

**2009 SOUTHEAST ARIZONA
TRANSMISSION SYSTEM
STUDY REPORT**

January 21, 2010

Executive Summary

The Southeast Arizona Transmission System (SATS) study group, consisting of Transmission Providers, Transmission Customers, Distribution Providers, and other interested parties, has performed and reviewed analyses of the transmission system in Southeast Arizona to determine if the North American Electric Reliability Corporation (NERC) Reliability Standards and Western Electricity Coordinating Council (WECC) System Performance Criteria can be met for the planned system. Tasks completed as part of the SATS 2009 Study Plan include development of power flow cases to represent the planned system for the years 2010 through 2014 and 2019, revision of load forecasts, addressing expected increases in mining load, evaluation of the planned system for the years 2010 through 2014 and 2019, and identification of planned and potential projects for these time periods.

Each entity provided updated load forecasts for the 2010 – 2019 time period and these updated forecasts were reflected in the base cases developed for the SATS study. These forecasts reflected a reduction between 300 and 750 MW from the 2008 forecasts provided by the same entities.

A work group of SATS was formed to address the continuity of service issue in Cochise County raised in the 2008 Biennial Transmission Assessment by the Arizona Corporation Commission (ACC). This work group, the Cochise County Study Group (CCSG), completed a separate report, which has been filed with the ACC, along with a summary report and reference filing document.

Power flow analysis for the SATS footprint was conducted using the base cases developed for the years 2010 through 2014 and 2019. These base cases included planned projects that were expected to be in service prior to the system peak for each year. With the planned projects and the additional mitigation measures proposed for each year, the transmission system within the SATS footprint meets the NERC Reliability Standards and WECC System Performance Criteria.

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1. Introduction

The Southeast Arizona Transmission System (SATS) study group consists of entities in the region that provide generation, transmission, and distribution services in Southeast Arizona. Other interested parties include Project Developers, State and Federal Agencies, and neighboring utilities. The SATS study area includes all or portions of Cochise, Graham, Pima, Pinal, and Santa Cruz counties in Arizona. Within this region are generation, transmission and distribution facilities operated by:

- Arizona Public Service (APS)
- Central Arizona Water Conservation District / Central Arizona Project (CAWCD/CAP)
- Duncan Valley Electric Cooperative (DVEC)
- Graham County Electric Cooperative (GCEC)
- Southwest Transmission Cooperative (SWTC)
- Sulphur Springs Valley Electric Cooperative (SSVEC)
- Trico Electric Cooperative (Trico)
- Tucson Electric Power Company (TEP)
- UniSource Energy Services (UNSE)
- Western Area Power Administration (Western)

Other SATS participants include:

- Acciona
- Arizona Corporation Commission (ACC) Staff
- Arizona Power Authority (APA)
- Arizona Independent Scheduling Administrator (AzISA)
- Black Forest Partners
- El Paso Electric (EPE)
- Environmental Planning Group (EPG)
- Federal Energy Regulatory Commission (FERC) Staff
- Fort Huachuca
- New Mexico Renewable Energy Transmission Authority (NM RETA)
- Public Service Company of New Mexico (PNM)
- Southwestern Power Group
- Tessera Solar
- United States Bureau of Reclamation (USBR)
- WestConnect Planning Staff
- Western States Energy Solutions (WSES)

2. Study Scope

The SATS 2009 Study Plan was originally approved by the SATS participants on a conference call hosted on December 5, 2008 and approved by the Southwest Area

Transmission (SWAT) Subregional Planning Group (SPG) on January 13, 2009. The SATS 2009 Study Scope included:

- 1) Present Plan and subsequent findings to SWAT, WestConnect, and local stakeholders;
- 2) Revise load forecasts;
- 3) Engage SATS in early case building to ensure accuracy of database for 2009 ten-year planning cases;
- 4) Investigate implications of increased Freeport-McMoRan (FMI) loads in the SATS study footprint;
- 5) Investigate alternative configurations to mitigate high flows on the Winchester 345/230 kV transformer, Apache – Bicknell 230 kV line, and Bicknell 345/230 kV transformer caused by EHV system contingencies;
- 6) Develop and evaluate alternatives to the two joint Tortolita – North Loop 345 kV proposals based on the Southwest Public Power Resources Group (SPPR) Three Terminal Plan (TTP);
- 7) Investigate the impact of SunZia in coordination with other SWAT subcommittees and task forces, specifically the CATS-EHV and NM subcommittees and the Renewable Energy Transmission Task Force (RTTF);
- 8) Develop and evaluate alternatives for joint SWTC/TEP substation(s) to supply TEP/Trico loads south of Tucson;
- 9) Continue Cochise County Planning in an effort to comply with ACC recommendations;
- 10) May conduct studies to accommodate renewable projects;
- 11) Complete capital cost estimates and economic analysis, including losses;
- 12) Identify potential projects in the SATS footprint;
- 13) Conduct scenario sensitivity analysis, such as load forecast, efficiency, local renewable resources, local and distributed generation, and location of external resources.

During the August 6th, 2009 SATS meeting, the group deferred a number of the study scope items. Item 6 and 8 were deferred due to a reduction in the load forecasts which led to a number of future projects to be delayed. Item 7 was eliminated from the scope due to the advancement of the Sun Zia project. The project has advanced into Phase 2 of the WECC Three-Phase Rating Process and a peer review group has been formed to address any issues associated with the project. Item 10 was eliminated from the scope in order to avoid duplication efforts with the SWAT Renewable Transmission Task Force (RTTF). Item 13 was removed due to a reduction in the load forecasts within the SATS footprint. If new generation is proposed, it will be addressed by the transmission provider to which the generator intends to connect, through an Interconnection Study.

