



SPP 2012 TPL Dynamic Stability Study

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Introduction

The objective of this study is to report findings from the 2012 Stability Compliance Assessment process to support compliance with NERC TPL- 001, TPL- 002, TPL-003, and TPL-004 Reliability Standards for future years 2013 and 2018. This report along with the Near-Term and Long-Term Load Flow Assessments will help fulfill requirements of applicable TPL Standards.

This report will summarize potential transient stability violations anticipated by SPP and the applicable mitigation plans developed by SPP Member Entities and SPP Engineering Staff.

A separate, comprehensive report will be issued detailing the 2012 Transmission Planning Compliance Statement for each TPL Standard. These statements will address how each requirement defined in the TPL Standards is fulfilled by one or more mechanism in the TPL Near-Term or Longer-Term Compliance Assessments.

Study Scope

Compliance with TPL Standards with respect to system stability requires that the following be completed:

- **Dynamic Screening**
Perform a dynamic screening of the SPP Transmission System on the MDWG 2012 Series 2013 Light Load and 2018 Summer Peak Case.
- **Dynamic Assessment of Member Specified Events**
SPP Members provided SPP Staff with the list, shown in Table 1 of Appendix A, of one hundred and fifteen (115) NERC Category B, C and D reliability events for transient stability performance analysis. This analysis has been completed for both the 2013 Light Load and 2018 Summer Peak Cases.
- **Mitigation of Unstable Events**
Determine mitigation measures for unstable events that will, by implementation, provide system stability.

Methodology

SPP Transmission System Screenings

The stability screening methodology consists of the application of a 3-phase fault at a specified bus “A” and subsequent tripping of the branch or transformer between bus “A” and bus “B”. The method would then be repeated with the fault at bus “B”. The 3-phase fault is applied for a sufficient duration that produces adequate system stress based on the voltage class (i.e., 8 cycles for less than 200 kV and 5 cycles for greater than 200 kV). This methodology will not identify instability regarding wind turbines or other types of asynchronous connections. SPP is currently developing a transient disturbance performance requirement that will identify unstable voltage deviations in asynchronous machines along with other voltage measurements (voltage recovery and stabilization) during transient events.

This screening tool used is PowerTech Lab’s Transient Stability Assessment Tool (TSAT). It is used to find areas of potential instability with the SPP Member baseline synchronous generators.

Member Specified Events

The events shown in Table 1 of Appendix A were simulated in PTI’s PSS/E Dynamics Package and the PSSPLT Plotting Package. A small number of events noted in the results section were studied in PLI’s Transient Stability Assessment Tool (TSAT). The events shown in Table 2 are those tested in previous years and removed for this year’s analysis since they may be invalid for current model sets or may have been redefined in a different contingency category.

Generator rotor speed, rotor angle, real power, and reactive power output were monitored for all SPP generators. Those generators exhibiting rotor speed and angle instability were marked for further analysis. This analysis consisted of determining and correcting the cause of instability and is further detailed in Appendix B of this report.

Some events necessitated a change in generation differing from that amount in the power flow models. In such cases, an offset amount was included to balance generation prior to event simulation.

Results

SPP Transmission System Screenings

Nine (9) 2013 Light Load and nineteen (19) 2018 Summer Peak contingencies were shown to have issues during the screening as shown in Appendix B, Tables 3 and 4. These contingencies were found to be stable through re-evaluation by reducing the screened clearing time to member specified, actual clearing times.

Member Specified Events

Appendix A, Table 1 shows that for both the 2013 Light Load and 2018 Summer Peak Cases, members provided 28 Category B, 44 Category C, and 43 Category D events for examination. Unstable events, along with implemented mitigation measures are shown in Appendix B, Tables 5 and 6.

Event C31 caused the Dolet Hills unit to be unstable. Therefore, an operating guide is needed such that the prior outage of Dolet Hills – Carrol 230 kV will necessitate Dolet Hills be curtailed to maximum net output of 400 MW in order to remain stable to protect for the fault and trip of Dolet Hills – SW Shreveport 345 kV. The owners are developing an operating guide to ensure stability.

The remaining Category C unstable events were corrected by correcting existing model data or fault descriptions. Satisfactory results were found for all Category D events showing instability by disconnecting the unstable units at the member recommended clearing time.

