



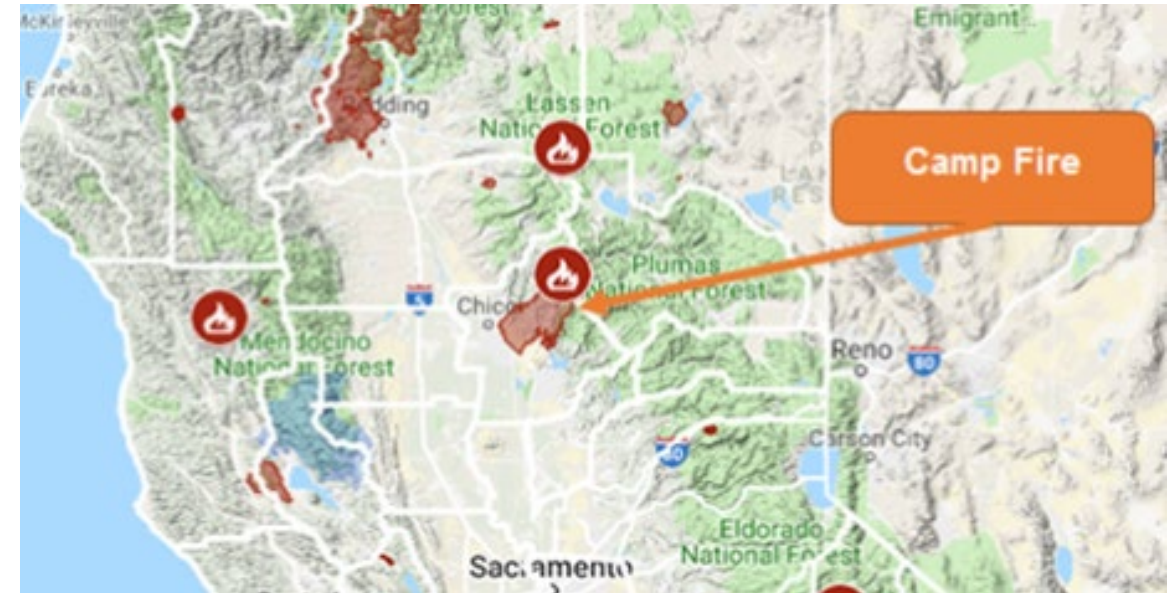
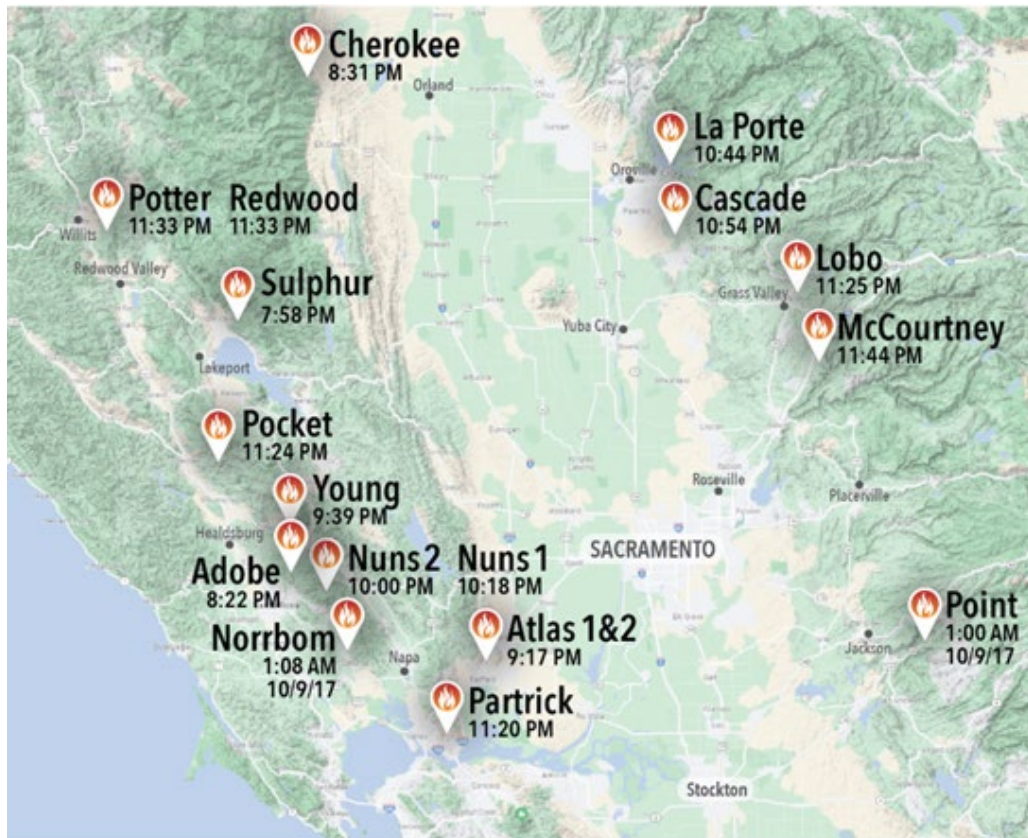
# ROOT CAUSE ANALYSIS

VIRTUAL WORKSHOP

DECEMBER 5, 2022



# The 2017 & 2018 Wildfires





# SCOPE

**1. Conduct Root Cause Analyses for 18 individual wildfires (17 of 18 fires from Oct 2017 and Camp Fire).**

**2. Identify gaps that can be closed by Corrective Actions to reduce the risk of future catastrophic wildfires.**

**3. Identify deficiencies and make recommendations for changes to the CPUC's General Orders for utility operations.**

4. Evaluate PG&E's Public Safety Power Shut-off (PSPS) program & their integration of wildfire threat maps into risk planning.

5. Prepare a survey of other contributing factors to wildfires without recommendations.

# THE ROOT CAUSE ANALYSIS (RCA) TEAM

## ENVISTA FORENSICS

## WITT O'BRIEN'S

### ANDREW BENNETT

Project Oversight & Fire Forensics Lead

### MATTHEW STEINER

Project Infrastructure & Interviewer

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Editor

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### DOUG MAYNE

Emergency Management SME

### JASON SIRNEY

California Emergency Management SME



# BACKGROUND

- **LIMITATIONS:**

- No physical evidence available for this effort.
- Many relevant PG&E employees involved are no longer with the company.
- Requested & received unredacted reports and analyses of the ignitions from CAL FIRE & CPUC staff. Requested PGE's analyses of circuitry involved in the fires, without success.

- **METHODOLOGIES**

- Therefore, developed & applied methodology to determine root causes from available data from public sources and confidential internal PG&E data.
- Developed a Failure Decision Analysis methodology and applied it to each of the 20 ignitions to determine the true root causes.

