(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

I.18-11-006

Workpapers

Rosemead CA
November 15, 2018

SCE 2018 RAMP Workpapers

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

SCE 2018 RAMP Workpapers

Index of Workpapers

<u>Excel versions of Workpapers are available online</u>

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

SCE 2018 RAMP Workpapers

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

SCE 2018 RAMP Workpapers

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 1
RAMP Report Overview

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 1 - RAMP Overview

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

WP Ch. 1 - Recorded and Forecast Costs Workpaper[1,2]

$ in Millions

			Capital											O&M										
			Recorded					Forecast						Recorded					Forecast					
RAMP Chapter	Control/ Mitigation ID	Control/Mitigation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cyber Attack	C1a	Perimeter Defense	4.8	12.2	11.8	5.7	18.2	13.4	13.1	13.6	13.6	13.6	13.6	-	-	-	-	-	4.2	4.5	5.4	6.9	6.9	7.0
Cyber Attack	C2a	Interior Defense	12.0	4.7	7.4	7.8	10.1	7.2	8.3	8.1	8.1	8.1	8.1	-	-	-	-	-	2.9	2.9	3.5	4.7	4.9	4.9
Cyber Attack	C3a	Data Protection	3.1	8.2	9.0	3.7	10.4	0.5	6.0	6.1	6.1	6.1	6.1	-	-	-	-	-	1.7	1.7	2.3	3.6	3.7	3.7
Cyber Attack	C4a	SCADA Cybersecurity	-	-	-	-	10.6	7.1	2.4	2.5	2.6	2.6	2.6	-	-	-	-	-	2.6	2.5	2.8	4.0	4.0	4.1
Cyber Attack	C5a	Grid Modernization Cybersecurity	-	-	-	2.9	15.0	24.7	32.0	36.0	26.2	20.6	29.8	-	-	-	-	-	2.3	4.3	5.8	7.1	7.1	7.2
Cyber Attack	C0	Common Cyber Security (CCS)	8.2	9.8	7.4	0.8	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyber Attack	CM1	IT NERC CIP Compliance	0.9	4.9	7.1	2.6	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyber Attack	CYB O&M[3]	Total Cyber O&M Recorded	-	-	-	-	-	-	-	-	-	-	-	8.2	11.7	12.6	13.5	12.8	-	-	-	-	-	-
Underground Equipment Failure	CM1	Underground Detail Inspections (UDI) and Underground Preventive Maintenance	-	-	-	-	-	-	-	-	-	-	-	55.4	57.8	40.6	38.5	36.7	-	-	-	-	-	-
Underground Equipment Failure	M1	Cover Pressure Relief and Restraint (CPRR) Program	-	-	-	-	-	-	8.0	15.0	15.0	15.0	15.0	-	-	-	-	-	-	-	-	-	-	-
Underground Equipment Failure	C1	Cable Replacement Programs (WCR)	121.0	153.0	117.7	143.2	135.3	117.3	103.7	93.4	93.4	93.4	99.7	-	-	-	-	-	-	-	-	-	-	-
Underground Equipment Failure	C2	Cable Replacement Programs (CIC)	21.3	36.3	65.7	56.3	74.4	62.2	64.6	60.3	60.3	60.3	60.3	-	-	-	-	-	-	-	-	-	-	-
Underground Equipment Failure	C3	UG Oil Switch Replacement Program	18.8	19.6	25.9	17.6	19.1	12.8	16.7	17.4	17.8	22.0	23.1	-	-	-	-	-	-	-	-	-	-	-
Employee, Contractor & Public Safety	CM1	Compliance-Based Safety Standards, Programs and Procedures	-	-	-	-	-	-	-	-	-	-	-	8.4	9.2	8.1	10.1	11.2	-	-	-	-	-	-
Employee, Contractor & Public Safety	CM2	Compliance-Based Technical Training	-	-	-	-	-	-	-	-	-	-	-	44.4	53.0	46.7	54.8	57.5	-	-	-	-	-	-
Employee, Contractor & Public Safety	C1	Safety Controls	-	-	-	-	-	-	-	-	-	-	-	0.3	0.3	0.3	0.2	0.3	2.3	2.3	2.3	2.3	2.3	2.3
Employee, Contractor & Public Safety	C2	Contractor Safety Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Employee, Contractor & Public Safety	M1a	Safety Culture Transformation - Core Program	-	-	-	-	-	-	5.0	4.0	4.0	-	-	0.5	1.6	0.9	0.8	1.4	14.0	17.7	0.9	0.3	0.3	0.3
Employee, Contractor & Public Safety	M2	Industrial Ergonomics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employee, Contractor & Public Safety	M3a	Office Ergonomics - Core Program	0.0	0.0	0.0	0.0	0.0	2.3	2.4	2.4	2.5	2.5	2.6	-	-	-	-	0.0	0.5	0.5	0.5	0.5	0.5	0.5
Climate Change	C1	Emergency Management	-	-	-	-	-	-	-	-	-	-	-	1.3	2.2	3.2	2.8	3.7	3.2	3.5	3.5	3.6	3.7	3.8
Climate Change	C2	Fire Management	-	-	-	-	-	-	-	-	-	-	-	0.3	0.5	0.5	0.5	0.5	0.6	0.8	0.8	0.8	0.8	0.9
Climate Change	M1	Climate Adaptation & Severe Weather Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	0.4	0.4	0.3	0.4
Climate Change	M2a	Situational Awareness, Monitoring & Analytics (Optimal)	-	-	-	-	-	6.2	12.0	8.6	0.0	-	-	-	-	-	-	-	2.2	4.8	6.1	4.8	5.0	5.1
Contact w/ Energized Equipment	C1	Overhead Conductor Program (OCP)	-	-	60.7	97.3	138.7	138.8	139.0	127.9	102.5	99.5	107.5	-	-	-	-	-	-	-	-	-	-	-
Contact w/ Energized Equipment	C1a	OCP Utilizing Targeted Covered Conductor	-	-	-	-	-	-	-	-	11.4	11.1	11.9	-	-	-	-	-	-	-	-	-	-	-
Contact w/ Energized Equipment	C2	Public Outreach	-	-	-	-	-	-	-	-	-	-	-	5.5	7.1	7.7	5.2	5.1	5.5	5.5	5.5	5.5	5.5	5.5
Contact w/ Energized Equipment	M4	Infrared Inspections	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5
Contact w/ Energized Equipment	M5	Wildfire Covered Conductor Program	-	-	-	-	-	32.1	42.4	194.6	236.5	296.1	359.1	-	-	-	-	-	-	-	-	-	-	-
Contact w/ Energized Equipment	CM1	Distribution Deteriorated Pole Remediation Program and Pole Loading Program (PLP)	161.3	206.9	456.0	347.3	273.9	-	-	-	-	-	-	-	-	-	28.1	30.9	-	-	-	-	-	-
Contact w/ Energized Equipment	CM2	Vegetation Management	-	-	-	-	-	-	-	-	-	-	-	30.7	34.0	41.7	67.8	84.3	-	-	-	-	-	-
Contact w/ Energized Equipment	CM3	Overhead Detailed Inspection, Apparatus Inspections, and Preventative Maintenance	-	-	-	-	-	-	-	-	-	-	-	47.0	49.7	37.1	33.9	36.0	-	-	-	-	-	-
Contact w/ Energized Equipment	CM4	Intrusive Pole Inspections and Pole Loading Assessments	-	-	-	-	-	-	-	-	-	-	-	9.5	6.7	6.5	6.8	6.0	-	-	-	-	-	-
Hydro Asset Safety	CM1	Hydro Operations	-	-	-	-	-	-	-	-	-	-	-	1.4	1.3	1.4	1.3	1.2	-	-	-	-	-	-
Hydro Asset Safety	CM2	Hydro Maintenance	-	-	-	-	-	-	-	-	-	-	-	1.7	0.9	0.9	0.9	1.3	-	-	-	-	-	-
Hydro Asset Safety	CM3	Dam Safety Program	-	-	-	-	-	-	-	-	-	-	-	1.4	1.3	1.4	1.3	1.2	-	-	-	-	-	-
Hydro Asset Safety	CM4	External Inspections	-	-	-	-	-	-	-	-	-	-	-	0.6	0.6	0.6	0.6	0.7	-	-	-	-	-	-
Hydro Asset Safety	C1	Seismic Retrofit	0.6	0.2	0.0	0.1	-	4.9	0.5	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-
Hydro Asset Safety	C2	Dam Surface Protection	0.5	6.3	4.8	2.6	5.3	0.1	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
Hydro Asset Safety	C3	Spillway Remediation and Improvement	1.1	0.0	-	0.0	0.3	0.5	4.0	3.0	2.5	2.0	-	-	-	-	-	-	-	-	-	-	-	-
Hydro Asset Safety	C4	Low Level Outlet Improvements	-	-	0.1	0.6	-	1.3	5.6	1.5	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-
Hydro Asset Safety	C5	Seepage Mitigation	-	-	-	-	-	-	2.0	2.0	3.9	2.6	-	-	-	-	-	-	-	-	-	-	-	-
Hydro Asset Safety	C6	Instrumentation / Communication Enhancements	-	-	-	-	0.7	1.8	1.5	2.9	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Building Safety	CM1	Fire Life Safety Compliance	0.6	0.2	0.2	1.0	0.6	-	-	-	-	-	-	0.2	0.2	0.2	0.1	0.3	-	-	-	-	-	-
Building Safety	CM2	Electrical Compliance	1.7	0.6	0.7	3.0	2.6	-	-	-	-	-	-	0.1	0.1	0.1	0.2	0.2	-	-	-	-	-	-
Building Safety	C1	Seismic Building Safety Program	-	-	-	2.3	8.9	10.5	6.6	5.6	6.5	6.5	6.5	-	-	-	-	0.0	0.7	1.0	1.0	1.0	1.0	1.0
Building Safety	C2	Facility Emergency Management Program	-	-	-	-	-	-	-	-	-	-	-	0.1	0.2	0.2	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1
Building Safety	M1	Fire Life Safety Portfolio Assessment	-	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	0.2	0.2	0.2	0.2	0.2
Building Safety	M2	Electrical Inspections	-	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	1.3	1.6	1.7	1.6	1.6	1.7
Physical Security	CM1	NERC CIP-014	-	-	13.4	16.9	26.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physical Security	CM2	NERC CIP 006	-	-	-	-	3.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physical Security	C1b[4]	Grid Infrastructure Protection - Enhanced	5.3	1.1	3.6	10.2	11.6	14.6	19.7	39.5	31.1	19.6	20.1	-	-	-	-	-	-	0.1	0.1	0.1	0.2	0.2
Physical Security	C2[4]	Protection of Generation Capabilities	-	-	-	-	-	2.4	3.3	4.5	4.5	4.1	3.8	-	-	-	-	-	-	-	0.1	0.2	0.2	0.2
Physical Security	C3b	Non-Electric Facilities Blanket/Protection of Major Business Functions - Enhanced	1.4	2.1	8.9	0.9	10.2	8.3	11.8	14.2	13.6	14.1	12.0	-	-	-	-	-	-	-	0.2	0.2	0.3	0.2
Physical Security	C4	Asset Protection	-	-	-	-	-	-	-	1.9	0.0	2.0	6.0	25.7	26.6	28.9	28.6	25.7	21.2	21.2	20.6	19.8	20.0	20.3
Physical Security	M1a	Insider Threat Program Enhancement - Information Analysis - Base	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.3	0.3	0.3	0.2	0.2
Physical Security	M2	Smart Key Program Phase 1 - Listed BR/ CS Critical Sites	-	-	-	-	-	-	1.2	4.4	3.4	-	-	-	-	-	-	-	-	-	-	0.1	0.1	0.1
Wildfire	CM1	Vegetation Management	-	-	-	-	-	-	-	-	-	-	-	30.7	34.0	41.7	67.8	84.3	-	-	-	-	-	-
Wildfire	C1[5]	Overhead Conductor Program	-	-	60.7	97.3	138.7	21.5	30.9	18.4	5.1	13.5	12.9	-	-	-	-	-	-	-	-	-	-	-
Wildfire	C2	FR3 Overhead Distribution Transformers	-	-	-	-	-	12.5	12.9	13.3	13.7	14.1	14.5	-	-	-	-	-	-	-	-	-	-	-
Wildfire	M1	Wildfire Covered Conductor Program	-	-	-	-	-	32.1	42.4	194.6	236.5	296.1	359.1	-	-	-	-	-	-	-	-	-	-	-
Wildfire	M2	Remote-Controlled Automatic Reclosers (RARs) and Fast Curve Settings	-	-	-	-	-	-	9.1	19.3	-	-	-	-	-	-	-	-	2.5	0.3	-	-	-	-
Wildfire	M3	Public Safety Power Shutoff (PSPS) Protocol and Support Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8	3.7	3.8	3.5	2.8	2.8
Wildfire	M4	Infrared (IR) Inspection Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5
Wildfire	M5	Expanded Vegetation Management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40.8	80.7	81.8	82.8	84.2
Wildfire	M7	Enhanced Situational Awareness	-	-	-	-	-	9.7	12.5	8.5	0.0	-	-	-	-	-	-	-	1.7	4.5	5.9	4.6	4.7	4.8
Wildfire	M8	Fusing Mitigation	-	-	-	-	-	11.9	46.5	10.0	-	-	-	-	-	-	-	-	-	1.7	21.7	-	-	-
Wildfire	M9	Fire Resistant Poles	-	-	-	-	-	-	5.1	23.6	28.7	36.0	43.6	-	-	-	-	-	-	-	-	-	-	-
			437.6	**717.5**	**926.6**	**820.0**	**863.6**	**556.5**	**673.2**	**958.9**	**951.8**	**1,063.4**	**1,227.4**	**273.4**	**299.0**	**281.4**	**364.3**	**401.9**	**76.0**	**128.2**	**177.3**	**159.1**	**160.4**	**162.8**