Conclusion

The MDWG 2012 Series 2013 Light Load and 2018 Summer Peak Load Cases were tested to be stable during normal conditions prior to this study, satisfying NERC TPL Category A requirements.

All unstable screened events shown in Appendix B, tables 3 and 4 were found to be stable when the member submitted fault clearing times were tested, satisfying NERC TPL Category B requirements.

All unstable, member specified events shown in Appendix B, tables 5 and 6 were found to be stable when the specified mitigation measures were applied, thereby satisfying NERC TPL Category C and D requirements. Category C, Event C31, requires an operating guide, which the owners are developing.

APPENDIX A – Events

Table 1: NERC Category B, C, and D Events

Event	Contingency
B1	3-Ø fault at Wolf Creek 345kV for 3.6 cycles. Trip Wolf Creek – Rose Hill Line. No reclosing.
B2	3-Ø fault at Wolf Creek 345kV for 3.6 cycles. Trip Wolf Creek – Benton Line. No reclosing.
B3	3-Ø fault at Wolf Creek 345kV 3.6 cycles. Trip Wolf Creek – LaCygne Line. No reclosing.
B4	3-Ø fault at JEC 345kV for 3.6 cycles. Trip JEC – Hoyt Line. No reclosing.
B5	3-Ø fault at JEC 230kV for 6 cycles. Trip JEC – Auburn Line. No reclosing.
B6	Tolk GSU outage with unit at 540 MW. No reclosing.
B7	Plant X to Tolk 230 kV line 3-Ø fault. No reclosing
B8	Tolk to Eddy 345 kV line outage. Typical reclosing
B9	Yoakum to Sundown 230 kV line outage. Typical reclosing.
B10	Tolk to TUCO 230 kV line 3-Ø fault. No reclosing
B11	Potter 345/230 kV transformer 3-Ø fault. No reclosing
B12	Iatan to Stranger Creek 345 kV 3-Ø fault. Clear fault 3.6 cycles. No reclosing.
B13	Iatan to Eastowne 345 kV 3-Ø fault. Clear fault 3.6 cycles. No reclosing.
B14	3-Ø fault at S3451 on T3 transformer. Normal clearing.
B15	3-Ø fault at S1211 on the S1211-S1220 line. Normal clearing.
B16	3-Ø fault at S1206 on the S1206-S1232 line. Normal clearing.
B17	3-Ø fault at S3458 on the S3458 - Cooper line. Normal clearing.
B19	N01A: 3PH fault at GGS on GGS-Sweetwater 345 kV Circuit #1; Normal clearing; No reclose attempts
B20	N07A: 3PH fault at GGS on GGS-Red Willow 345 kV; Normal clearing; No reclose attempts.
B21	N25A: 3PH fault at GGS on GGS-North Platte 230 kV Circuit #1; Normal clearing; No reclose attempts.
B22	3PH fault at GGS on high side of GGS 345/230 kV T-1 transformer; Normal clearing; No reclose attempts.
B23	Brookline to Monett to Flint Creek 345 kV 3-phase fault, reclosing on one terminal only and rotated every year (549984 – 547481 – 506935).
B24	ANO - Ft. Smith 500 kV Line
B26	3-Ø fault on Knoll-Smoky Hill 230 kV reclose once at 90 cycles and trip permanently.
B27	3-Ø fault on Smoky Hill to Summit 230 kV reclose once at 90 cycles and trip permanently.

