City of Truth or Consequences
Asset Management Plan

Distribution System Performance Assessment

Prepared by T & D Services

9/19/2025

Foreword

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Any correspondence concerning this document, including technical and commercial questions should be referred to:

Mr. Bo Easley
The City of Truth or Consequences
505 Sims St.
Truth or Consequences, NM 87901
Phone: 575-894-6673
Fax: 575-894-7767

I hereby certify that this Distribution System Performance Assessment was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of New Mexico.

Robert A. Perea

Digitally signed by Robert A. Perea
Date: 2025.09.21 21:02:08 -06'00'

Robert Perea, P.E.

ROBERT A. PEREA
NEW MEXICO
16036
PROFESSIONAL ENGINEER

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Executive Summary

The City of Truth or Consequences (T or C) commissioned Transmission & Distribution Services, LLC(T&D) to analyze the distribution system's ability to serve present demand and forecast growth through 2045. A field inventory fed a GIS database and a WindMil power-flow model. T&D utilized LightTable to check protective-device coordination under fault scenarios. Peak-load studies were performed at five-year intervals in a twenty-year horizon (2025–2045) at 1.5 % annual load growth, covering both normal (N-0) and contingency (N-1) configurations. The analysis flags thermal, voltage, and protection limits that could threaten reliability as load rises.

Study Findings

Peak Loading

The peak-load review for 2025-2045 shows no conductor or equipment overloads and no power-factor deviations. Undervoltage violations are projected on C-Phase of Williamsburg Feeder starting in 2040 and South Broadway Feeder starting in 2045.

Loss of Feeder

The 2025-2045 peak-load contingency N-1 analysis shows the following violations: starting in 2040 the South Broadway–Williamsburg tie drives C-phase undervoltage at the end of the line. By 2045, the South Broadway–Williamsburg tie overloads conductor near the feeder getaway. Shifting part of the C-phase load on both feeders to B-phase clears both issues.

Substation/Feeder Protection

Protection analysis of the Hot Springs Substation overcurrent protection indicated possible miss coordination issues with the feeder relays and the upline bus protection. The analysis indicated the instantaneous trip settings need to be adjusted to avoid possible miss coordination issues with the feeder relays and the upline bus protection. Updated feeder and bus protection settings for the Basler BE1-951 and Basler BE1-851G relays are recommended.

Additionally, T&D recommends for T or C to upgrade the transformer bus and feeder protection to a SEL751 relay as part of a refresh of Hot Springs Substation. The SEL751 relay provides greater visibility, event history for analyzing fault events, and aid in fault location.

Substation

T&D performed a substation visit to evaluate equipment condition, maintenance practices, and operational status. Observations and recommendations were documented and organized for T or C's consideration. Recommendations are detailed in the Recommendations section, with supporting photos included in Appendix B

Introduction

T&D has completed a series of load flow and protection studies to assess the performance of the T or C electric distribution system during both normal and outage operating conditions. T&D's assessments address the performance of the T or C electric distribution system for current and projected loads through 2045. This report summarizes T&D's study results and recommendations for correcting or mitigating performance deficiencies.

Background

Prior to conducting its load flow and protection assessments of the T or C electric distribution system, T&D carried out a field inventory and physical assessment of the T or C electric distribution system and Hot Springs Substation. The results of the field inventory and physical assessments have been provided to T or C. The field inventory data collected by T&D was used as the basis for creating an up-to-date WindMil model of the T or C electric distribution system to assess system performance.

Project Description and Purpose

The load flow and fault-current results in this report, together with the recommendations, provide T or C a basis for setting priorities and drafting its electric Asset Management Plan. Developing that plan, though, brings policy questions that fall outside the scope of this technical study.

System Description

T or C's distribution grid covers about 15 square miles and serves 3,770 residential, 559 commercial, and 83 government accounts. The network operates at 12.47 kV (phase-to-phase)/ 7.2 kV (phase-to-ground) and includes roughly 65 miles of overhead conductor and 1.5 miles of underground cable. Six feeders originate at Hot Springs Substation, where two 10/12.5/14 MVA, 115 to 12.47 kV transformers that are fed by a Tri-State G&T 115 kV line. Figure 1 outlines the service area and feeder layout.

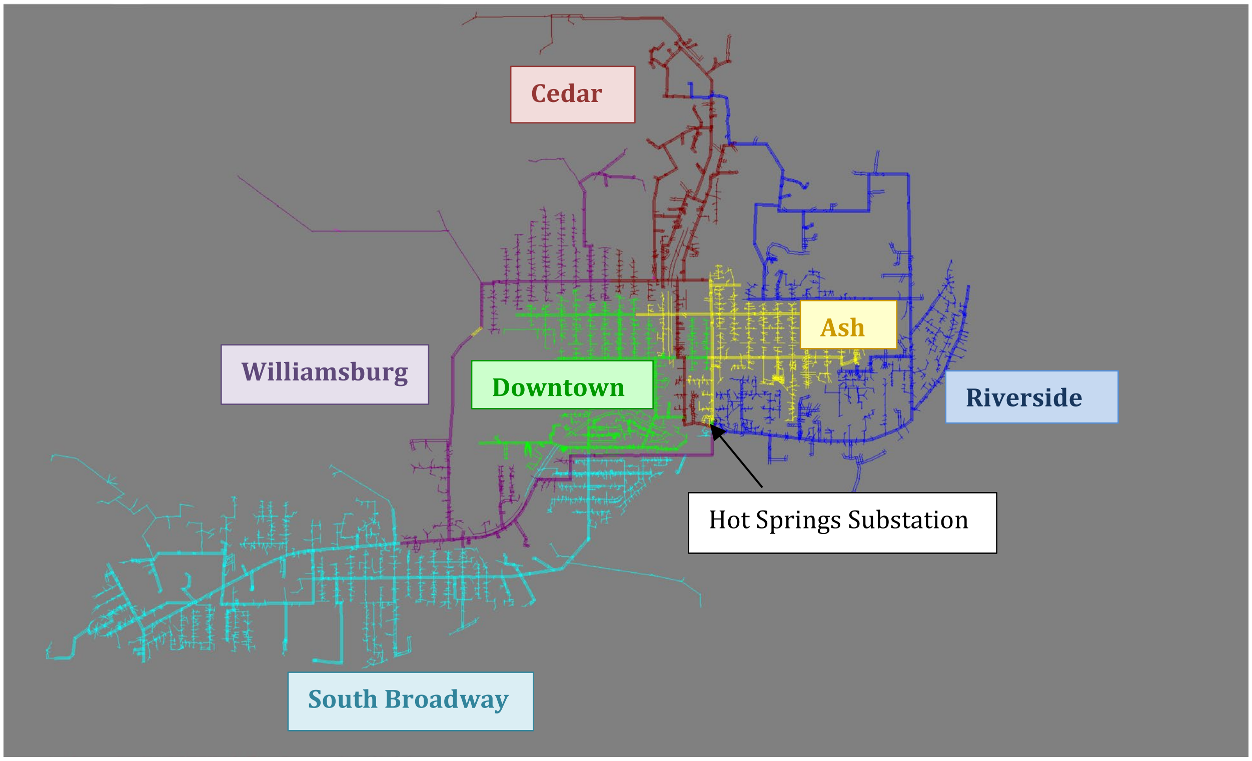


Figure 1: T or C Service Area and 12.47kV Feeders.

Hot Springs Substation

Hot Springs Substation uses two 115 to 12.47 kV transformers, labeled North and South, each rated 10/12.5/14 MVA. Both transformers have on-load tap changers (LTC) set to hold 123 V on the secondary bus within a ±1 V bandwidth. No-load high-side taps provide ±5 % in 2.5 % steps.

Each transformer's 12.47 kV low side feeds metal-clad outdoor switchgear through a 1,200 A main breaker, with the North and South units normally supplying three feeders each. A 1,200 A bus-tie breaker links the two buses so any of the six feeders can be fed by either transformer during planned or emergency outages. Figure 2 presents the Hot Springs Substation one-line diagram.

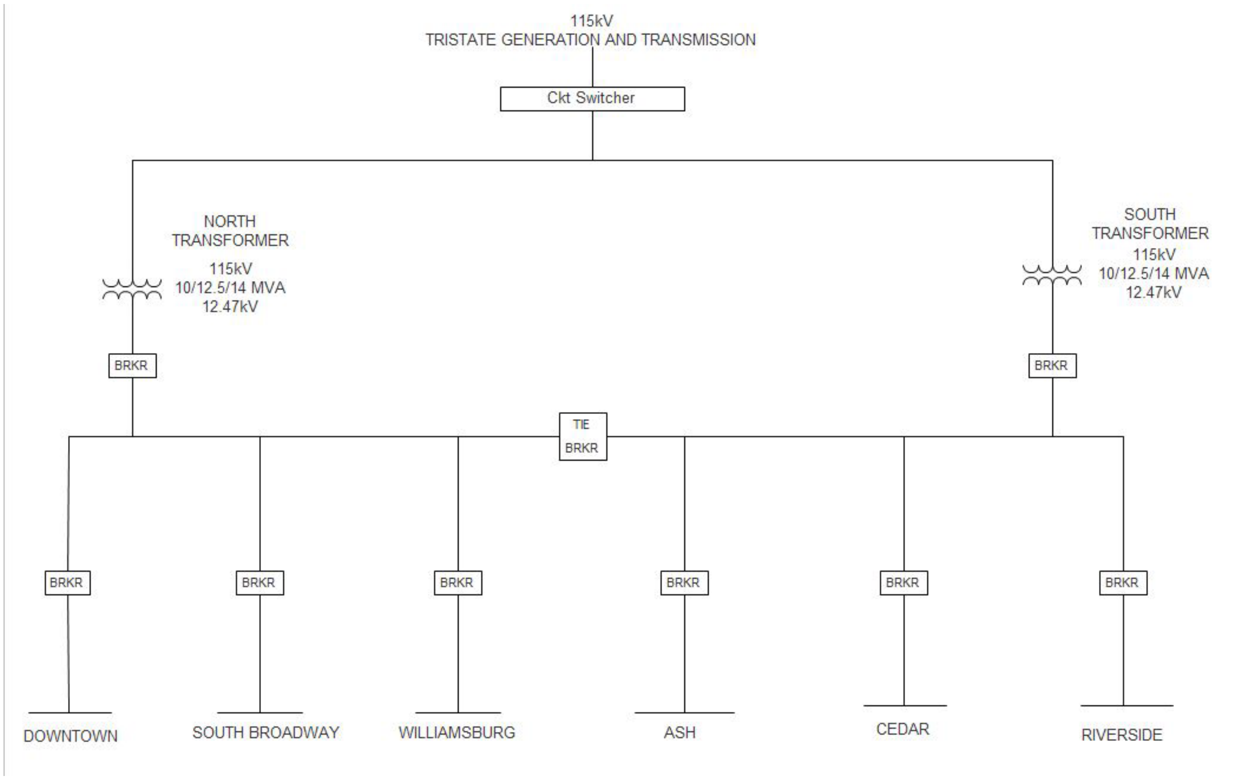


Figure 2. Hot Springs Substation Diagram

Distribution Primary System

The 12.47 kV distribution network comprises six feeders sourced from Hot Springs Substation. The North transformer supplies Downtown, Williamsburg, and South Broadway feeders; the South transformer supplies Ash, Cedar, and Riverside feeders. Approximately 65 miles of overhead circuit use 2/0 ACSR, 4/0 ACSR, and 397 kcmil AAC conductors. Underground primary construction totals about 1.5 miles of 1/0 AWG, 15 kV concentric-neutral aluminum cable; each feeder get-away is built with 350 kcmil, 15 kV, one-third-neutral aluminum cable.

Downstream protection is limited to distribution fuses; no reclosers or sectionalizers are installed beyond the substation breakers. Feeder voltage regulation depends solely on transformer LTC/LDC settings—no line regulators are in service. Four capacitor banks exist with one each on Downtown, Cedar, Riverside, and South Broadway feeders.

Distribution System Study

The distribution-system model begins with a GPS field survey that captured pole locations, conductor types and sizes, and equipment size and locations. Arc GIS software was utilized in collecting and compiling data in to a working GIS system map. Data from the GIS system map was imported directly into Milsoft WindMil®, creating a primary-voltage network model that mirrors the physical system. Transformer demand measured at the substation was then allocated by transformer kVA to each of the feeders.

Steady-state load-flow studies were analyzed under two operating conditions. The N-0 condition represents normal operating conditions with every feeder serving its designated loads. Results are judged against ANSI C84.1 Range A which limits acceptable primary voltages to fall between 118 V and 126 V. The N-1 condition removes the single largest element—either one 10/12.5/14 MVA substation transformer or an entire feeder. Results are judged against ANSI C84.1 Range B, which limits acceptable primary voltages to fall between 114 V–127 V. For a transformer outage the bus-tie breaker is closed, and total substation demand must remain below the surviving unit's 14 MVA rating. For each feeder outage the adjacent circuits are re-switched to pick up the load, and both voltage and thermal criteria are verified.

Table 1 lists the scenario criteria. Any equipment outside the limits shown in Table 1 is flagged for corrective action.

Table 1. Scenario Criteria

Scenario	Equipment status	Service Voltage limits	Primary voltage limits	Initial LTC setpoint
N-0 (all in service)	Normal topology	C84 Range A (114 – 126 V)	118 – 126 V	123 V
N-1 (single element out)	One feeder or transformer removed	C84 Range B (110 – 127 V)	114 – 127 V	125 V

Analysis Methods

The assumptions and process of preparing the T or C distribution model for analysis are described below.

Substation Transformer Loading

Transmission meter data sets the peak and minimum demand for each transformer. Hot Springs South and Hot Springs North are evaluated independently, so their peaks don't have to coincide. This non-coincident treatment of the data will give a more conservative approach to the analysis.

Figure 3 shows the distribution of delivered KVA for the Hot Springs South and Hot Springs North transformers. Hot Springs South had a peak load of 6,173 KVA on July 20, 2023, with a power factor (PF) of 0.98, and a minimum load of 1,327 KVA on January 2, 2023, at a PF of 0.94. Hot Springs North reached a peak load of 7,252 KVA on July 26, 2023, with a PF of 0.97, and a minimum load of 606 KVA on April 4, 2023, at a PF of 0.99. The dashed vertical lines indicate these extreme values on each histogram. Table 2 shows the transformer loading data.

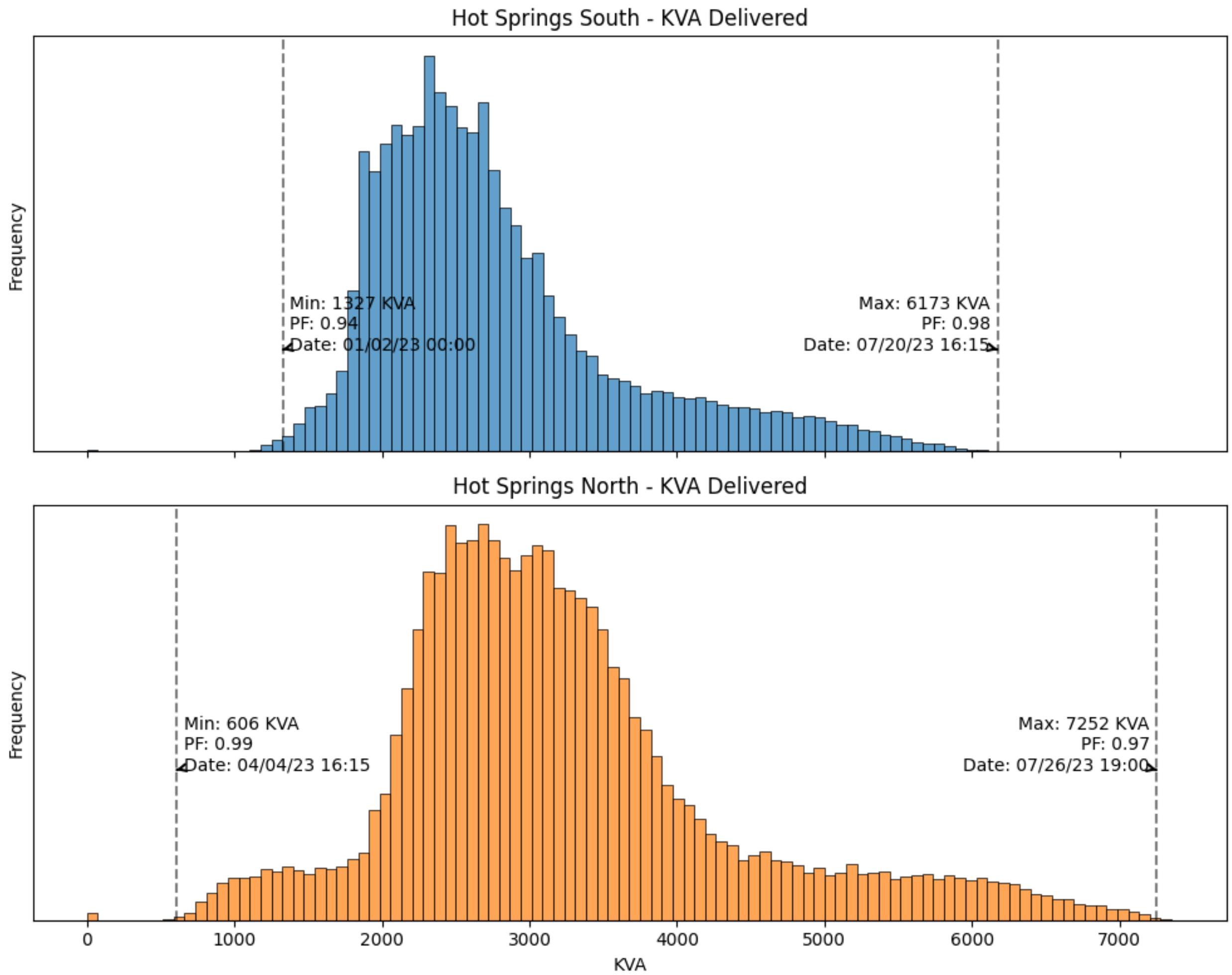


Figure 3. Substation Transformer Loading (2023-2024)

Transformer Loading Based on Transmission Delivery Data

Table 2. Transformer loading.

