Don Carlos Wind Farm
Generator Interconnection

FINAL

System Impact Study

Prepared By:
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Version 3.5

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FOREWORD

Lucky Corridor has identified PNM and Tri-State as affected systems. Both parties have been engaged at the onset of this Version 2 re-study which was triggered by comments received from both parties on Version 1-6 of this System Impact Study. This most recent version includes mitigation solutions that are feasible for all parties.

This Version 3 is a significant update that includes a mitigation plan that is agreeable to both Tri-State and PNM. The mitigation plan includes a modification to the Mora Line Transmission Project design coupled with a Don Carlos Wind Farm generation tripping RAS.

This System Impact Study report is prepared for Lucky Corridor, LLC by Utility System Efficiencies, Inc. (USE). Any correspondence concerning this document, including technical questions, should be referred to:

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DON CARLOS WIND FARM SYSTEM IMPACT STUDY

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1 EXECUTIVE SUMMARY

Lucky Corridor LLC, has performed this System Impact Study (SIS) under provisions of the pro forma Open Access Transmission Tariff (OATT) Section 32 to be filed by Lucky Corridor. PNM finalized a comprehensive Non-Tariff Wires to Wires System Impact Study[1] on November 16, 2017 that assessed the impact of 180 MW delivery from Lucky Corridor's Mora Line Transmission Project (MLTP) to PNM's Arriba 115 kV substation. The PNM study was reviewed and had input from Tri-State Generation and Transmission ("Tri-State") as an affected system. This SIS periodically references the results of the PNM SIS as a secondary source of detailed analysis per Section 32.2(i) of the pro forma OATT "*In performing the System Impact Study, the Transmission Provider shall rely, to the extent reasonably practicable, on existing transmission planning studies.*" However, this SIS is detailed in its scope to cover the work that was previously performed by PNM.

The MLTP has a completed Wires to Wires Facilities Study ("FaS") with PNM finalized on 11/16/2017, and a Transmission Construction and Interconnection Agreement ("TCIA") with PNM fully executed on 1/29/2018 and FERC approved on 3/27/2018. The Tri-State FaS is waiting to begin pending finalization of this coordinated generator interconnection System Impact Study.

The Don Carlos Wind Farm (DCWF) project has requested to interconnect 181.44 MW gross to the MLTP originally planned for October 31, 2018. The DCWF project submitted a Large Generator Interconnection request to Lucky Corridor on July 15, 2016.

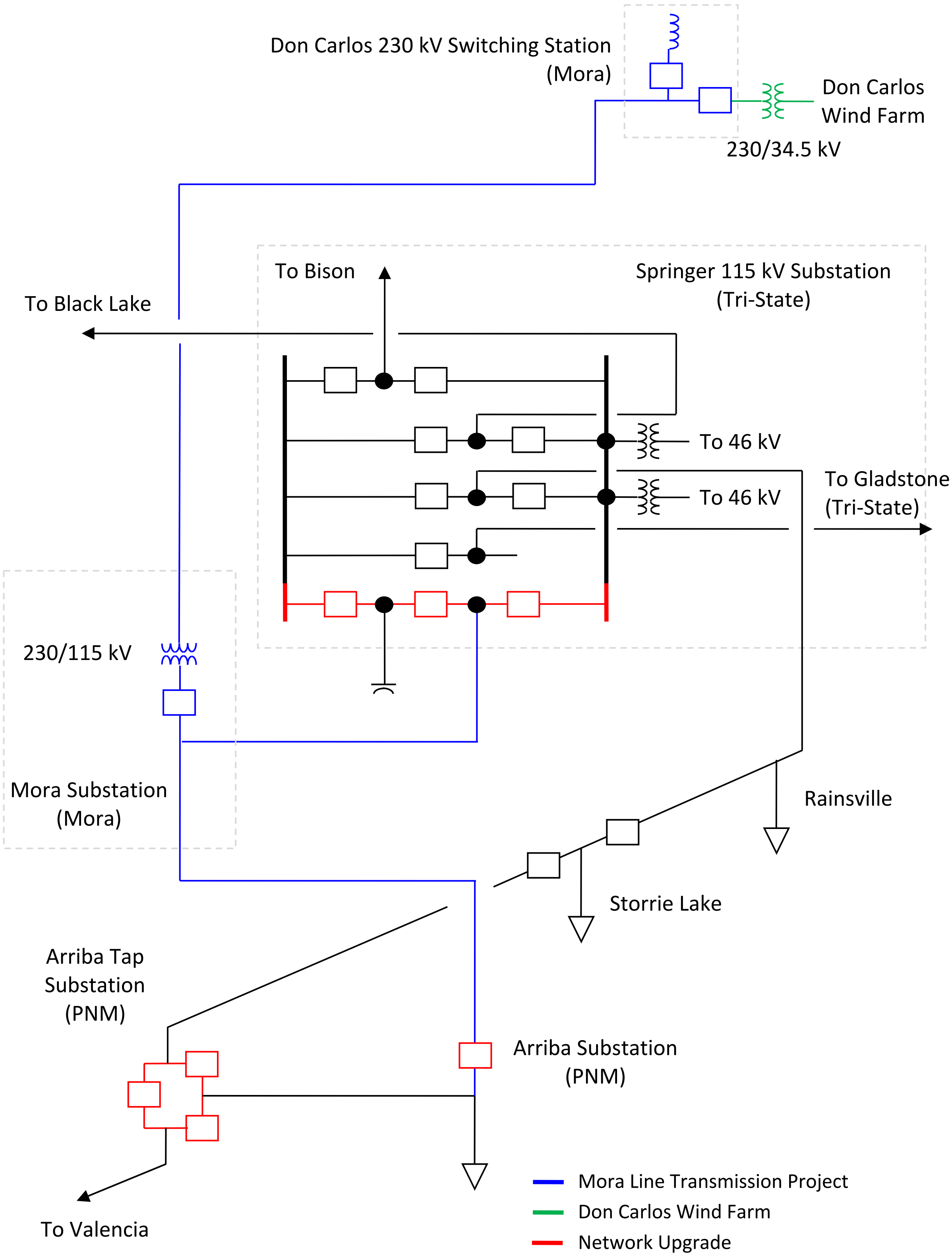
The MLTP design has been changed as it relates to the connections to Tri-State due to high voltage concerns raised during the course of this DCWF SIS (Version 2 studies). The previous MLTP design consisted of only 115 kV with connections to both Tri-State's Gladstone and Springer 115 kV substations before ultimately connecting to PNM's Arriba 115 kV substation. Study results showed that simultaneous loss of both Tri-State's Gladstone-Springer and MLTP's Gladstone-Springer 115 kV lines resulted in an instantaneous voltage in and around the Springer 115 kV system around 1.4 p.u. The high voltage is due to the area shunt capacitors being switched in-service to accommodate the high transfer of flow from both the Gladstone Phase Shifting Transformer (PST) and the DCWF followed by a contingency that eliminates both sources of the flow transfer. Numerous mitigation measures were explored including siting SVC or STATCOM in the area. After much investigation, Tri-State and Lucky agreed that the preferred mitigation alternative is to redesign the MLTP to bypass Gladstone and significantly reduce the potential for the simultaneous loss of both resources. This study shows that in the unlikely event that both resources be lost under the new MLTP design, the post-transient voltage performance is significantly improved. The highest potential voltage following the Extreme Event common corridor outage of Tri-State's Gladstone-Springer 115 kV line and the Don Carlos-Mora 230 kV line is 1.123 p.u. at the Springer 69 kV bus. The details about this high voltage concern and the mitigation alternatives evaluated can be found in **Appendix E**.

[1] Report is posted to PNM OASIS at: http://www.oasis.oati.com/PNM/PNMdocs/MoraTransmissionLineProject-FinalReport_11-16-17.pdf

The new MLTP design includes an initial 230 kV portion that bypasses Gladstone substation. The line will now step the voltage down from 230 kV to 115 kV at a new substation called Mora in the vicinity of Springer. The MLTP will connect to Springer through a single 115 kV tie and continue to Arriba as originally planned. The conductor size also increased from 954 ACSR to 1272 ACSR (a more typical 230 kV conductor).

Figure 1 on the following page illustrates the proposed DCWF generator interconnection, the new MTLP design, and nearby Tri-State and PNM transmission facilities.

FIGURE 1. DON CARLOS WIND FARM, MORA, AND NEARBY TRANSMISSION SYSTEM



OVERVIEW

The technical analysis conducted as part of this study includes power factor, power flow, post-transient, transient stability, and short circuit analysis. System upgrades/curtailments associated with the reliability concerns identified in this study are evaluated to ensure sufficient system performance. This study also identifies the Interconnection Facilities required to connect the DCWF to the MLTP's Don Carlos 230 kV Switching Station, and provides cost and time estimates for the construction of the Interconnection Facilities and potential system upgrades.

RESULTS

This study has the following notable results:

- The DCWF will connect to the MLTP at the Don Carlos 230 kV Switching Station by installing one circuit breaker. The associated terminating equipment have been identified as the customer's Interconnection Facilities. The circuit breaker will be part of Mora's Don Carlos 230 kV switching station.

- The DCWF satisfies the +/- 0.95 power factor requirement at the high side of the generator substation.

- The DCWF turbines will be utilized to regulate voltage at Don Carlos 230 kV Switching Station.

- The MLTP will install a 20 MVAr shunt reactor at the Don Carlos 230 kV Switching Station used to control high voltage at the Don Carlos 230 kV Switching Station and minimize reactive power flow through the Mora 230/115 kV transformer when the DCWF is offline and the MLTP facilities are energized.

- The DCWF will be required to install a Remedial Action Scheme (RAS) that ensures reliable system performance when the DCWF is at maximum output. The specific parameters of the RAS are discussed in **Section 5.7** Don Carlos Wind Farm System Upgrades.

- The DCWF will be limited to 175 MW gross (172 MW net) in the heavy winter and 157 MW gross (155 MW net) in the light spring conditions when the Gladstone PST is importing 190 MW. The actual limitation will be dictated by the Arriba Tap-Valencia 115 kV Line loading. The DCWF RAS will trip the project back to 100 MW if the line loading exceeds the rating.

- The Gladstone PST is manually adjusted by Tri-State to maintain power schedules or to mitigate unscheduled flow. Post-contingency, the Gladstone PST may not be immediately adjusted. However, Tri-State operations or the reliability coordinator may initiate a manual adjustment post-contingency after 30 minutes to mitigate unscheduled flow. In the event Tri-State needs to make a Gladstone PST adjustment, coordination will need to be made with the DCWF to ensure an appropriate generation curtailment is made to maintain acceptable loading on PNM's Arriba Tap-Valencia 115 kV Line. An operating procedure is recommended in order to facilitate such coordination

- **Transient Stability Concerns**
  This study will defer the specific solutions to Tri-State's Facilities Study to: (1) determine the preferred feasible setup at Springer given the unique challenges facing any 115 kV bus work at Springer, and (2) GE wind turbine dynamic model changes needed for adequate system performance. It is recommended that transient stability analysis be performed after the PSCAD results during Tri-State's Facilities Study to ensure that the final Springer substation design and any dynamic model parameter setting changes sufficiently address these transient stability concerns.

  <u>Diverged Dynamic Simulation</u>
  The dynamic simulation diverges for the P4-2 event single line to ground fault near Springer on the Taos-Springer 115 kV line followed by a stuck breaker on the west side of the line (referred to as CB 5 in this study) which also open ends the Gladstone-Springer 115 kV line. This outage results in a long radial connection to Springer through the MLTP and the existing Springer-Storrie Lake 115 kV line and ultimately connects to Zia substation near Santa Fe.

  The system performance will be re-evaluated in the PSCAD study. If confirmed, one potential solution is to add a second 115 kV circuit breaker on the east side of the Springer-Gladstone 115 kV line termination in the Springer 115 kV bus to eliminate tripping the Springer-Gladstone 115 kV line with the Taos-Springer 115 kV line for this stuck breaker contingency.

  <u>DCWF Ringing</u>
  A ringing is observed at the DCWF and propagates to nearby Cimarron Solar project. The ringing may be resolved by a dynamic model parameter setting change or may be due to the weak nature of the NENM system coupled with the radial MTLP connection to Springer. In either case, the dynamic performance will be re-evaluated in the PSCAD analysis. If confirmed by the PSCAD study, the mitigation noted below may apply for the following outages:

  - *P1-2 Gladstone-Springer 115 kV line (3 phase fault near Springer)* observed in the Heavy Summer and Heavy Winter seasons only. Reducing the DCWF project from 180 MW to 160 MW results in a damped ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.

  - *P4-3 Springer-Storrie Lake 115 kV line (single line to ground fault near Springer) with Springer CB 8 stuck tripping the Springer-Gladstone 115 kV line* observed in the Heavy Summer and Heavy Winter seasons only. Addition of the second 115 kV circuit breaker at Springer for the Springer-Gladstone 115 kV line will mitigate this issue as well. Alternatively, reducing the output of the DCWF from 180 MW to 170 MW will result in a damped ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.

- *P5-2 Gladstone-Springer 115 kV line (single line to ground fault near Springer) with non-redundant relay failure tripping resulting in delayed clearing* observed in the Heavy Summer season only. Reducing the output of the DCWF from 180 MW to 170 MW eliminates the ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.

TIME AND COST ESTIMATES

The time and cost estimates of constructing the customer's Interconnection Facilities and the DCWF RAS are outlined in **Table 1** below and in **Section 6** of this report.

TABLE 1. CONSTRUCTION TIME AND COST ESTIMATES

Equipment Description	Time to Construct (Months)	Cost Estimate ($000,000)
Don Carlos Wind Farm		
Transmission Provider's Interconnection Facilities (add one 230 kV breaker and associated equipment at Don Carlos Switching Station)	14	2.26
DCWF RAS System Upgrade	12	1.0
Totals	14	3.26

VALIDITY OF PREVIOUS STUDIES

The PNM Non-Tariff Wires to Wires System Impact Study completed on November 16, 2017 that assessed the wires interconnection of the MLTP is no longer entirely valid due to the changes in the MTLP design necessitated by this study. However, the significant changes are all on the Tri-State end of the line while the changes to the PNM side of the MLTP are minor. The System Upgrades at Arriba Tap and Arriba are still valid. The only change to the MLTP on the PNM side is the size of the conductor and the size of the towers which result in a minor change to the line impedance between Springer and Arriba. The MLTP remains energized at 115 kV and plans to connect to PNM's Arriba substation.

The PNM cost estimates in both the PNM Wires System Impact Study and the PNM Facilities Study should still apply. They detail how the MLTP will terminate at Arriba substation and the System Upgrade addition of 115 kV breakers at Arriba Tap.

The Tri-State cost estimates found in the PNM Wires System Impact Study no longer apply. The MLTP no longer plans to terminate at Gladstone, and the termination at Springer requires a more detailed evaluation to be performed in their Facilities Study. The Tri-State Facilities Study will proceed once this DCWF System Impact Study is completed.

Lucky Corridor welcomes PNM and Tri-State to utilize this detailed study report to satisfy its wires interconnection study process. Both utilities have been engaged as affected systems throughout the course of these Version 2 and Version 3 studies.

2 STUDY DESCRIPTION AND ASSUMPTIONS

This study evaluates the impact of the DCWF under heavy summer, heavy winter, and light spring seasonal conditions with the Gladstone Phase Shifting Transformer (PST) at or near the upper bound of the operating nomogram (maximum flow) for each season. The lower bound of the nomogram does not need verification because the addition of the MLTP and the DCWF is expected to be a benefit to the minimum flow requirement necessary to serve the Tri-State Northeast New Mexico load. The heavy winter basecase utilizes the Gladstone PST dispatched near the minimum typical dispatch in addition to the maximum in order to demonstrate the impact of the Gladstone PST flow.

2.1 SYSTEM IMPACT STUDY CASES

A total of 11 cases are needed to properly evaluate the impact of the project. This study utilizes the WECC 23HS2a.sav case for the heavy summer season, dated July 19, 2017. This case was adjusted to represent 2020 heavy summer conditions. It has the planned Gladstone-Springer #2 115 kV line which was removed. This study utilizes the WECC 20HW1a.sav case for the heavy winter season, dated January 19, 2018. Lastly, this study utilizes the WECC 21LSP1a.sav case for the light spring season, dated November 3, 2017. **Table 2** below lists the cases and specific modeling attributes. The resulting power flow attributes of each case are tabulated in **Table 3** on the following page.

A version of each case below is created with the Clapham #2 SVC out of service. The Rosebud motor load is limited to 52 MW under these conditions. This case is used to evaluate the dynamic performance of the system under P6-3 conditions. The Clapham #2 SVC out of service will also be evaluated in the power flow analysis.

TABLE 2. STUDY CASE SUMMARY

#	Scenario Description	Season			Scenario			
		Heavy Summer	Heavy Winter	Light Spring	Gladstone PST	NENM Load	Cimarron Gen	PNM Dist Solar PV
2020 Heavy Summer Case								
1.	Pre-Project	√			180	111	10	18.5
2.	Pre-Project, Mora Line Only, Gladstone PST at 180 MW	√			180	111	10	18.5
3.	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√			180	111	10	18.5
2020 Heavy Winter Case								
4.	Pre-Project		√		115	74	10	0
5.	Pre-Project, Mora Line Only		√		115	74	10	0
6.	Post-Project, Don Carlos at 180 MW		√		115	74	10	0
7.	Pre-Project, Mora Line Only, Gladstone PST at 190 MW		√		190	74	10	0
8.	Post-Project, Don Carlos at 175 MW, Gladstone PST at 190 MW		√		190	74	10	0
2021 Light Spring								
9.	Pre-Project			√	190	91	30	0
10.	Pre-Project, Mora Line Only, Gladstone PST at 190 MW			√	190	91	30	0
11.	Post-Project, Don Carlos at 157 MW, Gladstone PST at 190 MW			√	190	91	30	0

TABLE 3. STUDY CASE ATTRIBUTES

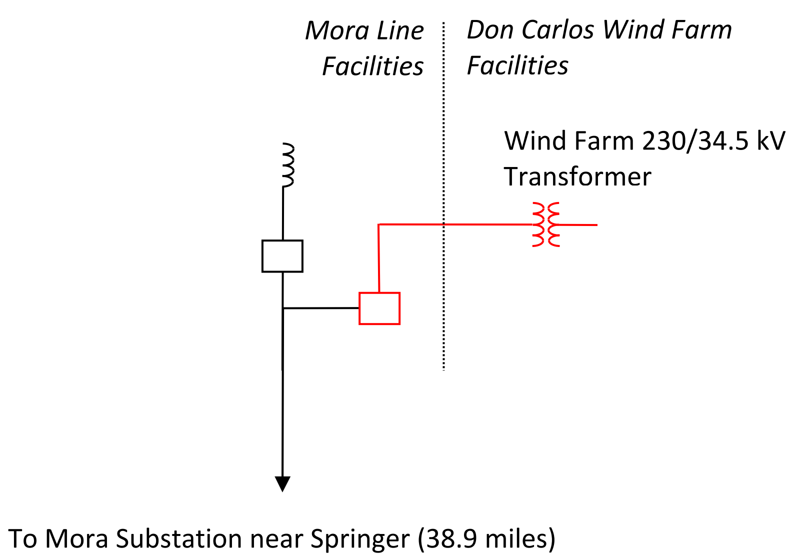
	Heavy Summer			Heavy Winter					Light Spring		
Element/Characteristic	Pre-Project	Pre-Project wMLTP	Post-Project wMLTP	Pre-Project	Pre-Project wMLTP	Post-Project wMLTP	Pre-Project wMLTP	Post-Project wMLTP	Pre-Project	Pre-Project wMLTP	Post-Project wMLTP
Path 22 Southwest of Four Corners	1,069	1,068	1,065	620	620	617	620	620	1,085	1,083	1,089
Path 31 TOT 2A	3	3	2	42	42	42	42	43	-38	-39	-39
Path 47 Southern New Mexico	2	2	2	129	129	128	129	128	387	387	387
Path 48 Northern New Mexico	1,681	1,680	1,513	1,652	1,651	1,478	1,659	1,504	710	708	575
Gladstone PST	178	174	176	113	116	119	187	188	190	187	189
Gladstone PST Angle (Degrees)	0	4	-23	8	8	-19	-23	-49	-34	-30	-53
Northeast New Mexico Load	111	111	111	74	74	74	74	74	91	91	91
San Juan-Jicarilla 345 kV	182	188	103	210	213	125	179	98	39	44	-23
Jicarilla-Ojo 345 kV	176	182	98	204	206	120	173	93	38	43	-24
Ojo-Taos 345 kV	66	72	-13	98	101	14	68	-11	-10	-3	-69
BA-Norton 345 kV	129	128	79	159	156	104	136	91	24	23	-19
Ojo 345/115 kV	109	108	111	105	104	106	104	104	47	46	44
Taos #1 345/115 kV	36	39	-7	53	55	7	37	-6	-5	-2	-37
Taos #2 345/115 kV	30	33	-6	45	46	6	31	-5	-4	-1	-31
BA 345/115 kV	223	222	212	234	233	222	229	220	106	105	96
Norton 345/115 kV	129	128	79	158	155	104	136	91	24	23	-19
Comanche-Walsenburg 230 kV	208	204	206	145	148	150	202	203	195	192	194
Walsenburg-Gladstone 230 kV	184	180	182	115	118	121	194	195	197	193	195
Gladstone-Springer 115 kV	57	53	56	35	38	40	108	109	91	88	90
Springer-Rainsville 115 kV	27	16	50	29	18	52	30	63	37	21	36
Arriba Tap-Valencia 115 kV	25	30	96	3	11	77	35	96	29	36	101
Springer-Black Lake 115 kV	1	-7	102	-17	-21	89	19	124	47	38	126
Ojo-Hernandez 115 kV	109	108	111	105	104	106	104	104	47	46	44
Hernandez-Norton 115 kV	78	75	96	64	62	83	70	88	49	45	58
Don Carlos-Mora 230 kV (Mora Line)	0	0	179	0	0	179	0	172	0	0	155
Mora Tap-Springer 115 kV (Mora Line)	0	-15	126	0	-18	124	-31	107	0	-22	117
Mora Tap-Arriba 115 kV (Mora Line)	0	15	50	0	18	53	31	64	0	22	36
NM Load	3,009	3,009	3,009	2,424	2,424	2,424	2,424	2,424	1,256	1,256	1,256
NM Losses	126	125	140	115	114	122	118	138	54	53	76
NM Generation	2,745	2,745	2,760	2,133	2,131	2,139	2,067	2,096	1,159	1,156	1,180
NM Interchange	-390	-389	-389	-406	-408	-407	-475	-465	-151	-152	-152
Case	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**

2.2 DON CARLOS WIND PROJECT INTERCONNECTION MODELING

The DCWF will connect to the MLTP at the Don Carlos 230 kV Switching Station. The DCWF collector station will be constructed immediately adjacent to the Don Carlos 230 kV Switching Station and connect with a 100 ft 115 kV line. The short generator tie line will terminate at the Don Carlos 230 kV Switching Station by adding one 230 kV circuit breaker.

The interconnection will require a 20 MVAr shunt reactor needed to control the voltage post-contingency and when the wind farm is offline. A second 230 kV circuit breaker will be needed to connect the shunt reactor.

FIGURE 2. INTERCONNECTION FACILITIES AT DON CARLOS 230 KV SWITCHING STATION

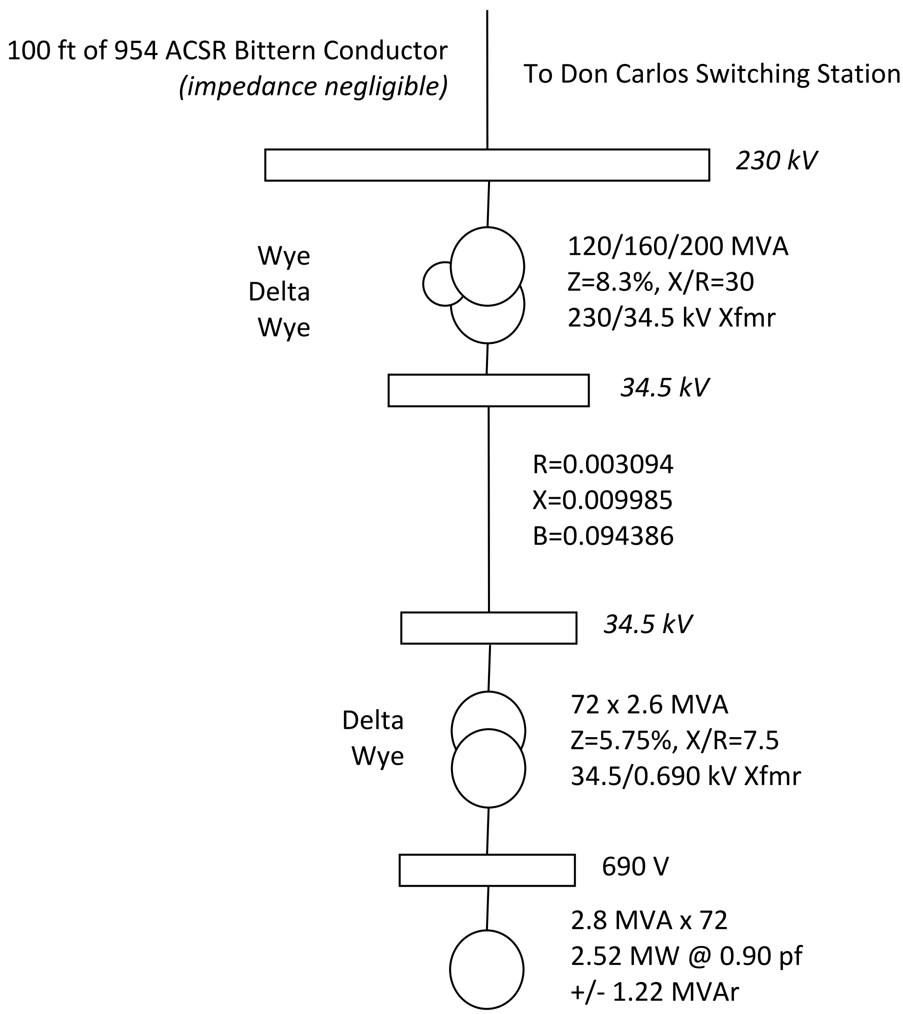


Denotes Generator Interconnection Facilities

Denotes Mora Transmission Line Project Facilities

The detailed power flow model of the DCWF project is depicted in **Figure 3** below. The DCWF project is modeled as an aggregate of 72 GE 2.5-127 wind turbines[2]. The generation has a terminal voltage of 690 V and is stepped up to 34.5 kV through a series of 0.69/34.5 kV Generator Step-Up (GSU) transformers. These GSUs are also aggregated into a single unit in the power flow model. Eight 34.5 kV collector circuits are aggregated into a single 34.5 kV collector line per the WECC PV Plant Power Flow Modeling Guide.[3] The feeder circuits are gathered at a common 34.5 kV bus which is stepped up to 230 kV through a 200 MVA transformer. A short 100 foot 230 kV generator tie line connects the project to the Don Carlos Switching Station 230 kV bus.

FIGURE 3. DON CARLOS WIND FARM POWER FLOW MODEL



[2] This model is a revision to what was used in the PNM System Impact Study.

[3] While the WECC PV Plant Power Flow Modeling Guide is specifically written for Solar PV facilities, the aggregation methodology can also be applied to wind facilities.

2.3 DYNAMIC DATA

Appendix A provides details of the dynamic model parameters used for the transient stability analysis. Modeling of the new generation utilizes the updated characteristics provided by the applicant for the new GE 2.5-127 wind turbines and are slightly different than those assumed in the PNM study.

3 STUDY CRITERIA

Performance of the transmission system is measured against the following planning criteria: the Western Electricity Coordinating Council (WECC) Reliability Criteria, the North American Electric Reliability Council (NERC) Planning Standards, and any applicable Federal Energy Regulatory Commission (FERC) orders. If system reliability problems resulting from the interconnection of the project are discovered, the study will identify the system facilities or operational measures that will be necessary to mitigate reliability criteria violations. Addition of these new facilities would maintain the reliability to the transmission network.

3.1 RELIABILITY CRITERIA

In general, an evaluation of the system reliability investigates the system's thermal loading capability, voltage performance (not too high or low), transient stability (the system should not oscillate excessively and generators should remain synchronized), and fault duty (increase in fault current does not overstress any circuit breakers). The evaluation of these analyses must be conducted for P0 - P7 events as identified in Table 1 of the NERC TPL-001-4 standard. NERC P6 events allow for system readjustment between events and will be considered only for the Clapham #2 SVC outage in this generator interconnection study at the request of Tri-State. All other P6 outages will not be evaluated because all generation is considered for reduction during the readjustment period, potentially nullifying the effect of the new interconnection.

3.2 POWER FACTOR CRITERIA

FERC Order 827 eliminates the exemption of wind generation from reactive power requirements. All non-synchronous generators, including wind generators, must provide dynamic reactive support within the range of +/-0.95 power factor at the high side of the generator substation. Static devices can be used to make up for reactive losses that occur between the inverters and the high side of the generator substation. This study calculates the net power factor capability of the project to determine compliance with this FERC order.

3.3 STEADY STATE POWER FLOW CRITERIA

All power flow analysis is conducted with version 21.0_05 of General Electric's PSLF software. Traditional power flow analysis is used to evaluate equipment and voltage performance of the system under pre-contingency and post-contingency conditions.

The power flow performance criteria utilized to assess the impact of the generator throughout the SIS are shown in **Table 4**. This criteria generally aligns with WECC-0100 Posting 4 TPL-001-WECC-CRT-3 R5 and R6.

TABLE 4. POWER FLOW SYSTEM PERFORMANCE CRITERIA

Area	Condition	Loading Limit	Voltage Rage	Voltage Deviation	Application
EPEC (Area11)	P0	< Normal Rating	0.95 - 1.05	N/A	BES Facilities
	P1	< Emergency Rating	0.90 - 1.10	8 %[5]	BES Facilities
	P2-P7	< Emergency Rating	0.90 - 1.10	N/A	BES Facilities
PNM (Area 10)	P0	< Normal Rating	0.95 - 1.05	N/A	BES Facilities
	P1	< Emergency Rating	0.90 - 1.10	8 %	BES Facilities
	P2-P7	< Emergency Rating	0.90 - 1.10	N/A	BES Facilities
Tri-State (Zone 120-123)	P0	< Normal Rating	0.95 - 1.05	N/A	BES Facilities
	P1	< Normal Rating	0.90 - 1.10	8 %	BES Facilities
	P2-P7	< Normal Rating	0.90 - 1.10	N/A	BES Facilities

1) Taiban Mesa 345 kV, Guadalupe 345 kV, and Jicarilla 345 kV voltages 0.950 and 1.10 under normal and contingency conditions
2) PNM will monitor 46 kV & 69 kV facilities
3) El Paso will monitor 69 kV facilities
4) Greenlee 345 kV is a 5 % voltage drop
5) 7% voltage drop will be used for 345 kV busses
6) EPE will modify its criteria in the 2017 FERC 715 filing

3.4 TRANSIENT STABILITY CRITERIA

The NERC/WECC transient stability performance requirements for transmission contingencies identified in WECC-0100 Posting 4 TPL-001-WECC-CRT-3 are as follows:

- All machines will remain in synchronism
- All voltage swings are well damped
- Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events, for each applicable BES bus serving load.
- Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70 % of pre-contingency voltage for more than 30 cycles nor remain below 80% of the pre-contingency voltage for more than two seconds, for all P1 through P7 events.
- All frequency dips are well damped.

Fault clearing times used in this SIS for the PNM system are the same as was used for the MLTP PNM SIS shown in **Table 5** on the following page.