# INTERVIEWS

PG&E Employees

Current and former PG&E vegetation management contractors

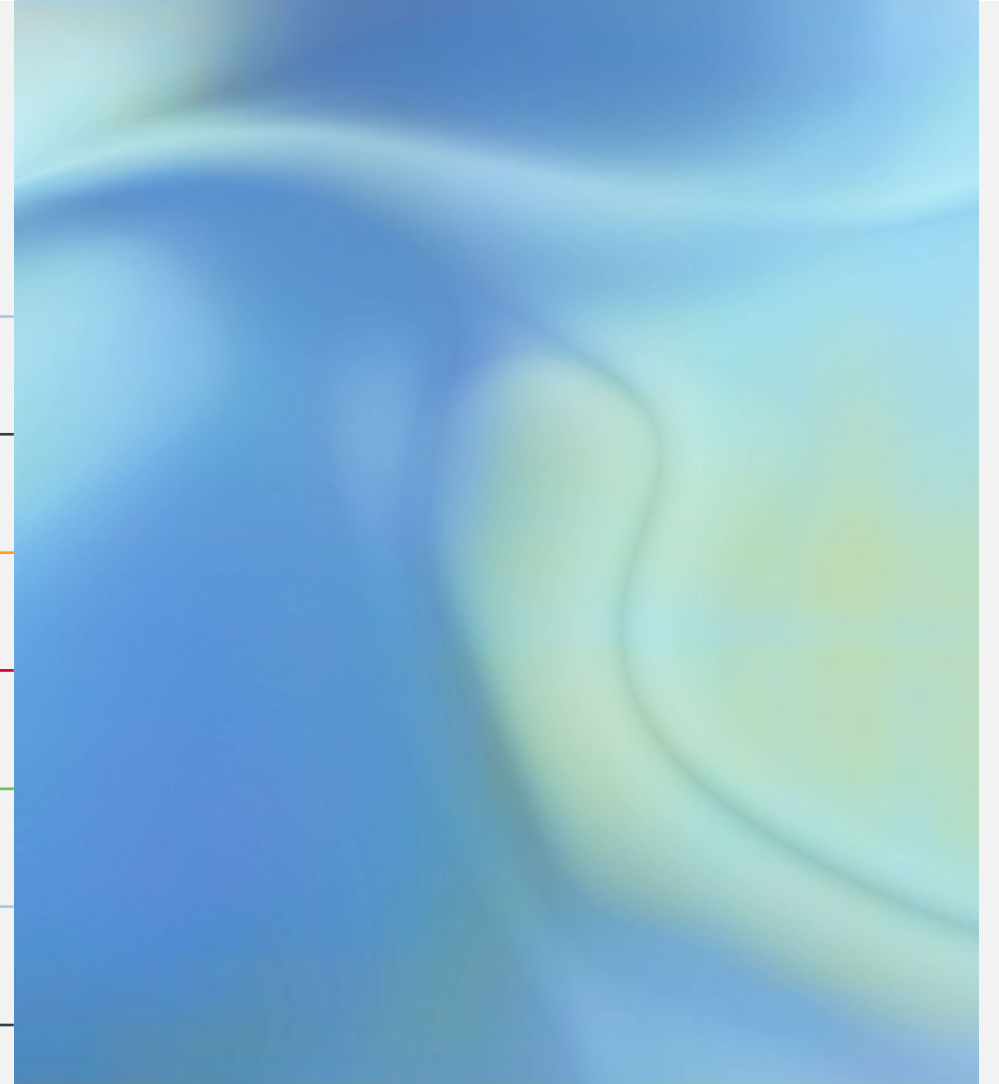
CAL FIRE Employees

CPUC Staff & Consultants: SPD, SED & NorthStar

California Office of Energy Infrastructure Safety

Federal Monitor Team at Kirkland Ellis

Stakeholders for PSPS input: Cities of San Jose & Santa Rosa; Sonoma County





# FORMAL REPORT OVERVIEW

- ▶ Root Cause Analysis (RCA) Summary
- ▶ Corrective Actions
- ▶ Proposed CPUC General Order Modifications
- ▶ Assessment: Mitigation Efforts
- ▶ Other Contributing Factors to Wildfires
- ▶ Appendix A: RCAs of 20 ignitions (236 pages)



Report is posted here: [https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-policy-division/reports/root-cause-analyses-of-the-2017-18-wildfires\\_070622.pdf](https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-policy-division/reports/root-cause-analyses-of-the-2017-18-wildfires_070622.pdf)

# ROOT CAUSE ANALYSES SUMMARY

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- CAL FIRE & CPUC SED found that PG&E was responsible for the 18 wildfires studied, primarily by **not identifying and removing threatening trees**. Our team concurs that the trees were an apparent cause of the wildfires.
- However, the root cause, in a significant majority of the 20 ignitions, was the **likely failure of the circuit protection system** to de-energize the fallen lines when severed, as intended.
- Key PG&E Distribution Systems **functional groups failed to identify the increasing risk** associated with downed energized conductors: Reliability; Planning & Protection; Engineering
- The primary **True Root Causes** of the 20 ignitions were:
  - Asset Maintenance **75%**
  - Circuit Design **70%**
  - Circuit Protection Design **65%**
  - Vegetation Management **55%**
- Although PG&E has taken actions to mitigate against this threat (PSPS, EPSS, etc.), **issues with high impedance faults on the 3-wire electric system remain**.

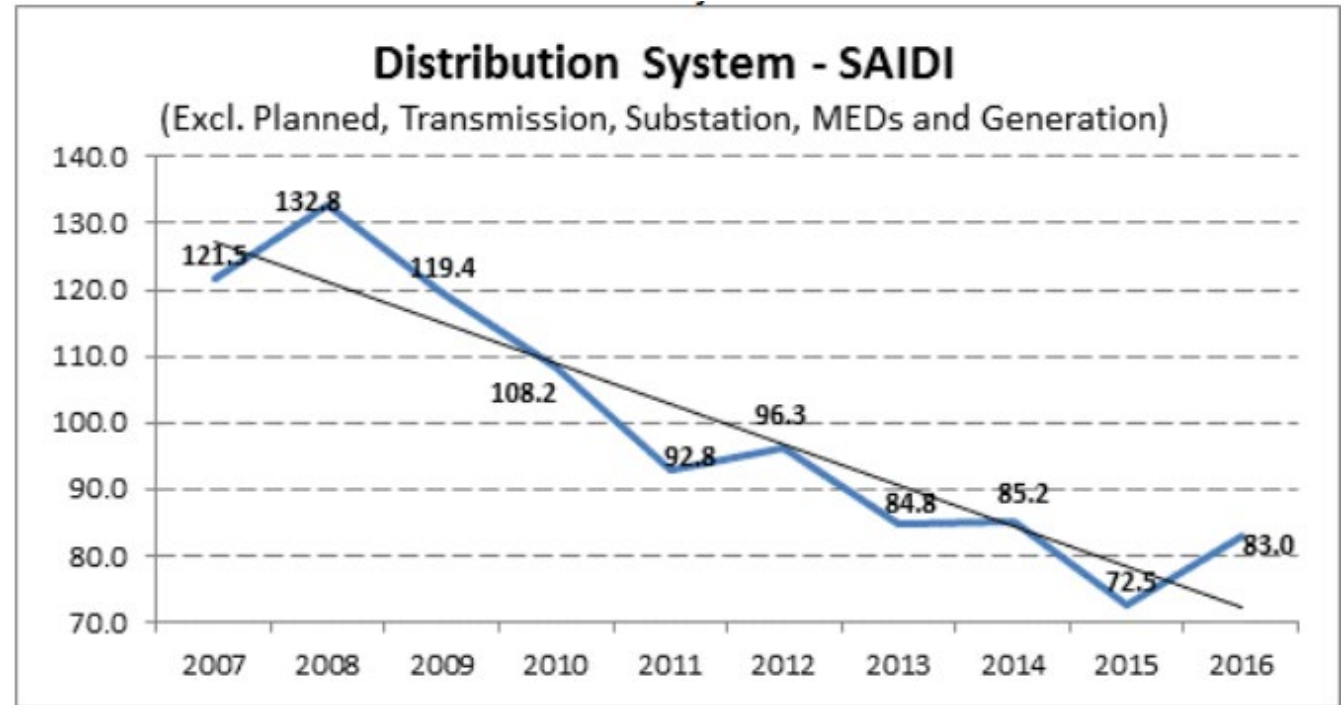


# Wildfire Circuit RCA Methodology

# PG&E DISTRIBUTION SYSTEMS

## RELIABILITY, PLANNING & ENGINEERING FUNCTIONS

Year	Major Events Included			Major Events Excluded		
	SAIDI	SAIFI	CAIDI	SAIDI	SAIFI	CAIDI
2007	131.1	1.047	125.2	121.5	1.019	119.2
2008	374.9	1.363	275.0	132.8	1.041	127.5
2009	191.2	1.151	166.1	119.4	0.974	122.5
2010	210.8	1.164	181.1	108.2	0.921	117.5
2011	239.2	1.041	229.7	92.8	0.796	116.5
2012	120.1	0.959	125.2	96.3	0.882	109.2
2013	100.1	0.869	115.2	84.8	0.804	105.5
2014	119.7	0.926	129.2	85.2	0.780	109.2
2015	99.4	0.804	123.6	72.5	0.689	105.3
2016	95.4	0.895	106.6	83.0	0.818	101.5




2007 – 2016  
Distribution Systems Indices Trending Favorably

Data from "Pacific Gas and Electric Company 2017 & 2018 Annual Electric Reliability Report", page 13





# PG&E DISTRIBUTION SYSTEMS

## RELIABILITY, PLANNING & ENGINEERING FUNCTIONS



Year	Major Events Included				Major Events Excluded			
	SAIDI	SAIFI	MAIFI	CAIDI	SAIDI	SAIFI	MAIFI	CAIDI
2009	212.1	1.280	1.551	165.7	134.5	1.084	1.401	124.0
2010	250.4	1.395	1.485	179.6	130.3	1.106	1.250	117.8
2011	279.5	1.276	1.472	219.1	109.6	0.974	1.163	112.5
2012	141.1	1.130	1.918	124.9	110.7	1.036	1.796	106.8
2013	117.0	1.070	1.633	109.3	95.8	0.969	1.523	98.9
2014	131.9	1.045	1.561	126.2	91.0	0.879	1.390	103.5
2015	131.8	0.967	1.812	136.3	80.7	0.787	1.585	102.5
2016	106.7	1.021	1.596	104.5	93.8	0.940	1.487	99.8
2017	357.8	1.466	2.403	244.1	97.3	0.878	1.566	110.8
2018	279.1	1.054	1.545	264.8	99.6	0.959	1.473	103.9



Key Functional Groups Failed to Identify the Increasing Risk Associated with Downed Energized Conductors.