3. Load Forecasts

The SATS area load forecast was provided for years 2009 through 2019. The 2009 forecasted load ranged from 3008 MW in 2009 to 3839 MW in 2019. Based on previous data from 2008 it is shown in Figure 1 that the load forecast for 2009 decreased between 300 and 750 MW in the 2009 – 2019 time period.

Figure 1. SATS Area Load Forecast

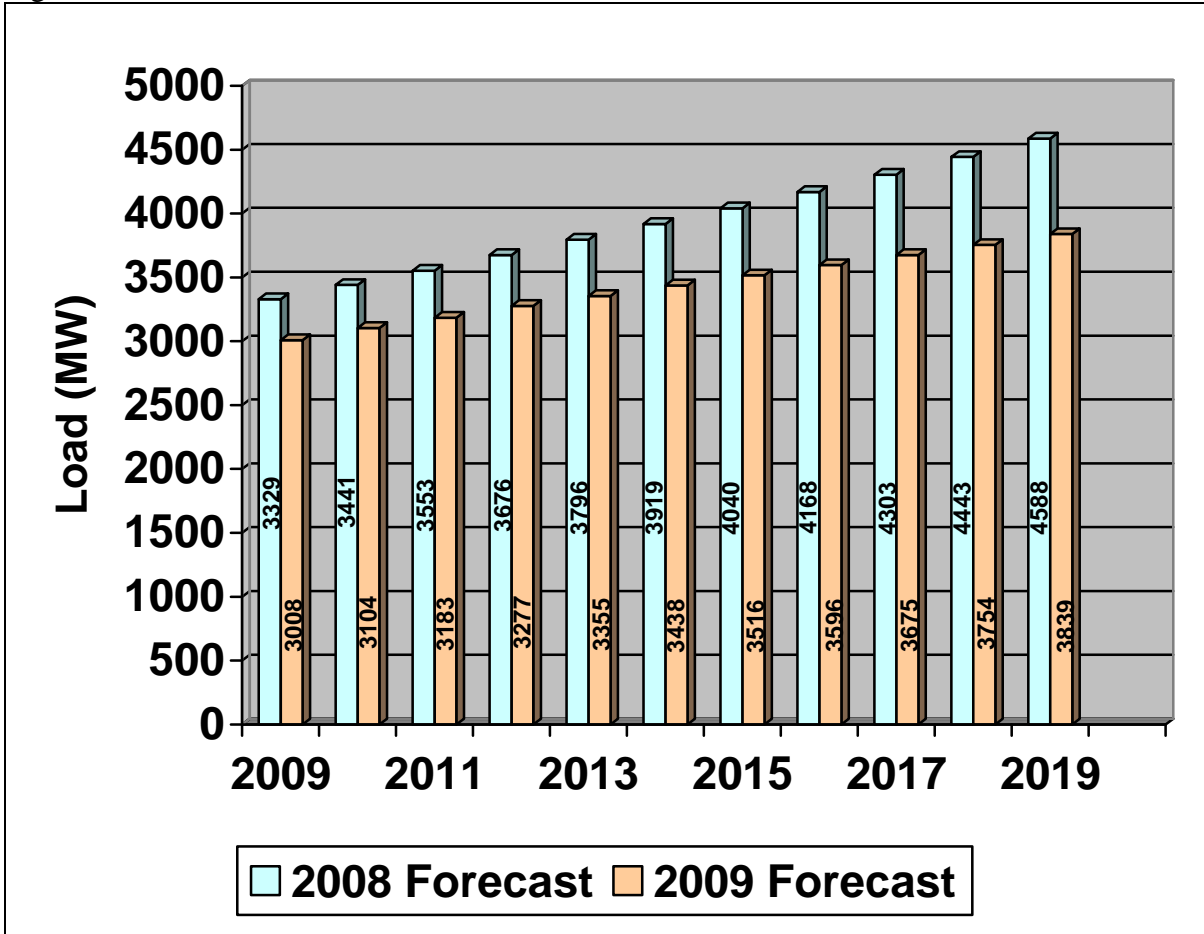
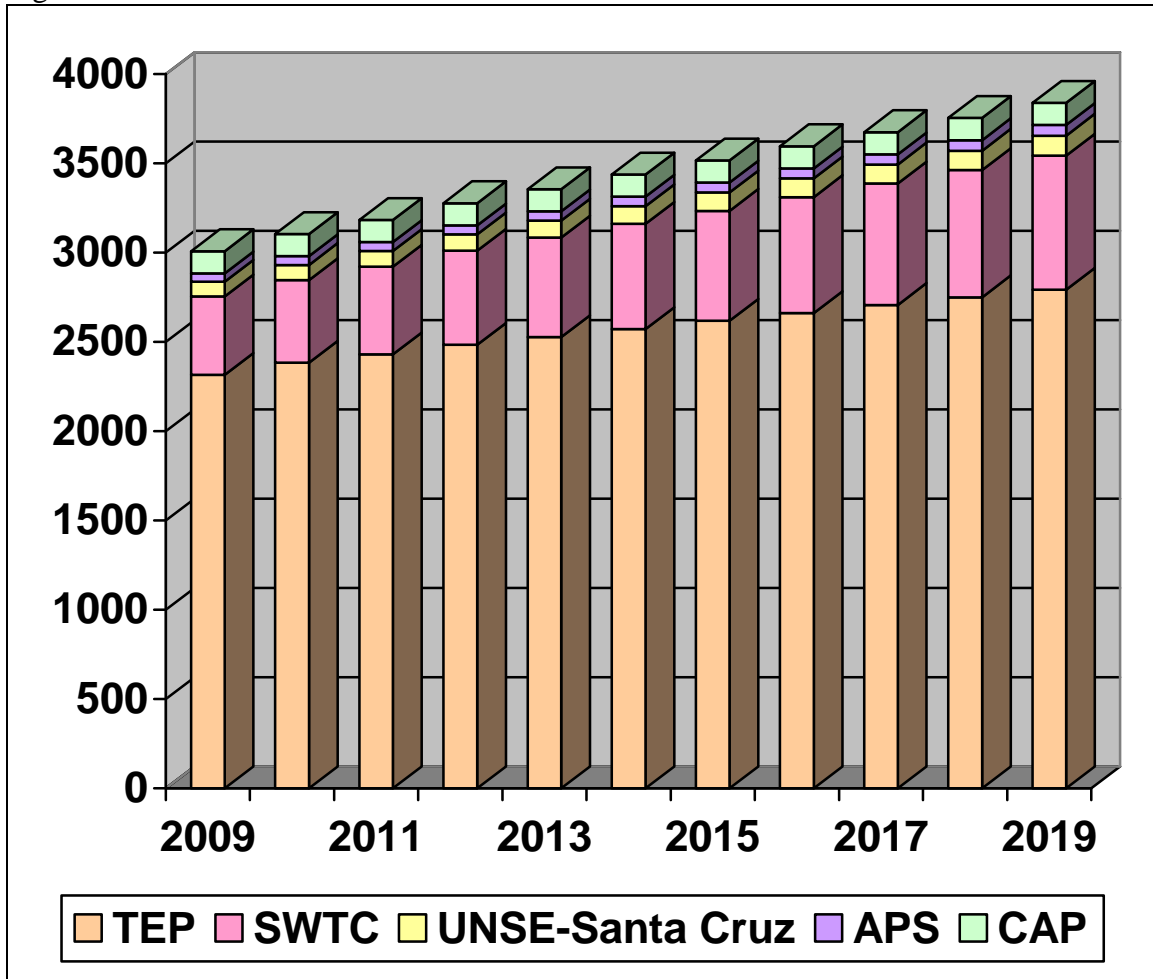


