4	102.5	89.0	13.5	93.9	80.7	13.2
532765 HOYT 7 345 532766 JEC N 7	532851 AUBURN 6 230 532852 JEC 6	102.3	87.4	14.9	86.9	75.2	11.7
530553 S HAYS 3 115 530562 HAYS 3	3Wnd: OPEN KNOLL T1 1	102.0	89.0	13.0	109.4	91.1	18.3

Similarly to the cases above, Table 5-6 shows the results for N-1-2 conditions where we see similar contingencies but higher loadings.

Table 5-6: 2017ITP Near-Term Scenario 5 vs. 2017 SP Build 2, N-1-2

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Project Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	204.7	79.6	125.1	162	23	139
533036 CLEARWT4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	167.5	57.9	109.6	130.2	15	115
533162 GOODYR 3 115 533166 INDIANH3	WRTOD400	131.6	106.0	25.6	71.3	45	26.3
539649 SAWYER 3 115 539651 RVROAD	531469 SPERVIL7 345 539800 CLARKCO 7	125.4	77.8	47.6	141.7	90.3	51.4
539651 RVROAD 115 539687 PRATT 3	532796 WICHITA7 345 539801 THISTLE 7	119.2	77.7	41.5	134.1	90.3	43.8
539679 MULGREN6 230 539695 SPEARVL6	539800 CLARKCO 7 345 539801 THISTLE 7	112.9	26.0	86.9	108.4	23	85.4
532851 AUBURN 6 230 532852 JEC 6	WRTOD400	105.4	97.0	8.4	92.5	82.3	10.2

Table 5-7 shows the results from a bi-pole outage of the Project under ITP Near-Term Scenario 5. The Mullegren-Spearville 230kV line was noted in previous runs for the ITP and Build 2 cases.

Table 5-7: 2017 ITP Near Term Scenario 5, N-2 Loadings

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	GBX DOUBLE POLE OUTAGE	102.1	23.0	79.1	534 SUNC	534 SUNC

5.4 ITP Scenario 0: 2017 Winter Peak

The tables below show the results of the contingency analysis performed for the 2017 Winter Peak ITP Scenario 0 as described in Section 2.1.2 (2017WP0) versus the corresponding Build 2 case. The results are presented through the Conditions described above and include N-1 (single pole DC outage on the Project), N-1-1, and N-1-2 contingencies. The results for this ITP Scenario 0 for N-2 (bi-pole outage) are also presented.

5.4.1 ITP Scenario 0: 2017 Winter Peak with Single Pole Outage (N-1)

The loss of a single pole DC outage on the Project does not create overloads in the system.

5.4.2 ITP Scenario 0: 2017 Winter Peak with N-1-1 and N-1-2 Contingencies

Table 5-8 shows the results of the comparison for those facilities that resulted in overloads in the ITP Scenario 0. Here we see that the only identified element is the Harper to Milan Tap line. Table 5-9 presents the results for N-1-2 conditions where we observe the same situation as above.

Table 5-8: 2017WP0 vs. 2017 WP Build 2, N-1-1

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading %	Pre-Project Loading %	Δ%	GBE Loading %	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	*118.6*	*67.2*	51.4	132.6	79.1	53.5

Table 5-9: 2017WP0 vs. 2017 WP Build 2, N-1-2

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading %	Pre-Project Loading %	Δ%	GBE Loading %	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	*153.7*	*67.2*	86.5	187.5	79.1	108.4
531469 SPERVIL7 345 B$1666 SPEARVL	539800 CLARKCO 7 345 539801 THISTLE 7	*143.2*	*22.0*	121.2	162.5	36.8	125.7
539695 SPEARVL6 230 B$1666 SPEARVL	539800 CLARKCO 7 345 539801 THISTLE 7	*143.2*	*22.0*	121.2	162.5	34.6	127.9
533036 CLEARWT4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	*124.3*	*47.0*	77.3	154.9	59.9	95
533162 GOODYR 3 115 533166 INDIANH3	WRTOD400	*113.0*	*88.2*	24.8	71.9	46	25.9
539692 SEWARD 3 115 539696 ST-JOHN3	539800 CLARKCO 7 345 539801 THISTLE 7	*100.3*	*23.0*	77.3	110	17.6	92.4

Table 5-10 shows the results for a bi-pole outage on the Project under ITP Scenario 0. In these results we observe that all overloads have been identified in previous cases.

Table 5-10: 2017 WP0 N-2 Loadings

** From bus **	** To bus **	CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	GBX DOUBLE POLE OUTAGE	135.5	67.2	68.3	534 SUNC	534 SUNC
531469 SPERVIL7 345	B$1666 SPEARVL 1.00	1	TR	GBX DOUBLE POLE OUTAGE	120.4	22.0	98.4	534 SUNC	534 SUNC
539695 SPEARVL6 230	B$1666 SPEARVL 1.00	1	TR	GBX DOUBLE POLE OUTAGE	120.4	22.0	98.4	534 SUNC	534 SUNC
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	GBX DOUBLE POLE OUTAGE	108.4	47.0	61.4	536 WERE	534 SUNC

5.5 ITP Scenario 5: 2017 Winter Peak

The tables below show the results of the contingency analysis performed for the 2017 Winter Peak ITP Near-Term Scenario5 (2017WP5) versus the corresponding Build 2 case. The results are presented through with the Conditions described above and include N-1 (single pole DC outage on the Project, "Post-Project"), N-1-1, and N-1-2 contingencies.

5.5.1 ITP Scenario 5: 2017 Winter Peak with HVDC Single Pole Outage (N-1)

As identified in the summer peak, in this case also the loss of a single pole on the Project overloaded the Harper-Milan Tap 138kV line, as shown it Table 5-11. The line was heavily loaded but not overloaded in the Build 2 case under similar conditions.

Table 5-11 2017WP5 vs 2017WP Build 2 (N-1)

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading %	Pre-Project Loading %	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	GBX POLE OUTAGE	*113.4*	*94.6*	18.8	98	79.1	18.9

5.5.2 ITP Scenario 5: 2017 Winter Peak with N-1-1 and N-1-2 Cont

As shown in

Table 5-12, under ITP Near-Term Scenario 5 Winter Peak case there are two facilities overloaded under Condition 1 which were not observed previously – AUBURN-JEC (Jeffrey Energy Center) 230kV line and SMOKYHL-SUMMIT 230kV line.

Table 5-12: 2017WP5 vs. 2017 WP Build 2, Condition 1

** From bus ** ** To bus ** CKT	Type	Contingency Description	ITP GBE Loading%	ITP Pre-Proj Loading%	ITP Δ	Build 2 GBE Loading%	Build 2 Pre-Proj Loading%	Build 2 Δ
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	225.7	94.6	131.1	187.5	79.1	108.4
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	186.6	73.5	113.1	154.9	59.9	95.0
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	148.0	94.6	53.4	132.6	79.1	53.5
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	533040 EVANS N4 138 533041 EVANS S4 138 1	119.1	73.5	45.6	105.7	59.9	45.8
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	106.9	31.0	75.9	110.0	17.6	92.4
532851 AUBURN 6 230 532852 JEC 6 230 1	LN	532765 HOYT 7 345 532766 JEC N 7 345 1	104.4	91.8	12.6	92.4	80.7	11.7
530592 SMOKYHL6 230 532873 SUMMIT 6 230 1	LN	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	100.0	40.0	60.0	70.0	13.0	57.0

Similar to the cases above, Table 5-13 shows the impact on those facilities that were overloaded on the ITP Near-Term Scenario 5 cases. It is noted that all overloads involve facilities that have already been identified. Similarly, Table 5-14 presents the results for N-1-2 conditions, with similar conclusions.

Table 5-13: 2017WP5 vs. 2017 WP Build 2, N-1-1

** From bus ** ** To bus ** CKT	Contingency Description	ITP Post-Project Loading %	ITP Pre-Project Loading %	ITP Δ%	Build 2 GBE Loading%	Build 2 Pre-Proj Loading%	Build 2 Δ%
539668 HARPER 4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	148.0	94.6	53.4	132.6	79.1	53.5
533036 CLEARWT4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	119.1	73.5	45.6	105.7	59.9	45.8
532851 AUBURN 6 230 532852 JEC 6	532765 HOYT 7 345 532766 JEC N 7	104.4	91.8	12.6	92.4	80.7	11.7

Table 5-14: 2017WP5 vs. 2017 WP Build 2, N-1-2

** From bus ** ** To bus ** CKT	Contingency Description	ITP Post-Project Loading %	ITP Pre-Project Loading %	ITP Δ%	Build 2 GBE Loading%	Build 2 Pre-Proj Loading%	Build 2 Δ%
539668 HARPER 4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	225.7	94.6	131.1	187.5	79.1	108.4
533036 CLEARWT4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	186.6	73.5	113.1	154.9	59.9	95
533162 GOODYR 3 115 533166 INDIANH3	WRTOD400	132.2	105.6	26.6	60	46	14
539692 SEWARD 3 115 539696 ST-JOHN3	539800 CLARKCO 7 345 539801 THISTLE 7	106.9	31.0	75.9	110	24	86
532851 AUBURN 6 230 532852 JEC 6	WRTOD400	101.2	91.8	9.4	91.2	80.7	10.5

Table 5-15 shows the results for a bi-pole outage of the Project under ITP Scenario 5. In this table, it is observed that all overloads were already identified.

Table 5-15: 2017 WP5 N-2 Loadings

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	166.8	94.6	72.2	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	135.5	73.5	62.0	536 WERE	536 WERE
300057 5BARNET 161 344532 5ELDON 161 1	LN	GBX DOUBLE POLE OUTAGE	105.9	76.6	29.3	330 AECI	356 AMMO

5.6 ITP Scenario 0: 2022 Summer Peak

5.6.1 ITP Scenario 0: 2022 Summer Peak with Single Pole Outage (N-1)

No overloads were noted for the 2022 Summer Peak ITP Near-Term Scenario 0.

5.6.2 ITP Scenario 0: 2022 Summer Peak with N-1-1 and N-1-2 Contingencies

As shown in Table 5-16, under ITP Scenario 0 for 2022 Summer Peak conditions no new overloads were observed that were not already detected in the Build 2 case.

Table 5-16: 2022SP0 vs. 2022 SP Build 2, N-1-1

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Proj Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
338813 5MIDWAY# 161 505460 BULL SH5 161 1	338138 5MORFLD 161 338142 5ISES-1 161 1	106.7	96.0	10.7	101.3	88.9	12.4
532851 AUBURN 6 230 B$0431 AUBRN77X 1.00 1	532765 HOYT 7 345 532766 JEC N 7 345 1	108.9	102.1	6.8	80.1	72.8	7.3
533151 AUBURN 3 115 B$0431 AUBRN77X 1.00 1	532765 HOYT 7 345 532766 JEC N 7 345 1	107.5	100.8	6.7	80.0	72.8	7.2

Table 5-17 shows the corresponding results for N-1-2 conditions, where we observe the same overloads as before.

Table 5-17: 2022SP0 vs. 2022 SP Build 2, N-1-2

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Proj Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
531469 SPERVIL7 345 B$1668 SPEARVL 1.00 1	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	139.4	14.0	14.0	151.0	39.0	112.0
539695 SPEARVL6 230 B$1668 SPEARVL 1.00 1	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	139.4	14.0	125.4	151.0	36.0	115.0
539668 HARPER 4 138 539675 MILANTP4 138 1	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	116.9	31.7	85.2	175.3	56.8	118.5

Table 5-18 shows the results for a double HVDC pole outage under ITP Scenario 0. No new overloads were determined in the ITP case.

Table 5-18: 2022 SP0 N-2 Loadings

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	119.6	31.7	87.9	534 SUNC	534 SUNC
531469 SPERVIL7 345 B$1668 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	114.9	18.0	96.9	534 SUNC	534 SUNC
539695 SPEARVL6 230 B$1668 SPEARVL 1.00 1	TR	GBX DOUBLE POLE OUTAGE	114.9	18.0	96.9	534 SUNC	534 SUNC

5.7 ITP Scenario 5: 2022 Summer Peak

5.7.1 ITP Scenario 5: 2022 Summer Peak with Single Pole Outage (N-1)

No N-1 violations were observed for the 2022 Summer Peak ITP Scenario 5 case.

5.7.2 ITP Scenario 5: 2022 Summer Peak with N-1-1 and N-1-2 Contingencies

As shown in Table 5-19, under ITP Near-Term Scenario 5 for 2022 Summer Peak, all of the reported overloads appear on previously identified facilities or on facilities that were loaded very close to their thermal rating during Pre-Project conditions. The differences are noted in on the following transmission elements:

- Overton 161kV Transformer (99% Pre-Project)
- Auburn-JEC 230kV line (93% Pre-Project)
- Truman-North Warsaw 161kV line (85% Pre-Project)
- WATLANT T1 & T2 138kV transformers (98% Pre-Project)

Table 5-19: 2022SP5 vs. 2022 SP Build 2, Condition 1

		ITP			Build 2		
** From bus ** ** To bus ** CKT	Contingency Description	Post-Project Loading%	Pre-Project Loading%	Δ%	GBE Loading%	Pre-Proj Loading%	Δ%
539668 HARPER 4 138 539675 MILANTP4	533040 EVANS N4 138 533041 EVANS S4	*115.6*	*59.7*	55.9	112.5	56.8	55.7
338813 5MIDWAY# 161 505460 BULL SH5	338138 5MORFLD 161 338142 5ISES-1	*121.9*	*109.6*	12.3	101.3	88.9	12.4
532851 AUBURN 6 230 B$0431 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	*115.8*	*109.5*	6.3	79.4	72.8	6.6
533151 AUBURN 3 115 B$0431 AUBRN77X	532765 HOYT 7 345 532766 JEC N 7	*114.4*	*108.1*	6.3	79.4	72.8	6.6
533021 NEOSHO 4 138 B$1341 NEOSH2AX	3Wnd: OPEN NEC3 GSU 1	*109.3*	*103.3*	6.0	103.7	99.2	4.5
532851 AUBURN 6 230 532852 JEC 6	532765 HOYT 7 345 532766 JEC N 7	*105.2*	*93.4*	11.8	92.2	80.7	11.5
B$1894 WATLANT2 1.00 508090 WATLANT4	3Wnd: OPEN WATLANT1 1	*102.8*	*98.4*	4.4	85.0	79.4	5.6
530553 S HAYS 3 115 530562 HAYS 3	3Wnd: OPEN KNOLL T1 1	*101.1*	*89.1*	12.0	114.1	91.1	23.0
541222 WSTELEC5 161 541224 LNGVW 5	541218 GRNWD 5 161 541233 LEESUM 5	*100.7*	*94.4*	6.3	105.1	99.1	6.0
505502 TRUMAN 5 161 541314 NWARSAW5	344224 7CALAWY 1 345 344225 1CAL G	*100.2*	*84.5*	15.7	81.0	67.1	13.9

Table 5-20 shows the corresponding overloads for N-1-2 conditions, where we note that no new elements are identified.

Table 5-20: 2022SP5 vs. 2022 Build 2, Condition 2

** From bus ** ** To bus ** CKT	Contingency Description	CONT	ITP Post-Project Loading%	ITP Pre-Project Loading%	ITP Δ%	Build 2 GBE Loading%	Build 2 Pre-Proj Loading%	Build 2 Δ%
539668 HARPER 4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	N-1-2	*175.5*	*59.7*	115.8	175.3	56.8	118.5
533036 CLEARWT4 138 539675 MILANTP4	532796 WICHITA7 345 539801 THISTLE 7	N-1-2	*141.9*	*33.0*	108.9	141.7	38.0	103.7
533162 GOODYR 3 115 533166 INDIANH3	WRTOD400	N-1-2	*129.7*	*104.1*	25.6	61.4	35	26.4
539649 SAWYER 3 115 539651 RVROAD	531469 SPERVIL7 345 539800 CLARKCO	N-1-2	*112.4*	*63.4*	49.0	132.8	85.1	47.7
539679 MULGREN6 230 539695 SPEARVL6	539800 CLARKCO 7 345 539801 THISTLE	N-1-2	*108.8*	*23.6*	85.2	110.4	25.0	85.4
539651 RVROAD 115 539687 PRATT 3	531469 SPERVIL7 345 539800 CLARKCO	N-1-2	*105.7*	*63.4*	42.3	125.5	85.1	40.4
532851 AUBURN 6 230 532852 JEC 6	WRTOD400	N-1-2	*101.8*	*93.4*	8.4	91.7	80.7	11.0

Finally, Table 5-21 shows the results for a bi-pole outage under ITP Near-Term Scenario 5. In this table, it is observed that the overloads occur on elements that have already been identified in the Build 2 cases or in the previous analysis in the ITP cases.

Table 5-21: 2022 SP5, N-2 Loadings

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-Proj Loading%	DELTA	FROM AREA	TO AREA
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	147.6	59.7	87.9	534 SUNC	534 SUNC
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	GBX DOUBLE POLE OUTAGE	116.0	38.7	77.3	536 WERE	534 SUNC
505502 TRUMAN 5 161 541314 NWARSAW5 161 1	LN	GBX DOUBLE POLE OUTAGE	110.6	84.5	26.1	515 SWPA	540 GMO
532765 HOYT 7 345 532766 JEC N 7 345 1	LN	GBX DOUBLE POLE OUTAGE	101.3	84.8	16.5	536 WERE	536 WERE

Section

6

Voltage Assessment

Voltage assessments of the Build 2 and ITP Near-Term cases were conducted under N-1 conditions. That is, following a single pole DC outage on the Project, an evaluation was conducted to determine which buses experience voltages outside the SPP acceptable range of 0.900 – 1.050 per unit voltage.

For the purpose of determining if the Project contributes to the voltage deviation, the affected bus should be within the required voltage range in the Pre-Project case and show a voltage excursion outside this range when there is a single HVDC pole outage.

It is important to mention that we let the capacitor banks at both converters to switch in order to maintain the voltage between 1.0 and 1.04 per unit at the corresponding AC bus.

The 2017 Light Load case indicated the most voltage violations. The violations were mostly outside the SPP footprint and were corrected allowing transformer taps to adjust. Also in some cases manual adjustment of the taps was required or adjustment of generators voltages. If this was the case the manipulated equipment is identified.

6.1 Build 2 Voltage Assessment

The Build 2 voltage assessment looked at multiple areas in and outside of the SPP footprint. The modeling outside of the SPP indicated a number of potential voltage but these were corrected as indicated below.

6.1.1 2017 Light Load – One Pole Out at GBX

As seen in Table 6-1, there are a number of voltage violations in the 2017 Light Load case. A closer observation indicates all the voltage issues are outside the SPP footprint. Allowing tap adjustments in the solution brought the voltages to acceptable levels. A number of generator set voltages were high for a light load case for generators modeled outside the SPP. The generator set voltages were reduced slightly to bring the voltages down outside the SPP. One of the primary causes of the high voltages outside the SPP are due to the voltage settings at the generators. No manual adjustments on transformers were required once generator set voltages were reduced.

Table 6-1 2017 Light Load Build 2 Voltage Analysis

Bus Number	Bus Name	Base kV	Area	Pre-Project Voltage (pu)	Post-Project Voltage (pu)	Post-Project with Solution & Manual Adjustments Voltage (pu)
256031	18ALBAJ	138	218 METC	1.0496	1.0542	1.0497
256035	18ABBEJ	138	218 METC	1.0471	1.0506	1.0477
256053	18BAGLEY	138	218 METC	1.0486	1.0536	1.0488
256069	BENNINGTN	138	218 METC	1.0498	1.0500	1.0476
256080	18CORWTJ	138	218 METC	1.0485	1.0552	1.0487
256102	18PLUM	138	218 METC	1.0473	1.0512	1.0474
256137	EMMET	138	218 METC	1.0393	1.0517	1.0402
256150	18GAYLRD	138	218 METC	1.0489	1.0540	1.0491
256152	18GDTR2J	138	218 METC	1.0482	1.0506	1.0483
256158	18GDTR1J	138	218 METC	1.0482	1.0506	1.0483
256187	18KEYSTONE	138	218 METC	1.0482	1.0506	1.0483
256194	18LEWSTJ	138	218 METC	1.0488	1.0531	1.0493
256201	18LVNSTN	138	218 METC	1.0496	1.0547	1.0498
256202	18LIVPKR	138	218 METC	1.0496	1.0547	1.0498
256211	18MCGLPN	138	218 METC	1.0391	1.0549	1.0401
256212	18MCGLP1	138	218 METC	1.0391	1.0549	1.0401
256213	18MCGLP2	138	218 METC	1.0391	1.0549	1.0401
256224	18MIO	138	218 METC	1.0482	1.0517	1.0489
256249	18PLYWDJ	138	218 METC	1.0486	1.0536	1.0488
256259	18RIGGSV	138	218 METC	1.0442	1.0550	1.0445
256263	18RONDO	138	218 METC	1.0471	1.0554	1.0473
256275	STOVER	138	218 METC	1.0498	1.0542	1.0499
256297	VANDERBLT	138	218 METC	1.0486	1.0552	1.0488
256522	18HBSTNJ	138	218 METC	1.0499	1.0502	1.0499
256527	18HAKWDJ	138	218 METC	1.0472	1.0554	1.0474
256529	18RYNOJ	138	218 METC	1.0480	1.0515	1.0488
256538	18CLRWTJ	138	218 METC	1.0473	1.0512	1.0474
258004	ABBE	138	218 METC	1.0471	1.0506	1.0477
258017	BEAVER CK	138	218 METC	1.0499	1.0526	1.0478
258026	BOARDMAN 1	138	218 METC	1.0481	1.0505	1.0482
258027	BOARDMAN 2	138	218 METC	1.0482	1.0506	1.0482
258028	BOARDMANB 2	138	218 METC	1.0482	1.0506	1.0482
258041	CLEARWATR	138	218 METC	1.0472	1.0510	1.0473
258065	ELMWOOD	138	218 METC	1.0483	1.0507	1.0484
258098	LEWISTON	138	218 METC	1.0488	1.0531	1.0493
258133	PIGEON RV	138	218 METC	1.0470	1.0553	1.0473
258134	SALVIUS	138	218 METC	1.0485	1.0535	1.0488
258182	BAGLEY 1	138	218 METC	1.0485	1.0536	1.0488
258183	BAGLEY 2	138	218 METC	1.0485	1.0536	1.0488
259351	HUBBARDSTN	138	218 METC	1.0498	1.0502	1.0499
259358	HAAKWOOD	138	218 METC	1.0472	1.0554	1.0474
259390	RYNO	138	218 METC	1.0480	1.0515	1.0488
259395	DICKERSON J	138	218 METC	1.0485	1.0535	1.0488
259396	DICKERSON	138	218 METC	1.0485	1.0535	1.0488
262498	ODAWA J	138	218 METC	1.0387	1.0511	1.0395
263655	18ODAWA	138	218 METC	1.0387	1.0511	1.0395
263656	18ODEN	138	218 METC	1.0396	1.0542	1.0407
263662	18GAYLORDW	138	218 METC	1.0489	1.0540	1.0491
263663	18CORWITH	138	218 METC	1.0484	1.0551	1.0486
263664	18GNDT1	138	218 METC	1.0483	1.0508	1.0484
263665	18GNDT3	138	218 METC	1.0482	1.0506	1.0483
263670	18ALBA	138	218 METC	1.0497	1.0543	1.0498
264799	19AIRPT	120	219 ITC	1.0498	1.0502	1.0499
264811	19COLNS	120	219 ITC	1.0499	1.0502	1.0500
300064	5CAMDEN	161	330 AECI	1.0491	1.0500	1.0495
301070	5ORLA	161	330 AECI	1.0488	1.0504	1.0493
306284	N CHARLT	100	342 DUKE	1.0493	1.0504	1.0478
699753	STRAITS	138	295 WEC	1.0370	1.0541	1.0395

6.1.2 2017 Summer Peak – One Pole Out at GBX

As shown in Table 6-2, there were six high voltage situations, of which only one was inside the SPP footprint. The case solution then allowed tap changers to adjust which resolved the voltage problems observed. No manual adjustment was required.

Table 6-2 2017 Summer Peak Build 2 Voltage Analysis

				Pre-Project	Post-Project	Post-Project with Solution & Manual Adjustments
Bus Number	Bus Name	Base kV	Area	Voltage (pu)	Voltage (pu)	Voltage (pu)
235112	01PRNTY	500	201 AP	1.0494	1.0501	1.0473
243213	05BREED	345	205 AEP	1.0404	1.0538	1.0318
346895	7COFFEEN	345	357 AMIL	1.0495	1.0500	1.0400
360541	8PLEASANT HL	500	347 TVA	1.0499	1.0505	1.0497
360586	8NEW ALBNYCT	500	347 TVA	1.0499	1.0505	1.0497
510896	LONEOAK2	69	520 AEPW	1.0452	1.0511	1.0091

6.1.3 2017 Winter Peak – One Pole Out at GBX

The 2017 Winter Peak case contained a number of buses with voltage violations. Table 6-3 also shows that allowing tap adjustments in the solution resolves the voltage violations. As in the Light Load case, most of the violations are outside the SPP footprint and are due to generator voltage settings. As in the Light Load case, the generator set voltages were reduced slightly resolving the issues noted.