2009 – 2018  
Distribution Systems Indices

# ILLUSTRATIVE VIDEO



Tree Contact

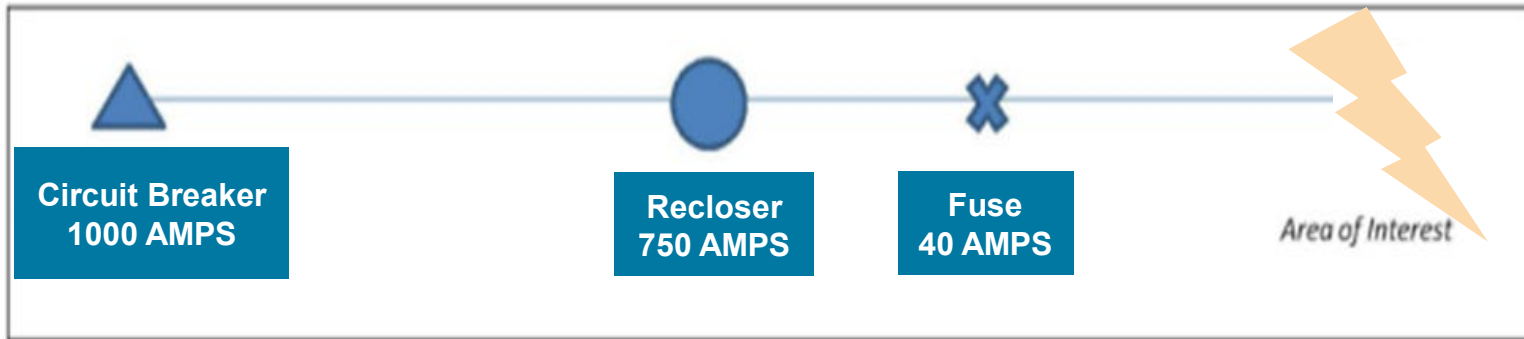
Electrical Circuit Protection Operation



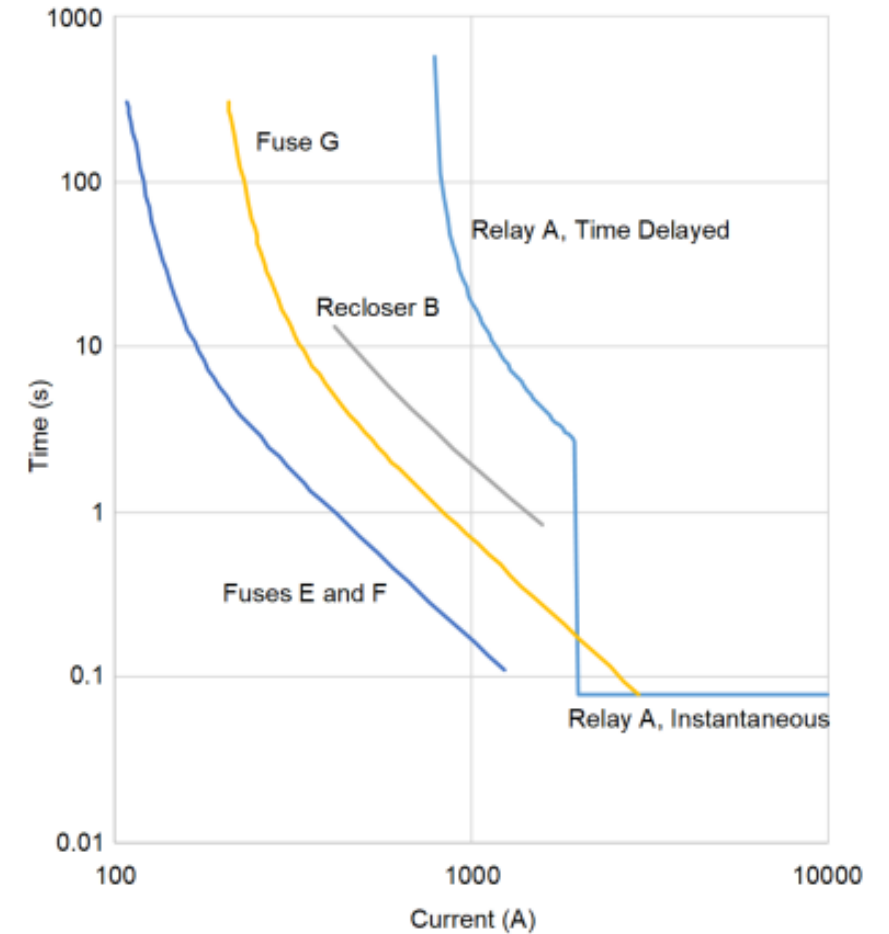
# PG&E DISTRIBUTION PROTECTION SCHEME

## DEVICE COORDINATION

### Incident Overview:



\*Source -- Understanding Ground Fault Detection Sensitivity and Ways to Mitigate Safety Hazards in Power Distribution Systems, Scott Hayes, Pacific Gas and Electric Company, 2019.



# Wildfire RCA Method – Using Available Fact-Based Records Only

## ▶ CAL FIRE

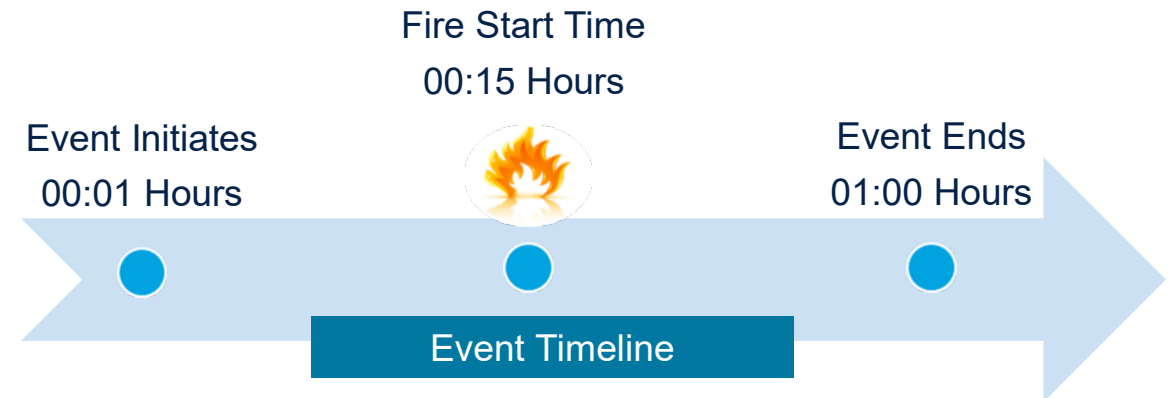
- Investigation Report

## ▶ CPUC

- SED Incident Investigation Report

## ▶ PG&E

1. Incident Description & Factual Summary Reports (IDFS)
2. Supplemental Reports (IDFS-SR)
3. Integrated Logging & Information System (ILIS)
4. Equipment Data Logs (Circuit breakers, line reclosers, fuses)
5. Outage Reports (System & Dispatcher Logs)