Note:

[1] Expenditures represent total company, unadjusted costs in nominal dollars. Includes costs recorded in balancing/memorandum accounts.

[2] Recorded costs provided for all compliance activities. Forecast costs are not included as these activities are not modeled in this RAMP report.

[3] SCE tracks recorded Cybersecurity O&M at a portfolio level, and not by each cybersecurity control. This proxy control (CYB - O&M) was provided to show the total O&M recorded across all Cyberattack controls.

[4] SCE has historically tracked costs related to protecting electric infrastructure (C1b) and generation capabilities (C2) collectively in one account. Therefore, the recorded costs shown for C1b include any recorded costs applicable to C2 over the 2013-2017 period, and the recorded cost cells for C2 are left blank.

[5] Wildfire: The full recorded costs of the OCP program are shown for C1, while the forecast costs for C1 are only applicable to OCP scope within HFRA.

WP Ch. 1 - 2013-2023 Recorded and Forecast Costs for Controls & Mitigations.xlsx

Workpaper: Mapping of Risk Register to RAMP Risks

Chapter 1 - RAMP Overview

Description: For the sake of relevancy and brevity, SCE has filtered its risk register to only display those risks that actually have a safety impact. This is what is shown in this document. We have mapped these risks to one or more RAMP Risk Chapters, where applicable. Risk scores found on the "SCE ERM Risk Register Detail" tab were developed using SCE's previous Risk Evaluation Tool (RET) and evaluation methodology to assess frequency, consequences, and risk "score" of each risk.

Risk ID	Risk Name	Risk Statement	RAMP Risk Chapter
1	Pole Failure	Overloaded or deteriorated infrastructure could lead to pole failures, resulting in serious injuries and/or outages, wildfires, financial awards to injured parties, and non-compliance consequences.	Contact with Energized Equipment, Wildfire
2	Worker/Public Safety - Worker Error	Worker error, and/or process failures could expose public or workers to potential hazards. This could result in serious injury and/or fatalities, financial awards to injured parties, non-compliance consequences, and outages.	Employee, Contractor & Public Safety
3	Worker/Public Safety - Fleet Accidents	SCE vehicle fleet accident could expose public and/or workers to hazards. This could result in injury, financial awards to injured parties, and non-compliance.	Employee, Contractor & Public Safety
5	Grid/(SCADA)- Destruction of the Grid (Cyber Attack)	Deliberate attack to SCE infrastructure could lead to serious damage or destruction to the grid, resulting in the loss of use of the grid for an extended period of time, and catastrophic outcomes at individual and community levels.	Cyberattack
7	Grid/(SCADA) - Comprise of the Grid (Cyber Attack)	Deliberate attack could lead to compromise of the grid, resulting in temporary loss of grid control. This could trigger outages, increased financial cost, and non-compliance.	Cyberattack
10	Public Safety - Copper theft	Attempted copper theft leading to human contact with energized equipment, resulting in serious injuries/fatalities.	Physical Security
13	Worker/Public Safety - System/Equipment Failure	Failure of system/equipment exposes workers or members of the public to hazards. This could result in serious injuries and/or fatalities, financial awards to injured parties, non-compliance, and outages.	Contact with Energized Equipment, Underground Equipment Failure, Wildfire, Hydro Asset Safety
15	Reliability of Critical IT Systems	The introduction of a new support model could expose the reliability of critical IT systems, resulting in compromised information and/or inability to provide/obtain information critical to business functions such as customer service, crew scheduling, outage management, etc.	Cyberattack
19	Worker/Public Safety - Electrical Contact	Due to either external or internal causes, down wires or induced voltages could lead to worker or public contact with energized equipment, resulting in serious injuries and/or fatalities to workers and/or public, and outages.	Contact with Energized Equipment, Employee, Contractor & Public Safety
23	Workplace Violence	Disgruntled employee(s) who may be more susceptible to workplace violence could harm themselves or others, resulting in serious injuries and/or fatalities to workers, severe negative psychological effects on workers, and lawsuits.	Physical Security
24	Grid/SCADA - Politically Motivated Cyber Attack	If an individual or group initiates a cyber-attack in an effort to influence political decision-making or send a political message, the company is exposed to heightened cyber risk that can result in attacks to our business networks and attacks on the grid, which lead to consequences for the company in all impact dimensions.	Cyberattack
28	Catastrophic Events - Natural Disasters - Wildfires	Ability to manage the effects of wildfires will require that the company effectively prevent, protect against, mitigate, respond, and recover from wildfires. If not effectively managed, wildfires can result in asset failure, serious public and employee safety incidents, and service delivery impacts.	Climate Change, Wildfire
33	Physical Security on Critical Infrastructure	Deliberate attack to SCE critical infrastructure could result in a security breach and potentially lead to damage of equipment (resulting in toxic spills), cascading outages, system failures, and serious injuries and/or fatalities to workers, and potentially members of the public.	Physical Security
36	Customer Service Systems Failure	Critical aging customer service platform and technology obsolescence could result in customer service system failures, and lead to delays and errors in handling routine customer requests, problems in outage management, additional operational costs, non-compliance, delays in collecting revenue, and potential impact to critical care customers.	N/A - Secondary safety impacts
40	Public Safety - Stray Voltage	As part of a routine overhead and underground construction practice, lines and equipment are grounded for purposes of stabilization and protection, which creates a current return path through earth. Members of the public in close proximity to a substation may become part of a current return path when making contact with a substation fence, making contact with a conductive indoor water fixture or outdoor conductive water pipe, or while exiting an ungrounded swimming pool surrounded by a concrete deck. This can potentially result in injuries and civil litigation.	N/A - Did not meet safety threshold
45	SmartConnect and/or Netcomm Metering System Failure	Asset, system, process or worker failure, or security breach could cause SCE's Advanced Metering Systems to fail. The outcomes of these types of failures may impact public and employee safety, cause loss or delay of corporate revenue, and trigger increased manual work arounds, loss of data, large-scale outages, and customer dissatisfaction.	N/A - Did not meet safety threshold