TABLE 5. PNM FAULT CLEARING TIMES

Category	Fault Type	Voltage	Clearing Time (near-far end breakers)
P1, P3, P6, P7	3 Phase, normal clearing	345	4-4 Cycles
		230	4-4 Cycles
		115	4-4 Cycles
			Clearing Time (normally opened breaker-stuck breaker end)
P2, P4, P5, P7	1 Phase, stuck breaker	345	4-12 Cycles
		230	4-12 Cycles
		115	4-15 Cycles

Tri-State 230 kV outages assume 5 cycle near end clearing and 7 cycles far end clearing. 115 kV outages assume 6 cycle near end clearing and 8 cycle far end clearing. Delayed clearing is the same as PNM which is 12 cycles for 230 kV and 15 cycles for 115 kV.

3.5 SHORT CIRCUIT CRITERIA

PNM previously studied the impact of the MLTP with generic wind generation connected to it and determined that all breakers remain within limits. The PNM criteria flags breakers whose fault current is in excess of 92 % of the breaker rating. Any breaker duty that exceeds 95 % requires upgrade.

Lucky performed the short circuit analysis on the Tri-State system to assess the impact of the DCWF. Tri-State provided their Aspen model to USE to perform the analysis. The study evaluates 3 phase and single line to ground faults to ensure the fault current does not exceed any breaker rating.

4 STUDY METHODOLOGY

This section summarizes the methods used to derive the power factor requirements, power flow/post-transient, transient stability, and fault duty/short circuit results. NERC P0 through P7 events as identified in Table 1 of the NERC TPL-001-4 standard will be simulated. An abbreviated version of NERC TPL-001-4 Table 1 is included below as **Table 6** on the following page. The list of events applied in this study is found in **Appendix B.**

TABLE 6. NERC TPL-001-4 STEADY STATE & STABILITY PERFORMANCE PLANNING EVENTS

Category	Initial Condition	Event	Fault Type
P0 No Contingency	Normal system	None	N/A
P1 Single Contingency	Normal system	Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device	3 ph
		5. Single Pole of DC line	SLG
P2 Single Contingency	Normal system	1. Opening of a line section without fault	N/A
		2. Bus section fault	SLG
		3. Internal breaker fault (non-bus-tie breaker)	SLG
		4. Internal breaker fault (bus-tie breaker)	SLG
P3 Multiple Contingency	Loss of generator followed by system adjustments	Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device	3 ph
		5. Single Pole of DC line	SLG
P4 Multiple Contingency *(Fault plus stuck breaker**)*	Normal system	Loss of multiple elements caused by a stuck breaker (non-bus-tie breaker) attempting to clear a Fault on one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device 5. Bus Section	SLG
		6. Loss of multiple elements caused by a stuck breaker** (Bus-tie Breaker) attempting to clear a Fault on the associated bus	SLG
P5 Multiple Contingency (Fault plus relay failure to operate)	Normal system	Delayed Fault Clearing due to the failure of a non-redundant relay protecting the Faulted element to operate as designed, for one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device 5. Bus Section	SLG
P6 Multiple Contingency (Two overlapping singles)	Loss of one of the following followed by system adjustments: 1. Transmission Ckt 2. Transformer 3. Shunt Device 4. Single Pole of a DC	Loss of one of the following: 1. Transmission Circuit 2. Transformer 3. Shunt Device	3 ph
		4. Single Pole of a DC line	SLG
P7 Multiple Contingency (Common Structure)	Normal system	The loss of 1. Any two adjacent (vertically or horizontally) circuits on common structure 2. Loss of a bipolar DC line	SLG

4.1 POWER FACTOR METHODOLOGY

The reactive power requirement is calculated based upon +/- 0.95 power factor of the net power injection at the POI. Any shunt devices in the collector system are turned off. The amount of project losses is determined by adding the MVAR flow into the project at the high-side of the generation substation (tie line or project step up transformer) and reactive power output of the project generator. The gross reactive capability of the project generator minus the project losses equals the net project capability. The project satisfies FERC Order 827 if the net project reactive power capability exceeds the minimum reactive power requirement.

4.2 POWER FLOW/POST-TRANSIENT METHODOLOGY

According to the Tri-State Engineering Standards Bulletin dated November 2016, section 8.1.1.4 System Adjustments, states that "Tri-State allows system adjustments to occur during single contingency outage simulations. This philosophy allows weaker rural systems to capture the advantages of installed LTC and switched VAR devices." As such, the post-transient post contingency solution will allow TCUL and SVD adjustments, while not allowing PST adjustments.

4.2.1 GLADSTONE PST AND CONTINGENCY SOLUTION PARAMETERS

The Gladstone PST is manually adjusted to maintain power schedules or to mitigate unscheduled flow. Post-contingency, the Gladstone PST may not be immediately adjusted. However, Tri-State operations or the reliability coordinator may initiate a manual adjustment post-contingency after 30 minutes to mitigate unscheduled flow. In the event that Tri-State needs to make a Gladstone PST adjustment, coordination will need to be made with the DCWF to ensure an appropriate generation curtailment is made to maintain loading on PNM's Arriba Tap-Valencia 115 kV Line. An operating procedure is recommended in order to facilitate such coordination.

All contingencies will be simulated in two ways to capture the impact of the DCWF to the capability of the Gladstone Phase-Shifting Transformer to adjust post-contingency. The first post-contingency post-transient solution will not allow the Gladstone PST (and all others) to regulate real power flow with an angular adjustment. The second post-contingency power flow solution will allow the Gladstone PST (and all others) to regulate real power flow with an angular adjustment. Transformer taps and switched shunts are not allowed to adjust in the first post-transient solution in order to capture the high voltage concerns raised in the previous version on this study. **Table 7** (on the following page) summarizes the solution parameters used in this study.

TABLE 7. SOLUTION PARAMETERS

Parameter	Pre-Contingency	Post-Contingency	
		Post-Transient	Power Flow
Tap Changer Under Load Adjustment	Yes	No	Yes
Automatic Phase Shifter Adjustment	Yes	No	Yes
Automatic Switched Voltage Device Adjustment	Yes	No	Yes
Area Interchange Control	Yes	No	Yes

4.3 TRANSIENT STABILITY METHODOLOGY

All transient stability simulations are conducted using version 21.0_04 of General Electric's PSLF/PSDS/SCSC software. The dynamic simulation is run out to 21 seconds with a 1 second flat run prior to applying a fault.

The Worst Condition Analysis (WCA) tool, available in the PSDS software package, tracks and records the transient stability behavior of all output channels contained within the binary output file of a transient stability simulation. The monitoring of channel output is initiated two cycles after fault clearing, to ensure that post-fault stability behavior is captured. System damping is assessed visually with the aid of stability plots.

PARAMETERS MONITORED TO EVALUATE SYSTEM STABILITY:

ROTOR ANGLE

Rotor angle plots provide a measure for determining how the proposed generation units swing with respect to other generating units in the area. This information is used to determine if a machine remains in synchronism or goes out-of-step from the rest of the system following an event.

BUS VOLTAGE

Bus voltage plots, in conjunction with the relative rotor angle plots, provide a means of detecting out-of-step conditions. The bus voltage plots are useful in assessing the magnitude and duration of post-event voltage dips and peak-to-peak voltage oscillations. Bus voltage plots also give an indication of system damping and the level to which voltages are expected to recover in the steady state conditions.

BUS FREQUENCY

Bus frequency plots provide information on magnitude and duration of post-fault frequency swings with the new project(s) in service. These plots indicate the extent of possible over-frequency or under-frequency, which can occur due to an area's imbalance between load and generation.

OTHER PLOTTED PARAMETERS
Real Power Output

STUDY EVENTS:
Select P1 through P7 events for transient stability simulations are listed in **Appendix B**.

4.4 SHORT CIRCUIT METHODOLOGY

PNM previously studied impact of the MLTP with generic generation connected to it and determined that all breakers remain within limits. The PNM study evaluated 3 phase and single line to ground faults at the following stations:

- Zia 115 kV
- Valencia 115 kV
- Storrie Lake 115 kV

Lucky performed short circuit analysis on the Tri-State system to assess the fault duty impact of the DCWF. Tri-State provided their Aspen short circuit model to USE to perform the analysis. The study evaluates 3 phase and single line to ground faults at the following stations:

- Gladstone 115 kV
- Springer 115 kV
- Clapham 115 kV
- Hess 115 kV

4.5 COST AND CONSTRUCTION SCHEDULE ESTIMATES

Cost and time estimates are supplied as part of this study which represents good faith estimates of the project interconnection facilities and any system upgrades specific to the MLTP. System upgrades associated with PNM or TSGT will be identified and estimated by the affected party.

5 RESULTS AND FINDINGS

5.1 POWER FACTOR CAPABILITY RESULTS

In order to meet the power factor requirements set by MLTP, the DCWF must be able to achieve ±0.95 p.f. at the project's POI which is at the high side terminals of the project's generator substation. This study determines that the project satisfies the minimum requirement by achieving 0.935 power factor at the high side of the generator substation. The project supplies a surplus of 8.1 MVAr above the minimum requirement.

TABLE 8. POWER FACTOR CAPABILITY CALCULATION

	Project Capability	
Dynamic Power Factor Capability at Generator Terminal	0.900	
Dynamic MVAr Capability at Generator Terminal	87.84	MVAr
Facility MVAr Losses	21.00	MVAr
Shunt Capacitor MVAr	0.0	MVAr
MVAr at High Side of Generator Substation	66.84	MVAr
MVAr required at the HSGS (based upon net real power injection)	58.74	MVAr
Power Factor at High Side of Generator Substation	0.935	
MVAr Surplus/Deficiency at High Side of Generator Substation	**+8.10**	MVAr

Furthermore the PNM SIS indicated that the MLTP will need to operate such that near unity power injection is achieved at the first connection point at Gladstone. They indicate that up to 30 MVAr of reactive support may be required to achieve such operation. The MLTP topology has significantly changed since the PNM SIS. The connection with Tri-State is not as straight forward as the original concept. The MLTP will now connect to Tri-State and PNM through a three-terminal 115 kV line from the new Mora substation to Springer and Arriba. The reactive power flow cannot be explicitly controlled through the Mora-Springer 115 kV line segment.

During planned or unplanned events that lead to the DCWF being offline, the 230 kV shunt reactor will be inserted in order to control voltage at the Don Carlos Switching Station 230 kV bus and also reactive power flow injected through the Mora 230/115 kV transformer. This study shows that less than 2 MVArs are expected to flow through the Mora 230/115 kV transformer when the DCWF is offline and the 230 kV shunt reactor is inserted.

5.2 NET POWER CALCULATION

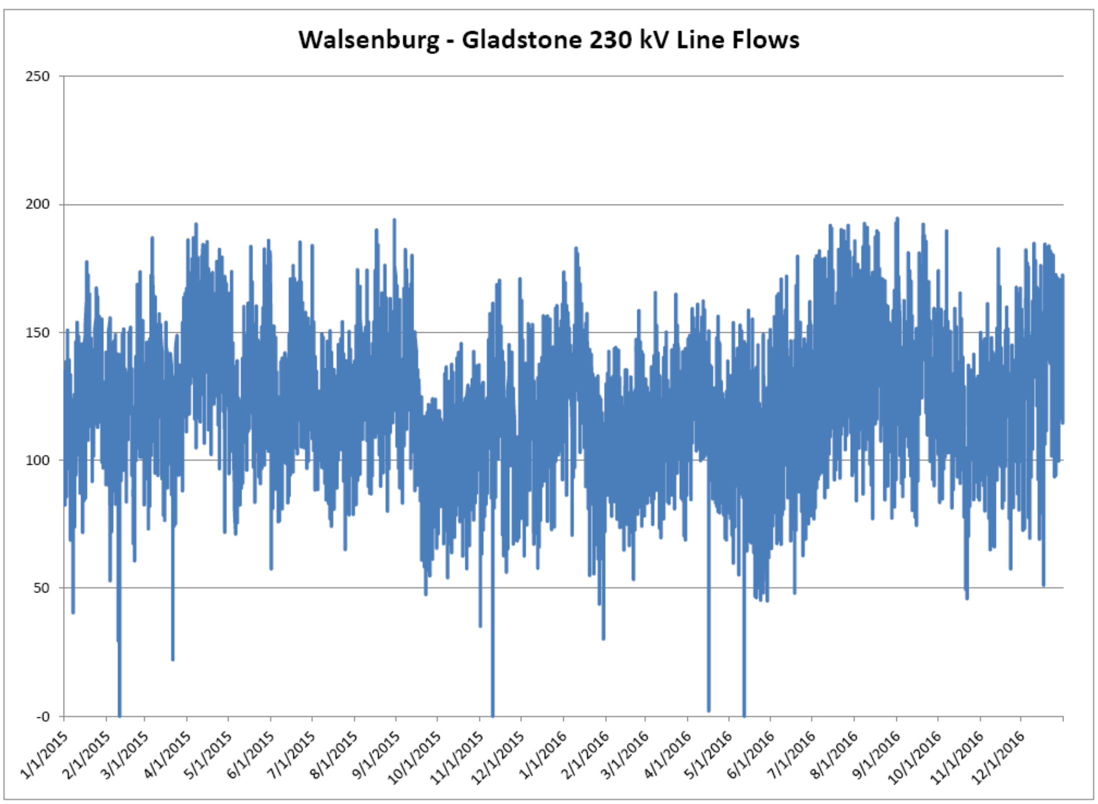
The DCWF plans to connect a gross capacity of 181.44 MW of wind generation capability. There will be power losses associated with the project's collection system and interconnection facilities. Losses determine the net capacity (less than the gross capacity generated) that can be delivered at the Point of Interconnection at Don Carlos 230 kV Switching Station. After modeling the interconnection facilities in detail, the net capability at Don Carlos 230 kV Switching Station is calculated to be 178.5 MW with 2.9 MW of losses.

5.3 THERMAL LOADING RESULTS WITHOUT SYSTEM UPGRADES

This study identifies thermal loading concerns associated with the DCWF interconnection. Two critical system variables determine the allowable generation output of the DCWF: (1) Northeastern New Mexico load, and (2) Gladstone PST flow through the Walsenburg-Gladstone 230 kV line. High imports into the Northeastern New Mexico system through the Gladstone PST coupled with low Northeastern New Mexico load is the most limiting system condition for DCWF generation.

The PNM report states "Historical flows on the Walsenburg-Gladstone line have ranged up to 180 MW with typical flows ranging in the 100 MW to 150 MW range.[4]" **Figure 4** on the following page is a chart of the historical flow on the Gladstone PST. This study assumes 180 MW of flow under Heavy Summer conditions, and 190 MW of flow under Heavy Winter and Light Spring conditions.

FIGURE 4. HISTORICAL WALSENBURG-GLADSTONE 230 KV LINE FLOW[5]



[4] PNM Mora Transmission Line Project SIS, page 4
[5] PNM Mora Transmission Line Project SIS, Appendix E - Historical Walsenburg - Gladstone 230 kV flows

The following discuss the system limitations by season. The most limiting outage in every season is the P1-2 Taos-Springer 115 kV line outage and the P2-3 Springer 115 kV East CB 6 (trips the Springer-Taos & Springer Load) outage which overloads PNM's Arriba Tap-Valencia 115 kV Line.

GLADSTONE PST ADJUSTMENT

The gray results in **Table 9** represent the event that Tri-State needs to make a manual Gladstone PST adjustment post-contingency. The PST flow is reduced post-contingency and any manual adjustment is shown to exacerbate the overloads noted in Table 9. Coordination will need to be made with the DCWF to ensure an appropriate generation curtailment is made to maintain loading on PNM's Arriba Tap-Valencia 115 kV Line. An operating procedure is recommended in order to facilitate such coordination.

HEAVY SUMMER THERMAL LOADING RESULTS

The DCWF loads PNM's Arriba Tap-Valencia 115 kV line to 94.9 % pre-contingency at full output.

The P1-2 Taos-Springer 115 kV Line outage overloads PNM's Arriba Tap-Valencia 115 kV Line to 143.9 %. The overload increases to 195.9 % when the Gladstone PST is allowed to adjust back to its pre-contingency schedule which pushes even more power through the area. Line sections further southwest of Valencia also overload but only this first section is reported in **Table 9** for simplicity. This PNM line overloads for numerous outages in the area that cause the north to south flow in New Mexico to redistribute.

The outage of the Springer 115 kV East CB 6 (trips the Springer-Taos & Springer Load) loads PNM's Arriba Tap-Valencia 115 kV line to 147.8 %. The overload increases to 200.6 % when the Gladstone PST is allowed to adjust back to its pre-contingency schedule.

HEAVY WINTER CONDITIONS

The DCWF loads PNM's Arriba Tap-Valencia 115 kV line to 76.5 % pre-contingency at full output when the Gladstone PST flow is 115 MW. The DCWF must be curtailed to 172 MW (net) when the Gladstone PST flow is 190 MW which results in the line being loaded to 98.7 % pre-contingency.

In general, the overloads noted in the heavy summer season trend higher in the heavy winter case. The P1-3 Gladstone 230/115 kV Transformer 1 outage overloads the parallel Gladstone 230/115 kV Transformer 2 pre-project and post-project when the Gladstone PST attempts to adjust back to the pre-contingency schedule. In practice, the PST will not be adjusted such that the remaining 230/115 kV transformer becomes overloaded. The inclusion of the DCWF reduces the magnitude of this overload.

The outage of the Taos-Springer is still the worst P1, loading the Arriba Tap-Valencia to 117.0 % with the Gladstone PST at 115 MW, and to 164.3 % with the Gladstone PST at 190 MW. The outage of the Springer 115 kV Center CB 5 (trips Springer-Taos and Springer-Gladstone) is the worst P2 outage when the Gladstone PST is 115 MW, loading the Arriba Tap-Valencia to 125.4 %. The outage of the Springer 115 kV East CB 6 (trips the Springer-Taos & Springer Load) is the worst P2 when the Gladstone PST is 190 MW, loading the Arriba Tap-Valencia 115 kV line to 165.4 %.

LIGHT SPRING CONDITIONS

The DCWF must be curtailed to 155 MW (net) when the Gladstone PST flow is 190 MW which results in PNM's Arriba Tap-Valencia 115 kV line being loaded to 99.9 % pre-contingency. The rest of the results are similar to the Heavy Winter season with higher loadings.

5.4 THERMAL RESULTS WITH OVERLAPPING CLAPHAM SVC #2 OUTAGE (P6)

All P1 outages were simulated with the Clapham #2 SVC out of service. This condition does not create any new thermal loading concerns, nor are the results significantly impacted.

TABLE 9. THERMAL RESULTS WITHOUT SYSTEM UPGRADES

					Heavy Summer			Heavy Winter					Light Spring		
					Gladstone: 180 MW			Gladstone: 115 MW			190 MW		Gladstone: 190 MW		
	Outage	Overloaded Element	Area	Rating	Pre	Pre wMLTP	Post wMLTP	Pre	Pre wMLTP	Post wMLTP	Pre wMLTP	Post[1] wMLTP	Pre	Pre wMLTP	Post[2] wMLTP
	NERC P0 Events														
0	No Outage Taken	ARRIBA_T - VALENCIA 115kV	10	497 A	25.6	28.5	94.9	4.5	10.0	76.5	34.7	98.7	29.8	35.6	99.9
	NERC P1 Events														
33	Taos-Springer 115kV Line	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A	25.7	24.5	**143.9**	4.9	2.0	**117.0**	44.6	**162.0**	50.9	55.1	**168.1**
					25.8	*24.7*	***195.9***	*8.3*	*11.6*	***164.3***	*54.4*	***177.3***	*73.8*	*73.1*	***178.4***
		SPRINGER - RAINVL_T 115 kV (to Storrie Lake)	10	462 A	30.6	16.1	78.1	23.7	14.5	76.7	38.4	**101.2**	63.1	34.5	62.8
					30.7	*16.2*	***105.6***	*19.0*	*9.0*	***102.7***	*43.7*	***109.9***	*87.7*	*44.2*	*66.4*
68	Gladstone 230/115kV Tran 1	Gladstone 230/115kV Tran 2	10	200 M	91.3	89.3	90.9	56.8	58.8	60.4	97.3	99.1	99.8	97.9	99.3
					95.1	*93.4*	*94.8*	*60.8*	*58.8*	*60.4*	***101.0***	*99.1*	***103.3***	***101.7***	***103.0***
35	Gladstone-Clapham 115 kV Line	SPRINGER - GLADSTON 115 kV	10	924 A	58.4	57.0	56.2	36.4	39.4	38.4	78.3	76.7	71.5	70.3	71.7
					93.7	*88.2*	*97.3*	*58.0*	*57.5*	*51.6*	*95.5*	*89.9*	***101.6***	***102.2***	*80.6*
	NERC P2 Events														
91.3	Springer 115kV East CB 6 (post Mora) (Springer-Taos & Springer Load)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A		28.7	**147.8**		3.4	**120.1**	48.2	**165.4**		56.5	**169.5**
						33.8	***200.6***		*3.5*	***178.3***	*58.2*	***181.0***		*74.5*	***179.8***
		SPRINGER - RAINVL_T 115kV (to Storrie Lake)	10	462 A		18.2	80.2		16.3	78.4	40.3	**103.1**		35.2	63.3
						21.0	***108.1***		*13.6*	***110.7***	*45.6*	***112.0***		*45.0*	*66.9*
91.2	Springer 115kV Center CB 5 (post Mora)(Springer-Taos & Springer-Gladstone)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A		*41.7*	***144.1***		*53.0*	***125.4***	*67.4*	***116.2***		*32.9*	***139.6***
						41.7	***144.1***		*53.0*	***125.4***	*53.0*	***118.0***		*32.8*	***139.6***
89	Gladstone 115 kV Center CB 1 (Gladstone Tran 2 & Gladstone-Clapham)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A	40.3	46.7	**113.3**	13.0	21.0	87.5	45.0	**109.3**	41.5	50.1	**116.1**
					55.9	*66.6*	***135.5***	*24.3*	*32.1*	*98.7*	*57.4*	***115.0***	*52.2*	*65.4*	***121.4***
		GLADSTON 115/230 kV Tran 2	10	200 M	63.7	64.2	64.5	39.5	42.8	44.2	79.8	81.1	77.7	77.5	77.8
					95.5	*97.6*	*99.0*	*59.5*	*58.5*	*59.4*	***101.3***	*90.8*	*99.4*	***105.5***	*84.3*
		SPRINGER – GLADSTON 115 kV	10	924 A	56.2	54.8	54.1	35.0	37.9	36.8	75.4	73.8	68.9	67.6	69.0
					89.7	*89.3*	*94.8*	*56.9*	*55.4*	*53.6*	*99.1*	*86.3*	*97.8*	***102.4***	*77.1*
				Case	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**

The outage that results in highest loading on the Arriba Tap-Valencia and Springer-Rainsville 115 kV Lines are reported.

Gray italic result represents 30 minutes after event with Phase Shifter Adjustment allowed

Note 1: Don Carlos Wind Farm curtailed to 172 MW net to manage N-0 loading on the Arriba Tap-Valencia 115 kV Line

Note 2: Don Carlos Wind Farm curtailed to 155 MW net to manage N-0 loading on the Arriba Tap-Valencia 115 kV Line

5.5 VOLTAGE RESULTS

The detailed voltage results of this study can be found in **Table 10** in this section. The result prior to allowing the PST adjustment and Area Interchange control is reported.

JICARILLA AND OJO 345 KV VOLTAGE DEVIATION

Loss of the San Juan-Jicarilla 345 kV line causes a -8.1 % voltage drop at the Jicarilla 345 kV bus in the pre-project heavy summer case. Addition of the DCWF increases the drop to -8.4 % in the summer and -8.5 % in the winter. The voltage magnitude remains above 0.90 p.u. both pre-project and project.

HIGH VOLTAGE CONCERNS

The contingency that triggered the high voltage identified in the previous Version 2 study is not applicable under the new MLTP design. The previous high voltage concern was caused by loss of Tri-State's Gladstone-Springer 115 kV Line and the MLTP Gladstone-Springer 115 kV Line. This outage was identified as an Extreme Event, however the likelihood of the event is increased due to an Out of Step (OOS) relay on the existing Gladstone-Springer line that could trip following loss of the MLTP Gladstone-Springer 115 kV Line.

Under the new MLTP design, the Gladstone-Springer 115 kV Line is not in danger of overloading and triggering the OOS when the DCWF is online, significantly reducing the likelihood of such outage. The most relative potential outage is a common corridor extreme event outage of the Don Carlos-Mora 230 kV Line and Tri-State's Gladstone-Springer 115 kV Line. This extreme event outage is much less likely since there is no interaction with the OOS relay. The post-transient voltage performance is significantly improved. The highest voltage is observed to be 1.136 p.u. at the Springer 69 kV bus in the Light Spring case as compared to 1.4 p.u. at the Cimarron Solar facility in the Version 2 studies.

HEAVY SUMMER CONDITIONS

The P1 outage of the Springer-Mora-Arriba 115 kV Line, Mora-Don Carlos 230 kV Line, or Mora 230/115 kV Transformer, or the P2 outage of the Springer 115 kV Center CB 14 (Springer-Mora-Arriba 115 kV line and Springer Shunt Capacitor) causes the Van Buren and Clayton and 69 kV bus voltage magnitude to drop below 0.90 p.u.

HEAVY WINTER CONDITIONS

No additional voltage concerns to note.

LIGHT SPRING CONDITIONS

No additional voltage concerns to note.

TABLE 10. VOLTAGE RESULTS WITHOUT SYSTEM UPGRADES

				Heavy Summer								
	Outage	Bus	Area	Pre			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events											
10	San Juan-Jicarilla 345 kV Line	JICARILLA 345	10	1.039	0.955	-8.1	1.041	0.974	-6.5	1.037	0.951	-8.4
		OJO 345	10	1.026	0.943	-8.0	1.029	0.961	-6.6	1.019	0.939	-7.9
55	Springer-Mora-Arriba 115 kV Line	VANBUREN 69	10				0.954	0.954	0.0	0.954	0.898	-5.9
		CLAYTON 69	10				0.956	0.956	0.0	0.956	0.900	-5.9
57	Mora-Don Carlos 230 kV Line or Mora 230/115 kV Tran	VANBUREN 69	10				0.954	0.954	0.0	0.954	0.900	-5.7
	NERC P2 Events											
92	Springer 115 kV Center CB 14	VANBUREN 69	10				0.954	0.954	0.0	0.954	0.898	-5.9
		CLAYTON 69	10				0.956	0.956	0.0	0.956	0.900	-5.9
			Case	**01**			**02**			**03**		

				Heavy Winter														
	Outage	Bus	Area	Pre			Pre wMLTP			Post wMLTP			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events																	
10	San Juan-Jicarilla 345 kV Line	JICARILLA 345	10	1.040	0.966	-7.1	1.042	0.972	-6.7	1.040	0.962	-7.5	1.043	0.970	-6.9	1.036	0.947	-8.6
		OJO 345	10	1.028	0.954	-7.2	1.031	0.959	-7.0	1.025	0.949	-7.3	1.032	0.958	-7.2	1.015	0.935	-7.9
		TAOS 115	10	1.038	0.997	-4.0	1.038	1.009	-2.7	1.035	0.986	-4.7	1.035	0.993	-4.1	1.029	0.943	-8.4
33	Taos-Springer 115 kV Line	VALENCIA 115	10	1.036	1.028	-0.8	1.057	1.051	-0.6	1.033	0.996	-3.5	1.045	1.042	-0.3	1.003	0.920	-8.3
	NERC EE Events																	
109	Gladstone-Springer 115 kV & Don Carlos-Mora 230 kV Common Corridor	SPRINGER 69	10				1.041	1.047		1.038	1.060		1.032	1.089		1.034	1.123	
		MORA TAP 115	10				1.057	1.063		1.047	1.069		1.041	1.099		1.029	1.119	
		SPRINGER 115	10				1.057	1.063		1.047	1.069		1.041	1.099		1.029	1.119	
		BISON 115	10				1.056	1.063		1.047	1.068		1.040	1.098		1.029	1.118	
		CIMARRON 115	10				1.056	1.063		1.047	1.068		1.040	1.098		1.029	1.118	
		VANBREMR 115	10				1.052	1.058		1.042	1.064		1.036	1.094		1.024	1.114	
		YORKCANY 115	10				1.051	1.057		1.041	1.063		1.034	1.093		1.023	1.113	
		CIM_GEN 0.3	10				1.054	1.059		1.047	1.064		1.042	1.091		1.033	1.112	
		YORKCANY 69	10				1.028	1.034		1.018	1.040		1.019	1.077		1.021	1.111	
		RAINVL1 115	10				1.058	1.063		1.036	1.068		1.043	1.092		1.009	1.109	
		BLACKLAK 69	10				1.025	1.024		1.025	1.045		1.025	1.049		1.031	1.107	
		STORRIE 24.9	10				1.063	1.066		1.041	1.070		1.051	1.091		1.012	1.106	
		ARRIBA 12.5	10				1.018	1.020		1.016	1.043		1.013	1.051		1.012	1.105	
		RAINVL2 24.9	10				1.054	1.058		1.031	1.063		1.038	1.087		1.004	1.104	
		BACA 12.5	10				1.007	1.009		0.995	1.025		1.007	1.043		1.010	1.103	
		GALLINAS 12.5	10				1.015	1.017		1.018	1.047		1.010	1.048		1.008	1.102	
		ARRIBA 115	10				1.058	1.060		1.035	1.065		1.046	1.086		1.008	1.101	
			Case	**04**			**05**			**06**			**07**			**08**		

	Outage	Bus	Area	Light Spring								
				Pre			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC EE Events											
109	Gladstone-Springer 115 kV & Don Carlos-Mora 230 kV Common Corridor	SPRINGER 69	10				1.035	1.071		1.038	1.136	
		BISON 115	10				1.047	1.083		1.037	1.134	
		CIMARRON 115	10				1.047	1.083		1.037	1.134	
		MORA TAP 115	10				1.046	1.083		1.036	1.134	
		SPRINGER 115	10				1.046	1.083		1.036	1.134	
		VANBREMR 115	10				1.045	1.081		1.035	1.133	
		RAINVL1 115	10				1.054	1.085		1.034	1.132	
		YORKCANY 115	10				1.044	1.081		1.034	1.132	
		RAINVL2 24.9	10				1.051	1.082		1.031	1.130	
		STORRIE 24.9	10				1.059	1.085		1.036	1.130	
		CIM_GEN 0.3	10				1.047	1.077		1.040	1.129	
		ARRIBA 115	10				1.056	1.082		1.035	1.128	
		STORRIE 115	10				1.056	1.082		1.033	1.127	
		VALENCIA 115	10				1.055	1.080		1.028	1.122	
		ROWE 24.9	10				1.074	1.091		1.027	1.114	
		YORKCANY 69	10				1.022	1.057		1.019	1.116	
		BLACKLAK 115	10				1.040	1.062		1.027	1.114	
		BLACKLAK 69	10				1.025	1.047		1.026	1.113	
		GALLINAS 12.5	10				1.010	1.035		1.012	1.105	
		ARRIBA 12.5	10				1.013	1.038		1.010	1.101	
			Case	**09**			**10**			**10**		

5.6 VOLTAGE RESULTS WITH OVERLAPPING CLAPHAM #2 SVC OUTAGE (P6)

As expected, the voltage performance of the system is worse without the Clapham SVC #2 in service. The 8 % deviation criteria does not apply due to these events being category P6-3 contingencies, only the high voltage of 1.10 p.u. and low voltage of 0.90 p.u. is applied.