Transformer	Load Scenario	KW	KVar	PF
Hot Springs South	Max	6050	1226	98
Hot Springs South	Min	1255	25	-94
Hot Springs North	Max	7034	1443	97
Hot Springs North	Min	597	150	99

Capacitor Configuration

Capacitors support voltage levels and regulate power factor. Transmission billing data indicates the current capacitor installations maintain power factor within acceptable limits.

Table 3 lists the installed capacitors. Figure 4 illustrates the locations of the installed capacitors.

Table 3. Installed Capacitors

Capacitor Name	Operating Mode
Cap 1 – Riverside Feeder	Fixed
Cap 2 – Cedar Feeder	Fixed
Cap 3 – Downtown Feeder	Fixed
Cap 4 – South Broadway Ckt	Fixed

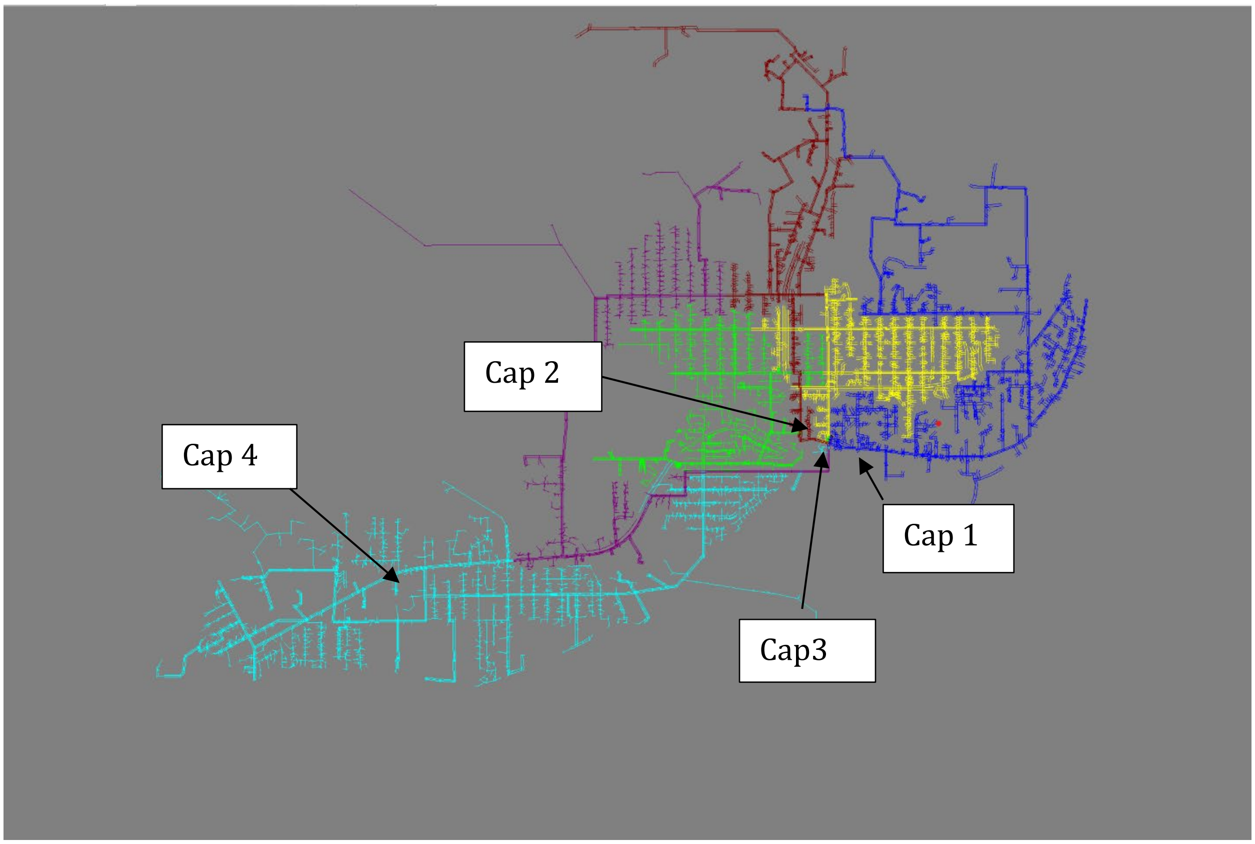


Figure 4. Capacitor Locations

Load Growth

The forecast applies a 1.5 % compound annual peak-demand growth to both Hot Springs transformers. SCADA data from 2014-2024 show lower historical growth—0.9 % /yr on the Hot Springs South Transformer and 1.2 % /yr on the Hot Springs North Transformer. but the higher 1.5% planning rate adds a safety margin that forces voltage and thermal limits to surface earlier in the study. Peak-demand growth is evaluated rather than average energy growth because equipment sizing is driven by the worst-hour load, not the annual mean. Table 4 provides the projected transformer loading.

Table 4. Projected Transformer Loading

Year	Hot Springs North KVA	Hot Springs South KVA
2025	7252	6173
2030	7812	6650
2035	8416	7164
2040	9067	7718
2045	9767	8314

LTC Settings

The substation voltage is maintained by an LTC. Table 5 provides the transformer LTC settings.

Table 5 Transformer Load Tap Changer Settings

Transformer	Send out Voltage	Bandwidth	Steps
Hot Springs North	123V	2V	32
Hot Springs South	123V	2V	32

Distributed Generation

In early 2015, the two photovoltaic(PV) sites were interconnected with the T or C distribution system. The 1 MW Walmart PV system was interconnected with the Riverside Circuit and the Housing Authority 100kW PV facility interconnected with the South Downtown feeder. The Williamsburg PV facility will be considered non-operational according to T or C. Table 6 lists the distributed generation.

Table 6. Distributed Generation

PV Generation	Feeder	Transformer	Size	Online
Walmart Parking	Riverside Feeder	Hot Springs North	1MW	Yes
Williamsburg PV	South Broadway Feeder	Hot Springs South	1.5MW	No
Housing Authority	Downtown Feeder	Hot Springs North	100kW	Yes

The T or C distribution system reaches its summer peak around 18:00 MDT in late July. By this hour, global horizontal irradiance has dropped below 100 W/m^2, so fixed-tilt behind-the-meter PV arrays produce under 5 % of nameplate and receive a 0 % capacity credit. System planning therefore sizes feeders, transformers, and voltage-regulation equipment with no PV contribution to the evening peak.

Figure 5 shows the transformer load by time of day.

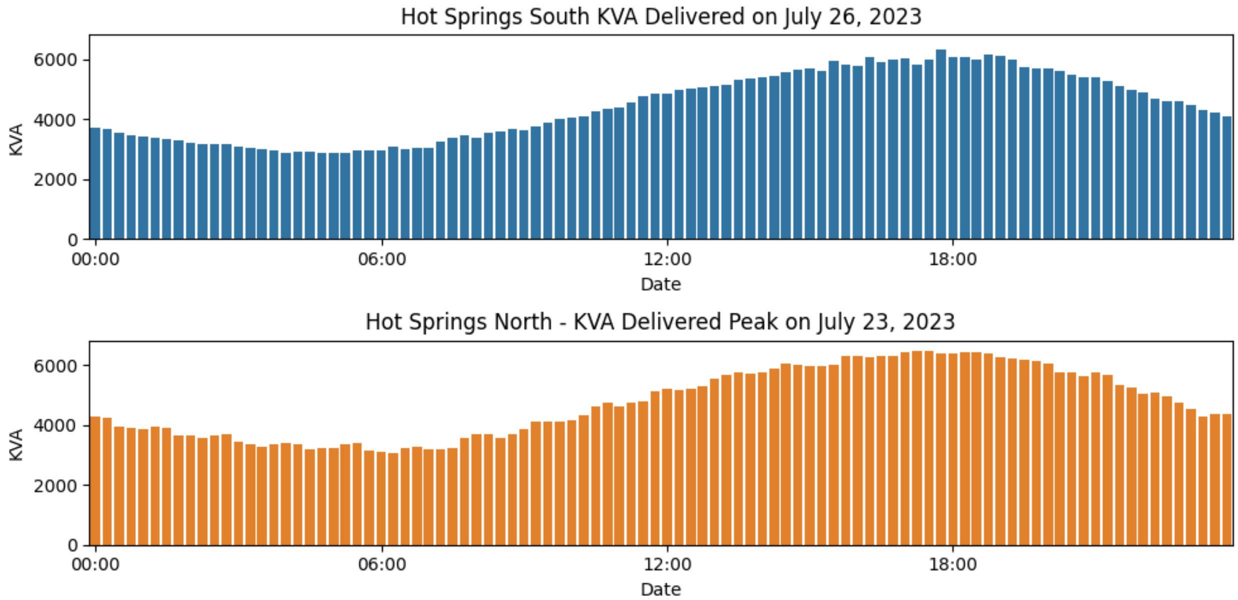


Figure 5. Transformer Load By Time of Day

N-0 Load Flow Study

N-0 Peak-Load Study — Method and Screening Rules

The base-case (N-0) analysis models the network in its normal configuration—every feeder in service, both 12.47 kV substation transformers energized, and existing behind-the-meter PV offline—under the summer evening peak. WindMil solves node voltages, phase currents, kW losses, and percent ampacity for each circuit element. Simulations are run for the 2025 load and for every study year through 2045, using a 1.5 % compound annual growth rate to capture incremental demand growth. Results quantify year-over-year trends in loading, losses, and voltage profile.

Service voltage compliance is checked against ANSI C84.1 Range A (114–126 V). Allowing 4 V drop between the service entrance and the distribution transformer, the acceptable primary window tightens to 118–126 V. The LTCs at both North and South transformers start at 123.0 V with line-drop compensation inactive. Any primary node outside 118–126 V is flagged.

Thermal limits are screened by comparing calculated current to conductor emergency ratings; conductors above 80 % of rating are treated as actionable. When a feeder first violates either voltage or thermal limits in a given study year, the recommended mitigation—reconductor, regulator addition, sectionalizing change, etc.—is added to the model before running the next-year case. For all years, the loading on each substation transformer is capped at 14 MVA (65 °C rating), the same limit applied in N-1 contingency studies.

Table 7 lists the N-0 study parameters.

Table 7. N-0 Study Parameters

Parameter	Screening limit	Rationale
Primary voltage (N-0)	118 V – 126 V	ANSI C84.1 Range A minus 4 V service drop
Conductor loading	> 80 % of thermal rating	Proactive threshold for thermal upgrades
Transformer loading	≤ 14 MVA per 10/12.5/14 MVA unit	Nameplate, 65 °C rating
Load growth model	1.5 % CAGR, 2025 → 2045	Matches long-term planning forecast
Power Factor	> 85 at each node	Ensures margin for avoiding Tri-State G&T power factor penalties.

This structured approach delivers a clear year-to-year roadmap of when and where voltage support, reconductoring, or transformer upgrades will be required as demand rises.

Hot Springs Substation

The load flow studies did not reveal any N-0 deficiencies for the Hot Springs Substation. The loads on the North and South transformers are well below their 10 MVA base ratings through 2045.

Both transformers are rated at 10/12.5/14 MVA for continuous operation. However, the South transformer is rated at 10 MVA for 55°C rise self-cooled operation, 12.5 MVA for 55°C rise forced air operation and 14 MVA for 65°C rise forced air operation. The North transformer is rated at 65°C for all MVA ratings.

Neither of the substation transformers are overloaded for N-0 operation during any year of study period. Table 8 shows the cumulative peak load on each of the Hot Springs transformers as well as the total load on the substation through 2045.

From the N-0 study results, Table 9 provides the minimum feeder voltages and Table 10 provides the peak feeder loads.

The single transformer capacity limitation is discussed in more detail with the N-1 results.

Table 8: Hot Springs Substation Peak Loading.

	Hot Springs South KVA	Hot Springs South Loading	Hot Springs North KVA	Hot Spring North Loading
2025	6173	44%	7252	52%
2030	6650	48%	7812	56%
2035	7164	51%	8416	60%
2040	7718	55%	9067	65%
2045	8314	59%	9767	70%

Table 9. N-0 Feeder Minimum Voltage

	Hot Springs North			Hot Spring South		
	Ash	Cedar	Riverside	Williamsburg	Downtown	South Broadway
	Volts	Volts	Volts	Volts	Volts	Volts
2025	122.4	120.8	120.5	120.1	121.8	119.6
2030	122.1	120.9	120.1	119.6	121.4	118.9
2035	121.8	120.0	119.7	119.8	120.9	118.1
2040	121.4	119.5	119.2	119.1	120.4	117.2
2045	121.1	119.0	118.6	117.7	119.8	116.3

Table 10. N-0 Feeder Peak Load

	Hot Springs North						Hot Springs South					
	Ash		Cedar		Riverside		Williamsburg		Downtown		South Broadway	
Year	KVA	% Rated	KVA	% Rated	KVA	Ash_%	KVA	% Rated	KVA	% Rated	KVA	% Rated
2025	1,278	17%	2,862	39%	3,118	42%	1,305	18%	1,995	27%	2,909	40%
2030	1,376	19%	3,086	42%	3,359	46%	1,376	19%	2,296	31%	3,273	45%
2035	1,481	20%	3,324	45%	3,620	49%	1,500	20%	2,314	32%	3,382	46%
2040	1,595	22%	3,582	49%	3,901	53%	1,609	22%	2,493	34%	3,647	50%
2045	1,656	23%	3,936	54%	4,197	55%	1,675	23%	2,731	37%	3,931	54%

Feeder Analysis:

Ash Feeder

Ash Feeder shows no capacity, voltage, or power-factor violations from 2025-2045. Table 11 Summarizes the Ash Feeder N-0 performance.

Table 11. N-0 Ash Feeder Performance

Parameter	Violations (Y/N)	Description
Voltage < 118V	N	No voltage violations exist.

Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Cedar Feeder

Cedar Feeder shows no capacity, voltage, or power-factor violations from 2025-2045. Table 12 Summarizes the Cedar Feeder N-0 performance.

Table 12. N-0 Cedar Feeder Performance

Parameter	Violations (Y/N)	Description
Voltage < 118V	N	No voltage violations exist.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Riverside Feeder

Riverside Feeder shows no capacity, voltage, or power-factor violations from 2025-2045. Table 13 Summarizes the Riverside Feeder N-0 performance.

Table 13. N-0 Riverside Feeder Performance

Parameter	Violations (Y/N)	Description
Voltage < 118V	N	No voltage violations exist.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Downtown Feeder

Downtown Feeder shows no capacity, voltage, or power-factor violations from 2025-2045. Table 14 Summarizes the Downtown Feeder N-0 performance.

Table 14. N-0 Downtown Feeder Performance

Parameter	Violations (Y/N)	Description
Voltage < 118V	N	No voltage violations exist.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

South Broadway Feeder

South Broadway Feeder shows no capacity or power-factor violations from 2025-2045. Undervoltage violations at the end of South Broadway Feeder on C-phase are projected starting in 2040. Table 15 Summarizes the South Broadway Feeder N-0 performance.

Figure 5 shows the locations of undervoltage violations in 2040. Figure 6 shows the locations of undervoltage violations in 2045.

Table 15. N-0 South Broadway Feeder Performance

Parameter	Violations (Y/N)	Description
Voltage < 118V	Y	Undervoltage violations at the end of feeder on C-phase starting in 2040.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