Risk ID	Risk Name	Risk Statement	RAMP Risk Chapter
48	Electronic Data Breach GRID - Intellectual Property /Company Confidential	Internal or external attack could result in the loss of, or unauthorized changes to, confidential/sensitive electronic data supporting the Grid or related intellectual property and trigger liability associated with data exposure and/or unauthorized changes to Grid data.	Cyberattack
53	Distribution Energy Resources (DER)	Advances in customer and distributed energy resource technologies will increase the pace of adoption and penetration of distributed energy resources on the distribution system, which may increase the risks to future reliability and power quality.	N/A - Did not meet safety threshold
57	Vendor Performance and Management - Non IT	Vendor/supplier performance (labor disputes, raw material shortage, etc.) could lead to disrupted supply chain and result in inability to complete work assigned to contract crews, and insufficient material to support O&M, capital, storm and emergency job activities.	N/A - Did not meet safety threshold
59	SONGS - Manage Decommissioning - Co-Owners	SONGS Co-Participants unanimous voting requirement produces slow decision-making or inability to reach consensus, preventing the completion of necessary work and/or delaying the decommissioning project and causing budget overruns.	N/A - See Appendix A (Nuclear Decommissioning)
61	Public Safety - Contact Voltage	Under abnormal operating conditions, a difference in potential (voltage) can exist between earth and a conductive surface or between two conductive surfaces as a result of direct contact with an exposed energized line conductor or cable, or as a result of induction. A person could become part of a current path while walking, or while simultaneously contacting earth and a conductive surface, resulting in a moderate to severe electric shock and potential civil litigation.	N/A - Did not meet safety threshold
63	Third Party Compliance	A significant noncompliance event occurs at a supplier. This impacts continuity of supply and presents financial and reputational risks.	Cyberattack, and other risks encompassing asset failure
64	Records and Information Management Compliance	Employees not following processes, or processes not accurately reflecting the operating needs, could lead to poor/inappropriate records management. This can result in inability to access information, and/or inability to respond fully, accurately, and timely to regulatory inquiries and data requests.	Employee, Contractor & Public Safety
67	Employee Misconduct	Unintentional or Intentional employee misconduct could result in violation of Employee Code of Conduct, policy, or law and cause harm to employees, customers or shareholders.	N/A - Did not meet safety threshold
72	Permitting	Permits not being filed properly (or filed properly but not actually taken out to the job site, as required) leads to SCE crews not having the required permits. This results in our workers not following the permitting rules and regulations, which carry safety, financial and compliance impacts for the company.	N/A - Did not meet safety threshold
73	Public Safety - Dam Failure	High-hazard dams being subjected to major natural hazards or failures could potentially cause an Uncontrolled Rapid Release of Water (URRW) leading to serious injuries and/or fatalities, destruction of property, long-term environmental damage, compliance failures, loss of operation and revenue, and destruction of the project.	Hydro Asset Safety
75	Worker/Public Safety - B Bank Transformer	B-bank transformer in service failure due to copper theft leading to B-bank transformer unavailability and potentially resulting in serious injuries and/or fatalities.	Physical Security
79	Response and Recovery from Manmade Disasters	Failure to implement an effective company-wide business resiliency planning and emergency management system in responding to man-made disasters could result in system failure; delayed or uncoordinated company response and recovery efforts; failure to timely communicate and coordinate with external agencies.	Applicable as response to all nine risk chapters
80	Response and Recovery from Business Disruptions	Failure to implement an effective company-wide business resiliency planning and emergency management system in preparation for business disruptions could result in delayed or uncoordinated company response and recovery efforts; failure to timely communicate and coordinate with external agencies; public or employee injuries or fatalities.	Applicable as response to all nine risk chapters
81	Response and Recovery from Environmental Issues	Failure to implement an effective company-wide business resiliency planning and emergency management system in preparation for climate change and/or other changing environmental conditions (e.g., increased wildfire risk due to drought) could result in public or employee injuries or and/or increased impact to SCE's assets.	Climate Change, Wildfire
84	Electrical System Failures - Southwestern Blackout	A combination of asset failures, worker error, and/or process failures could lead into a major electrical system failure resulting into a southwestern system blackout with safety, reliability and financial consequences.	N/A - Primarily a direct reliability impact, with a secondary safety impact
99	Uncertainties and the Potential Margin of Error in System Planning or Engineering Impacting Reliability	Uncertainties in demand forecast planning assumptions and increasing system complexities due to variable customer-side resources could lead to the actual demand exceeding the forecast, resulting in potential circuit overloads and customer outages	N/A - Secondary safety impacts

Risk ID	Risk Name	Risk Statement	RAMP Risk Chapter
100	Insider Threat	Accidental or deliberate actions of current or former employees, contractors, or business partners could expose the company to cyber risk s that involve unauthorized access to network, system, or data. These actions may negatively affected the confidentiality, integrity, or availability of the Grid systems and data, our information or information systems.	Cyberattack, Physical Security
101	Execution Risk Related to Decommissioning Project	Decommissioning General Contractor fails to successfully complete the decommissioning of SONGS per the fixed price contract specifications, leading to potential project delays, increased project costs and safety implications for SCE.	See generally Appendix A (Nuclear Decommissioning)
109	Policy Ruling Affecting Increased Adoption of Alternative Technologies	Policy ruling affecting investment opportunities and supporting advanced technologies could lead to SCE deploying DERs rapidly and in a widespread fashion. Supporting this effort without having the appropriate resources can result in potential safety issues, increased financial cost, and potential outages.	N/A - Secondary safety impacts
122	Catastrophic Events - Natural Disasters - Earthquakes	Ability to manage the effects of earthquakes and aftershocks will require that SCE effectively protect, mitigate, respond and recover from the consequences of earthquakes. If the efforts are not effectively managed, the result can be asset failure, public and employee safety incidents, and service delivery impacts.	Building Safety, Hydro Asset Safety, (also see Appendix C - Seismic Events)
123	Catastrophic Events - Other Natural Disasters - (Not related to Earthquakes or Wildfires)	Ability to manage the effects of natural disasters rainstorms and landslides will require that SCE effectively protect, mitigate, respond and recover from such natural disasters. These disasters, if not effectively managed, can result in asset failure, public and employee safety incidents, and service delivery impacts.	Climate Change
124	Worker/Public Safety - Process Failure	Worker error, and/or process failures could expose public or workers to potential hazards. This could result in serious injury and/or fatalities, financial awards to injured parties, non-compliance, outages, and negative public relations.	Employee, Contractor & Public Safety

ACCESS TO POWER BI

REQUESTING ACCESS

By signing or submitting this form, you agree that any information you obtain through this access to Power BI shall only be used in connection with SCE's Risk Assessment Mitigation Phase (RAMP) or General Rate Case proceedings. If any SCE confidential information is inadvertently disclosed to you as a result of your access to Power BI, you acknowledge that you will treat that information as confidential.

To receive access to the Power BI site, you should complete this form and send via email to:

Case Administration
Southern California Edison Company
Case.admin@sce.com

After SCE's acceptance, the User will be notified of activation by email within 2-3 days.

Access Request for Power BI

Case Name: SCE 2018 RAMP

User Name: __________ User Title: __________

Organization: __________

Mailing Address: __________

Email: __________

Telephone Number: __________

Party or Governmental Entity Represented by User: __________

By: __________

User Signature

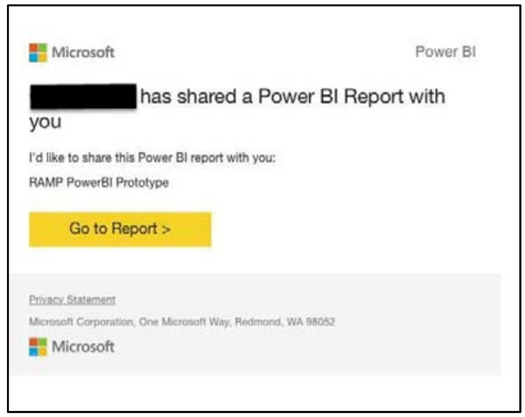
Date: __________

INSTRUCTIONS TO ACCESS POWER BI

If you don't have already Microsoft account, follow the steps below to create one. If you already have a Microsoft account for this email address, you can log-in as usual.

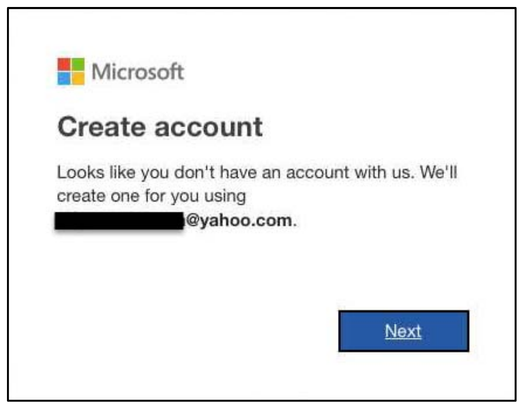
1. You will receive an invitation to access the site, with a link to the Report.

2. Click on the link in the email.



3. If you **don't** already have a Microsoft account, a new window will instruct you to create one.

4. Click on "Next"



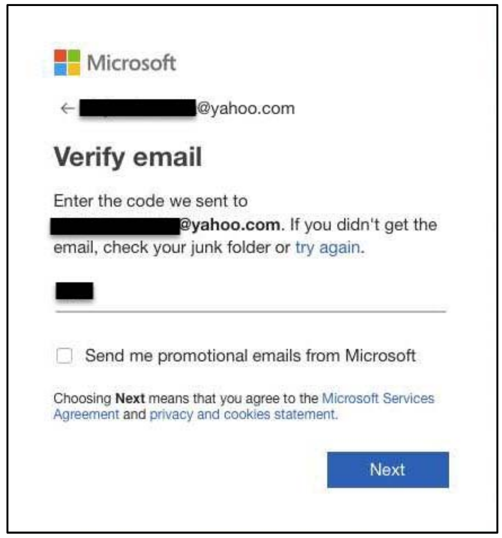
5. A new window will prompt you to create a password

6. Create a unique password, using uppercase, lowercase, a symbol, and a number

7. Once a password has been created, a verification email will be sent to your email.
8. Go to the email titled "Verify your email address" to get the **Security Code**

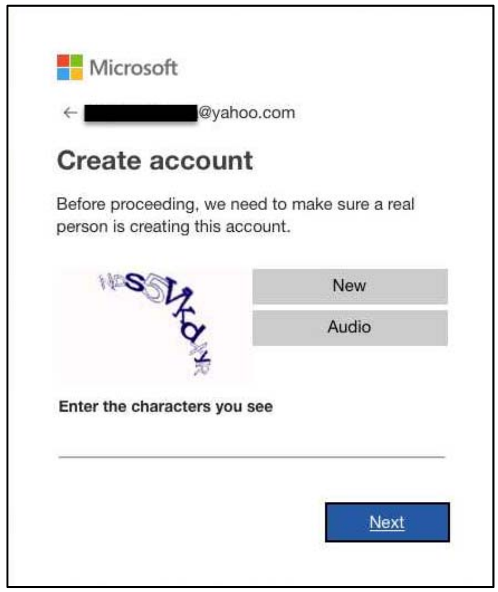
9. Enter your security code in the prompted window