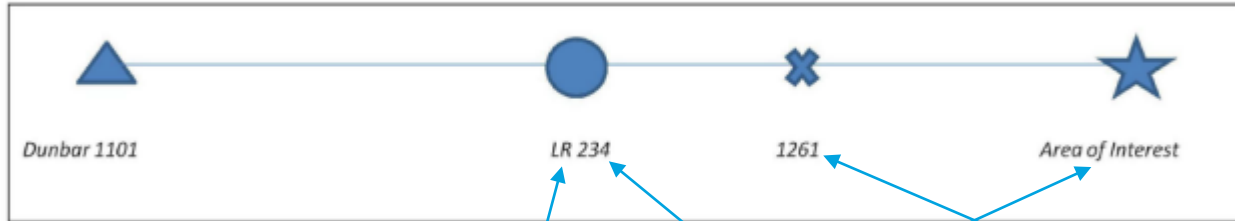
### Data Set Caveat

*“PG&E is not presently in possession of all information necessary to demonstrate whether all devices operated as intended.”*

*No one with direct experience in the PG&E’s wildfire circuit analysis was provided for interview by PG&E.*

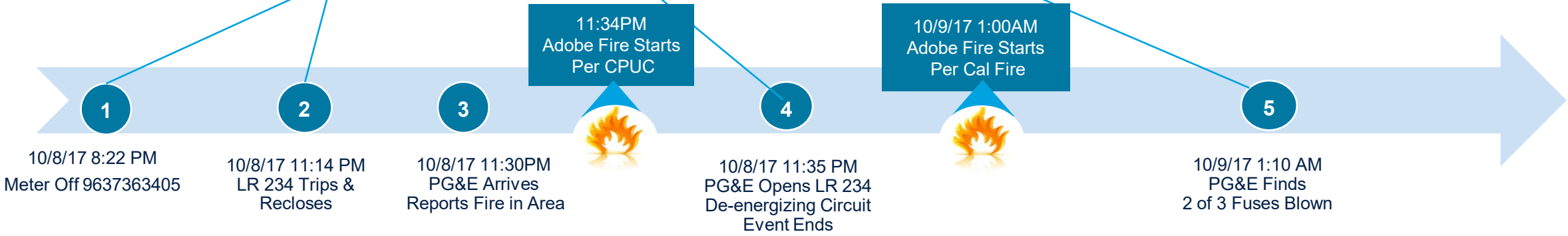
# ADOBE WILDFIRE – DUNBAR 1101

## Incident Overview:



### Incident Observations

- ▶ Tree Contacted Conductors From 60 Feet
- ▶ Possible Energized Downed Conductor From 8:22 PM–11:35 PM (193 minutes)
- ▶ Possible Failure of Fuse 1261
- ▶ Possible High-Impedance Fault Condition
- ▶ Possible Electrical Back-Feed Conditions



## Event Timeline

# ADOBE WILDFIRE – DUNBAR 1101

## PG&E EVIDENCE RECORD ILIS

Santa Rosa

17-0085330

**Outages**

**Circuit** 043071101, DUNBAR-1101 **District** Santa Rosa  
**Type** Unplanned **Customer Minutes** [Sus](#) 138495 [Mem](#) 0 [Adj](#) 138495 [CAID](#) 19785

**Customers** [CESO](#) 7 [CEMO](#) 0 [ADJ](#) 7 [Initial](#) 7 **Weather** Clear,32-90 F  
[CESO](#)

**Active** NO **Fault Type** Line to Line  
**Interval** Sustained **Action Required** No

**EquipID** 1261 **Construction OH Type**

**Equipment Type** Fuse **OIS Outage#** 1894854  
**Equipment Condition** Pole-Wood, Broken **Targets**

**Crew Notified Time** **Supervisor Notified**

**Equipment Address** 500 N/HWY 12 S/ADOBE CANY  
**Fault Location** MTR 1009435821  
**Previous Switching** LINE CUT IN CLEAR FOR FIRE INVESTIGATION OPEN MO (DMS# 1897214)

**Details**  
**Action Description**  
**Cause** Environmental/External, Fire, Forest/Grass **No Access Reason** Available  
**Distribution Wire Down** No **Wire Down Energized** No  
**Multi Damage Location** No **# of Operations**

**Counter Read** **Created By** KKCA  
**Outage Level** Distribution Circuit **Last Updated By** SMBATCH\_FO  
**Responsible Organization** Distribution **Fault Location Info**

**GPS MA Data** **Latitude & Longitude**

**FNL** 10/08/17 23:35 **Reviewed By** SPK8  
**End Date** 10/22/17 17:20 **Reviewed By Date** 10/22/17 17:58

**Actions**

Date	Description	Customers Restored	Customers Out	Minutes Out	Customer Minutes
10/08/17 01:10	FUSE 1261 OPEN; DEIGINAN RPTS FOUND 2/3 FU -IB- BLOWN, OPENED 0 REMAINING AND TAGGED MOL, WILL NEED A PATROL	0	7	-	-
10/14/17 10:48	MJLB: UPDATED NO ACCESS - Fire Activity	0	-	-	-
10/14/17 11:42	VMG1: UPDATED NO ACCESS - Available	0	-	-	-
10/15/17 13:14	MCGINLEY (661-978-0957 ASSUMES OWN CLEARANCE FROM 1261 TO EOL	0	-	-	-
10/15/17 18:03	MCGINLEY RELEASES OWN CLEARANCE FROM 1261 TO EOL, REPLACED POLE AT MTR 1009432581. STILL HAS LINE CUT GOING TWOS 7440	0	-	-	-
10/16/17 08:37	AEH9: UPDATED NO ACCESS - Fire Activity	0	-	-	-
10/18/17 10:31	RAEL (805-459-7148) RPTS ON SITE GIVEN THE OK TO HOLD OWN CLEARANCE FROM 1261 TO EOL TO MAKE REPAIRS, WILL CALL BACK BEFORE CLOSING	0	-	-	-
10/18/17 12:05	DPD3: UPDATED NO ACCESS - Available	0	-	-	-
10/18/17 12:54	JCSN: UPDATED NO ACCESS - Fire Activity	0	-	-	-

LR 234 Records  
10 MTT Alarm Events  
9:49 PM – 11:35 PM

2 of 3 Fuses Blown –  
Back Feed  
Conditions

Date	LogDescription
10/8/2017 21:49	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 21:49	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 22:34	(P04) 1-Santa Rosa sonoma lr 234 pwr ok is ALARM
10/8/2017 22:34	(P04) 1-Santa Rosa sonoma lr 234 pwr ok is NORMAL
10/8/2017 22:34	(P01) 1-Santa Rosa sonoma lr 234 ac pwr fail is NORMAL
10/8/2017 22:34	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 22:34	(P01) 1-Santa Rosa sonoma lr 234 ac pwr fail is ALARM
10/8/2017 22:34	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 22:35	(P01) 1-Santa Rosa sonoma lr 234 ac pwr fail is NORMAL
10/8/2017 22:35	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 22:35	(P01) 1-Santa Rosa sonoma lr 234 ac pwr fail is ALARM
10/8/2017 22:35	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 22:35	(P04) 1-Santa Rosa sonoma lr 234 pwr ok is NORMAL
10/8/2017 22:35	(P04) 1-Santa Rosa sonoma lr 234 pwr ok is ALARM
10/8/2017 22:37	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 22:37	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:09	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:09	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:12	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:12	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:13	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:13	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:13	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:14	(P08) 1-Santa Rosa sonoma lr 234 lr position is OPEN
10/8/2017 23:14	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:14	(P08) 1-Santa Rosa sonoma lr 234 lr position is CLOSED
10/8/2017 23:14	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:14	(P01) 1-Santa Rosa sonoma lr 234 ltc disable output mode is ON
10/8/2017 23:14	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:15	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:15	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:16	(P01) 1-Santa Rosa sonoma lr 234 ltc disable output mode is OFF
10/8/2017 23:15	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is NORMAL
10/8/2017 23:35	(P04) 1-Santa Rosa sonoma lr 234 lr above mtt is ALARM
10/8/2017 23:35	(P02) Control Select 1-Santa Rosa sonoma lr 234 rcl rly for C/OUT by rtwsnorth at rklldccws05
10/8/2017 23:35	(P02) Control Execute for 1-Santa Rosa sonoma lr 234 rcl rly by rtwsnorth at rklldccws05
10/8/2017 23:35	(P02) Commanded Change for 1-Santa Rosa sonoma lr 234 rcl rly is C/OUT
10/8/2017 23:36	(P02) Control Select 1-Santa Rosa sonoma lr 234 lr position for OPEN by rtwsnorth at rklldccws05
10/8/2017 23:36	(P02) Control Execute 1-Santa Rosa sonoma lr 234 lr position by rtwsnorth at rklldccws05



## VEGETATION MANAGEMENT

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- ▶ Based on CPUC’s SED Incident investigation, PG&E violated General Order 95, Rule 31.1.
  - Hazardous tree not identified and abated.
  - Records of 2015 CEMA inspection not retained.
  - Work order completed late.
- ▶ The Adobe fire was not a high wind event and is considered a normal weather event. Arborists use the Beauford Wind Scale to determine the effects of wind on trees.
- ▶ The subject tree was clearly a visible hazard tree that should have been identified and abated by PG&E. The primary form and structure defects would be readily visible to a diligent inspector performing a ground-based inspection along the right-of-way, especially one trained and sensitive to the electrical contact hazards posed by this tree.