Event	Contingency
B28	LaCygne-Stilwell 345kV 3PH fault at LaCygne, clear fault 3.6 cycles, with no reclosing.
C1	Prior outage of JEC-Auburn 230kV line; 3-Ø fault at JEC 345 kV for 3.6 cycles; Trip JEC-Hoyt line; No reclosing.
C3	Prior outage of Fairport - St Joe 345 kV with a 3-Ø fault near Cooper on Cooper - St Joe 345 kV.
C4	Prior outage of Holcomb generating unit with an outage of Mingo – Red Willow 345 kV line.
C5	3-Ø fault at Wolf Creek 345 kV for 3.6 cycles; Trip Wolf Creek-Benton line; No reclosing; Reduce Wolf Creek output to 800 MW (Transmission Operating Directive 300); 3-Ø fault for 3.6 cycles at Wolf Creek 345 kV; Trip Wolf Creek-LaCygne line; No reclosing
C6	Summit to Smoky Hills 230 kV 3-Ø fault and outage followed by Circle to Mullergren 230 kV 3-Ø fault, no reclosing.
C7	Knoll to Smoky Hills 230 kV 3-Ø fault and outage followed by Circle to Mullergren 230 kV 3-Ø fault, no reclosing.
C8	Prior outage of Tolk to Roosevelt #1 230 kV circuit with a 3-phase fault near Roosevelt on the Tolk to Roosevelt #2 230 kV circuit -- no reclosing.
C9	Prior outage Iatan-Stranger Creek 345kV, Iatan to Eastowne 345 kV 3-Ø fault, clear fault 3.6 cycles, no reclosing, trip Iatan unit #2.
C10	3-Ø fault at Wolf Creek 345 kV for 3.6 cycles; Trip Wolf Creek-LaCygne 345 kV line; No reclosing; Reduce Wolf Creek output to 800 MW (Transmission Operating Directive 302); 3-Ø fault at Wolf Creek 345 kV for 3.6 cycles; Trip Wolf Creek-Benton 345 kV; No reclosing.
C11	DLG fault at the S3451 end of the S3451-S3459 and S3451-S3454 lines. Normal clearing. Fault admittance 2240 - j 24526 MVA fault for 2013LL and 2246 - j 24574 MVA for 2018SP for initial fault.
C12	SLG fault at the S3451 end of the S3451-Raun line, followed by a stuck breaker and the opening of transformer T4 at S3451. Fault Admittance 576 - j 6089 MVA for 2013LL and 578 - j 6099 MVA for 2018SP for initial fault. Fault Admittance 450 - j 5339 MVA for 2013LL and 451 - j 5350 MVA for 2018SP after opening S3451-Raun.
C13	SLG fault at S1206 on the S1206 - S1232 line, followed by a stuck breaker and the opening of the S1206 - S1201 line. Fault Admittance 697 - j 5599 MVA for 2013LL and 699 - j 5607 MVA for 2018SP for initial fault. Fault Admittance 637 - j 5273 MVA for 2013LL and 638 - j 5280 MVA for 2018SP after opening S1206-S1232.
C14	N915: SLG fault at GGS on GGS-Sweetwater 345 kV Circuit #2, Stuck Breaker (GGS 3322), Drop GGS-Red Willow 345 kV line; Delayed clearing; No reclose attempts.
C15	Prior Outage of Brookline – Monett - Flint Creek 345 kV with a 3-phase fault near Brookline on Brookline - Morgan 345 kV, with reclosing first at Morgan and then Brookline (549984 – 547481 – 506935, 549984 – 300045).
C16	3-Ø fault and outage of the Brookline - Southwest Power Station (SWPS) John Twitty Energy Center (JTEC) 161 kV line followed by a 3-phase fault near JTEC SWPS on the JTEC SWPS - Southwest Treatment Plant - SPRM Battlefield 161 kV line, no reclosing (549969 – 549954, 549954 – 549960 – 549959).
C17	SLG fault on 531448 HOLCOMB3 which will trip Holcomb3 (531448) - HOLCOMB7 (531449) 345/115 kV transformer with breaker stuck which trips Holcomb3 (531448) to Jones3 (531379) 115 kV line (delayed trip).
C18	SLG Fault on the line Holcomb 3 (531448) to Fletcher3 (531393) 115 kV line with a SLG fault on Holcomb3 (531448) to Pioneer Tap (531392) (Fault at Holcomb).