JICARILLA AND OJO 345 KV VOLTAGE DEVIATION

The voltage deviations are slightly higher without the Clapham SVC, however the deviation is not a criteria violation under these conditions. The voltage magnitude remains above 0.90 p.u. both pre-project and project.

HEAVY SUMMER CONDITIONS

The outage of the Springer-Mora-Arriba 115 kV Line, Mora-Don Carlos 230 kV Line, or Mora 230/115 kV Transformer causes the Van Buren and Clayton and 69 kV bus voltage magnitude to drop further below 0.90 p.u. The Sedan 69 kV bus is also flagged as it dips below 0.90 p.u.

HEAVY WINTER CONDITIONS

The outage of the Springer-Mora-Arriba 115 kV Line, Mora-Don Carlos 230 kV Line, or Mora 230/115 kV Transformer causes the Gladstone PS 230 kV bus to drop below 0.90 p.u. when the Gladstone PST is 190 MW. The voltage remains well above the limit when the Gladstone PST is 115 MW.

LIGHT SPRING CONDITIONS

The outage of the Taos-Springer 115 kV Line causes the Rowe 24.9 kV bus to drop -8.9% but remains above 0.90 p.u. which is not a violation.

TABLE 11. VOLTAGE RESULTS WITHOUT CLAPHAM SVC #2 AND WITHOUT SYSTEM UPGRADES

	Outage	Bus	Area	Heavy Summer								
				Pre			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events											
10	San Juan-Jicarilla 345 kV Line	JICARILLA 345	10	1.040	0.971	-6.7	1.041	0.975	-6.4	1.035	0.942	-9.0
		OJO 345	10	1.027	0.958	-6.7	1.029	0.963	-6.4	1.015	0.930	-8.4
55	Springer-Mora-Arriba 115 kV Line	VANBUREN 69	10				0.954	0.954	0.0	0.954	0.876	-8.1
		CLAYTON 69	10				0.956	0.956	0.0	0.956	0.878	-8.1
		SEDAN69 69	10				0.974	0.974	0.0	0.974	0.898	-7.8
		GLDSTNPS 230	10				1.008	1.004	-0.4	1.005	0.924	-8.1
57	Mora-Don Carlos 230 kV Line or Mora 230/115 kV Tran	VANBUREN 69	10				0.954	0.954	0.0	0.954	0.877	-8.1
		CLAYTON 69	10				0.956	0.956	0.0	0.956	0.879	-8.0
		SEDAN69 69	10				0.974	0.974	0.0	0.974	0.899	-7.7
		GLDSTNPS 230	10				1.008	1.004	-0.4	1.005	0.921	-8.3
78	Clapham 115 kV SVC	VANBUREN 69	10	0.954	0.892	-6.5	0.954	0.899	-5.8	0.954	0.889	-6.8
		CLAYTON 69	10	0.956	0.894	-6.5	0.956	0.900	-5.8	0.956	0.891	-6.7
			Case	**01**			**02**			**03**		

	Outage	Bus	Area	Heavy Winter														
				Pre			Pre wMLTP			Post wMLTP			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events																	
10	San Juan-Jicarilla 345 kV Line	JICARILLA 345	10	1.040	0.966	-7.1	1.042	0.972	-6.7	1.039	0.956	-8.0	1.043	0.970	-6.9	1.035	0.947	-8.5
		OJO 345	10	1.028	0.954	-7.2	1.031	0.959	-7.0	1.023	0.943	-7.8	1.032	0.958	-7.2	1.014	0.935	-7.8
		TAOS 115	10	1.038	0.997	-4.0	1.038	1.009	-2.7	1.034	0.985	-4.8	1.035	0.993	-4.1	1.033	0.943	-8.7
55	Springer-Mora-Arriba 115 kV Line	GLDSTNPS 230	10				1.015	1.010	-0.5	1.018	0.981	-3.6	0.979	0.977	-0.2	0.978	0.893	-8.6
57	Mora-Don Carlos 230 kV Line or Mora 230/115 kV Tran	GLDSTNPS 230	10				1.015	1.011	-0.4	1.018	0.979	-3.8	0.979	0.975	-0.4	0.978	0.885	-9.5
			Case	**04**			**05**			**06**			**07**			**08**		

	Outage	Bus	Area	Light Spring								
				Pre			Pre wMLTP			Post wMLTP		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events											
33	Taos-Springer 115 kV Line	ROWE 24.9	10	1.064	1.053	-1.0	1.064	1.056	-0.7	1.036	0.944	-8.9
			Case	**09**			**10**			**11**		

5.7 DON CARLOS WIND FARM SYSTEM UPGRADES - PREFERRED MITIGATION

Numerous alternatives have been explored to address technical concerns discovered during previous versions of this SIS. The preferred solution agreed to be explored in detail by all affected parties is a design modification to the MLTP. This alternative design has been assumed as in-service from the onset of this version 3 of the DCWF SIS.

In summary, the MLTP design modification proposes to bypass Gladstone substation and proceed directly to Springer substation with a 38.9 mile 230 kV Don Carlos-Springer transmission line. The 230 kV line is assumed to be 1272 ACSR. A 200 MVA 230/115 kV transformer will step the voltage down to 115 kV at Springer and proceed to Arriba at 115 kV with 1272 ACSR conductor. The 115 kV uses the 230 kV conductor because the line will be constructed as 230 kV but energized at 115 kV. This alternative requires a revised definition of the Mora Line Transmission Project that only affects Tri-State facilities and has no impact at PNM's Arriba 115 kV connection.

The new MLTP 230/115 kV transformer at Springer will reside in its own substation constructed nearby but outside the Tri-State's Springer substation. The new substation will be called “Mora” for purposes of this study. Tri-State recommends the new substation connect to Springer from the south to the southern bus position due to physical congestion to the north of the substation. The 115 kV line from Springer to Arriba will connect to this Lucky Corridor-owned Mora substation, rather than directly to Springer and then connect to Tri-State's Springer substation through a single 115 kV line. Refer to **Figure 1** on page 5 for the detail drawing.

The breaker arrangement at the new Mora Substation ensures that the DCWF will trip in the event that any of the MLTP line segments are open. These outages are as follows:

- P1-2 outage of the Don Carlos-Mora 230 kV Line Segment, also trips the Mora 230/115 kV transformer (tripping the DCWF)
- P1-3 outage of the Mora 230/115 kV Transformer, also trips the Mora-Don Carlos 230 kV Line (tripping the DCWF), but keeps the Mora-Springer-Arriba 115 kV Line in service.
- P1-2 outage of the Mora-Springer-Arriba 115 kV Line Segment, also open-ends the Mora 230/115 kV Transformer (tripping the DCWF).

In addition to the MTLP design change and pre-contingency curtailments noted under heavy winter and light spring conditions, System Upgrades are required in order to maximize DCWF generation under the various system conditions evaluated. A Remedial Action Scheme (RAS) will be utilized to ensure reliability while also allowing for maximum utilization of the wind farm during normal pre-contingency operating conditions.

For reliability, one critical line needs to be protected by RAS against thermal overload. PNM's Arriba Tap-Valencia 115 kV Line is capable of up to 497 Amps. In the event that the PNM line segment exceeds its capability, the RAS will trip the DCWF back to 100 MW. If the line loading still exceeds the 497 Amp limit after 1 minute, then the remaining 100 MW will be tripped offline. Additionally, loss of PNM's Arriba-Arriba Tap 115 kV Line Segment open-ends the MLTP and will need to trip the DCWF.

DCWF RAS INPUT SUMMARY:

1. Trip DCWF offline for an outage of any of the following:
   - Arriba-Arriba Tap 115 kV Line Segment (PNM Line that open-ends the MLTP)

2. Trip DCWF back to 100 MW then trip offline if the facility is still overloaded after 1 minute:
   - PNM's Arriba Tap-Valencia 115 kV Line exceeds 497 Amps

The DCWF RAS will be owned by Lucky Corridor with inputs from equipment associated with the MLTP and the new Arriba Tap three breaker ring bus required of the MLTP by PNM as a Network Upgrade in PNM's SIS. It is not anticipated that any inputs will be required from Tri-State facilities not associated with the MLTP.

The specific capability of the DCWF RAS may be more complex than what is specified above. The requirements noted above may be considered the minimum design criteria. While this study assumes 2 blocks of generation to be armed, the RAS may be designed with more blocks in order to maximize the amount of DCWF generation that remains online post-contingency. The RAS controller may be utilized maximize the DCWF output while monitoring the flow on the Arriba Tap-Valencia 115 kV line under pre-contingency conditions.

5.8 THERMAL LOADING RESULTS WITH THE DCWF RAS

The DCWF RAS sufficiently mitigates all instantaneous thermal loading concerns identified in Table 9. Table 13 on the following page shows the thermal loading results. The sensitivity with the Gladstone PST adjustment is not performed since the DCWF RAS will operate within minutes while the Gladstone PST adjustment will be performed 30 minutes or longer after the contingency were to occur.

The DCWF RAS is observed to operate following many outages in the region. The table below summarizes the DCWF RAS action observed.

TABLE 12. DCWF RAS OPERATION

		Heavy Summer	Heavy Winter		Light Spring
	Outage	180	115	190	190
4	P1-1 San Juan Unit 4				1
9	P1-2 Ojo-Taos 345 kV Line				1
10	P1-2 San Juan-Jicarilla 345 kV Line				1
11	P1-2 Jicarilla-Ojo 345 kV Line				1

		Heavy Summer	Heavy Winter		Light Spring
	Outage	180	115	190	190
14	P1-2 Cabezon-Rio Puerco 345 kV Line	1		1	1
15	P1-2 San Juan-Hesperus 345 kV Line				1
17	P1-2 Four Corners-Rio Puerco 345 kV Line	1		1	1
20	P1-2 BA-Norton 345 kV Line			1	
21	P1-2 BA-Guadalupe 345 kV Line				1
23	P1-2 Comanche-Daniel Peak 345 kV Line 1				1
24	P1-2 West Mesa-Ambrosia 230 kV Line				1
30	P1-2 Comanche-CFIFURN 230 kV Line				1
33	P1-2 Taos-Springer 115 kV Line	2	1	2	2
34	P1-2 Clapham-Rosebud 115 kV Line	1		1	1
35	P1-2 Gladstone-Clapham 115 kV Line	1		1	2
36	P1-2 Gladstone-Hess 115 kV Line	1			1
37	P1-2 Taos-Hernandez 115 kV Line				1
39	P1-2 Springer-Bison 115 kV Line	1		1	
41	P1-2 York Canyon-Bison 115 kV Line	1		1	1
43	P1-2 Norton-Hernandez 115 kV Line	1		1	1
44	P1-2 Ojo-Hernandez 115 kV Line			1	1
54	P1-2 Arriba-Gallinas-Arriba Tap 115 kV Line	2	2	2	2
60	P1-3 Norton 345/115 kV Tran				1
62	P1-3 B-A 345/115 kV Tran				1
64	P1-3 Ojo 345/115 kV Tran			1	1
65	P1-3 Taos 345/115 kV Tran 1				1
81	P2-3 Rio Puerco 345 kV CB	1		1	
82	P2-3 Jicarilla 345 kV CB				1
89	P2-3 Gladstone 115 kV Center CB 1	1		1	1
91.2	P2-3 Springer 115 kV Center CB 5	1	1	1	1
91.3	P2-3 Springer 115 kV East CB 6	2	1	2	2
91.a2	P2-3 Springer 115 kV Center CB 2	1		1	1
	Case	03	06	08	11

Note 1: DCWF RAS trips project back to 100 MW net

Note 2: DCWF RAS trips project offline

TABLE 13. THERMAL RESULTS WITH DCWF RAS

					Heavy Summer			Heavy Winter					Light Spring		
					Gladstone: 180 MW			Gladstone: 115 MW			190 MW		Gladstone: 190 MW		
	Outage	Overloaded Element	Area	Rating	Pre	Pre wMLTP	Post wMLTP	Pre	Pre wMLTP	Post wMLTP	Pre wMLTP	Post[1] wMLTP	Pre	Pre wMLTP	Post[2] wMLTP
	NERC P0 Events														
0	No Outage Taken	ARRIBA_T - VALENCIA 115kV	10	497 A	25.6	28.5	94.9	4.5	10.0	76.5	34.7	98.7	29.8	35.6	99.9
	NERC P1 Events														
33	Taos-Springer 115kV Line	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A	25.7	24.5	**143.9**	4.9	2.0	**117.0**	44.6	**162.0**	50.9	55.1	**168.1**
					25.7	24.5	[4]58.5	4.9	2.0	[3]83.0	44.6	[4]75.4	50.9	55.1	[4]86.9
	NERC P2 Events														
91.3	Springer 115kV East CB 6 (post Mora) (Springer-Taos & Springer Load)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A		28.7	**147.8**		3.4	**120.1**	48.2	**165.4**		56.5	**169.5**
						28.7	[4]63.2		3.4	[3]86.3	48.2	[4]79.6			[4]88.5
		SPRINGER - RAINVL_T 115kV (to Storrie Lake)	10	462 A		18.2	80.2		16.3	78.4	40.3	**103.1**		35.2	63.3
						18.2	80.1		16.3	78.3	40.3	[3]84.8		35.2	63.2
91.2	Springer 115kV Center CB 5 (post Mora)(Springer-Taos & Springer-Gladstone)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A		*41.7*	***144.1***		*53.0*	***125.4***	*67.4*	***116.2***		*32.9*	***139.6***
						41.7	[3]65.4		53.0	[3]48.6	67.5	[3]48.0		32.9	[3]83.8
89	Gladstone 115 kV Center CB 1 (Gladstone Tran 2 & Gladstone-Clapham)	ARRIBA_T - VALENCIA 115kV (to Zia)	10	497 A	40.3	46.7	**113.3**	13.0	21.0	87.5	45.0	**109.3**	41.5	50.1	**116.1**
					40.3	46.7	[3]92.4	13.0	21.0	87.5	45.0	[3]88.7	41.5	50.1	[3]98.8
				Case	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**

Gray result is without RAS

Note 1: Don Carlos Wind Farm curtailed to 172 MW Net to manage N-0 loading on the Arriba Tap-Valencia 115 kV Line

Note 2: Don Carlos Wind Farm curtailed to 155 MW Net to manage N-0 loading on the Arriba Tap-Valencia 115 kV Line

Note 3: DCWF RAS trips project back to 100 MW net

Note 4: DCWF RAS trips project offline

5.9 VOLTAGE RESULTS WITH THE DCWF RAS

Addition of the DCWF RAS does not create any new voltage violations nor aggravate the voltage violations identified in Table 10.

5.10 MAXIMUM DCWF DISPATCH WITHOUT DCWF RAS EXPECTED ACTION

The DCWF RAS is not needed at lower DCWF output and/or lower Gladstone PST flow. The table below outlines the maximum safe output of the wind project under the various seasons and Gladstone PST flow without the DCWF RAS expected to operate. The most limiting outage is the P1 Taos-Springer 115 kV Line outage overloading the Arriba Tap-Valencia 115 kV Line.

The value in bold is the pre-contingency threshold, and the italic value below it is the post-contingency curtailment required within 30 minutes in order to allow the Gladstone PST to return to its pre-contingency flow.

TABLE 14. DCWF CAPABILITY WITHOUT DCWF RAS ACTION

Heavy Summer		Heavy Winter		Light Spring	
Gladstone PST	DCWF	Gladstone PST	DCWF	Gladstone PST	DCWF
No RAS Action Expected					
P1 Taos-Springer 115 kV Line					
180	**105**	**190**	**75**	**190**	**60**
	80		*50*		*25*
110	**180**	**95**	**180**	**71**	**180**
	145		*135*		*145*

Even with the DCWF RAS in place, the DCWF may be required to curtail its output post-contingency should Tri-State need to return flow through the Gladstone PST back to its pre-contingency flow. Operating Procedures may be required to properly coordinate these curtailments.

5.11 TRANSIENT STABILITY ANALYSIS

Prior to the dynamic simulation, the single line to ground fault impedances were calculated from the short circuit model for each of the three topology scenarios. The resulting fault impedances used in the GE PSLF dynamic simulation for category P2 outages and above are detailed in **Table 15** below.

TABLE 15. CALCULATED FAULT IMPEDANCES* PER SCENARIO IN PER-UNIT

	Pre-Project		Post-Project	
Location	R	X	R	X
Jicarilla 345 kV	0.0126	0.1044	0.0125	0.1037
Walsenburg 230 kV	0.0135	0.1115	0.0135	0.1115
Gladstone 230 kV	0.0232	0.1946	0.0232	0.1946
Gladstone 115 kV	0.0233	0.1897	0.0303	0.2260
Springer 115 kV	0.0589	0.3124	0.0405	0.2681
Valencia 115 kV	0.0860	0.5005	0.0665	0.3800
Storrie Lake 115 kV	0.1217	0.5895	0.0873	0.4301
Arriba 115 kV	0.1336	0.6528	0.0759	0.4098
Arriba Tap 115 kV	0.1103	0.5606	0.0721	0.3889

*GE PSLF utilizes the sum of the negative and zero sequence fault impedances in per-unit to simulate Single Line to Ground faults in the dynamic simulation.

The dynamic simulation had many results to note, a few of which may be attributed to the DCWF.

- **Diverged Dynamic Simulation**
  The dynamic simulation diverges for the P4-2 event single line to ground fault near Springer on the Taos-Springer 115 kV line followed by a stuck breaker on the west side of the line (referred to as CB 5 in this study) which also open ends the Gladstone-Springer 115 kV line. This outage results in a long radial connection to Springer through the MLTP and the existing Springer-Storrie Lake 115 kV line and ultimately connects to Zia substation near Santa Fe.

  The system performance will be re-evaluated in the PSCAD study. If confirmed, one potential solution is to add a second 115 kV circuit breaker on the east side of the Springer-Gladstone 115 kV line termination in the Springer 115 kV bus to eliminate tripping the Springer-Gladstone 115 kV line with the Taos-Springer 115 kV line for this stuck breaker contingency.

- **DCWF Ringing**
  A ringing is observed at the DCWF and propagates to nearby Cimarron Solar project. The ringing may be resolved by a dynamic model parameter setting change or may be due to the weak nature of the NENM system coupled with the radial MTLP connection to Springer. In either case, the dynamic performance will be re-evaluated in the PSCAD

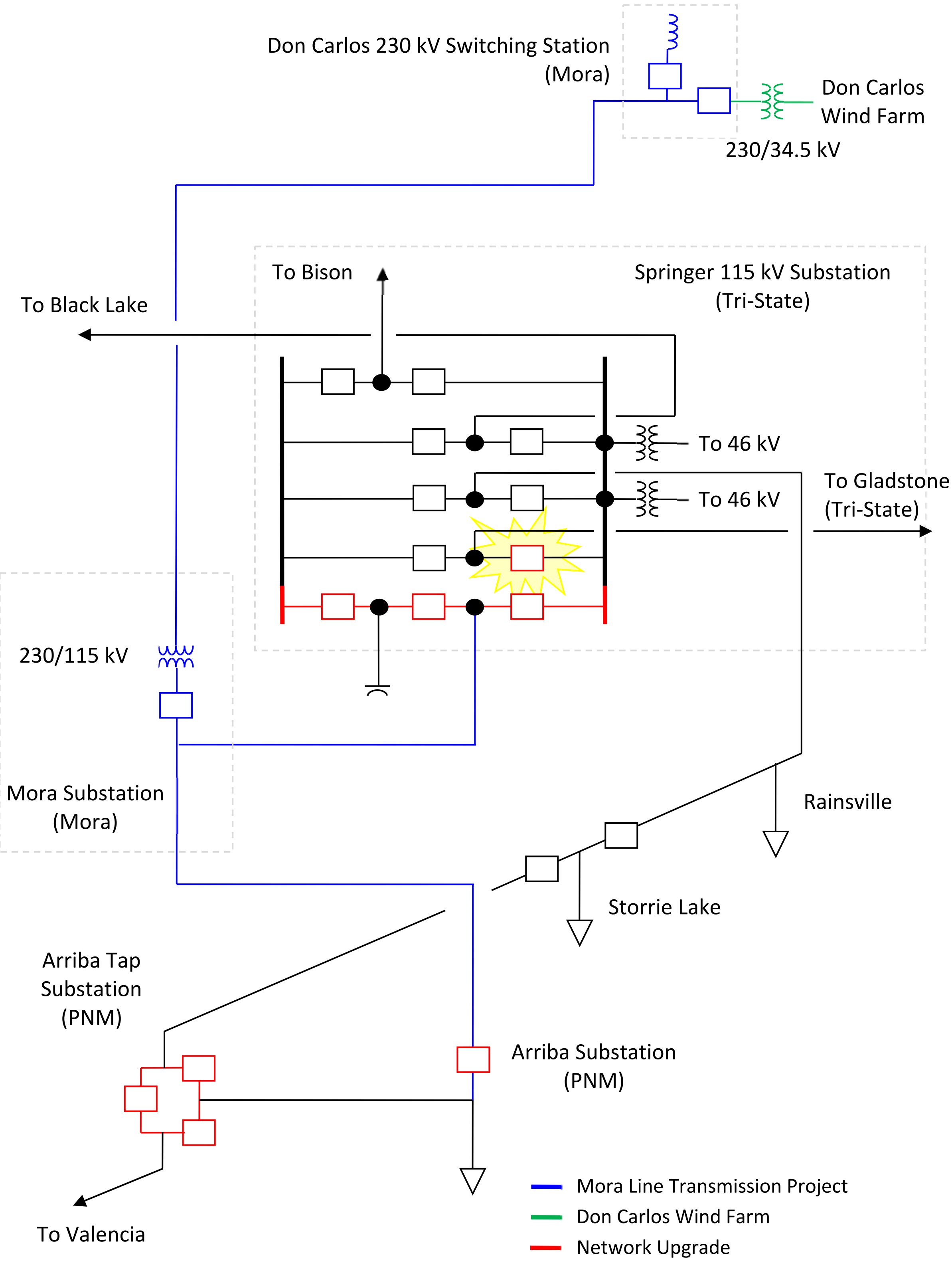
analysis. If confirmed by the PSCAD study, the mitigation noted below may apply for the following outages:

- *P1-2 Gladstone-Springer 115 kV line (3 phase fault near Springer)* observed in the Heavy Summer and Heavy Winter seasons only. Reducing the DCWF project from 180 MW to 160 MW results in a damped ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.
- *P4-3 Springer-Storrie Lake 115 kV line (single line to ground fault near Springer) with Springer CB 8 stuck tripping the Springer-Gladstone 115 kV line* observed in the Heavy Summer and Heavy Winter seasons only. Addition of the second 115 kV circuit breaker at Springer for the Springer-Gladstone 115 kV line will mitigate this issue as well. Alternatively, reducing the output of the DCWF from 180 MW to 170 MW will result in a damped ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.
- *P5-2 Gladstone-Springer 115 kV line (single line to ground fault near Springer) with non-redundant relay failure tripping resulting in delayed clearing* observed in the Heavy Summer season only. Reducing the output of the DCWF from 180 MW to 170 MW eliminates the ringing response. Adjustment to the GE dynamic model may also mitigate the ringing.

This study will defer the specific solutions to Tri-State's Facilities Study to: (1) determine the preferred feasible setup at Springer given the unique challenges facing any 115 kV bus work at Springer, and (2) GE wind turbine dynamic model changes needed for adequate system performance. It is recommended that transient stability analysis be performed after the PSCAD results during Tri-State's Facilities Study to ensure that the final Springer substation design and any dynamic model parameter setting changes sufficiently address these transient stability concerns.

Figure 5 on the following page is one suggested solution that can address the dynamic simulation divergence concern. This solution adds second circuit breaker to the east side of the Gladstone-Springer 115 kV line termination referenced above.

FIGURE 5. SPRINGER 115 KV BUS CONFIGURATION SUGGESTION



NOTABLE RESULTS NOT ATTRIBUTED TO THE DCWF

Comanche Solar PV generation is observed to trip on delta frequency of -3.0 Hz for the P1-2 Comanche-Boone 230 kV Line outage or the P1-2 Comanche-Midway 230 kV Line outage in all cases and all seasons.

The Clapham-Rosebud 115 kV Line out of step (OOS) relay is observed to trip the line and subsequently drop all Rosebud load for the outages listed in **Table 16** on the following page. Cells highlighted green represent a project benefit where the line tripping is observed in the pre-project case and not after the addition of the MLTP or the DCWF. Cells highlighted red represent a project impact where the line tripping is observed after the addition of the MLTP or the DCWF and not in the pre-project case. Cells highlighted gray represent a new contingency introduced by the MLTP or the DCWF that does not apply to the pre-project case. This line tripping behavior is recognized as a pre-existing issue and is not attributed to the project.

TABLE 16. CLAPHAM-ROSEBUD 115 KV OOS RELAY TRIPS

		Heavy Summer		Heavy Winter		Light Spring	
	Outage	Pre	Pst	Pre	Pst	Pre	Pst
7	P1-2 Gladstone-Walsenburg 230kV Line (G) wRAS	x	x	x		x	
8	P1-2 Comanche-Boone 230kV Line (C)	x	x			x	x
9	P1-2 Comanche-Midway 230kV Line (C)	x	x			x	x
6	P1-2 Comanche-Daniel Peak #1 345kV Line (C)	x	x	x			
10	P1-2 Gladstone-Springer 115kV Line (G)	x	x	x	x	x	x
11	P1-2 Gladstone-Springer 115kV Line (S)	x	x	x	x	x	x
12	P1-2 Gladstone-Springer 115kV Line (M)	x	x	x	x	x	x
14	P1-2 Taos-Springer 115kV Line (S)	x	x		x	x	x
15	P1-2 Mora-Don Carlos SS 230kV Line (MLTP)(D)		x				
17	P1-2 Mora-Springer-Arriba 115kV Line (MLTP)(M)		x		x		x
18	P1-2 Mora-Springer-Arriba 115kV Line (MLTP)(S)		x				x
20	P1-3 Gladstone #1 230/115kV Tran (H)	x	x	x	x	x	x
24	P4-2 Gladstone-Springer 115kV Line (G) CB stuck at Gladstone	x	x	x	x	x	x
25	P4-2 Springer-Taos 115kV Line (S) CB stuck at Springer	x	x			x	
26	P4-2 Springer-Storrie Lake 115kV (S) CB stuck at Springer	x	x				
32	P4-2 Springer-Bison 115kV (S) CB1 stuck at Springer		x				
33	P4-2 Springer-Bison 115kV (S) CB2 stuck at Springer		x				
35	P4-3 Springer-Taos 115kV (S) CB6 stuck at Springer		x				
36	P4-3 Springer-Storrie Lake 115kV (S) CB8 stuck at Springer	x	x			x	
37	P4-3 Springer-Storrie Lake 115kV (S) CB9 stuck at Springer		x				
38	P4-3 Springer Cap 115kV (S) CB13 stuck at Springer		x				
45	P4-3 Gladstone #1 230/115kV (H) CB 2 stuck at Gladstone with RAS	x	x			x	
46	P4-3 Gladstone #2 230/115kV (H) CB 2 stuck at Gladstone with RAS	x	x			x	
47	P4-3 Gladstone #1 230/115kV (H) CB 3 stuck at Gladstone with RAS	x	x			x	
48	P5-2 Gladstone-Springer 115kV (G) with relay failure	x	x			x	
49	P5-2 Gladstone-Springer 115kV (S) with relay failure	x	x	x	x	x	x
7	P6 Clapham #2 SVC & Gladstone-Walsenburg 230kV Line (G) wRAS	x	x	x	x	x	
8	P6 Clapham #2 SVC & Comanche-Boone 230kV (C)	x	x		x	x	

		Heavy Summer		Heavy Winter		Light Spring	
	Outage	Pre	Pst	Pre	Pst	Pre	Pst
9	P6 Clapham #2 SVC & Comanche-Midway 230kV (C)	x	x		x	x	
10	P6 Clapham #2 SVC & Gladstone-Springer 115kV (G)	x	x	x	x	x	x
11	P6 Clapham #2 SVC & Gladstone-Springer 115kV (S)	x	x	x	x	x	x
12	P6 Clapham #2 SVC & Gladstone-Springer 115kV (M)	x	x	x	x	x	x
14	P6 Clapham #2 SVC & Taos-Springer 115kV (S)	x	x	x	x		x
17	P6 Clapham #2 SVC & Mora-Springer-Arriba 115kV (MLTP)(M)		x		x		x
18	P6 Clapham #2 SVC & Mora-Springer-Arriba 115kV Line (MLTP)(S)		x		x		x
20	P6 Clapham #2 SVC & Gladstone #1 230/115kV (H)	x	x	x	x	x	x
	Case	1	3	4	8	9	11

The Hess motors are observed to be unstable and trip offline for the outages noted below. Cells highlighted green represent a project benefit where the instability is observed in the pre-project case and not after the addition of the MLTP or the DCWF. Cells highlighted red represent a project impact where the instability is observed after the addition of the MLTP or the DCWF and not in the pre-project case. Cells highlighted gray represent a new contingency introduced by the MLTP or the DCWF that does not apply to the pre-project case. This instability is recognized as a pre-existing issue and is not attributed to the project.

TABLE 17. HESS MOTOR OBSERVED INSTABILITY

		Heavy Summer		Heavy Winter		Light Spring	
	Outage	Pre	Pst	Pre	Pst	Pre	Pst
10	P1-2 Gladstone-Springer 115kV Line (G)	x	x	x	x	x	x
11	P1-2 Gladstone-Springer 115kV Line (S)	x	x	x	x	x	x
24	P4-2 Gladstone-Springer 115kV Line (G) with Gladstone CB Stuck	x		x	x	x	x
10	P6 Clapham #2 SVC & Gladstone-Springer 115kV (G)	x	x	x	x	x	x
11	P6 Clapham #2 SVC & Gladstone-Springer 115kV (S)	x	x	x	x	x	
	Case	1	3	4	8	9	11

Local loads are observed to reduce by an lsdt9 relay for the outages noted below. Cells highlighted green represent a project benefit where the load reduction is observed in the pre-project case and not after the addition of the MLTP or the DCWF. Cells highlighted gray represent a new contingency introduced by the MLTP or the DCWF that does not apply to the pre-project case. This load tripping is recognized as a pre-existing issue and is not attributed to the project.

TABLE 18. LOAD REDUCTION

		Heavy Summer		Heavy Winter		Light Spring	
	Outage	Pre	Pst	Pre	Pst	Pre	Pst
11	P1-2 Gladstone-Springer 115kV Line (S) at York Canyon and Springer	x	x	x	x		
13	P1-2 Zia-Valencia 115kV Line (Z) at Ft Marcy	x	x	x	x	x	x
14	P1-2 Taos-Springer 115kV Line (S) at York Canyon and Springer	x	x	x	x	x	

		Heavy Summer		Heavy Winter		Light Spring	
	Outage	Pre	Pst	Pre	Pst	Pre	Pst
17	P1-2 Mora-Springer-Arriba 115kV Line (MLTP)(M) at York Canyon and Springer		x		x		x
18	P1-2 Mora-Springer-Arriba 115kV Line (MLTP)(S) at York Canyon and Springer		x		x		x
19	P1-2 Mora-Springer-Arriba 115kV Line (MLTP)(A) at Arriba				x		
11	P6 Clapham #2 SVC & Gladstone-Springer 115kV Line (S) at York Canyon and Springer	x	x	x	x		
13	P6 Clapham #2 SVC & Zia-Valencia 115kV Line (Z) at Ft Marcy	x	x	x	x	x	x
14	P6 Clapham #2 SVC & Taos-Springer 115kV Line (S) at York Canyon and Springer	x	x	x	x	x	
17	P6 Clapham #2 SVC & Mora-Springer-Arriba 115kV Line (MLTP)(M) at York Canyon and Springer		x		x		x
18	P6 Clapham #2 SVC & Mora-Springer-Arriba 115kV Line (MLTP)(S) at York Canyon and Springer		x		x		x
19	P6 Clapham #2 SVC & Mora-Springer-Arriba 115kV Line (MLTP)(A) at Arriba				x		
	Case	1	3	4	8	9	11

DCWF generation is also observed to trip on delta voltage for various outages. The voltage and frequency protection models were disabled and the simulation re-run to ensure that reliability concerns are not present when the DCWF project remains online. It is recommended that the voltage and frequency protection settings be evaluated when the project is constructed to ensure that the project remains online for nearby contingencies.