# ADOBE WILDFIRE – DUNBAR 1101

## VEGETATION MANAGEMENT PHOTOGRAPHIC



PGE-CPUC\_00016059



**Figure 8.** Subject Eucalyptus tree laying across the road and subject conductor spans. The tree was rooted in the top left corner of the image. (October 17, 2017)



# ADOBE WILDFIRE – DUNBAR 1101

## CPUC SED & CAL FIRE EVIDENCE RECORD

PG&E CONFIDENTIAL UNDER NON-DISCLOSURE AGREEMENT

On October 12, 2018, SED staff, Wilson Tsai and Raymond Cho, met with CAL FIRE investigators in Santa Rosa to review evidence from the evidence site retained by CAL FIRE. Of the evidence reviewed and photographed, SED staff found multiple damaged electric facilities and hardware including a fulgurite-like mass, failed insulator tie wires and damaged conductors. Fulgurites<sup>33</sup> are naturally occurring masses of fused soil and/or other debris that can form when lightning discharges into the ground. In this case, a fulgurite-like mass was formed when conductors fell to the ground and discharged enough energy to fuse some of the ground material together.



Figure 10. Fulgurite-like mass found in the Adobe incident area.

SED staff did not unwind the multiple bundles of conductor wire but reviewed the failure points. The Eucalyptus tree and fire damaged the insulating rubber material around the conductors. SED found evidence of arcing exhibited by molten metal attached to failed pieces of conductor.

High Impedence Fault  
Condition  
Possible Back Feed  
Scenario



Figure 11. Failed pieces of conductor strands and evidence of arcing.

#### IV. CAL FIRE Investigation

CAL FIRE's investigation report determined that the subject Eucalyptus tree failed and fell into the three 12 kV conductors. The report notes that "(t)he electrical conductors broke and fell to the ground and onto surrounding vegetation. Several of the conductors remained energized and arced causing a vegetation fire..."<sup>34</sup>. The CAL FIRE investigator identified the grounded, energized conductors as the source of ignition.

# FINDINGS DEFINITIONS

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- ▶ Circuit Configurations
  - 3 – wire system grounded only at the source and customer (transformer).
  - 4 – wire system included a neutral conductor and is grounded at every pole.
- ▶ System Protection Failure - protection system/scheme failing to detect and clear a fault.
- ▶ Electrical Feedback - abnormal reverse electrical energization.
- ▶ High Impedance Fault Conditions - a faulted circuit not producing enough energy to be detected.
- ▶ Energized Downed Conductor(s) – energized conductor on the ground.



# ADOBE CIRCUIT FINDINGS: DUNBAR 1101

CIRCUIT  
CONFIGURATION

3-Wire

APPARENT CAUSE

Tree falling

LIKELY PROTECTION  
SYSTEM FAILURE?

Yes

POSSIBLE BACK  
FEED?

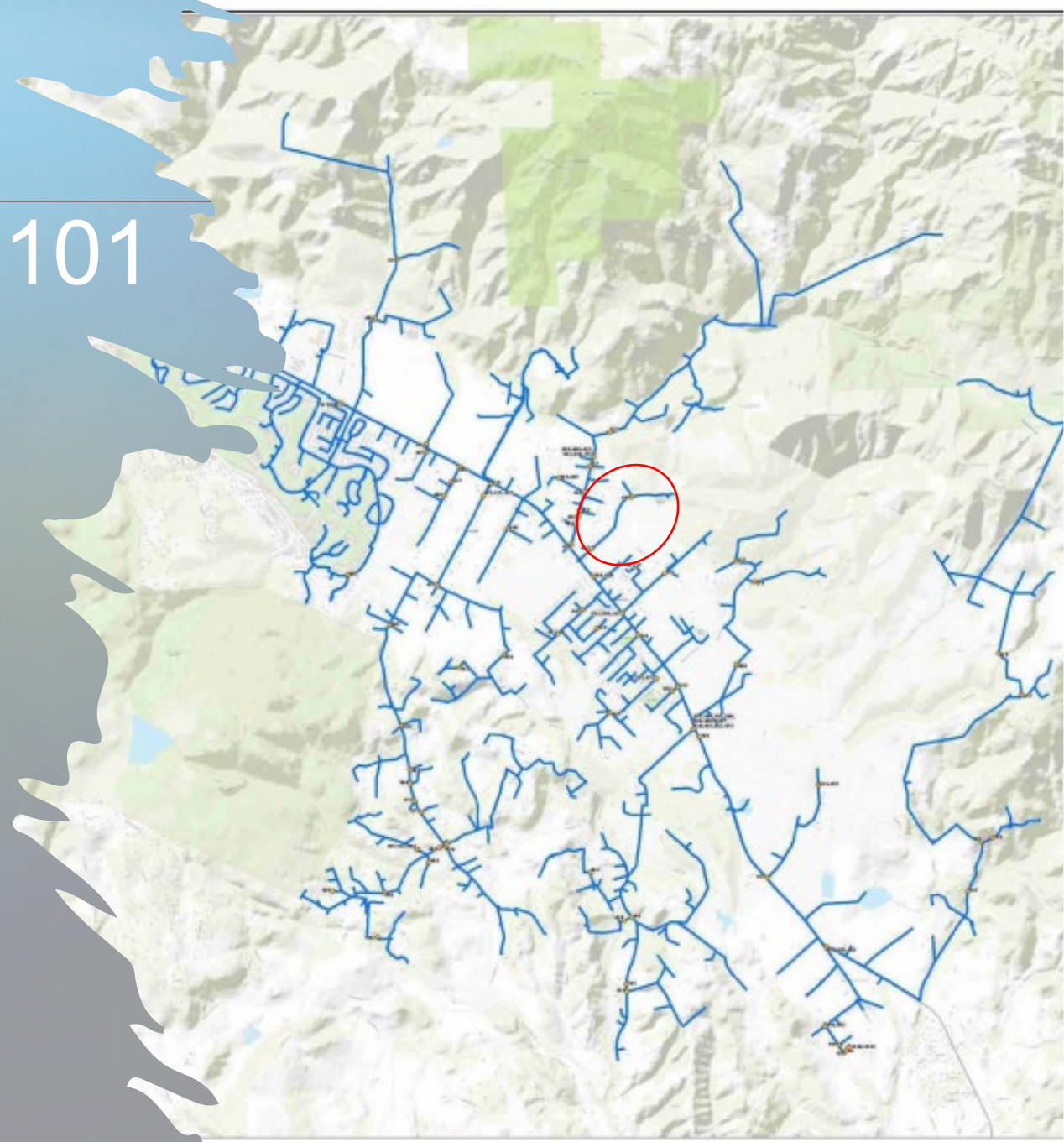
Yes

POSSIBLE DOWNED  
ENERGIZED  
CONDUCTOR?

193 minutes

POSSIBLE HIGH  
IMPEDANCE  
FAULT  
CONDITIONS?