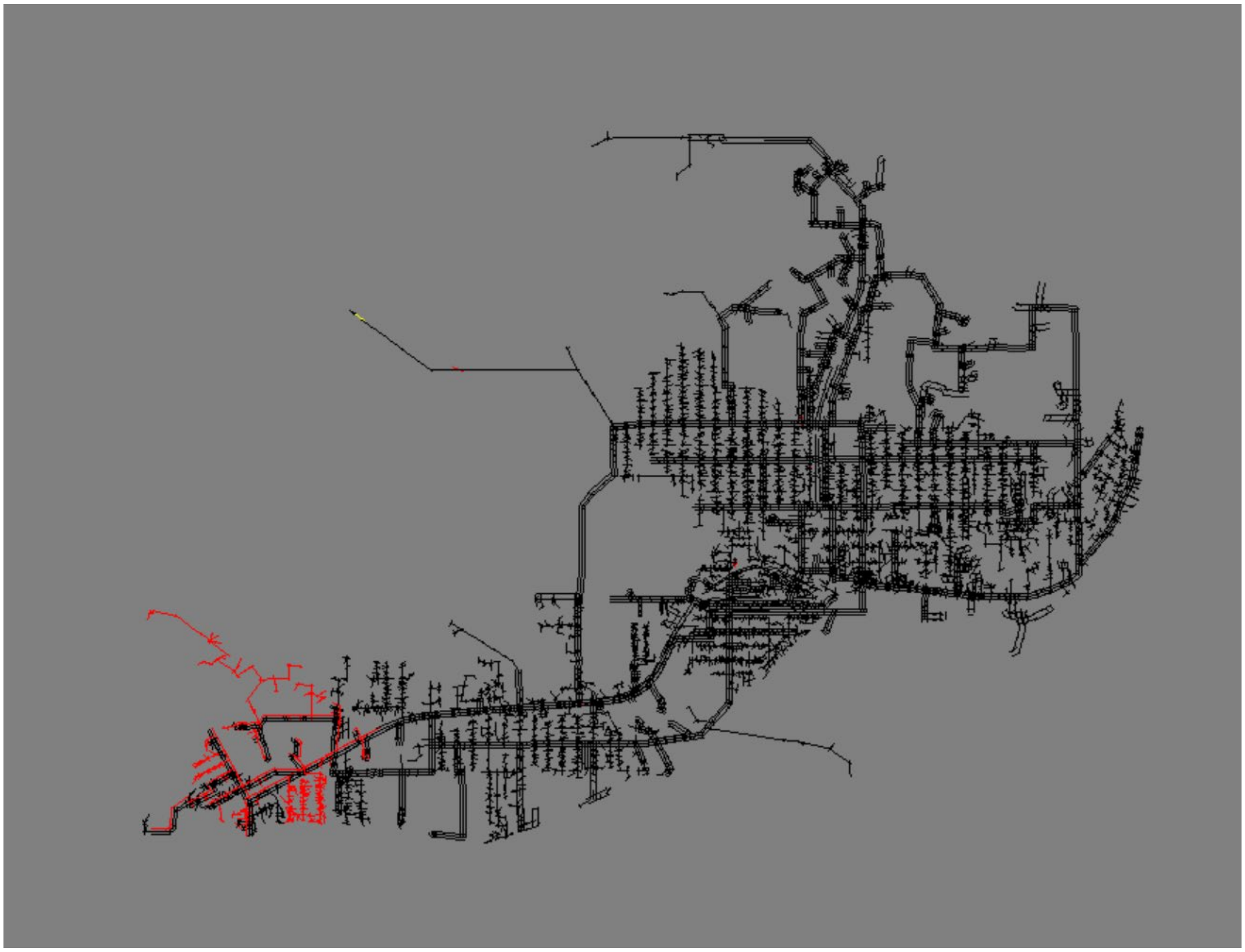


Figure 5. Locations of South Broadway Feeder undervoltage violations 2040

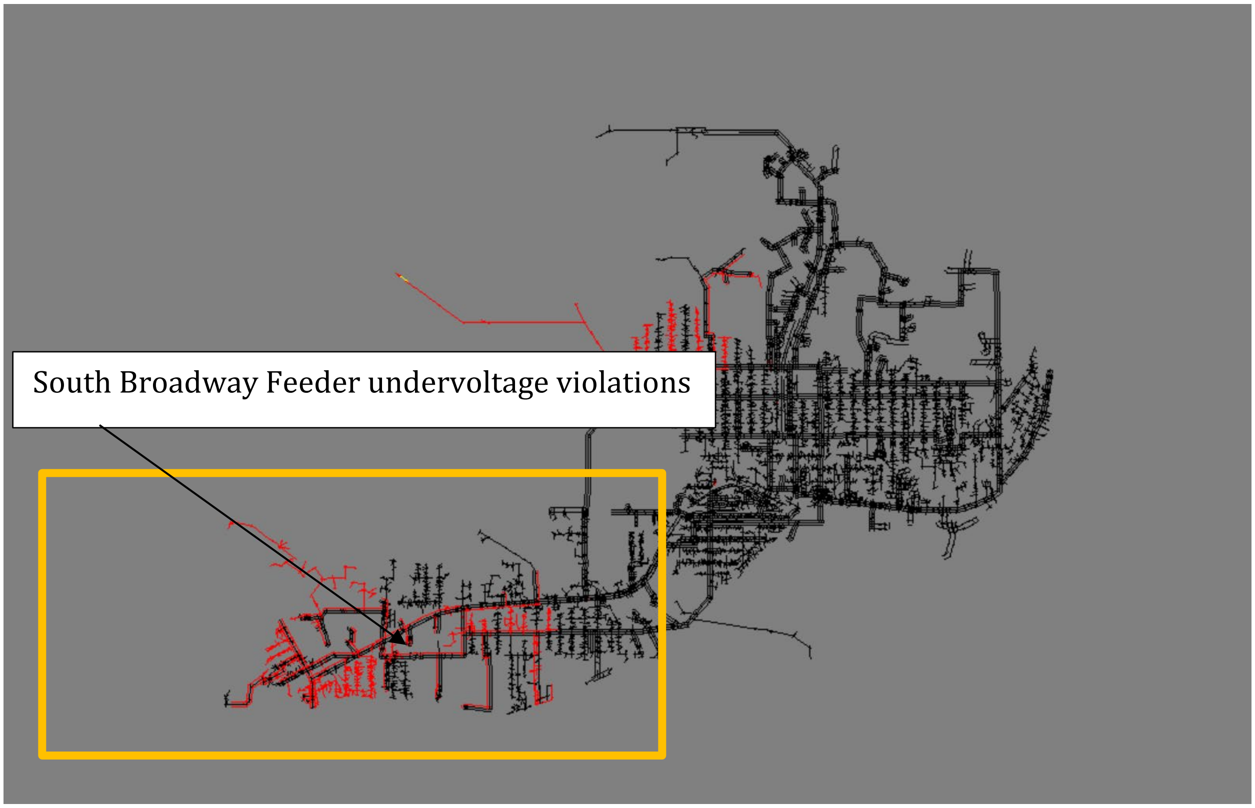


Figure 6. Locations of South Broadway Feeder undervoltage violations 2045

Williamsburg Feeder

Williamsburg Feeder shows no capacity, or power-factor violations from 2025-2045. Undervoltage violations at the end of Williamsburg Feeder on C-phase are projected in 2045. Table 16 Summarizes the Williamsburg Feeder N-0 performance. Figure 7 shows the locations of undervoltage violations in 2045.

Table 16. Williamsburg Feeder Peak Performance Summary

Parameter	Violations (Y/N)	Description
Voltage < 118V	Y	Undervoltage violations at the end of feeder on C-phase starting in 2045.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

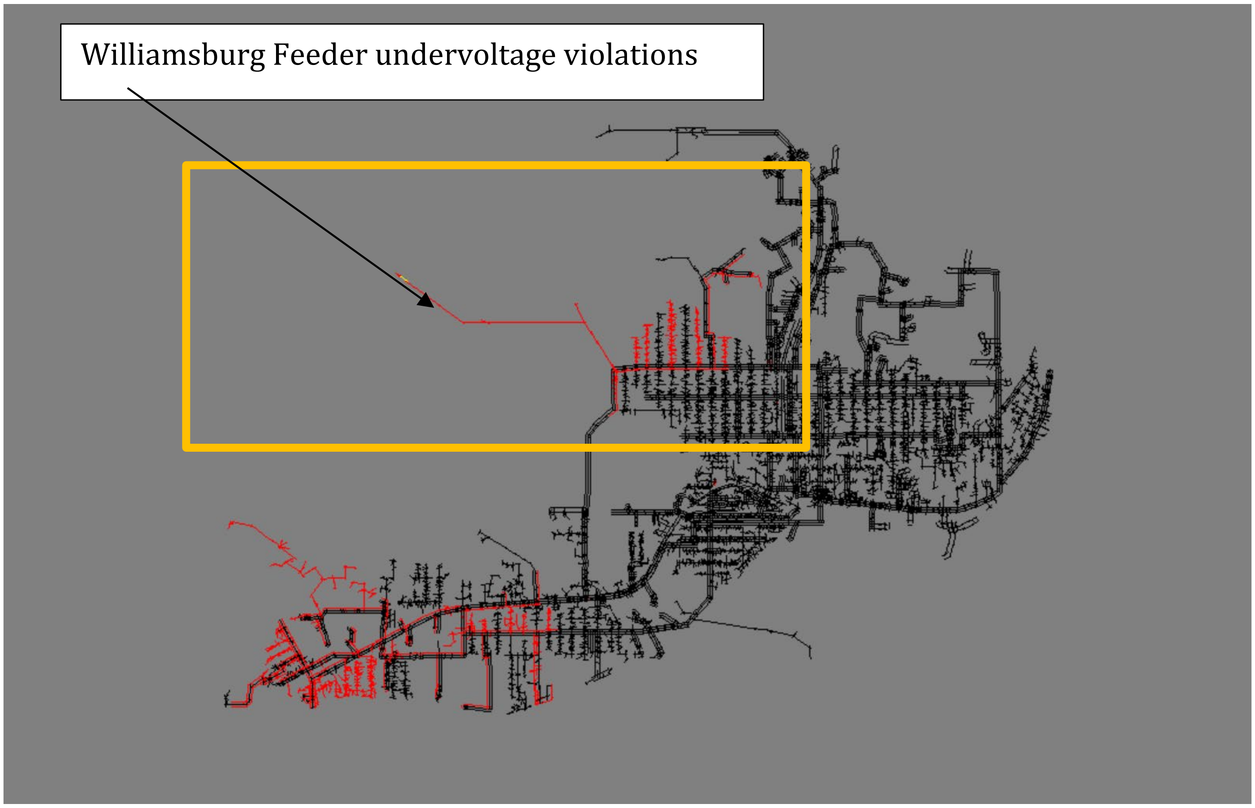


Figure 7. Locations of Williamsburg Feeder undervoltage violations 2045

N-0 Recommendations

The peak-load review for 2025-2045 shows no conductor or equipment overloads and no power-factor deviations. Undervoltage violations are projected on C-Phase of Williamsburg Feeder starting in 2040 and South Broadway Feeder starting in 2045.

Table 17 summarizes the T or C system N-0 performance.

Table 17. System Peak Performance Review

Parameter	Violations (Y/N)	Description
Voltage < 118V	Y	Undervoltage violations exist on Williamsburg Feeder and South Broadway Feeder.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

The undervoltage violations can be mitigated through phase balancing. It is recommended that T or C invest in per phase metering. Per phase metering would allow T or C to verify the load imbalance and balance the loads as load grows and shifts.

N-1 Contingency Load Flow Study

The N-1 study measures system robustness at the summer-peak hour when a single major element—one feeder or one 10/12.5/14 MVA substation transformer—is unavailable because of maintenance or a forced outage.

All behind-the-meter PV is modeled off-line. The same 1.5 % compound annual growth rate used in the base (N-0) cases projects demand from the 2025 reference year through 2045.

Each feeder outage scenario transfers load to adjacent circuits using recommended switching plans and verifies that the receiving conductors stay within thermal and voltage limits. For a transformer outage, the bus-tie closes and the surviving unit must pick up the entire substation; its loading is capped at the 14 MVA, 65 °C FA nameplate rating. All simulations to calculate system voltages and currents were run in Milsoft WindMil.

Voltage compliance follows ANSI C84.1 Range B (110–127 V). Allowing a 4 V service drop, the acceptable primary band tightens to 114–127 V. LTCs at both transformers start at 125V with line-drop compensation disabled. Conductors are flagged when calculated current exceeds 100 % of emergency (four-hour) ampacity; this threshold matches T&D's operating guidelines for short-duration contingencies. Any violation triggers a mitigation—reconductor, voltage regulator addition, sectionalizing change—which is included in the model before the next study year is run, so the plan evolves with the forecast.

Table 18 provides the N-1 study parameters.

Table 18. N-1 Study Parameters

Study Parameter	Criterion	Comment
Load horizon	2025 – 2045, 1.5 % CAGR	Same growth profile as N-0 base case
PV status	Off-line	No generation in contingency state
Primary-side voltage	114 V – 127 V	ANSI Range B minus 4 V service-drop allowance
Feeder conductor loading	≤100% emergency rating	Four-hour ampacity limit
Substation transformer (single-unit)	≤ 14 MVA	65 °C FA nameplate
LTC setpoint	125 V, LDC off	Starting tap for all scenarios
Power Factor	> 85 at each node	Ensures margin for avoiding Tri-State G&T power factor penalties.

The method quantifies each contingency, marks the first-year limits fail, and inserts the fix into later simulations to shape the annual reinforcement plan.

Substation Transformer Contingency

Loss of one Hot Springs Substation transformer (10/12.5/14 MVA) is managed by closing the 12.47 kV bus-tie, transferring the load to the remaining identical transformer. The table shows projected peak combined demands assuming 1.5% annual load growth, compared against the single-transformer capacity of 14 MVA.

Table 19 provides the projected substation transformer loading assuming the loss of the other transformer.

Table 19. N-1 Projected Substation Transformer Loading

	Hot Springs South KVA	Hot Springs North KVA	Total Load KVA	Loading %
2025	6173	7252	13425	96%
2030	6650	7812	14462	103%
2035	7164	8416	15580	111%
2040	7718	9067	16785	120%
2045	8314	9767	18081	129%

Figure 8 plots simulated hourly demand for selected years, illustrating the gradual increase in peak loads over time. Demand exceeds the single-unit limit of 14 MVA starting in 2029, with increasingly frequent overload hours from 2035 onward. When loads exceed 14 MVA, temporary load shedding occurs until repairs or alternative sources are available. Curtailments will affect only peak periods, but frequency and duration increase annually, making reliability risks unacceptable.

To ensure N-1 reliability long-term, a third 10/12.5/14 MVA transformer source (ideally near Williamsburg) should be planned before operational disruptions become significant. Tracking actual coincident loads and adjusting growth forecasts annually will help refine timing, ensuring investments maintain reliability without premature expenditures.

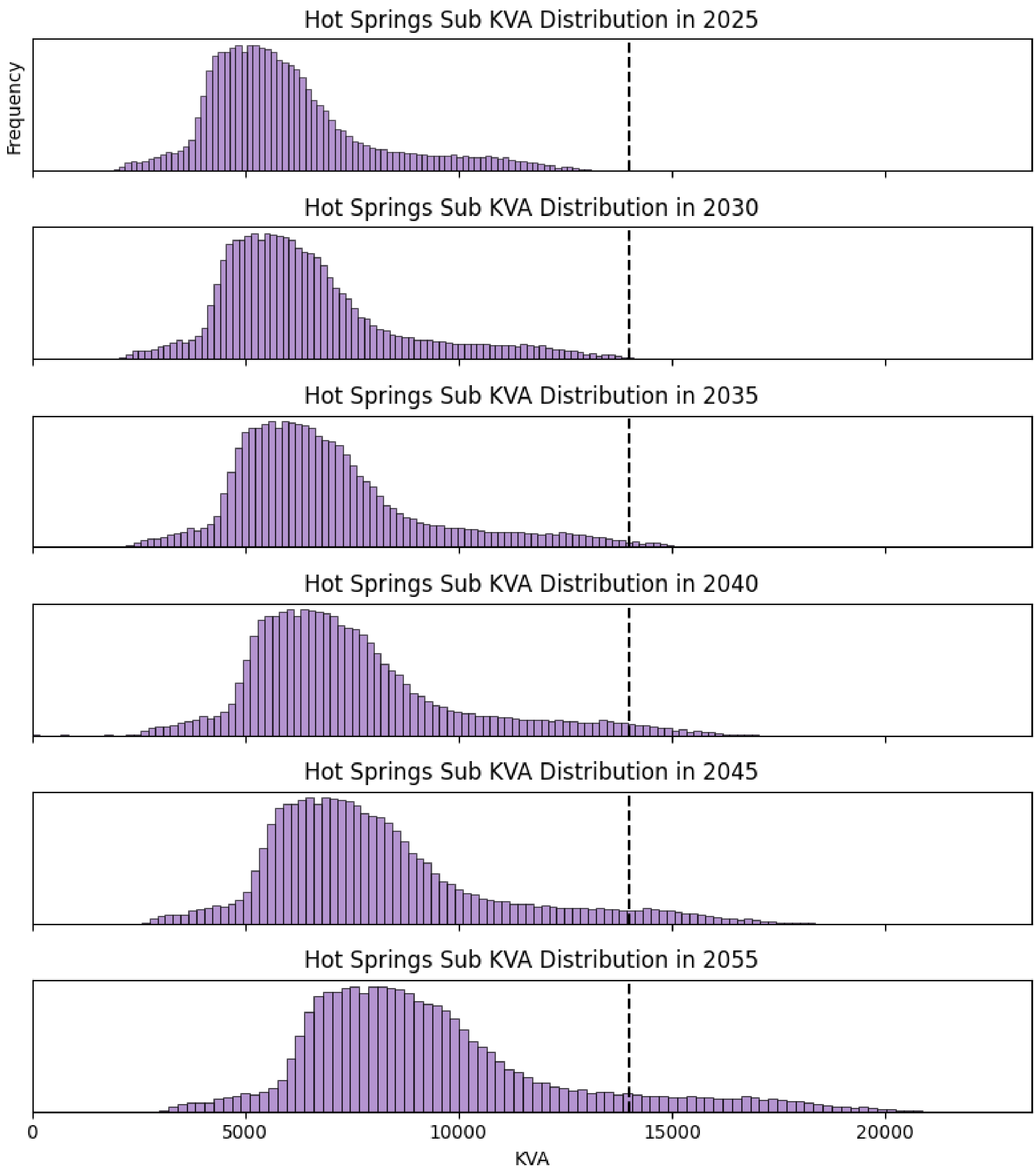


Figure 8. Projected hourly demand for the City of T or C compared to 14MVA transformer limits.

Feeder Contingency:

N-1 analyses were performed to evaluate the loss of each individual feeder. Each analysis considers the worst-case scenario: a fault in the feeder's underground substation get-a-way conductor or required maintenance on the substation breaker. Under these conditions, the entire load of the impacted feeder must be transferred to adjacent feeders.

Multiple switching configurations may exist to restore service to the affected feeder, using existing or proposed switches. However, the combined load must remain below the rated capacity of the backup feeders. Table 20 lists the backup feeders available to support each contingency scenario based on 2025 loads.

After the initial 2025 load analyses, further N-1 analyses were performed, incrementing feeder loads annually by 1.5% through 2045, to verify the continued suitability of the recommended switching configurations.

Feeder Out	Back Up Feeder
Ash Feeder	Downtown Feeder
Cedar Feeder	Ash Feeder
Downtown Feeder	Ash Feeder
Riverside Feeder	Ash Feeder
South Broadway Feeder	Williamsburg Feeder
Williamsburg Feeder	Cedar Feeder

Table 20: Contingency Feeder Load Transfers

Recommended Contingency Load Transfers:

Ash Feeder

On loss of Ash Feeder, T or C should transfer its load to the Downtown Feeder by closing the 7th Avenue Switch. This option results in lower losses and voltage drop compared to alternative transfers to Cedar or Riverside Feeders.

Figure 9 shows the tie between Ash and Downtown Feeders.

Figure 9. Ash to Downtown Feeder Tie

Loss of Ash Feeder creates no voltage, loading, or power-factor concerns for the study period 2025-2045.

Table 21 summarizes the performance of Ash to Downtown Feeder Tie performance for the 2025-2045 study period.

Table 21. Ash to Downtown Feeder Tie Performance 2025-2045

Parameter	Violations (Y/N)	Description
Voltage < 114V	N	No voltage violations exist.
Capacity > 100%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Cedar Feeder

On Cedar Feeder loss, T or C should shift its load to Ash Feeder by closing East 9th Ave Switch. This choice yields the lowest losses and voltage drop compared with routing to Riverside or Williamsburg.

Figure 10 shows the tie between Cedar and Ash Feeders.