Table 6-3: 2017 Winter Peak Build 2 Voltage Analysis

				Pre-Project	Post-Project	Post-Project with Solution & Manual Adjustments
Bus Number	Bus Name	Base kV	Area	Voltage (pu)	Voltage (pu)	Voltage (pu)
243213	05BREED	345	205 AEP	1.0302	1.0553	1.0217
250251	08ATTI23	69	208 DEM	1.0463	1.0546	1.0452
250255	08ATTICN	69	208 DEM	1.0419	1.0512	1.0417
250503	08HARR12	69	208 DEM	1.0416	1.0509	1.0415
250585	08HRS IN	69	208 DEM	1.0417	1.0510	1.0416
250586	08HRS ST	69	208 DEM	1.0418	1.0510	1.0416
300364	2NOVLTY	69	330 AECI	1.0410	1.0653	1.0336
343514	SPALDING	138	360 CWLP	1.0324	1.0536	1.0334
343515	CHATHAM	138	360 CWLP	1.0323	1.0638	1.0339
343541	CHTM IND	138	360 CWLP	1.0323	1.0601	1.0336
344001	5ADAIR	161	356 AMMO	1.0138	1.0786	1.0170
346555	4AUBURN N	138	357 AMIL	1.0327	1.0728	1.0348
346834	4CHARLSTN	138	357 AMIL	1.0262	1.0550	1.0272
347297	4JACKSNVL	138	357 AMIL	1.0290	1.0588	1.0321
347322	4JERSEYVL	138	357 AMIL	1.0120	1.0550	1.0160
347341	4KANSAS	138	357 AMIL	1.0292	1.0655	1.0308
347495	2WINCHSTR	69	357 AMIL	1.0345	1.0622	1.0230
347681	2MEREDOSA	69	357 AMIL	1.0467	1.0655	1.0307
347954	4PARIS AM	138	357 AMIL	1.0229	1.0594	1.0245
347963	4PAWNEE	138	357 AMIL	1.0329	1.1005	1.0361
348143	4ROODHSE	138	357 AMIL	1.0198	1.0504	1.0238
348306	4TAYLORVL	138	357 AMIL	1.0298	1.0642	1.0324
348307	4TAYLR NE	138	357 AMIL	1.0261	1.0607	1.0288
348408	4VIRDEN	138	357 AMIL	1.0272	1.0896	1.0307
348867	4ROUTE 51	138	357 AMIL	1.0205	1.0521	1.0266
348868	4ROUTE 51 TP	138	357 AMIL	1.0201	1.0546	1.0269
348872	4MT ZION 121	138	357 AMIL	1.0182	1.0737	1.0305
348873	4MT ZION PPG	138	357 AMIL	1.0184	1.0666	1.0288
348912	4JACKSNVL IP	138	357 AMIL	1.0273	1.0542	1.0307
500600	NATCH 2	69	502 CLEC	1.0493	1.0504	1.0436
507418	DEQUEEN2	69	520 AEPW	1.0486	1.0512	1.0187
508057	HOOKS 2	69	520 AEPW	1.0492	1.0503	1.0497
508063	LSORDTP2	69	520 AEPW	1.0493	1.0503	1.0497
668124	KIRKFLD7	110	667 MH	1.0499	1.0502	1.0499

6.1.4 2022 Summer Peak – One Pole Out at GBX

In the 2022 Summer Peak case, there are some buses with voltages slightly above the acceptable limits as shown below. However, when tap changers are allowed to adjust during the solution, all voltages fall within acceptable limits. All of the issues were outside the SPP footprint.

Table 6-4: 2022 Summer Peak Build 2 Voltage Analysis

				Pre-Project	Post-Project	Post-Project with Solution & Manual Adjustments
Bus Number	Bus Name	Base kV	Area	Voltage (pu)	Voltage (pu)	Voltage (pu)
200072	JACKMTN2	500	225 PJM	1.0498	1.0504	1.0498
200073	JMTNCAP2	500	225 PJM	1.0498	1.0504	1.0498
243213	05BREED	345	205 AEP	1.0389	1.0532	1.0317
249717	08CUMBAV	138	208 DEM	1.0176	1.0524	1.0234
249764	08KLONDK	138	208 DEM	1.0170	1.0555	1.0248
249815	08NW TAP	138	208 DEM	1.0172	1.0537	1.0239
249816	08NW TP1	138	208 DEM	1.0172	1.0537	1.0239
249817	08NW TP2	138	208 DEM	1.0171	1.0546	1.0243
249829	08PRD NW	138	208 DEM	1.0166	1.0532	1.0233
249868	08W LAF	138	208 DEM	1.0171	1.0535	1.0237
249873	08WESTW2	138	208 DEM	1.0172	1.0561	1.0252
249874	08WESTWD	138	208 DEM	1.0172	1.0561	1.0252
255177	17SPRARI	138	217 NIPS	1.0187	1.0570	1.0292
300364	2NOVLTY	69	330 AECI	1.0423	1.0520	1.0450
346895	7COFFEEN	345	357 AMIL	1.0467	1.0500	1.0494
668035	CN9 TAP7	110	667 MH	1.0496	1.0503	1.0498
668074	OAKBANK7	110	667 MH	1.0498	1.0504	1.0499

6.1.5 2022 Winter Peak – One Pole Out at GBX

Voltage impacts in the 2022 Winter Peak case are shown in Table 6-5 below. The voltage issues are easily resolved by allowing for tap adjustments in the solution. There was only one bus inside the SPP footprint.

Table 6-5: 2022 Winter Peak Single pole DC outage on the Project vs. Pre-Project

				Pre-Project	Post-Project	Post-Project with Solution & Manual Adjustments
Bus Number	Bus Name	Base kV	Area	Voltage (pu)	Voltage (pu)	Voltage (pu)
243213	05BREED	345	205 AEP	1.0302	1.0557	1.0215
250251	08ATTI23	69	208 DEM	1.0464	1.0508	1.0494
344146	4BLANCHET	138	356 AMMO	1.0498	1.0502	1.0470
510899	MCALEST2	69	520 AEPW	1.0493	1.0506	1.0278

6.2 ITP Voltage Assessment

The ITP Near-Term voltage assessment concentrates on the SPP footprint. The modeling outside of the SPP indicated a number of potential voltage issues. It should be noted that no voltage issues were noted on 100kV and higher voltage classes.

6.2.1 2017 Summer Peak Scenario 0 – One Pole Out at GBX

Voltage issues were noted in OKGE, MIDW and SUNC, as shown in Table 6-6. All the voltage issues were resolved with tap changer adjustments along with adjusting the desired voltage on the GMECG1 1 generator voltages.

Table 6-6 2017 Summer Peak Scenario 0 Single Pole DC Outage on the Project vs Pre-Project

				Pre-Project	Post-Project	Post-Project with Solution & Manual Adjustments
Bus Number	Bus Name	Base kV	Area Number/Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
515139	HEALDTN2	69.00	524 OKGE	1.0499	1.0537	1.0504
515140	HLTNTAP2	69.00	524 OKGE	1.0486	1.0525	1.0491
515145	SINCPLT2	69.00	524 OKGE	1.0486	1.0525	1.0491
515146	SINCLAR2	69.00	524 OKGE	1.0487	1.0525	1.0491
530674	GMECG1 1	13.80	531 MIDW	1.0186	1.0555	0.9654
539914	JEWEEL-T	2.40	534 SUNC	1.0493	1.0529	1.0456

6.2.2 2017 Summer Peak Scenario 5 – One Pole Out at GBX

The only voltage issue noted was on the GMECG1 generator voltage, as shown in Table 6-7. The desired voltage was manually lowered resolving the over voltage condition.

Table 6-7 2017 Summer Peak Scenario 5 Single Pole DC Outage on the Project vs Pre-Project

				Pre-Project	Post-Project	Post-Project with Manual Adjustments
Bus Number	Bus Name	Base kV	Area Number/Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
530674	GMECG1	13.8	531 MIDW	1.0412	1.0558	0.9631

6.2.3 2017 Winter Peak Scenario 0 – One Pole Out at GBX

To resolve the voltage issues identified in Table 6-8, a manual adjustment of the three-winding transformer at NNBOSTN1 connected to NEWBOST2 was required.

Table 6-8 2017 Winter Peak Scenario 0 Single Pole DC Outage on the Project vs Pre-Project

				Pre-Project	Post-Project	Post-Project with Manual Adjustments
Bus Number	Bus Name	Base kV	Area Number/Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
508067	NEWBOST2	69	520 AEPW	1.0500	1.0512	1.0476
512085	NWMEMPH2	69	520 AEPW	1.0461	1.0481	1.0474
512093	MEMPHIS2	69	520 AEPW	1.0464	1.0484	1.0478

6.2.4 2017 Winter Peak Scenario 5 – One Pole Out at GBX

The only voltage problem noted was at CLBYT1 1 as noted in Table 6-9 below. Allowing the solution to adjust phase shifters and tap changers resolved the issue.

Table 6-9 2017 Winter Peak Scenario 5 Single Pole DC Outage on the Project vs Pre-Project

					Pre-Project	Post-Project	Post-Project with Adjustments
Bus Number	Bus Name	Base kV	Area Num	Area Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
530645	CLBYT1 1	13.8	531	MIDW	1.0314	1.0511	1.0408

6.2.5 2022 Summer Peak Scenario 0 – One Pole Out at GBX

The voltage issues identified in Table 6-10 were resolved by allowing automatic adjustments of tap changers in the solution and then by making manual adjustments on the transformers at all three locations.

Table 6-10 2022 Summer Peak Scenario 0 Single Pole DC Outage on the Project vs Pre-Project

					Pre-Project	Post-Project	Post-Project with Automatic & Manual Adjustments
Bus Number	Bus Name	Base kV	Area Num	Area Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
507427	OKAY 2	69	520	AEPW	1.0497	1.0516	1.0415
523957	POTTER_TR 1	13.2	526	SPS	1.0444	1.0606	1.0489
539914	JEWEEL-T	2.4	534	SUNC	1.0432	1.0502	1.0494

6.2.6 2022 Summer Peak Scenario 5 – One Pole Out at GBX

The voltage issues identified in Table 6-11 were resolved allowing automatic adjustments of tap changers in the solution and manually adjusting generator voltages at COM2-1, SEMINL1 G and CLR 2 and by adjusting the transformer taps at KNOBHIL1.

Table 6-11 2022 Summer Peak Scenario 5 Single Pole DC Outage on the Project vs Pre-Project

					Pre-Project	Post-Project	Post-Project with Automatic & Manual Adjustments
Bus Number	Bus Name	Base kV	Area Num	Area Name	Voltage (pu)	Voltage (pu)	Voltage (pu)
511852	COM2-1	13.8	520	AEPW	1.0454	1.0512	1.0290
515040	SEMINL1G	20.9	524	OKGE	1.0497	1.0510	1.0026
515732	KNOBHIL1	13.2	524	OKGE	1.0477	1.0508	1.0471
539731	SMITH-C1	34.5	534	SUNC	1.0398	1.0502	1.0446
999014	CLR2_2	0.6	534	SUNC	1.0255	1.0608	1.0301
999914	CLR_2	0.6	534	SUNC	1.0289	1.0642	1.0335

Section
7

Short Circuit Analysis

Short circuit analysis was performed to assess the impact of the Grain Belt Express project on available short circuit levels at existing substations. The following scenarios are considered in the short circuit study:

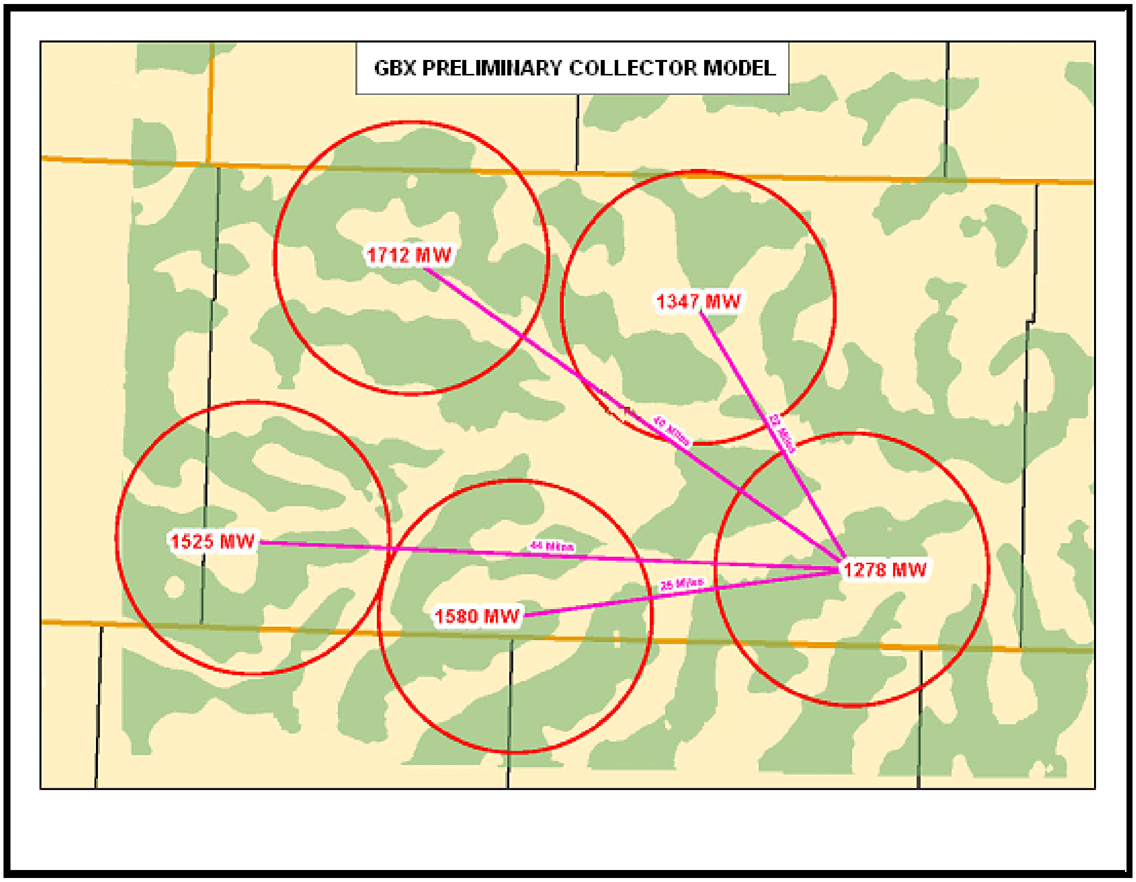
- 2017 Light Load Pre-Project & Post-Project
- 2017 Summer Peak Pre-Project & Post-Project
- 2017 Winter Peak Pre-Project & Post-Project
- 2022 Summer Peak Pre-Project & Post-Project
- 2022 Winter Peak Pre-Project & Post-Project

7.1 Project Collector System

At the time of the short circuit study, updated information was available regarding the possible wind locations. Hence, the short circuit study was performed using the updated collector system as described in this section.

The collector system is a best guess based upon the known wind resources, some analytical and environmental work around to site potential locations of wind farms, and the economics around the development of such a system relative to the project. Figure 7-1 shows the geographical locations where wind could be developed that could access the Project. The wind locations and levels were provided by Clean Line.

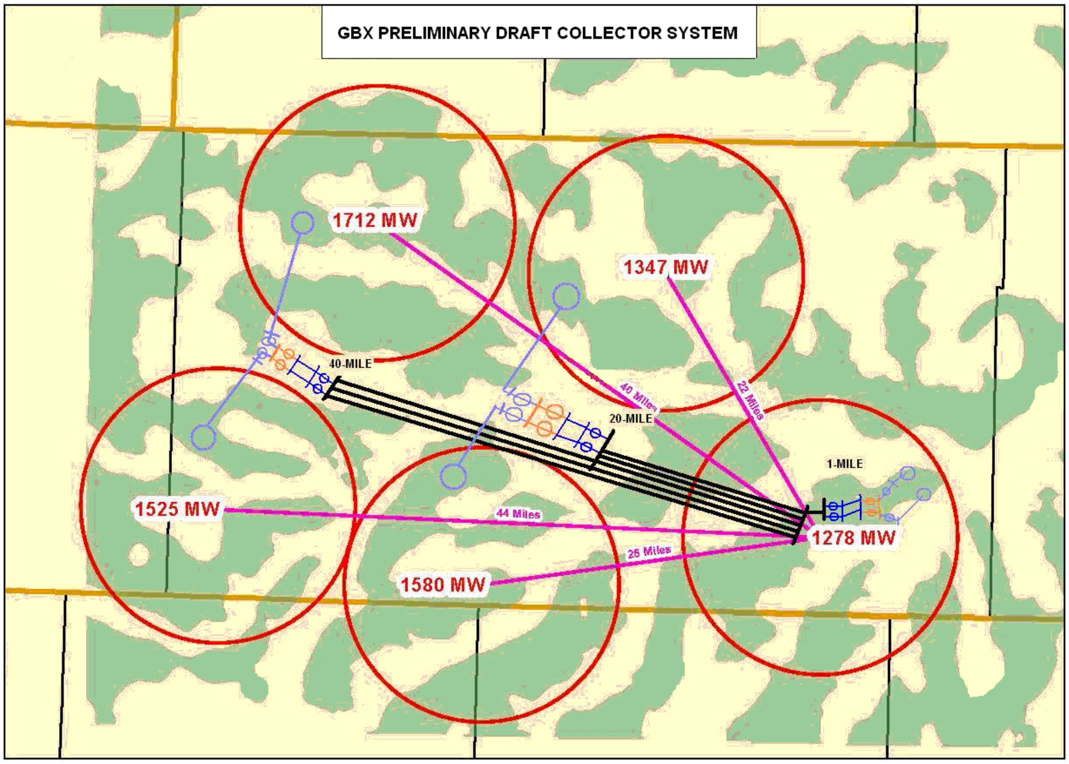
Figure 7-1: GBX Preliminary Draft Collector System



The information presented in Figure 7-1 shows 1,278MW of potential generation at and within approximately 10 miles of the rectifier station (Clark County). The subsequent circles show other wind rich areas at farther distances from the rectifier station. Each of the circles depicts the amount of possible wind megawatts available from within the area.

For the purposes of modeling this analysis, Siemens PTI recommends modeling only type 3 and type 4 WTG's in each of the resource areas. The model developed involves 345kV transmission as a backbone to move power from the wind areas to the rectifier station. Closer to the actual wind farm locations, the transmission will be stepped down until the voltage level of the WTG is modeled. Conceptually, Figure 7-2 shows the wind circles with a transmission system overlay comprised of 345kV, 138kV, 34.5kV and finally the voltage levels of the actual WTG's.

Figure 7-2: Proposed Study Collector System



The model shown in Figure 7-2 utilizes 345kV transmission radiating from the rectifier station at 1-mile, 20-mile and 40-mile distances. The proposed study collector system steps down from 345kV to 138kV to 34.5kV and finally to the voltage level of the type 3 or type 4 WTG. The number and sizing of the transmission elements is chosen to provide a viable path for the WTG's under N-1 conditions to transfer the full 3,800+MW's from the WTG's to the HVDC rectifier station.

For the Project, the key is how much WTG is needed to ensure collector and HVDC losses are covered as well as delivering 500MW to the AMMO system and the remaining 3,000MW to the AEP system while maintaining negligible to null real power flows across the interconnection between SPP and the GBX rectifier station. Figure 7-3 shows the collector system representation for 2017 Summer Peak case with the dispatched generation levels at each site (1-mile, 20-mile and 40-mile) for a total dispatched level of 3,700MW. Table 7-1 shows the dispatched generation at each site and also by WTG type.

The 138 kV network is currently modeled as zero impedance lines due to the lack of actual collector system representation within the wind parks. Otherwise these lines should represent the equivalent collector system impedance. The 345/138 kV and 138/34.5 kV transformers are assumed to have 8% impedance on winding base with X/R ratio of 35.

Figure 7-3 Collector System Representation - 2017 Summer Peak

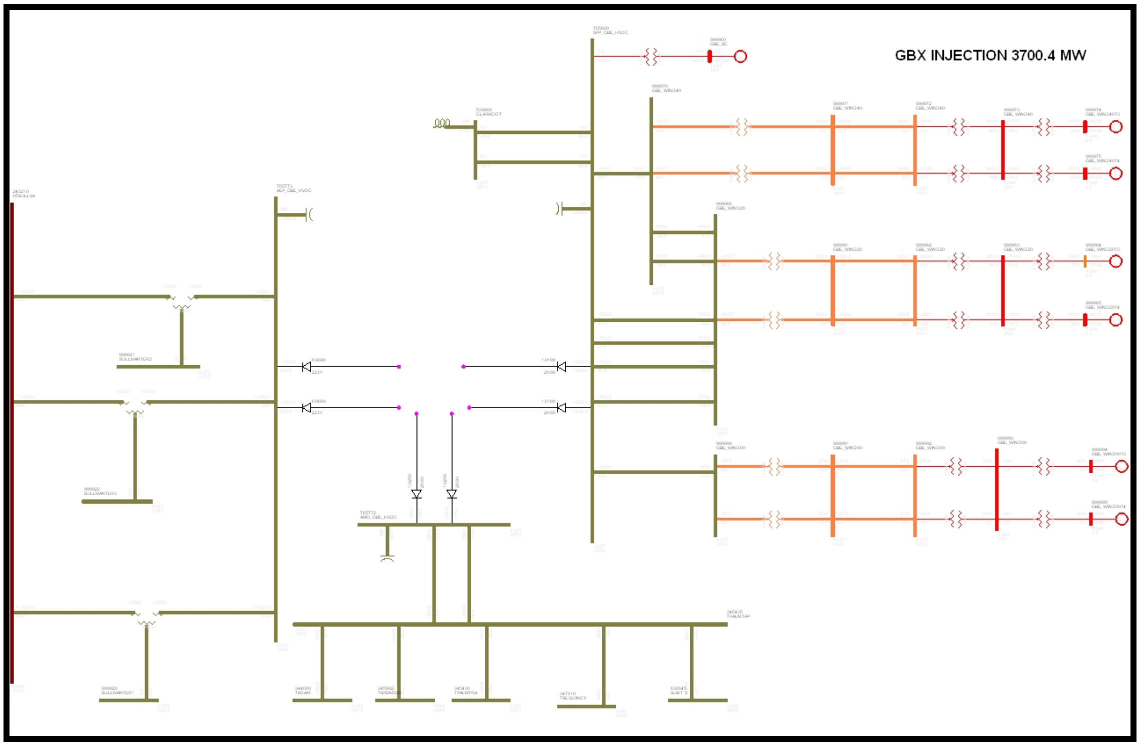


Table 7-1: 2017 Summer Peak Short Circuit Model Wind Collector Generation

Pgen	Site 1	Site 2	Site 3	Total
MW	197.12	1653.08	1850.20	**3700.4**
% of Total	5%	45%	50%	**100%**
Distance	**1 mile**	**20 miles**	**40 miles**	

	Pgen	Site 1	Site 2	Site 3	Total
Type 3	**MW**	98.56	749.45	985.60	**1833.61**
Type 4	**MW**	98.56	903.63	864.60	**1866.79**
Type 3	**% of Total**	5%	41%	54%	**100%**
Type 4	**% of Total**	5%	48%	46%	**100%**

7.2 Assumptions

The ANSI fault current calculation method (Activity ANSI in PSS®E) is used to calculate the fault currents. A portion of the simulation output taken directly from PSS®E is shown in Figure 7-4. This portion of the output shows the simulation options used while calculating the fault currents.

Figure 7-4 PSS®E Short Circuit Options

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OPTIONS USED:

   - SET GENERATOR POSITIVE SEQUENCE REACTANCES TO SUBTRANSIENT
   - ACCOUNT FOR DC DECREMENTS ONLY (REMOTE MULTIPLYING FACTORS)
   - CONSIDER X ONLY
   - BREAKERS RATED ON A TOTAL CURRENT BASIS
   - FOR BRANCHES WITH R=0, RESISTANCE SCALING FACTOR (X/R RATIO) IN POSITIVE SEQUENCE
NETWORK=   40.00
   - FOR MACHINES WITH R=0, RESISTANCE SCALING FACTOR (X/R RATIO) IN POSITIVE SEQUENCE
NETWORK=   80.00
   - FOR BRANCHES WITH R=0, RESISTANCE SCALING FACTOR (X/R RATIO) IN ZERO SEQUENCE
NETWORK=   40.00
   - FOR MACHINES WITH R=0, RESISTANCE SCALING FACTOR (X/R RATIO) IN ZERO SEQUENCE
NETWORK=   80.00


 ANSI FAULT CURRENTS ARE CALCULATED WITH FOLLOWING CHANGES APPLIED TO
WORKING CASE:

   - PRE-FAULT VOLTAGE ON ALL BUSES SET TO 1.0 PU AT 0 PHASE SHIFT ANGLE
   - SYNCHRONOUS/ASYNCHRONOUS MACHINE POWER OUTPUTS SET TO P=0.0, Q=0.0
   - TRANSFORMER TAP RATIOS UNCHANGED AND PHASE SHIFT ANGLES SET TO 0.0
   - LINE CHARGING SET TO 0.0 IN +/-/0 SEQUENCES
   - LINE/FIXED/SWITCHED SHUNTS AND TRANSFORMER MAGNETIZING ADMITTANCE SET TO 0.0 IN +/-/0
SEQUENCES
   - LOAD SET TO 0.0 IN +/-/0 SEQUENCES
   - DC LINES AND FACTS DEVICES BLOCKED
   - ZERO SEQUENCE MUTUAL COUPLING UNCHANGED
   - ZERO SEQUENCE MUTUAL IMPEDANCES AND GROUNDING IMPEDANCES WITH R=0 NOT SCALED
USING SCALING FACTORS

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The voltage is assumed to be 1.0 per unit and the breaker contact separation time is assumed to be 0.017 sec (1 cycle). Note that typically breakers interrupt at more than one cycle thus the measured currents are momentary currents. The actual breaker interrupting current would be less than this value depending on the time of breaker contact separation. Also, the measured fault currents are AC symmetrical currents thus the DC decaying component is not included.

Lastly, 900MVA of compensation was added at the Clark County rectifier as a synchronous condenser (SC) and this was accounted for in the study.

7.3 Results

The following four conditions are evaluated to assess the project impact on short circuit levels:

1. Without the project and prior the addition of the MISO MVP projects: fault currents are calculated without the Grain Belt Express and without MVPs for each scenario. The priority projects are still modeled in this case.

2. Without the project and after the addition of the MISO MVP projects: fault currents are calculated without the Grain Belt Express project for each scenario, but with the MVP. The priority projects are still modeled in this case.

3. With the project: The Grain Belt Express project is added and the fault currents are estimated. Any change in the fault current levels can be treated as the direct impact of the project.