10. Click “Next”



11. Verify that you are a human.

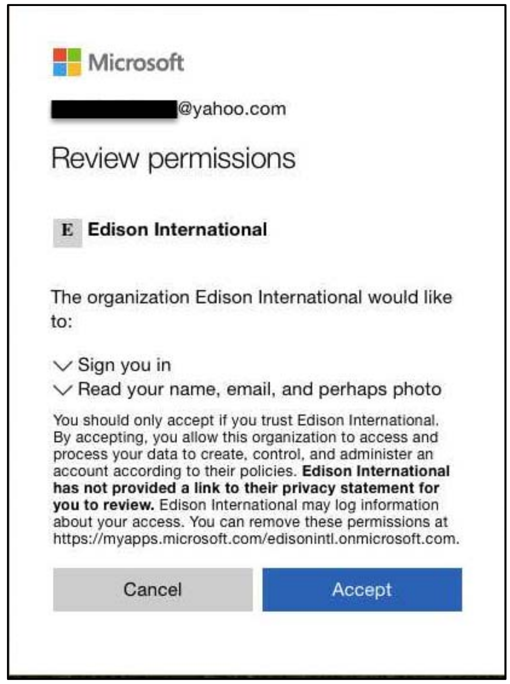
12. Click “Next”



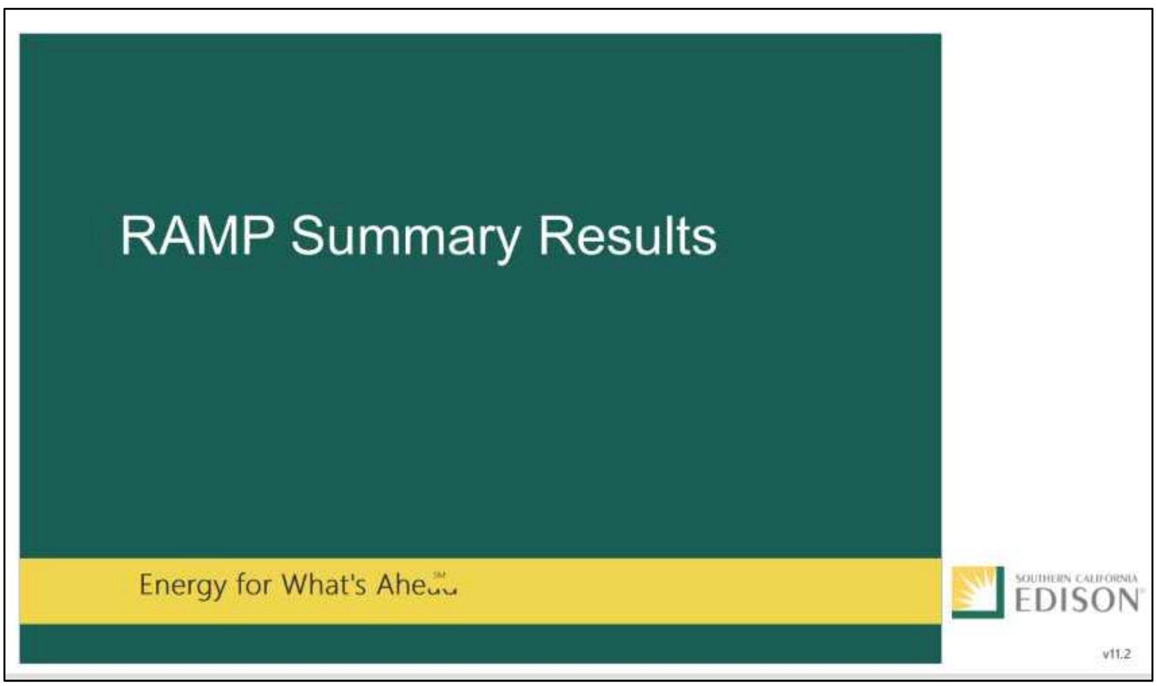
13. Verify your email address, if correct click on **“Looks Good!”**

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company

14. Review permissions and click on **"Accept"**



15. Congratulations, you have successfully accessed the site!



Power BI Roadmap to Visualizing RAMP Data

Energy for What's Ahead℠

Model Architecture Overview

Power BI is used to display the results of the RAMP simulation model in an intuitive and easy to filter manner.

SCE Input

Baseline Data
- Exposure
- Driver Frequency
- Outcome Probability
- Consequence Distribution

Mitigations Data
- Cost
- Mitigation Reduction Percentages
- Mitigation Exposure
- Mitigation Portfolios

Model Engine

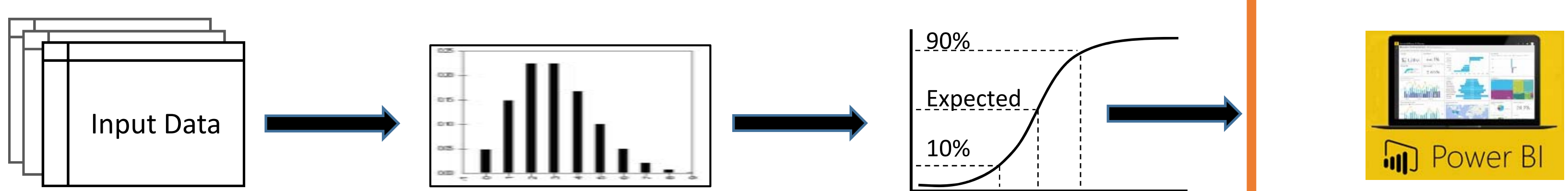
Monte Carlo Simulation
- Random draws from each bowtie component
- Iterate 10,000 times for each year
- Perform above steps for Baseline and each mitigation portfolio

Model Output

Output
- Distribution of consequences by outcome in natural units
- Mean and Tail Average
- MARS
- Risk Spend Efficiency for portfolio and mitigations

Reporting

Power BI
- Cloud based visualization tool
- Review input and output data



Energy for What's Ahead℠

Power BI Overview

Power BI is a Microsoft cloud-based business analytics software that harnesses the key strengths of Excel (analytical and charting capabilities) and Powerpoint (presentation capabilities).

SCE used this platform to transform RAMP data into easily digestible information.

Key Capabilities

- Cloud-based, no special software to install other than an internet browser
- Allows user to “slice and dice” the data versus a static file
- Underlying data can be downloaded
- The platform performs the “heavy lifting” in transforming data into information

Power BI Reports Overview

Power BI Report #	Power BI Report Name	Summary	Slides for Add'l Info
1	Risk Bowtie	Presents an interactive bowtie with baseline and mitigated bowtie data.	8-9
2	Risk Bowtie (Hydro)	Same report as Report #1, specific to Hydro Asset Safety due to the number of significant digits.	8-9
3	Input Detail	Provides tables with annual driver, outcome, and consequence data, for baseline and mitigated portfolios.	10-11
4	Mitigation Cost	Provides various charts showing costs of mitigations and mitigation plans, by year.	12-13
5	Consequences by Outcomes	Provides charts depicting the consequences associated with each risk outcome, for baseline and mitigated risk levels.	14-15
6	Consequences Summary	Provides a summary of each chapter's baseline and mitigated consequences, in natural units.	16-17
7	MARS by Scenario	Provides charts displaying mean and tail-average MARS results for baseline and mitigated risk.	18-19
8	MARS Stack	Provides a cross-risk comparison of baseline and mitigated risk levels on a MARS basis, with stacked bars to display consequence impacts.	20-21
9	Portfolio RSE	Provides a mapping of controls and mitigations to mitigation plans. Provides risk reduction, cost, and RSE for each mitigation plan considered.	22-23
10	Mitigation RSE	Provides risk reduction, cost, and RSE for each control and mitigation on a mean and tail-average basis, as well as their impacts to consequences.	24-25
11	Mitigation Cost Detail	Provides annual cost estimates over 2018 – 2023 period for each control / mitigation considered in this RAMP report	26-27

Note: These are the reports SCE has included at the time of our RAMP submission. Since Power BI is an active application, these reports may be adjusted and additional reports may be provided as needed.

Energy for What's Ahead℠ 4

SOUTHERN CALIFORNIA EDISON

Description: This is the title page

There are no buttons or any type of data interactions here.

Energy for What's Ahead℠ | 5

SCE RAMP Risks

Image	RISK	Full Name	Description
	BUS	Building Safety	Failure of building structural or non-structural components that potentially causes harm to occupants
	CEE	Contact with Energized Equipment	Energized equipment incident which potentially causes electric shock
	CMC	Climate Change	Failure of SCE to prepare for climate change which potentially causes loss of control or destruction of assets
	CYB	Cyber Attack	Compromise of SCE system controls which potentially leads to data exfiltration, loss of control, and/or adversary control of grid control systems
	HYD	Hydro Asset Safety	Uncontrolled rapid release of water that potentially inundates populated or unpopulated areas
	PHS	Physical Security	Compromise of SCE physical security which potentially leads to workplace violence, property theft, asset/equipment damage, or loss of control of asset
	UEF	Underground Equipment Failure	Asset failure which potentially causes substantial and uncontrolled release of energy from a vault or manhole
	WDF	Wildfire	Ignition Associated with SCE in High Fire Risk Area
	WSA	Employee, Contractor and Public Safety	Act performed which potentially exposes workers or public to hazards

<u>Description:</u> This report describes the 9 risks.

Please take note of the 9 risk icons and the 3-letter key that will be used throughout the reports.

There are no buttons or any type of data interactions here.