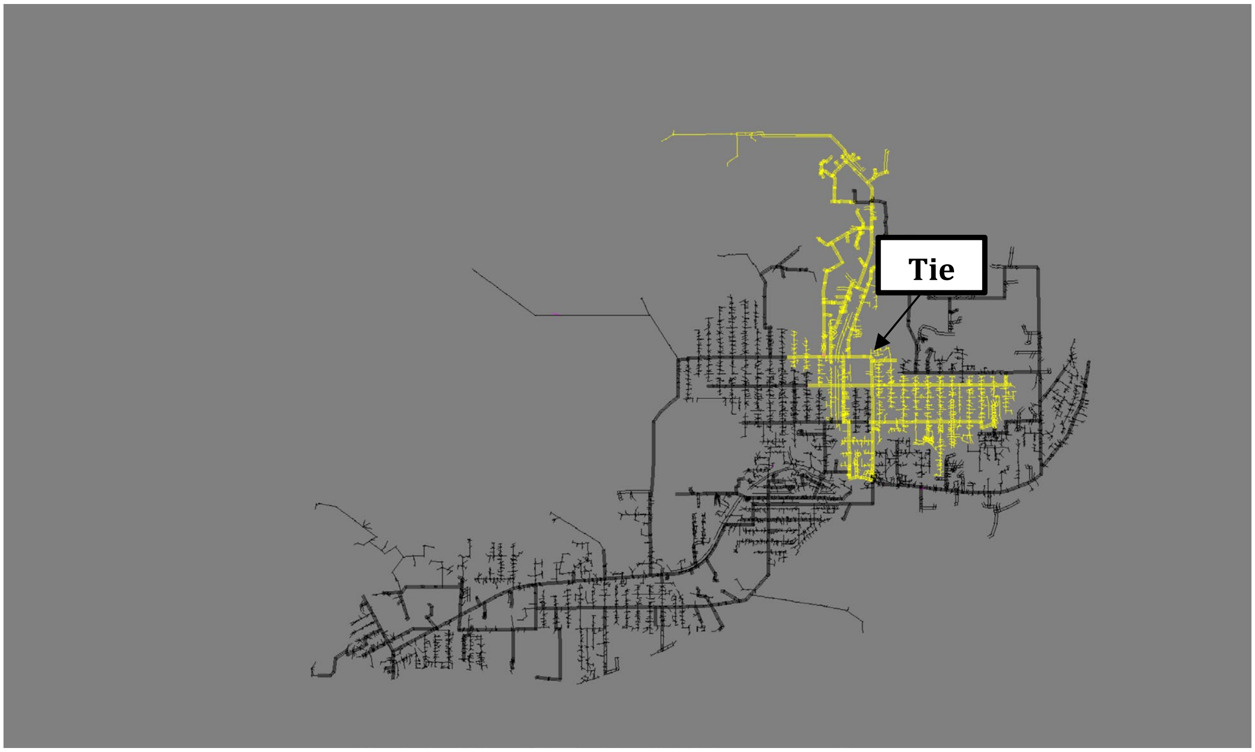


Figure 10. Cedar to Ash Feeder Tie

Loss of Cedar Feeder creates no voltage, loading, or power-factor concerns for the study period 2025-2045.

Table 22 summarizes the performance of the Cedar to Ash Feeder Tie for the 2025-2045 study period.

Table 22. Cedar to Ash Feeder Tie Performance 2025-2045

Parameter	Violations (Y/N)	Description
Voltage < 114V	N	No voltage violations exist.
Capacity > 100%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Riverside Feeder

On loss of Riverside Feeder, T or C should close switch East 8th Ave Switch and shift its load to Ash Feeder. Cedar Feeder could assume the load instead, but routing Riverside Feeder through Ash Feeder yields lower losses and smaller voltage drop.

Figure 11 shows the tie between Riverside and Ash Feeders.

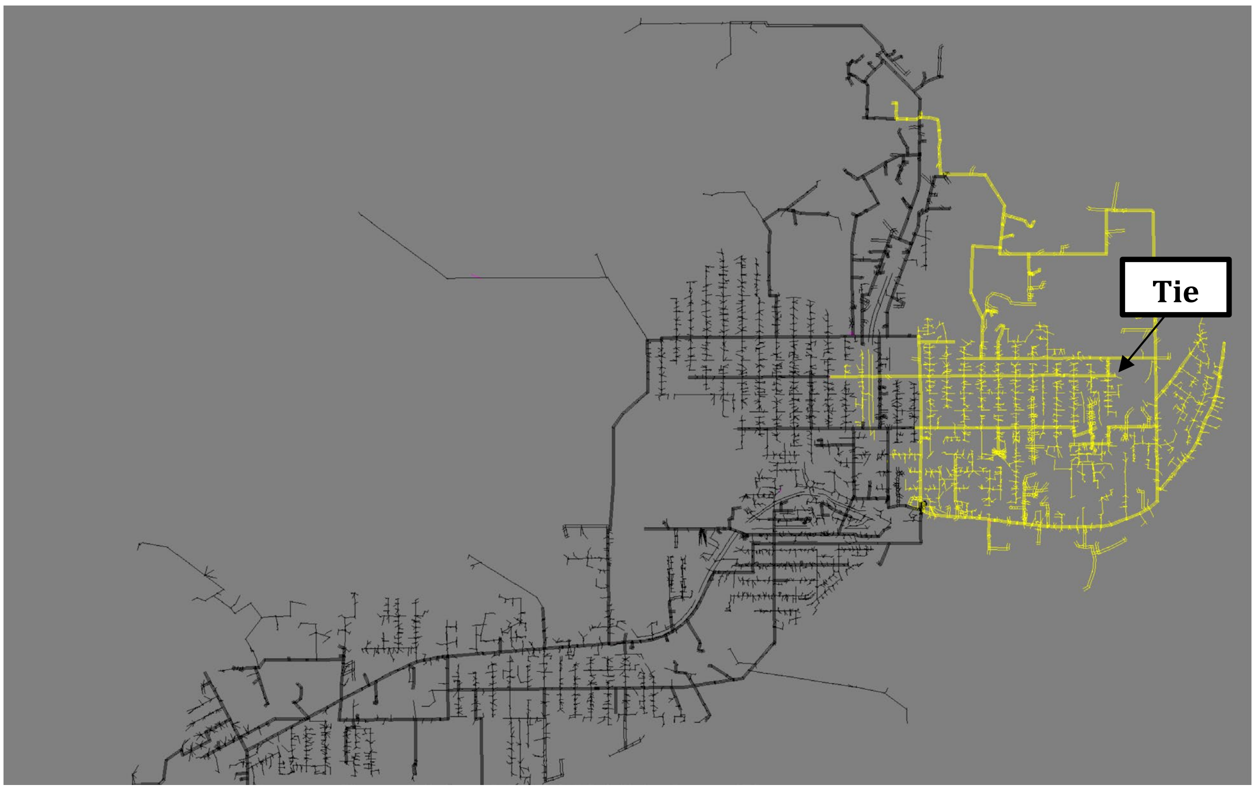


Figure 11. Riverside to Ash Feeder Tie

Loss of Riverside Feeder creates no voltage, loading, or power-factor concerns for the study period 2025-2045.

Table 23 summarizes the performance of the Riverside to Ash Feeder Tie for the 2025-2045 study period.

Table 23. Riverside to Ash Feeder Tie Performance 2025-2045

Parameter	Violations (Y/N)	Description
Voltage < 114V	N	No voltage violations exist.
Capacity > 100%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

Downtown Feeder

On loss of Downtown Feeder, T or C should close the West 7th Ave Switch to transfer its load to Ash Feeder. South Broadway or Williamsburg could carry the load instead, but Ash minimizes losses and voltage drop.

Figure 12 shows the tie between Downtown and Ash Feeders.

Figure 12. Downtown to Ash Feeder Tie

Loss of Downtown Feeder creates no voltage, loading, or power-factor concerns for the study period 2025-2045.

Table 24 summarizes the performance of the Downtown to Ash Feeder Tie for the 2025-2045 study period.

Table 24. Downtown to Ash Feeder Tie Performance 2025

Parameter	Violations (Y/N)	Description
Voltage < 114V	N	No voltage violations exist.
Capacity > 100%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

South Broadway Feeder

For the loss of South Broadway Feeder, T or C should close the South Broadway Switch and the Williamsburg Feeder be used to pick up the load. Another available switching option is to have Downtown Feeder backup the South Broadway Feeder. Transferring the South Broadway load to Williamsburg would result in the least losses and the lowest voltage drop.

Figure 13 shows the tie between South Broadway and Williamsburg Feeder.

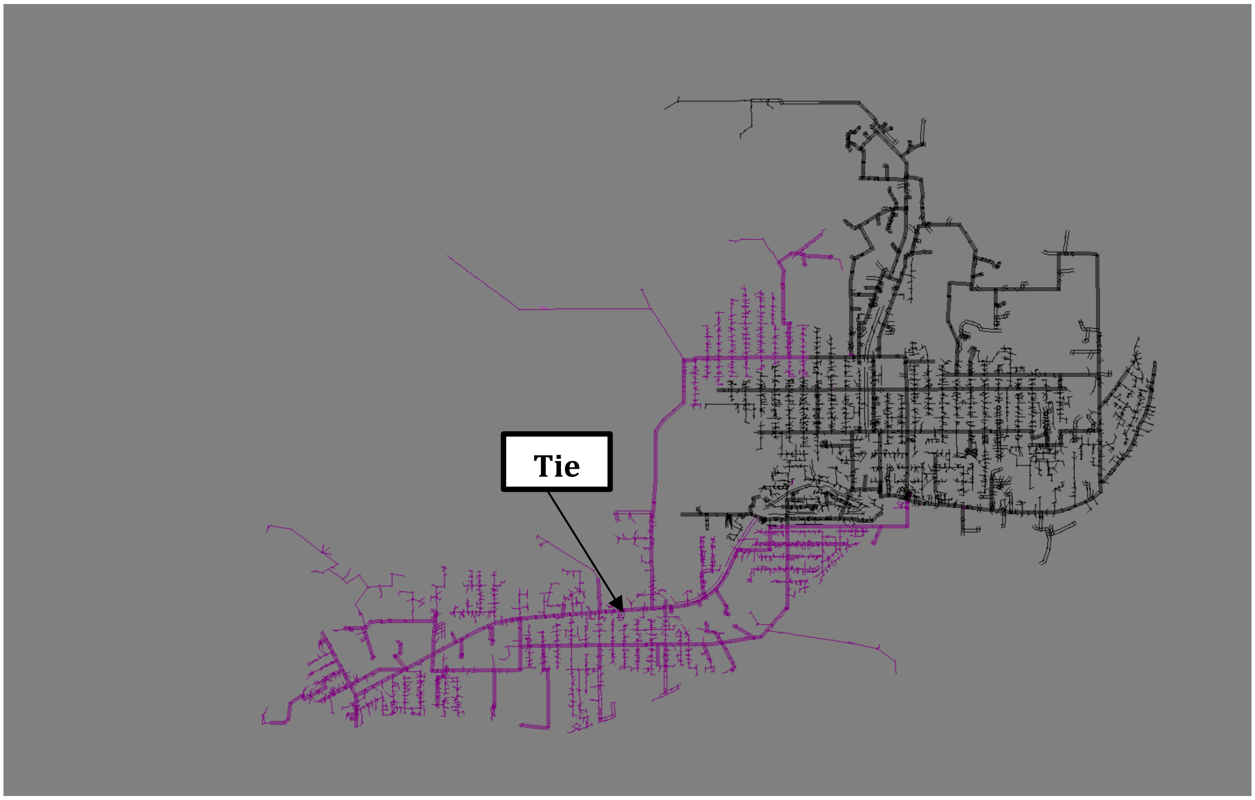


Figure 13. South Broadway to Williamsburg Feeder Tie

Table 25 summarizes the performance of the South Board to Williamsburg Feeder Tie for the 2025-2045 study period.

Table 25. South Broadway to Williamsburg Feeder Tie Performance 2025-2045

Parameter	Violations (Y/N)	Description
Voltage < 114V	Y	Voltage violations are projected to occur beginning in 2040.
Capacity > 100%	Y	Capacity violations are projected to occur beginning in 2045.
Power Factor < 85%	N	No power factor violations exist.

In 2040, tying South Broadway to Williamsburg Feeder produces C-phase undervoltage at the end of the line. Starting in 2045, in addition to the undervoltage violations, C-phase overload occurs on the Williamsburg getaway. Redistributing part of the C-phase load on both feeders to B-phase eliminates both issues.

Figure 14 shows the C-phase undervoltage sections on the South Broadway–Williamsburg tie in 2040 before phase balancing. Figure 15 shows the C-phase overload and undervoltage sections on the South Broadway–Williamsburg tie in 2045 before phase balancing. Red sections represent undervoltage conditions. Green sections represent

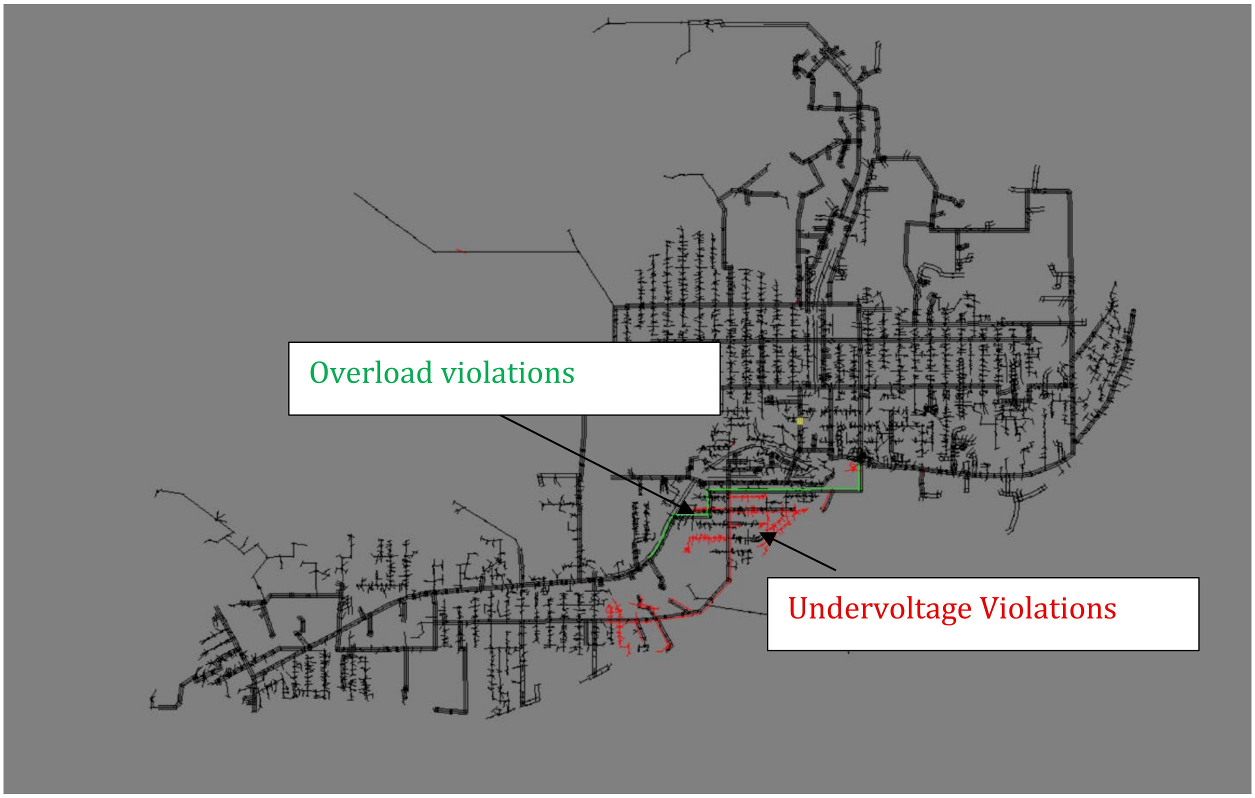


Figure 14. Voltage and Capacity 2040 violations due to South Broadway to Williamsburg Tie

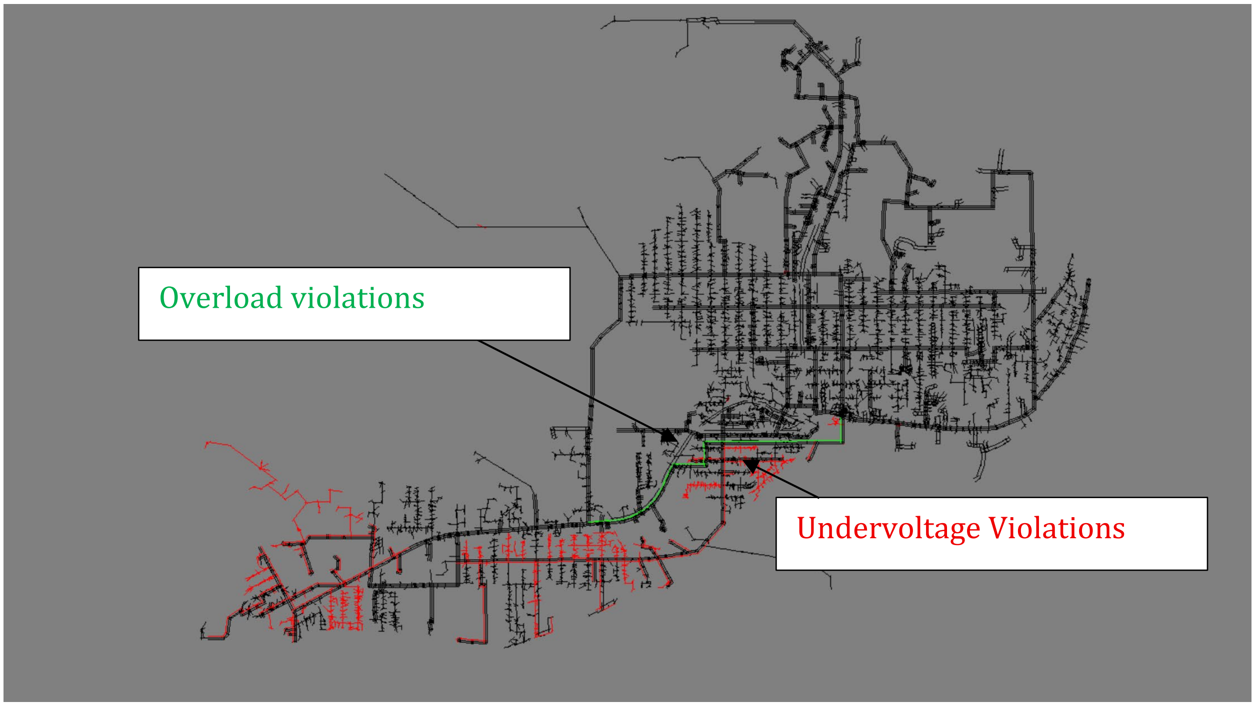


Figure 15. Voltage and Capacity 2045 violations due to South Broadway to Williamsburg Tie

Williamsburg Feeder

On loss of Williamsburg Feeder, T or C should close the West 9th Ave and shift its load to Cedar Feeder; Downtown or South Broadway could take the load, but Cedar yields the lowest losses and voltage drop.