4. With the project and Synchronous Condenser[11]: Part of the reactive compensation at the Clark County rectifier station is modeled as synchronous condenser (900 MVAr) and the fault current levels are computed again

The following substations that are located close to the project on the SPP, AMMO, and AEP were monitored in the study:

- Jefferson 765kV
- Rockport 765kV
- Sullivan 765kV
- Breed 345kV
- Dequin 345kV
- Clark County 345kV
- Spearville 345kV
- Post Rock 345kV
- Holcomb 345kV
- Palmyra Tap 345kV
- Spencer 345kV

Table 7-2 to Table 7-6 present the fault currents and short circuit MVA capabilities for each scenario. Also, each table shows the values for three conditions: without the project, with the project and with the project & synchronous condenser.

Following are the main observations of the short circuit study:

- There is a significant increase in fault current MVA due to the addition of the MVPs for all case, independent of the proposed HVDC project. The most significant increase in fault current MVA were observed in the AMMO region where the Palmyra Tap and Spencer 345kV increases by 2732 MVA and 830 MVA, correspondingly, when comparisons were made between the one with MVP verses without.

[11] During the stability analysis, we identified that a synchronous condenser is required to increase the short circuit level at the Clark County substation

- The fault currents and MVA levels at Clark County substation are increased with the Grain Belt Express project and further significantly increased by the addition of synchronous condenser at/near Clark County.
- In particular, the 2022 Winter Peak case short circuit level at Clark County substation without the project and without the MVPs is 5421 MVA (2022 Summer Peak) and increased to 7,997 MVA with the project. Further it is increased to 12,289 MVA with synchronous condenser in place.
- Increased fault levels are observed at substations Spearville, Post Rock, and Holcomb substation due to the addition of the GBX and in particular the synchronous condenser.
- The fault currents and MVA levels at AMMO and AEP substations are not affected by the project (largest change in MVA was observed on 2022 Summer Peak at 87MVA difference)
- The increased fault levels on SPP due to the project are mainly due to the synchronous condenser. Wind machines Type 3 and Type 4 contribute close to their nominal current.

In summary, the impact of the WTG associated with the Grain Belt Express project is to increase fault levels at the Clark County substation and to a lesser extent at other SPP substations. The impact of the project on the AMMO and AEP substations is negligible. All short-circuit values are within expected typical breaker capability.

Table 7-2 2017 Light Load

2017 Light Load with Priority Projects					3ph Fault MVA				3ph Symm Fault Current (kA)			
Bus	Station	Base kV	Max Op Volt (pu)	Brk Contact Time Sec	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE & MVPs	With GBE & Syn Cond	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE	With GBE & Syn Cond
243208	05JEFRSO	765	1	0.017	23029	23045	23045	23045	17.4	17.4	17.4	17.4
243209	05ROCKPT	765	1	0.017	18314	18393	18394	18394	13.8	13.9	13.9	13.9
243210	05SULLVA	765	1	0.017	13883	14113	14115	14115	10.5	10.7	10.7	10.7
243213	05BREED	345	1	0.017	14056	14445	14447	14447	23.5	24.2	24.2	24.2
243217	05DEQUIN	345	1	0.017	7826	7850	7886	7886	13.1	13.1	13.2	13.2
539800	CLARKCO 7	345	1	0.017	5157	5157	7730	11279	8.6	8.6	12.9	18.9
531469	SGBERVIL7	345	1	0.017	5541	5541	7041	8490	9.3	9.3	11.8	14.2
530583	POSTROCK7	345	1	0.017	3842	3842	4055	4196	6.4	6.4	6.8	7.0
531449	HOLCOMB7	345	1	0.017	4753	4753	4969	5148	8.0	8.0	8.3	8.6
345435	7PALM TAP	345	1	0.017	5069	7653	7653	7653	8.5	12.8	12.8	12.8
345992	7SPENCER	345	1	0.017	6418	7229	7229	7229	10.7	12.1	12.1	12.1

Table 7-3 2017 Summer Peak

2017Summer GBEak with Priority Projects					3ph Fault MVA				3ph Symm Fault Current (kA)			
Bus	Station	Base kV	Max Op Volt (pu)	Brk Contact Time Sec	Without GBE	Without GBE, With MVPs	With GBE	With GBE & Syn Cond	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE	With GBE & Syn Cond
243208	05JEFRSO	765	1	0.017	23745	23759	23757	23757	17.9	17.9	17.9	17.9
243209	05ROCKPT	765	1	0.017	18649	18718	18719	18719	14.1	14.1	14.1	14.1
243210	05SULLVA	765	1	0.017	14517	14729	14732	14732	11.0	11.1	11.1	11.1
243213	05BREED	345	1	0.017	15090	15468	15472	15472	25.3	25.9	25.9	25.9
243217	05DEQUIN	345	1	0.017	8207	8225	8305	8305	13.7	13.8	13.9	13.9
539800	CLARKCO 7	345	1	0.017	5671	5671	8244	11793	9.5	9.5	13.8	19.7
531469	SGBERVIL7	345	1	0.017	6228	6228	7687	9099	10.4	10.4	12.9	15.2
530583	POSTROCK7	345	1	0.017	4170	4170	4339	4456	7.0	7.0	7.3	7.5
531449	HOLCOMB7	345	1	0.017	6186	6186	6363	6520	10.4	10.4	10.6	10.9
345435	7PALM TAP	345	1	0.017	5295	8027	8028	8028	8.9	13.4	13.4	13.4
345992	7SPENCER	345	1	0.017	6820	7649	7649	7649	11.4	12.8	12.8	12.8

Table 7-4 2017 Winter Peak

2017 Winter GBEak with Priority Projects					3ph Fault MVA				3ph Symm Fault Current (kA)			
Bus	Station	Base kV	Max Op Volt (pu)	Brk Contact Time Sec	Without GBE	Without GBE, With MVPs	With GBE	With GBE & Syn Cond	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE	With GBE & Syn Cond
243208	05JEFRSO	765	1	0.017	23601.6	23617.7	23616	23616	17.8	17.8	17.8	17.8
243209	05ROCKPT	765	1	0.017	18555.9	18633.5	18634	18634	14.0	14.1	14.1	14.1
243210	05SULLVA	765	1	0.017	14313.4	14545.9	14548	14548	10.8	11.0	11.0	11.0
243213	05BREED	345	1	0.017	14747.2	15153.8	15157	15157	24.7	25.4	25.4	25.4
243217	05DEQUIN	345	1	0.017	8028.9	8050.5	8088	8088	13.4	13.5	13.5	13.5
539800	CLARKCO 7	345	1	0.017	5374.9	5374.9	7949	11498	9.0	9.0	13.3	19.2
531469	SGBERVIL7	345	1	0.017	5858.3	5858.3	7347	8786	9.8	9.8	12.3	14.7
530583	POSTROCK7	345	1	0.017	3940.4	3940.4	4134	4263	6.6	6.6	6.9	7.1
531449	HOLCOMB7	345	1	0.017	5862.1	5862.1	6069	6244	9.8	9.8	10.2	10.4
345435	7PALM TAP	345	1	0.017	5269	7966	7966	7966	8.8	13.3	13.3	13.3
345992	7SPENCER	345	1	0.017	6787.9	7611.4	7611	7611	11.4	12.7	12.7	12.7

Table 7-5 2022 Summer Peak

2022Summer GBEak with Priority Projects					3ph Fault MVA				3ph Symm Fault Current (kA)			
Bus	Station	Base kV	Max Op Volt (pu)	Brk Contact Time Sec	Without GBE	Without GBE, With MVPs	With GBE	With GBE & Syn Cond	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE	With GBE & Syn Cond
243208	05JEFRSO	765	1	0.017	23794	23808	23805	23805	18.0	18.0	18.0	18.0
243209	05ROCKPT	765	1	0.017	18664	18733	18734	18734	14.1	14.1	14.1	14.1
243210	05SULLVA	765	1	0.017	14540	14752	14755	14755	11.0	11.1	11.1	11.1
243213	05BREED	345	1	0.017	15128	15506	15511	15511	25.3	25.9	26.0	26.0
243217	05DEQUIN	345	1	0.017	8212	8231	8318	8318	13.7	13.8	13.9	13.9
539800	CLARKCO 7	345	1	0.017	5687	5687	8260	11810	9.5	9.5	13.8	19.8
531469	SGBERVIL7	345	1	0.017	6252	6252	7708	9119	10.5	10.5	12.9	15.3
530583	POSTROCK7	345	1	0.017	4179	4179	4345	4460	7.0	7.0	7.3	7.5
531449	HOLCOMB7	345	1	0.017	6259	6259	6434	6590	10.5	10.5	10.8	11.0
345435	7PALM TAP	345	1	0.017	5488	8242	8242	8242	9.2	13.8	13.8	13.8
345992	7SPENCER	345	1	0.017	7546	8376	8376	8376	12.6	14.0	14.0	14.0

Table 7-6 2022 Winter Peak

2022Winter GBEak with Priority Projects					3ph Fault MVA				3ph Symm Fault Current (kA)			
Bus	Station	Base kV	Max Op Volt (pu)	Brk Contact Time Sec	Without GBE	Without GBE, With MVPs	With GBE	With GBE & Syn Cond	Without GBE, Without MVPs	Without GBE, With MVPs	With GBE	With GBE & Syn Cond
243208	05JEFRSO	765	1	0.017	23602	23618	23617	23617	17.8	17.8	17.8	17.8
243209	05ROCKPT	765	1	0.017	18556	18634	18634	18634	14.0	14.1	14.1	14.1
243210	05SULLVA	765	1	0.017	14313	14546	14548	14548	10.8	11.0	11.0	11.0
243213	05BREED	345	1	0.017	14747	15154	15158	15158	24.7	25.4	25.4	25.4
243217	05DEQUIN	345	1	0.017	8029	8051	8111	8111	13.4	13.5	13.6	13.6
539800	CLARKCO 7	345	1	0.017	5421	5421	7997	12289	9.1	9.1	13.4	20.6
531469	SGBERVIL7	345	1	0.017	5897	5897	7381	9052	9.9	9.9	12.4	15.1
530583	POSTROCK7	345	1	0.017	3956	3956	4152	4297	6.6	6.6	6.9	7.2
531449	HOLCOMB7	345	1	0.017	5874	5874	6076	6273	9.8	9.8	10.2	10.5
345435	7PALM TAP	345	1	0.017	5280	7980	7980	7980	8.8	13.4	13.4	13.4
345992	7SPENCER	345	1	0.017	6798	7620	7620	7620	11.4	12.8	12.8	12.8

Section

8

Mitigation

The Grain Belt Express HVDC Project has the potential of overloading certain facilities when there is a pole outage (or a double pole outage), when another element in the system is already out of service either due a contingency or maintenance setting up a N-1-1 condition. Also as previously indicated, there is one situation where the single pole outage can result in an overload on the Harper-Milan Tap 138kV line. It should be noted that the N-1 violation was only noted in the ITP case evaluation of the 2017 Scenario 5 Summer and Winter Peak cases.

In this section, we present mitigation strategies that could be implemented by curtailing the generation associated with the Project (WTG direct connect generation) under various scenarios. The amount of generation to be curtailed is a function of the facility that is out of service (previous contingency) and the pole outage accompanying the previous outage.

The mitigation strategies are presented below for the 2011 Build 2 Cases and are followed by the mitigations that would be required under the ITP dispatches.

8.1 2011 Build 2 Cases Mitigation

8.1.1 Mitigation Under 2017 Summer Peak Conditions

Table 8-1 shows the wind turbine generation (WTG) curtailment required to alleviate the overloads that would otherwise occur for the various contingencies identified if there were concurrently a pole outage.

In this table, we also provide the OTDF which ranges from less than 1% (indicating limited impact of the GBX) to as high as 16%. WTG reductions of 54MW to 941MW are required to mitigate the overloads presented, however the higher values correspond to low OTDF.

Table 8-1: 2017SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	116.2	44.0	*13.29%*	408.49
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	116.2	31.0	*15.69%*	346.17
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	88.0	530558 KNOLL 6 230 530584 POSTROCK6 230 1	109.4	91.1	*0.88%*	940.60
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	162.0	338138 5MORFLD 161 338142 5ISES-1 161 1	107.0	87.0	*1.78%*	642.13
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	104.7	23.0	*4.28%*	105.15
336138 6FAIRVW 230 336190 6GYPSY 230 1	LN	454.0	303204 6FRNSTL 230 336060 6SORR 2 230 1	100.7	98.3	*0.60%*	535.98
336138 6FAIRVW 230 500510 MADISON6 230 1	LN	454.0	303204 6FRNSTL 230 336060 6SORR 2 230 1	100.2	97.8	*0.60%*	133.99
541222 WSTELEC5 161 541224 LNGVW 5 161 1	LN	224.0	541218 GRNWD 5 161 541233 LEESUM 5 161 1	100.2	94.2	*0.74%*	54.32

A double circuit outage combined with the GBX pole outage would require the WTG to reduce between 44MW to as high as 905MW to mitigate the overloads presented, as shown in Table 8-2. This is expected given the severity of the event and in most cases the OTDF is relevant.

Table 8-2: 2017SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DC	162.0	23.0	7.28%	814.41
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	155.1	44.0	20.45%	904.93
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	155.1	31.0	22.85%	810.14
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DC	130.2	15.0	6.94%	479.58
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	108.4	23.0	16.63%	179.24
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	79.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	102.2	14.0	3.85%	44.14
300071 5CLINTN 161 300124 5HOLDEN 161 1	LN	227.0	AI-OG4A	100.1	99.4	0.09%	229.70

The double pole outage would require WTG reductions of about 1261MW to mitigate the overloads shown in Table 8-3, even with cases with high OTDF.

Table 8-3: 2017SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	137.2	27.0	2.82%	1260.67
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	131.7	33.0	8.86%	1203.70
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	131.7	33.0	8.86%	1203.70
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	110.0	14.0	2.82%	389.71

8.1.2 Mitigation Under 2017 Winter Peak Conditions

The loss of a single circuit combined with the loss of a pole at the Project would require WTG reduction as high as 1113MW to mitigate the loading on the Harper-Milan Tap 138kV line, as shown in Table 8-4. Note that the OTDF is close to 3% in this case.

Table 8-4: 2017WP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	132.6	79.1	2.80%	1113.28
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	115.1	44.0	13.09%	386.55
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	115.1	42.0	13.46%	375.97
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	533040 EVANS N4 138 533041 EVANS S4 138 1	105.7	59.9	2.76%	224.59
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	88.0	3Wnd: OPEN KNOLL T1 1	103.4	89.7	0.66%	454.13

In the case of a double outage between Clark County and Thistle or Wichita and Thistle 345kV double circuit, approximately 1474MW curtailment would successfully alleviate overloads, as shown in Table 8-5. However, as indicated above, this event is very rare. The Harper-Milan Tap-Clearwater 138kV requires the greater reduction in WTG.

Table 8-5: 2017WP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DC	187.5	79.1	5.68%	1474.01
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	162.5	44.0	21.82%	962.55
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	162.5	42.0	22.19%	946.58
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DC	154.9	59.9	5.73%	1054.83
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	79.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	110.0	24.0	3.76%	210.35
539695 SPEARVL6 230 B$1668 SPEARVL6 1.00 1	TR	205.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	103.3	42.0	6.89%	97.30
539694 SPEARVL3 115 B$1668 SPEARVL6 1.00 1	TR	205.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	101.9	61.9	4.49%	89.02
B$1596 S975 T4 1.00 640234 HUMBOLT5 161 1	TR	67.2	S1263T1 AUTO	101.9	99.4	0.09%	1412.20

Finally, for the double pole outage, approximately 2610MW of curtailment would successfully eliminate the worse overload, which again happens in the Harper-Milan Tap 138kV line, as shown in Table 8-6.

Table 8-6: 2017WP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	152.4	79.1	1.92%	2609.57
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	135.5	44.0	8.42%	1416.36
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	135.5	42.0	8.61%	1386.06
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	122.9	59.9	1.90%	1327.27

8.1.3 Mitigation Under 2017 Light Load Conditions

Table 8-7 below shows, as before, that some level of WTG will be required to mitigate the overload on the Harper-Milan Tap 138kV line. We also note that significant WTG would need to be curtailed to eliminate the overload in some lines in Entergy, however in this case the OTDF is less than 1%, indicating that the Project has little impact and that this overload should be probably remediated locally.

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Table 8-7: 2017LL; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
334058 4L558T485 138 334060 4MT.ZION 138 1	LN	206.0	334325 8HARTBRG 500 337368 8MTOLIV 500 1	105.4	98.2	0.81%	1365.80
334026 4GRIMES 138 334040 4WALDEN 138 1	LN	191.0	334325 8HARTBRG 500 337368 8MTOLIV 500 1	104.7	98.0	0.70%	1283.50
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 1	103.8	50.4	2.80%	128.70

For the rare case that at GBX pole loss would be combined with an outage of either the Wichita-Thistle 345kV or Clark County-Thistle 345kV double circuits would require a reduction of 163MW to as much as 1069MW to resolve the overload conditions, as shown in Table 8-8. The Harper-Milan Tap 138kV line experiences the greatest need for WTG curtailment, which is consistent with the results above.

Table 8-8: 2017LL; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DO	170.1	50.4	6.27%	1068.53
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DO	141.3	26.0	6.95%	653.28
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	137.2	17.0	22.13%	563.94
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	137.2	17.0	22.13%	563.94
539671 FTDODGE3 115 539771 NFTDODG3 115 1	LN	177.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	111.2	57.0	5.28%	375.18
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	79.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	110.6	26.0	3.69%	230.07
539694 SPEARVL3 115 539771 NFTDODG3 115 1	LN	177.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	104.9	50.0	5.35%	162.75

A double pole outage requires WTG reductions ranging between 212MW to as much as 1581MW are required to mitigate the overloads noted in Table 8-9. Again, as in the N-1-2 condition, the Harper-Milan Tap 138kV line requires the most reduction to mitigate that overload.

Table 8-9: 2017LL; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	137.8	50.4	2.29%	1581.36
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	111.7	17.0	8.72%	449.67
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	111.7	50.4	1.85%	698.28
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	111.7	17.0	8.72%	449.67
514785 WOODWRD4 138 515785 WINDFRM4 138 1	LN	153.0	GBX DOUBLE POLE OUTAGE	103.3	46.0	2.40%	212.33

8.1.4 Mitigation Under 2022 Summer Peak Conditions

Table 8-10shows the curtailments of the WTG at the Project would range between 121MW to as high as 1546MW, however in this last case the OTDF is very small.

Also, as noted in Chapter 5, the CHADRON7 to WAYSIDE7 in NPPD, could be mitigated if the Rate C of this line (176 MVA) was considered – the line's normal rating (Rate A) and emergency rating (Rate B) are the same.

Table 8-10: 2022SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	88.0	530558 KNOLL 6 230 530584 POSTROCK6 230 1	114.1	91.1	1.11%	1118.08
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	112.5	56.8	2.92%	411.27
640109 CHADRON7 115 640405 WAYSIDE7 115 1	LN	160.0	640396 VICTRYH4 230 652573 STEGALL4 230 1	106.8	88.5	1.60%	679.39
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	106.5	36.1	12.96%	167.42
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	106.5	33.9	13.37%	162.35
541222 WSTELEC5 161 541224 LNGVW 5 161 1	LN	224.0	541218 GRNWD 5 161 541233 LEESUM 5 161 1	105.1	99.1	0.74%	1547.99
533021 NEOSHO 4 138 B$1342 NEOSH2AX 1.00 1	TR	19.8	3Wnd: OPEN NEC3 GSU 1	103.7	99.2	0.0005	1433.78
547483 JOP389 5 161 B$1047 JOPLINSW 1.00 1	TR	75.0	547472 TIP292 5 161 547483 JOP389 5 161 1	103.5	86.4	0.70%	384.21
640267 MAXWELS7 115 640287 N.PLATT7 115 1	LN	160.0	3Wnd: OPEN B$0653 CR.CREEK T1 1	102.6	90.2	1.09%	377.14
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	162.0	338138 5MORFLD 161 338142 5ISES-1 161 1	101.3	88.9	1.10%	199.87
510877 FIXCT4 138 515055 MAUD 4 138 1	LN	107.0	3Wnd: OPEN MAUD1 1	100.6	92.2	0.49%	121.83
531420 FLETCHR3 115 531448 HOLCOMB3 115 1	LN	198.0	531393 PLYMELL3 115 531448 HOLCOMB3 115 1	100.6	97.2	0.0037	325.31
541205 BLSPE 5 161 541211 BLSPS 5 161 1	LN	224.0	541235 DUNCAN 5 161 541250 SIBLEYPL 161 1	100.6	94.1	0.80%	175.48

Double circuit outages combined with the GBX pole outage indicates the WTG would need to be reduced between 240MW to 1160MW to mitigate all the problems noted in Table 8-11.

Table 8-11: 2022SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	175.3	56.8	6.21%	1159.90
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	151.0	36.1	21.15%	809.30
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	151.0	33.9	21.56%	794.09
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	141.7	35.5	6.40%	717.06
539692 SEWARD 3 115 539696 ST-JOHN3 115 1	LN	79.7	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	117.6	16.0	4.44%	317.78
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	110.4	31.5	15.36%	239.57

The double pole outage requires a WTG reduction between 541MW to 1852MW to mitigate the overloads resulting from the double outage, as shown in Table 8-12. As in most cases above Harper to Milan Tap requires the greatest reduction in generation.

Table 8-12: 2022SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	TYPE	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	144.6	56.8	2.30%	1852.47
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	121.8	39.0	7.62%	962.98
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	121.8	36.0	7.90%	929.31
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	116.4	6.0	3.33%	541.01

8.1.5 Mitigation Under 2022 Winter Peak Conditions

Table 8-13 shows the potential curtailments required for the overloads noted. As in the previous notations, the Harper-Milan Tap-Clearwater 138kV line is impacted requiring a significant reduction in WTG at the Project to mitigate the overload. The reduction in WTG ranges between 98MW to 1061MW.

Table 8-13: 2022WP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	128.9	75.7	2.79%	993.97
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	109.2	31.0	14.40%	216.01
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	88.0	3Wnd: OPEN KNOLL T1 1	107.4	94.7	0.61%	1061.43
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	533040 EVANS N4 138 533041 EVANS S4 138 1	102.4	56.8	2.75%	98.24

A double circuit contingency with the GBX pole outage is again noted on the Wichita-Thistle or Thistle-Clark County 345kV double circuit lines. As shown in Table 8-14 the curtailment values range from 813 MW to 1375 MW depending on the prior outage as shown in the table below.

Table 8-14: 2022WP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	174.3	75.7	5.17%	1374.63
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	155.4	31.0	22.90%	812.55
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	155.4	59.9	17.58%	1058.44
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	143.6	56.8	5.23%	917.47

The double pole outage requires a curtailment of approximately 2381MW to successfully mitigate the overloads experienced in the outage, as shown in Table 8-15.

Table 8-15: 2022WPeak; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	145.6	75.7	1.83%	2381.47
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	129.7	31.0	9.09%	1098.42
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	129.7	59.9	6.43%	1553.20
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	117.1	56.8	1.82%	1034.52

8.2 ITP Case Mitigation

The balance of this section provides the amount of Project generation that would need to be curtailed in order to mitigate overloads on the power system under the ITP cases. It should be considered that the ITP cases are a more stringent case than presented in the Build 2 cases.

8.2.1 Mitigation under ITP 2017 Scenario 0 Summer Peak Conditions

The tables below show the level of curtailment that would successfully mitigate the various contingency overloads. This mitigation is provided only for those cases that did not have Pre-Project overloads present in the ITP cases.

Table 8-16 indicates the Project generation that once reduced would alleviate overloads after N-1-1 contingencies (loss of a pole with loss of another transmission element). Results are consistent with previous findings.

Table 8-16: ITP 2017 S0 SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	112.2	58.3	2.82%	414.38
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	162.0	338138 5MORFLD 161 338142 5ISES-1 161 1	106.5	91.9	1.30%	802.47
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	100.6	44.0	10.42%	18.23
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	530583 POSTROCK7 345 531469 SPERVIL7 345 1	100.6	31.0	12.81%	14.83

Table 8-17 indicates the Project generation level reductions that could mitigate the overloads in the case for double outages. Results are again consistent with previous findings.

Table 8-17: ITP 2017 S0 SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	145.1	58.3	4.55%	950.10
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	139.4	44.0	17.56%	754.38
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	139.4	31.0	19.96%	663.91
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	115.5	15.0	6.06%	280.64
533162 GOODYR 3 115 533166 INDIANH3 115 1	LN	118.0	WRTOD400	105.6	80.8	1.60%	417.83
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT	101.6	23.0	15.30%	35.94

Table 8-18 indicates the Project generation to be reduced in order to alleviate overloads after N-2 contingencies (loss of a bipole) and is consistent with previous findings.

Table 8-18: ITP 2017 S0 SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	GBX DOUBLE POLE OUTAGE	130.1	58.3	1.88%	1531.45
531469 SPERVIL7 345	B$1665 SPEARVL 1.00	1	TR	336.0	GBX DOUBLE POLE OUTAGE	117.6	44.0	6.78%	873.77
539695 SPEARVL6 230	B$1665 SPEARVL 1.00	1	TR	336.0	GBX DOUBLE POLE OUTAGE	117.6	31.0	7.97%	742.60
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	GBX DOUBLE POLE OUTAGE	103.6	15.0	2.67%	146.06

8.2.2 Mitigation under ITP 2017 Scenario 0 Winter Peak Conditions

The tables below show the level of Project generation curtailment that could successfully mitigate overloads under different contingency pairs.

Table 8-19 to Table 8-21 present the Project generation that once curtailed would alleviate overloads after N-1-1, N-1-2 and N-2. All results are consistent with previous findings.