Figure 2 shows the SATS area load for each the entities in the SATS footprint. The SWTC forecasted load represents the loads of its cooperative members located in the SATS area. The members included in SATS are Trico, SSVEC, GCEC and DVEC.

Figure 2. Combined Load Forecast for SATS Entities



4. Power Flow Case Development

SATS Heavy Summer power flow cases were developed for years 2010 through 2014 and 2019. The cases were developed from the WECC approved heavy summer cases, however, not every year is available or current from WECC. Therefore, the 2010 case was developed from the WECC 2009 heavy summer (09HS1SA) case. The 2011 – 2014 cases were developed from the 2013 heavy summer case developed for the Cochise County study effort which was initially developed from the WECC 2012 heavy summer (12HS2S) case. The 2019 case was developed from the CATS-HV 2019 heavy summer case, which was developed from the WECC 2018 heavy summer (18HS1A) case.

5. FMI Load Impacts

In the past, the FMI mining loads in the SATS footprint have been a concern due to their expected/forecasted load increase. In 2009, SATS saw a decrease in the FMI load as opposed to the projected increase due to the downturn in the economic climate. The

decrease in load reduces any impacts and stress on the SATS area transmission system, thus, no further analysis was conducted.

6. Cochise County Planning

The Cochise County Study Group (CCSG) has met regularly to address ACC Decision No. 70635 in the 2008 Biennial Transmission Assessment (BTA). The focus of this effort was to address the continuity of service issues in Cochise County. The CCSG oversaw technical studies and reporting performed by PDS Consulting, PLC. A separate report, *Cochise County Electric Reliability Study*, was completed for this study. This report, along with *A Summary Report and Reference Filing of the Cochise County Technical Study Report*, will be filed separately by SWTC with the ACC under Docket Number E-00000D-00-0020, as part of their 2010 – 2019 Ten Year Plan filing.

7. Study Results

Power flow studies for the SATS footprint were conducted by SWTC and TEP for the years 2010 – 2014 and 2019. TEP's system analysis for the Required Local Generation (RLG) was determined based on TEP Internal Criteria. SWTC and TEP have determined that the most limiting condition could be a NERC Category A, B, C, or D condition. SWTC's Internal Planning Criteria are posted on SWTC's Open Access Same-Time Information System (OASIS) site at <http://www.oatioasis.com/SWTC/index.html>. TEP's Planning Process and Guidelines are posted on TEP's OASIS site at <http://www.oatioasis.com/tepc/index.html>.

The Adams Tap – Apache 115 kV line was originally identified as overloaded, however Western has determined that the 600 A (120 MVA) continuous and emergency ratings used in the base case were incorrect. Field checks confirmed these changes and once the actual ratings of 860 A (171 MVA) continuous and 1090 A (217 MVA) emergency were modeled, the overload violation was alleviated. This result is typical for study years 2010, 2011, and 2012 evaluated by SATS.