The DCWF RAS is not simulated in the dynamic simulations since it is not expected to trip in the transient timeframe.

5.12 SHORT CIRCUIT / FAULT DUTY ANALYSIS

PNM did not identify any fault duty concerns with the Mora Transmission Line Project in their study. This study evaluated the fault current at select locations from a Tri-State system perspective. The wind turbine will contribute up to 3.0 per unit fault current for up to 5 cycles, after which it returns to normal contribution of 1.0 per unit. The fault current is calculated under the current limiting conditions. The fastest breaker clearing time on the Tri-State 115 kV system is 6 cycles making the results in **Table 19** the most applicable.

TABLE 19. FAULT DUTY RESULTS (KA) AFTER 5 CYCLES

	Pre-Project		Post-Project					
Outage	3Φ	1Φ	3Φ	X/R	Inc	1Φ	X/R	Inc
Clapham 115kV	1.750	1.460	1.747	9.63	-0.00	1.423	6.90	-0.04
Gladstone 115kV	3.336	4.410	3.600	11.92	0.26	4.698	13.09	0.29
Hess 115kV	1.425	1.020	1.430	36.21	0.01	1.002	6.63	-0.02
Springer 115kV	3.586	3.290	4.592	10.44	1.01	4.841	9.58	1.55

The station with the largest increase in fault current is the Springer 115 kV bus with an increase in 1.550 kA after 5 cycles.

6 COST & CONSTRUCTION TIME ESTIMATES

The cost and construction times identified in this section represent good faith estimates to interconnect the DCWF to the MLTP. Not included in these estimates are any costs associated with the generator tie line after it leaves the Don Carlos 115 kV Switching Station and becomes the customer facilities, nor the additional reactive needs of the project.

TABLE 20. CONSTRUCTION TIME AND COST ESTIMATES

Equipment Description	Time to Construct (months)	Cost Estimate ($000,000)
Don Carlos Wind Farm		
Transmission Provider's Interconnection Facilities (add one breaker at Don Carlos 230 kV Switching Station)	14	2.26
DCWF RAS System Upgrade	12	1.0
Totals	14	3.26

APPENDIX A

DYNAMIC DATA

DON CARLOS WIND FARM - DYNAMIC DATA

The Don Carlos Wind Farm consists of 78 GE 2.3-116 wind turbine generators. The PSLF aggregate model consists of 1 generator model. The specific parameters of the dynamic models used for the aggregate generator in the System Impact Study are outlined below.

Wind Models: regc_a, reec_a, repc_a
Generator Protection Models: lhvrt, lhfrt

regc_a: Generator/converter model

Variable	Description	Project Data
	MVA Base	**201.6**
Lvplsw	Connect (1) / disconnect (0) Low Volt Power Logic switch	1
Rrpwr	LVPL ramp rate limit, pu	10
Brkpt	LVPL characteristic breakpoint, pu	0.9
Zerox	LVPL characteristic zero crossing, pu	0.5
Lvpl1	Lvpl breakpoint, pu	1.22
Vtmax	Voltage limit used in the high voltage reactive power logic, pu	1.2
Lvpnt1	High voltage point for low voltage active power logic, pu	0.8
Lvpnt0	Low voltage point for low voltage active power logic, pu	0.4
Qmin	Limit in the high voltage reactive power logic, pu	-1.3
Accel	Acceleration factor used in the high voltage reactive power logic, pu	0.7
Tg	Time constant, sec	0.02
Tfltr	Voltage measurement time constant, sec	0.02
Iqrmax	Upward rate limit on reactive current command, pu/sec	999
Iqrmin	Downward rate limit on reactive current command, pu/sec	-999
Xe	Generator effective reactance, pu	0.0

reec_a: Renewable energy electrical control model

Variable	Description	Project Data
Mvab	MVA base	0
Vdip	Vterm < vdip activates the current injection logic, pu	0
Vup	Vterm > vup activates the current injection logic, pu	2
Trv	Transducer time constant, sec	0.02
Dbd1	Deadband in voltage error, pu	0
Dbd2	Deadband in voltage error, pu	0
Kqv	Reactive current injection gain, pu/pu	1.2
Iqh1	Maximum limit of reactive current injection (iqinj), pu	1.0
Iql	Minimum limit of reactive current injection (iqinj), pu	-1.0

Variable	Description	Project Data
Vref0	Reference voltage	0
Iqfrz	Value at which IQinj is held for thld seconds following a voltage dip of thld > 0, p.u.	0
thld	Time delay associated with the computation of iqinj and with the operation of switch SW	0
thld2	The active current command (Ipcmd) is held for thld2 seconds after voltage_dip returns to zero	0
Tp	Electrical power transducer time constant , sec.	0.02
Qmax	Reactive power maximum limit, pu	0.436
Qmin	Reactive power minimum limit, pu	-0.436
Vrmax	Voltage control maximum limit, pu	1.1
rVmin	Voltage control minimum limit, pu	0.9
Kqp	Proportional gain, pu	0.05
Kqi	Integral gain, pu	0.05
Kvp	Proportional gain, pu	**1.4**
Kvi	Integral gain, pu	**0.05**
Vref1	User-defined reference on the inner-loop voltage control, pu	0
Tiq	Time constant, sec.	0.02
Dpmax	Up ramp rate on power reference, pu/sec	0.45
Dpmin	Down ramp rate on power reference, pu/sec	-0.45
Pmax	Maximum power reference, pu	1.12
Pmin	Minimum power reference, pu	0.04
Imax	Maximum allowable total current limit, pu	1.7
Tpord	Time constant, sec	0.0167
Pfflag	Power factor flag: =1 Power factor control =0 Q control	0
Vflag	Voltage control flag: =1 Q control =0 Voltage control	1
Qflag	Reactive power control flag: =1 Voltage/Q control =0 Constant power factor or Q control	1
Pflag	Power reference flag: =1 reference is Pref*speed =0 reference is Pref	0
Pqflag	Flag for P or Q priority selection on current limit =1 P priority =0 Q priority	0
Vq1	User defined voltage used to define VDL1 function, p.u.	0
Iq1	User defined current used to define VDL1 function, p.u.	0
Vq2	User defined voltage used to define VDL1 function, p.u.	0.4

Variable	Description	Project Data
Iq2	User defined current used to define VDL1 function, p.u.	1.1
Vq3	User defined voltage used to define VDL1 function, p.u.	0.8
Iq3	User defined current used to define VDL1 function, p.u.	1.1
Vq4	User defined voltage used to define VDL1 function, p.u.	2
Iq4	User defined current used to define VDL1 function, p.u.	1.1
Vp1	User defined voltage used to define VDL2 function, p.u.	0
Ip1	User defined current used to define VDL2 function, p.u.	0
Vp2	User defined voltage used to define VDL2 function, p.u.	0.4
Ip2	User defined current used to define VDL2 function, p.u.	1.1
Vp3	User defined voltage used to define VDL2 function, p.u.	0.8
Ip3	User defined current used to define VDL2 function, p.u.	1.1
Vp4	User defined voltage used to define VDL2 function, p.u.	2
Ip4	User defined current used to define VDL2 function, p.u.	1.1

wtgq_a: WTG Torque controller

Variable	Description	Project Data
Mvab	MVA base	0
Kip	Integral gain, pu/pu/sec	0.6
Kpp	Proportional gain, pu/pu	3
Tp	Power measurement lag time constant, sec	0.05
Twref	Speed reference time constant, sec	60
Temax	Maximum torque, pu	1.2
Temin	Minimum torque, pu	0.08
P1	User defined point, pu	0.2
Spd1	User defined point	0.69
P2	User defined point	0.4
Spd2	User defined point	0.78
P3	User defined point	0.6
Spd3	User defined point	0.98
P4	User defined point	0.74
Spd4	User defined point	1.2
flag	Flag to specify PI controller input	1

wtgt_a: Drive train model

Variable	Description	Project Data
Mvab	MVA base	0
Ht	Turbine inertia, MW-sec/MVA	2.94
Hg	Generator inertia, MW-sec/MVA	0.62
Dshaft	Damping coefficient, pu	1.5

Variable	Description	Project Data
Kshaft	Stiffness constant, pu	0
wo	Initial speed, pu	1.0

wtga_a: Simple aerodynamic model

Variable	Description	Project Data
Mvab	MVA base	0
Ka	Aerodynamic gain factor	0.007
Theta0	Initial blade pitch angle, deg	0

wtgp_a: WTG Pitch controller

Variable	Description	Project Data
Mvab	MVA base	0
Kiw	Pitch controller integral gain, pu/pu/sec	25
Kpw	Pitch controller proportional gain, pu/pu	150
Kic	Pitch compensation integral gain, pu/pu/sec	30
Kpc	Pitch compensation proportional gain, pu/pu	3
Kcc	Proportional gain, pu/pu	0
Tpi	Pitch time, sec	0.3
Pimax	Maximum pitch angle limit, deg	27
Pimin	Minimum pitch angle limit, deg	0
Piratmx	Maximum pitch angle rate, deg/sec	10
Piratmn	Minimum pitch angle rate, deg/sec	-10

repc_a: Power Plant Controller

Variable	Description	Project Data
Mvab	MVA base	0
tfltr	Voltage or reactive power transducer time constant, sec	0.02
Kp	Proportional gain, pu	2
Ki	Integral gain, pu	1
Tft	Lead time constant, sec	0
Tfv	Lag time constant, sec	0.5
Refflg	=1 Voltage control; = reactive control	1
Vfrz	If Vreg< vfrz, then state s2 is frozen	0.7
Rc	Line drop compensation resistance, pu	0
Xc	Line drop compensation reactance, pu	0
Kc	Droop gain, pu	0
Vcmpflg	Flag for selection of droop (=0), or line drop compensation (=1)	0
Emax	Maximum error limit, pu	0.1

Variable	Description	Project Data
Emin	Minimum error limit, pu	-0.1
Dbd	Deadband	0
Qmax	Maximum Q control output, pu	0.436
Qmin	Minimum Q control output, pu	-0.436
Kpg	Proportional gain for power control, pu	0
Kig	Integral gain for power control, pu	0
Tp	Lag time constant on Pgen measurement, sec	0.02
Fdbd1	Deadband downside, pu	0.003
Fdbd2	Deadband upside, pu	0.003
Femax	Maximum error limit, pu	1
Femin	Minimum error limit, pu	0
Pmax	Maximum power, pu	1
Pmin	Minimum power, pu	0.08
Tlag	Lag time constant on Pref feedback, sec	1
Ddn	Downside droop, pu	0.99
Dup	Upside droop, pu	0.99
Frqflg	Pref output flag	0
Outflag	Output flag: 0=Qref is reactive power, 1=Qref is voltage	0
Puflag	Per unit flag	0

lhvrt: Low-High Voltage Ride Through Generator Protection

Variable	Description	Project Data
Vref	Delta voltage is computed with respect to vref	1
Dvtrp1	Delta voltage trip level, pu	-0.6
Dvtrp2	Delta voltage trip level, pu	-0.4
Dvtrp3	Delta voltage trip level, pu	-0.25
Dvtrp4	Delta voltage trip level, pu	-0.15
Dvtrp5	Delta voltage trip level, pu	-0.1
Dvtrp6	Delta voltage trip level, pu	0.101
Dvtrp7	Delta voltage trip level, pu	0.15
Dvtrp8	Delta voltage trip level, pu	0.175
Dvtrp9	Delta voltage trip level, pu	0.2
Dvtrp10	Delta voltage trip level, pu	0.3
Dttrp1	Voltage trip time, sec	1
Dttrp2	Voltage trip time, sec	1.7
Dttrp3	Voltage trip time, sec	2.2
Dttrp4	Voltage trip time, sec	10
Dttrp5	Voltage trip time, sec	600
Dttrp6	Voltage trip time, sec	1
Dttrp7	Voltage trip time, sec	0.5

Variable	Description	Project Data
Dttrp8	Voltage trip time, sec	0.2
Dttrp9	Voltage trip time, sec	0.1
Dttrp10	Voltage trip time, sec	0.01
alarm	If greater than zero, no tripping action is enforced; a message is printed when a trip level is exceeded.	0

lhfrt: Low-High Frequency Ride Through Generator Protection

*lhfrt model not supplied by the customer. The customer will need to install frequency protection and provide the setting to Lucky Corridor. The lhfrt model described below use default values.

Variable	Description	Project Data
Fref	Delta frequency is computed with respect to vref	60
Dftrp1	Delta frequency trip level, pu	2.5
Dftrp2	Delta frequency trip level, pu	1.6
Dftrp3	Delta frequency trip level, pu	-2.5
Dftrp4	Delta frequency trip level, pu	-3.5
Dftrp5	Delta frequency trip level, pu	0
Dftrp6	Delta frequency trip level, pu	0
Dftrp7	Delta frequency trip level, pu	0
Dftrp8	Delta frequency trip level, pu	0
Dftrp9	Delta frequency trip level, pu	0
Dftrp10	Delta frequency trip level, pu	0
Dttrp1	Frequency trip time, sec	0.25
Dttrp2	Frequency trip time, sec	30
Dttrp3	Frequency trip time, sec	10
Dttrp4	Frequency trip time, sec	0.25
Dttrp5	Frequency trip time, sec	0
Dttrp6	Frequency trip time, sec	0
Dttrp7	Frequency trip time, sec	0
Dttrp8	Frequency trip time, sec	0
Dttrp9	Frequency trip time, sec	0
Dttrp10	Frequency trip time, sec	0
alarm	If greater than zero, no tripping action is enforced; a message is printed when a trip level is exceeded.	0

APPENDIX B

NERC TPL-001-4 CONTINGENCY LIST

POWER FLOW AND POST-TRANSIENT CONTINGENCY LIST

P1-1 Events: Single Contingency Loss of Generator

Generators

1. Don Carlos Wind Farm
2. Cimarron
3. San Juan Unit 1
4. San Juan Unit 4
5. Comanche Solar
6. Comanche Unit 1
7. Comanche Unit 2
8. Comanche Unit 3

P1-2 Events: Single Contingency Loss of Transmission Circuit

345 kV

9. Ojo-Taos 345 kV Line (with consequential loss of both Taos 345/115 kV transformers)
10. San Juan-Jicarilla 345 kV Line
11. Jicarilla-Ojo 345 kV Line
12. San Juan-McKinley #1 345 kV Line
13. San Juan-Shiprock 345 kV Line
14. Cabezon-Rio Puerco 345 kV Line
15. San Juan-Hesperus 345 kV Line
16. San Juan-Four Corners 345 kV Line
17. Four Corners-Rio Puerco 345 kV Line
18. Rio Puerco-West Mesa 345 kV Line
19. BA-Rio Puerco #1 345 kV Line
20. BA-Norton 345 kV Line
21. BA-Guadalupe 345 kV Line
22. West Mesa-Sandia 345 kV Line
23. Comanche-Daniel Peak #1 345 kV Line

230 kV

24. West Mesa-Ambrosia 230 kV Line
25. Gladstone-Walsenburg 230 kV Line without RAS
26. Gladstone-Walsenburg 230 kV Line with RAS
27. Comanche-Walsenburg 230 kV Line without RAS

28. Comanche-Walsenburg 230 kV Line with RAS
29. Comanche-Boone 230 kV Line
30. Comanche-CF&IFURN 230 kV Line
31. Comanche-Midway PS 230 kV Line

115 kV

32. Bison-Cimarron 115 kV Line
33. Taos-Springer 115 kV Line
34. Clapham-Rosebud 115 kV Line
35. Gladstone-Clapham 115 kV Line
36. Gladstone-Hess 115 kV Line
37. Taos-Hernandez 115 kV Line
38. Springer-Storrie Lake 115 kV Line
39. Springer-Bison 115 kV Line
40. Gladstone-Springer #1 115 kV Line
41. York Canyon-Bison 115 kV Line
42. Zia-Valencia 115 kV Line (Zia-El Dorado-Colinas-Rowe Tap-Valencia)
43. Norton-Hernandez 115 kV Line
44. Ojo-Hernandez 115 kV Line
45. Norton-Zia 115 kV Line
46. Norton-Zia-Algodones 115 kV Line
47. Zia-BA 115 kV Line
48. Zia 1-Zia 2 115 kV Line
49. Norton-ETA 115 kV Line
50. BA-STA Station 115 kV Line

Pre Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

51. Storrie Lake-Valencia-Arriba 115 kV Line

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

52. Storrie Lake-Arriba Tap 115 kV Line
53. Valencia-Arriba Tap 115 kV Line
54. Arriba-Gallinas-Arriba Tap 115 kV Line
55. Mora-Springer-Arriba 115 kV Line
56. Mora-Don Carlos SS 230 kV Line
57. Mora 230/115 kV Transformer

P1-3 Events: Single Contingency of Transformer

345/230 kV

58. Comanche #3 345/230 kV Transformer
59. San Juan 345/230 kV Transformer

345/115 kV

60. Norton 345/115 kV Transformer
61. Rio Puerco 345/115 kV Transformer
62. BA 345/115 kV Transformer
63. West Mesa #1 345/115 kV Transformer
64. Ojo 345/115 kV Transformer
65. Taos #1 345/115 Transformer

230/230 kV - Phase Shifting Transformer

66. Gladstone 230/230 kV Phase Shifting Transformer without RAS
67. Gladstone 230/230 kV Phase Shifting Transformer with RAS

230/115 kV

68. Gladstone #1 230/115 kV Transformer
69. Walsenburg #2 230/115 kV Transformer
70. West Mesa #1 230/115 kV Transformer
71. Comanche #1 230/115 kV Transformer

P1-4 Events: Single Contingency of Shunt Device

72. Gladstone115 kV Shunt Capacitor 1 of 2 (15 MVAr)
73. Springer 115 kV Shunt Capacitor
74. Black Lake 115 kV Shunt Capacitor 1 of 2 (15 MVAr)
75. York Canyon 115 kV Shunt Capacitor
76. Valencia 115 kV Shunt Capacitor
77. Clapham 115 kV Shunt Capacitor (12.75 MVAr)
78. Clapham 115 kV SVC (reduce MVAr from +/- 50 to +/- 25)

P1-5 Events: Single Contingency of DC Line

None

P2-1 Events - Steady State Only: Opening of a line section

None

P2-2 Events: Single Contingency of Bus Section Fault

230 kV

79. Walsenburg 230 kV Main Bus without RAS: Fault clears the entire 230 kV bus
    - Walsenburg-Gladstone 230 kV Line
    - Walsenburg-Comanche 230 kV Line
    - Walsenburg 230 kV Shunt Capacitor
    - Walsenburg #1 230/115 kV Transformer
    - Walsenburg #2 230/115 kV Transformer
80. Walsenburg 230 kV Main Bus with RAS: Fault clears the entire 230 kV bus
    - Walsenburg-Gladstone 230 kV Line
    - Walsenburg-Comanche 230 kV Line
    - Walsenburg 230 kV Shunt Capacitor
    - Walsenburg #1 230/115 kV Transformer
    - Walsenburg #2 230/115 kV Transformer

    RAS Actions
    - Gladstone-Hess 115 kV Line
    - Rosebud TS load

P2-3 Events: Single Contingency of Circuit Breaker (non-Bus-tie)

345 kV

81. *<outage moved to P7>*
82. Jicarilla 345 kV CB opens the:
    - Jicarilla-San Juan 345 kV Line
    - Jicarilla-Ojo 345 kV Line

230 kV

83. Gladstone 230 kV CB 1 without RAS opens the:
    - Gladstone #1 230/115 kV Transformer
    - Gladstone 230 kV PST
84. Gladstone 230 kV CB 1 with RAS opens the:
    - Gladstone #1 230/115 kV Transformer
    - Gladstone 230 kV PST

    RAS Actions
    - Gladstone-Hess 115 kV Line
    - Rosebud TS load
85. Gladstone 230 kV CB 2 without RAS opens the:
    - Gladstone #2 230/115 kV Transformer

- Gladstone 230 kV PST

86. Gladstone 230 kV CB 2 with RAS opens the:
    - Gladstone #2 230/115 kV Transformer
    - Gladstone 230 kV PST

    RAS Actions
    - Gladstone-Hess 115 kV Line
    - Rosebud TS load
87. Gladstone 230 kV CB 3 without RAS opens the:
    - Gladstone #1 230/115 kV Transformer
    - Gladstone #2 230/115 kV Transformer
88. Gladstone 230 kV CB 3 with RAS opens the:
    - Gladstone #1 230/115 kV Transformer
    - Gladstone #2 230/115 kV Transformer

    RAS Actions
    - Gladstone-Hess 115 kV Line
    - Rosebud TS load

115 kV

89. Gladstone 115 kV Center CB 1 opens the:
    - Gladstone #1 230/115 kV Transformer
    - Gladstone-Clapham115 kV Line
90. Gladstone 115 kV Center CB 2 opens the:
    - Gladstone #2 230/115 kV Transformer
    - Gladstone-Springer #1 115 kV Line

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

91. Springer 115 kV West CB 1 opens the:
    - Springer-York Canyon 115 kV Line
    - Springer-Gladstone 115 kV Line
92. Springer 115 kV Center CB 2 opens the:
    - Springer-York Canyon 115 kV Line
    - Springer Load

Pre Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

93. Springer 115 kV Center CB 5 opens the:
    - Springer-Black Lake-Taos 115 kV Line
    - Springer 115 kV Shunt Capacitor

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

94. Springer 115 kV Center CB 5 opens the:
    - Springer-Black Lake-Taos 115 kV Line
    - Springer 115 kV Shunt Capacitor
    - Springer-Gladstone 115 kV Line
95. Springer 115 kV East CB 6 opens the:
    - Springer-Black Lake-Taos 115 kV Line
    - Springer Load

Pre Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

96. Springer 115 kV Center CB 8 opens the:
    - Springer-Rainsville-Storrie Lake 115 kV Line
    - Springer 115 kV Shunt Capacitor

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

97. Springer 115 kV Center CB 8 opens the:
    - Springer-Rainsville-Storrie Lake 115 kV Line
    - Springer-Gladstone 115 kV Line
98. Springer 115 kV East CB 9 opens the:
    - Springer-Rainsville-Storrie Lake 115 kV Line
    - Springer Load
99. Springer 115 kV Center CB 11 opens the:
    - Springer-Gladstone 115 kV Line
100. Springer 115 kV West CB 13 opens the:
    - Springer 115 kV Shunt Capacitor
    - Springer-Gladstone 115 kV Line
101. Springer 115 kV Center CB 14 opens the:
    - Springer 115 kV Shunt Capacitor
    - Mora-Springer-Arriba 115 kV Line
102. Springer 115 kV Center CB 15 opens the:
    - Mora-Springer-Arriba 115 kV Line
    - Springer Load

103. Storrie Lake 115 kV CB 262 opens the:
    - Springer-Rainsville-Storrie Lake 115 kV Line
    - Storrie Lake Load

104. Valencia 115 kV CB 262 opens the:
    - Valencia-Rowe-Colinas-El Dorado-Zia 115 kV Line
    - Valencia Load
    - Valencia 115 kV Shunt Capacitor

Pre Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

105. Springer 115 kV Center CB 1 opens the:
    - Springer-Bison 115 kV Line
    - Springer-Gladstone 115 kV Line
106. Springer 115 kV Center CB 11 opens the:
    - Springer-Gladstone 115 kV Line
    - Springer 115 kV Shunt Capacitor
107. Storrie Lake 115 kV CB 162 opens the:
    - Storrie Lake-Gallinas-Arriba-Valencia 115 kV Line
    - Storrie Lake Load
108. Valencia 115 kV CB 03962 opens the:
    - Storrie Lake-Gallinas-Arriba-Valencia 115 kV Line
    - Valencia Load
    - Valencia 115 kV Shunt Capacitor

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

109. Storrie Lake 115 kV CB 162 opens the:
    - Storrie Lake-Arriba Tap 115 kV Line
    - Storrie Lake Load
110. Arriba 115 kV CB opens the:
    - Springer-Arriba 115 kV Line
    - Arriba-Arriba Tap 115 kV Line
    - Arriba Load
    - Gallinas Load
111. Arriba Tap 115 kV CB 1 opens the:
    - Arriba Tap-Storrie Lake 115 kV Line
    - Arriba Tap-Valencia 115 kV Line
112. Valencia 115 kV CB 03962 opens the:
    - Valencia-Arriba Tap 115 kV Line
    - Valencia Load
    - Valencia 115 kV Shunt Capacitor

P2-4 Events: Single Contingency of Circuit Breaker (Bus-tie)

None

P4-1 Events - Transient Stability Only: Fault plus Stuck Breaker of Generator

None

P4-2 Events - Transient Stability Only: Fault plus Stuck Breaker of Transmission Circuit

None - same power flow impact as the P2-2 and P2-3 events. P4-2 Events will only be simulated in the dynamic simulation.

P4-3 Events - Transient Stability Only: Fault plus stuck breaker of Transformer

None - same power flow impact as the P2-2 and P2-3 events. P4-3 Events will only be simulated in the dynamic simulation.

P4-4 Events: Fault plus stuck breaker of Shunt Device

None

P4-5 Events: Fault plus stuck breaker of Bus Section

None

P4-6 Events: Fault plus stuck breaker of Bus Section (Bus-tie)

None

P5-1 Events: Fault plus relay failure of Generator

None

P5-2 Events: Fault plus relay failure of Transmission Circuit

None

P5-3 Events: Fault plus relay failure of Transformer

None

P5-4 Events: Fault plus relay failure of Shunt Device

None

P5-5 Events: Fault plus relay failure of Bus Section

113. Gladstone 115 kV West Bus Differential Relay Failure:
    - Gladstone 115 kV Shunt Capacitor 1 & 2

P6-3 Events: Loss of a Shunt Device followed by System adjustments then loss of a Transmission Circuit

One set of P6-3 outages will be simulated with the Clapham #2 SVC out of service (capability reduced from +/- 50 MVAr to +/- 25 MVAr). All P1-2 through P1-4 outages will be applied with the Clapham #2 SVC out.

P7-1 Events: Common Structure of two adjacent circuits

345 kV

114. Rio Puerco-West Mesa #1 & #2 345 kV Lines

P7-2 Events: Loss of Bipolar DC Line

None

P-EE Events

115. Gladstone-Springer 115 kV and Don Carlos-Mora 230 kV common corridor (Extreme Event 2a)

TRANSIENT STABILITY CONTINGENCY LIST

P1-1 Events: Single Contingency Loss of Generator

Generators

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingency

1. Don Carlos Wind Farm: 3 Phase Fault near Don Carlos SS cleared in 4 cycles resulting in loss of generation

P1-2 Events: Single Contingency Loss of Transmission Circuit

345 kV

2. Ojo-Taos 345 kV Line: 3 Phase Fault near Taos cleared in 4 cycles at both ends (with consequential loss of both Taos 345/115 kV transformers)
3. San Juan-Jicarilla 345 kV Line: 3 Phase Fault near Jicarilla cleared in 4 cycles at both ends
4. Jicarilla-Ojo 345 kV Line: 3 Phase Fault near Ojo cleared in 4 cycles at both ends
5. BA-Norton 345 kV Line: 3 Phase Fault near Norton cleared in 4 cycles at both ends
6. Comanche-Daniel Peak #1 345 kV Line: 3 Phase Fault near Comanche cleared in 4 cycles at both ends

230 kV

7. Gladstone-Walsenburg 230 kV Line with RAS: 3 Phase Fault near Gladstone cleared in 5 cycles at Gladstone and 7 cycles at Walsenburg, with RAS trip the Gladstone-Hess 115 kV line and Rosebud TS load at 10 cycles
8. Comanche-Boone 230 kV Line: 3 Phase Fault near Comanche cleared in 5 cycles at Comanche and 7 cycles at Boone
9. Comanche-Midway PS 230 kV Line: 3 Phase Fault near Comanche cleared in 5 cycles at Comanche and 7 cycles at Midway

115 kV

10. Gladstone-Springer 115 kV Line: 3 Phase Fault near Gladstone cleared in 6 cycles at Gladstone and 8 cycles at Springer
11. Gladstone-Springer 115 kV Line: 3 Phase Fault near Springer cleared in 6 cycles at Springer and 8 cycles at Gladstone
12. Gladstone-Springer 115 kV Line: 3 Phase Fault midway along the line cleared in 6 cycles at both ends
13. Zia-Valencia 115 kV Line (Zia-El Dorado-Colinas-Rowe Tap-Valencia): 3 Phase Fault near Zia cleared in 4 cycles at both ends

14. Taos-Springer 115 kV Line: 3 Phase Fault near Springer cleared in 6 cycles at Springer and 8 cycles at Taos

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

15. Mora-Don Carlos SS 230 kV Line: 3 Phase Fault near Don Carlos SS cleared in 5 cycles at Don Carlos and 7 cycles at Gladstone
16. Mora-Springer-Arriba 115 kV Line: 3 Phase Fault near Mora cleared in 6 cycles at Mora and 8 cycles at Springer and Arriba
17. Mora-Springer-Arriba 115 kV Line: 3 Phase Fault near Springer cleared in 6 cycles at Springer and 8 cycles at Mora and Arriba
18. Mora-Springer-Arriba 115 kV Line: 3 Phase Fault near Arriba cleared in 6 cycles at Arriba and 8 cycles at Mora and Springer

P1-3 Events: Single Contingency of Transformer

19. Mora 230/115 kV Transformer: 3 Phase Fault near the 230 kV cleared in 4 cycles at both sides.
20. Gladstone #1 230/115 kV Transformer: 3 Phase Fault near 230 kV cleared in 4 cycles

P1-4 Events: Single Contingency of Shunt Device

None

P1-5 Events: Single Contingency of DC Line

None

P2-1 Events - Steady State Only: Opening of a line section

None

P2-2 Events: Single Contingency of Bus Section Fault

None - will run as P4-2 fault plus stuck breaker as the worst-case for transient stability

P2-3 Events: Single Contingency of Circuit Breaker (non-Bus-tie)

None - will run as P4-2 fault plus stuck breaker as the worst-case for transient stability

P2-4 Events: Single Contingency of Circuit Breaker (Bus-tie)

None

P4-1 Events - Transient Stability Only: Fault plus Stuck Breaker of Generator

None

P4-2 Events - Transient Stability Only: Fault plus Stuck Breaker of Transmission Circuit

345 kV

21. San Juan-Jicarilla 345 kV Line fault with Jicarilla CB stuck: SLG Fault near Jicarilla cleared in 4 cycles at San Juan, and cleared at Jicarilla and Ojo in 12 cycles opening the:
    - Jicarilla-San Juan 345 kV Line in 4 cycles
    - Jicarilla-Ojo 345 kV Line in 12 cycles
    - Jicarilla 345/115 kV Transformer in 12 cycles

230 kV

22. Comanche-Walsenburg 230 kV Line fault with Walsenburg CB 582 stuck with RAS: clearing the Walsenburg 230 kV Main Bus: SLG Fault near Walsenburg cleared in 7 cycles at Comanche, and cleared at Walsenburg in 12 cycles opening the:
    - Walsenburg-Comanche 230 kV Line in 12 cycles
    - Walsenburg-Gladstone 230 kV Line in 12 cycles
    - Walsenburg 230 kV Shunt Capacitor in 12 cycles
    - Walsenburg #1 230/115 kV Transformer in 12 cycles
    - Walsenburg #2 230/115 kV Transformer in 12 cycles