Figure 16 shows the tie between Williamsburg and Cedar Feeders.

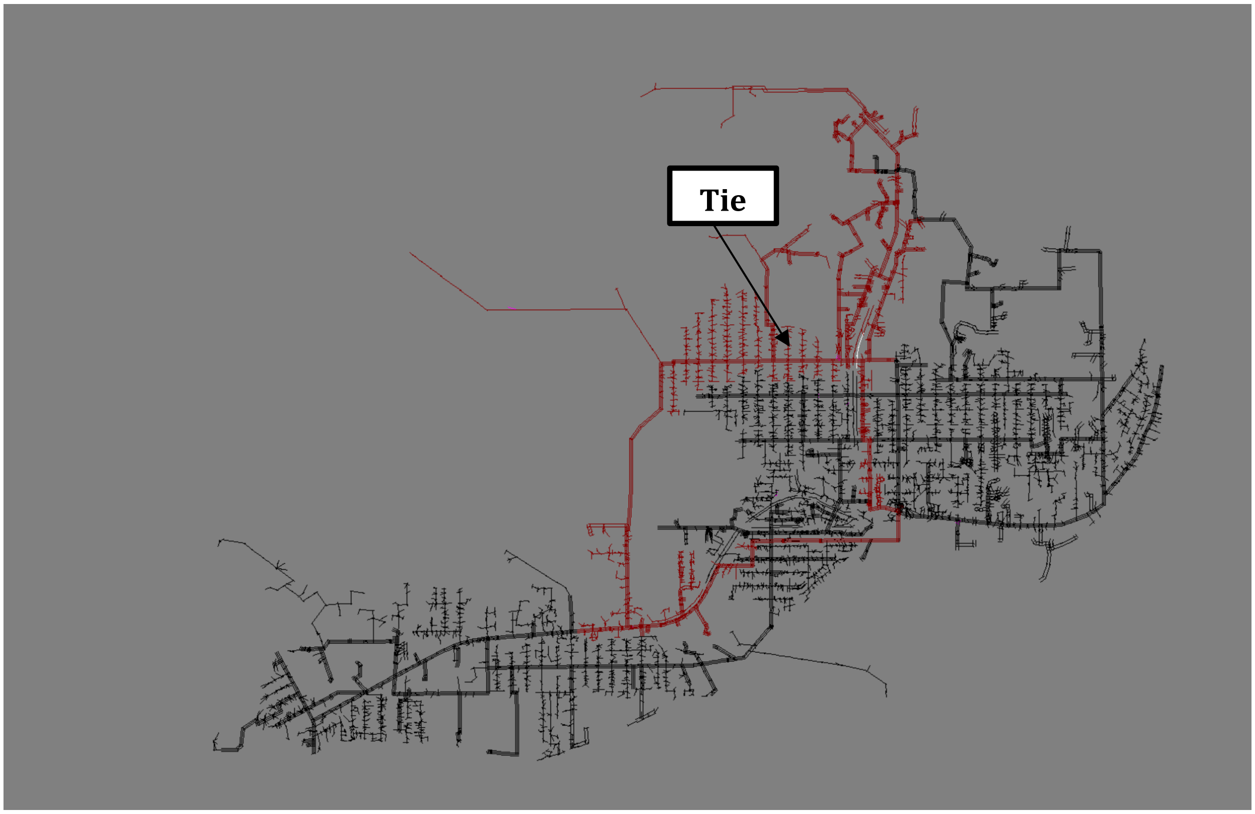


Figure 16. Williamsburg to Cedar Feeder Tie

Loss of Williamsburg Feeder creates no voltage, loading, or power-factor concerns for the study period 2025-2045.

Table 26 summarizes the performance of the Williamsburg to Cedar Feeder Tie for the 2025-2045 study period.

Table 26. Williamsburg to Cedar Feeder Tie Performance 2025-2045

Parameter	Violations (Y/N)	Description
Voltage < 114V	N	No voltage violations exist.
Capacity > 100%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

N-1 Recommendations

The loss of feeder contingency review for 2025-2045 shows no conductor or equipment overloads and no power-factor deviations. Starting in 2040 the South Broadway–Williamsburg tie drives C-phase undervoltage at the end of the line. By 2045, the South Broadway–Williamsburg tie overloads conductor near the feeder getaway. Shifting part of the C-phase load on both feeders to B-phase clears both issues.

Table 27 summarizes the T or C system N-1 performance.

Table 27. System Peak Performance Review

Parameter	Violations (Y/N)	Description
Voltage < 114V	Y	Undervoltage violations exist on South Broadway–Williamsburg tie starting in 2040.
Capacity > 100%	Y	Capacity violations exist on South Broadway–Williamsburg tie starting in 2045.
Power Factor < 85%	N	No power factor violations exist.

The undervoltage and capacity violations can be mitigated through phase balancing. It is recommended that T or C invest in per phase metering. Per phase metering would allow T or C to verify the load imbalance and balance the loads as load grows and shifts.

System Protection

Protection Philosophy

Electric distribution systems rely on protective devices, including breakers, relays, and fuses. The type, location, and settings of these devices dictate overall system performance.

T or C's distribution system has the following system protection components:

- **Bus Protection:** Breakers that safeguard transformers and, if activated, isolate all loads served by the transformer.
- **Feeder Protection:** Breakers that protect individual feeders, isolating all loads connected downstream in the event of a fault.
- **Fuses:** Devices installed on taps to confine outages to specific sections, minimizing impact.

T&D has conducted an analysis of the protection scheme, evaluating the installed devices, their settings, and anticipated fault current conditions.

Substation Breaker Settings

Coordination analysis indicates possible miss coordination between the feeder relays and the upline bus protection. If the bus protection ground overcurrent settings are set too quick, a low-current fault may result in miss coordination. Miss coordination between the feeder relay and the bus protection would result in a much larger outage than necessary due to isolating the other two unaffected feeders

Additionally, review of the calculated maximum fault currents indicate a possible miss coordination on the instantaneous trip settings between the feeder relays and the upline bus protection for a fault located close to the substation.

T&D reviewed the bus and feeder breaker settings and recommends the following:

- Increase Instantaneous Settings. Increase instantaneous phase and ground settings to improve coordination at maximum fault currents.
  - Bus breakers: increase from 4800A to 5800A.
  - Feeder breakers: increase from 4500A to 5400A.
- TCC Curve Slopes
  - Bus breaker: change from V1 (Very Inverse 1) to I1 (Inverse 1).
  - Feeder breakers: change from M (Moderate) to I2 (Inverse 2).
- Feeder Pickup Levels
  - Set all feeder breakers to the same pickup amps (raise Riverside to match the others).
- Feeder Time-Dial Settings
  - Adjust time dials so feeder breakers coordinate with downstream 40K fuses.

The Hot Springs Substation Fault Currents are Provided in Appendix A. Table 28 and 29 provide the existing and new settings.

Table 28. Existing Hot Springs Breaker Settings

Device Name	Device		Pickup Amps (Primary)	Curve	Time Dial	Instantaneous
North Main	Basler BE1-951	Phase	800	V1	2.0	4800
		Neutral	192	M	3.0	4800
South Main	Basler BE1-951	Phase	800	V1	2.0	4800
		Neutral	192	M	3.0	4800
Downtown	Basler BE1-851G	Phase	250	V1	2.2	4500
		Neutral	150	MR	3.0	4500
Ash	Basler BE1-851G	Phase	250	V1	2.2	4500
		Neutral	150	MR	3.0	4500
South Broadway	Basler BE1-851G	Phase	250	V1	1.4	4500
		Neutral	150	MR	3.0	4500
Cedar	Basler BE1-851G	Phase	250	V1	2.2	4500
		Neutral	150	MR	3.0	4500
Williamsburg	Basler BE1-851G	Phase	250	V1	1.4	4500
		Neutral	150	MR	3.0	4500
Riverside	Basler BE1-851G	Phase	200	V1R	2.2	4500
		Neutral	150	MR	3.0	4500

Table 29. Proposed Hot Spring Breaker Settings (Changes shown in red)

Device Name	Device		Pickup Amps (Primary)	Curve	Time Dial	Instantaneous
Bus Protection	Basler BE1-951	Phase	800	I1	2.0	5800
		Neutral	192	I1	3.0	5800
Feeder Protection	Basler BE1-851G	Phase	250	V2	1.3	5400
		Ground	100	V2	3.3	5400

Field Protection

System fuses currently sectionalize the T or C network and limit outage size. Installing three-phase reclosers would add sectionalizing points and further cut outage impact.

Fusing

The City of T or C plans to implement a fuse-blowing philosophy. Every fuse will clear the fault before the upstream recloser issues its first fast trip, eliminating feeder-wide blinks. The service area has few trees, so most temporary faults stem from lightning or wind.

Arresters absorb many lightning surges, and the compact service territory lets crews reach blown fuses quickly.

Fuse Sizing

T&D did not size every lateral fuse. Crews must follow the fuse table (Table 30) and policies when changing a blown link, because the right tap fuse is vital to coordination. The fusing is consistent with T or C plans to adopt a fuse-blowing scheme that clears faults with K-type fast-expulsion fuses before the upstream feeder relay operates.

Table 30 gives the largest fuse that can be installed downstream of each upstream protective device, and installers must know the rating of the nearest upstream device before selecting a fuse.

Table 30: Largest recommended Fuse.

Upstream Device	Largest Fuse
Feeder Protection	40K Fuse
40K Fuse	25K Fuse
25K Fuse	15K Fuse

Recloser Protection

T&D recommends installing distribution reclosers to improve service reliability. Industry data indicate that approximately 75 %–80 % of feeder faults are transient and clear once the arc is interrupted. A recloser trips, waits about one second, and recloses. It applies two fast time-current curves followed by two slow curves; if fault current still exceeds pickup after the fourth trip, the device locks open and requires manual restoration.

Two primary recloser solutions were evaluated. The S&C TripSaver II is a single-phase, current-sensing unit suitable for lateral protection and low-cost deployment, but it lacks voltage-sensing reclosing and remote communications. The G&W Viper-S equipped with an SEL-651R control provides three-phase interruption, voltage-sensing reclosing, and full SCADA integration at a higher installed cost. The need to accommodate reverse power flow from distributed PV and to interface with a future SCADA system will determine the preferred option.

Table 31 summarizes the recloser options.

Table 31. Recloser Options Summarized

Feature	S&C TripSaver II	G&W Viper-S (+ SEL-651R)
Typical application	Fuse replacement	Three-phase feeder/sectionalizing
Price – hardware	≈ $6,000	≈ $30,000
Price – installed	≈$10,000	≈ $60,000
Voltage-sensing reclosing (VSR)	No—current-only protection	Yes—six voltage inputs, sync-close, dead-line detect.

System Valuation

T&D estimated the replacement cost of the T or C distribution system. Net present value—derived by discounting that cost over the system's remaining service life—was not evaluated in this report.

T or C Distribution System Replacement Value

Category		Value
Poles and Assemblies	$	4,206,431
Conductor	$	1,165,414
Underground Construction	$	325,172
Overhead Construction	$	4,096,170
Transformers	$	9,733,935
Meter	$	944,600
Substation	$	8,150,000
Total	**$**	**28,621,722**

Figure 17. System Replacement Value

Recommendations

Using field inventory data, the 2025-2045 peak-load study, and the substation site visit, T&D recommends the following.

Load Flow – Peak Load

Recommendations from the peak-load study—normal state (N-0) and substation transformer/single-feeder loss (N-1)—are listed below.

N-0 Analysis

No recommended changes.

The peak-load review for 2025-2045 shows no conductor or equipment overloads and no power-factor deviations. Undervoltage violations are projected on C-Phase of Williamsburg Feeder starting in 2040 and South Broadway Feeder starting in 2045. The undervoltage violations can be mitigated through phase balancing.

Table 30 summarizes the T or C system N-0 performance.

Table 32. System Peak Performance Review

Parameter	Violations (Y/N)	Description
Voltage < 118V	Y	Undervoltage violations exist on Williamsburg Feeder and South Broadway Feeder.
Capacity > 80%	N	No capacity violations exist.
Power Factor < 85%	N	No power factor violations exist.

It is recommended the City of T or C invest in per phase metering. Per phase meter would allow the City of T or C verify the load imbalance and balance the loads as load grows and shifts.

N-1 Analysis

No recommended changes.

The loss of feeder contingency review for 2025-2045 shows no conductor or equipment overloads and no power-factor deviations. Starting in 2040 the South Broadway–Williamsburg tie drives C-phase undervoltage at the end of the line. By 2045, the South Broadway–Williamsburg tie overloads conductor near the feeder getaway. Shifting part of the C-phase load on both feeders to B-phase clears both issues.

Table 34 summarizes overall system performance for the study period.

Table 33. System Peak Performance Review

Parameter	Violations (Y/N)	Description
Voltage < 114V	Y	Voltage violations exist on loss of South Broadway based on 2040 projected loading
Capacity > 100%	Y	Capacity violations exist on loss of South Broadway based on 2045 projected loading
Power Factor < 85%	N	No power factor violations exist.

Protection

Substation

Minor recommended near-term changes.

Near-Term Substation Protection Recommendations

The following changes to the Bus and Feeder Breaker Settings are recommended.

- Increase Instantaneous Settings.
  - Bus breakers: increase from 4800A to 5800A.
  - Feeder breakers: increase from 4500A to 5400A.
- TCC Curve Slopes
  - Bus breakers: change from V1 (Very Inverse 1) to I1 (Inverse 1).
  - Feeder breakers: change from M (Moderate) to I2 (Inverse 2).
- Feeder Pickup Levels
  - Set all feeder breakers to the same pickup amps (raise Riverside to match the others).
- Feeder Time-Dial Settings
  - Adjust time dials so feeder breakers coordinate with downstream 40K fuses.

Long-Term Substation Protection Recommendations

If a project is planned to replace the incoming 115 kV structures or circuit switchers, new feeder and transformer bus protection relays should be installed. Upgrading the transformer differential and overcurrent relays will improve transformer protection and system reliability. In addition, the metering capabilities of digital relays will improve future planning studies by providing loading for each phase.

Field

T&D Services recommends using a max of 40K Fuse. If fuses are behind other uses, T&D recommends tapering the fuse sizes.

Substation Recommendations

T&D performed a substation visit to evaluate equipment condition, maintenance practices, and operational status. Observations and recommendations were documented and organized for T or C's consideration. Recommendations are detailed here, with supporting photos included in Appendix B

Safety & Security Measures

1. **Bond all fence sections and gates to ground:** Ensure every new or existing fence segment and gate (including rolling gates) is electrically bonded to the station ground grid. This reduces dangerous touch voltages if a ground fault occurs, and includes adding flexible grounding connectors for sliding gate sections.
2. **Secure interior fencing and barbed wire:** Tighten all barbed wire strands on interior fences and make sure they are properly grounded. If a section of fence needs to be electrically isolated from the main yard, install a short non-conductive section to maintain security without creating a grounding hazard.
3. **Restore the security camera system:** Repair or replace the non-functioning surveillance cameras so the station can be monitored 24/7. Continuous remote monitoring will help deter copper theft, vandalism, and unauthorized access at this critical facility.
4. **Remove on-site ladders:** Do not store ladders in the open within the substation (e.g. the 8' step ladder under the transformer radiators). Intruders could use them to climb into equipment or steal materials, so all ladders should be removed or kept securely out of sight.
5. **Store oil drums properly:** Move any transformer oil barrels into proper storage with spill containment (inside the existing containment area or in separate drip trays under cover). Outdoor drums can rust and contaminate oil; dispose of any old oil barrels that have been sitting for long periods or show signs of leakage.
6. **Remove climbing aids on structures:** Eliminate any fixed ladders or step bolts on the 115 kV dead-end structures up to a height of at least 8 feet above grade. This deters unauthorized persons from climbing; authorized line workers can use portable ladders or lifts to access equipment when needed.
7. **Update warning signage:** Upgrade all perimeter and interior fence signs to meet current OSHA/NESC standards for high-voltage areas. Ensure "Danger/Warning – High Voltage" signs (with proper colors and wording) are posted on each gate and fence section at intervals of no more than 50 feet to clearly alert anyone approaching the station.

Construction & Infrastructure Enhancements

1. **Provide fire separation for transformers:** Increase the distance between transformers or install a fire barrier wall between them and the switchgear building. IEEE Standard 980 recommends about a 50-foot separation or an equivalent fire barrier, which will prevent a catastrophic failure or oil fire in one unit from damaging adjacent equipment.
2. **Upgrade cable trench covers for traffic:** Reinforce or replace the cable trench covers where the new drive-through gates are located. The current trench sections

were not designed for vehicle loading and have broken; install traffic-rated trench covers or add supporting steel plates so trucks can drive over them safely without creating holes.

3. **Increase gravel depth in yard:** Add more crushed rock to the substation yard surface to achieve roughly 4–5 inches depth of gravel throughout (and extend it ~3 feet beyond the fence line and gate swings). A thicker layer of gravel improves step and touch potential safety for personnel by providing better insulation; use angular crushed rock (not round river rock) for stability underfoot and vehicle traction.
4. **Install an additional lightning shield wire:** Provide a continuous overhead ground wire to protect the incoming lines on the north side structure, similar to the existing shield wire on the south dead-end structure. This added lightning shield (connected with appropriate clamps or jumpers) will better protect the phase conductors from direct strikes and can be incorporated into future dead-end structure designs.