7.1. 2010 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2010 time frame are:

- TEP
 - Cienega 138/13.8 kV distribution substation
- SWTC
 - SWTC Valencia Substation tapped onto the CAP Black Mountain-Del Bac 115 kV Line
 - Saguaro to Adonis to North Loop 115 kV Line
 - North Loop to Rattlesnake 115 kV Line
 - CAP Sandario-Brawley 115 kV Line looped into the SWTC Sandario Substation
- WAPA

- None
- APS
 - None

TEP's RLG for the 2010 Heavy Summer case is 452 MW. This limiting condition is loss of one Saguaro 500 – Tortolita 138 transformer-terminated line which overloads the remaining Tortolita 500/138 kV transformer. With RLG, there are no voltage deviation violations but there are two overloaded transmission lines for Category B contingencies and nine overloaded transmission lines and transformers for Category C contingencies. The overloaded elements for Category B contingencies are the Greenlee-SW 345/230 kV transformer and the Twenty-Second – East Loop 138 kV line. These two elements, along with seven additional TEP 138 kV lines, overloaded due to Category C contingencies. The seven additional TEP 138 kV overloads are:

- DMP – North Loop
- East Loop – Pantano
- Irvington – Tucson
- Irvington – Vail
- Los Reales – Vail
- Pantano – Los Reales
- Irvington – Santa Cruz

The 2010 case shows an overload of the Greenlee-SW 345/230 kV transformer. The Greenlee transformer has an emergency rating of 193 MVA. In order to mitigate the problem, SWTC will remove the existing Bicknell 345/230 kV transformer, which will be replaced by a larger unit in 2012, and place it in parallel with the Greenlee-SW transformer in 2013. Prior to this transformer relocation, interruptible load will be called upon to alleviate overload conditions.

TEP has plans to uprate or rebuild the 138 kV lines identified above. A summary of the 2010 overloaded facilities and the proposed mitigation for each overload are in Table 1.

Table 1. 2010 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
Greenlee-SW 345/230	1	102.0	193 MVA	Cat B – GL-CV 345	2 nd transformer planned for 2012 by SWTC
	1	103.0		Cat C – GL-CV & GL-WN 345	
DMP – N. Loop 138	1	103.2	1301 A	Cat C – WN-VL & SP-VL 345	Line uprate to 1375 A
E. Loop – Pantano 138	2	153.3	955 A	Cat C – Irvington bus 138	Line uprate to 1750 A planned for 2010
Irvington – Tucson 138	1	102.9	1301 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1340 A
Irvington – Vail 138	2	105.3	1301 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1750 A planned for 2010
Los Reales – Vail 138	1	101.5	1700 A	Cat C – Irvington bus 138	Line uprate to 1725 A
Pantano – Los Reales 138	2	122.3	1301 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1750 A planned for 2010
Irvington – Santa Cruz 138	1	147.3	972 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1431 A
22 nd – E. Loop 138	2	109.3	941 A	Cat B – CH-SA 500	Line rebuild to achieve 2259 A continuous / 2535 A emergency
	1	137.7		Cat C – SA-TO 1 & 2 500/138	

7.2. 2011 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2011 time frame are:

- TEP
 - Tortolita 500/138 kV transformer #3 with breakers normally open
 - Canoa Ranch 138/13.8 kV distribution substation
 - New Rosemont load with a new radial 138 kV transmission line from TEP's South 138 kV substation
- SWTC
 - Avra Valley to Sandario Tap 115 kV Line Upgrade
 - Marana to Avra Valley 115 kV Line Upgrade
 - Marana Tap to Marana 115 kV Line Upgrade

- Pantano to Sahuarita 230 kV Line Loop-in to New Tucson
 - San Rafael Substation Upgrade/Addition of 2nd 230/69 kV Transformer
- WAPA
 - None
- APS
 - None

TEP's RLG for the 2011 Heavy Summer case is 419 MW. The limiting condition is loss of one Saguaro 500 – Tortolita 138 kV transformer terminated line which overloads the remaining Tortolita 500/138 kV transformer. The 3rd Tortolita 500/138 kV transformer does not prevent this overload since it is operated with normally open breakers that can be switched into operation for loss of either of the existing transformers. This process will not be automated but is expected to be accomplished in the 30 minute system adjustment phase allowing the system to return to pre-contingency conditions. With RLG, there are no voltage deviation violations but there are overloaded lines and transformers, one for Category B contingencies and three for Category C contingencies. The Greenlee-SW 345/230 kV transformer, which overloads for Category B and C contingencies, is a carryover from the 2010 analysis with mitigation planned for 2013. The Irvington – Tucson 138 kV line overloads due to a Category C contingency and is an increase from 2010 and requires additional mitigation. The Irvington – Drexel 138 kV line, overloaded due to a Category C contingency and is a new violation for 2011 time frame. These overloaded facilities and the proposed mitigation are in Table 2.