Yes



# WILDFIRE CIRCUIT ROOT CAUSE ANALYSIS

## RESULTS SUMMARY

Wildfire	Circuit	Circuit Configuration	Likely Protection System Failure	Possible Downed Energized Conductor (Mins)
Adobe	Dunbar 1101	3-Wire	Yes	193
Atlas 1 & 2	Pueblo 1104	3-Wire	Yes	87
Camp 1	Caribou-Palermo 115kV	Trans	No	UNKN
Camp 2	Wyandotte 1105	3-Wire	No	UNKN
Cascade	Bangor 1101	3-Wire	Yes	0
Cherokee	Clark Rd 1102	3-Wire	Yes	144
LaPorte	Bangor 1101	3-Wire	Yes	38
Lobo	Narrows 2102	4-Wire	Yes	0
McCourtney	Grass Valley 1103	3-Wire	Yes	109
Norrbom	Sonoma 1103	3-Wire	Yes	1,440
Nuns #1	Dunbar 1101	3-Wire	No	103
Nuns #2	Dunbar 1101	3-Wire	No	103
Oakmont	Rincon 1101	3-Wire	Yes	164
Partrick	Pueblo 2103	4-Wire	No	4
Pocket	Cloverdale 1102	3-Wire	Yes	186
Point	West Point 1102	3-Wire	Yes	378
Redwood	Potter Valley 1105	3-Wire	No	61
Redwood	Mendocino 60kV	Trans	No	0
Sulphur	Redbud 1101	3-Wire	No	62
Young	Fulton 1102	3-Wire	Yes	38

# WILDFIRE CIRCUIT ROOT CAUSE ANALYSIS

## RESULTS SUMMARY

Table 4. RCA Summary: High-Impedance Fault Conditions & Possible Back-Feed

Wildfire	Circuit	Cause	Possible High-Impedance Fault Conditions	Possible Back-Feed	Possible Downed Energized Conductor Envista (Mins)
Norrbom	Sonoma 1103	Tree	Yes	Yes	1,440
Point	West Point 1102	Tree	Yes	Yes	378
Adobe	Dunbar 1101	Tree	Yes	Yes	193
Oakmont	Rincon 1101	Error	Yes	Yes	164
Cherokee	Clark Rd 1102	Tree	Yes	Yes	144
McCourtney	Grass Valley 1103	Tree	Yes	Yes	109
Nuns #2	Dunbar 1101	Tree	Yes	Yes	103
Atlas 1 & 2	Pueblo 1104	Tree	Yes	Yes	87
Redwood	Potter Valley 1105	Tree	Yes	Yes	61
LaPorte	Bangor 1101	Tree	Yes	Yes	38

Table 5. Wildfire Circuit RCA Energized Downed Conductors Over 30 Minutes

Wildfire	Circuit	Circuit Configuration	Cause	Possible Downed Energized Conductor Envista (Mins)
Norrbom	Sonoma 1103	3-Wire	Tree	1,440
Point	West Point 1102	3-Wire	Tree	378
Adobe	Dunbar 1101	3-Wire	Tree	193
Pocket	Cloverdale 1102	3-Wire	Tree	186
Oakmont	Rincon 1101	3-Wire	Error	164
Cherokee	Clark Rd 1102	3-Wire	Tree	144
McCourtney	Grass Valley 1103	3-Wire	Tree	109
Nuns #1	Dunbar 1101	3-Wire	Tree	103
Nuns #2	Dunbar 1101	3-Wire	Tree	103
Atlas 1 & 2	Pueblo 1104	3-Wire	Tree	87
Sulphur	Redbud 1102	3-Wire	Pole Failure	62
Redwood	Potter Valley 1105	3-Wire	Tree	61
LaPorte	Bangor 1101	3-Wire	Tree	38
Youngs	Fulton 1102	3-Wire	Tree	38

# WILDFIRE CIRCUIT ROOT CAUSE ANALYSIS

## RESULTS SUMMARY

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### Key Points

Key Functional Groups Failed to Identify the Increasing Risk Associated with Downed Energized Conductors.