Event	Contingency
C19	3-Phase fault on the line from Bus 539695 to bus 539679 with breaker stuck which trips Spearville 345/230 kV transformer (531469/539695).
C20	3-phase fault on the line from Bus 531449 to bus 523853 with stuck breaker which trips the line from Bus 531449 to Bus 531465. Delayed trip.
C22	Prior outage of South Hays-Great Bend 230 kV (530582-539679 Circuit #1) followed by three-phase fault on Knoll-Smoky Hill 230 kV (530558-530592 Circuit #1) reclose once at 90 cycles and trip permanently.
C23	Prior outage of Colby-Mingo 115 kV (530555-531429 Circuit #1) followed by three-phase fault on Colby-Hoxie-Beach 115 kV (530555-530556 Circuit #1 and 530556-530557 Circuit #1) reclose once at 20 cycles and trip permanently.
C24	Fault on Knoll 230/115 kV transformer (530561-530558-530629 ckt 1) with breaker 3010 failure resulting in clearing Knoll-Redline-Beach 115 kV line (530561-530605 Circuit #1 and 530605-530557 Circuit #1).
C25	3-Ø fault at Wolf Creek for 3.6 Cycles; Trip Wolf Creek-Rose Hill line; No reclosing; Reduce Wolf Creek output to 800 MW (Transmission Operating Directive 301); 3-Ø fault at Wolf Creek 345 kV for 3.6 cycles; Trip Wolf Creek-LaCygne line; No reclosing.
C26 ¹	Trip all generation at bus 539653 followed by a SLG fault from Holcomb (531448) to Plymell (531393) to PionTAP (Do this contingency for 18Summer) only (531392) (Fault at Pioneer Tap).
C27 ¹	3-Ø fault on Crockett (509240) - Latexo (509323) followed by 3 phase fault on Jacksonville (509242) - Overton (509080).
C28 ¹	Prior outage of Muskogee - Fort Smith 345 kV; 3-phase fault and trip Valliant - Lydia 345 kV.
C29 ¹	Prior outage of Diana - SW Shreveport 345 kV; 3-phase fault and trip Wilkes - Longwood 345 kV.
C30 ¹	Prior outage of Welsh - Lydia 345 kV; 3-phase fault and trip Welsh - NW Texarkana 345 kV. Welsh generation at Pmax.
C31 ¹	Prior outage of Dolet Hills - Carroll 230 kV; 3-phase fault and trip Dolet Hills - SW Shreveport 345 kV. Dolet Hills Plant at Pmax.
C32 ¹	Prior outage of Flint Creek Generator; 3-phase fault and trip GRDA1 - Flint Creek 345 kV.
C33 ¹	3-Ø fault and trip Welsh - Wilkes / Welsh - NW Texarkana 345 kV DCT. Welsh generation at Pmax.
C34 ¹	3-Ø fault and trip Diana - SW Shreveport / Longwood - SW Shreveport 345 kV DCT
C35 ¹	Phase-to-ground fault Welsh - NW Texarkana 345 kV with CB (#10610) failure at Welsh. 15-cycle delayed clearing removing Welsh - Wilkes 345 kV. Welsh generation at Pmax.
C36 ¹	Phase-to-ground fault Wilkes - Longwood 345 kV with CB (#1W10) failure at Wilkes. 15-cycle delayed clearing removing Wilkes - Welsh 345 kV. Wilkes generation at Pmax.
C37 ¹	Prior outage of Northeastern Station - Tulsa North 345 kV; 3-phase fault and trip Northeastern Station - Oneta 345 kV. Northeastern generation at Pmax.
C38 ¹	Prior outage of Northeastern Station - Tulsa North 345 kV; 3-phase fault and trip Northeastern Station - Delaware 345 kV. Northeastern generation at Pmax.