Key Terms

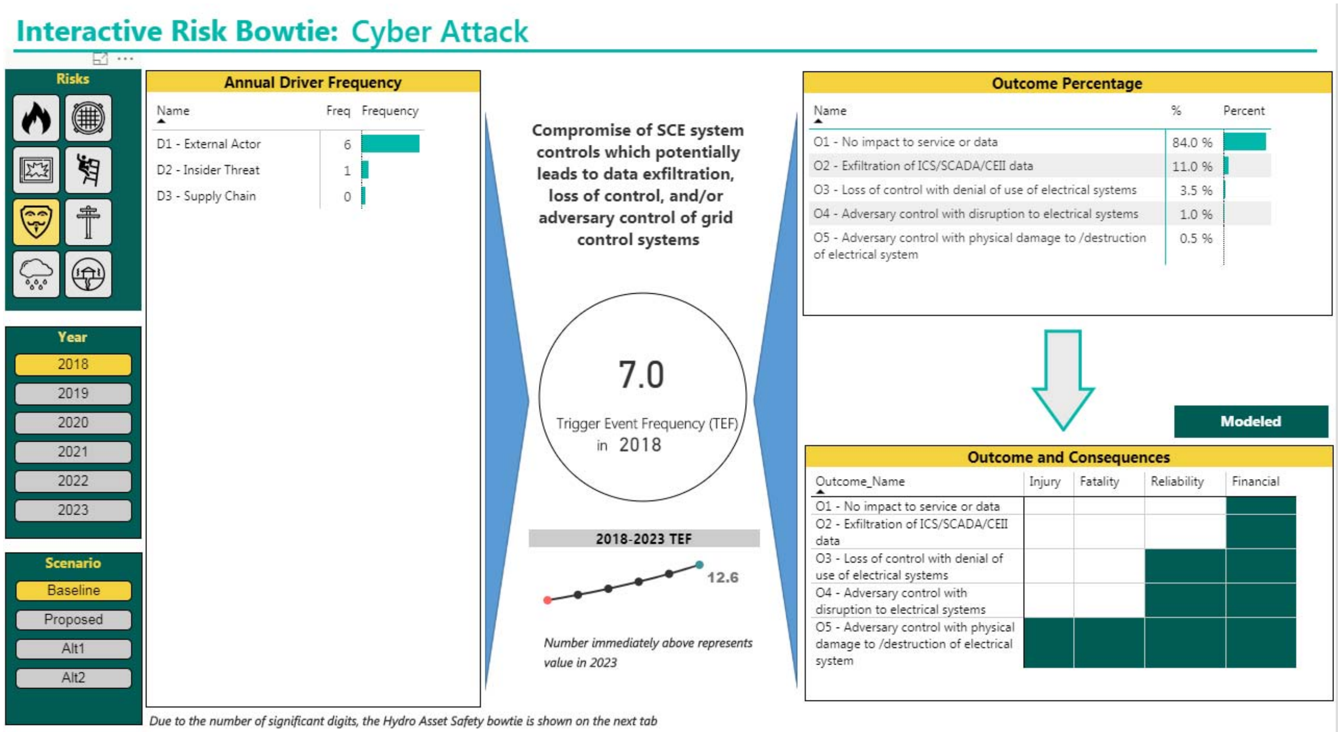
Term	Description
Consequence	We measure four consequences in this RAMP report: Serious Injury, Fatality, Reliability, Financial
Driver	Contributing factor causing a triggering event, measured in terms of annual frequency. Summation of drivers equals the number of triggering events.
Fatality	One of the four consequences, measured in terms of number of fatalities.
Financial	One of the four consequences, measured in terms of dollar impact to the customers and/or third parties.
MARS	Multi-Attribute Risk Score
Mean	The average of all simulated results from the model.
MRR	The amount of risk reduced from the baseline level by a control, mitigation, or portfolio thereof.
NU	Natural Units (e.g. dollars, number of serious injuries, CMI)
Outcome	The potential result of a Triggering Event, as measured as a percentage likelihood of occurrence if the triggering event occurs. Each outcome leads to one or more consequences.
Proposed	Represents proposed mitigation plan for addressing the risk, as defined in the RAMP report.
RAMP	Risk Assessment Mitigation Phase
Reliability	One of the four consequences, measured as impact to service or grid reliability in terms of CMI.
RSE	Risk Spend Efficiency. The is the ratio between MRR (in MARS units) and Cost.
Serious Injury	One of the four consequences, measured in terms of number of serious injuries.
Tail Average	The average of the worst 10% of all simulated results from the model.
TEF	Trigger Event Frequency. The middle of the bow-tie. It is the number of times a particular risk event happens per year.

<u>Description:</u> This report details key terms used within Power BI.

There are no buttons or any type of data interactions in this report

Please note, where there are instances of the word "injury" throughout the Power BI reports, they should be considered short-hand for "serious injury." This was used for simplifying the formatting in certain reports.

Reports 1 and 2: Risk Bowtie



Description: This report illustrates the bowtie components (Driver Frequency, Outcomes, Consequences) by risk

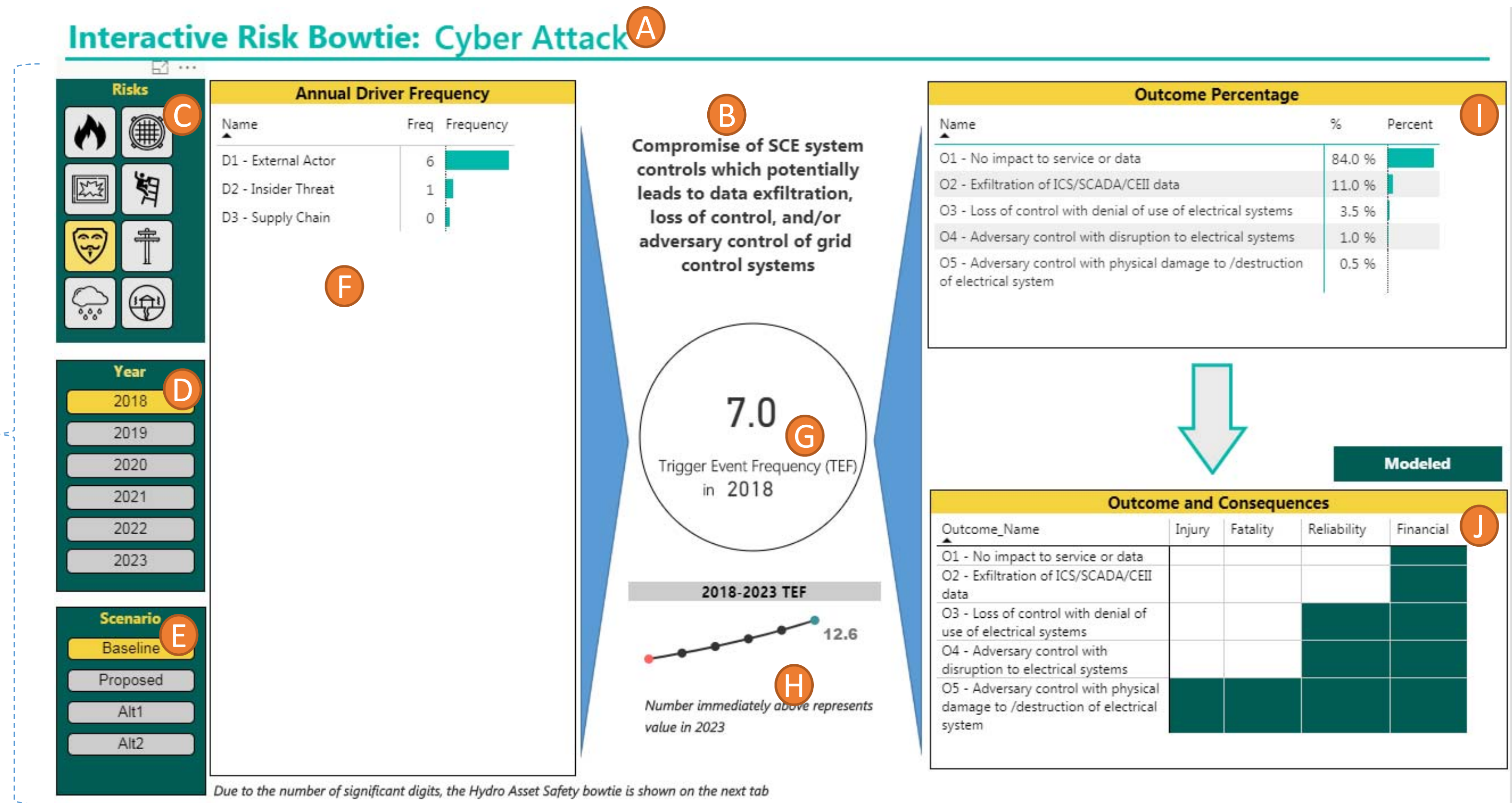
Key Features:

- ***Filter*** by Risk, Year and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- Shows 6-year driver frequency trend
- Shows which consequences are mapped to each outcome.

Note: SCE developed a second bowtie report (Report 2) specifically for Hydro Asset Safety to accommodate showing driver frequencies which are very low.

Energy for What's Ahead℠ 8

“Filter Panel”



A. Name of the Risk – it dynamically changes depending on the selection in the Risk Filter **(C)**

B. Description of the Risk – it dynamically changes depending on the selection in the Risk Filter **(C)**

C. Risk Filter – Filter risks by selecting ***one*** of the icons

D. Year Filter – Select ***one*** of the years

E. Scenario Filter – Select ***one*** [Baseline, Proposed, Alternative-1, Alternative-2]

Filter Panel

F. Driver Information: Name and Annual Frequency based on the Filter Panel selections

G. Annual Trigger Event Frequency: Summation of the Driver frequencies in **(F)**

H. Trigger Event Frequency trend over the 6 years

I. Outcome percentages based for selected risk

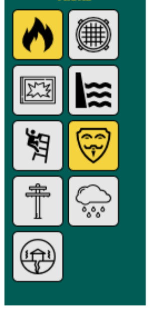
J. Shows which consequences are mapped too each outcome. Green shaded box indicates consequence is modeled for the corresponding outcome.