Table 2. 2011 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
Greenlee-SW 345/230	1	102.2	193 MVA	Cat B – GL-CV 345	2 nd transformer planned for 2012 by SWTC
	1	114.0		Cat C – GL-CV & GL-WN 345	
E. Loop – Pantano 138	1	105.2	1351 A	Cat C – Irvington bus 138	Line uprate to 1750 A planned for 2010
Irvington – Tucson 138	1	117.7	1301 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1535 A
Pantano – Los Reales 138	1	102.8	1506 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1750 A planned for 2010 is sufficient
Irvington – Santa Cruz 138	1	135.5	972 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1431 A proposed for 2010 is sufficient
Drexel – Irvington 138	1	106.2	1301 A	Cat C – PW-SO & VL-SO 345	Line uprate to 1385 A
Rancho Vistoso – La Canada 138	1	100.4	971 A	Cat C – WN-VL & SP-VL	Rating has been increased to 1435 A

7.3. 2012 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2012 time frame are:

- TEP
 - Vail 345/138 kV transformer #3
 - New Vail – Nogales 138 kV line and conversion of the UNSE system to 138 kV (potentially deferred to 2013 or later)
- SWTC
 - Bicknell 345/230 kV Transformer Replacement
 - Greenlee 345/230 kV Transformer #2 (now deferred to 2013)
 - CAP Brawley-San Xavier 115 kV line looped into the SWTC San Joaquin Substation
- WAPA
 - None
- APS
 - None

TEP's RLG for the 2012 Heavy Summer case is 452 MW. The limiting condition is loss of one Saguaro 500 – Tortolita 138 transformer terminated line which overloads the remaining Tortolita 500/138 kV transformer. As previously described, the 3rd Tortolita 500/138 kV transformer does not prevent this overload but allows the system to return to pre-contingency conditions by closing a normally open breaker. With RLG, there are no voltage deviation violations but there are eight overloaded lines due to Category C contingencies. TEP had seven 138 kV lines overloaded due to Category C contingencies. These overloaded elements are:

- Irvington – Tucson
- Santa Cruz – Irvington
- Drexel – Irvington
- Rancho Vistoso – La Canada
- Pantano – Los Reales
- East Loop – Pantano
- Los Reales - Vail

The Irvington – Tucson 138 kV line overload due to a Category C contingency is an increase from 2010 and 2011 case and requires additional mitigation. There are no new overloads identified for 2012 however, the mitigation proposal of re-rating the Los Reales – Vail 138 kV line will need to be increased to 1755 A in 2012.

The Apache – Butterfield 230 kV line overloads for the Category C contingency of the Springerville – Vail and Winchester – Vail 345 kV lines. TEP direct load tripping was not sufficient to alleviate this overload. Tripping the Winchester 345/230 kV transformer and the Bicknell 345/230 kV transformers were evaluated as mitigation options. Tripping the Bicknell transformer was the only successful option to mitigate the overload, until the Apache – Butterfield 230 kV line is rebuilt in 2016. Re-rating the line segments between Apache and Bicknell is being investigated and may also provide adequate mitigation. This will require further analysis once the re-rating process is complete.

The overloaded facilities and the proposed mitigation are in Table 3.

Table 3. 2012 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
E. Loop – Pantano 138	1	108.3	1351 A	Cat C – Irvington bus 138	Line uprate to 1750 A planned for 2010 is sufficient
Irvington – Tucson 138	1	112.7	1301 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1535 A proposed in 2011 is sufficient
Pantano – Los Reales 138	1	105.8	1506 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1750 A planned for 2010 is sufficient
Irvington – Santa Cruz 138	1	126.3	991 A	Cat C – SA-TO 1 & 2 500/138	Line uprate to 1431 A proposed for 2010 is sufficient
Drexel – Irvington 138	1	1046.2	1356 A	Cat C – PW-SO & VL-SO 345	Line uprate to 1385 A proposed for 2011 is sufficient
Rancho Vistoso – La Canada 138	1	101.6	971 A	Cat C – WN-VL & SP-VL with Bicknell 345/230 transformer trip	Rating has been increased to 1435 A
Los Reales – Vail 138	1	100.1	1753 A	Cat C – Irvington bus 138	Line uprate to 1755 A is needed
Apache – Butterfield 230	1	> 100% Case quit solving while attempting to unload line with TEP direct load tripping	924 A	Cat C – WN-VL and SP-VL 345	Trip Bicknell 345/230 kV transformer or Trip Vail – Bicknell 345 kV line

7.4. 2013 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2013 time frame are:

- TEP
 - Pinal West – Pinal Central 500 kV transmission line (now deferred to 2014)

- Pinal Central – Tortolita 500 kV transmission line (now deferred to 2014)
- Expansion of the Tortolita substation to include a 500 kV yard and the 3rd 500/138 kV transformer normally in service
- Harrison 138/13.8 kV distribution substation
- TEP’s Spencer 138/13.8 kV distribution substation (now deferred to 2015)
- Craycroft-Barril 138/13.8 kV distribution substation
- Orange Grove 138/13.8 kV distribution substation (now deferred to 2014)
- Hartt 138/13.8 kV distribution substation (now deferred to 2015)
- Duval CLEAR 138 kV switchyard
- TEP 138 kV line between Duval CLEAR and Canoa Ranch substations
- SWTC
 - 2nd Greenlee 345/230 kV transformer
- WAPA
 - None
- APS
 - None
- Other
 - Bowie Power Plant and transmission interconnection at the proposed Willow 345 kV substation on TEP’s Greenlee – Winchester 345 kV line