Event	Contingency
C39 ¹	Prior outage of Riverside Station - Sapulpa Rd 345 kV; 3-phase fault and trip Riverside Station - Pecan Creek 345 kV. Riverside (Cogentrix) generation at Pmax.
C40 ¹	Prior outage of Pittsburg - Muskogee 345 kV; 3-phase fault and trip Pittsburg - Seminole 345 kV. Kiowa generation at Pmax.
C41 ¹	Prior outage of Pittsburg - Valiant 345 kV; 3-phase fault and trip Pittsburg - Johnston County 345 kV. Kiowa generation at Pmax.
C42 ¹	3-Ø fault and trip Northeastern Station - Tulsa North 345 / 138 kV DCT (90-909 & 81-822). Northeastern generation at Pmax.
C43 ¹	Phase-to-ground fault Oneta - Riverside Station 345 kV with CB (#3405A) at Oneta. 15-cycle delayed clearing removing Oneta - Clarksville 345 kV.
C44 ¹	Phase-to-ground fault Riverside Station - Red Bud 345 kV with CB (#3405A) at Riverside. 15-cycle delayed clearing removing Riverside - Sapulpa 345 kV. Riverside (Cogentrix) generation at Pmax.
C45 ¹	Phase-to-ground fault Pittsburg - Muskogee 345 kV with CB (#3441A) at Pittsburg. 15-cycle delayed clearing removing Pittsburg - Seminole 345 kV. Kiowa generation at Pmax.
C46 ¹	Phase-to-ground fault Pittsburg - Valiant 345 kV with CB (#3329A) at Pittsburg. 15-cycle delayed clearing removing Pittsburg - Johnston County 345 kV. Kiowa generation at Pmax.
D2	3-Ø fault on Holcomb – Setab 345 kV with breaker failure taking out the 345-115 kV autotransformer.
D3	Jeffrey Energy Center (JEC) to Hoyt 345 kV 3-Ø fault, no reclosing, and trip JEC Unit #2.
D4	3-Ø fault on Auburn-Jeffery Energy Center (JEC) 230 kV; followed by 3-Ø fault on Hoyt-JEC 345 kV, no reclosing, and trip JEC Unit#2.
D5	Run fault on GRDA1 345 kV bus for 5 cycles. Then open Tonnece end of Tonnece-GRDA1 345 kV line, but stuck breaker 9580 at GRDA1. Run for 25 cycles and then drop GRDA 345/161 transformer #1 & breaker 9080 (GRDA bkr 500T opens correctly).
D7	Loss of Ft. Smith 500/345/161 kV Substation.
D9	3-Ø fault at the S3451 on T3 transformer, followed by a stuck breaker and the opening of the S3451-S3459 line.
D10	3-Ø fault at S3458 on the S3458 - Cooper line, followed by a stuck breaker and the opening of the west bus at S3458.
D11	Loss of the entire substation S3456, including the transformer to the 161-kV level.
D14	N902 : Simultaneous SLG fault on GGS-Sweetwater 345 kV Circuit #1 and 3PH fault on GGS-Sweetwater 345 kV Circuit #2 at cross point; Normal clearing; Reclose far end.
D15	5 cycle SLG fault on the 84th & Bluff end of the 84th & Bluff - Waverly 115 kV line breaker #7502 fails. The 84th & Bluff - 70th & Bluff 115 kV line is opened to clear the fault. There is no reclosure.
D16	Loss of Summit 230 kV Substation.
D17	Loss of JEC 345 kV Substation.
D18	3-Ø fault w/breaker failure at Hoyt 345 kV; After +4.6 cycles trip Hoyt-Stranger 345 kV line at Stranger; After +9 cycles breaker failure trip Hoyt-JEC line; Hoyt 345-43 breaker failure.
D19	3-Ø fault w/breaker failure at JEC 345 kV; After +4.6 cycles trip JEC-Hoyt line at Hoyt; After +9 cycles breaker failure trip JEC-Hoyt line and JEC 345-230 #26 transformer;

Event	Contingency
	JEC 345-17 breaker failure.
D20	3-Ø fault w/breaker failure at JEC 345 kV; After +4.6 cycles trip JEC-Summit line at Summit; After +9 cycles breaker failure trip JEC-Summit line and JEC 345-230 #26 transformer; JEC 345-25 breaker failure.
D21	3-Ø fault w/breaker failure at JEC 345 kV; After +4.6 cycles trip the JEC-Morris line at Morris; After +9 cycles breaker failure trip JEC-Morris line and JEC 345-230 #26 transformer; JEC 345-21 breaker failure.
D22	Loss of Knoll 115 kV Substation.
D23	Loss of Heizer 115 kV Substation.
D24	Brookline 345 kV double Circuit 3-phase fault on 161 kV bus 549969.
D25 ¹	3-Ø fault on Holcomb 345/115 kV Transformer (531448-531449-531450) followed by a trip of Holcomb 115/22 kV Transformer (531447-531448).
D26 ¹	3-Ø fault Hawthorn 161 kV bus with breaker failure that trips entire bus at 25 cycles.
D27	Loss of Wolf Creek 345 kV Substation.
D28 ¹	3-Ø fault Welsh - NW Texarkana 345 kV with CB (#10610) failure at Welsh. 15-cycle delayed clearing removing Welsh - Wilkes 345 kV. Welsh generation at Pmax.
D29 ¹	3-Ø fault Wilkes - Longwood 345 kV with CB (#1W10) failure at Wilkes. 15-cycle delayed clearing removing Wilkes - Welsh 345 kV. Wilkes generation at Pmax.
D30 ¹	3-Ø fault and trip NW Texarkana 345 kV Station.
D31 ¹	3-Ø fault and trip Flint Creek 161 kV Station.
D32 ¹	3-Ø fault and trip Diana 345 kV Station.
D33 ¹	3-Ø fault and trip Welsh 345 kV Station.
D34 ¹	3-Ø fault Oneta - Riverside Station 345 kV with CB (#3405A) at Oneta. 15-cycle delayed clearing removing Oneta - Clarksville 345 kV. Oneta generation at Pmax.
D35 ¹	3-Ø fault Tulsa SE 138 kV bus tie CB (#1345B) and clear entire station.
D36 ¹	3-Ø fault Tulsa PS 138 kV bus tie CB (#1349B) and clear entire station.
D37 ¹	3-Ø fault and trip Oneta 345 kV Station.
D38 ¹	3-Ø fault and trip Oneta 138 kV Station.
D39 ¹	3-Ø fault and trip Riverside 138 kV Station.
D40 ¹	3-Ø fault and trip Pittsburg 345 kV Station.
D41 ¹	3-Ø fault and trip Tulsa North 138 kV Station.
D42 ¹	3-Ø fault and trip Valliant 345 kV Station.
D43 ¹	3-Ø fault and trip Oklaunion - Lawton Eastside 345 kV with SPS failure.
D44 ¹	3-Ø fault Riverside Station - Red Bud 345 kV with CB (#3405A) at Riverside. 15-cycle delayed clearing removing Riverside - Sapulpa 345 kV. Riverside (Cogentrix) generation at Pmax.