Table 8-19: ITP 2017 S0 WP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	118.6	67.2	2.69%	661.09

Table 8-20: ITP 2017 S0 WP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	153.7	67.2	4.53%	1132.16
531469 SPERVIL7 345	B$1666 SPEARVL 1.00	1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	143.2	22.0	22.31%	650.26
539695 SPEARVL6 230	B$1666 SPEARVL 1.00	1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	143.2	22.0	22.31%	650.26
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	124.3	47.0	4.66%	573.06
533162 GOODYR 3 115	533166 INDIANH3 115	1	LN	118.0	WRTOD400	113.0	88.2	1.60%	954.16
539692 SEWARD 3 115	539696 ST-JOHN3 115	1	LN	88.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	100.3	23.0	3.73%	8.05

Table 8-21: ITP 2017 S0 WP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	GBX DOUBLE POLE OUTAGE	135.5	67.2	1.79%	1900.61
531469 SPERVIL7 345	B$1666 SPEARVL 1.00	1	TR	336.0	GBX DOUBLE POLE OUTAGE	120.4	22.0	9.06%	757.33
539695 SPEARVL6 230	B$1666 SPEARVL 1.00	1	TR	336.0	GBX DOUBLE POLE OUTAGE	120.4	22.0	9.06%	757.33
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	GBX DOUBLE POLE OUTAGE	108.4	47.0	1.85%	502.59

8.2.3 Mitigation under ITP 2022 Scenario 0 Summer Peak Conditions

The tables below show the level of Project generation curtailment that could successfully mitigate overloads under different contingency pairs.

Table 8-22 to Table 8-24 present the Project generation that once curtailed would alleviate overloads after N-1-1, N-1-2 and N-2. All results are consistent with previous findings.

Table 8-22: ITP 2022 S0 SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
338813 5MIDWAY# 161 505460 BULL SH5 161 1	LN	162.0	338138 5MORFLD 161 338142 5ISES-1 161 1	106.7	96.0	0.95%	1147.60

Table 8-23: ITP 2022 S0 SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
531469 SPERVIL7 345 B$1668 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCK	139.4	18.0	22.35%	591.47
539695 SPEARVL6 230 B$1668 SPEARVL 1.00 1	TR	336.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 DCK	139.4	18.0	22.35%	591.92
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCKT	116.9	31.7	4.46%	360.74

Table 8-24: ITP 2022 S0 SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	119.6	31.7	2.30%	812.25
531469 SPERVIL7 345 B$1668 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	114.9	18.0	8.92%	561.65
539695 SPEARVL6 230 B$1668 SPEARVL 1.00 1	TR	336.0	GBX DOUBLE POLE OUTAGE	114.9	18.0	8.92%	561.65

8.2.4 Mitigation under ITP 2017 Scenario 5 Summer Peak Conditions

Table 8-25 indicates the Project generation that needs to be reduced in order to alleviate overloads after a N-1 contingency (specifically the loss of a GBX pole). This is the most important result of this section and we observe that a limited reduction of about 250 MW would resolve the observed overload.

Table 8-25 ITP 2017 S5 SP; Project Generation Curtailment to Eliminate N-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX POLE OUTAGE	103.1	79.6	1.23%	243.70

The balance (Table 8-26 to Table 8-28) shows the mitigation required for the N-1-1, N-1-2 and N-2 and the results are consistent with previous findings.

Table 8-26: ITP 2017 S5 SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	134.5	79.6	2.88%	1147.48
532851 AUBURN 6 230 532852 JEC 6 230 1	LN	565.0	532765 HOYT 7 345 532766 JEC N 7 345 1	108.8	97.0	3.65%	1363.21
533021 NEOSHO 4 138 B$1341 NEOSH2CX 1.00 2	TR	16.5	3Wnd: OPEN NEC3 GSU 1	107.9	85.1	0.21%	630.65
533021 NEOSHO 4 138 B$1340 NEOSH2BX 1.00 1	TR	16.5	3Wnd: OPEN NEC3 GSU 1	107.8	85.0	0.21%	630.65
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	533040 EVANS N4 138 533041 EVANS S4 138 1	106.0	57.9	2.90%	227.65
533021 NEOSHO 4 138 B$1339 NEOSH2AX 1.00 1	TR	19.8	3Wnd: OPEN NEC3 GSU 1	105.9	83.6	0.24%	495.99
533040 EVANS N4 138 533054 MAIZE 4 138 1	LN	382.0	533040 EVANS N4 138 533041 EVANS S4 138 1	102.5	89.0	2.83%	336.19
532765 HOYT 7 345 532766 JEC N 7 345 1	LN	1076.0	532851 AUBURN 6 230 532852 JEC 6 230 1	102.3	87.4	8.78%	282.30
530553 S HAYS 3 115 530562 HAYS 3 115 1	LN	99.0	3Wnd: OPEN KNOLL T1 1	102.0	89.0	0.71%	269.43
B$1216 MARSH 1 1.00 508557 MARSHL-4 138 1	TR	143.0	3Wnd: OPEN MARSH 2 2	100.5	95.1	0.42%	189.07
B$1217 MARSH 2 1.00 508557 MARSHL-4 138 2	TR	143.0	3Wnd: OPEN MARSH 1 1	100.4	95.2	0.41%	147.26

Table 8-27: ITP 2017 S5 SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	204.7	79.6	6.55%	1527.50
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	167.5	57.9	6.61%	1123.22
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	112.9	23.0	17.50%	261.68
532851 AUBURN 6 230 532852 JEC 6 230 1	LN	565.0	WRTOD400	105.4	97.0	2.60%	1168.98

Table 8-28: ITP 2017 S5 SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
532765 HOYT 7 345 532766 JEC N 7 345 1	LN	1076.0	GBX DOUBLE POLE OUTAGE	103.5	87.4	4.75%	792.21
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	124.5	57.9	2.01%	1340.23
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	157.4	79.6	2.04%	2694.19
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	GBX DOUBLE POLE OUTAGE	102.1	23.0	7.70%	96.11

8.2.5 Mitigation under ITP 2017 Scenario 5 Winter Peak Conditions

The tables below show the level of Project generation curtailment that could successfully mitigate overloads under different contingency pairs.

As in the summer case, there is a N-1 overload in the Harper to Milan Tap, which due to the lower OTDF in this case requires significant amount of WTG curtailment, as shown in Table 8-29.

Table 8-29 ITP 2017 S5 WP; Project Generation Curtailment to Eliminate N-1 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX POLE OUTAGE	113.4	94.6	0.98%	1299.74

The balance of Table 8-30 to Table 8-32 indicates the Project generation that could be reduced in order to alleviate various contingency overloads.

Table 8-30: ITP 2017 S5 WP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	148.0	94.6	2.80%	1640.88
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	533040 EVANS N4 138 533041 EVANS S4 138 1	119.1	73.5	2.75%	764.06
532851 AUBURN 6 230	532852 JEC 6 230	1	LN	565.0	532765 HOYT 7 345 532766 JEC N 7 345 1	104.4	91.8	3.90%	640.89

Table 8-31: ITP 2017 S5 WP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	225.7	94.6	6.87%	1750.28
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	186.6	73.5	6.82%	1397.98
539692 SEWARD 3 115	539696 ST-JOHN3 115	1	LN	88.0	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	106.9	31.0	3.66%	166.67
532851 AUBURN 6 230	532852 JEC 6 230	1	LN	565.0	WRTOD400	101.2	91.8	2.91%	233.67

Table 8-32: ITP 2017 S5 WP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	GBX DOUBLE POLE OUTAGE	166.8	94.6	1.89%	3379.08
533036 CLEARWT4 138	539675 MILANTP4 138	1	LN	110.0	GBX DOUBLE POLE OUTAGE	135.5	73.5	1.87%	2087.24
300057 5BARNET 161	344532 5ELDON 161	1	LN	167.0	GBX DOUBLE POLE OUTAGE	105.9	76.6	1.34%	731.03

8.2.6 Mitigation under ITP 2022 Scenario 5 Summer Peak Conditions

The tables below show the level of Project generation curtailment that could successfully mitigate overloads under different contingency pairs.

Table 8-33 to Table 8-35 presents the corresponding results for this scenario and again we note that with the exception of those cases where there is very low OTDF (indicating little influence of the project) curtailment is an effective way of dealing with system outages concurrent with GBX outages.

Table 8-33: ITP 2022 S5 SP; Project Generation Curtailment to Eliminate N-1-1 Overloads

** From bus **	** To bus **	CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138	539675 MILANTP4 138	1	LN	95.6	533040 EVANS N4 138 533041 EVANS S4 138 1	115.6	59.7	2.93%	508.84
532851 AUBURN 6 230	532852 JEC 6 230	1	LN	565.0	532765 HOYT 7 345 532766 JEC N 7 345 1	105.2	93.4	3.65%	804.78
B$1894 WATLANT2 1.00	508090 WATLANT4 138	2	TR	46.0	3Wnd: OPEN WATLANT1 1	102.8	99.3	0.09%	1473.60
B$1893 WATLANT1 1.00	508090 WATLANT4 138	1	TR	46.0	3Wnd: OPEN WATLANT2 2	101.9	98.4	0.09%	1020.19
530553 S HAYS 3 115	530562 HAYS 3 115	1	LN	99.0	3Wnd: OPEN KNOLL T1 1	101.1	89.1	0.65%	168.98
541222 WSTELEC5 161	541224 LNGVW 5 161	1	LN	224.0	541218 GRNWD 5 161 541233 LEESUM 5 161 1	100.7	94.4	0.77%	206.92
505496 NIXA 5 161	B$1377 NXA X2 1.00	1	TR	22.4	3Wnd: OPEN NXA X1 1	100.6	99.7	0.01%	905.26
345409 5OVERTON 161	B$0195 1.00	1	TR	300.0	300049 7THOMHL 345 300120 5THMHIL 161 1	100.5	99.5	0.16%	912.50
505502 TRUMAN 5 161	541314 NWARSAW5 161	1	LN	223.0	344224 7CALAWY 1 345 344225 1CAL G1 25.0 1	100.2	84.5	1.92%	20.85

Table 8-34: ITP 2022 S5 SP; Project Generation Curtailment to Eliminate N-1-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	175.5	59.7	6.07%	1190.24
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	532796 WICHITA7 345 539801 THISTLE 7 345 DCK	141.9	38.7	6.22%	741.12
539679 MULGREN6 230 539695 SPEARVL6 230 1	LN	355.3	539800 CLARKCO 7 345 539801 THISTLE 7 345 D	108.8	23.6	16.59%	188.10
532851 AUBURN 6 230 532852 JEC 6 230 1	LN	565.0	WRTOD400	101.8	93.4	2.60%	392.23

Table 8-35: ITP 2022 S5 SP; Project Generation Curtailment to Eliminate N-2 Overloads

** From bus ** ** To bus ** CKT	Type	Rating	Contingency Description	Loading%	Pre-Proj Loading%	OTDF	CURTAIL
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	95.6	GBX DOUBLE POLE OUTAGE	147.6	59.7	2.30%	1976.32
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	110.0	GBX DOUBLE POLE OUTAGE	116.0	38.7	2.33%	755.50
505502 TRUMAN 5 161 541314 NWARSAW5 161 1	LN	223.0	GBX DOUBLE POLE OUTAGE	110.6	84.5	1.59%	1479.99
532765 HOYT 7 345 532766 JEC N 7 345 1	LN	1076.0	GBX DOUBLE POLE OUTAGE	101.3	84.8	4.86%	296.05

Section

9

Receiving End Impacts

Although detailed interconnection studies will be carried out by PJM and MISO for the project POI at Sullivan and Palmyra, in this section of the report we present the results of a limited N-1 analysis conducted for the main transmission facilities in the vicinity of the project's POIs.

Contrary to the analysis above, this study was conducted for the case where both poles are in service as this represents the condition of maximum injection and hence most severe from the receiving end point of view.

N-1 contingency analysis was performed for a list of contingencies shown in Table 9-1. All results correspond to cases where the Pre-Project loading is less than 100% and loading of the same element is at or above 100% in Post-Project case. Note that voltage assessment was not studied in this limited N-1 analysis.

Table 9-1 List of Contingencies Studied for N-1 Analysis

No	Description	kV
1	Sullivan 765/345 kV TF (243210 - 243213)	765/345
2	Sullivan 243210 - Rockport 243209 ckt 1	765
3	Breed 243213 - Casey 346809 ckt 1	345
4	Breed 243213 - Darwin 243216 ckt 1	345
5	Breed 243213 - Dequine 243217 ckt 1	345
6	Breed 243213 - Wheat 254539 ckt 1	345
7	Rockport 243209 - Jefferson 243208 ckt 1	765
8	Palmyra 765772 - Palmyra tap 345435 ckt 1	345
9	Palmyra Tap 345435 - Sub T 636645 ckt 1	345
10	Palmyra Tap 345435 - Plamyra 345436 ckt 1	345
11	Palmyra Tap 345435 - Adair 344000 ckt 1	345
12	Palmyra Tap 345435 - Spencer 345992 ckt 1	345
13	Palmyra Tap 345435 - Se Quincy 347010 ckt 1	345

The load flow did not converge for the outage of following contingencies:

- Rockport – Jefferson 765 kV line (Not converged in all scenarios except Build2 2017 Light Load case)
- Sullivan – Rockport 765 kV line (Not converged in all scenarios)

The first contingency is an expected condition as it results in shifting of all the Project generation and the Rockport generation into the underlying 345 kV networks, which results in voltage and angular instability, as was confirmed during the stability studies of this project.

The second non-convergence issue is due to reactive power shortage at the Sullivan / Breed substation. When the Rockport line is tripped, all of the GBX power is redirected to the two existing Sullivan to Breed 765/345 transformers, which have a relatively high impedance (13% on their base) and produces an increase in their reactive consumption of 300 MVAr. As the GBX reactive power production is pre-contingency already at its limits (5x420 = 2100 MVAr) and there is reactive power flow (200 MVAr) from Sullivan 765 kV to the Project to compensate for the reactive consumption for the 3 x 345/765 kV transformers; once the only source of reactive power is lost (the line to Rockport), the case stops converging.

We tested successfully a solution of increasing the reactive production at the project to 6x420 = 2520 MVAr and achieved convergence. However, also the HVDC controls could be used to resolve this issue, as was evidenced during the stability runs; where the case was shown to be stable by a reduction on the reactive consumption of the HVDC link.

With respect to the other contingencies, the study results indicated that:

- Each 765/345 kV transformer connecting Sullivan 765 kV bus to Breed 345 kV bus would overload for all conditions in both Build2 and ITP Near-Term scenarios, if the other transformer trips. In Section 10 of this report, this overload is not a concern when the Project is connected to the 345 kV bus at Sullivan.
- In addition, the 345 kV lines Breed – Wheat and Breed – Casey would overload in Build2 Light Load conditions, when the Rockport to Jefferson 765 kV line trips.

The following sections present the study results.

9.1 Build 2 Scenarios

Table 9-2, Table 9-3 and Table 9-4 show N-1 violations for Summer Peak and Light Load conditions, respectively. The 765/345 kV transformers connecting Sullivan to Breed were loaded up to 108% while the Pre-Project contingency loading of these transformers is around 40% to 70%.

The Palmyra 345/161 kV transformer was overloaded in Summer Peak conditions as shown in Table 9-2 and Table 9-3, for the outage of the 345 kV line Palmyra Tap to Adair. The Pre-Project contingency loading of this transformer is around 80% and increased to 106% in Post-Project contingency conditions. Further investigation into this situation revealed that in the load flow cases the Se Quincey 345 kV substation was not connected to the 138 kV network (the transformer were present but not the connection). This error in modeling once corrected eliminated the problems observed at Palmyra substation in this and subsequent cases.

Table 9-4 shows overloading of Breed – Wheat 345 kV line and Breed – Casey 345 kV lines for the outage of Rockport – Jefferson 765 kV line. These lines are loaded up to 44% in Pre-Project contingency conditions and increased to 109.6% in Post-Project contingency conditions.

No additional overloads are observed in Winter Peak scenarios compared to Pre-Project scenarios.

Table 9-2 Post-Project 2017 Summer Peak N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	101.4	65.6	35.8
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	100.2	68.9	31.3
345437 5PALMYRA 161 345436 7PALMYRA345 1	TR	Palmyra Tap 345435 - Adair 344000	106.6	83.3	23.3

Table 9-3 Post-Project 2022 Summer Peak N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	102.2	65.7	36.5
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	100.9	69	31.9
345437 5PALMYRA 161 345436 7PALMYRA345 1	TR	Palmyra Tap 345435 - Adair 344000	105.7	88.5	17.2

The overload at Palmyra substation was determined to be not valid.

Table 9-4 Post-Project 2017 Light Load N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Rockport 243209 - Jefferson 243208	108.1	44.4	63.7
243210 05SULLVA 765 243213 05BREED 345 2	TR	Rockport 243209 - Jefferson 243208	113.5	46.6	66.9
243213 05BREED 345 254539 16WHEAT 345 1	LN	Rockport 243209 - Jefferson 243208	109.6	38.4	71.2
243213 05BREED 345 346809 7CASEY 345 1	LN	Rockport 243209 - Jefferson 243208	103.8	43.8	60.0

9.2 ITP Near-Term Scenarios

Table 9-5 and Table 9-6 shows violations for 2017 Summer Peak conditions while Table 9-7 and Table 9-8 shows violations for 2022 Summer Peak conditions. Similar to Build2 scenario results, the 765/345 kV transformers connecting Sullivan to Breed were loaded up to 102% while the Pre-Project contingency loading of these transformers is around 70%.

No additional overloads are observed in Winter Peak scenarios compared to Pre-Project scenarios.

Table 9-5 Post-Project 2017 Summer Peak 0: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	101.6	65.6	36.0
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	100.4	68.9	31.5

Table 9-6 Post-Project 2017 Summer Peak 5: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	100.9	65.6	35.3
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	99.7	68.9	30.8

Table 9-7 Post-Project 2022 Summer Peak 0: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	101.9	65.7	36.2
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	100.6	69	31.6

Table 9-8 Post-Project 2022 Summer Peak 5: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243210 05SULLVA 765 243213 05BREED 345 1	TR	Sullivan 765/345 kV TF(243210-243213)Ckt2	102.1	65.7	36.4
243210 05SULLVA 765 243213 05BREED 345 2	TR	Sullivan 765/345 kV TF(243210-243213)Ckt1	100.8	69	31.8

Section

10

345 kV Connection at Sullivan

A sensitivity case of connecting the Project directly to the 345 kV network at Sullivan substation (opposed to 765 kV Sullivan bus via three transformers) was studied, and the corresponding results are presented in this section. Figure 10-1 shows the connection of the Project inverter station to the Breed 345 kV substation through 345 kV lines. Though these lines are modeled as double circuit, the final configuration may have more than two circuits for N-1 capability depending on the conductor ratings. The length of these lines is assumed to be approximately 10 miles.

The following analyses were conducted to evaluate the impact of connecting the Project directly to 345 kV network at Sullivan:

- **Impacts on SPP Side:** Given that the configuration change is at Sullivan substation and the Project dispatch is still the same (3,000 MW into Sullivan and 500 MW into Palmyra Tap), connecting the Project to 345 kV network should not create additional impacts within the study area on SPP side than those that were already identified and presented in previous sections of this report. However, single pole outage (N-1) and single pole outage followed by additional element (N-1-1) were simulated for selected contingencies to confirm that the change in configuration (765 kV to 345 kV Connection) does not create additional impacts.

- **Impacts around Sullivan Area (AEP) and Palmyra (AMEREN):** The change in configuration may create additional impacts around Sullivan area; hence another sensitivity analysis was performed to identify such impacts. An N-1 analysis was conducted for selected contingencies with both poles in service (i.e. 3000 MW of injection at Sullivan). This injection is more stressful for the receiving end than having one pole out and it corresponds to our Base Case. However, it should be indicated that this is not the theoretical maximum stress condition which could happen when 3,500 MW are injected. As indicated previously, this 3,500 MW injection with one pole out does not create additional problems in the SPP region as compared with the 3,000 MW injection. However, at the receiving end with both poles in service, problems were identified for the 3,000 MW and these are expected to become more pronounced for the 3,500 MW. Solutions to these problems are being assessed as part of the stability studies for both 3,000 MW and 3,500 MW injections and once they are finalized a revised version of this report will be produced.

  Additionally, we verified that no new issues were introduced around the Palmyra area.

The sensitivity analyses were conducted on Build2 cases, and ITP Near-Term Scenario 0 and Scenario 5 cases. Table 10-1 shows the list of selected contingencies considered for the sensitivity studies. The following sections present the assumptions and results of the sensitivity analyses. All results correspond to cases where the Pre-Project loading is less than 100% and loading of the same element is at or above 100% in Post-Project case.

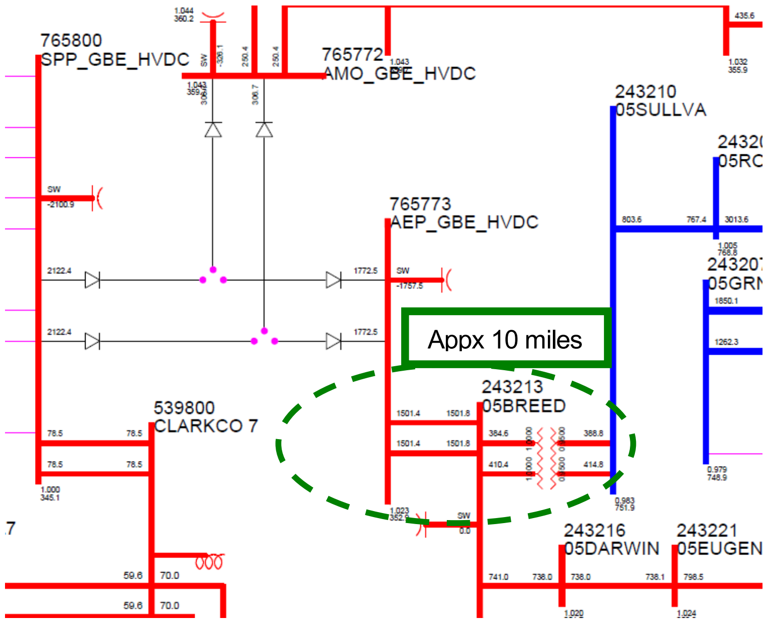

Figure 10-1 Project is Connected to 345 kV Network at Sullivan

Table 10-1 List of Contingencies

No	Description	kV
1	Clarck Co 539800 - Thistle 539801 ckt 1	345
2	Clark Co 539800 - Spearville 531469 ckt 1	345
3	Thistle 539801 - Witchita 532796 ckt 1	345
4	Thistle 539801 - Woodward 515375 ckt 1	345
5	Woodward 515375 - Tatonga 515407 ckt 1	345
6	Spearville 531469 - Holcomb 531449 ckt 1	345
7	Spearville 531469 - Postrock 530583 ckt 1	345
8	Spearville 345/230 kV TF (531469 - 539695)	345/230
9	Spearville 539695 - Mulgreen 539679 ckt 1	345
10	Postrock 530583 - Axtell 640065 ckt 1	345
11	Holcomb 531449 - Finney 523853 ckt 1	345
12	Holcomb 531449 - Setab 531465 ckt 1	345
13	Finney 523853 - Hitchland 523080 ckt 1	345
14	Finney 523853 - Lamar 599950 ckt 1	345
15	Setab 531465 - Mingo 531451 ckt 1	345
16	Mingo 531451 - Redwillow 640325 ckt 1	345
17	Sullivan 765/345 kV TF (243210 - 243213)	765/345
18	Sullivan 243210 - Rockport 243209 ckt 1	765
19	Breed 243213 - Casey 346809 ckt 1	345
20	Breed 243213 - Darwin 243216 ckt 1	345
21	Breed 243213 - Dequine 243217 ckt 1	345
22	Breed 243213 - Wheat 254539 ckt 1	345
23	Rockport 243209 - Jefferson 243208 ckt 1	765
24	Palmyra 765772 - Palmyra tap 345435 ckt 1	345
25	Palmyra Tap 345435 - Sub T 636645 ckt 1	345
26	Palmyra Tap 345435 - Plamyra 345436 ckt 1	345
27	Palmyra Tap 345435 - Adair 344000 ckt 1	345
28	Palmyra Tap 345435 - Spencer 345992 ckt 1	345
29	Palmyra Tap 345435 - Se Quincy 347010 ckt 1	345

10.1 Impacts on SPP side

The analysis presented provides the results of a single pole outage (N-1) and single pole outages coupled with a concurrent single contingency (N-1-1) listed in Table 10-1. The loss of both HVDC poles (N-2) is not studied separately because the results presented in previous sections are still valid.

The study results show that the Harper – Milan Tap 138 kV line is overloaded in ITP Near-Term 2017 Summer Peak and Winter Peak scenarios for N-1 (pole outage) condition. The Spearville 345/230 kV transformer and Harper – Milan Tap 138 kV line are overloaded almost in all scenarios under N-1-1 conditions. Further, the Milan Tap – Clear Water 138 kV line overloaded only in ITP 2017 Summer Peak 5 scenario. These facilities are also overloaded accordingly in original study i.e. Project is connected to Sullivan 765 kV bus.

10.1.1 Build 2 scenarios

10.1.1.1 Post-Project 2017 Summer Peak

The loss of a single pole of the Project (N-1) does not result in any additional overloads in the system compared to the Pre-Project case.