    RAS Action (5 cycle delay after Walsenburg-Gladstone 230 kV Line opens)
    - Gladstone-Hess 115 kV Line in 17 cycles
    - Rosebud TS load in 17 cycles

115 kV

23. Gladstone-Clapham 115 kV Line fault with Gladstone Center CB 1 stuck: SLG Fault near Gladstone cleared in 15 cycles at Clapham (no breaker), and in 15 cycles at Gladstone opening:
    - Gladstone-Clapham115 kV Line in 15 cycles
    - Gladstone #1 230/115 kV Transformer in 15 cycles
24. Gladstone-Springer 115 kV Line fault with Gladstone Center CB 2 stuck: SLG Fault near Gladstone cleared in 8 cycles at Springer, and in 15 cycles at Gladstone opening:
    - Gladstone-Springer #1 115 kV Line in 8 cycles
    - Gladstone #2 230/115 kV Transformer in 15 cycles
25. Springer-Black Lake-Taos 115 kV Line fault with Springer Center CB 2 stuck: SLG Fault near Springer cleared in 8 cycles at Black Lake and Taos, and in 15 cycles at Springer opening:
    - Springer-Black Lake-Taos 115 kV Line in 8 cycles

- Springer 115 kV Shunt Capacitor in 15 cycles

26. Springer-Storrie Lake 115 kV Line fault with Springer Center CB 3 stuck: SLG Fault near Springer cleared in 8 cycles at Storrie Lake, and in 15 cycles at Springer opening:
    - Springer-Rainsville-Storrie Lake 115 kV Line in 8 cycles
    - Springer 115 kV Shunt Capacitor in 15 cycles
27. Valencia-Zia 115 kV Line fault with Valencia CB 262 stuck: SLG Fault near Valencia cleared in 4 cycles at Rowe, Colinas, El Dorado, and Zia, and in 15 cycles at Valencia opening:
    - Valencia-Rowe-Colinas-El Dorado-Zia 115 kV Line in 4 cycles
    - Valencia Load in 15 cycles
    - Valencia 115 kV Shunt Capacitor in 15 cycles

Pre Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

28. Springer-Bison 115 kV Line fault with Springer Center CB 1 stuck: SLG Fault near Springer cleared in 15 cycles at Bison (no breaker at Bison), and in 15 cycles at Springer and Gladstone opening:
    - Springer-Bison 115 kV Line in 15 cycles
    - Springer-Gladstone #1 115 kV Line in 15 cycles
29. Springer-Gladstone #1 115 kV Line fault with Springer Center CB 4 stuck: SLG Fault near Springer cleared in 8 cycles at Gladstone, and in 15 cycles at Springer opening:
    - Springer-Gladstone #1 115 kV Line in 8 cycles at Gladstone, 15 cycles at Springer
30. Storrie Lake-Arriba-Valencia 115 kV Line fault with Storrie Lake CB 162 stuck: SLG Fault near Storrie Lake cleared in 8 cycles at Arriba and Valencia, and in 15 cycles at Storrie Lake opening:
    - Storrie Lake-Gallinas-Arriba-Valencia 115 kV Line in 8 cycles
    - Storrie Lake Load in 15 cycles
31. Valencia-Arriba-Storrie Lake 115 kV Line fault with Valencia CB 03962 stuck: SLG Fault near Valencia cleared in 8 cycles at Arriba and Storrie Lake, and in 15 cycles at Valencia opening:
    - Storrie Lake-Gallinas-Arriba-Valencia 115 kV Line in 8 cycles
    - Valencia Load in 15 cycles
    - Valencia 115 kV Shunt Capacitor in 15 cycles

Post Mora Transmission Line Project and Don Carlos Wind Farm Contingencies

32. Springer-Bison 115 kV Line fault with Springer Center CB 1 stuck: SLG Fault near Springer cleared in 15 cycles at Bison (no breaker at Bison), and in 15 cycles at Springer and Gladstone opening:
    - Springer-Bison 115 kV Line in 15 cycles
    - Springer-Gladstone 115 kV Line in 15 cycles
33. Springer-Bison 115 kV Line fault with Springer Center CB 2 stuck: SLG Fault near Springer cleared in 15 cycles at Bison (no breaker at Bison), and in 15 cycles at Springer and Gladstone opening:
    - Springer-Bison 115 kV Line in 15 cycles
    - Springer Load in 15 cycles
34. Springer-Black Lake-Taos 115 kV Line fault with Springer CB 5 stuck: SLG Fault near Springer cleared in 15 cycles at Bison (no breaker at Bison), and in 15 cycles at Springer and Gladstone opening:
    - Springer-Bison 115 kV Line in 15 cycles
    - Springer-Gladstone 115 kV Line in 15 cycles
35. Springer-Black Lake-Taos 115 kV Line fault with Springer CB 6 stuck: SLG Fault near Springer cleared in 15 cycles at Bison (no breaker at Bison), and in 15 cycles at Springer and Gladstone opening:
    - Springer-Bison 115 kV Line in 15 cycles
    - Springer Load in 15 cycles
36. Springer-Storrie Lake 115 kV Line fault with Springer CB 8 stuck: SLG Fault near Springer cleared in 8 cycles at Storrie Lake, and in 15 cycles at Springer opening:
    - Springer-Storrie Lake 115 kV Line in 15 cycles
    - Springer-Gladstone 115 kV Line in 15 cycles
37. Springer-Storrie Lake 115 kV Line fault with Springer CB 9 stuck: SLG Fault near Springer cleared in 8 cycles at Storrie Lake, and in 15 cycles at Springer opening:
    - Springer-Storrie Lake 115 kV Line in 15 cycles
    - Springer Load in 15 cycles
38. Springer 115 kV Shunt Capacitor fault with Springer CB 13 stuck: SLG Fault at Springer cleared in 15 cycles at Springer, opening:
    - Springer 115 kV Shunt Capacitor in 15 cycles
    - Springer-Gladstone 115 kV Line in 15 cycles
39. Springer 115 kV Shunt Capacitor fault with Springer CB 14 stuck: SLG Fault at Springer cleared in 15 cycles at Springer, opening:
    - Springer 115 kV Shunt Capacitor in 15 cycles
    - Mora-Springer-Arriba 115 kV Line in 15 cycles

40. Springer 115/69 kV Transformer fault with Springer CB 15 stuck: SLG Fault at Springer cleared in 15 cycles at Springer, opening:
    - Springer 115/69 kV Transformer in 8 cycles
    - Mora-Springer-Arriba 115 kV Line in 15 cycles
41. Storrie Lake-Arriba Tap 115 kV Line fault with Storrie Lake CB 162 stuck: SLG Fault near Storrie Lake cleared in 8 cycles at Arriba Tap, and in 15 cycles at Storrie Lake opening:
    - Storrie Lake-Arriba Tap 115 kV Line in 8 cycles
    - Storrie Lake Load in 15 cycles
42. Arriba-Arriba Tap 115 kV Line fault with Arriba CB stuck: SLG Fault near Arriba cleared in 4 cycles at Arriba Tap, and in 15 cycles at Springer opening:
    - Arriba-Arriba Tap 115 kV Line in 4 cycles
    - Springer-Arriba 115 kV Line in 15 cycles
    - Arriba Load in 15 cycles
    - Gallinas Load in 15 cycles
43. Arriba Tap-Storrie Lake 115 kV Line fault with Arriba Tap CB 1 stuck: SLG Fault near Arriba Tap cleared in 8 cycles at Storrie Lake, and in 15 cycles at Arriba Tap and Valencia opening:
    - Arriba Tap-Storrie Lake 115 kV Line in 8 cycles
    - Arriba Tap-Valencia 115 kV Line in 15 cycles
44. Valencia-Arriba Tap 115 kV Line fault with Valencia CB 03962 stuck: SLG Fault cleared in 4 cycles at Arriba Tap, and in 15 cycles at Valencia opening:
    - Valencia-Arriba Tap 115 kV Line in 4 cycles
    - Valencia Load in 15 cycles
    - Valencia 115 kV Shunt Capacitor in 15 cycles

P4-3 Events - Transient Stability Only: Fault plus stuck breaker of Transformer

230 kV

45. Gladstone #1 230/115 kV Transformer fault with Gladstone 230 kV CB 1 stuck with RAS: SLG Fault near 230 kV cleared in 4 cycles at the 115 kV, and in 12 cycles at Gladstone and Walsenburg opening:
    - Gladstone #1 230/115 kV Transformer in 4 cycles
    - Gladstone 230 kV PST in 12 cycles

    RAS Action (5 cycle delay after Gladstone PST opens)
    - Gladstone-Hess 115 kV Line in 17 cycles
    - Rosebud TS load in 17 cycles

46. Gladstone #2 230/115 kV Transformer fault with Gladstone 230 kV CB 2 stuck with RAS: SLG Fault near 230 kV cleared in 4 cycles at the 115 kV, and in 12 cycles at Gladstone and Walsenburg opening:
    - Gladstone #2 230/115 kV Transformer in 4 cycles
    - Gladstone 230 kV PST in 12 cycles

    RAS Action (5 cycle delay after Gladstone PST opens)
    - Gladstone-Hess 115 kV Line in 17 cycles
    - Rosebud TS load in 17 cycles
47. Gladstone #1 230/115 kV Transformer fault with Gladstone 230 kV CB 3 stuck with RAS: SLG Fault near 230 kV cleared in 4 cycles at 115 kV, and in 12 cycles at the 230 kV and 115 kV opening:
    - Gladstone #1 230/115 kV Transformer in 4 cycles
    - Gladstone #2 230/115 kV Transformer in 12 cycles

    RAS Action (5 cycle delay after both Gladstone 230/115 kV Transformers opens)
    - Gladstone-Hess 115 kV Line in 17 cycles
    - Rosebud TS load in 17 cycles

P4-4 Events: Fault plus stuck breaker of Shunt Device

None

P4-5 Events: Fault plus stuck breaker of Bus Section

None

P4-6 Events: Fault plus stuck breaker of Bus Section (Bus-tie)

None

P5-1 Events: Fault plus relay failure of Generator

None

P5-2 Events: Fault plus relay failure of Transmission Circuit

48. Gladstone-Springer 115 kV Line fault with relay communication failure: SLG Fault near Gladstone cleared in 6 cycles at Gladstone, and in 20 cycles at Springer
49. Gladstone-Springer 115 kV Line fault with relay communication failure: SLG Fault near Springer cleared in 6 cycles at Springer, and in 20 cycles at Gladstone

P5-3 Events: Fault plus relay failure of Transformer

None

P5-4 Events: Fault plus relay failure of Shunt Device

None

P5-5 Events: Fault plus relay failure of Bus Section

None

P6-3 Events: Loss of a Shunt Device followed by System adjustments then loss of a Transmission Circuit

A separate basecase will be created with the Clapham SVC #2 out of service. The SVC power flow and dynamic models will be updated with +/- 25 MVAr limits. No system adjustments will be made other than a power flow solution that allows:

- *Transformer taps to adjust*
- *Phase Shifting Transformers to adjust*
- *Switched Voltage Devices to adjust*

All P1-2 through P1-4 outages will be applied to this case.

P7-1 Events: Common Structure of two adjacent circuits

None

P7-2 Events: Loss of Bipolar DC Line

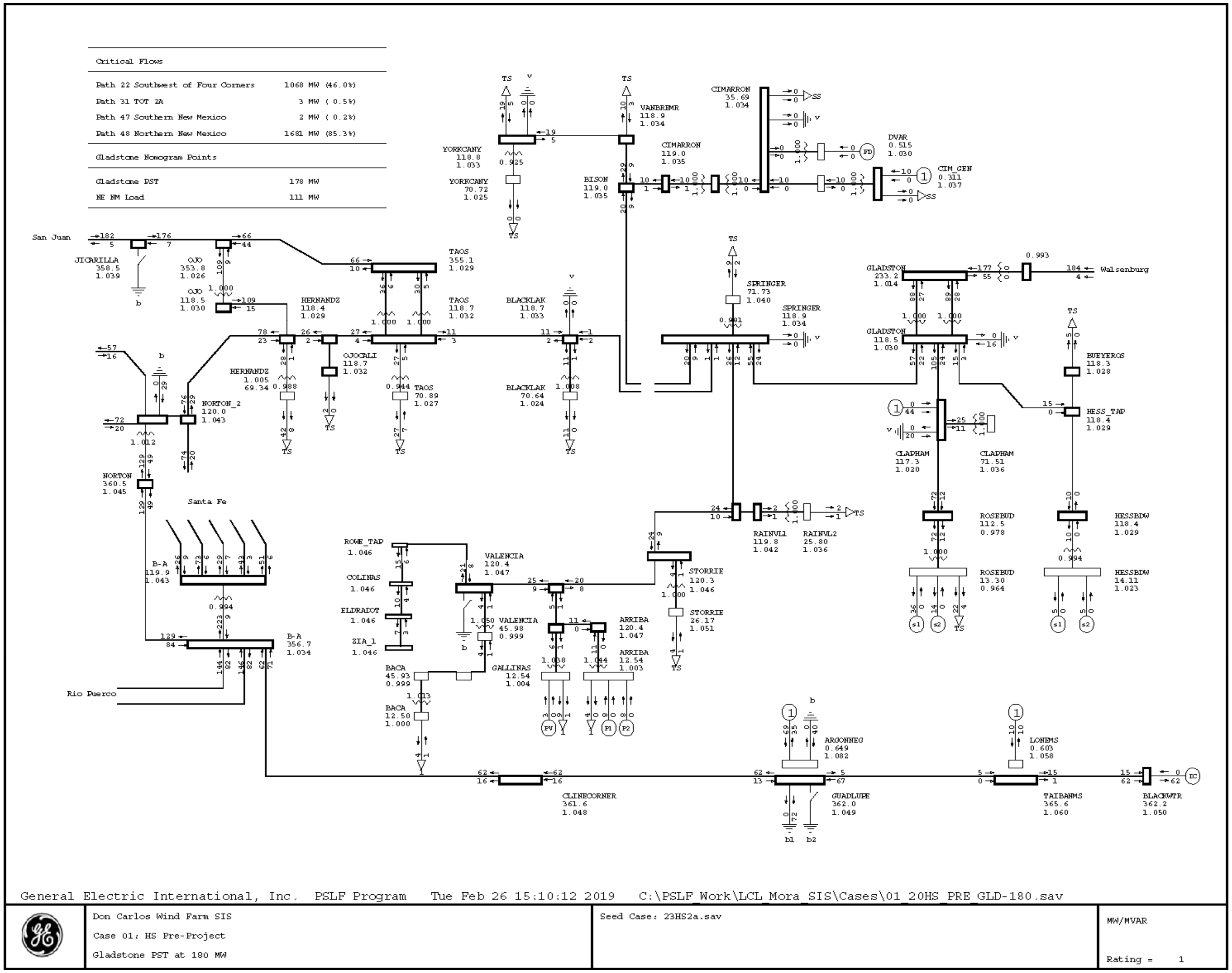
None

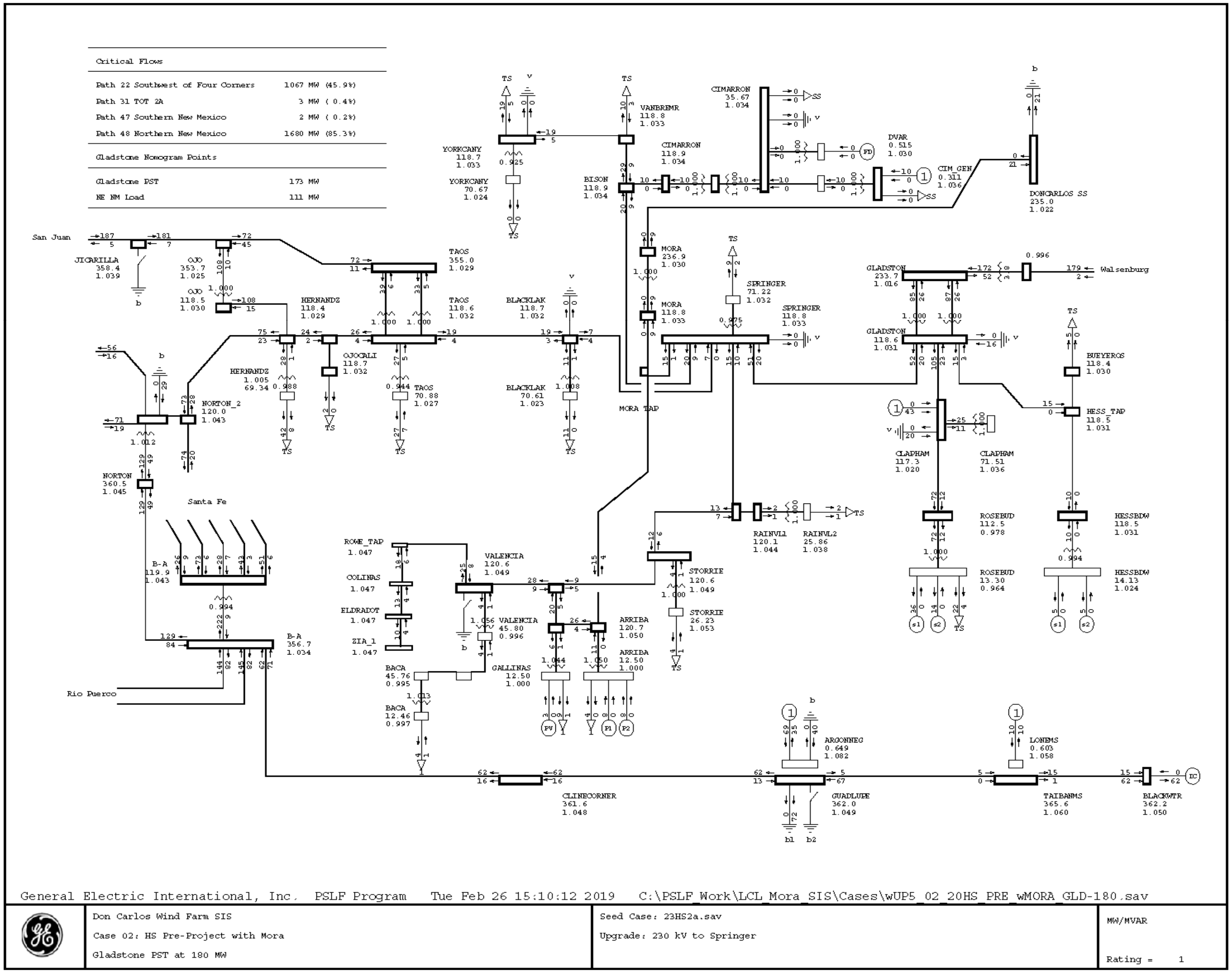
P-EE Events

None

APPENDIX C

POWER FLOW PLOTS


Critical Flows
Path 22 Southwest of Four Corners 1068 MW (46.0%)
Path 31 TOT 2A 3 MW (0.5%)
Path 47 Southern New Mexico 2 MW (0.2%)
Path 48 Northern New Mexico 1681 MW (85.3%)
Gladstone Nomogram Points
Gladstone PST 178 MW
NE NM Load 111 MW
San Juan
JICARILLA 358.5 1.039
OJO 353.8 1.026
OJO 118.5 1.030
HERNANDZ 118.4 1.029
TAOS 355.1 1.029
TAOS 118.7 1.032
BLACKLAK 118.7 1.033
YORKCANY 118.8 1.033
YORKCANY 70.72 1.025
VANBREMR 118.9 1.034
BISON 119.0 1.035
CIMARRON 119.0 1.035
CIMARRON 35.69 1.034
DVAR 0.515 1.030
CIM_GEN 0.311 1.037
SPRINGER 71.73 1.040
SPRINGER 118.9 1.034
GLADSTON 233.2 1.014
Walsenburg
GLADSTON 118.5 1.030
BUEYEROS 118.3 1.028
HESS_TAP 118.4 1.029
CLAPHAM 117.3 1.020
CLAPHAM 71.51 1.036
NORTON_2 120.0 1.043
HERNANDZ 1.005 69.34
OJOCALI 118.7 1.032
TAOS 70.89 1.027
BLACKLAK 70.64 1.024
NORTON 360.5 1.045
Santa Fe
B-A 119.9 1.043
B-A 356.7 1.034
Rio Puerco
ROWE_TAP 1.046
COLINAS 1.046
ELDRADOT 1.046
ZIA_1 1.046
VALENCIA 120.4 1.047
VALENCIA 45.98 0.999
ARRIBA 120.4 1.047
ARRIBA 12.54 1.003
GALLINAS 12.54 1.004
BACA 45.93 0.999
BACA 12.50 1.000
STORRIE 120.3 1.046
STORRIE 26.17 1.051
RAINVL1 119.8 1.042
RAINVL2 25.80 1.036
ROSEBUD 112.5 0.978
ROSEBUD 13.30 0.964
HESSBDW 118.4 1.029
HESSBDW 14.11 1.023
ARGONNEG 0.649 1.082
LONEMS 0.603 1.058
CLINECORNER 361.6 1.048
GUADLUPE 362.0 1.049
TAIBANMS 365.6 1.060
BLACKWTR 362.2 1.050
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:12 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\01_20HS_PRE_GLD-180.sav
Don Carlos Wind Farm SIS
Case 01: HS Pre-Project
Gladstone PST at 180 MW
Seed Case: 23HS2a.sav
MW/MVAR
Rating = 1