Event	Contingency
D45 ¹	3-Ø fault Pittsburg - Muskogee 345 kV with CB (#3441A) at Pittsburg. 15-cycle delayed clearing removing Pittsburg - Seminole 345 kV. Kiowa generation at Pmax.
D46 ¹	3-Ø fault Pittsburg - Valiant 345 kV with CB (#3329A) at Pittsburg. 15-cycle delayed clearing removing Pittsburg - Johnston County 345 kV. Kiowa generation at Pmax.
D47 ¹	3-Ø fault and trip Riverside Station - Oneta / Red Bud / Pecan Creek 345 kV ROW. Riverside generation (Cogentrix) at Pmax.
D48 ²	3-phase fault on the line from Bus 531449 to bus 523853 with stuck breaker which trips the line from Bus 531449 to Bus 531465. Delayed trip.

[1]: Contingency introduced for 2012 TPL Study

[2]: Formerly known as contingency C20

Table 2: NERC Category B, C, and D Events Removed for 2012 TPL

Event	Contingency
B18	Sarepta to Longwood 345 kV 3-phase fault
B25	Grimes to Crockett 345kV Line (Pirkey to Grimes 345kV Line)
C2	Prior outage of GRDA 1 – Tonnece 345 kV with a 3-Ø fault near GRDA 1 on GRDA – Tulsa 345 kV.
C21	SLG fault 10% away from Wolf Creek on the Wolf Creek-LaCygne 345 kV line At 3.6 cycles, trip the LaCygne end. At 11.6 cycles trip the Wolf Creek end and clear the fault (Assume 3.6 cycles for 345 kV normal clearing and 8 more cycles for breaker failure).
D1	SLG fault 10% away from Wolf Creek on the Wolf Creek-LaCygne 345 kV line. At 4 cycles, trip the LaCygne end. At 12 cycles trip the Wolf Creek end and clear the fault (Assume 4 cycles for 345 kV normal clearing and 8 more cycles for breaker failure).
D6	Loss of Flint Creek 161 kV bus
D8	Loss of AEP’s NW Texarkana 345 kV bus
D12	Valliant to Welsh to NW Texarkana 345 kV 3-phase fault.
D13	NE Station to Tulsa North 345/138 kV double circuit 3-phase fault.