The N-1-1 overloads include overloading of Spearville 345/230 kV transformer and Harper to Milan Tap 138 kV line as shown in Table 10-2. These overloads were also observed during the analysis with the Project connected to Sullivan 765 kV bus and the relevant discussion is presented in Section 4. No additional impacts were observed for the selected list of contingencies other than what were already identified in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-2 Post-Project 2017 Summer Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	116.2	39.66	76.5
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	100.6	25.209	75.4
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	116.2	37.69	78.5

10.1.1.2 Post-Project 2017 Winter Peak Case

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Table 10-3 shows N-1-1 violations which are the same facilities noted as overloaded in 2017 Summer Peak case. No additional impacts were observed for the selected list of contingencies other than what was already identified in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-3 Post-Project 2017 Winter Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	115.1	37.22	77.9
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	119.8	46.96	72.8
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	115.1	35.07	80.0

10.1.1.3 Post-Project 2017 Light Load Case

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Under N-1-1 conditions, it was observed that the Harper to Milan Tap 138 KV line is overloaded as shown in Table 10-4. No additional impacts were observed for the selected list of contingencies other than what was already identified in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-4 Post-Project 2017 Light Load N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	104.0	32.0	72.0

10.1.1.4 Post-Project 2022 Summer Peak Case

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Table 10-5 shows N-1-1 violations which are the same facilities noted as overloaded in the 2017 Summer Peak case. No additional impacts were observed for the selected list of contingencies other than what was already identified in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-5 Post-Project 2022 Summer Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
531469 SPERVIL7 345 B$1667 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	106.5	28.65	77.9
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	109.2	16.94	92.3
539695 SPEARVL6 230 B$1667 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	106.5	26.37	80.1

10.1.1.5 Post-Project 2022 Winter Peak Case

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Table 10-6 shows N-1-1 violations which are the same facilities noted as overloaded in the 2017 Summer Peak case. No additional impacts were observed for the selected list of contingencies other than what was already identified in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-6 Post-Project 2022 Winter Peak N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
531469 SPERVIL7 345 B$1666 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	109.2	32.04	77.2
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	111.2	10.87	100.3
539695 SPEARVL6 230 B$1666 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	109.2	29.62	79.6

10.1.2 ITP Near-Term Scenarios

10.1.2.1 ITP Scenario 0 – 2017 Summer Peak

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Table 10-7 shows thermal violations under N-1-1 conditions. The Spearville transformer was observed to be overloaded in all Build2 scenario cases as well.

Table 10-7 Post-Project 2017 Summer Peak 0: N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
531469 SPERVIL7 345 B$1665 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	100.6	25.67	74.9
539695 SPEARVL6 230 B$1665 SPEARVL 1.00 1	TR	Spearville 531469 - Postrock 530583	100.6	21.48	79.1

10.1.2.2 ITP Scenario 5 – 2017 Summer Peak

The loss of a single pole of the Project (N-1) results in overloading of Harper – Milan Tap 138 kV line as shown in Table 10-8. This overload was also observed during the analysis with the Project connected to Sullivan 765 kV bus and the relevant discussion is presented in Section 5.

Table 10-9 shows the overloads under N-1-1 conditions, similar what were observed in ITP scenario 0 – 2017 Summer Peak case.

Table 10-8 Post-Project 2017 Summer Peak 5: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX Pole Outage	103.1	54.8	48.3

Table 10-9 Post-Project 2017 Summer Peak 5: N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	100.6	34.27	66.3
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	127.5	54.8	72.7

10.1.2.3 ITP Scenario 0 – 2017 Winter Peak

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Also, no additional N-1-1 violations were observed compared to the Pre-Project case.

10.1.2.4 ITP Scenario 5 – 2017 Winter Peak

The loss of a single pole of the Project (N-1) results in overloading of Harper – Milan Tap 138 kV line as shown in Table 10-10, similar to the analysis with the Project connected to Sullivan 765 kV bus.

Table 10-11 shows overloads under N-1-1 conditions which are again similar to what was observed in previous analysis with the Project connected to Sullivan 765 kV bus.

Table 10-10 Post-Project 2017 Winter Peak 5: N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	GBX Pole Outage	113.4	66.8	46.6

Table 10-11 Post-Project 2017 Winter Peak 5: N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
533036 CLEARWT4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	114.5	50.2	64.3
539668 HARPER 4 138 539675 MILANTP4 138 1	LN	Thistle 539801 - Witchita 532796	140.5	66.8	73.7

10.1.2.5 ITP Scenario 0 – 2022 Summer Peak

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Also, no additional N-1-1 violations were observed compared to the Pre-Project case.

10.1.2.6 ITP Scenario 5 – 2022 Summer Peak

The loss of a single pole of the Project (N-1) does not create any additional overloads in the system compared to the Pre-Project case.

Table 10-12 shows overloads under N-1-1 conditions. All of them were observed in earlier analyses except the following two lines. These lines were loaded close to 100% in Pre-Project case and further increased by less than 2.5% and thus the impact can be omitted.

- 6FRNSTL – 6SORR 230 kV line Circuit 2 (332 LAGN – 351 EES), 98.5% loading in Pre-Project case
- 3MAYFL – 3MORGAN 115 kV Circuit 1 (351 EES), 99.5% loading in Pre-Project case

In summary, connecting the Project to 345 kV network at Sullivan does not create additional overloads other than what were observed with connecting the Project to Sullivan 765 kV bus.

Table 10-12 Post-Project 2022 Summer Peak 5: N-1-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
303204 6FRNSTL 230 336060 6SORR 2 230	LN	Finney 523853 - Lamar 599950	100.3	98.5	1.8
337930 3MAYFL 115 337931 3MORGAN 115	LN	Finney 523853 - Lamar 599950	101.4	99.2	2.2
539668 HARPER 4 138 539675 MILANTP4 138	LN	Thistle 539801 - Witchita 532796	112.5	38.91	73.6

10.2 Impacts around Receiving Substations: Sullivan Area (AEP) and Palmyra (MISO) Area

The focus of this sensitivity study is to identify the impacts around Sullivan area with the Project being connected to 345 kV network at Sullivan. As pointed out in the previous section, since the study focus is around Sullivan, single contingency analysis on a prior pole outage case (N-1-1) would be less severe as the Project injection would be 1,500 MW opposed to both poles in service with the Project injection of 3,000 MW. Hence, single contingency (N-1) analysis was conducted on Post-Project case with both HVDC poles in service.

Table 10-1 shows the list of contingencies considered for this sensitivity study. This list does not include the N-1 pole outage as it was already studied and the results are discussed in previous section. Also, the loss of both HVDC poles (N-2) is not studied separately because the results presented in previous sections with the Project connected to Sullivan 765 kV bus are still valid.

The load flow did not converge for the outage of Rockport – Jefferson 765 kV line in all scenarios including Build2, ITP0 and ITP5 except in Build2 2017 Light Load case. This is an expected condition as the outage of Rockport – Jefferson 765 kV line results in shifting all the Project generation and the Rockport plant generation into the underlying 345 kV network at Sullivan.

The situation above was not observed in Light Load condition as the Rockport plant is dispatched at reduced generation compared to peak loading conditions. No attempt has been made to resolve the issue here as this contingency and its impacts are more appropriately studied during the stability assessment of the GBX Project. The stability assessment will be presented in a separate report together with the adequacy of the mitigation strategy proposed.

The outage of the Sullivan to Rockport 765 kV line did converge in all cases as the problems with increased reactive consumption at the transformation 345 to 765 kV at the Project and 765 kV to 345 kV at Sullivan / Breed were eliminated with the direct connection to 345 kV.

All results correspond to cases where the Pre-Project loading is less than 100% and loading of the same element is at or above 100% in the Post-Project case.

The study results indentified no problems in the Palmyra area (beyond those associated with inaccuracies with the model).

In AEP, the study results show that the Breed – Wheat 345 kV line would overloaded in Build2 Light Load conditions.

10.2.1 Build 2 Scenarios

Table 10-13 shows overloading of Breed – Wheat 345 kV line for the outage of Rockport – Jefferson 765 kV line. The line is loaded up to 40% in Pre-Project contingency conditions and increased to 100.2% in Post-Project contingency conditions. Note that the load flow did not converge for this contingency in other Build2 scenarios.

No additional overloads are observed in Winter Peak scenarios compared to Pre-Project scenarios.

Table 10-13 Post-Project 2017 Light Load N-1 Violations

** From bus ** ** To bus ** CKT	Type	Contingency Description	Loading %	Pre-project loading %	Delta %
243213 05BREED 345 254539 16WHEAT 345 1	LN	Rockport 243209 - Jefferson 243208	100.2	38.4	61.8

10.2.2 ITP Near-Term Scenarios

No additional overloads are observed in Winter Peak scenarios compared to Pre-Project scenarios.

Section

11

Summary of Observations

Based on the results of this study, it can be concluded that only one facility – the HARPER4-MILANTP4138kV line is the most affected element and it overloads during a single pole DC outage on the Project in the 2017 Summer and Winter Peak conditions under ITP Scenario 5. The overload does not occur in the Build 2 cases until a more stringent contingency (N-1-1) occurs. Additionally, the Sunflower 138 kV HARPER4 to MILANTP4 line and its continuation to CLEARWT4 was found to overload under various conditions (particularly N-1-2).

Another overload that appeared repeatedly in the study is the line 5MIDWAY# (338813) to BULL SH5 (505460) which is an interface between SWPA and Entergy Energy Services (EES). Entergy was not recognized as an affected party as the line ownership resides with the SWPA. In this overload, a 20% increase in flow occurs during a single pole DC outage on the Project and before the Project's direct-connected WTG's is ramped down.

For other observed overloads, please refer to Tables E-1 in the executive summary, which shows a summary of all facilities that were found to be affected in this study. In these tables, for each of the scenarios, we indicate under which condition and case a facility would see an increase from below 100% of its rating to 100% or above its rating. If a given facility is affected under both N-1-1 and N-1-2 situations, then the most stringent (N-1-1) is reported in the summary.

The results of the limited N-1 analysis at the receiving ends of the Project with both poles in-service are summarized below. Note that this analysis was performed to screen potential impacts on the main transmission system and does not substitute for the detailed system impact study to be conducted by MISO and PJM.

- Each 765/345 kV transformer connecting Sullivan 765 kV bus to Breed 345 kV bus would overload if the other transformer is out for all conditions in both Build2 and ITP Near-Term scenarios.
- The 345 kV lines from Breed to Wheat and Casey would overload in Build2 Light Load conditions, when the Rockport to Jefferson 765 kV line trips.
- The trip of the Rockport to Jefferson line did not converge, except for the Build2 2017 Light Load condition, and this can be associated with voltage and angular instability. This contingency will be studied in detail during the stability assessment of the GBX project which will be presented in a separate report.
- The trip of the Sullivan to Rockport line did not converge due to reactive power deficiency at Sullivan 765 kV or the GBX. Increasing the reactive power at GBX to 2520 MVAr solved this issue. However, other alternatives maybe as effective or more effective as for example the direct connection to 345 kV discussed below.

The sensitivity study (connecting the Project to the 345 kV network at Sullivan) results, with focus on SPP side, are consistent with the results of the original study (connecting the Project to Sullivan 765 kV bus) and no additional overloads were observed. The following overloads are observed which were also observed in the original study:

- The Harper – Milan Tap 138 kV line is overloaded in ITP Near-Term 2017 Summer Peak and Winter Peak scenarios for N-1 (pole outage) condition.
- The Spearville 345/230 kV transformer and Harper – Milan Tap 138 kV line are overloaded almost in all scenarios for N-1-1 conditions. Further, the Milan Tap – Clear Water 138 kV line was overloaded only in ITP 2017 Summer Peak 5 scenario.

The sensitivity study (connecting the Project to 345 kV network at Sullivan), with focus on the receiving end Sullivan (AEP) and Palmyra (MISO) side, shows that the AEP 345 kV line Breed – Wheat overloads in Build2 Light Load conditions, for the trip of the Rockport – Jefferson 765 kV line. This contingency did not converge for other loading scenarios, where the Rockport Plant was dispatched at close to full capacity. This contingency assessment and the proposed mitigation (tripping of one pole) are presented in the GBX Stability Assessment report.

Appendix

A

Subsystem, Monitoring and Contingency Files (sub, mon, con)

A.1 GBX Subsystem File (*.sub)

```
subsystem SPS_CONT
 join
   AREA 526
    zone 1500     /* Municipals
    zone 1501     /* Caprock
    zone 1502     /* Oaklahoma, Panhandle North
    zone 1503     /* Amarillo Metro
    zone 1504     /* Clovis, Hereford
    zone 1505     /* Central Plains (Happy, Plainview, Hale County, Lubbock, etc.)
    zone 1506     /* Yoakum County, Gaines County, Denver City, Mustang
    zone 1507     /* Pecos Valley (Roswell, Artesia, Carlsbad, Eddy County, Cunningham)
    zone 1508     /* Hobbs, Jal, Wipp, Maddox
    zone 1509     /* Lea County Cooperative
    KVRANGE 115 500
    END
End
system 'SPP-Modified'
    JOIN
    AREA 357
    AREA 361
    AREA 362
    KVRANGE 115 999
    END
end
system 'PE_XPOLE'
    JOIN
    BUS 999906
    BUS 999907
    BUS 999908
    END
end
system 'Internal-1'
    JOIN
    AREAS 502 546
    AREA 640
    AREA 645
    AREA 650
    AREA 998
    AREA 999
```

```
   KVRANGE 115 999
   END
end
system 'Internal-2'
   JOIN
   ZONE 301
   ZONES 304 305
   KVRANGE 115 999
   END
end
system 'ExternalM'
   JOIN
   AREA 332
   AREA 356
   AREA 635
   AREA 652
   KVRANGE 230 999
   END
end
system 'ExternalC'
   JOIN
   AREA 332
   AREA 356
   AREA 635
   AREA 652
   KVRANGE 230 999
   END
end
/* THIS INFORMATION MATCHES DATA SUBMITTED BY AECI
system 'AECI'
   JOIN
   AREA 330
   KVRANGE 115 999
   END
end
system 'AEP'
   JOIN
   AREA 205
   KVRANGE .1 999
   END
end
system 'ENTR'
   JOIN
   AREA 351
   AREA 328
   AREA 329
   AREA 334
   AREA 335
   AREA 336
   AREA 337
   AREA 338
   AREA 339
   KVRANGE 115 999
```

```
   END
end
system 'NPPD'
   JOIN
   AREA 640
   KVRANGE 115 999
   END
end
system 'OPPD'
   JOIN
   AREA 645
   KVRANGE 115 999
   END
end
system 'LES'
   JOIN
   AREA 650
   KVRANGE 115 999
   END
end
system 'CELE'
   JOIN
   AREA 502
   KVRANGE 115 999
   END
end
system 'LAFA'
   JOIN
   AREA 503
   KVRANGE 115 999
   END
end
system 'LEPA'
   JOIN
   AREA 504
   KVRANGE 115 999
   END
end
system 'SWPA'
   JOIN
   AREA 515
   KVRANGE 115 999
   END
end
system 'AEPW'
   JOIN
   AREA 520
   KVRANGE 115 999
   END
end
system 'GRRD'
   JOIN
   AREA 523
```

```
   KVRANGE 115 999
   END
end
system 'OKGE'
   JOIN
   AREA 524
   KVRANGE 115 999
   END
end
system 'WFEC'
   JOIN
   AREA 525
   KVRANGE 115 999
   END
end
system 'SWPS'
   JOIN
   AREA 526
   KVRANGE 115 999
   END
end
system 'TVA'
   JOIN
   AREA 347
   KVRANGE .1 999
   END
end
system 'OMPA'
   JOIN
   AREA 527
   KVRANGE 115 999
   END
end
system 'MIDW'
   JOIN
   AREA 531
   KVRANGE 115 999
   END
end
system 'SEPC'
   JOIN
   AREA 534
   KVRANGE 115 999
   END
end
system 'WERE-L'
   JOIN
   AREA 536
   KVRANGE 65 200
   END
end
system 'WERE-H'
   JOIN
```

```
   AREA 536
   KVRANGE 200 999
   END
end
system 'MIPU'
   JOIN
   AREA 540
   KVRANGE 115 999
   END
end
system 'KCPL'
   JOIN
   AREA 541
   KVRANGE 115 999
   END
end
system 'KACY'
   JOIN
   AREA 542
   KVRANGE 115 999
   END
end
system 'EMDE-L'
   JOIN
   AREA 544
   KVRANGE 65 158
   END
end
system 'EMDE-H'
   JOIN
   AREA 544
   KVRANGE 159 999
   END
end
system 'INDN'
   JOIN
   AREA 545
   KVRANGE 115 999
   END
end
system 'SPRM'
   JOIN
   AREA 546
   KVRANGE 115 999
   END
end
system 'ERCOT'
   JOIN
   AREA 998
   KVRANGE 115 999
   END
end
system 'WSCC'
```

```
   JOIN
   AREA 999
   KVRANGE 115 999
   END
end
END
```

A.2 GBX Monitoring File (*.mon)

```
/
/% SPS MONITOR FILE %/
/
MONITOR BRANCHES in subsystem SPS_CONT
MONITOR VOLTAGE RANGE subsystem SPS_CONT 0.90 1.05     /* SPS Voltages
MONITOR VOLTAGE RANGE BUS 599950 0.950 1.05           /* Lamar HVDC 230kV Bus
MONITOR VOLTAGE RANGE BUS 525830 0.925                /* Tuco Interchange 230kV Bus
MONITOR TIES FROM ZONE 1500 TO AREA 526
MONITOR TIES FROM ZONE 1501 TO AREA 526
MONITOR TIES FROM ZONE 1502 TO AREA 526
MONITOR TIES FROM ZONE 1503 TO AREA 526
MONITOR TIES FROM ZONE 1504 TO AREA 526
MONITOR TIES FROM ZONE 1505 TO AREA 526
MONITOR TIES FROM ZONE 1506 TO AREA 526
MONITOR TIES FROM ZONE 1507 TO AREA 526
MONITOR TIES FROM ZONE 1508 TO AREA 526
MONITOR TIES FROM ZONE 1509 TO AREA 526
MONITOR TIES FROM AREA 526 TO AREA 526
/
/ AECI SPECIFIC BRANCHES TO MONITOR
/
MONITOR BRANCH FROM BUS 505490 TO BUS 505488 TO BUS 505487 CKT 1
         /*CARTHAGE 161/69
MONITOR BRANCH FROM BUS 549969 TO BUS 549984 TO BUS 549988 CKT 1
         /*BROOKLINE 345/161
MONITOR BRANCH FROM BUS 345437 TO BUS 345436 CKT 1
             /*PALMYRA 345/161
/
monitor branches in system SPP-Modified IN KVRANGE 100 999
monitor branches in system Internal-1
monitor branches in system Internal-2
monitor branches in system ExternalM
monitor branches in system AECI /* AECI.MON MATCHED
monitor branches in system ENTR
monitor ties from system Internal-1
monitor ties from system Internal-2
monitor ties from system ExternalM
monitor ties from system AECI/* AECI.MON MATCHED
monitor ties from system ENTR
/
monitor voltage range system SPP-Modified 0.90 1.05
```

monitor voltage range system CELE 0.92 1.05
monitor voltage range system LAFA 0.90 1.05
monitor voltage range system LEPA 0.90 1.05
monitor voltage range system SWPA 0.90 1.05
monitor voltage range system AEPW 0.90 1.05
monitor voltage range system GRRD 0.90 1.05
monitor voltage range system OKGE 0.90 1.05
monitor voltage range system WFEC 0.90 1.05
monitor voltage range system SWPS 0.90 1.05
monitor voltage range system OMPA 0.90 1.05
monitor voltage range system MIDW 0.90 1.05
monitor voltage range system SEPC 0.90 1.05
monitor voltage range system WERE-L 0.93 1.05
monitor voltage range system WERE-H 0.95 1.05
monitor voltage range system MIPU 0.90 1.05
monitor voltage range system KCPL 0.90 1.05
monitor voltage range system KACY 0.90 1.05
monitor voltage range system EMDE-L 0.90 1.05
monitor voltage range system EMDE-H 0.92 1.05
monitor voltage range system INDN 0.90 1.05
monitor voltage range system SPRM 0.90 1.05
monitor voltage range system ERCOT 0.90 1.05
monitor voltage range system WSCC 0.90 1.05
monitor voltage range system NPPD 0.90 1.05
monitor voltage range system LES 0.95 1.05
monitor voltage range system OPPD 0.95 1.05
monitor voltage range system Internal-2 0.90 1.05
monitor voltage range system AECI 0.90 1.05 /* AECI.MON MATCHED
monitor voltage range system ExternalM 0.90 1.05
monitor voltage range system ENTR 0.92 1.05
monitor voltage range bus 525830 0.925 1.05 /Tuco 230kV
monitor voltage range bus 532797 0.985 1.03 /Wolf Creek
monitor voltage range bus 646251 1.001863 1.047205 /OPPD FCS Off-site power limits added 3.15.2010
/*Reciprocal 2nd Tier flowgates
/*Need to update the bus numbers
/*Reciprocal 2nd Tier flowgates
/MONITOR INTERFACE 'ANOFTSANOPHI' RATING 1299 MW /SP Normal = MW Emergency = 1299 MW TRM 0
/MONITOR BRANCH FROM BUS 337909 TO BUS 515305 CKT 1 /'8ANO 50 500' - 'FTSMITH8 500'
/END
/MONITOR INTERFACE 'BLAFRASTFLUT' RATING 1254 MW /SP Normal = 1248 MW Emergency = 1279 MW TRM 25
/MONITOR BRANCH FROM BUS 344154 TO BUS 300041 CKT 1 /'BLAND 345' - '7FRANKS 345'
/END
/MONITOR INTERFACE 'BLAFRKLUTESS' RATING 1254 MW /SP Normal = 1248 MW Emergency = 1279 MW TRM 25
/MONITOR BRANCH FROM BUS 344154 TO BUS 300041 CKT 1 /'BLAND 345' - '7FRANKS 345'

/END
/MONITOR INTERFACE 'BLAFRKMCCOVR' RATING 1254 MW /SP Normal = 1248 MW Emergency = 1279 MW TRM 25
/MONITOR BRANCH FROM BUS 344154 TO BUS 300041 CKT 1 /'BLAND 345' - '7FRANKS 345'
/END
/MONITOR INTERFACE 'BRACLIBRALAK' RATING 239 MW /SP Normal = 239 MW Emergency = 239 MW TRM
/MONITOR BRANCH FROM BUS 336880 TO BUS 336883 CKT 1 /'3R.BRAS 115' - '3CLINTN 115'
/END
/MONITOR INTERFACE 'CAHXFRCAHXFR' RATING 689 MW /SP Normal = 689 MW Emergency = 700 MW TRM 11
/MONITOR BRANCH FROM BUS 346714 TO BUS 346715 CKT 1 /'CAHOKIA 345' - 'CAHOK 1 138'
/END
/MONITOR INTERFACE 'CORNELQUAH47' RATING 1500 MW /SP Normal = 1500 MW Emergency = 1530 MW TRM 30
/MONITOR BRANCH FROM BUS 270828 TO BUS 270700 CKT 1 /'CORDO; B 345' - 'NELSO; B 345'
/END
/MONITOR INTERFACE 'CUMJVICUMDAV' RATING 2467 MW /SP Normal = 2467 MW Emergency = 2597 MW TRM 130
/MONITOR BRANCH FROM BUS 360040 TO BUS 360037 CKT 1 /'8CUMBERL 500' - '8JVILLE 500'
/END
/MONITOR INTERFACE 'ESSIDAMADXFR' RATING 338 MW /SP Normal = 322 MW Emergency = 351 MW TRM 13
/MONITOR BRANCH FROM BUS 300075 TO BUS 505434 CKT 1 /'5ESSEX 161' - 'IDALIA 5 161'
/END
/MONITOR INTERFACE 'GRIMTZGRIWAL' RATING 206 MW /SP Normal = MW Emergency = 206 MW TRM 0
/MONITOR BRANCH FROM BUS 334026 TO BUS 334060 CKT 1 /'4GRIMES 138' - '4MT.ZION 138'
/END
/MONITOR INTERFACE 'HSBIS_ELDXF' RATING 98 MW /SP Normal = 98 MW Emergency = 98 MW TRM 0
/MONITOR BRANCH FROM BUS 337685 TO BUS 337678 CKT 1 /'3HSEHVW 115' - '3BISMRK 115'
/END
/MONITOR INTERFACE 'HSEETTSHEELD' RATING 2165 MW /SP Normal = MW Emergency = 2165 MW TRM 0
/MONITOR BRANCH FROM BUS 337753 TO BUS 337754 CKT 1 /'8HSEHV 500' - '8ETTA 500'
/END
/MONITOR INTERFACE 'LUTESSBLAFRK' RATING 1195 MW /SP Normal = 1195 MW Emergency = 1195 MW TRM 0
/MONITOR BRANCH FROM BUS 344974 TO BUS 300038 CKT 1 /'LUTESVIL 345' - '7ESSEX 345'
/END

/MONITOR INTERFACE 'LUTESSWILNWM' RATING 1195 MW /SP Normal = 1195 MW Emergency = 1195 MW TRM 0
/MONITOR BRANCH FROM BUS 344974 TO BUS 300038 CKT 1 /'LUTESVIL 345' - '7ESSEX 345'
/END
/MONITOR INTERFACE 'MABSHEWHBSHE' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 337808 TO BUS 337643 CKT 1 /'8MABEL 500' - '8SHERID 500'
/END
/MONITOR INTERFACE 'MARCLRMARCRE' RATING 161 MW /SP Normal = 161 MW Emergency = 168 MW TRM 7
/MONITOR BRANCH FROM BUS 541251 TO BUS 635034 CKT 1 /'MARYVLE5 161' - 'CLRNDA 5 161'
/END
/MONITOR INTERFACE 'MCCOVTNLDFKS' RATING 844 MW /SP Normal = 921 MW Emergency = 921 MW TRM 77
/MONITOR BRANCH FROM BUS 345088 TO BUS 345408 CKT 1 /'MCCREDIE 345' - 'OVERTON 345'
/END
/MONITOR INTERFACE 'MICFROMCKFRK' RATING 571 MW /SP Normal = 571 MW Emergency = 641 MW TRM 70
/MONITOR BRANCH FROM BUS 336462 TO BUS 500360 CKT 1 /'6MICHO 230' - 'FRONTST6 230'
/END
/MONITOR INTERFACE 'NODMARSTJMID' RATING 247 MW /SP Normal = 247 MW Emergency = 247 MW TRM 0
/MONITOR BRANCH FROM BUS 300097 TO BUS 300104 CKT 1 /'5MARYVL 161.00' - '5NODWAY 161.00'
/END
/MONITOR INTERFACE 'PALXFRPALSUB' RATING 328 MW /SP Normal = 328 MW Emergency = 370 MW TRM 42
/MONITOR BRANCH FROM BUS 345436 TO BUS 345437 CKT 1 /'PALMYRA 345' - 'PALMYRA 161'
/END
/MONITOR INTERFACE 'QUAH47CORNEL' RATING 1557 MW /SP Normal = 1557 MW Emergency = 1589 MW TRM 32
/MONITOR BRANCH FROM BUS 270864 TO BUS 270890 CKT 1 /'QUAD ; 345' - 'H471 ; 345'
/END
/MONITOR INTERFACE 'RICCOLRICSCO' RATING 209 MW /SP Normal = 209 MW Emergency = 209 MW TRM 0
/MONITOR BRANCH FROM BUS 335366 TO BUS 335375 CKT 1 /'4RICHARD 138' - '4COLACDY 138'
/END
/MONITOR INTERFACE 'RICXFRRICXFR' RATING 625 MW /SP Normal = 560 MW Emergency = 625 MW TRM 0
/MONITOR BRANCH FROM BUS 335367 TO BUS 335366 CKT 1 /'8RICHARD 500' - '4RICHARD 138'
/END