Critical Flows
Path 22 Southwest of Four Corners 1067 MW (45.9%)
Path 31 TOT 2A 3 MW (0.4%)
Path 47 Southern New Mexico 2 MW (0.2%)
Path 48 Northern New Mexico 1680 MW (85.3%)
Gladstone Nomogram Points
Gladstone PST 173 MW
NE NM Load 111 MW
San Juan
JICARILLA 358.4 1.039
OJO 353.7 1.025
OJO 118.5 1.030
TAOS 355.0 1.029
TAOS 118.6 1.032
HERNANDZ 118.4 1.029
OJOCALI 118.7 1.032
TAOS 70.88 1.027
BLACKLAK 118.7 1.032
BLACKLAK 70.61 1.023
YORKCANY 118.7 1.033
YORKCANY 70.67 1.024
VANBREMR 118.8 1.033
BISON 118.9 1.034
CIMARRON 35.67 1.034
CIMARRON 118.9 1.034
DVAR 0.515 1.030
CIM_GEN 0.311 1.036
DONCARLOS SS 235.0 1.022
MORA 236.9 1.030
MORA 118.8 1.033
MORA TAP
SPRINGER 71.22 1.032
SPRINGER 118.8 1.033
GLADSTON 233.7 1.016
GLADSTON 118.6 1.031
Walsenburg
BUEYEROS 118.4 1.030
HESS_TAP 118.5 1.031
CLAPHAM 117.3 1.020
CLAPHAM 71.51 1.036
ROSEBUD 112.5 0.978
ROSEBUD 13.30 0.964
HESSBDW 118.5 1.031
HESSBDW 14.13 1.024
RAINVL1 120.1 1.044
RAINVL2 25.86 1.038
STORRIE 120.6 1.049
STORRIE 26.23 1.053
HERNANDZ 1.005 69.34
NORTON_2 120.0 1.043
NORTON 360.5 1.045
Santa Fe
B-A 119.9 1.043
B-A 356.7 1.034
Rio Puerco
ROWE_TAP 1.047
COLINAS 1.047
ELDRADOT 1.047
ZIA_1 1.047
VALENCIA 120.6 1.049
VALENCIA 45.80 0.996
BACA 45.76 0.995
BACA 12.46 0.997
GALLINAS 12.50 1.000
ARRIBA 120.7 1.050
ARRIBA 12.50 1.000
ARGONNEG 0.649 1.082
LONEMS 0.603 1.058
CLINECORNER 361.6 1.048
GUADLUPE 362.0 1.049
TAIBANMS 365.6 1.060
BLACKWTR 362.2 1.050
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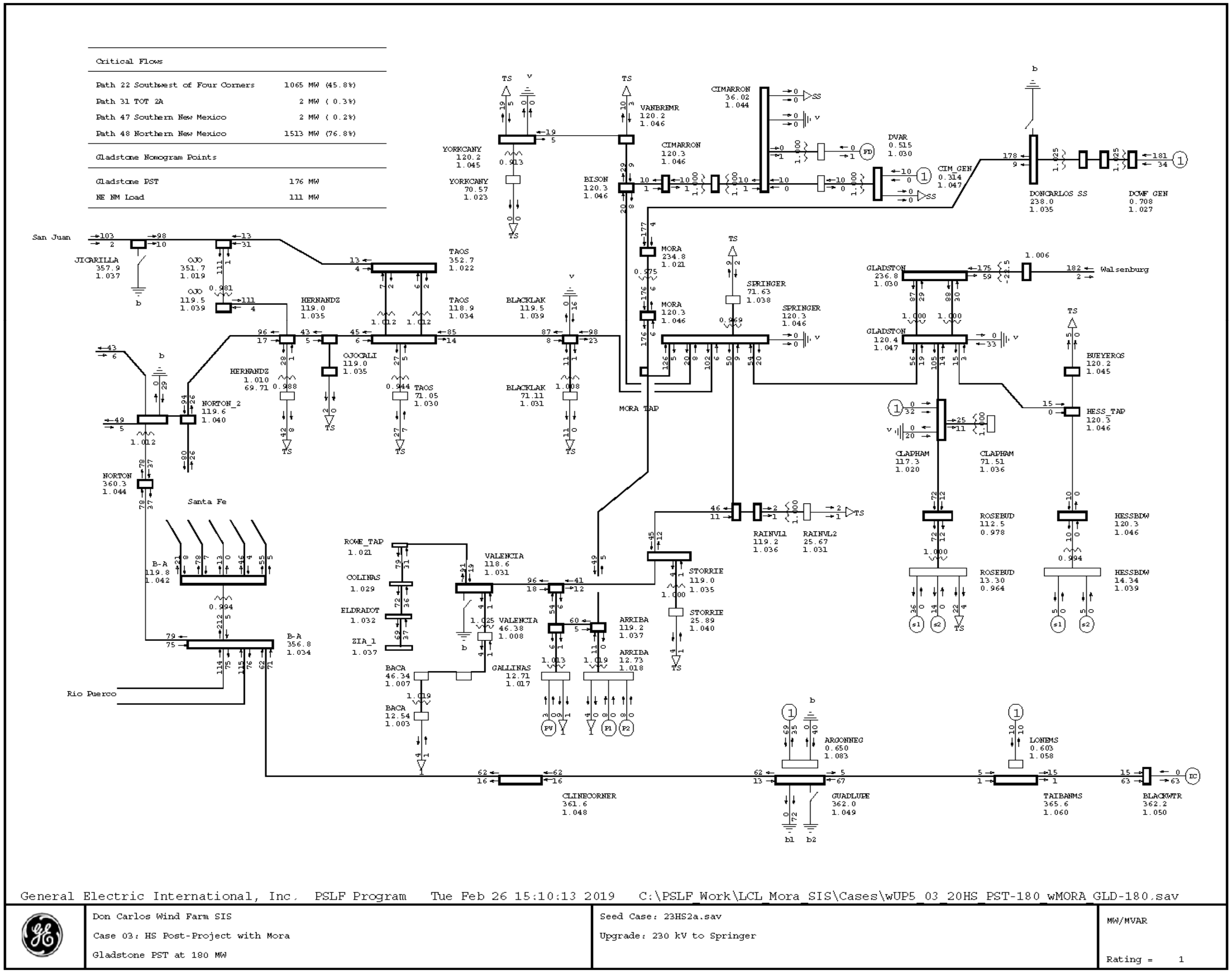
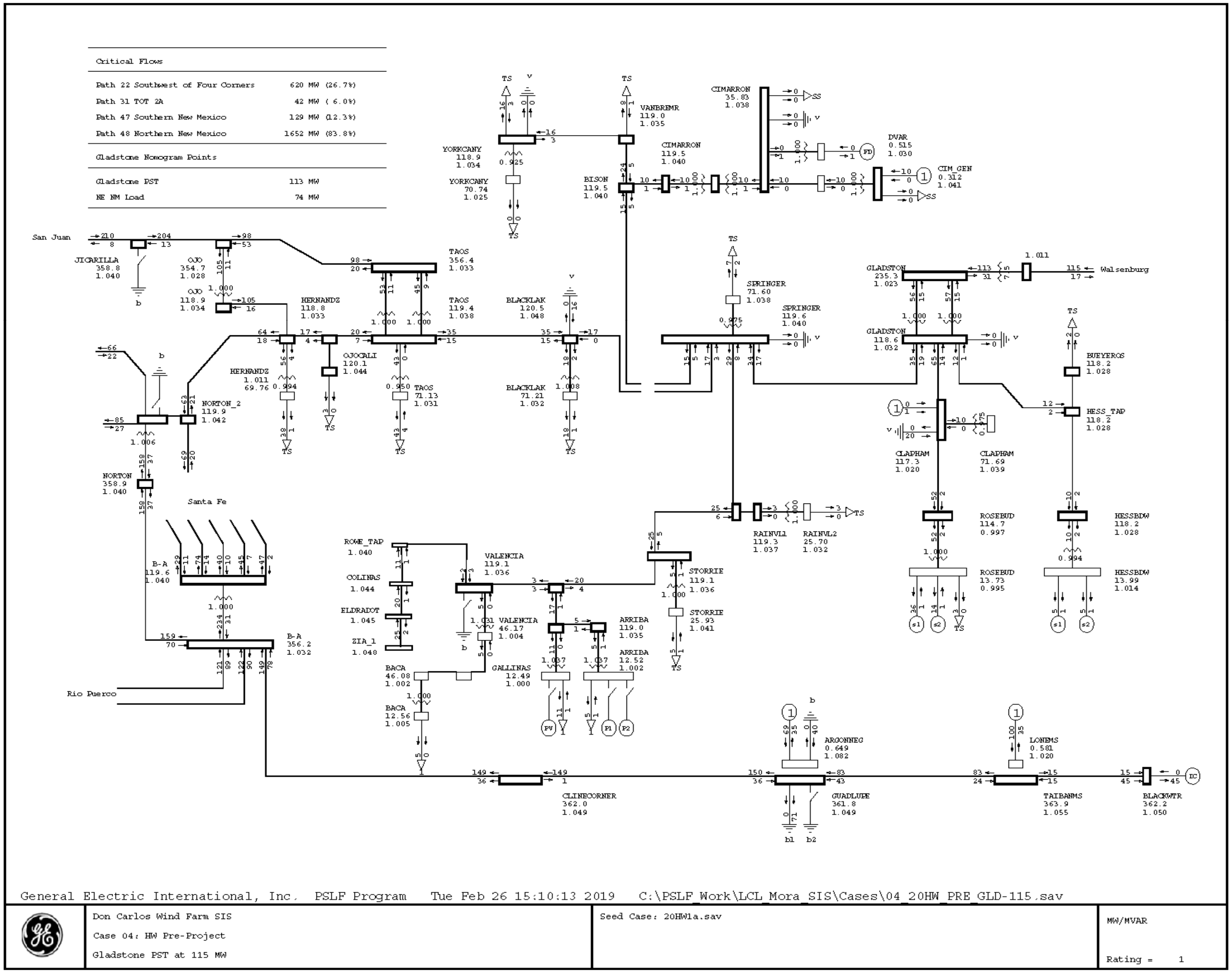
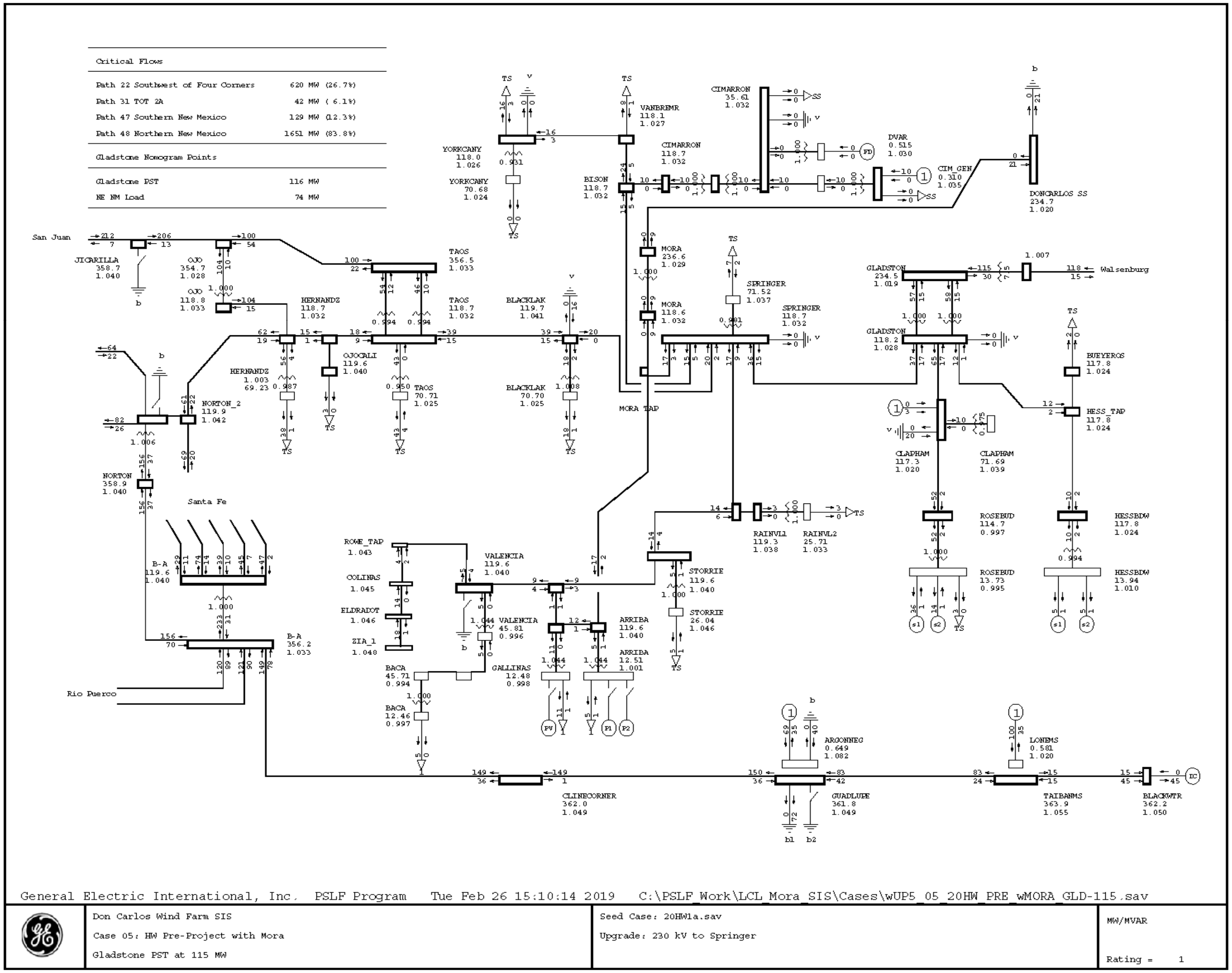
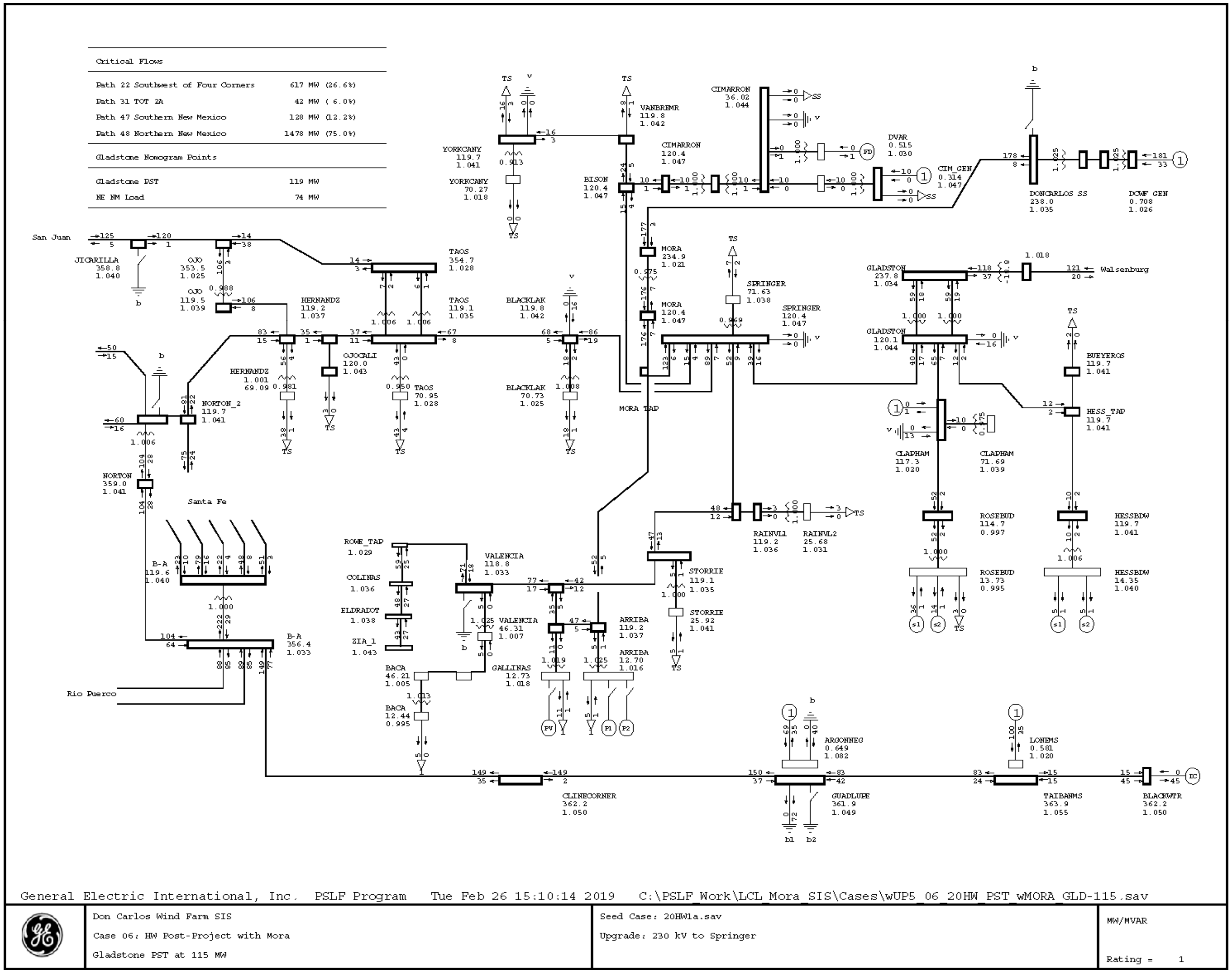
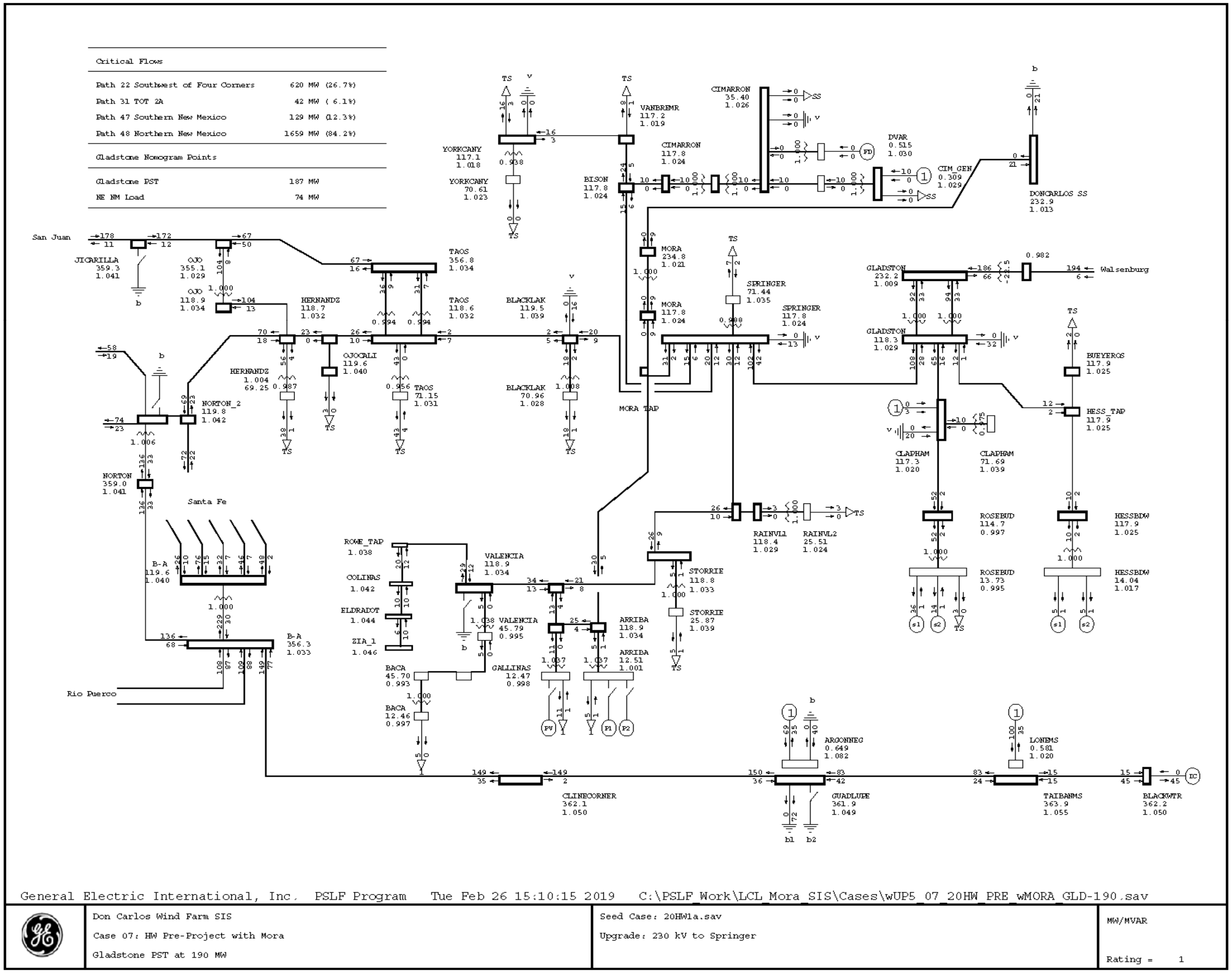
Don Carlos Wind Farm SIS
Case 02: HS Pre-Project with Mora
Gladstone PST at 180 MW
Seed Case: 23HS2a.sav
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1

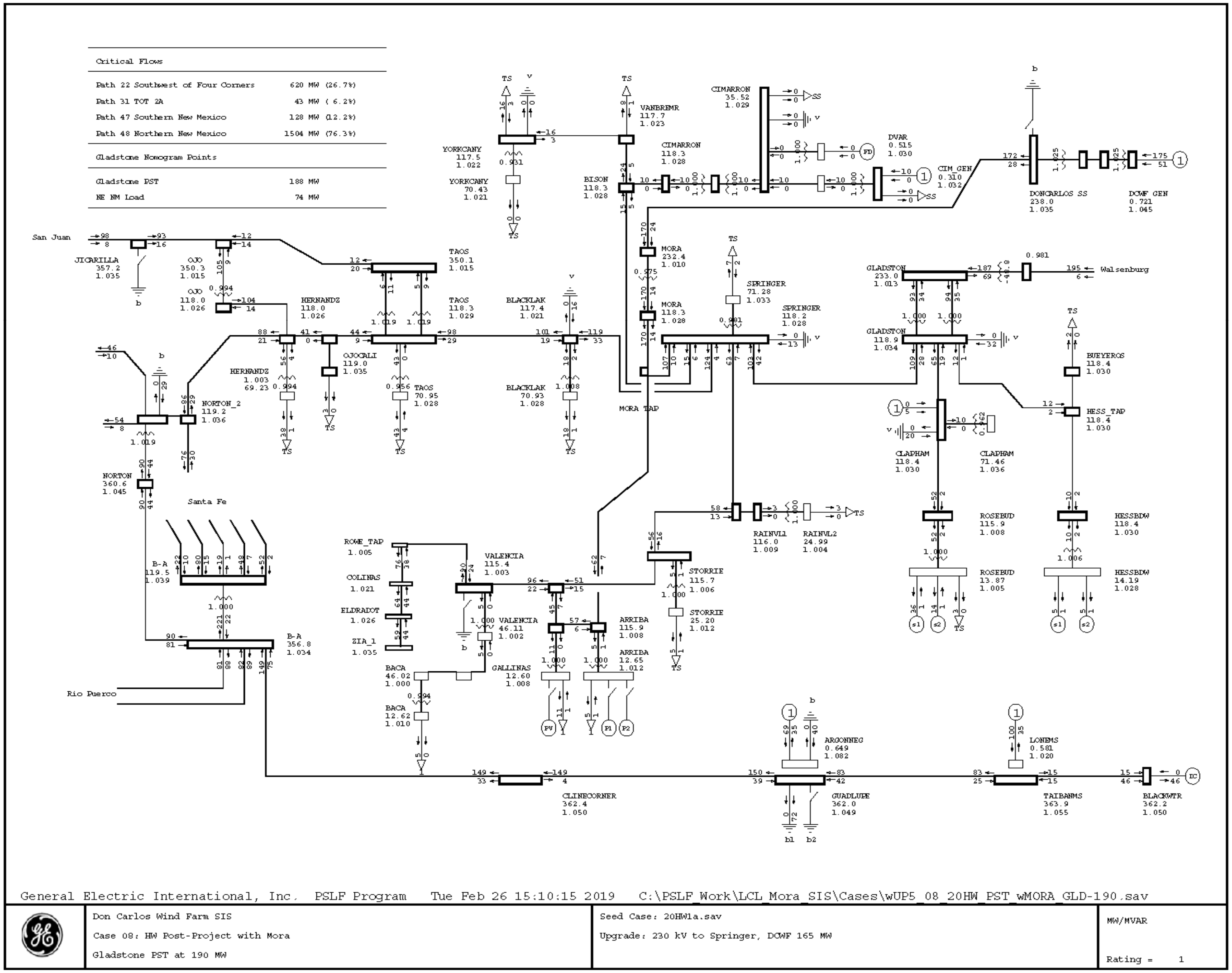

Critical Flows
Path 22 Southwest of Four Corners 1065 MW (45.8%)
Path 31 TOT 2A 2 MW (0.3%)
Path 47 Southern New Mexico 2 MW (0.2%)
Path 48 Northern New Mexico 1513 MW (76.8%)
Gladstone Nomogram Points
Gladstone PST 176 MW
NE NM Load 111 MW
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:13 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_03_20HS_PST-180_wMORA_GLD-180.sav
Don Carlos Wind Farm SIS
Case 03: HS Post-Project with Mora
Gladstone PST at 180 MW
Seed Case: 23HS2a.sav
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1

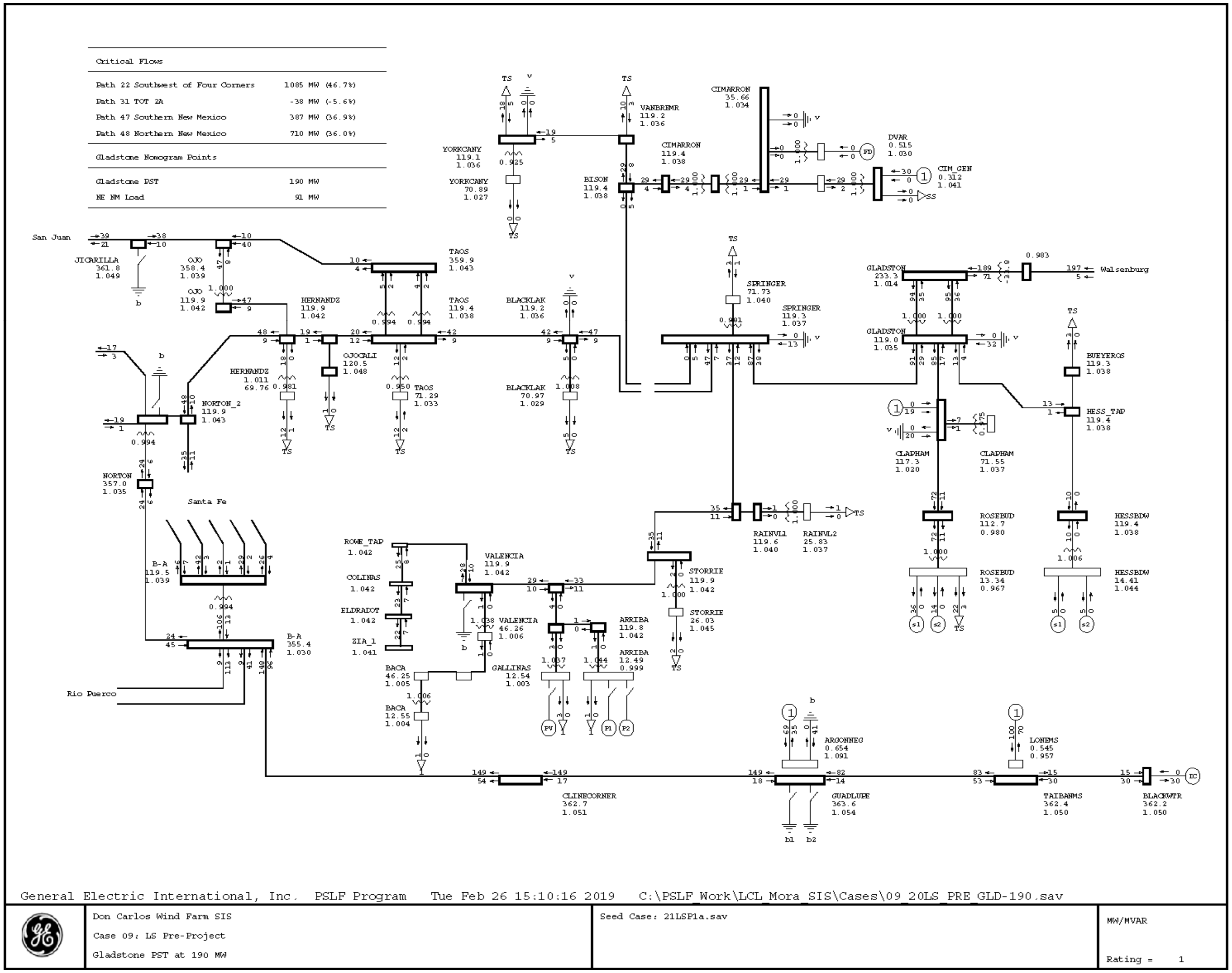

Critical Flows
Path 22 Southwest of Four Corners 620 MW (26.7%)
Path 31 TOT 2A 42 MW (6.0%)
Path 47 Southern New Mexico 129 MW (12.3%)
Path 48 Northern New Mexico 1652 MW (83.8%)
Gladstone Nomogram Points
Gladstone PST 113 MW
NE NM Load 74 MW
San Juan
Santa Fe
Rio Puerco
Walsenburg
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:13 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\04_20HW_PRE_GLD-115.sav
Don Carlos Wind Farm SIS
Case 04: HW Pre-Project
Gladstone PST at 115 MW
Seed Case: 20HW1a.sav
MW/MVAR
Rating = 1

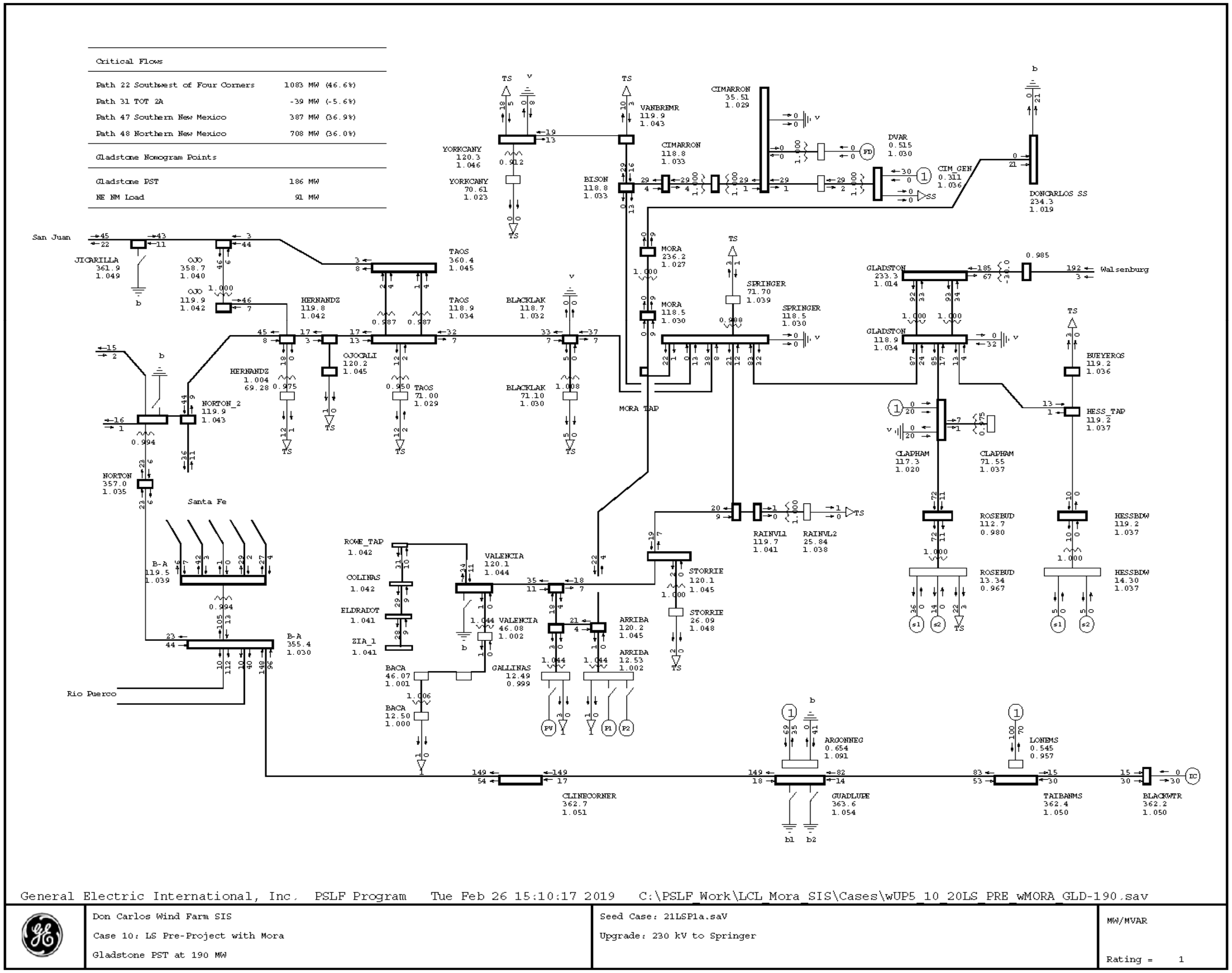

Critical Flows
Path 22 Southwest of Four Corners 620 MW (26.7%)
Path 31 TOT 2A 42 MW (6.1%)
Path 47 Southern New Mexico 129 MW (12.3%)
Path 48 Northern New Mexico 1651 MW (83.8%)
Gladstone Nomogram Points
Gladstone PST 116 MW
NE NM Load 74 MW
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:14 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_05_20HW_PRE_wMORA_GLD-115.sav
Don Carlos Wind Farm SIS
Case 05: HW Pre-Project with Mora
Gladstone PST at 115 MW
Seed Case: 20HW1a.sav
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1

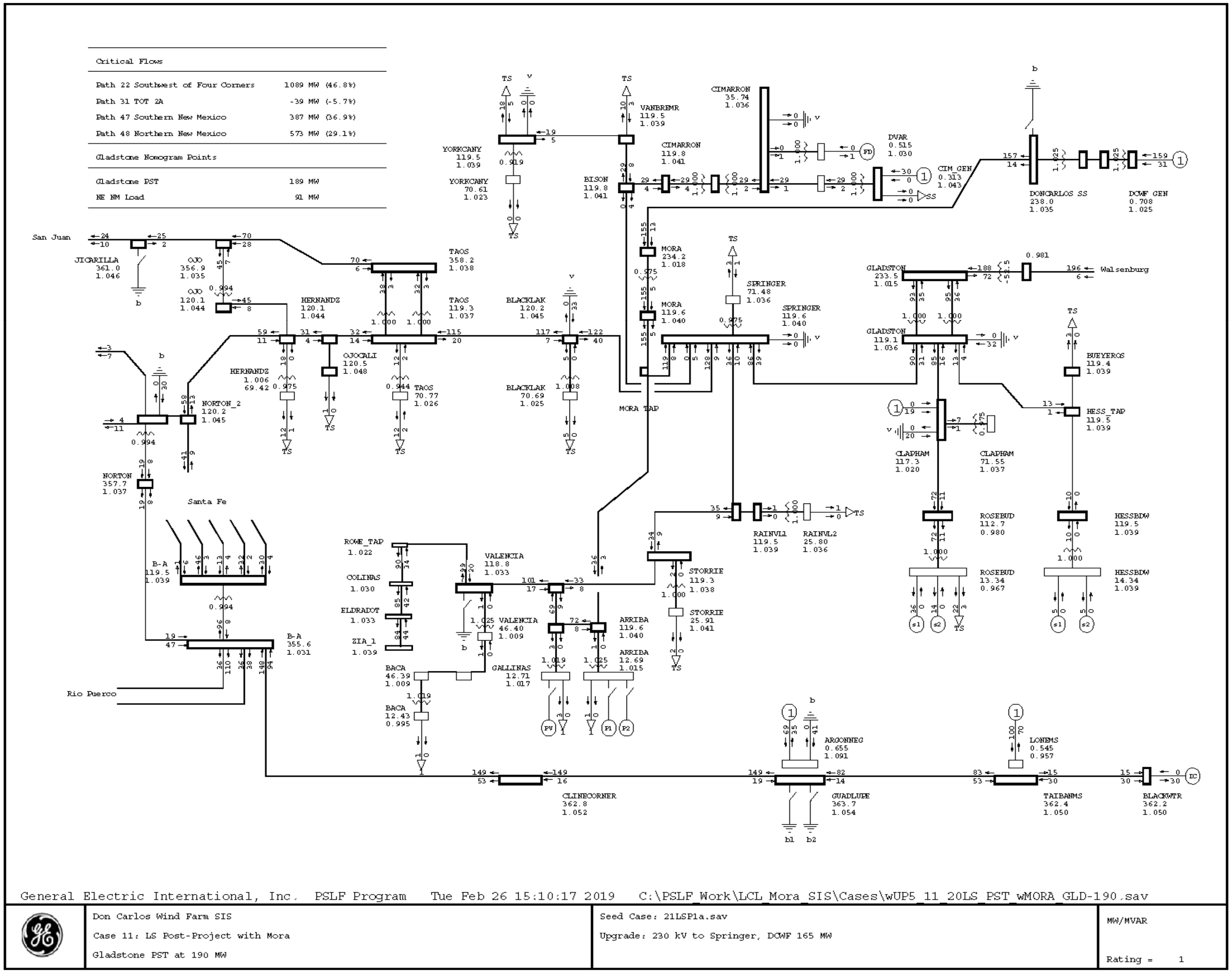

Critical Flows
Path 22 Southwest of Four Corners 617 MW (26.6%)
Path 31 TOT 2A 42 MW (6.0%)
Path 47 Southern New Mexico 128 MW (12.2%)
Path 48 Northern New Mexico 1478 MW (75.0%)
Gladstone Nomogram Points
Gladstone PST 119 MW
NE NM Load 74 MW
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:14 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_06_20HW_PST_wMORA_GLD-115.sav
Don Carlos Wind Farm SIS
Case 06: HW Post-Project with Mora
Gladstone PST at 115 MW
Seed Case: 20HW1a.sav
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1


Critical Flows
Path 22 Southwest of Four Corners 620 MW (26.7%)
Path 31 TOT 2A 42 MW (6.1%)
Path 47 Southern New Mexico 129 MW (12.3%)
Path 48 Northern New Mexico 1659 MW (84.2%)
Gladstone Nomogram Points
Gladstone PST 187 MW
NE NM Load 74 MW
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:15 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_07_20HW_PRE_wMORA_GLD-190.sav
Don Carlos Wind Farm SIS
Case 07: HW Pre-Project with Mora
Gladstone PST at 190 MW
Seed Case: 20HW1a.sav
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1


Critical Flows
Path 22 Southwest of Four Corners 620 MW (26.7%)
Path 31 TOT 2A 43 MW (6.2%)
Path 47 Southern New Mexico 128 MW (12.2%)
Path 48 Northern New Mexico 1504 MW (76.3%)
Gladstone Nomogram Points
Gladstone PST 188 MW
NE NM Load 74 MW
San Juan
Santa Fe
Rio Puerco
Walsenburg
MORA TAP
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:15 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_08_20HW_PST_wMORA_GLD-190.sav
Don Carlos Wind Farm SIS
Case 08: HW Post-Project with Mora
Gladstone PST at 190 MW
Seed Case: 20HW1a.sav
Upgrade: 230 kV to Springer, DCWF 165 MW
MW/MVAR
Rating = 1


Critical Flows
Path 22 Southwest of Four Corners 1085 MW (46.7%)
Path 31 TOT 2A -38 MW (-5.6%)
Path 47 Southern New Mexico 387 MW (36.9%)
Path 48 Northern New Mexico 710 MW (36.0%)
Gladstone Nomogram Points
Gladstone PST 190 MW
NE NM Load 91 MW
San Juan
JICARILLA
OJO
HERNANDZ
NORTON_2
NORTON
Santa Fe
B-A
Rio Puerco
TAOS
OJOCALI
BLACKLAK
YORKCANY
BISON
VANBREMR
CIMARRON
DVAR
CIM_GEN
SPRINGER
GLADSTON
Walsenburg
BUEYEROS
HESS_TAP
CLAPHAM
ROSEBUD
HESSBDW
RAINVL1
RAINVL2
STORRIE
VALENCIA
ROWE_TAP
COLINAS
ELDRADOT
ZIA_1
BACA
GALLINAS
ARRIBA
ARGONNEG
LONEMS
CLINECORNER
GUADLUPE
TAIBANMS
BLACKWTR
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:16 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\09_20LS_PRE_GLD-190.sav
Don Carlos Wind Farm SIS
Case 09: LS Pre-Project
Gladstone PST at 190 MW
Seed Case: 21LSP1a.sav
MW/MVAR
Rating = 1