Energy for What's Ahead℠ 9

Report 3: Bowtie Details

RAMP Model Input Details

Risks



Scenario: Baseline, Proposed, Alt1, Alt2

Consequences: Injury, Fatality, Reliability, Financial

Annual Driver Frequency

Full Name	2018	2019	2020	2021	2022	2023	Total
Cyber Attack							
Baseline	**7.00**	**7.86**	**8.82**	**9.93**	**11.19**	**12.62**	**57.42**
Driver							
D1 - External Actor	5.95	6.74	7.62	8.63	9.77	11.06	**49.77**
D2 - Insider Threat	0.70	0.70	0.70	0.70	0.70	0.70	**4.20**
D3 - Supply Chain	0.35	0.42	0.50	0.60	0.72	0.86	**3.45**
Wildfire							
Baseline	**44.00**	**44.00**	**44.00**	**44.00**	**44.00**	**44.00**	**264.00**
Driver							
D1 - Contact From Object	23.00	23.00	23.00	23.00	23.00	23.00	**138.00**
Total	**51.00**	**51.86**	**52.82**	**53.93**	**55.19**	**56.62**	**321.42**

Outcome Probability

Full Name	2018	2019	2020	2021	2022	2023
Cyber Attack						
Baseline						
Outcome						
O1 - No impact to service or data	84.0 %	84.0 %	84.0 %	84.0 %	84.0 %	84.0 %
O2 - Exfiltration of ICS/SCADA/CEII data	11.0 %	11.0 %	11.0 %	11.0 %	11.0 %	11.0 %
O3 - Loss of control with denial of use of electrical systems	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %
O4 - Adversary control with disruption to electrical systems	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %

Consequences - Impact (mean) per event per year

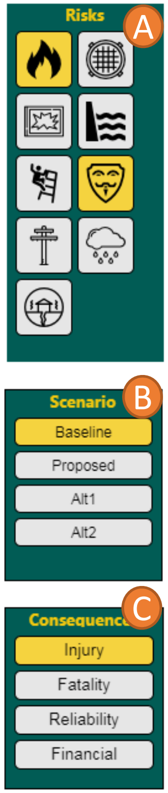
Full Name	2018	2019	2020	2021	2022	202
Cyber Attack						
Baseline						
Injury						
O5 - Adversary control with physical damage to /destruction of electrical system	1.000	1.000	1.000	1.000	1.000	1.0
Wildfire						
Baseline						
Injury						
O1 - Wildfire Red Flag Warning in Effect Greater than 5,000 Acres	22.161	22.161	22.161	22.161	22.161	22.1
O2 - Wildfire Red Flag Warning in Effect Less Than 5,000 Acres	0.007	0.007	0.007	0.007	0.007	0.0
O3 - Wildfire Red Flag Warning Not in Effect Greater Than 5,000 Acres	8.300	8.300	8.300	8.300	8.300	8.3
O4 - Wildfire Red Flag Warning Not in Effect Less Than 5,000 Acres	0.007	0.007	0.007	0.007	0.007	0.0

Description: This report provides RAMP bowtie inputs by year

Key Features:

- ***Filter*** by Risk, Scenario (Baseline, Proposed, Alternative 1, Alternative 2), and Consequence
- Shows inputs by year (2018 – 2023)
- Consequence inputs is the mean value per event.

RAMP Model Input Details



Annual Driver Frequency (D)

Full Name	2018	2019	2020	2021	2022	2023	Total
Cyber Attack							
Baseline	**7.00**	**7.86**	**8.82**	**9.93**	**11.19**	**12.62**	**57.42**
Driver							
D1 - External Actor	5.95	6.74	7.62	8.63	9.77	11.06	**49.77**
D2 - Insider Threat	0.70	0.70	0.70	0.70	0.70	0.70	**4.20**
D3 - Supply Chain	0.35	0.42	0.50	0.60	0.72	0.86	**3.45**
Wildfire							
Baseline	**44.00**	**44.00**	**44.00**	**44.00**	**44.00**	**44.00**	**264.00**
Driver							
D1 - Contact From Object	23.00	23.00	23.00	23.00	23.00	23.00	**138.00**
Total	**51.00**	**51.86**	**52.82**	**53.93**	**55.19**	**56.62**	**321.42**

Outcome Probability (E)

Full Name	2018	2019	2020	2021	2022	2023
Cyber Attack						
Baseline						
Outcome						
O1 - No impact to service or data	84.0 %	84.0 %	84.0 %	84.0 %	84.0 %	84.0 %
O2 - Exfiltration of ICS/SCADA/CEII data	11.0 %	11.0 %	11.0 %	11.0 %	11.0 %	11.0 %
O3 - Loss of control with denial of use of electrical systems	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %	3.5 %
O4 - Adversary control with disruption to electrical systems	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %

Consequences - Impact (mean) per event per year (F)

Full Name	2018	2019	2020	2021	2022	202:
Cyber Attack						
Baseline						
Injury						
O5 - Adversary control with physical damage to /destruction of electrical system	1.000	1.000	1.000	1.000	1.000	1.(
Wildfire						
Baseline						
Injury						
O1 - Wildfire Red Flag Warning in Effect Greater than 5,000 Acres	22.161	22.161	22.161	22.161	22.161	22.1
O2 - Wildfire Red Flag Warning in Effect Less Than 5,000 Acres	0.007	0.007	0.007	0.007	0.007	0.(
O3 - Wildfire Red Flag Warning Not in Effect Greater Than 5,000 Acres	8.300	8.300	8.300	8.300	8.300	8.3
O4 - Wildfire Red Flag Warning Not in Effect Less Than 5,000 Acres	0.007	0.007	0.007	0.007	0.007	0.(

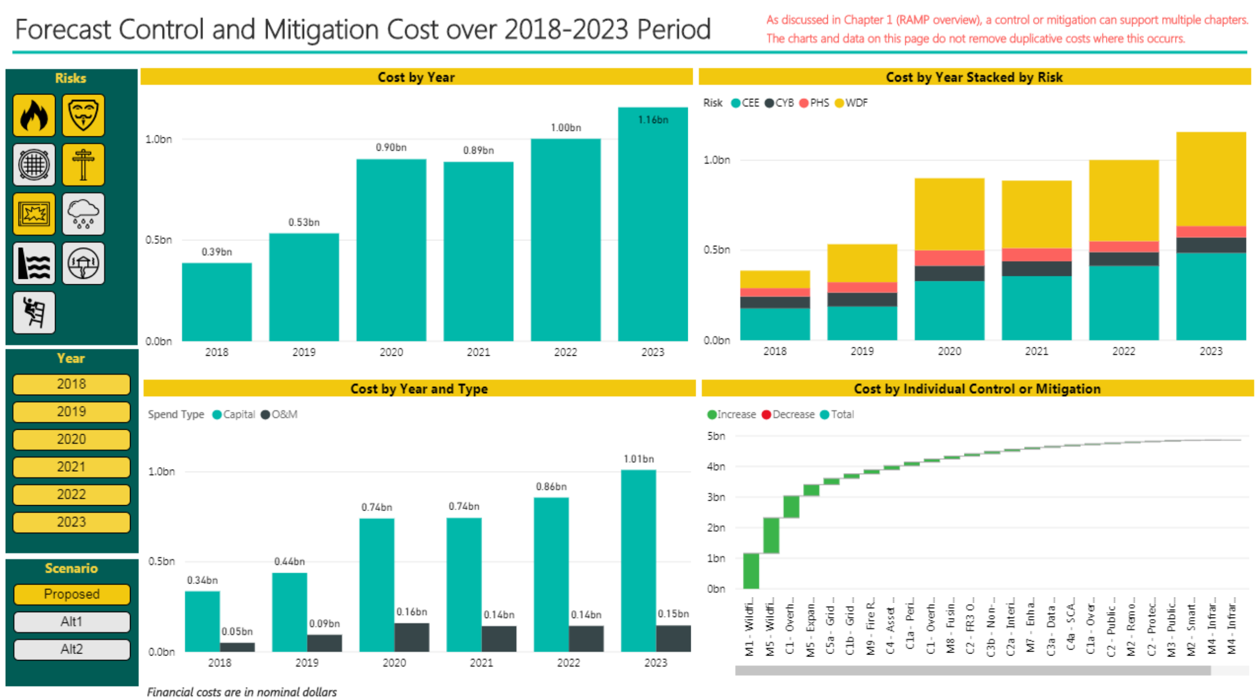
Filter Panel

- (A) Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons
- (B) Scenario Filter – Select ***any (one to all)*** [Baseline, Proposed, Alternative-1, Alternative-2]
- (C) Consequence Filter – Select ***any (one to all)*** [Injury, Fatality, Reliability, Financial]

- (D) Driver Name and Frequency by Year, based on Filter selections
- (E) Outcome Name and Probability by Year, based on Filter selections
- (F) Consequence Mean (by event) by Year, based on Filter selections

Energy for What's Ahead℠ | 11

Report 4: Mitigation Cost



Description: This report illustrates the mitigation costs

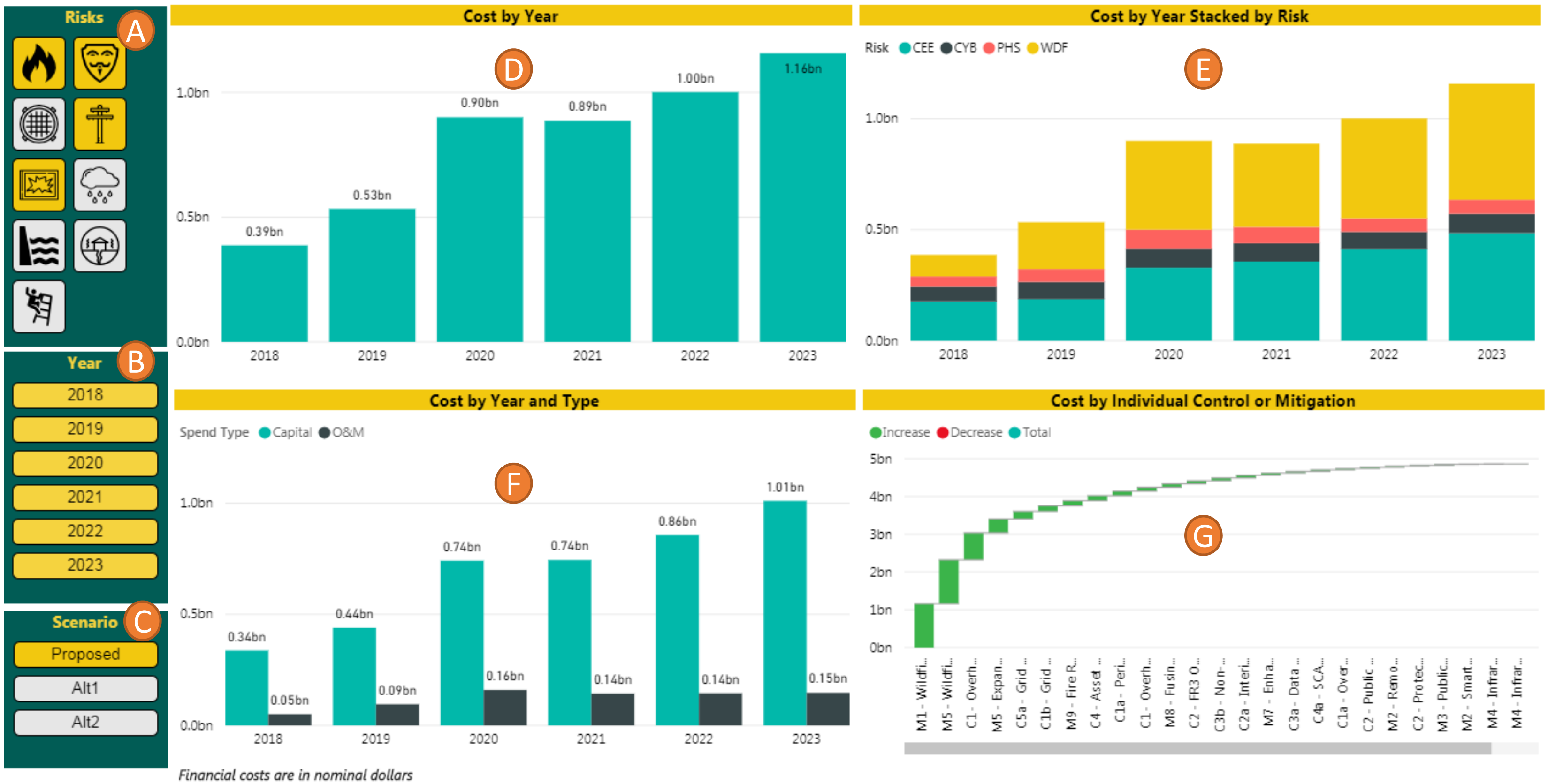
Key Features:

- ***Filter*** by Risk, Year and Scenario (Proposed, Alternative 1, Alternative 2)
- Mitigation cost by year and by risk
- Mitigation cost split into Capital vs O&M
- Waterfall chart of mitigation costs

Note: The same mitigation can span multiple risks. Please refer to Ch. 1 - RAMP Overview for further details

Forecast Control and Mitigation Cost over 2018-2023 Period

As discussed in Chapter 1 (RAMP overview), a control or mitigation can support multiple chapters. The charts and data on this page do not remove duplicative costs where this occurs.



A Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

B Spend by Year – Select ***any (one to all)*** years

C Scenario Filter – Select ***one*** [Proposed, Alternative-1, Alternative-2]

Filter Panel

D Cost by Year – Total cost of all selected Risks by Scenario and Year

E Cost by Year – Total Costs, stacked by Risk

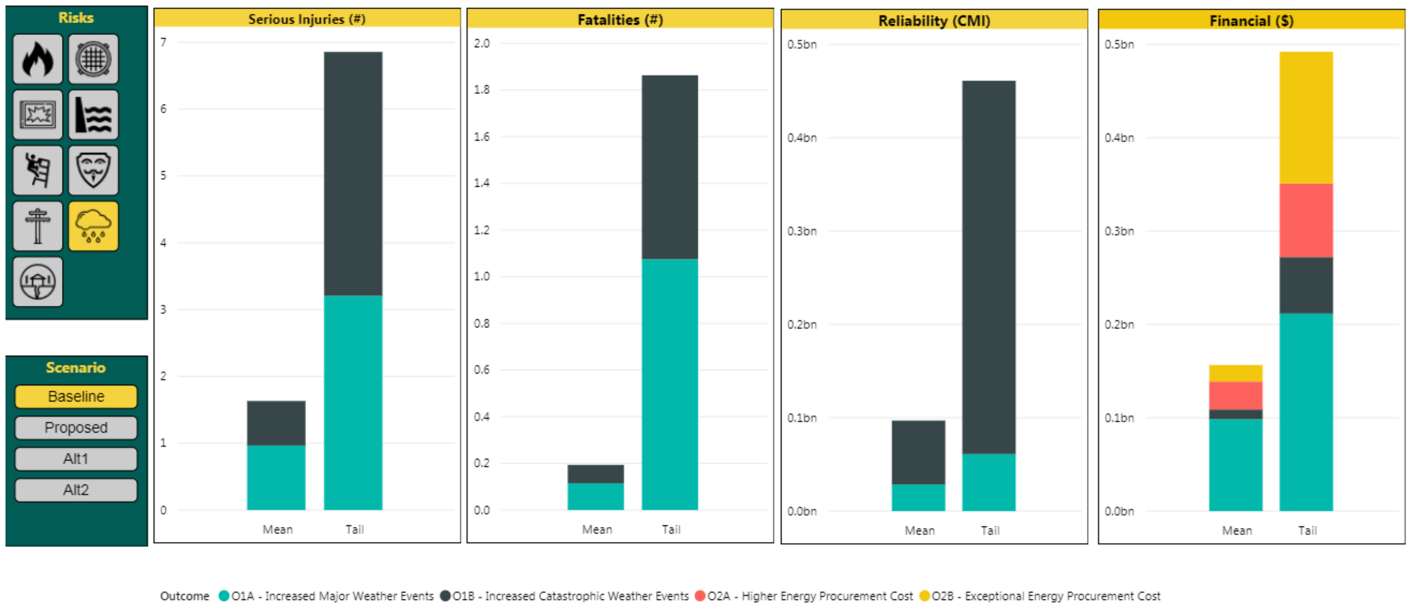
F Cost by Year – Capital vs O&M, based on filter selections

G Waterfall chart of control/mitigation activities contributing to overall total cost, based on filter selections

Energy for What's Ahead℠ 13

Report 5: Consequences by Outcomes

Consequences by Outcomes: Annual Average results over 2018 - 2023 Period in Natural Units



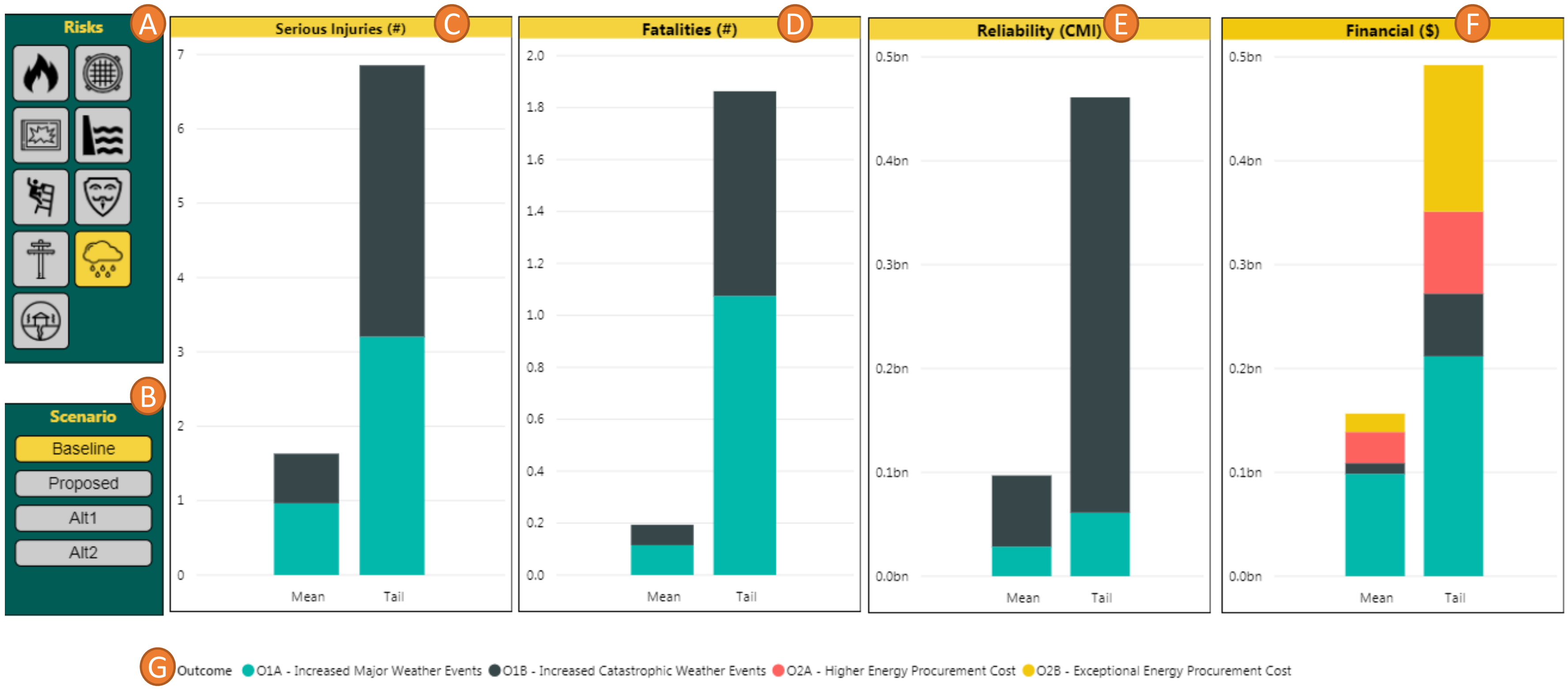
Description: This report illustrates the annual consequence impacts by outcome

Key Features:

- ***Filter*** by Risk, Year and Scenario (Baseline Proposed, Alternative 1, Alternative 2)
- The 6-year annual average of the Mean and Tail average (stacked by outcomes) is shown for each consequence
- Results are in Natural units

Energy for What's Ahead℠ 14

Consequences by Outcomes: Annual Average results over 2018 - 2023 Period in Natural Units



A Risk Filter - Select ***one*** risk

B Scenario Filter – Select ***one*** [Proposed, Alternative-1, Alternative-2]

Filter Panel

C Annual average of serious injuries for both mean and tail average

D Annual average of fatalities for both mean and tail average

E Annual average of Customer Minutes of Interruption for both mean and tail average