/MONITOR INTERFACE 'SCBBONRENBON' RATING 225 MW /SP Normal = 160 MW Emergency = 225 MW TRM 0
/MONITOR BRANCH FROM BUS 335379 TO BUS 502404 CKT 1 /'4SCOTT 138' - 'BONIN 4 138'
/END
/MONITOR INTERFACE 'SCOBONCOCVIL' RATING 160 MW /SP Normal = 160 MW Emergency = 225 MW TRM 65
/MONITOR BRANCH FROM BUS 335379 TO BUS 502404 CKT 1 /'4SCOTT 138' - 'BONIN 4 138'
/END
/MONITOR INTERFACE 'SHEELDHSEETT' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 337643 TO BUS 337561 CKT 1 /'8SHERID 500' - '8ELDEHV 500'
/END
/MONITOR INTERFACE 'SHEMAGSHEELD' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 337643 TO BUS 337763 CKT 1 /'8SHERID 500' - '8MAGCOVE 500'
/END
/MONITOR INTERFACE 'SHEWHBMABWRI' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 337643 TO BUS 337651 CKT 1 /'8SHERID 500' - '8WH BLF 500'
/END
/MONITOR INTERFACE 'STFLUTBLAFRA' RATING 1138 MW /SP Normal = 1135 MW Emergency = 1195 MW TRM 57
/MONITOR BRANCH FROM BUS 345773 TO BUS 344974 CKT 1 /'ST FRANC 345' - 'LUTESVIL 345'
/END
/MONITOR INTERFACE 'STFLUTEWFSHA' RATING 1172 MW /SP Normal = 1171 MW Emergency = 1195 MW TRM 23
/MONITOR BRANCH FROM BUS 345773 TO BUS 344974 CKT 1 /'ST FRANC 345' - 'LUTESVIL 345'
/END
/MONITOR INTERFACE 'STOMORLACNEO' RATING 212 MW /SP Normal = 212 MW Emergency = 227 MW TRM 15
/MONITOR BRANCH FROM BUS 505498 TO BUS 300101 CKT 1 /'STOCKTN5 161' - '5MORGAN 161'
/END
/MONITOR INTERFACE 'STOMORMORBRK' RATING 209 MW /SP Normal = 206 MW Emergency = 227 MW TRM 18
/MONITOR BRANCH FROM BUS 505498 TO BUS 300101 CKT 1 /'STOCKTN5 161' - '5MORGAN 161'
/END
/MONITOR INTERFACE 'SUMHE_BULSLD' RATING 122 MW /SP Normal = 133 MW Emergency = 151 MW TRM 29
/MONITOR BRANCH FROM BUS 338121 TO BUS 338104 CKT 1 /'5SUMMIT 161' - '5HARR-E 161'
/END

/MONITOR INTERFACE 'THMMOBTHMSAL' RATING 418 MW /SP Normal = 372 MW Emergency = 446 MW TRM 28
/MONITOR BRANCH FROM BUS 300120 TO BUS 300126 CKT 1 /'5THMHIL 161' - '5MOBTAP 161'
/END
/MONITOR INTERFACE 'THMMOBTHOMCC' RATING 411 MW /SP Normal = 372 MW Emergency = 446 MW TRM 35
/MONITOR BRANCH FROM BUS 300120 TO BUS 300126 CKT 1 /'5THMHIL 161' - '5MOBTAP 161'
/END
/MONITOR INTERFACE 'WEBWELMTOHAR' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 335500 TO BUS 335368 CKT 1 /'8WEBRE 500' - '8WELLS 500'
/END
/MONITOR INTERFACE 'WEBWELPERSTE' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 335500 TO BUS 335368 CKT 1 /'8WEBRE 500' - '8WELLS 500'
/END
/MONITOR INTERFACE 'WHBSHEMABSHE' RATING 1732 MW /SP Normal = MW Emergency = 1732 MW TRM 0
/MONITOR BRANCH FROM BUS 337651 TO BUS 337643 CKT 1 /'8WH BLF 500' - '8SHERID 500'
/END
/MONITOR INTERFACE 'WILLIVWEBRIC' RATING 289 MW /SP Normal = 289 MW Emergency = 289 MW TRM 0
/MONITOR BRANCH FROM BUS 335507 TO BUS 335505 CKT 1 /'4WILBT 138' - '4LIVON 138'
/END
END

A.3 GBX Contingency File (*.con)

/ Contingency list generated on Wed Sep 21 12:38:04 2011
/ Total Contingencies
busnumbers
/ Contingency 'GBX DC TIE #2'
/ OPEN LINE 33 765800 765773 / GRAIN BELT EXPRESS DC LINE POLE 2
/ end
/ Contingency 'GBX DC TIE #2'
/ OPEN DCLINE 35 / GRAIN BELT EXPRESS DC LINE POLE 2
/ end
Contingency '335772 6ENJAY 230 335825 6FANCY 230 1'
Open branch from bus 335772 to bus 335825 ckt 1 / 335772 6ENJAY 230 335825 6FANCY 230 1
end
Contingency '1CHM G1'
Remove unit 1 from bus 300018 / 300018 1CHM G1 13.8
end

Contingency '335375 4COLACDY 138 335376 4ACADGSU 138 1 '
Open branch from bus 335375 to bus 335376 ckt 1 / 335375 4COLACDY 138 335376 4ACADGSU 138 1
end
Contingency '335376 4ACADGSU 138 335377 4SCANLN 138 1 '
Open branch from bus 335376 to bus 335377 ckt 1 / 335376 4ACADGSU 138 335377 4SCANLN 138 1
end
Contingency '500880 VILPLT 6 230 500920 WSTFORK6 230 1 '
Open branch from bus 500880 to bus 500920 ckt 1 / 500880 VILPLT 6 230 500920 WSTFORK6 230 1
end
Contingency '500920 WSTFORK6 230 500940 WELLS 6 230 1 '
Open branch from bus 500920 to bus 500940 ckt 1 / 500920 WSTFORK6 230 500940 WELLS 6 230 1
end
Contingency '303199 6AIRLINE 230 303200 6VIGNES 230 1 '
Open branch from bus 303199 to bus 303200 ckt 1 / 303199 6AIRLINE 230 303200 6VIGNES 230 1
end
Contingency '303199 6AIRLINE 230 336060 6SORR 2 230 1 '
Open branch from bus 303199 to bus 336060 ckt 1 / 303199 6AIRLINE 230 336060 6SORR 2 230 1
end
Contingency '508550 LIBCYTP4 138 508560 NEWGLAD4 138 1 '
Open branch from bus 508550 to bus 508560 ckt 1 / 508550 LIBCYTP4 138 508560 NEWGLAD4 138 1
end
Contingency '659106 LELANDO4 230 659202 LELND2TY 345 1 '
Open branch from bus 659106 to bus 659202 ckt 1 / 659106 LELANDO4 230 659202 LELND2TY 345 1
end
Contingency '3Wnd: OPEN KNOLL T1 1 '
Open branch from bus 530558 to bus 530561 to bus 530629 ckt 1 / 3Wnd Xfmr B$1095 : KNOLL T1
end
Contingency '3Wnd: OPEN MULGREN6 1 '
Open branch from bus 539678 to bus 539679 to bus 539920 ckt 1 / 3Wnd Xfmr B$1285 : MULGREN6
end
Contingency '3Wnd: OPEN POSTROCK T1 1 '
Open branch from bus 530583 to bus 530584 to bus 530673 ckt 1 / 3Wnd Xfmr B$1502 : POSTROCK T1
end
Contingency '533041 EVANS S4 138 533074 45TH ST4 138 1 '
Open branch from bus 533041 to bus 533074 ckt 1 / 533041 EVANS S4 138 533074 45TH ST4 138 1
end
Contingency '533038 COWSKIN4 138 533074 45TH ST4 138 1 '
Open branch from bus 533038 to bus 533074 ckt 1 / 533038 COWSKIN4 138 533074 45TH ST4 138 1

end
Contingency '533049 HOOVERN4 138 533053 LAKERDG4 138 1 '
Open branch from bus 533049 to bus 533053 ckt 1 / 533049 HOOVERN4 138 533053 LAKERDG4 138 1
end
Contingency '3Wnd: OPEN WICHT11X 1 '
Open branch from bus 532796 to bus 533040 to bus 532829 ckt 1 / 3Wnd Xfmr B$1931 : WICHT11X
end
Contingency '3Wnd: OPEN WICHT12X 1 '
Open branch from bus 532796 to bus 533040 to bus 532830 ckt 1 / 3Wnd Xfmr B$1932 : WICHT12X
end
Contingency '515375 WWRDEHV7 345 515407 TATONGA7 345 1 '
Open branch from bus 515375 to bus 515407 ckt 1 / 515375 WWRDEHV7 345 515407 TATONGA7 345 1
end
Contingency '533034 CENTENN4 138 533038 COWSKIN4 138 1 '
Open branch from bus 533034 to bus 533038 ckt 1 / 533034 CENTENN4 138 533038 COWSKIN4 138 1
end
Contingency '338145 8ISES 500 338187 8DELL 500 1 '
Open branch from bus 338145 to bus 338187 ckt 1 / 338145 8ISES 500 338187 8DELL 500 1
end
Contingency '344224 7CALAWY 1 345 344225 1CAL G1 25.0 1 '
Open branch from bus 344224 to bus 344225 ckt 1 / 344224 7CALAWY 1 345 344225 1CAL G1 25.0 1
end
Contingency '337909 8ANO 50 500 515305 FTSMITH8 500 1 '
Open branch from bus 337909 to bus 515305 ckt 1 / 337909 8ANO 50 500 515305 FTSMITH8 500 1
end
Contingency '300044 7MCCRED 345 300049 7THOMHL 345 1 '
Open branch from bus 300044 to bus 300049 ckt 1 / 300044 7MCCRED 345 300049 7THOMHL 345 1
end
Contingency '509849 ORU ETP4 138 509858 WARNTAP4 138 1 '
Open branch from bus 509849 to bus 509858 ckt 1 / 509849 ORU ETP4 138 509858 WARNTAP4 138 1
end
Contingency '509813 SHILETP4 138 509853 ORU-WTP4 138 1 '
Open branch from bus 509813 to bus 509853 ckt 1 / 509813 SHILETP4 138 509853 ORU-WTP4 138 1
end
Contingency '3Wnd: OPEN ABB LLL58861 1 '
Open branch from bus 527914 to bus 522992 to bus 527912 ckt 1 / 3Wnd Xfmr B$0364 : ABB LLL58861
end
Contingency '514865 COUNCIL4 138 514866 WESTOAK4 138 1 '

Open branch from bus 514865 to bus 514866 ckt 1 / 514865 COUNCIL4 138 514866 WESTOAK4 138 1
end
Contingency '338170 5JONES 161 505418 JONESBO5 161 1 '
Open branch from bus 338170 to bus 505418 ckt 1 / 338170 5JONES 161 505418 JONESBO5 161 1
end
Contingency '640351 ST.FRANC 115 652482 MISSION7 115 1 '
Open branch from bus 652482 to bus 640351 ckt 1 / 640351 ST.FRANC 115 652482 MISSION7 115 1
end
Contingency '532851 AUBURN 6 230 532852 JEC 6 230 1 '
Open branch from bus 532851 to bus 532852 ckt 1 / 532851 AUBURN 6 230 532852 JEC 6 230 1
end
Contingency '532766 JEC N 7 345 532773 SUMMIT 7 345 1 '
Open branch from bus 532766 to bus 532773 ckt 1 / 532766 JEC N 7 345 532773 SUMMIT 7 345 1
end
Contingency '3Wnd: OPEN WOODWRD2 1 '
Open branch from bus 514782 to bus 514785 to bus 515771 ckt 1 / 3Wnd Xfmr B$1954 : WOODWRD2
end
Contingency '514796 IODINE-4 138 515376 WWRDEHV4 138 1 '
Open branch from bus 514796 to bus 515376 ckt 1 / 514796 IODINE-4 138 515376 WWRDEHV4 138 1
end
Contingency '514787 DEWEY 4 138 514796 IODINE-4 138 1 '
Open branch from bus 514787 to bus 514796 ckt 1 / 514787 DEWEY 4 138 514796 IODINE-4 138 1
end
Contingency '511456 O.K.U.-7 345 511468 L.E.S.-7 345 1 '
Open branch from bus 511456 to bus 511468 ckt 1 / 511456 O.K.U.-7 345 511468 L.E.S.-7 345 1
end
Contingency '500280 ELEESV 6 230 500470 LEESV 6 230 1 '
Open branch from bus 500280 to bus 500470 ckt 1 / 500280 ELEESV 6 230 500470 LEESV 6 230 1
end
Contingency '500280 ELEESV 6 230 500770 RODEMR 6 230 1 '
Open branch from bus 500280 to bus 500770 ckt 1 / 500280 ELEESV 6 230 500770 RODEMR 6 230 1
end
Contingency '500470 LEESV 6 230 500480 LEESV 4 138 1 '
Open branch from bus 500470 to bus 500480 ckt 1 / 500470 LEESV 6 230 500480 LEESV 4 138 1
end
Contingency '334028 7GRIMES 345 509241 CROCKET7 345 1 '
Open branch from bus 334028 to bus 509241 ckt 1 / 334028 7GRIMES 345 509241 CROCKET7 345 1
end

Contingency '500190 COCODR 6 230 500770 RODEMR 6 230 1 '
Open branch from bus 500190 to bus 500770 ckt 1 / 500190 COCODR 6 230 500770 RODEMR 6 230 1
end
Contingency '500190 COCODR 6 230 500880 VILPLT 6 230 1 '
Open branch from bus 500190 to bus 500880 ckt 1 / 500190 COCODR 6 230 500880 VILPLT 6 230 1
end
Contingency '500200 COLFAX 6 230 500770 RODEMR 6 230 1 '
Open branch from bus 500200 to bus 500770 ckt 1 / 500200 COLFAX 6 230 500770 RODEMR 6 230 1
end
Contingency '500250 DOLHILL7 345 507760 SW SHV 7 345 1 '
Open branch from bus 500250 to bus 507760 ckt 1 / 500250 DOLHILL7 345 507760 SW SHV 7 345 1
end
Contingency '500265 DTOWN 138 500420 HUNTER4 138 1 '
Open branch from bus 500265 to bus 500420 ckt 1 / 500265 DTOWN 138 500420 HUNTER4 138 1
end
Contingency '500340 FHILL 6 230 500760 RAPIDES6 230 1 '
Open branch from bus 500340 to bus 500760 ckt 1 / 500340 FHILL 6 230 500760 RAPIDES6 230 1
end
Contingency '500410 HOPKINS4 138 500774 SEGURA4 138 1 '
Open branch from bus 500410 to bus 500774 ckt 1 / 500410 HOPKINS4 138 500774 SEGURA4 138 1
end
Contingency '500680 PINEV 6 230 500690 PINEV 4 138 1 '
Open branch from bus 500680 to bus 500690 ckt 1 / 500680 PINEV 6 230 500690 PINEV 4 138 1
end
Contingency '500735 PSCOTT 138 500816 SW_BRAPI 138 1 '
Open branch from bus 500735 to bus 500816 ckt 1 / 500735 PSCOTT 138 500816 SW_BRAPI 138 1
end
Contingency '500760 RAPIDES6 230 500770 RODEMR 6 230 1 '
Open branch from bus 500760 to bus 500770 ckt 1 / 500760 RAPIDES6 230 500770 RODEMR 6 230 1
end
Contingency '500760 RAPIDES6 230 500840 TWINBR6 230 1 '
Open branch from bus 500760 to bus 500840 ckt 1 / 500760 RAPIDES6 230 500840 TWINBR6 230 1
end
Contingency '500770 RODEMR 6 230 500790 SHERWD 6 230 1 '
Open branch from bus 500770 to bus 500790 ckt 1 / 500770 RODEMR 6 230 500790 SHERWD 6 230 1
end
Contingency '504010 ELMSPRGS 5 161 506957 TONTITN5 161 1 '
Open branch from bus 504010 to bus 506957 ckt 1 / 504010 ELMSPRGS 5 161 506957 TONTITN5 161 1

end
Contingency '504020 FARMNGTN 5 161 506944 CHAMSPR5 161 1 '
Open branch from bus 504020 to bus 506944 ckt 1 / 504020 FARMNGTN 5 161 506944 CHAMSPR5 161 1
end
Contingency '505400 N MADRD5 161 505410 KENNETT5 161 1 '
Open branch from bus 505400 to bus 505410 ckt 1 / 505400 N MADRD5 161 505410 KENNETT5 161 1
end
Contingency '3Wnd: OPEN SIK X1 1 '
Open branch from bus 505428 to bus 505430 to bus 505429 ckt 1 / 3Wnd Xfmr B$1642 : SIK X1
end
Contingency '3Wnd: OPEN SIK X2 1 '
Open branch from bus 505428 to bus 505430 to bus 505431 ckt 1 / 3Wnd Xfmr B$1643 : SIK X2
end
Contingency '3Wnd: OPEN PBL X1 1 '
Open branch from bus 505436 to bus 505438 to bus 505435 ckt 1 / 3Wnd Xfmr B$1438 : PBL X1
end
Contingency '3Wnd: OPEN PBL X3 1 '
Open branch from bus 505436 to bus 505438 to bus 505439 ckt 1 / 3Wnd Xfmr B$1440 : PBL X3
end
Contingency '505486 NEO SPA5 161 547472 TIP292 5 161 1 '
Open branch from bus 505486 to bus 547472 ckt 1 / 505486 NEO SPA5 161 547472 TIP292 5 161 1
end
Contingency '3Wnd: OPEN CRG X1 1 '
Open branch from bus 505490 to bus 505488 to bus 505487 ckt 1 / 3Wnd Xfmr B$0660 : CRG X1
end
Contingency '3Wnd: OPEN CRG X2 1 '
Open branch from bus 505490 to bus 505488 to bus 505489 ckt 1 / 3Wnd Xfmr B$0661 : CRG X2
end
Contingency '3Wnd: OPEN NXA X1 1 '
Open branch from bus 505501 to bus 505496 to bus 505497 ckt 1 / 3Wnd Xfmr B$1371 : NXA X1
end
Contingency '506927 DYESS 5 161 506949 SOSPRDL5 161 1 '
Open branch from bus 506927 to bus 506949 ckt 1 / 506927 DYESS 5 161 506949 SOSPRDL5 161 1
end
Contingency '506927 DYESS 5 161 506957 TONTITN5 161 1 '
Open branch from bus 506927 to bus 506957 ckt 1 / 506927 DYESS 5 161 506957 TONTITN5 161 1
end
Contingency '507711 ARSHILL4 138 507789 ARSGENS4 138 1 '

Open branch from bus 507711 to bus 507789 ckt 1 / 507711 ARSHILL4 138 507789 ARSGENS4 138 1
end
Contingency '3Wnd: OPEN RDPOINT1 1 '
Open branch from bus 507750 to bus 507751 to bus 507780 ckt 1 / 3Wnd Xfmr B$1522 : RDPOINT1
end
Contingency '3Wnd: OPEN RDPOINT2 2 '
Open branch from bus 507750 to bus 507751 to bus 507781 ckt 2 / 3Wnd Xfmr B$1523 : RDPOINT2
end
Contingency '3Wnd: OPEN BANN 1 1 '
Open branch from bus 508053 to bus 508054 to bus 508097 ckt 1 / 3Wnd Xfmr B$0438 : BANN 1
end
Contingency '3Wnd: OPEN SETEXARK 1 '
Open branch from bus 508077 to bus 508078 to bus 508102 ckt 1 / 3Wnd Xfmr B$1625 : SETEXARK
end
Contingency '3Wnd: OPEN SUGAR HL 1 '
Open branch from bus 508079 to bus 508080 to bus 508103 ckt 1 / 3Wnd Xfmr B$1706 : SUGAR HL
end
Contingency '3Wnd: OPEN WATLANT1 1 '
Open branch from bus 508089 to bus 508090 to bus 508045 ckt 1 / 3Wnd Xfmr B$1885 : WATLANT1
end
Contingency '3Wnd: OPEN WATLANT2 2 '
Open branch from bus 508089 to bus 508090 to bus 508046 ckt 2 / 3Wnd Xfmr B$1886 : WATLANT2
end
Contingency '508297 LSSOUTH4 138 508313 PITTSB_4 138 1 '
Open branch from bus 508297 to bus 508313 ckt 1 / 508297 LSSOUTH4 138 508313 PITTSB_4 138 1
end
Contingency '508297 LSSOUTH4 138 508840 WILKES 4 138 1 '
Open branch from bus 508297 to bus 508840 ckt 1 / 508297 LSSOUTH4 138 508840 WILKES 4 138 1
end
Contingency '508351 PERDUE 4 138 508831 DIANA 4 138 1 '
Open branch from bus 508351 to bus 508831 ckt 1 / 508351 PERDUE 4 138 508831 DIANA 4 138 1
end
Contingency '508544 HARRISN4 138 508550 LIBCYTP4 138 1 '
Open branch from bus 508544 to bus 508550 ckt 1 / 508544 HARRISN4 138 508550 LIBCYTP4 138 1
end
Contingency '3Wnd: OPEN MARSH 1 1 '
Open branch from bus 508576 to bus 508557 to bus 508591 ckt 1 / 3Wnd Xfmr B$1214 : MARSH 1
end

Contingency '3Wnd: OPEN MARSH 2 2 '
Open branch from bus 508576 to bus 508557 to bus 508592 ckt 2 / 3Wnd Xfmr B$1215 : MARSH 2
end
Contingency '3Wnd: OPEN WHITNEY1 1 '
Open branch from bus 508574 to bus 508575 to bus 508589 ckt 1 / 3Wnd Xfmr B$1928 : WHITNEY1
end
Contingency '3Wnd: OPEN WHITNEY2 2 '
Open branch from bus 508574 to bus 508575 to bus 508590 ckt 2 / 3Wnd Xfmr B$1929 : WHITNEY2
end
Contingency '508806 LIEBERM4 138 508811 NBENTON4 138 1 '
Open branch from bus 508806 to bus 508811 ckt 1 / 508806 LIEBERM4 138 508811 NBENTON4 138 1
end
Contingency '3Wnd: OPEN DIANA 2 2 '
Open branch from bus 508831 to bus 508832 to bus 508843 ckt 2 / 3Wnd Xfmr B$0698 : DIANA 2
end
Contingency '509060 CARTHGT4 138 509088 TENAHA 4 138 1 '
Open branch from bus 509060 to bus 509088 ckt 1 / 509060 CARTHGT4 138 509088 TENAHA 4 138 1
end
Contingency '509066 JOAQUIN4 138 509071 LOGANSP4 138 1 '
Open branch from bus 509066 to bus 509071 ckt 1 / 509066 JOAQUIN4 138 509071 LOGANSP4 138 1
end
Contingency '3Wnd: OPEN NWHENDR1 1 '
Open branch from bus 509075 to bus 509076 to bus 509095 ckt 1 / 3Wnd Xfmr B$1366 : NWHENDR1
end
Contingency '3Wnd: OPEN NWHENDR2 2 '
Open branch from bus 509075 to bus 509076 to bus 509096 ckt 2 / 3Wnd Xfmr B$1367 : NWHENDR2
end
Contingency '3Wnd: OPEN ROKHILL1 1 '
Open branch from bus 509082 to bus 509083 to bus 509090 ckt 1 / 3Wnd Xfmr B$1550 : ROKHILL1
end
Contingency '509242 JACKSNV4 138 509250 COFFEE 4 138 1 '
Open branch from bus 509242 to bus 509250 ckt 1 / 509242 JACKSNV4 138 509250 COFFEE 4 138 1
end
Contingency '509752 INOLATP4 138 509790 CATOOSA4 138 1 '
Open branch from bus 509752 to bus 509790 ckt 1 / 509752 INOLATP4 138 509790 CATOOSA4 138 1
end
Contingency '509769 BA101-N4 138 509806 ONETA--4 138 1 '
Open branch from bus 509769 to bus 509806 ckt 1 / 509769 BA101-N4 138 509806 ONETA--4 138 1

end
Contingency '509783 R.S.S.-4 138 509849 ORU ETP4 138 1 '
Open branch from bus 509783 to bus 509849 ckt 1 / 509783 R.S.S.-4 138 509849 ORU ETP4 138 1
end
Contingency '509783 R.S.S.-4 138 509853 ORU-WTP4 138 1 '
Open branch from bus 509783 to bus 509853 ckt 1 / 509783 R.S.S.-4 138 509853 ORU-WTP4 138 1
end
Contingency '509783 R.S.S.-4 138 515248 EXPLGLN4 138 1 '
Open branch from bus 509783 to bus 515248 ckt 1 / 509783 R.S.S.-4 138 515248 EXPLGLN4 138 1
end
Contingency '509788 T.P.S.-4 138 509800 36LEWIS4 138 1 '
Open branch from bus 509788 to bus 509800 ckt 1 / 509788 T.P.S.-4 138 509800 36LEWIS4 138 1
end
Contingency '3Wnd: OPEN COFAUTO1 1 '
Open branch from bus 512735 to bus 512734 to bus 512740 ckt 1 / 3Wnd Xfmr B$0618 : COFAUTO1
end
Contingency '3Wnd: OPEN COFAUTO2 2 '
Open branch from bus 512735 to bus 512734 to bus 512741 ckt 2 / 3Wnd Xfmr B$0619 : COFAUTO2
end
Contingency '514798 SNRPMPT4 138 514802 SOONER 4 138 1 '
Open branch from bus 514798 to bus 514802 ckt 1 / 514798 SNRPMPT4 138 514802 SOONER 4 138 1
end
Contingency '514861 MUSTANG4 138 514865 COUNCIL4 138 1 '
Open branch from bus 514861 to bus 514865 ckt 1 / 514861 MUSTANG4 138 514865 COUNCIL4 138 1
end
Contingency '3Wnd: OPEN NORTWST3 1 '
Open branch from bus 514879 to bus 514880 to bus 515743 ckt 1 / 3Wnd Xfmr B$1363 : NORTWST3
end
Contingency '514880 NORTWST7 345 515407 TATONGA7 345 1 '
Open branch from bus 514880 to bus 515407 ckt 1 / 514880 NORTWST7 345 515407 TATONGA7 345 1
end
Contingency '514884 DUNJEE 4 138 514941 HSL 4 138 1 '
Open branch from bus 514884 to bus 514941 ckt 1 / 514884 DUNJEE 4 138 514941 HSL 4 138 1
end
Contingency '3Wnd: OPEN MAUD1 1 '
Open branch from bus 515054 to bus 515055 to bus 515736 ckt 1 / 3Wnd Xfmr B$1222 : MAUD1
end
Contingency '3Wnd: OPEN CHIGLEY3 1 '