Circuit Configuration = “3 Wire” System

High Impedance Fault Conditions

Long Duration Energized Downed Conductors

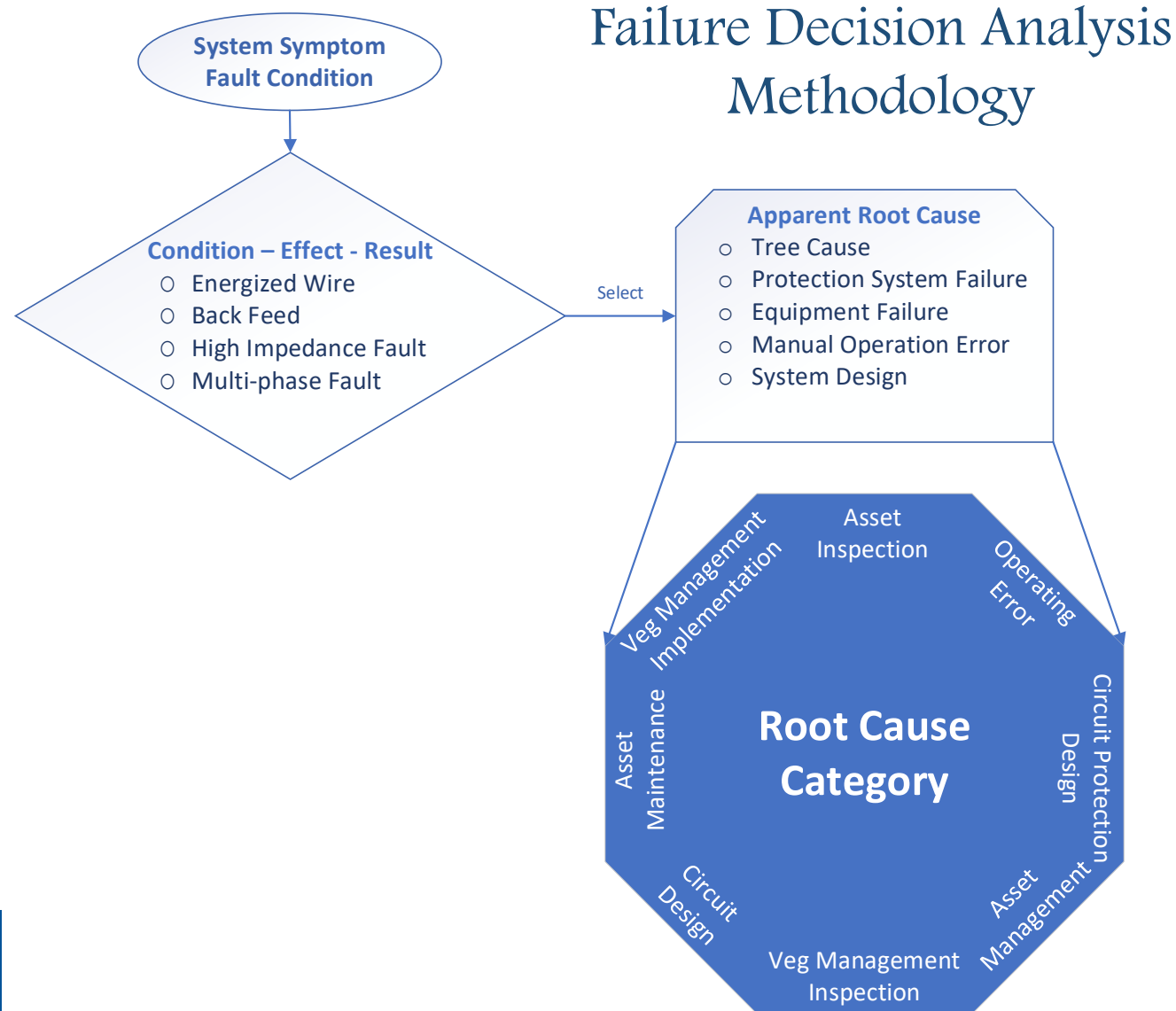
Electrical Back Feed Conditions



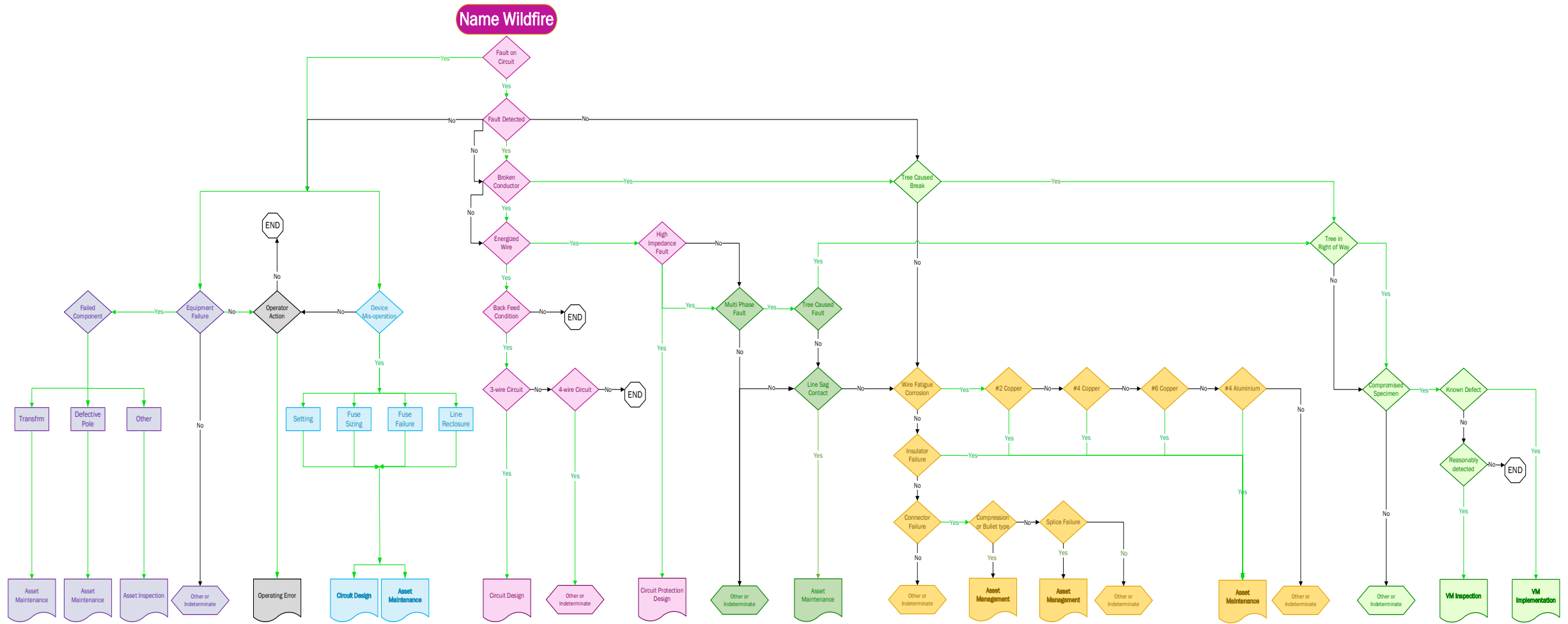


# FAILURE DECISION ANALYSIS

# Failure Decision Analysis Methodology



# Failure Decision Analysis Process Diagram



# Failure Decision Analysis

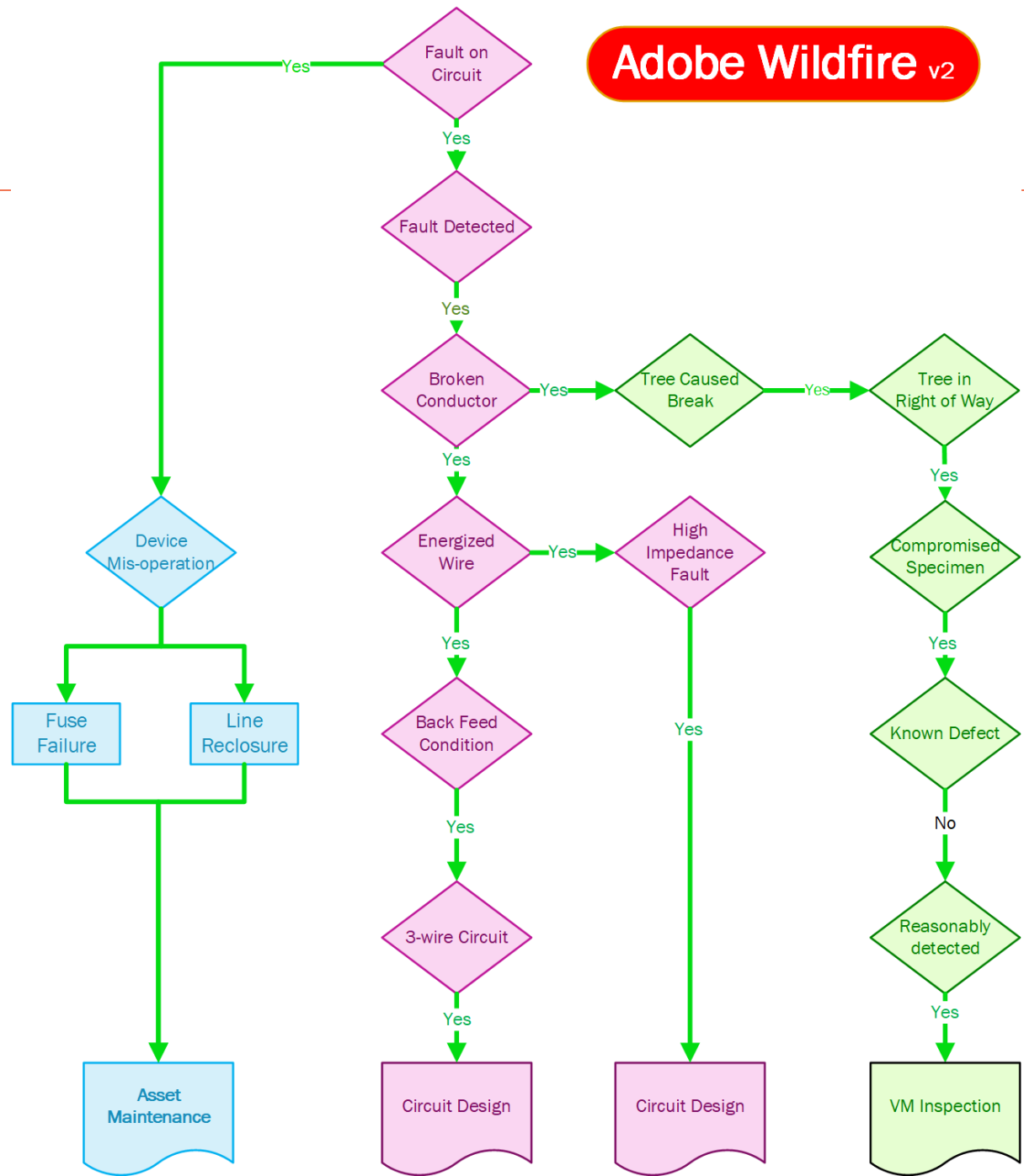
## Adobe Wildfire

Criteria 1	Condition	Criteria 2	Condition	Criteria 3	Condition
Fault on Circuit	Yes	Wire Down	Yes	Tree-Caused Break	Yes
Fault Detected	Yes	Multi-Phase Fault	No	Tree in or Along ROW	Yes
Conductor Broken	Yes	Tree-Caused Fault	No	Compromised Specimen	Yes
Energized Conductor	Yes	Line Sag Caused	No	Known Defect or Condition	No
Back-Feed Condition	Yes			Reasonably Detected	Yes
High-Impedance	Yes				

Criteria 4	Condition	Criteria 5	Condition
Wire Fatigue	No	Protection System Failure	Yes
Wire Type	#4 al	Protection System Failure Device	Fuse &
Insulator Failure	No	Equipment Failure	No
Connector Failure	No	Failed Component	N/A
Connector Type	N/A		



# Adobe Wildfire v2



# SUMMARY OF ROOT CAUSE BY CATEGORY AND FREQUENCY

Root Cause	Frequency
Asset Maintenance	75%
Circuit Design	70%
Circuit Protection Design	65%
Vegetation Management Inspections	55%
Asset Inspections	< 2%
Vegetation Management Implementation	< 2%
Asset Management Implementations	< 1%
Operating Error	< 1%

# CORRECTIVE ACTIONS

# CORRECTIVE ACTION THEMES

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CIRCUIT DESIGN & MAINTENANCE

---

INSTITUTIONALIZED LEARNING

---

EMERGENCY & CRISIS  
MANAGEMENT

---

VEGETATION MANAGEMENT



# CIRCUITS: SYSTEM DESIGN AND MAINTENANCE

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- ▶ The fundamental design of the overall PG&E electric system permits undetected ground-faulted overhead conductors to **remain electrically energized** in contrast to industry best practice.
- ▶ A large portion of the system inherently creates a condition in which the circuit **protection system may not detect and interrupt** a phase to ground fault caused by downed conductors.
- ▶ PG&E has taken efforts to mitigate against this problem, but the problem remains.

**RECOMMENDATION:** PG&E and CPUC should expeditiously proceed with System Enhancement Initiative 20 to engage **an independent study** of grounding methods and transformer configuration in the Transmission and Distribution (T&D) system.

# CIRCUITS: CORRECTIVE MAINTENANCE BACKLOG

- ▶ The **corrective maintenance (tag) backlog** was significant in both duration and number, which contributed to degraded system conditions.