APPENDIX B – Results

Table 3: Mitigated Unstable Events for the 2013 Light Load Case Screening

Event	Fault Clearing Time	Event	Result	Corrected Clearing Time and Result
SCR13L-1	8.0 cy	Apply fault on bus 337903 and outage branch from Bus 337903 to Bus 505508	Unstable	Stable after 5 cycles
SCR13L -2	8.0 cy	Apply fault on bus 505508 and outage branch from Bus 505508 to Bus 337903	Unstable	Stable after 4.5 cycles
SCR13L -3	8.0 cy	Apply fault on bus 337904 and outage branch from Bus 337904 to Bus 505508	Unstable	Stable after 5 cycles
SCR13L -4	8.0 cy	Apply fault on bus 505508 and outage branch from Bus 505508 to Bus 337904	Unstable	Stable after 4.5 cycles
SCR13L -5	8.0 cy	Apply fault on bus 505508 and outage branch from Bus 505508 to Bus 338110	Unstable	Stable after 4.5 cycles
SCR13L -6	8.0 cy	Apply fault on bus 505508 and outage branch from Bus 505508 to Bus 505514	Unstable	Stable after 4.5 cycles
SCR13L -7	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 527848	Unstable	Stable after 7 cycles
SCR13L -8	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 528325	Unstable	Stable after 7 cycles
SCR13L -9	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 528618	Unstable	Stable after 7 cycles

Table 4: Mitigated Unstable Events for the 2018 Summer Peak Case Screening

Event	Fault Clearing Time	Event	Result	Corrected Clearing Time and Result
SCR18S-1	8.0 cy	Apply fault on bus 505502 and outage branch from Bus 505502 to Bus 300071	Unstable	Stable after 4.5 cycles
SCR18S-2	8.0 cy	Apply fault on bus 549954 and outage branch from Bus 549954 to Bus 300348	Unstable	Stable after 6 cycles
SCR18S-3	8.0 cy	Apply fault on bus 549954 and outage branch from Bus 549954 to Bus 549960	Unstable	Stable after 6 cycles
SCR18S-4	8.0 cy	Apply fault on bus 549954 and outage branch from Bus 549954 to Bus 549961	Unstable	Stable after 6 cycles
SCR18S-5	8.0 cy	Apply fault on bus 549954 and outage branch from Bus 549954 to Bus 549969	Unstable	Stable after 6 cycles
SCR18S-6	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509753	Unstable	Stable after 4.5 cycles
SCR18S-7	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509773	Unstable	Stable after 4.5 cycles
SCR18S-8	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509775	Unstable	Stable after 4.5 cycles
SCR18S-9	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509814	Unstable	Stable after 4.5 cycles
SCR18S-10	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509849	Unstable	Stable after 4.5 cycles
SCR18S-11	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509850	Unstable	Stable after 4.5 cycles
SCR18S-12	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509853	Unstable	Stable after 4.5 cycles
SCR18S-13	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 509875	Unstable	Stable after 4.5 cycles
SCR18S-14	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 510898	Unstable	Stable after 4.5 cycles
SCR18S-15	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 510904	Unstable	Stable after 4.5 cycles
SCR18S-16	8.0 cy	Apply fault on bus 509783 and outage branch from Bus 509783 to Bus 515473	Unstable	Stable after 4.5 cycles
SCR18S-17	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 527891	Unstable	Stable after 7 cycles
SCR18S-18	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 528325	Unstable	Stable after 7 cycles
SCR18S-19	8.0 cy	Apply fault on bus 528334 and outage branch from Bus 528334 to Bus 528618	Unstable	Stable after 7 cycles

Table 5: Mitigated Unstable Member Submitted Events for 2013 Light Load

Event	Unit(s)	Implemented Mitigation Measure and Results
C15	JTEC #2	High amplitude, low frequency oscillations found due to JTEC #2. Model verification produced new dynamics data for this unit. <u>All</u> units were stable subsequent to insertion of new dynamics data
C16	JTEC #2	High amplitude, low frequency oscillations found due to JTEC #2. Model verification produced new dynamics data for this unit. <u>All</u> units were stable subsequent to insertion of new dynamics data
C31	Dolet Hills	Dolet Hills Plant curtailed to 400 MW and the system returned to stability. Future Operating Guide will be required.
C37	Northeastern Units 3 & 4	High speed reclosing was removed from the fault description and the case was re-simulated. There was a low damping problem with Northeastern U3 and U4; however, they are considered stable.
C40	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C41	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C45	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C46	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
D5	Salina Units, Fort Gibson Units, and GRDA Unit 2.	All unstable units tripped at 5 cycles. System stability resulted.
D9	Fort Calhoun Unit 1	Ft. Calhoun Unit 1 tripped at 7.5 cycles. System stability resulted.
D26	Hawthorn Unit 5	Hawthorn Unit 5 tripped at 5 cycles. System stability resulted.
D28	Welsh Units 1,2,&3	Welsh units tripped at 3% overspeed. System stability resulted.
D29	Wilkes Units 1,2, & 3	Wilkes units tripped at 3% overspeed. System stability resulted.
D31	Flint Creek	Flint Creek unit tripped at 3% overspeed. System stability resulted.
D33	Welsh Unit 1	Welsh unit tripped at 3% overspeed. System stability resulted.
D36	TPS 2-1	TPS 2-1 unit tripped at 3% overspeed. System stability resulted.
D37	Oneta Plant	Oneta units tripped at 3% overspeed. System stability resulted.
D44	Cogentrix Unit S1	Cogentrix Unit S1 tripped at 3% overspeed. System stability resulted.
D45	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated resulting in instability. Repeated simulation removing all Kiowa units at 3.5 cycles and system stability resulted
D46	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated resulting in instability. Repeated simulation removing all Kiowa units at 3.5 cycles and system stability resulted.