Open branch from bus 515113 to bus 515114 to bus 515712 ckt 1 / 3Wnd Xfmr B$0591 : CHIGLEY3
end
Contingency '3Wnd: OPEN ARBUCKL2 1 '
Open branch from bus 515116 to bus 515117 to bus 515702 ckt 1 / 3Wnd Xfmr B$0407 : ARBUCKL2
end
Contingency '515261 BONANZT5 161 515262 AES 5 161 1 '
Open branch from bus 515261 to bus 515262 ckt 1 / 515261 BONANZT5 161 515262 AES 5 161 1
end
Contingency '515262 AES 5 161 515264 TARBY 5 161 1 '
Open branch from bus 515262 to bus 515264 ckt 1 / 515262 AES 5 161 515264 TARBY 5 161 1
end
Contingency '3Wnd: OPEN TARBY1 1 '
Open branch from bus 515263 to bus 515264 to bus 515764 ckt 1 / 3Wnd Xfmr B$1783 : TARBY1
end
Contingency '3Wnd: OPEN TARBY2 1 '
Open branch from bus 515263 to bus 515264 to bus 515765 ckt 1 / 3Wnd Xfmr B$1784 : TARBY2
end
Contingency '522861 LP-SOUTHEST6 230 526269 LUBBCK_STH 6 230 1 '
Open branch from bus 522861 to bus 526269 ckt 1 / 522861 LP-SOUTHEST6 230 526269 LUBBCK_STH 6 230 1
end
Contingency '522870 LP-HOLLY 6 230 526338 JONES_BUS2 6 230 1 '
Open branch from bus 522870 to bus 526338 ckt 1 / 522870 LP-HOLLY 6 230 526338 JONES_BUS2 6 230 1
end
Contingency '522888 LP-WADSWRTH6 230 526299 LUBBCK_EST 6 230 1 '
Open branch from bus 522888 to bus 526299 ckt 1 / 522888 LP-WADSWRTH6 230 526299 LUBBCK_EST 6 230 1
end
Contingency '3Wnd: OPEN ABB MLL92046 2 '
Open branch from bus 523090 to bus 523089 to bus 523086 ckt 2 / 3Wnd Xfmr B$0374 : ABB MLL92046
end
Contingency '3Wnd: OPEN ABB MLL92047 1 '
Open branch from bus 523090 to bus 523089 to bus 523085 ckt 1 / 3Wnd Xfmr B$0375 : ABB MLL92047
end
Contingency '523977 HARRNG_WST 6 230 524010 CHERRY 6 230 1 '
Open branch from bus 523977 to bus 524010 ckt 1 / 523977 HARRNG_WST 6 230 524010 CHERRY 6 230 1
end
Contingency '3Wnd: OPEN ABB 801466 1 '
Open branch from bus 524415 to bus 524414 to bus 524410 ckt 1 / 3Wnd Xfmr B$0354 : ABB 801466
end

Contingency '3Wnd: OPEN UPDATE DATA 2 '
Open branch from bus 524567 to bus 524573 to bus 524564 ckt 2 / 3Wnd Xfmr B$1841 : UPDATE DATA
end
Contingency '524606 HEREFORD 3 115 524622 DEAFSMITH 3 115 1 '
Open branch from bus 524606 to bus 524622 ckt 1 / 524606 HEREFORD 3 115 524622 DEAFSMITH 3 115 1
end
Contingency '3Wnd: OPEN ABB MLL92041 2 '
Open branch from bus 524746 to bus 524745 to bus 524743 ckt 2 / 3Wnd Xfmr B$0370 : ABB MLL92041
end
Contingency '3Wnd: OPEN ABB MLL92042 1 '
Open branch from bus 524746 to bus 524745 to bus 524744 ckt 1 / 3Wnd Xfmr B$0371 : ABB MLL92042
end
Contingency '3Wnd: OPEN ABB 859701 1 '
Open branch from bus 525028 to bus 525027 to bus 525025 ckt 1 / 3Wnd Xfmr B$0357 : ABB 859701
end
Contingency '3Wnd: OPEN ABB 859702 2 '
Open branch from bus 525028 to bus 525027 to bus 525026 ckt 2 / 3Wnd Xfmr B$0358 : ABB 859702
end
Contingency '3Wnd: OPEN ENRCO 136155 1 '
Open branch from bus 525192 to bus 525191 to bus 525190 ckt 1 / 3Wnd Xfmr B$0786 : ENRCO 136155
end
Contingency '3Wnd: OPEN NA 70430A 2 '
Open branch from bus 525828 to bus 525826 to bus 525822 ckt 2 / 3Wnd Xfmr B$1303 : NA 70430A
end
Contingency '3Wnd: OPEN NA 70430B 1 '
Open branch from bus 525828 to bus 525826 to bus 525823 ckt 1 / 3Wnd Xfmr B$1304 : NA 70430B
end
Contingency '3Wnd: OPEN MLNY P650187 1 '
Open branch from bus 525926 to bus 525925 to bus 525923 ckt 1 / 3Wnd Xfmr B$1263 : MLNY P650187
end
Contingency '3Wnd: OPEN PENN 0047052 2 '
Open branch from bus 525926 to bus 525925 to bus 525924 ckt 2 / 3Wnd Xfmr B$1453 : PENN 0047052
end
Contingency '3Wnd: OPEN ENRCO 136153 1 '
Open branch from bus 526020 to bus 526019 to bus 526017 ckt 1 / 3Wnd Xfmr B$0784 : ENRCO 136153
end
Contingency '3Wnd: OPEN ENRCO 136154 2 '
Open branch from bus 526020 to bus 526019 to bus 526018 ckt 2 / 3Wnd Xfmr B$0785 : ENRCO 136154

end
Contingency '526160 CARLISLE 3 115 526192 MURPHY 3 115 1 '
Open branch from bus 526160 to bus 526192 ckt 1 / 526160 CARLISLE 3 115 526192 MURPHY 3 115 1
end
Contingency '526213 ALLEN 3 115 526268 LUBBCK_STH 3 115 1 '
Open branch from bus 526213 to bus 526268 ckt 1 / 526213 ALLEN 3 115 526268 LUBBCK_STH 3 115 1
end
Contingency '526268 LUBBCK_STH 3 115 526602 SP-WOODROW 3 115 1 '
Open branch from bus 526268 to bus 526602 ckt 1 / 526268 LUBBCK_STH 3 115 526602 SP-WOODROW 3 115 1
end
Contingency '3Wnd: OPEN ENRCO 136712 1 '
Open branch from bus 526298 to bus 526297 to bus 526295 ckt 1 / 3Wnd Xfmr B$0794 : ENRCO 136712
end
Contingency '3Wnd: OPEN ENRCO 136713 2 '
Open branch from bus 526298 to bus 526297 to bus 526296 ckt 2 / 3Wnd Xfmr B$0795 : ENRCO 136713
end
Contingency '526299 LUBBCK_EST 6 230 526338 JONES_BUS2 6 230 1 '
Open branch from bus 526299 to bus 526338 ckt 1 / 526299 LUBBCK_EST 6 230 526338 JONES_BUS2 6 230 1
end
Contingency '526338 JONES_BUS2 6 230 526677 GRASSLAND 6 230 1 '
Open branch from bus 526338 to bus 526677 ckt 1 / 526338 JONES_BUS2 6 230 526677 GRASSLAND 6 230 1
end
Contingency '3Wnd: OPEN PENN 0154552 1 '
Open branch from bus 526656 to bus 526655 to bus 526653 ckt 1 / 3Wnd Xfmr B$1456 : PENN 0154552
end
Contingency '3Wnd: OPEN WAUK A4941T 2 '
Open branch from bus 526656 to bus 526655 to bus 526654 ckt 2 / 3Wnd Xfmr B$1888 : WAUK A4941T
end
Contingency '526677 GRASSLAND 6 230 526830 BORDEN 6 230 1 '
Open branch from bus 526677 to bus 526830 ckt 1 / 526677 GRASSLAND 6 230 526830 BORDEN 6 230 1
end
Contingency '3Wnd: OPEN GE M100899 1 '
Open branch from bus 526935 to bus 526934 to bus 526931 ckt 1 / 3Wnd Xfmr B$0879 : GE M100899
end
Contingency '3Wnd: OPEN PENN C010585 2 '
Open branch from bus 526935 to bus 526934 to bus 526932 ckt 2 / 3Wnd Xfmr B$1459 : PENN C010585
end
Contingency '527080 EL_PASO 3 115 527130 DENVER_N 3 115 1 '

Open branch from bus 527080 to bus 527130 ckt 1 / 527080 EL_PASO 3 115 527130 DENVER_N 3 115 1
end
Contingency '527130 DENVER_N 3 115 527146 MUSTANG 3 115 1 '
Open branch from bus 527130 to bus 527146 ckt 1 / 527130 DENVER_N 3 115 527146 MUSTANG 3 115 1
end
Contingency '527136 DENVER_S 3 115 527146 MUSTANG 3 115 2 '
Open branch from bus 527136 to bus 527146 ckt 2 / 527136 DENVER_S 3 115 527146 MUSTANG 3 115 2
end
Contingency '527146 MUSTANG 3 115 527202 SEAGRAVES 3 115 1 '
Open branch from bus 527146 to bus 527202 ckt 1 / 527146 MUSTANG 3 115 527202 SEAGRAVES 3 115 1
end
Contingency '3Wnd: OPEN NA 51295-A 1 '
Open branch from bus 527262 to bus 527261 to bus 527259 ckt 1 / 3Wnd Xfmr B$1308 : NA 51295-A
end
Contingency '3Wnd: OPEN WAU A3258T 2 '
Open branch from bus 527262 to bus 527261 to bus 527260 ckt 2 / 3Wnd Xfmr B$1887 : WAU A3258T
end
Contingency '527482 CHAVES_CNTY3 115 527501 URTON 3 115 1 '
Open branch from bus 527482 to bus 527501 ckt 1 / 527482 CHAVES_CNTY3 115 527501 URTON 3 115 1
end
Contingency '527482 CHAVES_CNTY3 115 527546 SAMSON 3 115 1 '
Open branch from bus 527482 to bus 527546 ckt 1 / 527482 CHAVES_CNTY3 115 527546 SAMSON 3 115 1
end
Contingency '3Wnd: OPEN ABB 801429 1 '
Open branch from bus 527483 to bus 527482 to bus 527478 ckt 1 / 3Wnd Xfmr B$0353 : ABB 801429
end
Contingency '3Wnd: OPEN GE C254477 1 '
Open branch from bus 527707 to bus 527701 to bus 527699 ckt 1 / 3Wnd Xfmr B$0873 : GE C254477
end
Contingency '3Wnd: OPEN MNLY 2118072 2 '
Open branch from bus 527707 to bus 527701 to bus 527700 ckt 2 / 3Wnd Xfmr B$1266 : MNLY 2118072
end
Contingency '3Wnd: OPEN WH XHS70551 1 '
Open branch from bus 527800 to bus 527798 to bus 527797 ckt 1 / 3Wnd Xfmr B$1917 : WH XHS70551
end
Contingency '527849 LEA_CNTY 6 230 527894 HOBBS_INT 6 230 1 '
Open branch from bus 527849 to bus 527894 ckt 1 / 527849 LEA_CNTY 6 230 527894 HOBBS_INT 6 230 1
end

Contingency '527894 HOBBS_INT 6 230 527914 MIDLAND 6 230 1 '
Open branch from bus 527894 to bus 527914 ckt 1 / 527894 HOBBS_INT 6 230 527914 MIDLAND 6 230 1
end
Contingency '3Wnd: OPEN GE M102072 1 '
Open branch from bus 528095 to bus 528094 to bus 528090 ckt 1 / 3Wnd Xfmr B$0884 : GE M102072
end
Contingency '528355 MADDOX 3 115 528463 SANGER_SW 3 115 1 '
Open branch from bus 528355 to bus 528463 ckt 1 / 528355 MADDOX 3 115 528463 SANGER_SW 3 115 1
end
Contingency '528355 MADDOX 3 115 528491 MONUMENT 3 115 1 '
Open branch from bus 528355 to bus 528491 ckt 1 / 528355 MADDOX 3 115 528491 MONUMENT 3 115 1
end
Contingency '528498 W_HOBBS 3 115 528533 DRINKARD_TP3 115 1 '
Open branch from bus 528498 to bus 528533 ckt 1 / 528498 W_HOBBS 3 115 528533 DRINKARD_TP3 115 1
end
Contingency '530558 KNOLL 6 230 530584 POSTROCK6 230 1 '
Open branch from bus 530558 to bus 530584 ckt 1 / 530558 KNOLL 6 230 530584 POSTROCK6 230 1
end
Contingency '530583 POSTROCK7 345 531469 SPERVIL7 345 1 '
Open branch from bus 531469 to bus 530583 ckt 1 / 530583 POSTROCK7 345 531469 SPERVIL7 345 1
end
Contingency '531393 PLYMELL3 115 531448 HOLCOMB3 115 1 '
Open branch from bus 531393 to bus 531448 ckt 1 / 531393 PLYMELL3 115 531448 HOLCOMB3 115 1
end
Contingency '532765 HOYT 7 345 532766 JEC N 7 345 1 '
Open branch from bus 532765 to bus 532766 ckt 1 / 532765 HOYT 7 345 532766 JEC N 7 345 1
end
Contingency '532765 HOYT 7 345 532772 STRANGR7 345 1 '
Open branch from bus 532765 to bus 532772 ckt 1 / 532765 HOYT 7 345 532772 STRANGR7 345 1
end
Contingency '3Wnd: OPEN SUMMIT2X 1 '
Open branch from bus 532773 to bus 533381 to bus 532899 ckt 1 / 3Wnd Xfmr B$1709 : SUMMIT2X
end
Contingency '3Wnd: OPEN BENTON2X 1 '
Open branch from bus 532986 to bus 532791 to bus 532822 ckt 1 / 3Wnd Xfmr B$0468 : BENTON2X
end
Contingency '532852 JEC 6 230 532861 EMANHAT6 230 1 '
Open branch from bus 532852 to bus 532861 ckt 1 / 532852 JEC 6 230 532861 EMANHAT6 230 1

end
Contingency '532861 EMANHAT6 230 532865 NWMANHT6 230 1 '
Open branch from bus 532861 to bus 532865 ckt 1 / 532861 EMANHAT6 230 532865 NWMANHT6 230 1
end
Contingency '3Wnd: OPEN EMANHT3X 1 '
Open branch from bus 532861 to bus 533326 to bus 532888 ckt 1 / 3Wnd Xfmr B$0780 : EMANHT3X
end
Contingency '532986 BENTON 4 138 532990 MIDIAN 4 138 1 '
Open branch from bus 532986 to bus 532990 ckt 1 / 532986 BENTON 4 138 532990 MIDIAN 4 138 1
end
Contingency '3Wnd: OPEN HALSTD1X 1 '
Open branch from bus 533012 to bus 533736 to bus 533092 ckt 1 / 3Wnd Xfmr B$0954 : HALSTD1X
end
Contingency '3Wnd: OPEN NEC3 GSU 1 '
Open branch from bus 533021 to bus 533768 to bus 532711 ckt 1 / 3Wnd Xfmr B$1329 : NEC3 GSU
end
Contingency '533040 EVANS N4 138 533041 EVANS S4 138 1 '
Open branch from bus 533040 to bus 533041 ckt 1 / 533040 EVANS N4 138 533041 EVANS S4 138 1
end
Contingency '533041 EVANS S4 138 533053 LAKERDG4 138 1 '
Open branch from bus 533041 to bus 533053 ckt 1 / 533041 EVANS S4 138 533053 LAKERDG4 138 1
end
Contingency '533180 TEC E 3 115 533182 TECHILE3 115 1 '
Open branch from bus 533180 to bus 533182 ckt 1 / 533180 TEC E 3 115 533182 TECHILE3 115 1
end
Contingency '3Wnd: OPEN ARNOLD4X 1 '
Open branch from bus 533211 to bus 533471 to bus 533449 ckt 1 / 3Wnd Xfmr B$0416 : ARNOLD4X
end
Contingency '533249 LEC U4 3 115 533250 LWRNCHL3 115 1 '
Open branch from bus 533249 to bus 533250 ckt 1 / 533249 LEC U4 3 115 533250 LWRNCHL3 115 1
end
Contingency '533371 NORTHVW3 115 533381 SUMMIT 3 115 1 '
Open branch from bus 533371 to bus 533381 ckt 1 / 533371 NORTHVW3 115 533381 SUMMIT 3 115 1
end
Contingency '533375 NESALIN3 115 533379 SO GATE3 115 2 '
Open branch from bus 533375 to bus 533379 ckt 2 / 533375 NESALIN3 115 533379 SO GATE3 115 2
end
Contingency '533413 CIRCLE 3 115 533419 HEC 3 115 1 '

Open branch from bus 533413 to bus 533419 ckt 1 / 533413 CIRCLE 3 115 533419 HEC 3 115 1
end
Contingency '533415 DAVIS 3 115 533416 RENO 3 115 1 '
Open branch from bus 533415 to bus 533416 ckt 1 / 533415 DAVIS 3 115 533416 RENO 3 115 1
end
Contingency '533441 MEADOW 115 533455 TWR 33 3 115 2 '
Open branch from bus 533441 to bus 533455 ckt 2 / 533441 MEADOW 115 533455 TWR 33 3 115 2
end
Contingency '539642 ELLSWTP3 115 539678 GRTBEND3 115 1 '
Open branch from bus 539642 to bus 539678 ckt 1 / 539642 ELLSWTP3 115 539678 GRTBEND3 115 1
end
Contingency '3Wnd: OPEN OTISSUB3 2 '
Open branch from bus 539723 to bus 539684 to bus 539926 ckt 2 / 3Wnd Xfmr B$1405 : OTISSUB3
end
Contingency '3Wnd: OPEN OTISSUB3 1 '
Open branch from bus 539723 to bus 539684 to bus 539925 ckt 1 / 3Wnd Xfmr B$1406 : OTISSUB3
end
Contingency '3Wnd: OPEN STJOE T1 1 '
Open branch from bus 541253 to bus 541199 to bus 541370 ckt 1 / 3Wnd Xfmr B$1690 : STJOE T1
end
Contingency '3Wnd: OPEN STJOE T2 2 '
Open branch from bus 541253 to bus 541199 to bus 541371 ckt 2 / 3Wnd Xfmr B$1691 : STJOE T2
end
Contingency '541205 BLSPE 5 161 541237 BLSPW 5 161 1 '
Open branch from bus 541205 to bus 541237 ckt 1 / 541205 BLSPE 5 161 541237 BLSPW 5 161 1
end
Contingency '541218 GRNWD 5 161 541233 LEESUM 5 161 1 '
Open branch from bus 541218 to bus 541233 ckt 1 / 541218 GRNWD 5 161 541233 LEESUM 5 161 1
end
Contingency '541235 DUNCAN 5 161 541250 SIBLEYPL 161 1 '
Open branch from bus 541235 to bus 541250 ckt 1 / 541235 DUNCAN 5 161 541250 SIBLEYPL 161 1
end
Contingency '542985 NEAST 5 161 542990 CROSTWN5 161 1 '
Open branch from bus 542985 to bus 542990 ckt 1 / 542985 NEAST 5 161 542990 CROSTWN5 161 1
end
Contingency '542988 GRAND W5 161 542990 CROSTWN5 161 1 '
Open branch from bus 542988 to bus 542990 ckt 1 / 542988 GRAND W5 161 542990 CROSTWN5 161 1
end

Contingency '542997 LEEDS 5 161 543009 WINJT N5 161 1 '
Open branch from bus 542997 to bus 543009 ckt 1 / 542997 LEEDS 5 161 543009 WINJT N5 161 1
end
Contingency '547467 ORO110 5 161 547469 RIV4525 161 1 '
Open branch from bus 547467 to bus 547469 ckt 1 / 547467 ORO110 5 161 547469 RIV4525 161 1
end
Contingency '547472 TIP292 5 161 547483 JOP389 5 161 1 '
Open branch from bus 547472 to bus 547483 ckt 1 / 547472 TIP292 5 161 547483 JOP389 5 161 1
end
Contingency '547483 JOP389 5 161 547498 STL439 5 161 2 '
Open branch from bus 547483 to bus 547498 ckt 2 / 547483 JOP389 5 161 547498 STL439 5 161 2
end
Contingency '549958 MAIN STREET5 161 549959 BATTLEFIELD5 161 1 '
Open branch from bus 549958 to bus 549959 ckt 1 / 549958 MAIN STREET5 161 549959 BATTLEFIELD5 161 1
end
Contingency '640065 AXTELL 3 345 640374 SWEET W3 345 1 '
Open branch from bus 640065 to bus 640374 ckt 1 / 640065 AXTELL 3 345 640374 SWEET W3 345 1
end
Contingency '640093 C.CREEK4 230 640286 N.PLATT4 230 1 '
Open branch from bus 640093 to bus 640286 ckt 1 / 640093 C.CREEK4 230 640286 N.PLATT4 230 1
end
Contingency '3Wnd: OPEN B$0653 CR.CREEK T1 1 '
Open branch from bus 640093 to bus 640094 to bus 643026 ckt 1 / 3Wnd Xfmr B$0653 : CR.CREEK T1
end
Contingency '640109 CHADRON7 115 652311 DUNLAP 7 115 1 '
Open branch from bus 640109 to bus 652311 ckt 1 / 640109 CHADRON7 115 652311 DUNLAP 7 115 1
end
Contingency '640183 GENTLMN3 345 640252 KEYSTON3 345 1 '
Open branch from bus 640183 to bus 640252 ckt 1 / 640183 GENTLMN3 345 640252 KEYSTON3 345 1
end
Contingency '640196 GOTHNBG7 115 640238 JEFFREY7 115 1 '
Open branch from bus 640196 to bus 640238 ckt 1 / 640196 GOTHNBG7 115 640238 JEFFREY7 115 1
end
Contingency '3Wnd: OPEN S975 T4 1 '
Open branch from bus 640234 to bus 647975 to bus 648275 ckt 1 / 3Wnd Xfmr B$1592 : S975 T4
end
Contingency '640265 MALONEY7 115 640287 N.PLATT7 115 1 '
Open branch from bus 640265 to bus 640287 ckt 1 / 640265 MALONEY7 115 640287 N.PLATT7 115 1

end
Contingency '640267 MAXWELS7 115 640359 STAPLETON 7 115 1 '
Open branch from bus 640267 to bus 640359 ckt 1 / 640267 MAXWELS7 115 640359 STAPLETON 7 115 1
end
Contingency '3Wnd: OPEN N.PLATTE T9 2 '
Open branch from bus 640287 to bus 640286 to bus 640291 ckt 2 / 3Wnd Xfmr B$1301 : N.PLATTE T9
end
Contingency '3Wnd: OPEN SPALDING T1 1 '
Open branch from bus 640348 to bus 640347 to bus 643139 ckt 1 / 3Wnd Xfmr B$1660 : SPALDING T1
end
Contingency '3Wnd: OPEN SPALDING T2 2 '
Open branch from bus 640348 to bus 640347 to bus 643169 ckt 2 / 3Wnd Xfmr B$1661 : SPALDING T2
end
Contingency '642070 SUB-C 7 115 642072 SUB-E 7 115 1 '
Open branch from bus 642070 to bus 642072 ckt 1 / 642070 SUB-C 7 115 642072 SUB-E 7 115 1
end
Contingency '642071 SUB-D 7 115 642076 SUB-J 7 115 1 '
Open branch from bus 642071 to bus 642076 ckt 1 / 642071 SUB-D 7 115 642076 SUB-J 7 115 1
end
Contingency '3Wnd: OPEN S3455 T1 1 '
Open branch from bus 645455 to bus 646255 to bus 648255 ckt 1 / 3Wnd Xfmr B$1588 : S3455 T1
end
Contingency '3Wnd: OPEN S3459 T3 1 '
Open branch from bus 645459 to bus 646209 to bus 648259 ckt 1 / 3Wnd Xfmr B$1591 : S3459 T3
end
Contingency '646211 S1211 5 161 646299 S1299 5 161 1 '
Open branch from bus 646211 to bus 646299 ckt 1 / 646211 S1211 5 161 646299 S1299 5 161 1
end
Contingency '3Wnd: OPEN S1221 T9 1 '
Open branch from bus 646221 to bus 647921 to bus 648221 ckt 1 / 3Wnd Xfmr B$1582 : S1221 T9
end
Contingency '659130 GRANTNB7 115 659132 OGALALA7 115 2 '
Open branch from bus 659130 to bus 659132 ckt 2 / 659130 GRANTNB7 115 659132 OGALALA7 115 2
end
Contingency '659132 OGALALA7 115 659187 ROSCOE 7 115 1 '
Open branch from bus 659132 to bus 659187 ckt 1 / 659132 OGALALA7 115 659187 ROSCOE 7 115 1
end
Contingency '300071 5CLINTN 161 300124 5HOLDEN 161 1 '