Equipment Upgrades & Replacements

1. **Remove redundant 115 kV fused disconnects:** Eliminate the old high-voltage disconnect switches that still contain fuses or jumpers in series with the transformers. With the Siemens circuit switchers now handling switching duties, these fuses are unnecessary and could create a hazardous single-phase condition if one blew while the circuit switcher remains closed, so removing them will reduce failure points.
2. **Replace aging high-voltage switches and insulators:** The 115 kV switches, fused disconnect assemblies, and cap-and-pin bus support insulators (approximately 50+ years old) are near end-of-life. New equipment should be installed to replace these – spare parts for the old GE switches are scarce and a failure (e.g. a cracked insulator or broken mechanism) would be hard to fix. Installing modern high-side disconnect switches and SF_6 circuit switchers for each transformer (reusing existing foundations if possible) will improve reliability and eliminate these outdated components, especially since one circuit switcher has already experienced an operating rod failure.
3. **Add local alarm indicators:** Install simple flashing LED alarm indicators on critical cabinets such as the battery charger and relay panels. These visible alarms will immediately alert personnel to issues like a charger AC power loss or a relay failure during routine visits, allowing corrective action before a total DC system failure or protection outage occurs.
4. **Replace faulty temperature gauge:** The liquid temperature gauge on the south transformer is not functioning and should be repaired or replaced. A working temperature gauge is necessary to monitor the transformer's cooling performance and will ensure any overheating condition is noticed in time.
5. **Upgrade surge arresters to polymer station-class:** Substitute older porcelain-type surge arresters on the system with modern polymer-housed station-class arresters. For example, the porcelain arresters on the south transformer (and the mix of polymer/porcelain arresters on feeder risers) should be standardized to polymer units, which are less prone to shattering and have higher energy absorption ratings – improving safety and better protecting the aging feeder cables from voltage surges.
6. **Feeder Cable Replacement:** The feeder cables are likely the same vintage as the station components. The City should plan for their replacement during scheduled

maintenance rather than wait for a failure. Modern cables benefit from significant improvements in manufacturing. Maintaining adequate stock of cable, terminations, lugs, and related accessories will position the City well to support feeder circuit replacements or upgrades.

Maintenance & Inspection Tasks

1. **Check SF_6 gas pressure on circuit switchers:** During every inspection, verify and log the gas pressure on each circuit switcher pole. One pole currently shows a lower pressure (indicating a slow SF_6 leak), so if the pressure continues to decline, use an SF_6 leak detection camera to locate the leak and repair it before it triggers a low-pressure alarm.
2. **Regularly test yard lighting:** Include substation lighting in routine inspections to ensure all lights are functional, including any dusk-to-dawn sensors or timers. Adjust or repair fixtures as needed so that at night the yard is well-lit with no blind spots – proper lighting should complement the security cameras' coverage.
3. **Fix cooling fan on South transformer:** Repair or replace the non-working fan on the south transformer to restore full cooling capacity. Since the transformer fans at this site are often operated manually to control temperature, it's important that all cooling fans are operational to prevent overheating of the unit.
4. **Insulate exposed bus connections:** Install insulating boots or tape on the bus bar connections inside the North transformer's air terminal cabinet (and similarly in switchgear terminations if ever reworked). Proper insulation on these connections will prevent a single-phase fault inside the cabinet from escalating into a three-phase fault, thereby limiting damage and reducing arc flash hazards during a fault.
5. **Maintain cleanliness and organization:** Perform periodic clean-ups of the entire station to remove debris, old equipment parts, or trash that may have accumulated (e.g. broken blocks, scrap wood, old chair, etc.). Keeping the yard clear of unnecessary items deters theft (discarded items can attract intruders) and reduces nesting spots for pests that might damage equipment; similarly, regularly clean inside cabinets (especially those with louvers or screens like battery chargers, switchgear backs, and control panels) to minimize dust and dirt buildup from the New Mexico wind.
6. **Repaint and seal the switchgear enclosure:** The metal switchgear house is showing surface rust and should be primed and painted to prevent further corrosion. Additionally, consider adding baffled hood covers over the lower louvered vents in the doors to block wind-driven dust and rain from entering the cubicles, thus protecting the gear inside.
7. **Address minor oil leaks on transformers:** Clean any oily residue on both the North and South transformers to determine if each leak is active. If a leak is still present (and especially if the unit is under warranty), arrange for the manufacturer or maintenance crew to repair the source of the leak, and ensure that any oil-soaked insulation, paint, or wiring near the leak is cleaned or replaced to prevent long-term damage.
8. **Inspect incoming line structures monthly:** During monthly checks, include the 115 kV transmission poles and hardware just outside the station in the inspection routine. Even if these belong to the utility supplier, examine them for issues like dark burn marks along ground wires, loose guy wires or hardware, and any signs of

deterioration – since a failure of a dead-end pole or its components could bring down the entire substation supply.

9. **Replace saturated transformer breather desiccant:** The south transformer's air breather color indicator is fully red, signifying the drying agent is spent. Service this breather by replacing or regenerating the desiccant per the manufacturer's instructions so it can properly keep moisture out of the transformer oil.
10. **Repair corroded junction box:** Check the heavily rusted junction box on the side of the south transformer's air terminal chamber. If it's just surface rust, wire-brush and repaint it; if the box is compromised or holding water, replace it with a new weatherproof junction box to ensure reliable protection for the connections inside.
11. **Reset relay flags after events:** Some transformer differential relay targets/flags were found in the tripped position. Develop a practice to record any relay operations and then promptly reset the flags after each event, so that future faults can be diagnosed without confusion from previous trip indications left uncleared.
12. **Fix gasket seal on North transformer cabinet:** In the north transformer's air terminal chamber, replace or refit the drooping top gasket (near the roof where the surge arresters are mounted). Resealing this gasket will prevent rainwater from entering and channeling down onto the surge arrester, which could cause tracking or flashover during wet conditions.

System Planning & Reliability

1. **Coordinate relay upgrades with high-side replacements:** If a project is planned to replace the incoming 115 kV structures or circuit switchers, time it alongside the installation of new transformer protection relays. Upgrading the transformer differential and overcurrent relays at the same time as the high-side equipment swap will allow all new protective devices to be tested and commissioned together, ensuring the protection scheme is integrated and up to date.
2. **Ensure feeder bypass capability:** Verify that the distribution system has switching arrangements to bypass or backfeed each feeder in case it must be taken out of service. Ideally, install gang-operated tie switches and prepare written procedures so any one feeder circuit can be isolated and its load picked up by others, minimizing outage impact if a feeder cable or breaker fails.
3. **Plan for a second substation (redundancy):** Consider developing a second delivery point or substation for the city to add redundancy to the electric supply. The current station is a single point of failure – a major incident (like a transformer fire and oil spill) could knock out power to the entire city, so having a geographically separate backup substation would significantly improve system reliability in such a worst-case scenario.

Appendix A: Protection Analysis

Device Pickup Settings Table

Device Name	Reach				Minimum Pickup Setting		Maximum Pickup Setting	
	3Ph Fault (Amps)	Ph-Ph Fault (Amps)	LG Fault (Amps)	MinFault (Amps)	Phase *	Ground	Phase	Ground
Williamsburg Bkr	1704	1583	1325	169	120	**	743	426
South Broadway Bkr	2179	2016	1744	172	230	**	926	551
Downtown Bkr	3107	2938	2727	177	160	**	1324	843
Riverside Bkr	1597	1467	1208	392	210	**	689	389
Cedar Bkr	1987	1837	1554	169	220	**	735	423
Ash Bkr	3387	3227	3039	177	110	**	1430	924

* The minimum pickup is set to 1.5 × the maximum modeled phase load.
** Insufficient data to determine minimum ground pickup.

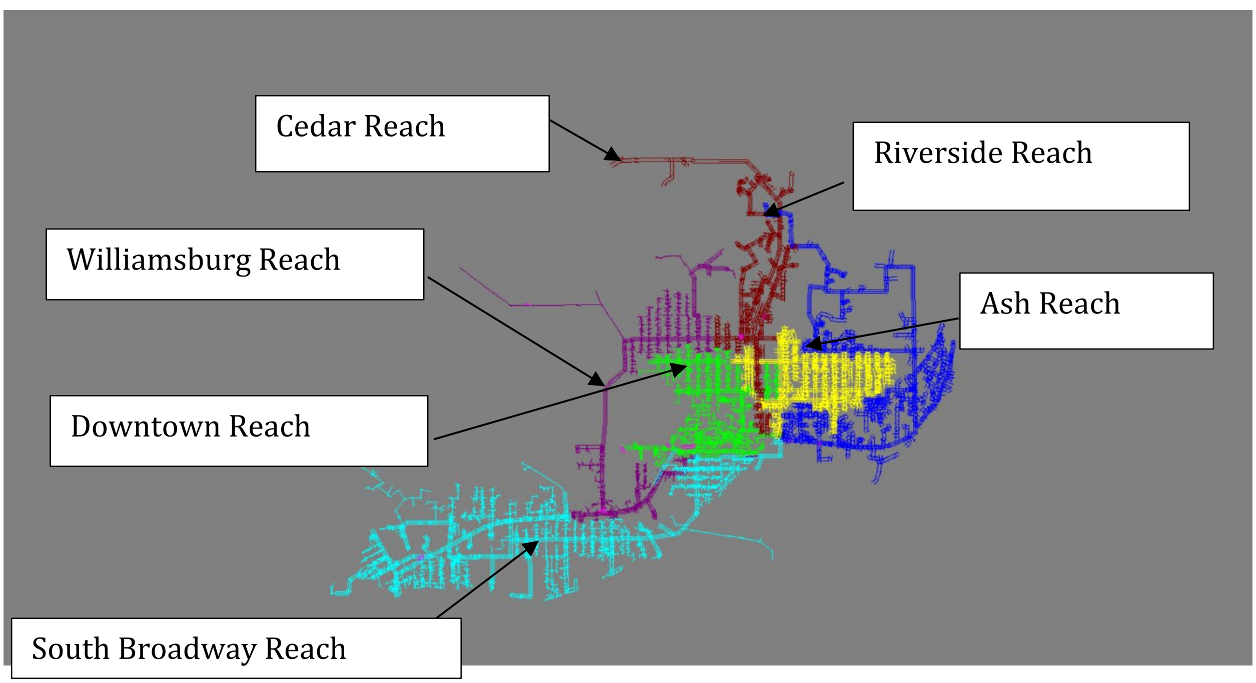
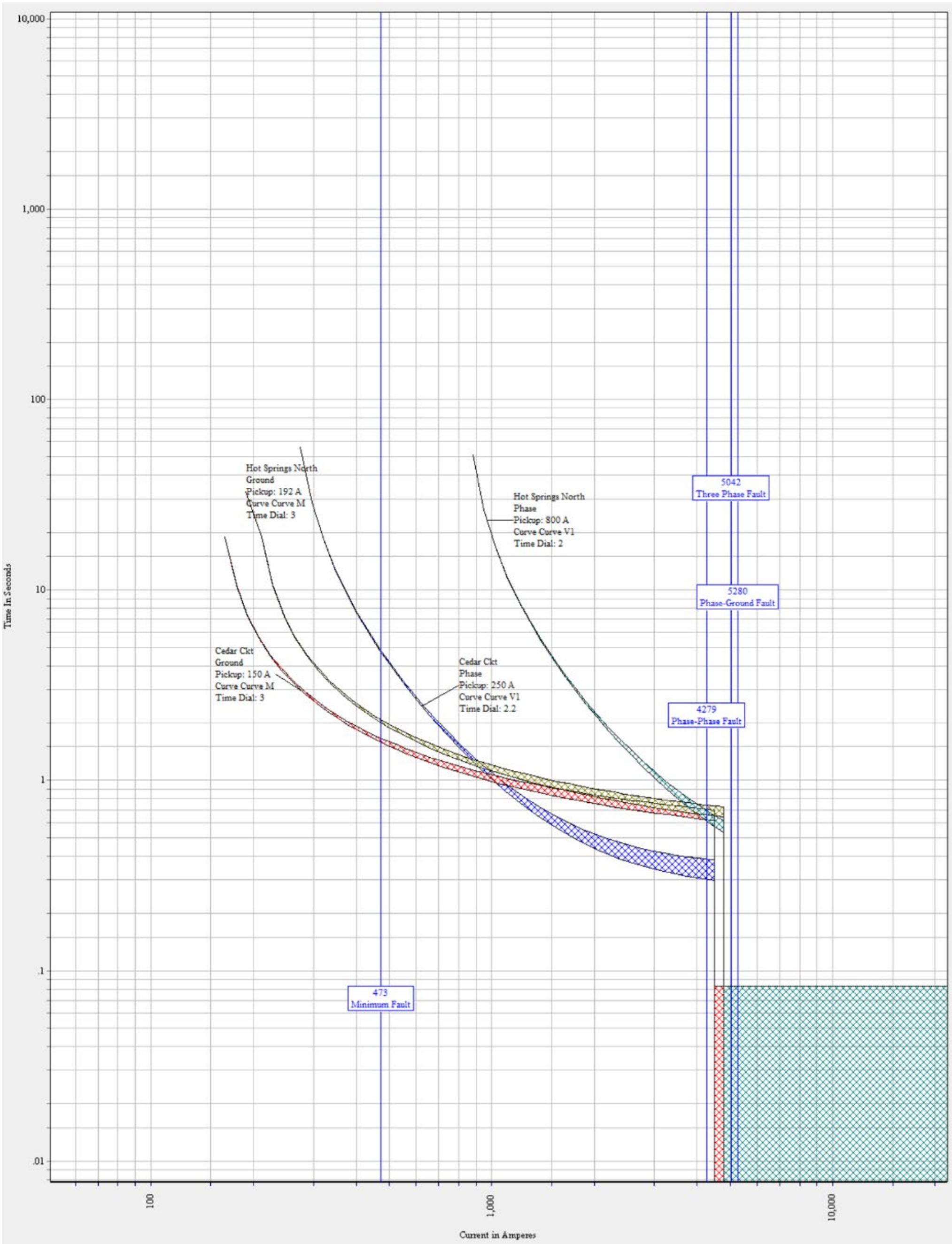


Figure 18. Locations of Feeder Reach

Existing System Analysis

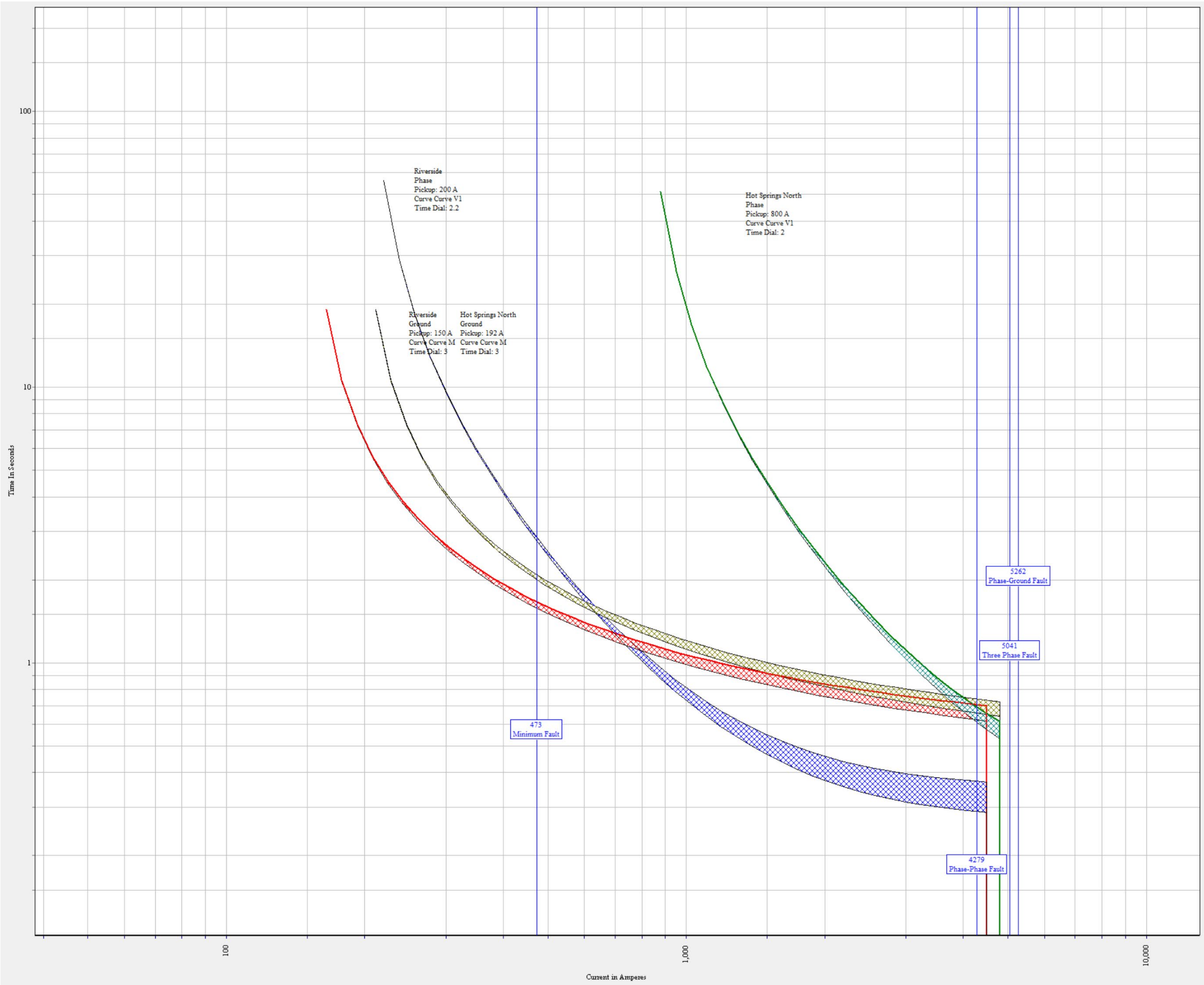
Bus Protection (Existing Settings) and Feeder Relay (Existing Settings). Excluding Riverside Feeder



Ash feeder represents the other feeders (except Riverside) due to be the location of the highest fault current. Instantaneous element clears the max fault current. The existing settings do not coordinate at maximum fault currents.

Figure 19. Bus Protection (Existing Settings) to Feeder Relay (Existing Settings)

Bus Protection (Existing Settings) and Riverside Feeder Relay



Instantaneous element clears the max fault current. The existing settings do not coordinate at maximum fault currents.