Table 6: Mitigated Unstable Member Submitted Events for 2018 Summer Peak Load

Event	Unit(s)	Implemented Mitigation Measure and Results
C1	JEC 1, 2, & 3	JEC - Auburn 230kV outage corrected to exist prior to fault. System stability resulted.
C31	Dolet Hills 1	Dolet Hills Plant curtailed to 400 MW and the system returned to stability. Future Operating Guide will be required.
C37	Northeastern 3 & 4	High speed reclosing was removed from the fault description and the case was re-simulated. There was a low damping problem with Northeastern U3 and U4; however, they are considered stable.
C40	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C41	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C45	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
C46	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated. System stability resulted.
D2	Holcomb 1 & 2, S2, and S5	Unstable units tripped at 5 cycles. System stability resulted.
D4	JEC 1 & 3	JEC units tripped at 11 cycles. System stability resulted.
D5	All Salina units, GRDA 15, GRDA 17, CHOTST6, and CHOTS3	All unstable units tripped at 5 cycles. System stability resulted.
D10	Nebraska City 1 & 2	Nebraska City units tripped at 13.5 cycles. System stability resulted.
D19	JEC 1,2, & 3	JEC units tripped at 13.6 cycles. System stability resulted.
D20	JEC 1,2, & 3	JEC units tripped at 13.6 cycles. System stability resulted.
D21	JEC 1,2, & 3	JEC units tripped at 13.6 cycles. System stability resulted.
D26	Hawthorn and Blue Valley units	All unstable units tripped at 5 cycles. System stability resulted
D28	Welsh Units 1,2,&3	Welsh units tripped at 3% overspeed. System stability resulted.
D29	Wilkes 3-1	Wilkes 3-1 tripped at 3% overspeed. System stability resulted.
D31	Flint Creek	Flint Creek tripped at 3% overspeed. System stability resulted.
D33	Welsh Units 1,2,&3	Welsh units tripped at 3% overspeed. System stability resulted.
D34	All Oneta Units	Oneta units tripped at 3% overspeed. System stability resulted.
D36	TPS2-1 and TPS4-1	Unstable TPS units tripped at 3% overspeed. System stability resulted.

Event	Unit(s)	Implemented Mitigation Measure and Results
D37	All Oneta Units	Oneta units tripped at 3% overspeed. System stability resulted.
D39	RSS1-1 and RSS2-1	Unstable RSS units tripped at 3% overspeed. System stability resulted.
D44	All Cogentrix Units, RSS1-1, RSS2-1, and KEY 1 & 2	All unstable units tripped at 15 cycles. System stability resulted.
D45	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated resulting in instability. Repeated simulation removing all Kiowa units at 3.5 cycles and system stability resulted
D46	All Kiowa Units	Model data for Kiowa units was corrected and the study was repeated resulting in instability. Repeated simulation removing all Kiowa units at 3.5 cycles and system stability resulted
D48	Holcomb 1 and 2, S2, and S5	Unstable units tripped at 15 cycles. System stability resulted.

APPENDIX C – Plots

Generator responses showing the six (6) largest excursions for rotor speed, rotor angle, electrical power, and reactive power output were plotted in .pdf format and posted on TrueShare at: TWG >TPL Compliance Reports>2012 TPL Assessment>Results.