TEP’s RLG for the 2013 Heavy Summer case is 430 MW. This limiting condition is the Category D double outage of the Springerville – Coronado and Winchester – Willow 345 kV lines causing an overload of the Vail T2 345/138 kV transformer. This element cannot be unloaded with direct load tripping via TEP’s Tie-Open Load Shed (TOLS) scheme. With RLG, seven SWTC 115 and 230 kV buses have voltage deviations greater than 5% for a single contingency and there are two overloads of the SWTC Apache – Butterfield 230 kV transmission line for a Category B and a Category C contingency. This line is planned to be rebuilt in 2016, and as a mitigation procedure SWTC is evaluating the process of re-rating the 230 kV lines. Tripping the Winchester or Bicknell 345/230 transformers were evaluated as an interim operating solution for this overload. As in the 2012 case, tripping the Bicknell transformer was the only option evaluated that mitigated the overload. Many of the voltage violations seen on SWTCs system are due to the loss of the Winchester – Vail 345 kV line. The buses with voltage violations are shown in Table 4 and the overloaded facilities and the proposed mitigation are in Table 5.

Table 4. 2013 Voltage Deviation Violations for the Winchester – Vail Outage

Bus	Initial Voltage (pu)	Post-Contingency Voltage (pu)	% Difference
Bicknell 230	1.0222	0.9662	5.48
New Tucson 230	1.0232	0.9630	5.89
Pantano 230	1.0236	0.9651	5.72
Sahuarita 230	1.0222	0.9626	5.83
Bicknell 115	1.0184	0.9659	5.15
Kartchner 115	1.0130	0.9466	6.55
Pantano 115	1.0349	0.9736	5.92

SWTC is planning to install two 50 MVAR capacitor banks on its system in 2014. One bank will be located at Hackberry and the other located at Pantano. The effect of these additional capacitor banks and other potential mitigation measures will require further analysis.

Table 5. 2013 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
Apache – Butterfield 230	1	112.8	924 A	Cat B – WN-VL 345	Line upgrade planned in 2016 by SWTC Trip Bicknell 345/230 kV transformer or Vail – Bicknell 345 kV line
	2	117.0		Cat C – WN-VL & SP-VL 345	
Irvington – Drexel 138	1	106.2	1301 A	Cat C – PW-SO & VL-SO 345	Line uprate to 1385 A proposed for 2011 is sufficient

7.5. 2014 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2014 time frame are:

- TEP
 - TechPark 138/13.8 kV distribution substation (now deferred to 2015)
- SWTC
 - 50 MVAR Capacitor Bank at Hackberry
 - 50 MVAR Capacitor Bank at Pantano
 - Sandario to Three Points 115 kV Line Upgrade
 - Apache/Hayden to San Manual 115 kV Line
 - Reconductor 230 kV line between Apache and Butterfield (now deferred to 2016)
- WAPA
 - None
- APS
 - None

TEP's RLG for the 2014 Heavy Summer case is 150 MW. The limiting outage is the Category D loss of two Tortolita 500/138 kV transformers. For this contingency, the remaining Tortolita transformer is overloaded and the flow cannot be reduced below the emergency rating of the transformer before the case ceases to solve. With RLG, seven SWTC 115 and 230 kV buses have voltage deviations greater than 5% for a single

contingency and six overloaded TEP transmission lines for Category C contingencies. The voltage violations are all due to the loss of the Winchester – Vail 345 kV line. The buses with voltage violations are shown in Table 6 and the overloaded facilities and the proposed mitigation are in Table 7.

Table 6. 2014 Voltage Deviation Violations for the Winchester – Vail Outage

Bus	Initial Voltage (pu)	Post-Contingency Voltage (pu)	% Difference
Bicknell 230	1.0173	0.9602	5.61
New Tucson 230	1.0186	0.9595	5.80
Pantano 230	1.0191	0.9623	5.87
Sahuarita 230	1.0173	0.9576	5.87
Bicknell 115	1.0103	0.9565	5.33
Kartchner 115	1.0067	0.9443	6.19
Pantano 115	1.0299	0.9710	5.72

The 50 MVAR capacitor banks at Hackberry and Pantano were not included in this analysis. The effect of these additional capacitor banks and other potential mitigation measures will be further analyzed.

Table 7. 2014 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
Irvington – Drexel 138	1	107.9	1301 A	Cat C – PW-SO and VL-SO	Line uprate to 1405 A
Irvington – RBWilmot 138	1	108.7	1301 A	Cat C – PW-SO and VL-SO	Line uprate to 1415 A
Irvington – Techpark 138	1	106.4	1749 A	Cat C – PW-SO and VL-SO	Reconductor to achieve 2259 A continuous / 2535 A emergency ratings
Techpark – Vail 138	1	110.9	1749 A	Cat C – PW-SO and VL-SO	Reconductor to achieve 2259 A continuous / 2535 A emergency ratings
Rancho Vistoso – La Canada 138	2	107.2	971 A	CAT C – SP-VL and WN-VL with Bowie trip	Actual rating of 1435 A is sufficient
NE. Loop – Rillito 138	1	103.8	1547 A	CAT C – SP-VL and WN-VL with Bowie trip	Line uprate to 1610 A
Butterfield – Pantano 230	1	> 100% Case quit solving while attempting to unload line with TEP direct load tripping	924 A	CAT C – SP-VL and WN-VL	Trip Bicknell 345/230 kV transformer or Trip Winchester 345/230 kV transformer

With the deferral of the Apache – Butterfield 230 kV line upgrade to 2016, the overload of the Apache – Butterfield 230 kV for the loss of Winchester – Vail and Springerville – Vail 345 kV lines can be expected to continue until the upgrade is complete. Tripping the Winchester 345/230 kV transformer is sufficient, with TEP direct load tripping, to alleviate the overload of the Butterfield – Pantano 230 kV line but not the overload of the Apache – Butterfield 230 kV line. Tripping the Bicknell 345/230 kV transformer will mitigate both overloads. Additionally, SWTC is reviewing information regarding the potential re-rate of the Apache – Butterfield 230 kV line as another means, in the short term, to alleviate these overloads.