Figure 20. Bus Protection (Existing Settings) to Feeder Relay (Existing Settings)

Feeder (Existing Settings) and Nearest/Largest Fuse

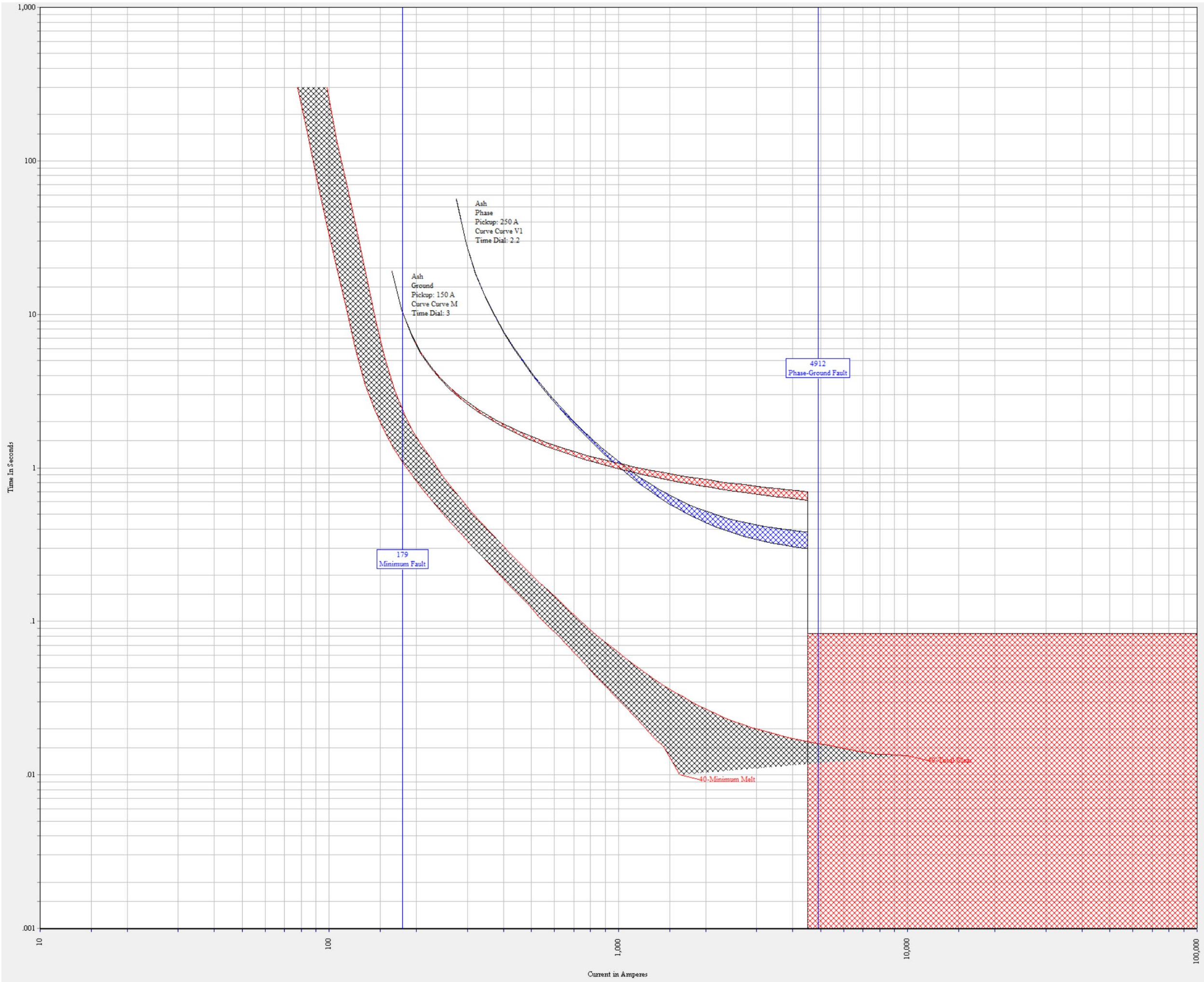


Figure 21. Feeder (Existing Settings) and Nearest/Largest Fuse (40T) -Faults Demonstrated at 40T Fuse.

Ash feeder represents the other feeders (except Riverside) due to be the location of the highest fault current. Instantaneous element clears the max fault current. The existing settings do not coordinate at maximum fault currents.

Riverside Feeder (Existing Settings) and Nearest/Largest Fuse

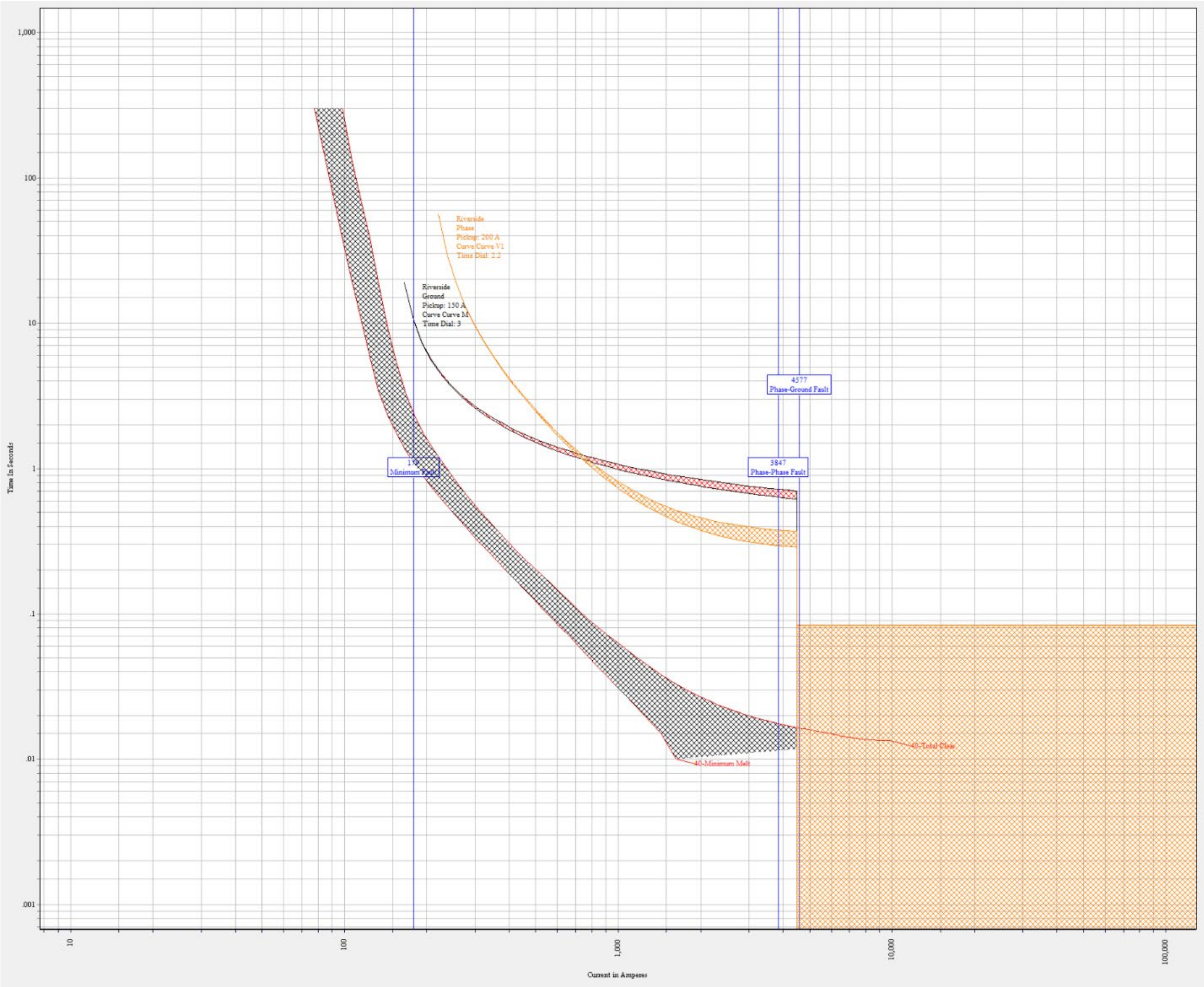


Figure 22. Riverside Feeder (Existing Settings) and Nearest/Largest Fuse (40K)-Faults Demonstrated at 40K Fuse.

Instantaneous element clears the max fault current. The existing settings do not coordinate at maximum fault currents.

Proposed System Analysis

Bus Protection (Proposed Settings) and Feeder Relay (Proposed Settings)

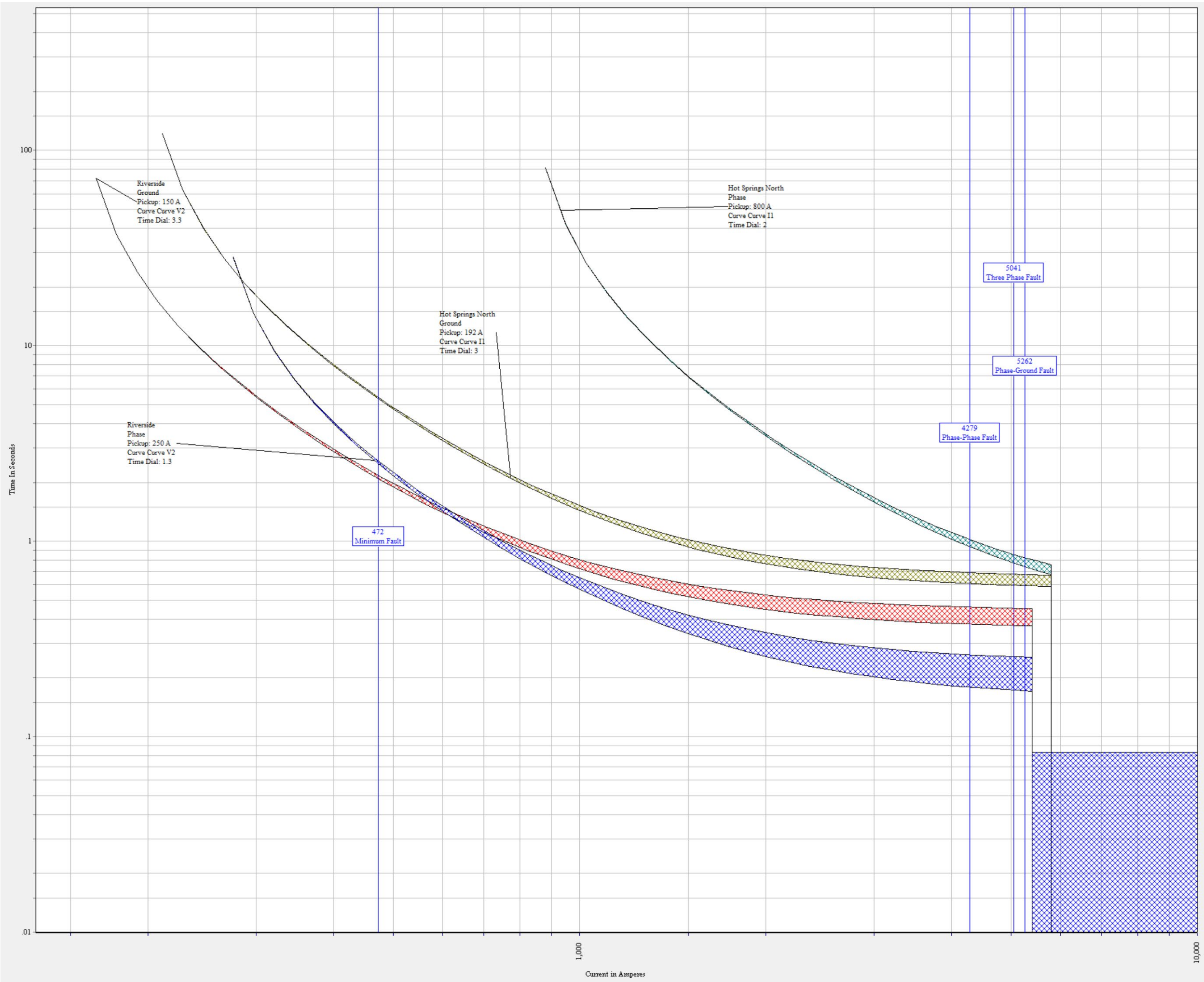


Figure 23. Bus Protection (Proposed Settings) and Feeder Relay (Proposed Settings)

Feeder Relay (Proposed Settings) and Nearest/Largest Fuse

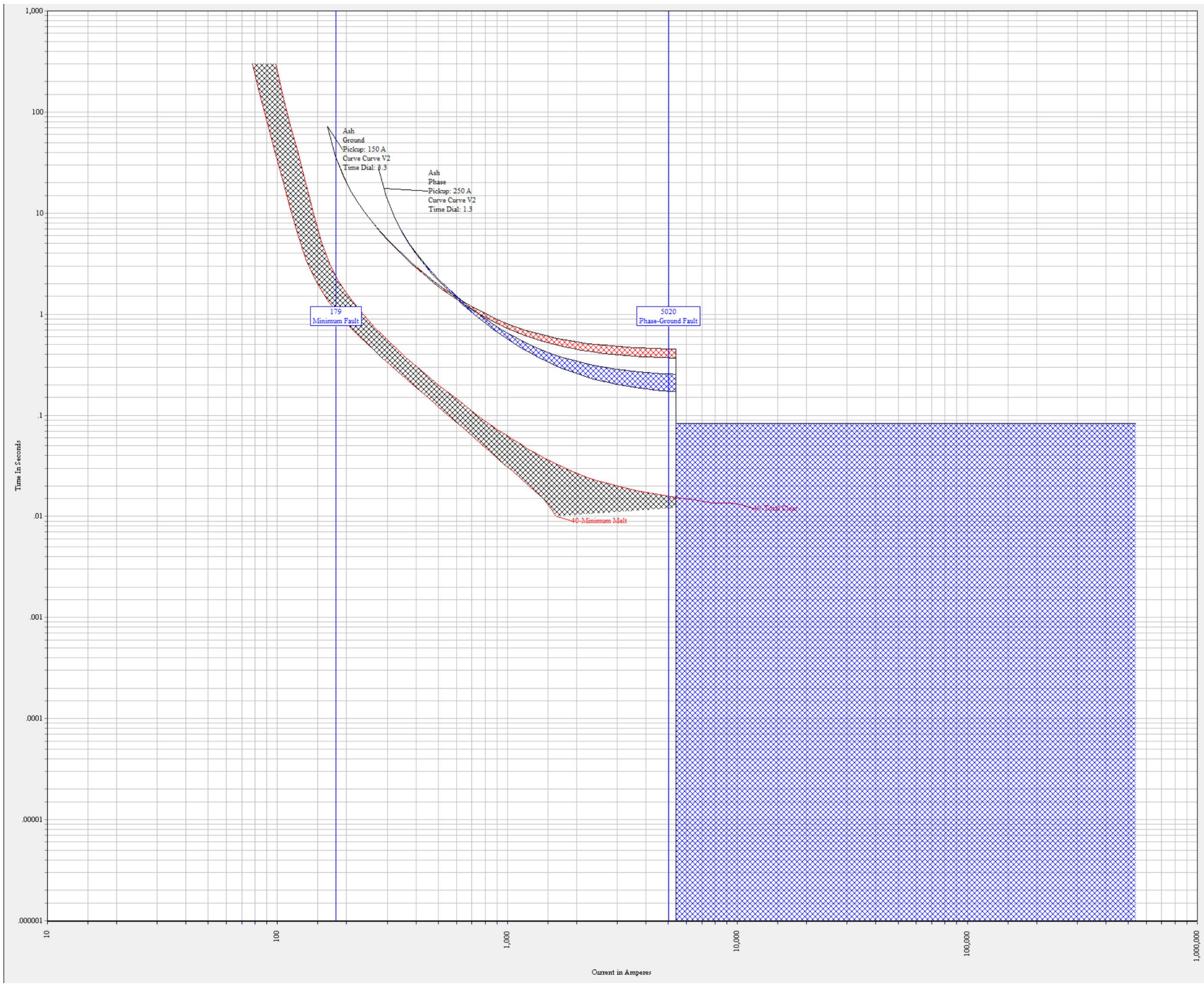


Figure 24. Coordination Between Feeder Relay (Proposed Settings) and Nearest/Largest Fuse (40K) - Faults Demonstrated at 40K Fuse.

Feeder Relay (Proposed Settings) Reach (Minimum Fault)

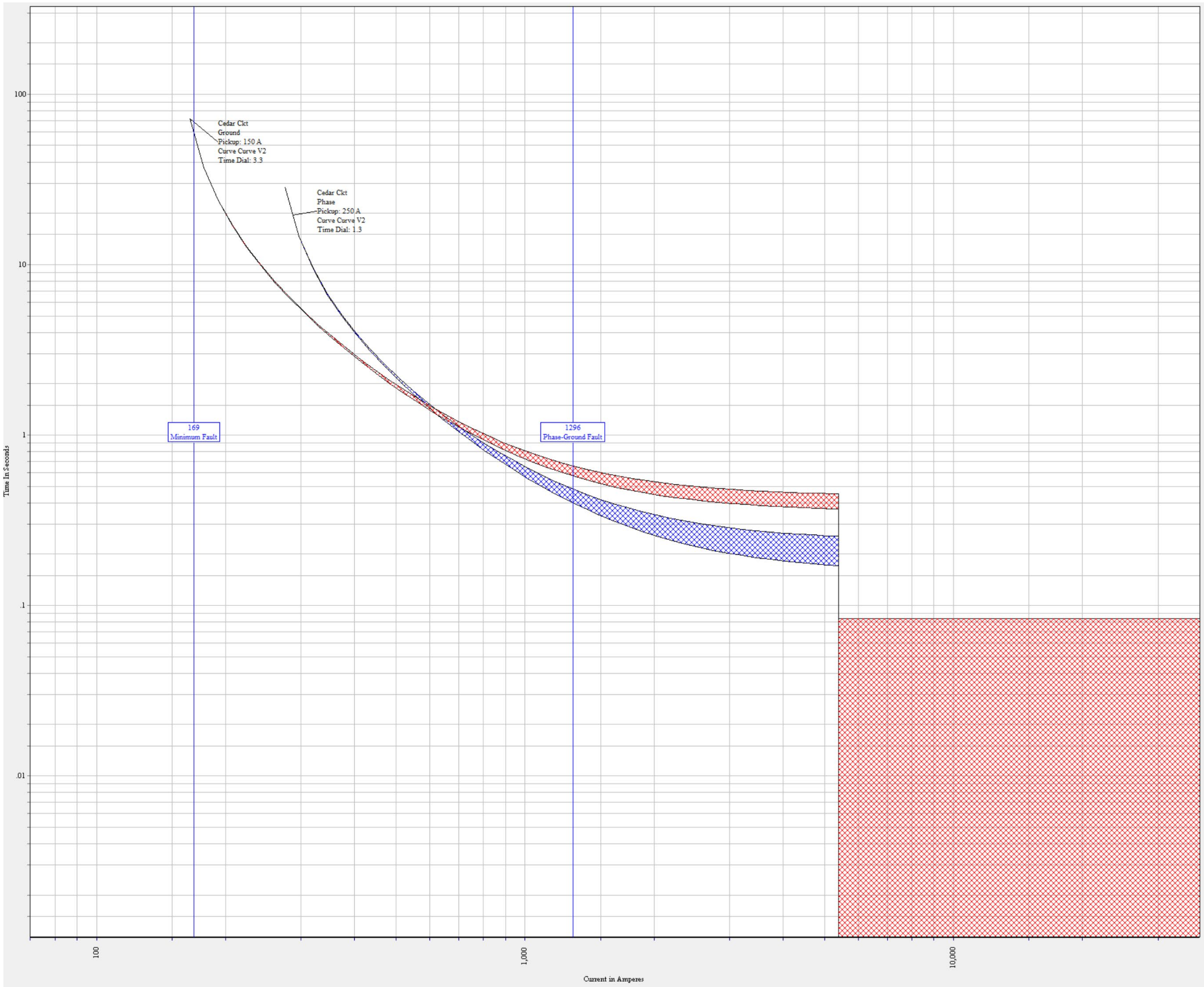


Figure 25. Coordination Between Feeder Relay (Proposed Settings) and minimum fault current (end of line Cedar Feeder).