Year	Count
2015	540
2016	382
2017	613
2018	533
2019	995
2020	847
2021 (thru March)	470

**RECOMMENDATION:** PG&E should implement a comprehensive program that includes the proper balance of various approaches to maintenance including preventative, predictive and corrective, not replace on failure.

# INSTITUTIONALIZED LEARNING

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- ▶ The De-Energization Protocol (PSPS) was not implemented until **after the 2017 wildfires.**

# INSTITUTIONALIZED LEARNING

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- ▶ Lack of an enterprise-wide effective **Corrective Action Program (CAP)** resulted in the absence of a mechanism to trend all identified deficiencies.
  - “Each line of business is required to incorporate a corrective action process in its operating procedures and governance processes.” ---PG&E Utility Policy GOV-3
- ▶ Prior to 2017, PG&E had standalone CAPs.
  - Only prepared for select unplanned outages (about 10%).
  - The lack of AAR, RCA, or other lessons learned documentation indicates lack of a robust best practice CAP.

**RECOMMENDATION:** Implement an enterprise-wide CAP that requires its use for all incidents and events, as well as trends issues across lines of business.



# OTHER INSTITUTIONALIZED LEARNING & EMERGENCY/CRISIS MANAGEMENT RECOMMENDATIONS

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- ▶ Institute a process to ensure that relevant plans, operational programs and procedures are aligned with actions to address identified threats.
- ▶ Redefine the role of the executive management team during an event to that of a Crisis Management Team.
- ▶ PG&E should realign the Officer-in-Charge responsibilities to be centralized under the Incident Commander.
  
- ▶ Given risks faced, PG&E should consider **full implementation of the Incident Command System**, including for daily operations as has been done at other major utilities.

# VEGETATION MANAGEMENT: FINDINGS

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- ▶ Many **PG&E Senior Manager, Director, VP, and Pre-inspector level positions lacked required education, skill, and experience to reliably perform their work.** PG&E did not verify that they met PG&E's minimum qualifications.
- ▶ **Quality Assurance & Quality Control** program was **not designed for auditing tree populations**, which results in a deceptively positive performance measure.
- ▶ PG&E uses **lump sum pre-inspection contract** strategy, contrary to majority industry practice, focused on managing costs and frustrating effective hazard tree identification.
- ▶ There are **too many vegetation management programs** that result in excessive customer contacts by various contractors.

# VEGETATION MANAGEMENT: RECOMMENDATIONS

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- ▶ All PG&E and contractor **personnel** shall be **required to possess the professional VM education, experience, training, certifications, and competency to adequately administer and manage their applicable vegetation management functions.**
- ▶ Use **tree miles as denominator** and conduct **QA/QC** programs at same time with the **emphasized priority of identifying hazard trees.**
- ▶ PG&E should **convert to time and material contracts for pre-inspection.**
- ▶ **Combine VM programs**, consistent with utilities nationwide, resulting in a more efficient, streamlined program.

# POTENTIAL CHANGES TO CPUC GENERAL ORDERS



# POTENTIAL CHANGES TO CPUC GENERAL ORDERS

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- ▶ Modify GO 95 to require California utilities to implement a **comprehensive maintenance program** for T&D systems that includes proper balance of the various approaches to maintenance, e.g., **preventative, predictive or corrective**. This action would align GO 95 with GO 167 which requires such for Electric Generating Facilities.

# POTENTIAL CHANGES TO CPUC GENERAL ORDERS (CONT'D)

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- ▶ The CPUC could consider realigning GO 95 to address requirements for vegetation management to **better align with Public Resource codes**. The CPUC's GO 95 and the Public Resource code (4292 and 4293) both address the distance required for trees from electric lines. Utilities and their contractors are challenged by sometimes-conflicting requirements.

# POTENTIAL CHANGES TO CPUC GENERAL ORDERS (CONT'D)

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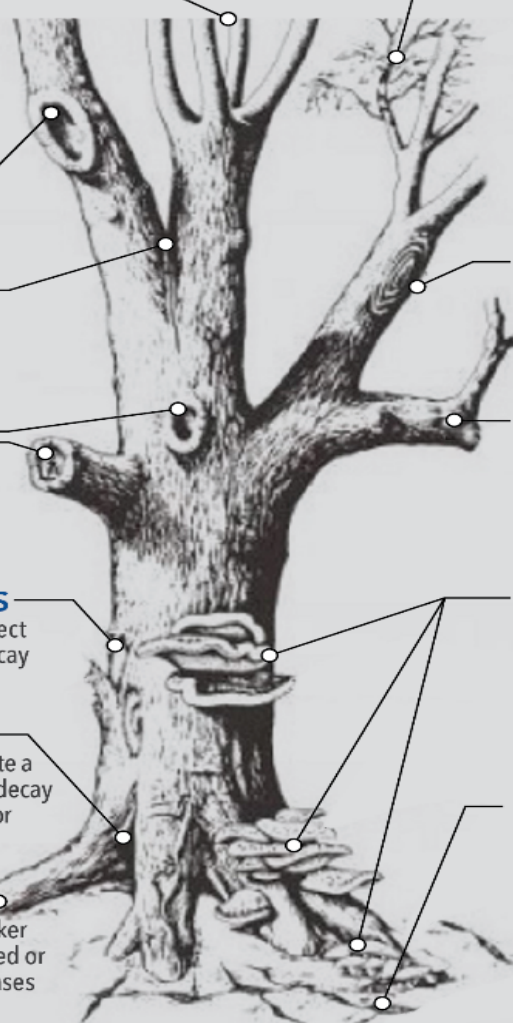
▶ **Consider requiring utilities to use the following standards and best management practices:**

- ANSI-A300 (Part 9) Tree Risk Assessment a. Tree Failure – Tree, Shrub, and other Woody Plant Management-Standard Practices (Tree Risk Assessment a. Tree Failure) Latest Edition, American National Standards for Tree Care Operations.
- International Society of Arboriculture's Best Management Practice, Utility Tree Risk Assessment Practices Edition 2020.

# POTENTIAL CHANGES TO CPUC GENERAL ORDERS (CONT'D)

- ▶ Consider requiring that the California utilities vegetation management managers develop a pocket field guide and a quantitative risk matrix for identifying and removing hazard trees.

## The Recognition of Hazardous Trees



**TOPPING**  
Often indicated by a sudden change in stem diameter, Weakly attached adventitious branches often leads to the likelihood of failure.

**BREAK-OUT CAVITY**  
Decay may develop in wounds caused by branches breaking.

**CODOMINANT STEM**  
Forked branches nearly the same site in diameter, arising from a common junction and lacking a normal branch union.

**PRUNING WOUNDS**  
An opening that is created when the bark of a live branch or stem is cut, penetrated, damaged or removed. Decay may be present.

**MISSING BARK OR WOUNDS**  
Can be caused by mechanical, animal or insect damage and potential points of entry for decay organisms.

**CAVITIES**  
Cavities are locations of past injury and create a place for decay fungi to enter. The extent of decay needs to be determined to assess the tree for removal.

**ROOT DEFECTS**  
Dead, decaying or missing roots can be identified by a cavity in the root collar, a canker that extends to the soil line or a visibly pruned or broken root stub. Likelihood of failure increases with the severity of decay within the roots.

**DEAD BROKEN AND/OR HANGING BRANCHES**  
A lack of live bark, foliage, buds or leaf growth are indicators of dead branches. The likelihood of failure for dead branches ranges from possible to imminent depending on species, branch weight, type and extent of decay and infestation of insects.

**CANKERS**  
Cankers are areas of dead or dying wood, cambium or bark caused by diseases or repeated mechanical injury.

**SHARP BENDS**  
These are caused by past pruning practices which can lead to branch loading and excessive decay. Consider removing branch to eliminate failure.

**FUNGAL FRUITING BODIES**  
Fruiting bodies or sterile conks is a fungus which is often associated with internal decay. It should be noted not all fungi are not harmful to the tree.

**OTHER ROOT PROBLEMS**  
Soil mounding or cracking or disturbance, stem girdling and buried root collar can be conditions indicating root related structural problems.

# POTENTIAL CHANGES TO CPUC GENERAL ORDERS (CONT'D)

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- ▶ Modify GO 95 to better support **utilities' access to threatening vegetation** on private property.



# Q & A

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