Critical Flows
Path 22 Southwest of Four Corners 1083 MW (46.6%)
Path 31 TOT 2A -39 MW (-5.6%)
Path 47 Southern New Mexico 387 MW (36.9%)
Path 48 Northern New Mexico 708 MW (36.0%)
Gladstone Nomogram Points
Gladstone PST 186 MW
NE NM Load 91 MW
San Juan
JICARILLA
OJO
HERNANDZ
TAOS
OJOCALI
BLACKLAK
YORKCANY
VANBREMR
BISON
CIMARRON
DVAR
CIM_GEN
DONCARLOS SS
MORA
MORA TAP
SPRINGER
GLADSTON
Walsenburg
BUEYEROS
HESS_TAP
CLAPHAM
ROSEBUD
HESSBDW
RAINVL1
RAINVL2
STORRIE
NORTON_2
NORTON
Santa Fe
B-A
Rio Puerco
ROWE_TAP
COLINAS
ELDRADOT
ZIA_1
VALENCIA
BACA
GALLINAS
ARRIBA
ARGONNEG
LONEMS
CLINECORNER
GUADLUPE
TAIBANMS
BLACKWTR
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:17 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_10_20LS_PRE_wMORA_GLD-190.sav
Don Carlos Wind Farm SIS
Case 10: LS Pre-Project with Mora
Gladstone PST at 190 MW
Seed Case: 21LSP1a.saV
Upgrade: 230 kV to Springer
MW/MVAR
Rating = 1


Critical Flows
Path 22 Southwest of Four Corners 1089 MW (46.8%)
Path 31 TOT 2A -39 MW (-5.7%)
Path 47 Southern New Mexico 387 MW (36.9%)
Path 48 Northern New Mexico 573 MW (29.1%)
Gladstone Nomogram Points
Gladstone PST 189 MW
NE NM Load 91 MW
San Juan
JICARILLA 361.0 1.046
OJO 356.9 1.035
OJO 120.1 1.044
HERNANDZ 120.1 1.044
TAOS 358.2 1.038
TAOS 119.3 1.037
BLACKLAK 120.2 1.045
YORKCANY 119.5 1.039
YORKCANY 70.61 1.023
VANBREMR 119.5 1.039
BISON 119.8 1.041
CIMARRON 35.74 1.036
CIMARRON 119.8 1.041
DVAR 0.515 1.030
CIM_GEN 0.313 1.043
DONCARLOS SS 238.0 1.035
DCWF GEN 0.708 1.025
MORA 234.2 1.018
MORA 119.6 1.040
SPRINGER 71.48 1.036
SPRINGER 119.6 1.040
GLADSTON 233.5 1.015
GLADSTON 119.1 1.036
Walsenburg
BUEYEROS 119.4 1.039
HESS_TAP 119.5 1.039
CLAPHAM 117.3 1.020
CLAPHAM 71.55 1.037
OJOCALI 120.5 1.048
HERNANDZ 1.006 69.42
TAOS 70.77 1.026
BLACKLAK 70.69 1.025
MORA TAP
NORTON_2 120.2 1.045
NORTON 357.7 1.037
Santa Fe
B-A 119.5 1.039
B-A 355.6 1.031
Rio Puerco
ROWE_TAP 1.022
COLINAS 1.030
ELDRADOT 1.033
ZIA_1 1.039
VALENCIA 118.8 1.033
VALENCIA 46.40 1.009
BACA 46.39 1.009
BACA 12.43 0.995
GALLINAS 12.71 1.017
ARRIBA 119.6 1.040
ARRIBA 12.69 1.015
STORRIE 119.3 1.038
STORRIE 25.91 1.041
RAINVL1 119.5 1.039
RAINVL2 25.80 1.036
ROSEBUD 112.7 0.980
ROSEBUD 13.34 0.967
HESSBDW 119.5 1.039
HESSBDW 14.34 1.039
ARGONNEG 0.655 1.091
LONEMS 0.545 0.957
CLINECORNER 362.8 1.052
GUADLUPE 363.7 1.054
TAIBANMS 362.4 1.050
BLACKWTR 362.2 1.050
General Electric International, Inc. PSLF Program Tue Feb 26 15:10:17 2019 C:\PSLF_Work\LCL_Mora_SIS\Cases\wUP5_11_20LS_PST_wMORA_GLD-190.sav
Don Carlos Wind Farm SIS
Case 11: LS Post-Project with Mora
Gladstone PST at 190 MW
Seed Case: 21LSP1a.sav
Upgrade: 230 kV to Springer, DCWF 165 MW
MW/MVAR
Rating = 1

APPENDIX D

TRANSIENT STABILITY PLOTS

Available upon request due to large number of plots

APPENDIX E

HIGH VOLTAGE MITIGATION ALTERNATIVES STUDY

Don Carlos Wind Farm
Generator Interconnection

System Impact Study
Mitigation Alternatives

Prepared By:
Utility System Efficiencies, Inc. (USE)

November 16, 2018
Version 1.2

Prepared by
Ben Stephenson, P.E. Utility System Efficiencies, Inc.
Lynn Chapman Greene Lucky Corridor, LLC

FOREWORD

Lucky Corridor has identified PNM and Tri-State as affected systems. Both parties have been engaged in the System Impact Study Version 2 re-study. Tri-State expressed concern over the outage event that results in loss of both 115 kV line segments between Gladstone and Springer. This event results in dangerously high instantaneous high voltage at York Canyon, Bison, Van Bremer, and Springer around 1.35 p.u.

This Mitigation Alternatives report is prepared for Lucky Corridor, LLC by Utility System Efficiencies, Inc. (USE). Any correspondence concerning this document, including technical questions, should be referred to:

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7 EXECUTIVE SUMMARY

On August 30, 2018 Lucky Corridor held an Affected System Review and Comment Forum. At that forum Tri-State expressed concern over the outage event that results in loss of both line segments between Gladstone and Springer. This event results in instantaneous high voltage at York Canyon, Bison, Van Bremer, and Springer around 1.4 p.u. This outage condition can occur a number of ways. Tri-State specifically identified an Out of Step relay on the existing Tri-State Gladstone-Springer 115 kV line that opens the line when the loading exceeds the 923 Amp rating.

This Mitigation Alternatives report is focused on addressing this high voltage concern. The Don Carlos Wind Farm (DCWF) System Impact Study (SIS) identifies other reliability concerns that are proposed to be mitigated by a generator tripping Remedial Action Scheme (RAS). The mitigation project proposed within this report will be in addition to the RAS proposed in the current Version 2 draft DCWF SIS report.

This study captures the pertinent results of which will be added to the DCWF SIS report if the affected parties find the results and recommendations acceptable.

<u>Preferred Mitigation Alternative</u>

This Mitigation Alternatives study recommends Alternative 5 which changes the plan for the first two segments of the Mora Line Transmission Project. The new plan would be to construct a 230 kV line from Don Carlos directly to Springer, bypassing Gladstone substation. The 230 kV voltage class allows the Mora Line distance to reach 32 miles further, bypassing Gladstone which eliminates the Out of Step relay concern that triggers the simultaneous loss of both Gladstone-Springer 115 kV lines resulting instantaneous high voltage in the Northeast New Mexico system.

The DCWF will be curtailed to 165 MW during the heavy winter and light spring condition when Gladstone PST flow is 190 MW, limited by the pre-contingency loading of PNM's Arriba Tap-Valencia 115 kV line loading. The DCWF RAS will protect this line from post-contingency overloads.

Alternative 5 consists of a new 954 ACSR 230 kV line from Don Carlos to Springer, 200 MVA 230/115 kV transformer at Springer, and a 20 MVAr shunt reactor at the Don Carlos 230 kV switching station. The 115 kV Mora Line segment from Springer to Arriba will remain unchanged.

Alternative 5 is preferred over the other Alternatives that add SVC/STATCOM because of the instantaneous nature of the high voltage concern. Even though the new device is dynamic, all equipment in the affected area will be exposed to the extremely high voltage for a few cycles endangering facilities and/or risking flashover.

8 INTRODUCTION

The high voltage concern was not identified in the version 2 report discussed at the forum because of the following:

- The existence of the Out of Step relay was unknown by Lucky Corridor until Tri-State notified Lucky Corridor shortly before the forum. The simultaneous outage of both the Tri-State Gladstone-Springer 115 kV Line and the Mora Gladstone-Springer 115 kV Line was originally identified as an Extreme Event outage rather than a common corridor P7-1 Event outage. The existence of the OOS relay increases the likelihood of the extreme event coupled with the ramifications of dangerously high voltage make the mitigation of this condition important to Tri-State.

- The post-contingency solution parameters used in the Version 2 System Impact Study align with the Tri-State Engineering Standards Bulletin (ESB) which allows transformer taps and switch shunt devices to adjust. The high voltage is not a concern once these elements respond to the voltage excursion. The high voltage is observed to be a post-transient issue that occurs prior to transformer tap and switch shunt device adjustment.

A myriad of options have been considered by Lucky Corridor and the preferred solutions that warrant detailed evaluation in this Mitigation Alternatives report are as follows:

- **Alternative 1: 25 MVAr SVC at Springer**
  Install a 25 MVAr SVC at Springer to replace the existing 12.5 MVAr shunt capacitor. The new SVC will utilize the shunt capacitor bus position. No new circuit breakers at Springer are expected to be required.

- **Alternative 2: 50 MVAr SVC at Springer**
  Increase the size of the new Springer SVC to 50 MVAr.

- **Alternative 3: 25 MVAr SVC at Arriba Tap**
  Install a 25 MVAr SVC at Arriba Tap and terminate the Mora Line at Arriba Tap rather than at Arriba. PNM requires a 3 breaker ring at Arriba Tap as part of the MLTP. This station will need to be expanded to allow for 5 connections. Hopefully PNM will allow for a 5 breaker ring bus.

- **Alternative 4: 50 MVAr SVC at Arriba Tap**
  Increase the size of the new Arriba Tap SVC to 50 MVAr.

- **Alternative 5: Bypass Gladstone with a 230 kV connection to Springer**
  Bypass Gladstone substation and proceed directly to Springer substation with a 230 kV Don Carlos-Springer transmission line. The line will assumed to be the same conductor

as planned for the 115 kV, 954 ACSR. A 200 MVA 230/115 kV transformer will step the voltage down to 115 kV at Springer and proceed to Arriba as originally planned.

In order to maintain pre-contingency loading on the Arriba Tap-Valencia 115 kV line, the project will need to curtail to 165 MW (net) in the light load period in the heavy winter and light spring seasons. The 180 MW (net) output is acceptable in the heavy summer season.

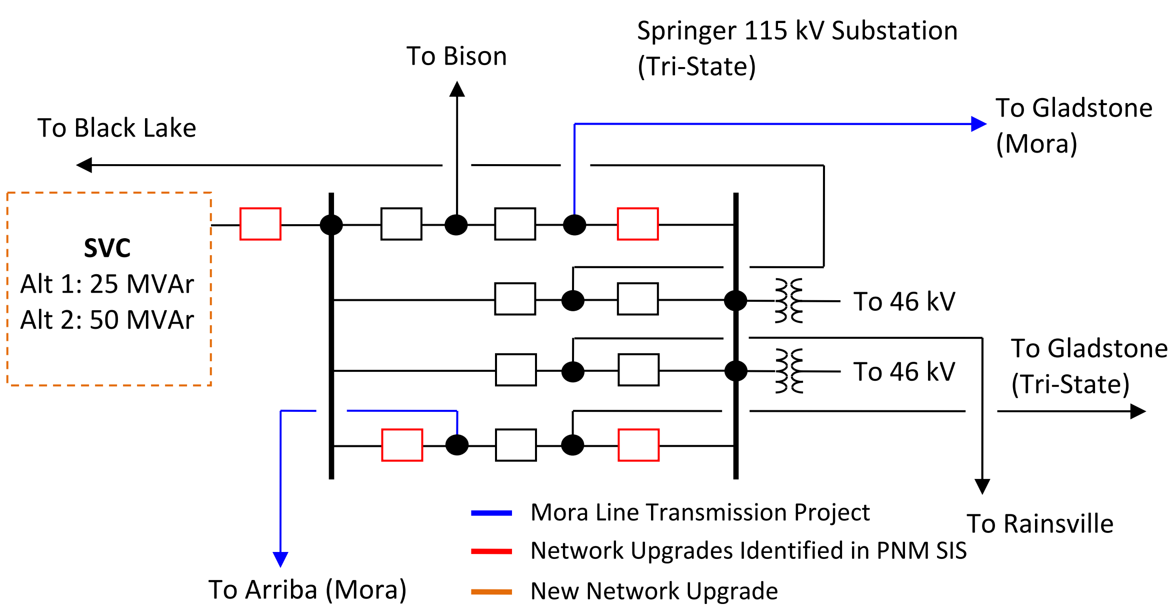
9 MITIGATION ALTERNATIVES MODELING

This section discusses the details of how each alternative will be physically connected. The power flow model and the dynamic model created for the new SVC are copies from the 50 MVAr Clapham SVC.

9.1 ALTERNATIVES 1 AND 2: SPRINGER SVC

Figure 1 below shows how the Springer SVC might connect to the Tri-State Springer 115 kV Bus. The SVC would replace the existing shunt capacitor at Springer.

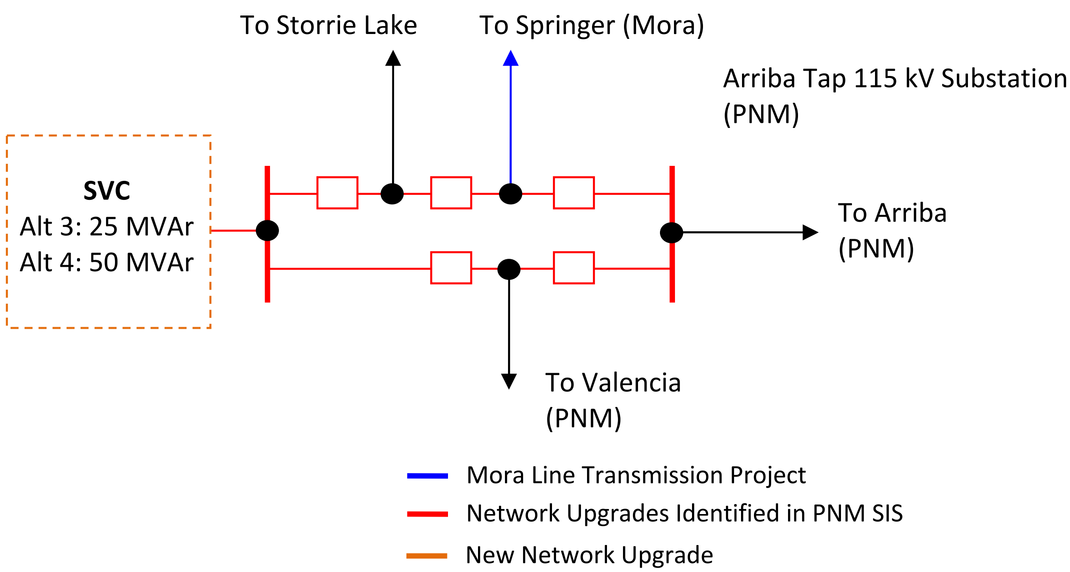
FIGURE 6. ALTERNATIVES 1 AND 2: SPRINGER SVC INTERCONNECTION



9.2 ALTERNATIVES 3 AND 4: ARRIBA TAP SVC

Figure 2 below shows how the Arriba Tap SVC might connect to the PNM Arriba Tap 115 kV Bus with the Mora Line termination moved to Arriba Tap as well. A five breaker ring bus is proposed at Arriba Tap to accommodate all 5 terminations.

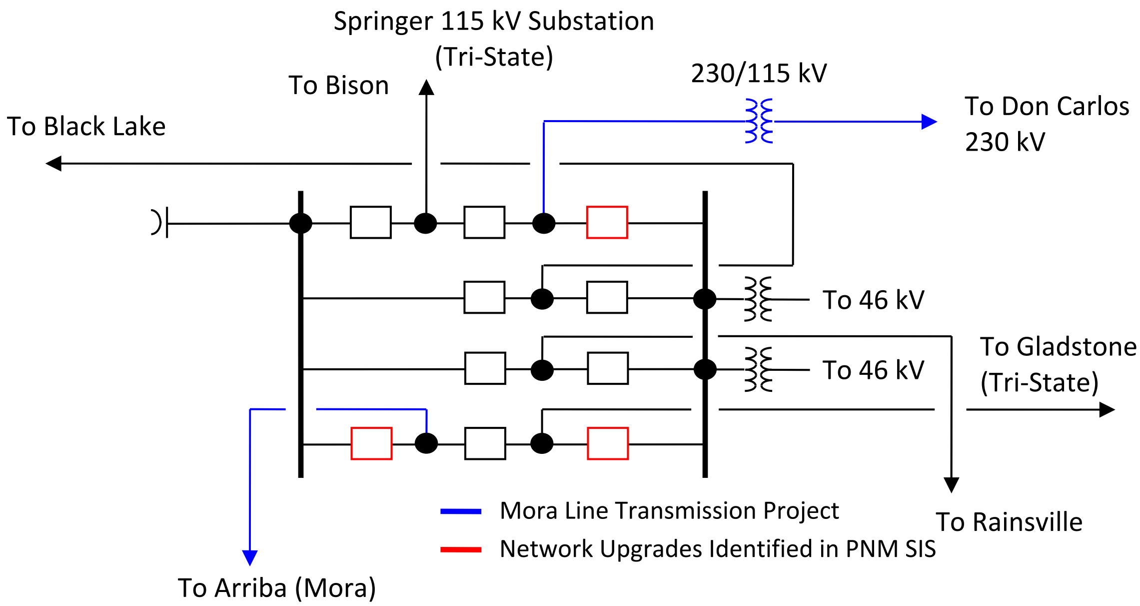
FIGURE 7. ALTERNATIVES 3 AND 4: ARRIBA TAP SVC INTERCONNECTION



9.3 ALTERNATIVE 5: BYPASS GLADSTONE WITH A 230 KV CONNECTION TO SPRINGER

Figure 3 below shows how a 230 kV line can be used to bypass any connection with the Gladstone substation and connect directly to Springer. The 115 kV bus connection originally planned for Mora's Gladstone-Springer 115 kV line can be substituted for the 200 MVA 230/115 kV transformer. It is assumed that the same conductor size and type planned for the 115 kV line , 954 ACSR, will be used for the 230 kV line.

FIGURE 8. ALTERNATIVE 5: SPRINGER 230/115 KV DIRECT CONNECTION



10 STUDY DESCRIPTION AND ASSUMPTIONS

This study evaluates the impact of various mitigation solutions that mitigate the high voltage concern.

10.1 SYSTEM IMPACT STUDY CASES

A total of 15 cases were created to properly evaluate the impact of each Mitigation Alternative. **Table 1** below lists the cases and specific modeling attributes.

TABLE 21. STUDY CASE SUMMARY

		Season			Mitigation Alternative				
#	Scenario Description	Heavy Summer	Heavy Winter	Light Spring	Springer 25 MVAr	Springer 50 MVAr	Arriba Tap 25 MVAr	Arriba Tap 50 MVAr	Springer 230 kV
2020 Heavy Summer Case									
Case 3 Alt1	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√			√				
Case 3 Alt2	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√				√			
Case 3 Alt3	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√					√		
Case 3 Alt4	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√						√	
Case 3 Alt5	Post-Project, Don Carlos at 180 MW, Gladstone PST at 180 MW	√							√
2020 Heavy Winter Case									
Case 9 Alt1	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW		√		√				
Case 9 Alt2	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW		√			√			
Case 9 Alt3	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW		√				√		
Case 9 Alt4	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW		√					√	
Case 9 Alt5	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW		√						√
2021 Light Spring									
Case 11 Alt1	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW			√	√				
Case 11 Alt2	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW			√		√			
Case 11 Alt3	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW			√			√		
Case 11 Alt4	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW			√				√	
Case 11 Alt5	Post-Project, Don Carlos at 180 MW, Gladstone PST at 190 MW			√					√

The resulting power flow attributes of each case are tabulated in **Table 2** on the following page. The green highlighted cells represent a reduction in fixed reactive support switched into service pre-contingency.

TABLE 22. STUDY CASE ATTRIBUTES

	Heavy Summer						Heavy Winter						Light Spring					
Element/Characteristic	SIS	Alt1	Alt2	Alt3	Alt4	Alt5	SIS	Alt1	Alt2	Alt3	Alt4	Alt5	SIS	Alt1	Alt2	Alt3	Alt4	Alt5
Gladstone 230 kV	234.0	234.1	235.0	233.7	233.7	235.4	229.7	230.1	232.7	229.9	230.0	233.4	231.0	231.9	232.6	231.7	231.3	231.6
Gladstone 115 kV	119.0	119.0	119.5	118.8	118.8	119.6	117.1	117.3	118.6	117.3	117.3	118.9	117.7	118.3	118.6	118.1	117.9	118.2
Springer 115 kV	117.8	117.9	119.0	117.5	117.5	118.5	115.0	115.5	117.7	115.5	115.6	117.9	116.2	116.8	117.6	116.7	116.2	117.6
Springer 69 kV	71.5	71.6	71.3	71.8	71.8	71.5	72.0	71.4	71.4	71.9	71.9	72.0	71.7	71.6	71.6	71.5	71.6	71.6
Black Lake 115 kV	118.3	118.4	117.5	118.2	118.2	118.6	117.9	118.2	117.6	118.3	118.3	118.1	118.3	118.3	117.0	118.6	116.6	118.8
Black Lake 69 kV	70.8	70.8	70.8	70.7	70.7	70.5	71.2	70.5	71.0	71.0	71.1	70.9	70.9	71.3	70.9	71.0	70.7	70.8
Bison 115 kV	118.2	118.0	119.1	117.6	117.6	118.6	115.7	116.0	118.0	116.0	116.0	118.1	117.0	117.4	117.9	117.2	116.7	117.7
Van Bremer 115 kV	119.4	117.9	119.0	117.5	117.5	118.5	117.8	116.8	118.8	116.8	116.8	117.5	119.5	118.5	117.6	118.3	117.8	117.5
York Canyon 115 kV	119.8	117.8	118.9	117.5	117.5	118.5	118.5	117.0	119.1	117.0	117.0	117.4	120.2	118.8	117.5	118.6	118.1	117.4
York Canyon 69 kV	70.8	70.6	70.3	70.4	70.4	70.5	71.0	70.6	70.9	70.6	70.6	70.3	70.6	70.7	70.4	70.6	70.3	70.4
Taos 345 kV	351.5	351.6	349.0	351.4	351.4	351.7	350.2	350.5	350.4	350.8	350.7	350.2	352.6	353.5	351.3	352.7	350.2	354.3
Taos 115 kV	118.4	118.5	118.7	118.4	118.4	118.5	118.5	118.7	118.5	118.8	118.8	119.0	119.1	118.8	118.5	119.2	118.7	119.1
Taos 69 kV	70.8	70.8	70.9	70.7	70.7	70.8	71.1	70.7	71.1	71.2	71.2	70.9	70.7	70.9	70.8	70.7	70.9	70.7
Rainsville 115 kV	117.7	117.8	118.0	118.1	118.1	117.6	114.0	114.4	116.4	116.2	116.9	116.6	116.1	116.6	117.2	117.7	117.5	116.6
Rainsville 24.9 kV	25.3	25.4	25.4	25.4	25.4	25.3	24.6	24.7	25.1	25.0	25.2	25.1	25.1	25.2	25.3	25.4	25.4	25.2
Storrie Lake 115 kV	118.2	118.2	117.9	119.0	119.0	117.5	114.5	114.9	116.7	117.7	118.9	116.7	116.6	116.9	117.4	118.9	118.9	116.5
Storrie Lake 24.9 kV	25.7	25.7	25.6	25.9	25.9	25.6	24.9	25.0	25.4	25.6	25.9	25.4	25.3	25.4	25.5	25.8	25.8	25.3
Arriba 115 kV	118.3	118.4	118.0	119.1	119.1	117.6	114.6	115.0	116.8	117.8	119.0	116.9	116.7	117.0	117.5	119.0	119.0	116.6
Arriba 12.5 kV	12.6	12.6	12.5	12.7	12.7	12.7	12.7	12.6	12.6	12.7	12.8	12.8	12.7	12.6	12.6	12.7	12.7	12.5
Gallinas 115 kV	118.2	118.2	117.9	119.0	119.0	117.5	114.5	114.9	116.7	117.8	119.0	116.8	116.6	116.9	117.4	119.0	119.0	116.5
Arriba Tap 115 kV	118.2	118.2	117.8	119.0	119.0	117.4	114.5	114.9	116.7	117.8	119.0	116.7	116.6	116.9	117.4	119.0	119.0	116.5
Valencia 115 kV	118.0	118.1	117.4	118.6	118.6	117.1	114.6	114.9	116.6	117.5	118.6	116.6	116.5	116.8	117.3	118.6	118.6	116.2
New SVC	0	25	46	14	14	0	0	25	50	25	33	0	0	25	50	21	23	0
Gladstone SVD	32	32	32	32	32	32	31	31	32	31	31	32	31	32	32	32	32	32
Clapham SVC	41	40	37	42	42	37	16	14	7	15	15	5	27	30	28	30	32	24
Clapham SVD	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Springer SVD	13	0	0	13	13	0	12	0	0	13	13	13	13	0	0	13	13	13
Black Lake SVD	16	16	0	16	16	16	32	32	16	32	32	16	32	32	16	32	15	32
York Canyon SVD	8	0	0	0	0	0	16	8	8	8	8	0	16	8	0	8	8	0
Cimarron SVD	4	0	0	4	4	0	13	13	4	13	9	9	9	9	4	9	9	0
Cimarron DVAr	-1	0	0	0	0	0	-1	-1	-1	-1	0	-2	-1	-1	0	-1	0	1
Valencia Capacitor	8	8	0	0	0	0	7	7	8	0	0	8	8	8	8	0	0	0
Case	**3**	**3a1**	**3a2**	**3a3**	**3a4**	**3a5**	**8**	**8a1**	**8a2**	**8a3**	**8a4**	**8a5**	**11**	**11a1**	**11a2**	**11a3**	**11a4**	**11a5**

11 STUDY METHODOLOGY

This section summarizes the methods used to derive the post-transient and transient stability results. The full outage list applied in the DCWF SIS Version 2 are applied in this evaluation, however the focus of both the post-transient and transient study is upon safe and acceptable voltage performance.

11.1 POST-TRANSIENT METHODOLOGY

Only post-transient solution parameters are used in this technical evaluation which are different than what was applied in the DCWF SIS Version 2. As such, the post-transient post contingency solution will not allow TCUL, SVD, nor PST adjustment. **Table 3** summarizes the solution parameters used in this study.

TABLE 23. SOLUTION PARAMETERS

Parameter	Pre-Contingency	Post-Contingency
Tap Changer Under Load Adjustment	Yes	No
Automatic Phase Shifter Adjustment	Yes	No
Automatic Switched Voltage Device Adjustment	Yes	No
Area Interchange Control	Yes	No

11.2 TRANSIENT METHODOLOGY

The full contingency list was applied to the cases, but the focus was on the transient voltage behavior of the York Canyon, Van Bremer, Bison, Springer, Black Lake, and Cimarron 115 kV busses.

12 RESULTS AND FINDINGS

The focus of this study is upon mitigation of the post-contingency transient and post-transient voltage performance in the Northeast New Mexico 115 kV system without creating any new reliability concerns. Addition of the SVC is not expected to impact the thermal loading results reported in the DCWF SIS Version 2 report. The thermal loading results are only reported for mitigation Alternative 5.

The contingencies were also simulated on the post-project DCWF SIS seasonal cases using the revised methodology to demonstrate the high voltage concern.

12.1 THERMAL LOADING RESULTS: ALTERNATIVE 5

The thermal loading results with Alternative 5 appear to be reasonable. The Don Carlos Wind Farm RAS (DCWF RAS) sufficiently mitigates all post-contingency loading concerns on the ARRIBA_T - VALENCIA 115kV Line and the SPRINGER - RAINVL_T 115 kV Line.

The ARRIBA_T - VALENCIA 115kV Line is 96.3 % loaded pre-contingency in the heavy winter case and 97.4 % loaded pre-contingency in the light spring case, which limits the output to 165 MW net during these light load seasons with high Gladstone PST north to south flow.

The design of the DCWF RAS will be slightly simpler with Alternative 5 because the input of the Gladstone-Springer 115 kV Lines are no longer necessary.

TABLE 24. ALTERNATIVE 5 (SPRINGER 230KV) THERMAL LOADING RESULTS WITH DCWF RAS

					Heavy Summer Gladstone: 180 MW			Heavy Winter Gladstone: 190 MW			Light Spring Gladstone: 190 MW		
	Outage	Overloaded Element	Area	Rating	Pre	Post wMLTP	Post wAlt5 DCWF @180	Pre	Post wMLTP	Post wAlt5 DCWF @165	Pre	Post wMLTP	Post wAlt5 DCWF @165
	NERC P0 Events												
0	No Outage Taken	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	25.6	96.0	95.8	26.8	99.9	96.3	29.8	99.6	97.4
	NERC P1 Events												
33	Taos-Springer 115 kV Line	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	25.7	141.7	144.8	40.7	158.1	154.2	50.9	166.0	168.5
	Taos-Springer 115 kV Line (wDCWF RAS)	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	25.7	[2]75.7	[2]58.7	40.7	[2]91.1	[2]72.9	50.9	[2]99.9	[2]86.9
35	Gladstone-Clapham 115 kV Line)	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	41.5	117.5	116.1	36.7	113.8	109.0	36.7	118.3	114.9
	Gladstone-Clapham 115 kV Line (wDCWF RAS)	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	41.5	[1]101.6	[1]94.6	36.7	[1]97.2	[1]90.6	36.7	[1]101.1	[1]95.8
55	Springer-Arriba 115 kV Line (Mora)	SPRINGER - RAINVL_T 115 kV Line 1	10	462 A		85.5	85.0		109.3	106.3		94.0	91.9
	Springer-Arriba 115 kV Line (Mora)(wDCWF RAS)	SPRINGER - RAINVL_T 115 kV Line 1	10	462 A		85.5	85.0		[2]73.8	[2]65.6		94.0	91.9
68	Gladstone 230/115kV Tran 1	Gladstone 230/115kV Tran 2	10	200 M	91.3	93.1	90.0	99.2	97.3	96.1	99.8	96.6	99.2
	NERC P2 Events												
91	Springer 115kV Center CB 2	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	25.7	141.8	144.8	41.0	158.1	154.5	51.0	166.0	168.8
	Springer 115kV Center CB 2 (wDCWF RAS)	ARRIBA_T - VALENCIA 115kV Line 1	10	497 A	25.7	[2]75.5	[2]58.7	41.0	[2]90.9	[2]73.2	51.0	[2]99.7	[2]87.1
				Case	**01**	**03**	**03a5**	**PRE**	**08**	**08a5**	**09**	**11**	**11a5**

Note 1: DCWF RAS ramps project back to 100 MW

Note 2: DCWF RAS trips project offline

Note 3: The outages that result in the highest ARRIBA_T - VALENCIA 115kV Line loading are reported. Other outages can cause the line to overload that will also be mitigated by the DCWF RAS.

12.2 POST-TRANSIENT VOLTAGE RESULTS: ALTERNATIVES 1-4

The post-transient voltage concern is only fully-mitigated for all seasons by Alternative 2, the 50 MVAr SVC at Springer. The other three alternatives result in voltage magnitudes greater than the 1.1 p.u. performance standard, the highest location being the Springer 69 kV bus.

Heavy Summer

The post-transient voltage results are shown in **Table 5** on the following page. The 25 MVAr or the 50 MVAr SVC at Springer appears to mitigate the high voltage concern. There are a few low voltage concerns identified in the Clapham 69 kV system using the revised methodology. These concerns are slightly aggravated when the SVC is located at Arriba and somewhat improved when the SVC is located at Springer.