Open branch from bus 300071 to bus 300124 ckt 1 / 300071 5CLINTN 161 300124 5HOLDEN 161 1
end
Contingency '345435 7PALM TAP 345 636645 SUB T 3 345 1 '
Open branch from bus 345435 to bus 636645 ckt 1 / 345435 7PALM TAP 345 636645 SUB T 3 345 1
end
Contingency '345667 7RUSH 1 345 345857 7TYSON 3 345 1 '
Open branch from bus 345667 to bus 345857 ckt 1 / 345667 7RUSH 1 345 345857 7TYSON 3 345 1
end
Contingency '3Wnd: OPEN 2 '
Open branch from bus 635700 to bus 635701 to bus 635707 ckt 2 / 3Wnd Xfmr B$0069 :
end
Contingency '640404 WAYSIDE4 230 652573 STEGALL4 230 1 '
Open branch from bus 640404 to bus 652573 ckt 1 / 640404 WAYSIDE4 230 652573 STEGALL4 230 1
end
Contingency '3Wnd: OPEN SC2 KU1A 1 '
Open branch from bus 652564 to bus 652565 to bus 652304 ckt 1 / 3Wnd Xfmr B$1609 : SC2 KU1A
end
Contingency '3Wnd: OPEN SC2 KU1B 1 '
Open branch from bus 652564 to bus 652565 to bus 652305 ckt 1 / 3Wnd Xfmr B$1610 : SC2 KU1B
end
Contingency '659101 ANTELOP3 345 659183 CHAR.CK3 345 1 '
Open branch from bus 659101 to bus 659183 ckt 1 / 659101 ANTELOP3 345 659183 CHAR.CK3 345 1
end
Contingency '659105 LELANDO3 345 659202 LELND2TY 345 1 '
Open branch from bus 659105 to bus 659202 ckt 1 / 659105 LELANDO3 345 659202 LELND2TY 345 1
end
Contingency '3Wnd: OPEN GLENHAM1 1 '
Open branch from bus 661038 to bus 661035 to bus 661600 ckt 1 / 3Wnd Xfmr B$0904 : GLENHAM1
end
Contingency '3Wnd: OPEN GLENHAM2 2 '
Open branch from bus 661038 to bus 661035 to bus 661600 ckt 2 / 3Wnd Xfmr B$0905 : GLENHAM2
end
Contingency '300046 7NEWMAD 345 300103 5NEWMAD 161 1 '
Open branch from bus 300046 to bus 300103 ckt 1 / 300046 7NEWMAD 345 300103 5NEWMAD 161 1
end
Contingency '300046 7NEWMAD 345 300103 5NEWMAD 161 2 '
Open branch from bus 300046 to bus 300103 ckt 2 / 300046 7NEWMAD 345 300103 5NEWMAD 161 2
end
Contingency '300049 7THOMHL 345 300120 5THMHIL 161 1 '

Open branch from bus 300049 to bus 300120 ckt 1 / 300049 7THOMHL 345 300120 5THMHIL 161 1
end
Contingency '300069 5CHOTEAU 161 300741 5SPORTSMAN 161 1 '
Open branch from bus 300069 to bus 300741 ckt 1 / 300069 5CHOTEAU 161 300741 5SPORTSMAN 161 1
end
Contingency '334204 6CHINA 230 334327 6AMELIA 230 1 '
Open branch from bus 334204 to bus 334327 ckt 1 / 334204 6CHINA 230 334327 6AMELIA 230 1
end
Contingency '334320 8CYPRESS 500 334325 8HARTBRG 500 1 '
Open branch from bus 334320 to bus 334325 ckt 1 / 334320 8CYPRESS 500 334325 8HARTBRG 500 1
end
Contingency '334325 8HARTBRG 500 334363 6HARTBRG 230 1 '
Open branch from bus 334325 to bus 334363 ckt 1 / 334325 8HARTBRG 500 334363 6HARTBRG 230 1
end
Contingency '334325 8HARTBRG 500 337368 8MTOLIV 500 1 '
Open branch from bus 334325 to bus 337368 ckt 1 / 334325 8HARTBRG 500 337368 8MTOLIV 500 1
end
Contingency '335074 6DYNEGY 230 335077 6PGROVE 230 1 '
Open branch from bus 335074 to bus 335077 ckt 1 / 335074 6DYNEGY 230 335077 6PGROVE 230 1
end
Contingency '335366 4RICHARD 138 335375 4COLACDY 138 1 '
Open branch from bus 335366 to bus 335375 ckt 1 / 335366 4RICHARD 138 335375 4COLACDY 138 1
end
Contingency '335537 6DOWMETR 230 335565 6AIRLQTP 230 1 '
Open branch from bus 335537 to bus 335565 ckt 1 / 335537 6DOWMETR 230 335565 6AIRLQTP 230 1
end
Contingency '335568 6WGLEN 230 336001 6EVGREN 230 1 '
Open branch from bus 335568 to bus 336001 ckt 1 / 335568 6WGLEN 230 336001 6EVGREN 230 1
end
Contingency '335568 6WGLEN 230 336001 6EVGREN 230 2 '
Open branch from bus 335568 to bus 336001 ckt 2 / 335568 6WGLEN 230 336001 6EVGREN 230 2
end
Contingency '335569 6POLSCAR 230 335573 6A.A.C. 230 1 '
Open branch from bus 335569 to bus 335573 ckt 1 / 335569 6POLSCAR 230 335573 6A.A.C. 230 1
end
Contingency '335618 8WGLEN 500 335837 8COLY 5 500 1 '
Open branch from bus 335618 to bus 335837 ckt 1 / 335618 8WGLEN 500 335837 8COLY 5 500 1
end

Contingency '335645 6EXXON 230 335655 6DWNTOWN 230 1 '
Open branch from bus 335645 to bus 335655 ckt 1 / 335645 6EXXON 230 335655 6DWNTOWN 230 1
end
Contingency '335771 6COLY 2 230 335837 8COLY 5 500 1 '
Open branch from bus 335771 to bus 335837 ckt 1 / 335771 6COLY 2 230 335837 8COLY 5 500 1
end
Contingency '335815 6PT.HUD 230 335825 6FANCY 230 1 '
Open branch from bus 335815 to bus 335825 ckt 1 / 335815 6PT.HUD 230 335825 6FANCY 230 1
end
Contingency '335815 6PT.HUD 230 335825 6FANCY 230 2 '
Open branch from bus 335815 to bus 335825 ckt 2 / 335815 6PT.HUD 230 335825 6FANCY 230 2
end
Contingency '335836 8MCKNT 500 335837 8COLY 5 500 1 '
Open branch from bus 335836 to bus 335837 ckt 1 / 335836 8MCKNT 500 335837 8COLY 5 500 1
end
Contingency '335836 8MCKNT 500 336562 8FRKLIN 500 1 '
Open branch from bus 335836 to bus 336562 ckt 1 / 335836 8MCKNT 500 336562 8FRKLIN 500 1
end
Contingency '336042 6RACLND 230 336154 6WATFRD 230 1 '
Open branch from bus 336042 to bus 336154 ckt 1 / 336042 6RACLND 230 336154 6WATFRD 230 1
end
Contingency '336131 6ADMSCRK 230 336136 6BOGALUS 230 1 '
Open branch from bus 336131 to bus 336136 ckt 1 / 336131 6ADMSCRK 230 336136 6BOGALUS 230 1
end
Contingency '336131 6ADMSCRK 230 336136 6BOGALUS 230 2 '
Open branch from bus 336131 to bus 336136 ckt 2 / 336131 6ADMSCRK 230 336136 6BOGALUS 230 2
end
Contingency '336154 6WATFRD 230 336250 69MILE 230 1 '
Open branch from bus 336154 to bus 336250 ckt 1 / 336154 6WATFRD 230 336250 69MILE 230 1
end
Contingency '336155 6HOOKER 230 336166 6OXYTAFT 230 1 '
Open branch from bus 336155 to bus 336166 ckt 1 / 336155 6HOOKER 230 336166 6OXYTAFT 230 1
end
Contingency '336155 6HOOKER 230 336166 6OXYTAFT 230 2 '
Open branch from bus 336155 to bus 336166 ckt 2 / 336155 6HOOKER 230 336166 6OXYTAFT 230 2
end
Contingency '336562 8FRKLIN 500 336820 8G.GULF 500 1 '
Open branch from bus 336562 to bus 336820 ckt 1 / 336562 8FRKLIN 500 336820 8G.GULF 500 1

end
Contingency '337040 6ANDRUS 230 337042 3ANDRUS 115 1 '
Open branch from bus 337040 to bus 337042 ckt 1 / 337040 6ANDRUS 230 337042 3ANDRUS 115 1
end
Contingency '337098 3CLARKMUN 115 337099 3CLARKD 115 1 '
Open branch from bus 337098 to bus 337099 ckt 1 / 337098 3CLARKMUN 115 337099 3CLARKD 115 1
end
Contingency '338138 5MORFLD 161 338142 5ISES-1 161 1 '
Open branch from bus 338138 to bus 338142 ckt 1 / 338138 5MORFLD 161 338142 5ISES-1 161 1
end
Contingency '338165 5MTREE 161 338167 5HRSBRG* 161 1 '
Open branch from bus 338165 to bus 338167 ckt 1 / 338165 5MTREE 161 338167 5HRSBRG* 161 1
end
Contingency '300069 5CHOTEAU 161 512648 MAID 5 161 1 '
Open branch from bus 300069 to bus 512648 ckt 1 / 300069 5CHOTEAU 161 512648 MAID 5 161 1
end
Contingency '300140 4SILVCTY 138 509757 WEKIWA-4 138 1 '
Open branch from bus 300140 to bus 509757 ckt 1 / 300140 4SILVCTY 138 509757 WEKIWA-4 138 1
end
Contingency '640396 VICTRYH4 230 652573 STEGALL4 230 1 '
Open branch from bus 652573 to bus 640396 ckt 1 / 640396 VICTRYH4 230 652573 STEGALL4 230 1
end
Contingency '640252 KEYSTON3 345 659133 SIDNEY 3 345 1 '
Open branch from bus 659133 to bus 640252 ckt 1 / 640252 KEYSTON3 345 659133 SIDNEY 3 345 1
end
Contingency '500250 DOLHILL7 345 501801 G1DOLHIL 24.0 1 '
Open branch from bus 500250 to bus 501801 ckt 1 / 500250 DOLHILL7 345 501801 G1DOLHIL 24.0 1
end
Contingency '532751 WCGS U1 25.0 532797 WOLFCRK7 345 1 '
Open branch from bus 532751 to bus 532797 ckt 1 / 532751 WCGS U1 25.0 532797 WOLFCRK7 345 1
end
Contingency '303000 6CAJUN1 230 335536 6ADDIS 230 1 '
Open branch from bus 303000 to bus 335536 ckt 1 / 303000 6CAJUN1 230 335536 6ADDIS 230 1
end
Contingency '303005 8CAJUN2 500 335500 8WEBRE 500 1 '
Open branch from bus 303005 to bus 335500 ckt 1 / 303005 8CAJUN2 500 335500 8WEBRE 500 1
end
Contingency '303021 8COTNWD2 500 334325 8HARTBRG 500 1 '

Open branch from bus 303021 to bus 334325 ckt 1 / 303021 8COTNWD2 500 334325 8HARTBRG 500 1
end
Contingency '303200 6VIGNES 230 335771 6COLY 2 230 1 '
Open branch from bus 303200 to bus 335771 ckt 1 / 303200 6VIGNES 230 335771 6COLY 2 230 1
end
Contingency '303204 6FRNSTL 230 336060 6SORR 2 230 1 '
Open branch from bus 303204 to bus 336060 ckt 1 / 303204 6FRNSTL 230 336060 6SORR 2 230 1
end
Contingency '344102 7BELLEAU 345 344103 4BELLEAU 138 1 '
Open branch from bus 344102 to bus 344103 ckt 1 / 344102 7BELLEAU 345 344103 4BELLEAU 138 1
end
Contingency '652519 OAHE 4 230 652520 OAHE 7 115 1 '
Open branch from bus 652519 to bus 652520 ckt 1 / 652519 OAHE 4 230 652520 OAHE 7 115 1
end
Contingency '300112 5SALEM 161 301027 2SALEM3 69.0 2 '
Open branch from bus 300112 to bus 301027 ckt 2 / 300112 5SALEM 161 301027 2SALEM3 69.0 2
end
Contingency '300112 5SALEM 161 301027 2SALEM3 69.0 1 '
Open branch from bus 300112 to bus 301027 ckt 1 / 300112 5SALEM 161 301027 2SALEM3 69.0 1
end
Contingency '337040 6ANDRUS 230 337041 1ANDRUS U1 24.0 1 '
Open branch from bus 337040 to bus 337041 ckt 1 / 337040 6ANDRUS 230 337041 1ANDRUS U1 24.0 1
end
Contingency 'T63'
Open branch from bus 524567 to bus 524622 ckt 1 / 524567 NE_HEREFORD3 115 524622 DEAFSMITH 3 115 1
Open branch from bus 524567 to bus 524573 to bus 524565 ckt 1 / 3Wnd Xfmr B$0368 : ABB MLL92041
end
Contingency 'SPP-AEPW-15'
Open branch from bus 509756 to bus 509777 ckt 1 / 509756 CARSN-S4 138 509777 KENSH-W4 138 1
Open branch from bus 509756 to bus 509778 ckt 1 / 509756 CARSN-S4 138 509778 CARSON-1 13.8 1
Open branch from bus 509756 to bus 509788 ckt 1 / 509756 CARSN-S4 138 509788 T.P.S.-4 138 1
Open branch from bus 509742 to bus 509777 ckt 1 / 509742 DENVR-C4 138 509777 KENSH-W4 138 1
Move 100.0 percent load from bus 509777 to bus 509744 / 509777 KENSH-W4 138
end
Contingency 'SPP-AEPW-18'

Open branch from bus 509783 to bus 509849 ckt 1 / 509783 R.S.S.-4 138 509849 ORU ETP4 138 1
Open branch from bus 509738 to bus 509849 ckt 1 / 509738 ORU E4 138 509849 ORU ETP4 138 1
Open branch from bus 509849 to bus 509858 ckt 1 / 509849 ORU ETP4 138 509858 WARNTAP4 138 1
Open branch from bus 509810 to bus 509858 ckt 1 / 509810 81YALES4 138 509858 WARNTAP4 138 1
Open branch from bus 509847 to bus 509858 ckt 1 / 509847 96YALE-4 138 509858 WARNTAP4 138 1
Open branch from bus 509810 to bus 509857 ckt 1 / 509810 81YALES4 138 509857 WAREN-W4 138 1
Move 100.0 percent load from bus 509738 to bus 509732 / 509738 ORU E4 138
Move 100.0 percent load from bus 509810 to bus 509730 / 509810 81YALES4 138
Move 100.0 percent load from bus 509857 to bus 509729 / 509857 WAREN-W4 138
end
Contingency 'KCPL-MSL#02'
Open branch from bus 300044 to bus 300049 ckt 1 / 300044 7MCCRED 345 300049 7THOMHL 345 1
Open branch from bus 300043 to bus 300044 ckt 1 / 300043 7KINGDM 345 300044 7MCCRED 345 1
end
Contingency 'TRF-NP-T8'
Open branch from bus 640287 to bus 640286 to bus 640290 ckt 1 / 3Wnd Xfmr B$1300 : N.PLATTE T8
end
Contingency 'OGE3TERM7'
Open branch from bus 514760 to bus 514761 ckt 1 / 514760 KILDARE4 138 514761 WHEAGLE4 138 1
Open branch from bus 514757 to bus 514760 ckt 1 / 514757 CHIKASI4 138 514760 KILDARE4 138 1
Open branch from bus 514759 to bus 514760 ckt 1 / 514759 NEWKIRK4 138 514760 KILDARE4 138 1
end
Contingency 'OGE3TERM45'
Open branch from bus 515261 to bus 515262 ckt 1 / 515261 BONANZT5 161 515262 AES 5 161 1
Open branch from bus 515261 to bus 515299 ckt 1 / 515261 BONANZT5 161 515299 BEVYTAP5 161 1
Open branch from bus 507182 to bus 515261 ckt 1 / 507182 BONANZA5 161 515261 BONANZT5 161 1
Open branch from bus 504181 to bus 507182 ckt 1 / 504181 HACKETT 5 161 507182 BONANZA5 161 1
Open branch from bus 504181 to bus 507185 ckt 1 / 504181 HACKETT 5 161 507185 REVESRD5 161 1
end
Contingency 'S1206T1 BSCL'
Close branch from bus 647006 to bus 647906 ckt 1 / 647006 S906 N 8 69.0 647906 S906 S 8 69.0 1

Open branch from bus 646206 to bus 647906 to bus 648206 ckt 1 / 3Wnd Xfmr B$1575 : S1206 T1
end
Contingency 'S1206T2 BSCL'
Close branch from bus 647006 to bus 647906 ckt 1 / 647006 S906 N 8 69.0 647906 S906 S 8 69.0 1
Open branch from bus 646206 to bus 647006 to bus 648306 ckt 1 / 3Wnd Xfmr B$1576 : S1206 T2
end
Contingency 'S1263T1 AUTO'
Open branch from bus 646263 to bus 647111 to bus 648263 ckt 1 / 3Wnd Xfmr B$1585 : S1263 T1
Open branch from bus 647111 to bus 647963 ckt 1 / 647111 W BROCK8 69.0 647963 S963 8 69.0 1
Open branch from bus 647111 to bus 647967 ckt 1 / 647111 W BROCK8 69.0 647967 S967 8 69.0 1
end
Contingency 'WR-DOUBLE3'
Open branch from bus 533153 to bus 533192 ckt 1 / 533153 COLINE 3 115 533192 HOOKJCT3 115 1
Open branch from bus 533153 to bus 533192 ckt 2 / 533153 COLINE 3 115 533192 HOOKJCT3 115 2
end
Contingency 'WRTOD400'
Open branch from bus 532765 to bus 532766 ckt 1 / 532765 HOYT 7 345 532766 JEC N 7 345 1
Open branch from bus 533172 to bus 533186 ckt 1 / 533172 QUINTON3 115 533186 29 GAGE3 115 1
Open branch from bus 533178 to bus 533190 ckt 1 / 533178 S GAGEE3 115 533190 UNDERPS3 115 1
Open branch from bus 533178 to bus 533190 ckt 2 / 533178 S GAGEE3 115 533190 UNDERPS3 115 2
end
Contingency 'AI-OG4A'
Open branch from bus 300110 to bus 300124 ckt 1 / 300110 5PITTSV 161 300124 5HOLDEN 161 1
Open branch from bus 300327 to bus 300336 ckt 1 / 300327 2ELM 69.0 300336 2HOLDEN 69.0 1
end
Contingency 'AI-OG4B'
Open branch from bus 300071 to bus 300124 ckt 1 / 300071 5CLINTN 161 300124 5HOLDEN 161 1
Open branch from bus 300327 to bus 300336 ckt 1 / 300327 2ELM 69.0 300336 2HOLDEN 69.0 1
end
Contingency 'TRF-NP-T8'
Open branch from bus 640287 to bus 640286 to bus 640290 ckt 1 / 3Wnd Xfmr B$1300 : N.PLATTE T8
end
Contingency 'Cooper-Nelson'

Open branch from bus 500220 to bus 500240 ckt 1 / 500220 COOPER 4 138 500240 DERID 4 138 1
Open branch from bus 335200 to bus 500240 ckt 1 / 335200 4NELSON 138 500240 DERID 4 138 1
end
Contingency 'NEB01WapaB3'
Open branch from bus 659135 to bus 659207 ckt 1 / 659135 STEGALL3 345 659207 STEGALTY 345 1
Open branch from bus 659167 to bus 659207 ckt 1 / 659167 STEGALLM 13.8 659207 STEGALTY 345 1
Open branch from bus 659206 to bus 659207 ckt 1 / 659206 STGXFMR4 230 659207 STEGALTY 345 1
end
Contingency 'NEB02WapaB3'
Open branch from bus 659209 to bus 659210 ckt 1 / 659209 SIDNEYTY 345 659210 SIDXFMR4 230 1
Open branch from bus 659133 to bus 659209 ckt 1 / 659133 SIDNEY 3 345 659209 SIDNEYTY 345 1
Open branch from bus 659168 to bus 659209 ckt 1 / 659168 SIDNEY M 13.8 659209 SIDNEYTY 345 1
end
Contingency '515375 WWRDEHV7 345 539801 THISTLE 7 345 1 '
Open branch from bus 515375 to bus 539801 ckt 1 / 515375 WWRDEHV7 345 539801 THISTLE 7 345 1
end
Contingency '515375 WWRDEHV7 345 539801 THISTLE 7 345 2 '
Open branch from bus 515375 to bus 539801 ckt 2 / 515375 WWRDEHV7 345 539801 THISTLE 7 345 2
end
Contingency '515375 WWRDEHV7 345 539801 THISTLE 7 345 DCKT '
Open branch from bus 515375 to bus 539801 ckt 1 / 515375 WWRDEHV7 345 539801 THISTLE 7 345 1
Open branch from bus 515375 to bus 539801 ckt 2 / 515375 WWRDEHV7 345 539801 THISTLE 7 345 2
END
Contingency '515375 WWRDEHV7 345 523080 HITCHLAND#2 345 1 '
Open branch from bus 515375 to bus 523080 ckt 1 / 515375 WWRDEHV7 345 523080 HITCHLAND#2 345 1
end
Contingency '515375 WWRDEHV7 345 523080 HITCHLAND#2 345 2 '
Open branch from bus 515375 to bus 523080 ckt 2 / 515375 WWRDEHV7 345 523080 HITCHLAND#2 345 2
end
Contingency '515375 WWRDEHV7 345 523080 HITCHLAND#2 345 DCKT '
Open branch from bus 515375 to bus 523080 ckt 1 / 515375 WWRDEHV7 345 523080 HITCHLAND#2 345 1
Open branch from bus 515375 to bus 523080 ckt 2 / 515375 WWRDEHV7 345 523080 HITCHLAND#2 345 2
END
Contingency '515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1 '

Open branch from bus 515375 to bus 523097 ckt 1 / 515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
end
Contingency '515375 WWRDEHV7 345 523097 HITCHLAND 7 345 2 '
Open branch from bus 515375 to bus 523097 ckt 2 / 515375 WWRDEHV7 345 523097 HITCHLAND 7 345 2
end
Contingency '515375 WWRDEHV7 345 523097 HITCHLAND 7 345 DCKT '
Open branch from bus 515375 to bus 523097 ckt 1 / 515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
Open branch from bus 515375 to bus 523097 ckt 2 / 515375 WWRDEHV7 345 523097 HITCHLAND 7 345 2
end
Contingency '539800 CLARKCO 7 345 539801 THISTLE 7 345 1 '
Open branch from bus 539800 to bus 539801 ckt 1 / 539800 CLARKCO 7 345 539801 THISTLE 7 345 1
end
Contingency '539800 CLARKCO 7 345 539801 THISTLE 7 345 2 '
Open branch from bus 539800 to bus 539801 ckt 2 / 539800 CLARKCO 7 345 539801 THISTLE 7 345 2
end
Contingency '539800 CLARKCO 7 345 539801 THISTLE 7 345 DCKT '
Open branch from bus 539800 to bus 539801 ckt 1 / 539800 CLARKCO 7 345 539801 THISTLE 7 345 1
Open branch from bus 539800 to bus 539801 ckt 2 / 539800 CLARKCO 7 345 539801 THISTLE 7 345 2
END
Contingency '531469 SPERVIL7 345 539800 CLARKCO 7 345 1 '
Open branch from bus 531469 to bus 539800 ckt 1 / 531469 SPERVIL7 345 539800 CLARKCO 7 345 1
end
Contingency '531469 SPERVIL7 345 539800 CLARKCO 7 345 2 '
Open branch from bus 531469 to bus 539800 ckt 2 / 531469 SPERVIL7 345 539800 CLARKCO 7 345 2
end
Contingency '531469 SPERVIL7 345 539800 CLARKCO 7 345 DCKT '
Open branch from bus 531469 to bus 539800 ckt 1 / 531469 SPERVIL7 345 539800 CLARKCO 7 345 1
Open branch from bus 531469 to bus 539800 ckt 2 / 531469 SPERVIL7 345 539800 CLARKCO 7 345 2
END
Contingency '532796 WICHITA7 345 539801 THISTLE 7 345 1 '
Open branch from bus 532796 to bus 539801 ckt 1 / 532796 WICHITA7 345 539801 THISTLE 7 345 1
END
Contingency '532796 WICHITA7 345 539801 THISTLE 7 345 2 '
Open branch from bus 532796 to bus 539801 ckt 2 / 532796 WICHITA7 345 539801 THISTLE 7 345 2
END
Contingency '532796 WICHITA7 345 539801 THISTLE 7 345 DCKT '

Open branch from bus 532796 to bus 539801 ckt 1 / 532796 WICHITA7 345 539801 THISTLE 7 345 1
Open branch from bus 532796 to bus 539801 ckt 2 / 532796 WICHITA7 345 539801 THISTLE 7 345 2
END
End