7.6. 2019 Heavy Summer

For this study, the new facilities planned to be in-service prior to summer peak for the 2019 time frame are:

- TEP
 - Vail 345/138 kV transformer #4 (now moved forward to 2014)

- Marana 138/13.8 kV distribution Substation (2015)
- Naranja 138/13.8 kV distribution Substation (2015)
- Kino 138/13.8 kV distribution Substation (2015)
- Irvington – Tucson 138 kV circuit #2 (2015)
- Corona 138/13.8 kV distribution Substation (2016)
- Anklam 138/13.8 kV distribution Substation (2016)
- Reconductor North Loop – Rillito 138 kV line (2016)
- Reconductor DMP – Northeast 138 kV line (2016)
- East Ina 138/13.8 kV distribution Substation (2017)
- Medina 138/13.8 kV distribution Substation (2018)
- Raytheon 138/13.8 kV distribution Substation (2019)
- UA Med 138/13.8 kV distribution Substation (2019)
- SWTC
 - Reconductor 230 kV line between Apache and Bicknell (now deferred to 2016 – 2017)
 - Saguaro to Adonis 115 kV Line Loop-in to Naviska
 - CAP 115 kV Line Loop-in to Picture Rocks
- WAPA
 - None
- APS
 - None

TEP's RLG for the 2019 Heavy Summer case is 340 MW. The limiting outage is the Category D loss of the Greenlee – Greenlee-SW and Greenlee – Copper Verde 345 kV lines. This contingency did not solve with lower TEP local generation. With RLG, ten 115, 138, and 230 kV buses have voltage deviations greater than 5% for a single contingency and six 115 and 230 kV buses had voltage deviations greater than 10% for Category C contingencies. In addition, nine TEP 138 kV transmission lines overloaded for Category C contingencies. The Category B voltage violations are due to the loss of the Winchester – Vail 345 kV line and the Category C voltage violations are due to the loss of the Winchester – Vail and Springerville – Vail 345 kV lines. The voltage violations due to the Category B and C contingencies are shown in Tables 8 and 9 and the overloaded facilities and the proposed mitigation are in Table 10.

Table 8. 2019 Voltage Deviation Violations for the Winchester – Vail Outage

Bus	Initial Voltage (pu)	Post-Contingency Voltage (pu)	% Difference
Bicknell 230	1.0276	0.9667	5.92
New Tucson 230	1.0293	0.9657	6.18
Pantano 230	1.0304	0.9692	5.94
Sahuarita 230	1.0279	0.9639	6.23
Canez 138	0.9601	0.9119	5.02
Sonoita 138	0.9562	0.9076	5.08
Valencia 138	0.9491	0.8998	5.19
Bicknell 115	1.0103	0.9675	5.54
Kartchner 115	1.0067	0.9545	6.42
Pantano 115	1.0299	0.9775	6.03

Table 9. 2019 Voltage Deviation Violations for the Winchester – Vail / Springerville – Vail Outage

Bus	Initial Voltage (pu)	Post-Contingency Voltage (pu)	% Difference
Bicknell 230	1.0276	0.9239	10.09
New Tucson 230	1.0293	0.9129	11.31
Pantano 230	1.0304	0.9171	11.00
Sahuarita 230	1.0279	0.9148	11.00
Kartchner 115	1.0200	0.8940	12.35
Pantano 115	1.0403	0.9226	11.31

The 50 MVAR capacitor banks proposed for 2014 at Hackberry and Pantano were not included in this analysis. The effect of these additional capacitor banks and other potential mitigation measures will be further analyzed.

Table 10. 2019 Overload Summary

Element	Frequency	Max PCT OL	Rating	Worst Outage	Proposed Mitigation
Irvington – Corona 138	1	114.9	1301 A	Cat C – PW-SO and VL-SO	Line uprate to 1500 A
Corona – South 138	1	108.0	1301 A	Cat C – PW-SO and VL-SO	Line uprate to 1415 A
Irvington – RBWilmot 138	1	104.2	1301 A	Cat C – PW-SO and VL-SO	Line uprate to 1415 A proposed for 2014 is sufficient
Irvington – Techpark 138	1	101.3	1749 A	Cat C – PW-SO and VL-SO	2014 proposed reconductor is sufficient
RBWilmot – Vail 138	1	102.3	1455 A	Cat C – PW-SO and VL-SO	Line uprate to 1500 A
Techpark – Vail 138	1	106.2	1749 A	Cat C – PW-SO and VL-SO	2014 proposed reconductor is sufficient
North Loop – West Ina 138	1	105.5	1547 A	Cat C – SP-VL and WN-VL	Line uprate to 1635 A
Tortolita – North Loop 138	3	114.6	1699 A	Cat C – SP-VL and WN-VL	Planned reconfiguration in 2010 is sufficient
Los Reales – Vail 138	1	105.9	1699 A	Cat C – Irvington 138 bus	Reconductor to achieve 2259 A continuous / 2535 A emergency ratings

8. Conclusions

The transmission system in the SATS footprint can reliably meet the needs of Southeastern Arizona with the projects proposed by the SATS participants. There are overloads on the TEP 138 kV system and the SWTC 230 kV system but these overloads will be mitigated with planned projects, operating procedures, or automated actions. As load forecasts change, the planned mitigation may be altered. Reduced forecasts will allow deferment of projects while increased forecasts may require acceleration of projects.