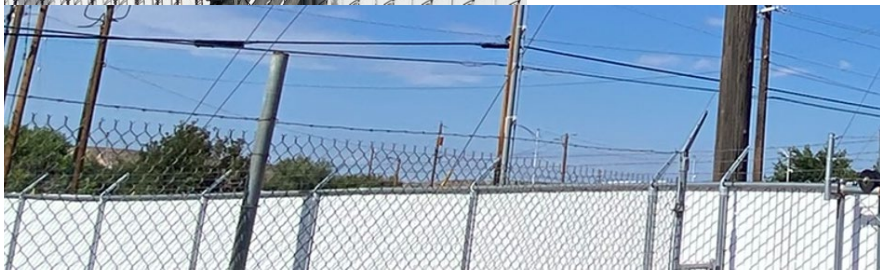
Appendix B: Substation Photos

Safety & Security Measures

Bond all fence sections and gates to ground

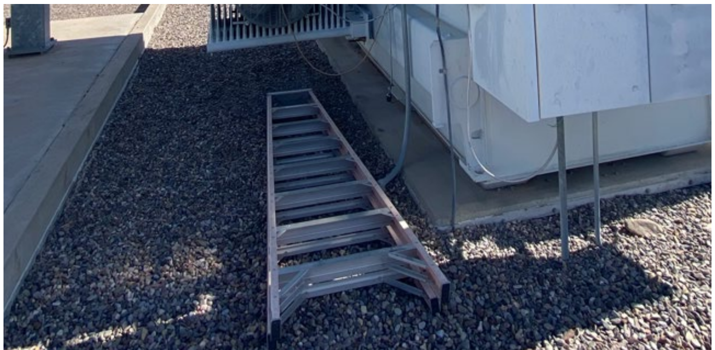


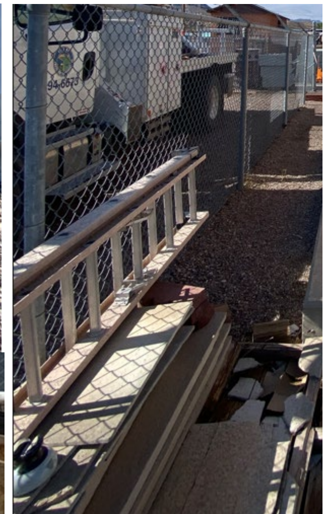
Secure interior fencing and barbed wire



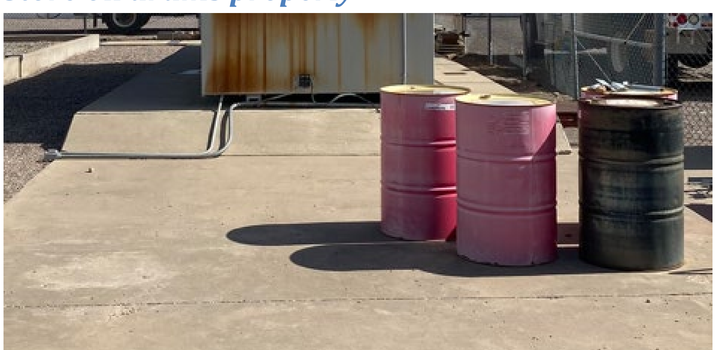
Restore the security camera system

Remove on-site ladders





Store oil drums properly

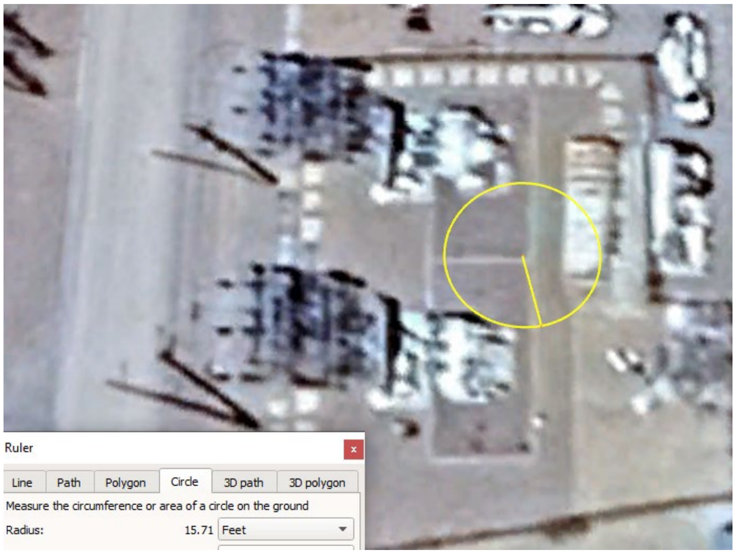


Remove climbing aids on structures

Update warning signage

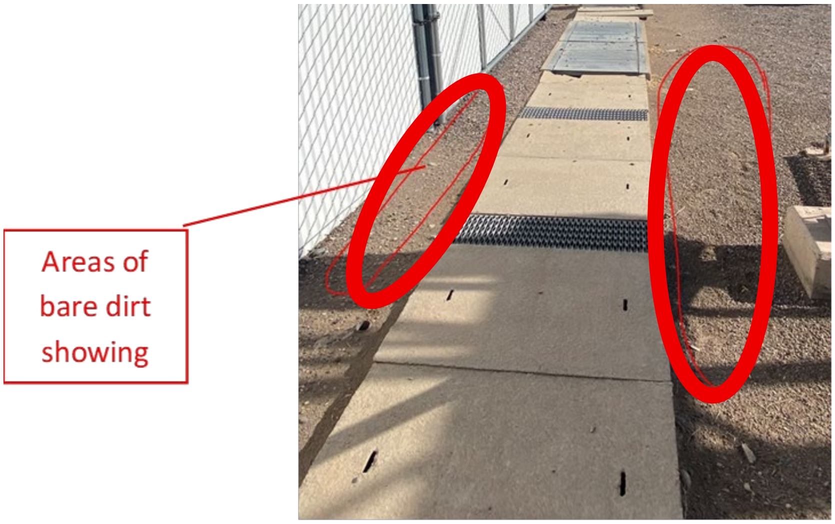
Construction & Infrastructure Enhancements

Provide fire separation for transformers



Upgrade or replace cable trench covers for traffic (Safety Hazard):

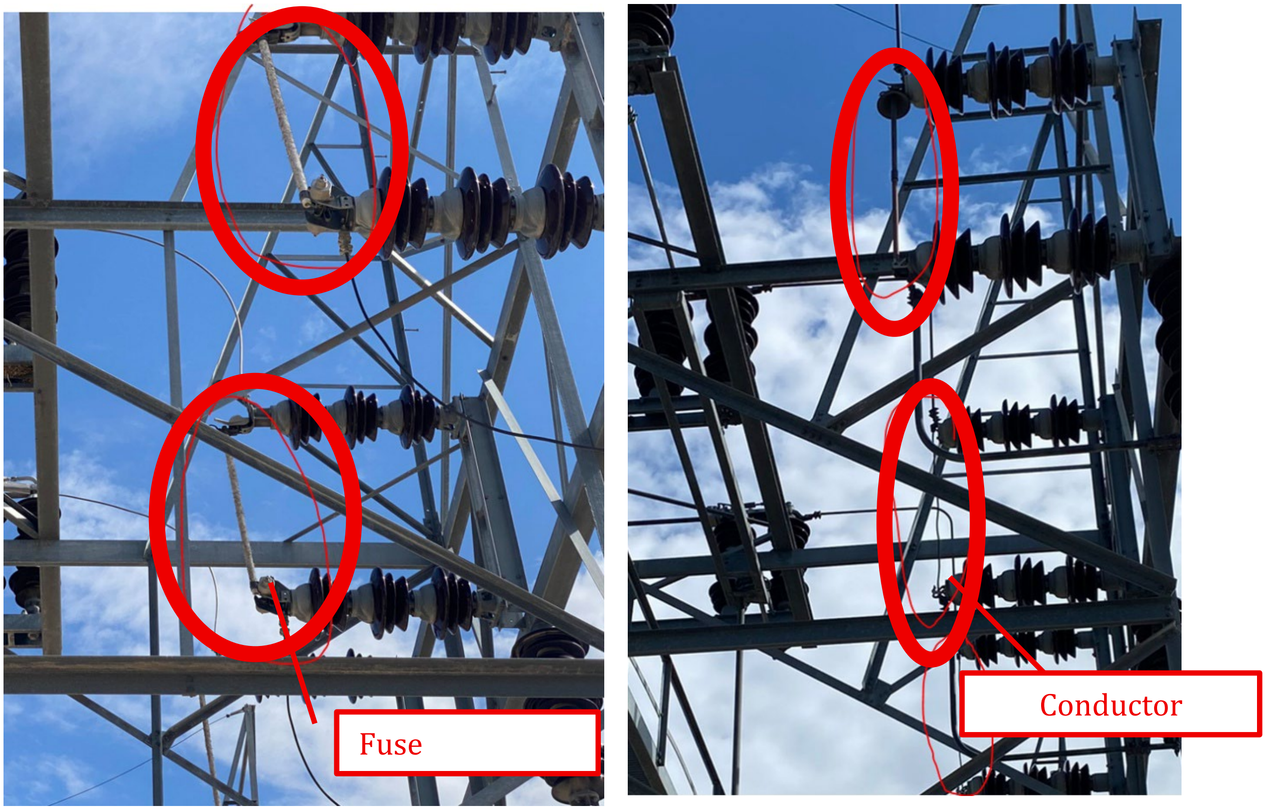
Increase gravel depth in yard



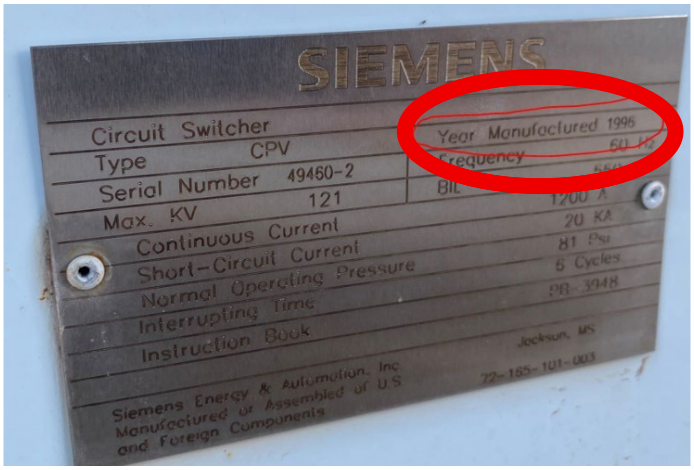
Install an additional lightning shield wire

Equipment Upgrades & Replacements

Remove redundant 115 kV fused disconnects.



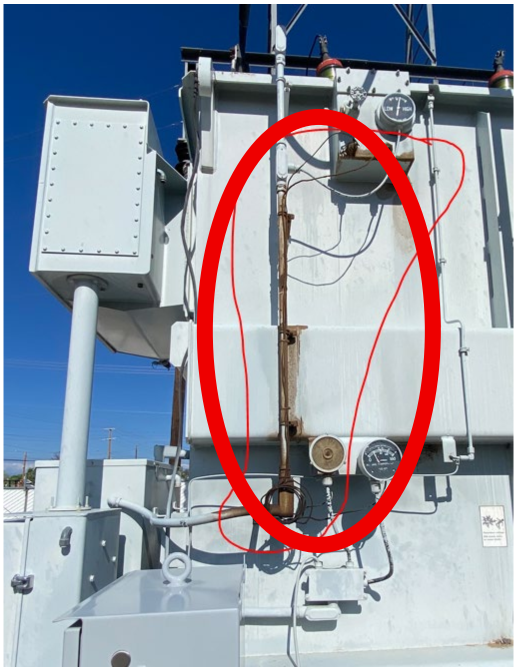
Replace aging high-voltage switches and insulators



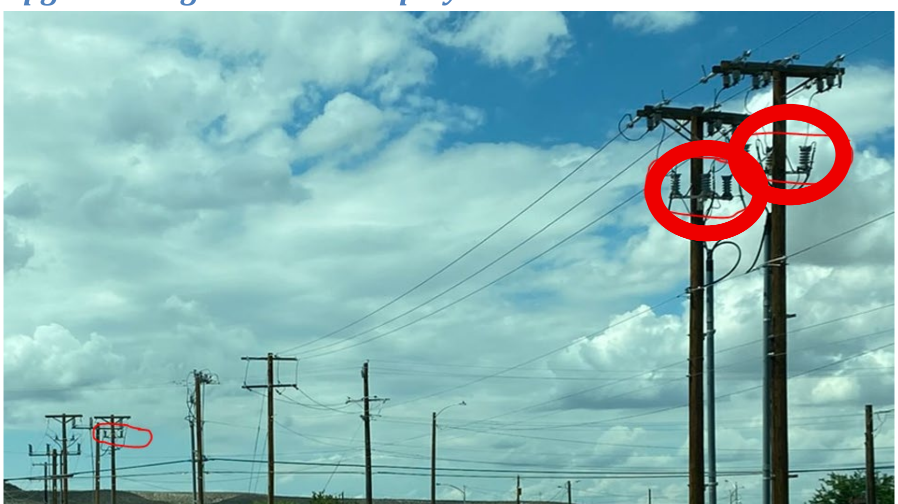
Add local alarm indicators

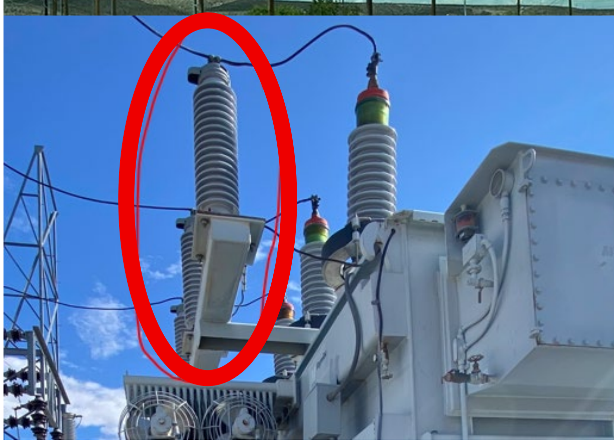
No photos of the existing battery charger are available. Local alarm indicators can easily be added to the existing battery charger/battery cabinets or relay enclosures.

Replace faulty temperature gauge



Upgrade surge arresters to polymer station-class





Maintenance & Inspection Tasks

Check SF_6 gas pressure on circuit switchers

No photo available.

Regularly test yard lighting.

Fix cooling fan on South transformer.

Insulate exposed bus connections.

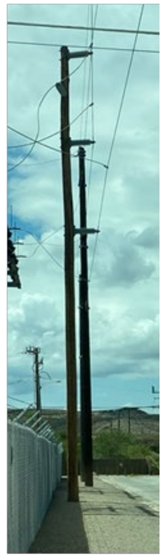
Maintain cleanliness and organization.

Repaint and seal the switchgear enclosure.

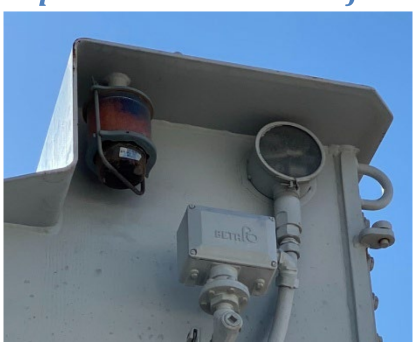
Address minor oil leaks on transformers:

Inspect incoming line structures monthly

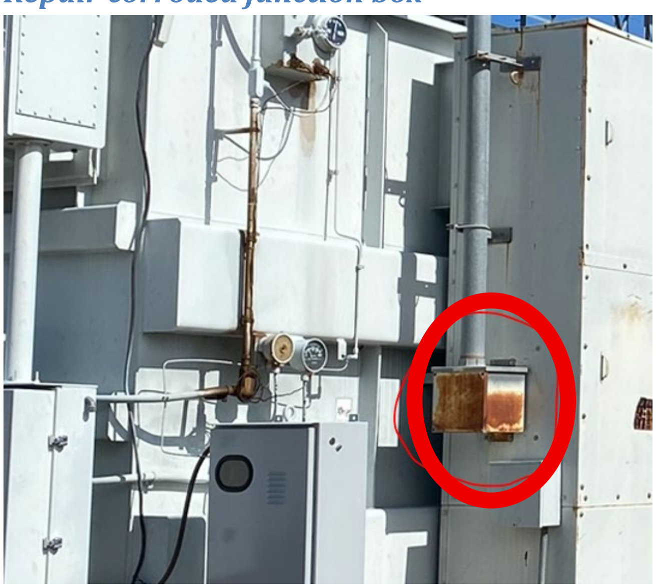




Replace saturated transformer breather desiccant.



Repair corroded junction box



Reset relay flags after events

Resetting the relay flags should be a part of every fault review and monthly checks.

Fix Upper door gasket seal on North transformer cabinet

System Planning & Reliability

Coordinate relay upgrades with high-side replacements

Ensure feeder bypass capability

No Photo Available.