Heavy Winter

The post-transient voltage results are shown in **Table 6** a few pages down. Only the 50 MVAr SVC at Springer appears to mitigate the high voltage concern. There is also a high voltage deviation in the PNM Valencia 46 kV system that is mitigated by either the 50 MVAr SVC at Springer or either size SVC at Arriba Tap. There is also a low voltage concern in the same PNM Valencia 46 kV system that is slightly aggravated by placing the SVC at Springer. The DCWF RAS will initiate tripping the DCWF back to 100 MW, after which the voltages in the 46 kV system return to acceptable magnitudes.

Light Spring

The post-transient voltage results are shown in **Table 7** a few pages down. Only the 50 MVAr SVC at Springer appears to mitigate the high voltage concern. There is also a high voltage deviation in the PNM Valencia 46 kV system that is mitigated by either the 50 MVAr SVC at Springer or either size SVC at Arriba Tap. There is also a low voltage concern in the same PNM Valencia 46 kV system that is slightly aggravated by placing the SVC at Springer. The DCWF RAS will initiate tripping the DCWF offline, after which the voltages in the 46 kV system return to acceptable magnitudes.

TABLE 25. HEAVY SUMMER VOLTAGE RESULTS WITH SVC ALTERNATIVES 1-4

				Heavy Summer														
	Outage	Bus	Area	SIS			Alt1: Springer 25 MVAr			Alt2: Springer 50 MVAr			Alt3: Arriba T 25 MVAr			Alt3: Arriba T 50 MVAr		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events																	
1	Don Carlos Wind Farm	GLDSTNPS 230	10	0.993	0.927	-6.6	0.993	0.923	-7.1	0.997	0.923	-7.4	0.992	0.910	-8.3	0.992	0.910	-8.3
57	Gladstone-Don Carlos 115 kV	CLAYTON 12.5	10	1.009	0.949	-5.9	1.009	0.953	-5.5	1.009	0.973	-3.6	1.009	0.922	-8.6	1.009	0.922	-8.6
		VANBUREN 69	10	0.954	0.898	-5.9	0.954	0.902	-5.5	0.954	0.920	-3.5	0.954	0.872	-8.6	0.954	0.872	-8.6
		CLAYTON 69	10	0.956	0.900	-5.8	0.956	0.903	-5.5	0.956	0.922	-3.5	0.956	0.874	-8.5	0.956	0.874	-8.5
		ROSEBUD 13.8	10	0.964	0.914	-5.2	0.964	0.917	-4.8	0.964	0.934	-3.1	0.964	0.891	-7.5	0.964	0.891	-7.5
		SEDAN 24.9	10	0.991	0.934	-5.8	0.991	0.937	-5.4	0.991	0.954	-3.5	0.991	0.907	-8.4	0.991	0.907	-8.4
		SEDAN_T 69	10	0.982	0.928	-5.5	0.982	0.931	-5.2	0.982	0.949	-3.3	0.982	0.903	-8.0	0.982	0.903	-8.0
		GLDSTNPS 230	10	0.993	0.906	-8.7	0.993	0.908	-8.6	0.997	0.917	-8.0	0.992	0.894	-9.8	0.992	0.894	-9.8
78	Clapham 115 kV SVC 1	VANBUREN 69	10	0.954	0.889	-6.8	0.954	0.891	-6.7	0.954	0.908	-4.9	0.954	0.889	-6.9	0.954	0.889	-6.9
		CLAYTON 69	10	0.956	0.891	-6.8	0.956	0.893	-6.6	0.956	0.910	-4.8	0.956	0.891	-6.8	0.956	0.891	-6.8
	NERC EE Events																	
109	Gladstone-Springer 1&2 115 kV	YORKCANY 115	10	1.042	1.200	15.2	1.025	1.040	1.5	1.034	1.034	0.0	1.022	1.105	8.2	1.022	1.081	5.9
		VANBREMR 115	10	1.039	1.196	15.1	1.025	1.040	1.5	1.035	1.035	0.0	1.022	1.105	8.2	1.022	1.082	5.9
		SPRINGER 69	10	1.037	1.191	14.9	1.037	1.053	1.5	1.034	1.034	0.0	1.040	1.124	8.1	1.040	1.101	5.8
		CIM_GEN 0.3	10	1.042	1.191	14.3	1.030	1.042	1.2	1.038	1.038	0.0	1.038	1.113	7.2	1.038	1.089	4.9
		BISON 115	10	1.028	1.182	15.0	1.026	1.041	1.5	1.035	1.035	0.0	1.023	1.106	8.1	1.023	1.082	5.8
		YORKCANY 69	10	1.026	1.182	15.2	1.023	1.038	1.5	1.019	1.019	0.0	1.020	1.104	8.2	1.020	1.080	5.9
		SPRINGER 115	10	1.025	1.179	15.1	1.025	1.041	1.5	1.035	1.035	0.0	1.021	1.105	8.2	1.021	1.081	5.9
			Case	**03**			**03 Alt1**			**03 Alt 2**			**03 Alt 3**			**03 Alt 4**		

TABLE 26. HEAVY WINTER VOLTAGE RESULTS WITH SVC ALTERNATIVES 1-4

				Heavy Winter														
	Outage	Bus	Area	SIS			Alt1: Springer 25 MVAr			Alt2: Springer 50 MVAr			Alt3: Arriba T 25 MVAr			Alt3: Arriba T 50 MVAr		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events																	
1	Don Carlos Wind Farm	GLDSTNPS 230	10	0.969	0.900	-7.1	0.969	0.898	-7.3	0.982	0.912	-7.1	0.968	0.893	-7.7	0.968	0.892	-7.9
57	Gladstone-Don Carlos 115 kV	GLDSTNPS 230	10	0.969	0.894	-7.8	0.969	0.893	-7.9	0.982	0.908	-7.5	0.968	0.888	-8.4	0.968	0.886	-8.5
53	Valencia-Arriba Tap 115 kV	12ST_TAP 46	10	1.008	1.093	8.4	1.004	1.086	8.2	1.000	1.065	6.5	1.007	1.032	2.5	1.004	1.016	1.3
		BACA 46	10	1.007	1.092	8.4	1.003	1.085	8.2	0.999	1.064	6.5	1.006	1.031	2.5	1.003	1.015	1.3
		BACA 12.5	10	1.017	1.102	8.4	1.012	1.095	8.2	1.002	1.067	6.5	1.003	1.028	2.5	0.994	1.006	1.3
		VALENCIA 46	10	1.009	1.094	8.4	1.005	1.087	8.2	1.001	1.066	6.5	1.008	1.033	2.5	1.005	1.017	1.3
		VALENCIA 115	10	0.997	1.081	8.4	1.000	1.081	8.1	1.014	1.080	6.5	1.021	1.047	2.5	1.031	1.044	1.2
	NERC P2 Events																	
91	Springer 115 kV Center CB 2	12ST_TAP 46	10	1.008	0.916	-9.2	1.004	0.900	-10.3	1.000	0.893	-10.7	1.007	0.926	-8.0	1.004	0.960	-4.4
		BACA 46	10	1.007	0.915	-9.2	1.003	0.899	-10.3	0.999	0.892	-10.7	1.006	0.925	-8.0	1.003	0.959	-4.4
		BACA 12.5	10	1.017	0.924	-9.1	1.012	0.908	-10.3	1.002	0.895	-10.6	1.003	0.923	-8.0	0.994	0.950	-4.4
		VALENCIA 46	10	1.009	0.917	-9.1	1.005	0.902	-10.3	1.001	0.895	-10.6	1.008	0.927	-8.0	1.005	0.961	-4.4
		VALENCIA 115	10	0.997	0.907	-9.1	1.000	0.897	-10.2	1.014	0.907	-10.6	1.021	0.940	-7.9	1.031	0.986	-4.3
99	Gladstone 115 kV Center CB 3	GLDSTNPS 230	10	0.969	0.902	-6.9	0.969	0.902	-7.0	0.982	0.917	-6.7	0.968	0.897	-7.4	0.968	0.895	-7.5
	NERC EE Events																	
EE	Gladstone-Springer 1&2 115 kV	CIM_GEN 0.3	10	1.045	1.323	26.5	1.047	1.144	9.2	1.040	1.049	0.9	1.046	1.212	15.8	1.037	1.131	9.1
		SPRINGER 69	10	1.038	1.307	25.9	1.035	1.137	9.8	1.035	1.046	1.1	1.041	1.210	16.2	1.043	1.146	10.0
		YORKCANY 115	10	1.032	1.306	26.6	1.018	1.120	10.0	1.035	1.047	1.1	1.017	1.186	16.6	1.018	1.121	10.2
		VANBREMR 115	10	1.026	1.299	26.6	1.016	1.117	10.0	1.033	1.045	1.1	1.015	1.184	16.6	1.016	1.119	10.2
		YORKCANY 69	10	1.023	1.296	26.6	1.023	1.126	10.0	1.027	1.039	1.1	1.023	1.193	16.6	1.023	1.127	10.2
		BISON 115	10	1.007	1.271	26.2	1.009	1.108	9.8	1.026	1.037	1.1	1.009	1.173	16.3	1.009	1.110	10.0
		SPRINGER 115	10	1.001	1.262	26.1	1.005	1.104	9.9	1.023	1.035	1.1	1.004	1.168	16.3	1.005	1.107	10.1
			Case	**08**			**08 Alt1**			**08 Alt 2**			**08 Alt 3**			**08 Alt 4**		

TABLE 27. LIGHT SPRING VOLTAGE RESULTS WITH SVC ALTERNATIVES 1-4

				Light Spring														
	Outage	Bus	Area	SIS			Alt1: Springer 25 MVAr			Alt2: Springer 50 MVAr			Alt3: Arriba T 25 MVAr			Alt3: Arriba T 50 MVAr		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events																	
1	Don Carlos Wind Farm	GLDSTNPS 230	10	0.972	0.902	-7.2	0.975	0.900	-7.8	0.978	0.900	-7.9	0.974	0.899	-7.7	0.973	0.897	-7.8
57	Gladstone-Don Carlos 115 kV	GLDSTNPS 230	10	0.972	0.895	-7.9	0.975	0.896	-8.2	0.978	0.896	-8.3	0.974	0.890	-8.6	0.973	0.886	-8.9
33	Taos-Springer 115 kV	12ST_TAP 46	10	1.008	0.924	-8.3	0.998	0.917	-8.1	0.996	0.923	-7.3	1.007	0.941	-6.5	1.007	0.990	-1.7
		BACA 46	10	1.008	0.924	-8.3	0.998	0.917	-8.1	0.996	0.922	-7.3	1.006	0.941	-6.5	1.007	0.989	-1.7
		BACA 12.5	10	1.012	0.929	-8.2	0.996	0.916	-8.0	0.994	0.922	-7.3	1.005	0.940	-6.5	1.005	0.988	-1.7
		VALENCIA 46	10	1.008	0.924	-8.3	0.998	0.917	-8.1	0.996	0.923	-7.3	1.007	0.941	-6.5	1.007	0.990	-1.7
		VALENCIA 115	10	1.013	0.929	-8.3	1.016	0.933	-8.1	1.020	0.945	-7.4	1.031	0.963	-6.5	1.031	1.013	-1.7
		ROWE 24.9	10	1.037	0.950	-8.4	1.037	0.951	-8.3	1.039	0.957	-7.9	1.046	0.969	-7.4	1.047	1.000	-4.4
		ROWE_TAP 115	10	1.013	0.927	-8.4	1.012	0.927	-8.4	1.014	0.934	-7.9	1.021	0.945	-7.4	1.022	0.976	-4.4
	NERC P2 Events																	
91	Springer 115 kV Center CB 2	12ST_TAP 46	10	1.008	0.913	-9.5	0.998	0.895	-10.3	0.996	0.880	-11.6	1.007	0.930	-7.6	1.007	0.979	-2.7
		ARRIBA 12.5	10	1.015	0.928	-8.6	1.006	0.910	-9.5	1.004	0.895	-10.9	1.017	0.946	-6.9	1.017	0.998	-1.9
		BACA 46	10	1.008	0.912	-9.5	0.998	0.895	-10.3	0.996	0.880	-11.6	1.006	0.930	-7.6	1.007	0.979	-2.7
		BACA 12.5	10	1.012	0.917	-9.4	0.996	0.894	-10.2	0.994	0.880	-11.5	1.005	0.929	-7.5	1.005	0.978	-2.7
		GALLINAS 12.5	10	1.019	0.929	-8.8	1.003	0.905	-9.7	1.007	0.895	-11.1	1.021	0.950	-7.0	1.021	1.001	-1.9
		VALENCIA 46	10	1.008	0.913	-9.5	0.998	0.895	-10.3	0.996	0.880	-11.6	1.007	0.930	-7.6	1.007	0.979	-2.7
		VALENCIA 115	10	1.013	0.917	-9.5	1.016	0.911	-10.3	1.020	0.901	-11.6	1.031	0.952	-7.6	1.031	1.003	-2.7
	NERC EE Events																	
109	Gladstone-Springer 1&2 115 kV	YORKCANY 115	10	1.045	1.350	29.2	1.033	1.161	12.4	1.022	1.034	1.2	1.031	1.231	19.4	1.027	1.153	12.3
		CIM_GEN 0.3	10	1.044	1.348	29.2	1.046	1.169	11.7	1.040	1.050	0.9	1.045	1.240	18.7	1.042	1.160	11.4
		VANBREMR 115	10	1.039	1.342	29.1	1.030	1.158	12.4	1.022	1.035	1.2	1.028	1.227	19.3	1.024	1.150	12.2
		SPRINGER 69	10	1.039	1.337	28.7	1.038	1.165	12.3	1.038	1.051	1.2	1.036	1.234	19.1	1.038	1.164	12.1
		YORKCANY 69	10	1.023	1.321	29.2	1.025	1.152	12.4	1.021	1.033	1.2	1.023	1.221	19.4	1.019	1.144	12.3
		BISON 115	10	1.017	1.310	28.9	1.020	1.146	12.3	1.025	1.037	1.2	1.019	1.214	19.1	1.015	1.138	12.1
		SPRINGER 115	10	1.011	1.302	28.8	1.016	1.141	12.3	1.023	1.035	1.2	1.014	1.209	19.2	1.010	1.133	12.2
			Case	**11**			**11 Alt1**			**11 Alt 2**			**11 Alt 3**			**11 Alt 4**		

12.3 POST-TRANSIENT SVC VOLTAGE EXPOSURE: ALTERNATIVES 1-4

The voltage is expected to rise immediately following the events that open both Gladstone-Springer 115 kV Lines. The new SVC is designed to respond to the voltage excursion and detect the high voltage and quickly begin to switch out the capacitive elements and insert the reactive elements. Tri-State has expressed some concern over the whether the SVC will remain connected to the system and bring the voltage down or if it's own protection step in and trip the unit before it has a chance to respond.

This section evaluates the post-transient voltage that the SVC will be exposed to prior to any response by locking the unit output at the pre-contingency output during the post-transient power flow solution. The Gladstone-Springer Double Line Outage is applied to the light spring case because it exhibits the highest voltage magnitude. **Table 8** below identifies the post-transient voltage exposure for each mitigation alternative.

TABLE 28. ALTERNATIVES 1-4 POST-TRANSIENT HIGH VOLTAGE SVC EXPOSURE

Mitigation Alternative	Location	Voltage (p.u.)	Voltage (kV)
1: 25 MVAr SVC at Springer	Springer 115 kV	1.273	146.3
2: 50 MVAr SVC at Springer	Springer 115 kV	1.263	145.2
3: 25 MVAr SVC at Arriba Tap	Arriba Tap 115 kV	1.266	145.5
4: 50 MVAr SVC at Arriba Tap	Arriba Tap 115 kV	1.256	144.5

12.4 POST-TRANSIENT VOLTAGE RESULTS: ALTERNATIVE 5

The only post-transient voltage concern is mitigated by the DCWF RAS. Loss of the Taos-Springer 115 kV Line or the Springer 115 kV Center CB 2 (which open-ends the Taos-Springer) causes significant voltage deviation in the southern portion of the Northeast New Mexico system under light spring conditions. The DCWF RAS will automatically trip the generation post-contingency, mitigating the voltage deviation.

There are no post-transient high voltage concerns with this alternative. Since Gladstone is bypassed, eliminating the original concern raised by Tri-State.

The project is observed to be of benefit in the heavy summer following an outage of the Clapham #1 SVC. The Tri-State voltages are less than 0.9 p.u. in the post project case, which is a significant improvement to the voltages less than 0.8 p.u. in the pre-project case.

TABLE 29. POST-TRANSIENT VOLTAGE RESULTS ALTERNATIVE 5

				Heavy Summer			Heavy Winter			Light Spring		
	Outage	Bus	Area	Alt5: Springer 230			Alt5: Springer 230			Alt5: Springer 230		
				Vpre	Vpst	Vdev	Vpre	Vpst	Vdev	Vpre	Vpst	Vdev
	NERC P1 Events											
33	Taos-Springer 115 kV	12ST_TAP 46	10	1.007	0.953	-5.3	1.003	0.931	-7.2	1.005	0.911	-9.4
		ARRIBA 12.5	10	1.016	0.968	-4.7	1.017	0.952	-6.4	1.015	0.930	-8.3
		BACA 12.5	10	1.008	0.956	-5.2	1.012	0.938	-7.2	1.003	0.910	-9.3
		GALLINAS 12.5	10	1.015	0.965	-4.9	1.014	0.946	-6.7	1.011	0.924	-8.6
		VALENCIA 46	10	1.007	0.954	-5.3	1.004	0.932	-7.2	1.005	0.911	-9.3
		ROWE 24.9	10	1.038	0.983	-5.4	1.033	0.961	-7.0	1.036	0.939	-9.3
		STORRIE 24.9	10	1.025	0.976	-4.7	1.018	0.951	-6.5	1.016	0.931	-8.4
	Taos-Springer 115 kV (wDCWF RAS)	*No voltage concerns*[2]										
78	Clapham SVC Unit 1	VANBUREN 69	10	0.954	[3]0.881	-7.6	1.007	1.007	0.0	1.019	1.019	0.0
		CLAYTON 69	10	0.956	[3]0.883	-7.6	1.008	1.008	0.0	1.020	1.020	0.0
		ROSEBUD 13.8	10	0.964	[3]0.899	-6.7	1.005	1.005	0.0	0.967	0.967	0.0
	NERC P2 Events											
91	Springer 115 kV Center CB 2	12ST_TAP 46	10	1.007	0.953	-5.3	1.003	0.924	-7.9	1.005	0.904	-10.0
		ARRIBA 12.5	10	1.016	0.968	-4.7	1.017	0.945	-7.1	1.015	0.923	-9.0
		BACA 12.5	10	1.008	0.956	-5.2	1.012	0.932	-7.9	1.003	0.904	-9.9
		GALLINAS 12.5	10	1.015	0.965	-4.9	1.014	0.939	-7.4	1.011	0.917	-9.3
		VALENCIA 46	10	1.007	0.954	-5.3	1.004	0.925	-7.9	1.005	0.905	-10.0
		ROWE 24.9	10	1.038	0.983	-5.4	1.033	0.957	-7.3	1.036	0.936	-9.7
		STORRIE 24.9	10	1.025	0.976	-4.7	1.018	0.944	-7.2	1.016	0.924	-9.1
	Springer 115 kV Center CB 2 (wDCWF RAS)	*No voltage concerns*[2]										
			Case	**03 Alt5**			**08 Alt5**			**11 Alt5**		

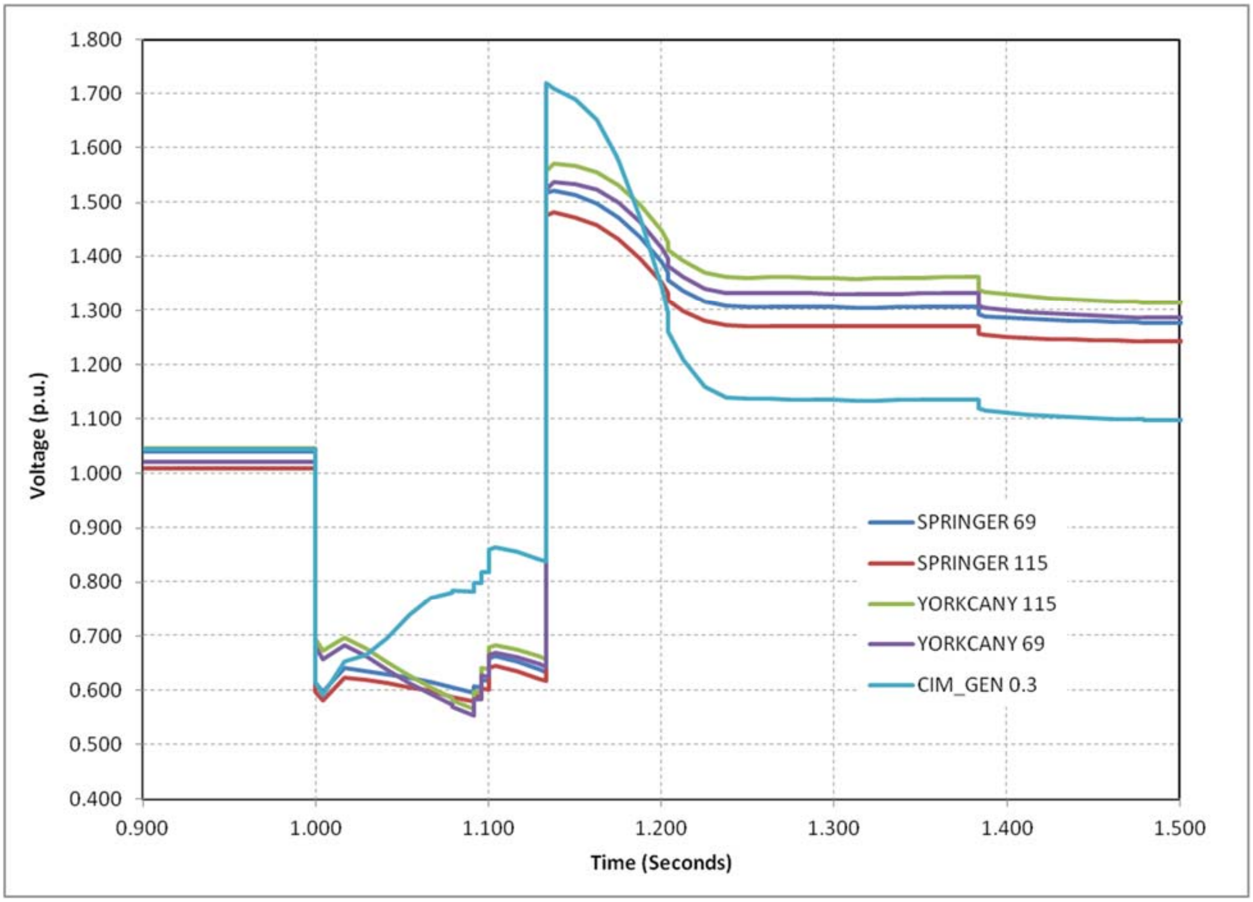
Note 2: DCWF RAS trips project offline

Note3: Pre-existing issue with significant post-project performance improvement

12.5 TRANSIENT STABILITY ANALYSIS: ALTERNATIVES 1-4

The transient voltage performance of the critical busses in the Northeast New Mexico system following the simultaneous outage of both Springer-Gladstone 115 kV Lines is shown in Figure 3 below. The Cimmarron Solar 300 V bus exhibits the highest transient voltage at 1.719 p.u. The York Canyon 115 kV bus sees the second highest voltage at 1.571 p.u.

FIGURE 9. NORTHEAST NEW MEXICO TRANSIENT VOLTAGE WITHOUT MITIGATION



The Cimmarron Solar 300 V bus remains above 1.1 p.u. for 0.342 seconds in the unmitigated simulation. The addition of the SVC reduces the time that the transient voltage is above 1.1 p.u. **Figure 5** on the following page demonstrates the benefit of the SVC. While the SVC does not benefit the instantaneous transient voltage deviation, it does reduce the amount of time that the voltage remains above the 1.1 p.u. threshold.

FIGURE 10. CIMARRON SOLAR TRANSIENT VOLTAGE WITH MITIGATION ALTERNATIVES 1-4

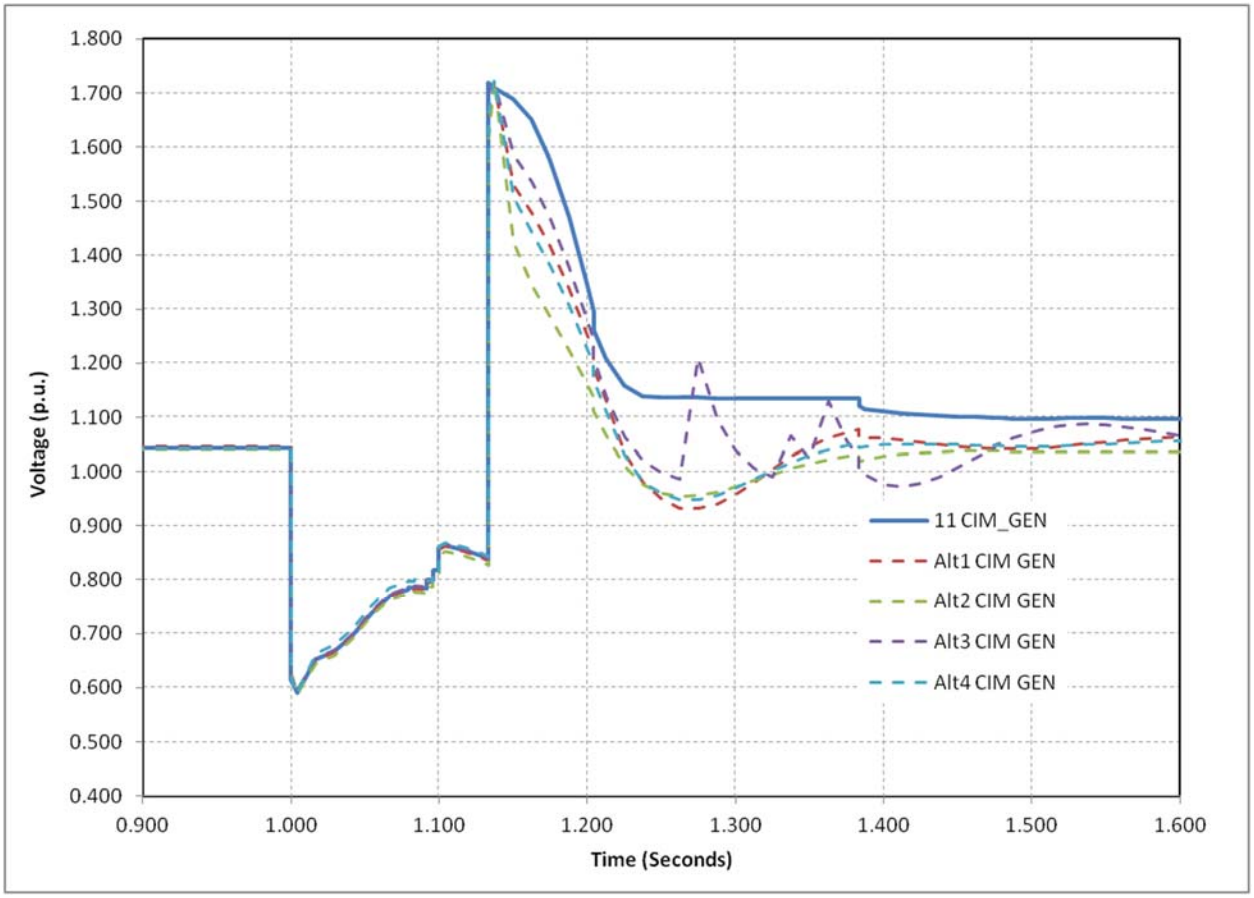


Table 10 below lists the maximum transient voltage observed and the duration of that transient voltage above 1.1 p.u. All four mitigation alternatives significantly reduce the transient overvoltage time from 0.342 seconds to less than 0.1 second. The most beneficial mitigation alternative is the 50 MVAr SVC at Springer which aligns with the post-transient analysis.

TABLE 30. TRANSIENT HIGH VOLTAGE DURATION FOR ALTERNATIVES 1-4

Mitigation Alternative	Location	Maximum Voltage (p.u.)	Over Voltage Duration (sec)
Unmitigated	CIM_GEN 0.3	1.719	0.342
1: 25 MVAr SVC at Springer	CIM_GEN 0.3	1.716	0.092
2: 50 MVAr SVC at Springer	CIM_GEN 0.3	1.723	0.080
3: 25 MVAr SVC at Arriba Tap	CIM_GEN 0.3	1.721	0.092
4: 50 MVAr SVC at Arriba Tap	CIM_GEN 0.3	1.724	0.092

12.6 NEUTRAL REACTIVE POWER TRI-STATE REQUIREMENT: ALTERNATIVE 5

Tri-State will require the reactive power flow on the new Springer 230/115 kV transformer to be less than 2 MVAr when the DCWF project is offline. This study finds that a 20 MVAr shunt reactor will be required at either Don Carlos or Springer 230 kV substations to manage the reactive power flow into Springer from the Mora Line.

The voltage at the 230 kV Don Carlos Switching Station is 250.4 kV or 1.089 p.u. when the DCWF is offline. This voltage is at the high-end of the acceptable post-contingency voltage standard of 1.10 p.u. and is above the pre-contingency voltage standard of 1.05 p.u. Therefore, it is recommended that the 20 MVAr shunt reactor be placed at the Don Carlos 230 kV station to meet the Tri-State neutral reactive power requirement and also manage Don Carlos 230 kV station voltage should the DCWF be taken out of service or offline for any reason.

TABLE 31. REACTIVE POWER FLOW ALTERNATIVE 5

Element	Heavy Summer	Heavy Winter	Light Spring
Springer 230/115 kV Transformer			
No shunt device	24 MVAr	23 MVAr	23 MVAr
20 MVAr Shunt Reactor at Springer 230 kV	1 MVAr	1 MVAr	1 MVAr
20 MVAr Shunt Reactor at Don Carlos 230 kV	1 MVAr	1 MVAr	1 MVAr

13 COST & CONSTRUCTION TIME ESTIMATES

13.1 COST ESTIMATE FOR ALTERNATIVES 1-4

The "Capital Costs for Transmission and Substations" prepared by Black and Veatch for the WECC published October 2012 posted on the WECC website describes the Capital Costs of an SVC:

Static VAr Compensators (SVCs) combine both technologies, while adding speed of support. SVCs are constantly connected to the grid, whereas capacitors and reactors typically have to be switched. SVCs are more expensive than their static counterparts; however, they offer more flexibility in resources. The costs for SVCs vary based on size and the assumptions made about the ease of installation. Table 3-5 below shows SVC costs identified by HydroOne, Arizona Public Service Company (APS), and the Peer Review Group adopted costs. Like Shunt Reactor and Series Capacitor capital costs, SVC costs assume a "turnkey" installation. (Page 3-4)

The table referenced in the quotation above identifies the cost of a 115 kV SVC to be $141,000 per MVAr. Using this unit cost, **Table 12** details the cost of each alternative evaluated in this study.

TABLE 32. ALTERNATIVES 1-4 SVC COST ESTIMATES

Equipment Description	Cost Estimate ($000,000)
Alternative 1: 25 MVAr SVC at Springer	3.525
Alternative 2: 50 MVAr SVC at Springer	7.050
Alternative 3: 25 MVAr SVC at Arriba Tap	3.525
Alternative 4: 50 MVAr SVC at Arriba Tap	7.050

13.2 COST ESTIMATE FOR ALTERNATIVE 5

The costs associated with Alternative 5 are not considered System Upgrades and will not be recoverable. Rather, Alternative 5 is a scope change to the existing Mora Transmission Line Project.