Proposed projects for the SATS Area for the 2010 – 2014 time frame are:

- 2010
 - TEP – Cienega 138/13.8 kV distribution substation
 - SWTC – Valencia substation tapped onto the CAP Black Mountain-Del Bac 115 kV Line
 - SWTC – Saguaro to Adonis to North Loop 115 kV Line

- SWTC – North Loop to Rattlesnake 115 kV Line
- SWTC –CAP Sandario-Brawley 115 kV looped into the Sandario Substation.
- 2011
 - TEP – Tortolita 500/138 kV transformer #3 with a breakers normally open
 - TEP – Canoa Ranch 138/13.8 kV distribution substation
 - TEP – Irvington – 22nd 138 kV line reconductor
 - New Rosemont load with a new radial 138 kV transmission line from TEP's South 138 kV substation
 - SWTC – Avra Valley to Sandario Tap 115 kV Line Upgrade
 - SWTC – Marana to Avra Valley 115 kV Line Upgrade
 - SWTC – Marana Tap to Marana 115 kV Line Upgrade
 - SWTC – Pantano to Sahuarita 230 kV Line Loop-in to New Tucson
 - SWTC – San Rafael Substation Upgrade/Addition of 2nd 230/69 kV Transformer
- 2012
 - TEP – Vail 345/138 kV transformer #3
 - New Vail – Nogales 138 kV line and conversion of the UNSE system to 138 kV (potentially deferred to 2013 or later)
 - SWTC – Bicknell 345/230 kV Transformer Replacement
 - SWTC – Greenlee 345/230 kV Transformer #2 (now deferred to 2013)
 - SWTC – CAP Brawley-San Xavier 115 kV Line looped into the San Joaquin Substation.
- 2013
 - TEP – Pinal West – Pinal Central 500 kV transmission line (now deferred to 2014)
 - TEP – Pinal Central – Tortolita 500 kV transmission line (now deferred to 2014)
 - TEP – Expansion of the Tortolita substation to include a 500 kV yard and the 3rd 500/138 kV transformer normally in service
 - Bowie Power Plant and transmission interconnection at Willow 345 substation on the TEP Greenlee – Winchester 345 kV line
 - TEP – Harrison 138/13.8 kV distribution substation
 - TEP – Spencer 138/13.8 kV distribution substation (now deferred to 2015)
 - TEP – Craycroft-Barril 138/13.8 kV distribution substation
 - TEP – Orange Grove 138/13.8 kV distribution substation (now deferred to 2014)
 - TEP – Hartt 138/13.8 kV distribution substation (now deferred to 2015)
 - TEP – Duval CLEAR 138 kV switchyard
 - TEP – 138 kV line between Duval CLEAR and Canoa Ranch substations
 - SWTC – Greenlee 2nd 345/230 kV transformer
- 2014
 - TEP – TechPark 138/13.8 kV distribution substation (now deferred to 2015)
 - SWTC – 50 MVAR Capacitor Bank at Hackberry
 - SWTC – 50 MVAR Capacitor Bank at Pantano

- SWTC – Sandario to Three Points 115 kV Line Upgrade
- SWTC – Apache/Hayden to San Manual 115 kV Line
- SWTC – 230 kV line reconductor between Apache and Butterfield (now deferred to 2016)

In addition to the above proposed projects, various TEP 138 kV lines will be updated as needed. These projects will increase the ratings of the lines by raising conductors where line clearances or hardware limits the rating of the line but otherwise will not change any line parameters.

Other projects proposed by 2019 are:

- TEP – Vail 345/138 kV transformer #4 (2014)
- TEP – Marana 138/13.8 kV distribution Substation (2015)
- TEP – Naranja 138/13.8 kV distribution Substation (2015)
- TEP – Kino 138/13.8 kV distribution Substation (2015)
- TEP – Irvington – Tucson 138 kV circuit #2 (2015)
- TEP – Corona 138/13.8 kV distribution Substation (2016)
- TEP – Anklam 138/13.8 kV distribution Substation (2016)
- TEP – North Loop – Rillito 138 kV line reconductor (2016)
- TEP – DMP – Northeast 138 kV line reconductor (2016)
- TEP – East Ina 138/13.8 kV distribution Substation (2017)
- TEP – Medina 138/13.8 kV distribution Substation (2018)
- TEP – Raytheon 138/13.8 kV distribution Substation (2019)
- TEP – UA Med 138/13.8 kV distribution Substation (2019)
- SWTC – Saguario to Adonis 115 kV Line Loop-in to Naviska (2015)
- SWTC – 230 kV line reconductor between Apache and Bicknell (2016-17)
- SWTC – CAP Twin Peaks – Sandario 115 kV Line loop-in to Picture Rocks (2018)