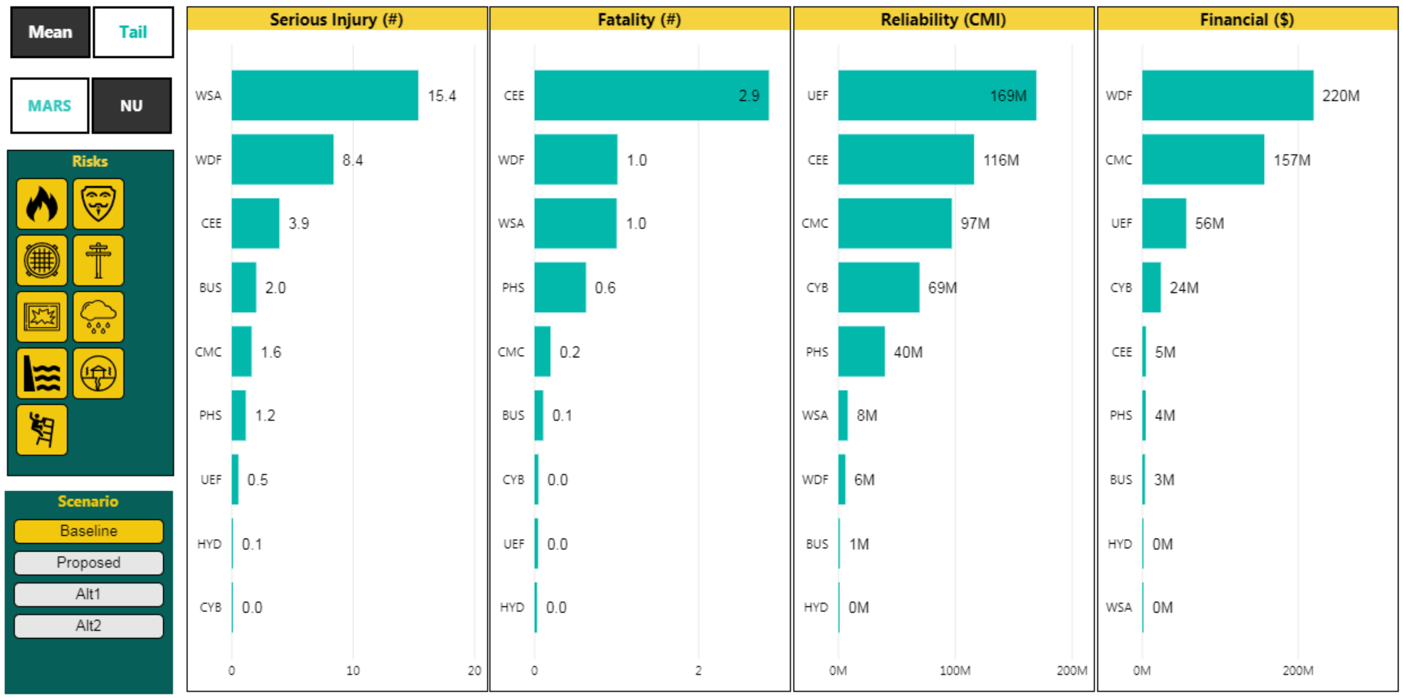
F Annual average of financial impacts for both mean and tail average

G Outcomes legend

Energy for What's Ahead℠ | 15

Report 6: Consequences Summary

Consequence Impacts by Risk: Annual Average results over the 2018-2023 Period



Description: This report illustrates the 6-year average of consequence results

Key Features:

- ***Filter*** by Risk and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- ***Toggle*** between
  - MARS and Natural Units
  - Mean and Tail Average

Consequence Impacts by Risk: Annual Average results over the 2018-2023 Period

A Mean / Tail Average Toggle - Select ***one.***
Mean is currently selected in this snapshot

B MARS / Natural Units Toggle – Select ***one.***
Natural Units is currently selected in this snapshot

C Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

D Scenario Filter – Select ***one***
[Baseline, Proposed, Alternative-1, Alternative-2]

Filter Panel

E Annual average of serious injuries

F Annual average of fatalities

G Annual average of reliability impacts in CMI's

H Annual average of financial impacts in dollars

Energy for What's Ahead℠ | 17

Report 7: MARS by Scenario

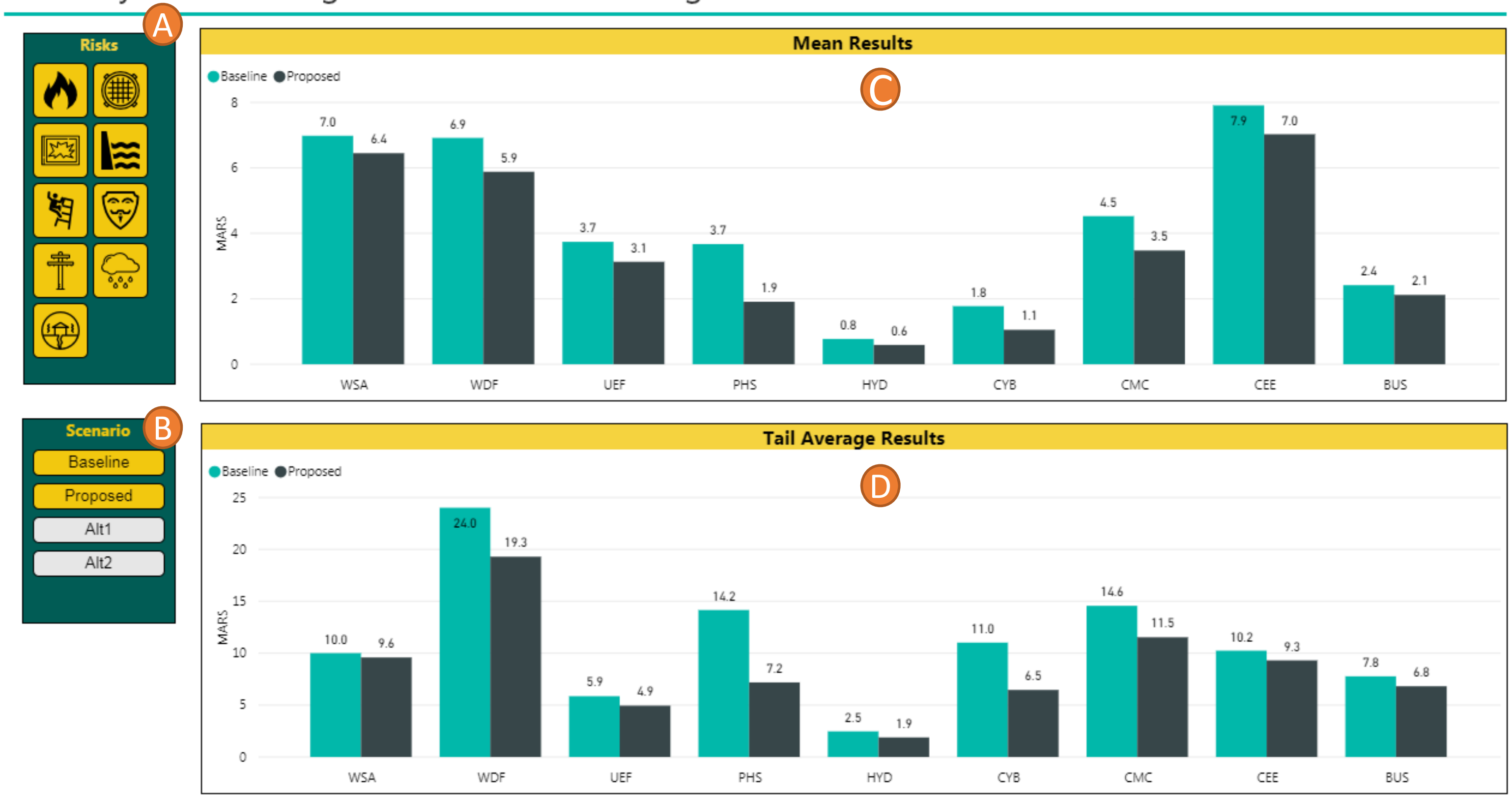
MARS by Risk and Mitigation Plan: Annual Average results over 2018-2023 Period

Description: This report illustrates the 6-year average MARS by risk and scenario

Key Features:

- ***Filter*** by Risk and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- Shows both Mean and Tail Average
- Ability to put all 4 scenarios next to each other for comparison

MARS by Risk and Mitigation Plan: Annual Average results over 2018-2023 Period



A Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

B Scenario Filter – Select ***any (one to all)*** [Baseline, Proposed, Alternative-1, Alternative-2]

Filter Panel

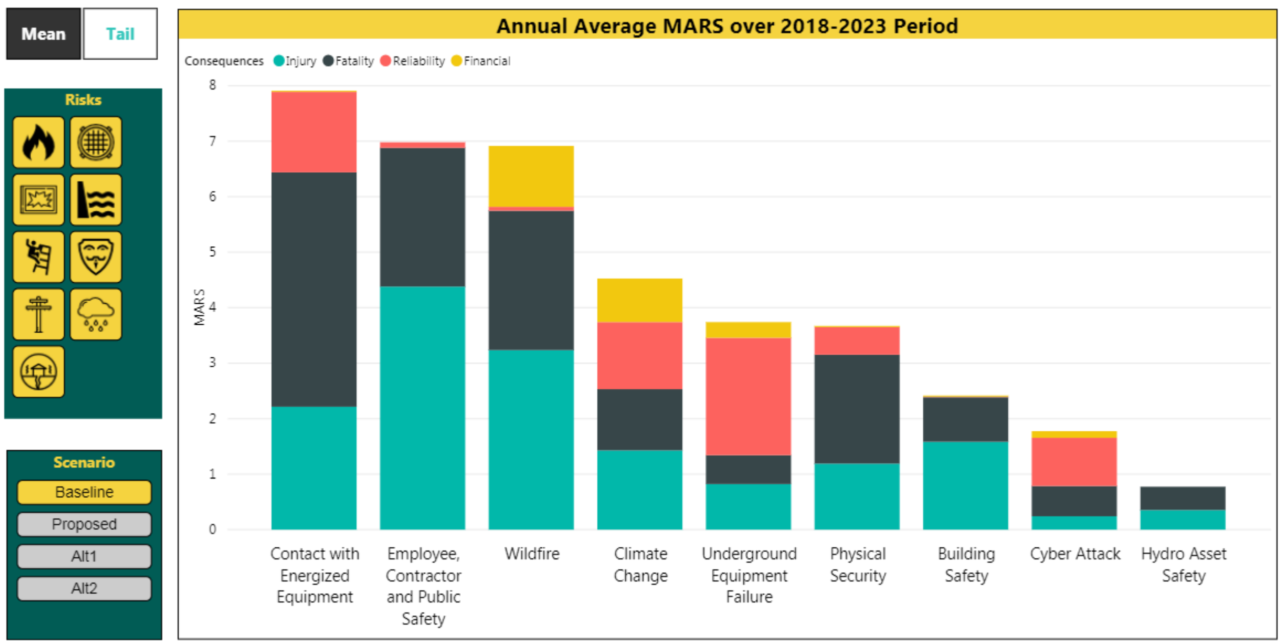
C Annual average (2018-2023) of the MARS mean

D Annual average (2018-2023) of the MARS tail average

Energy for What's Ahead[SM] 19

Report 8: MARS by Scenario

MARS Results by Risk and Consequence



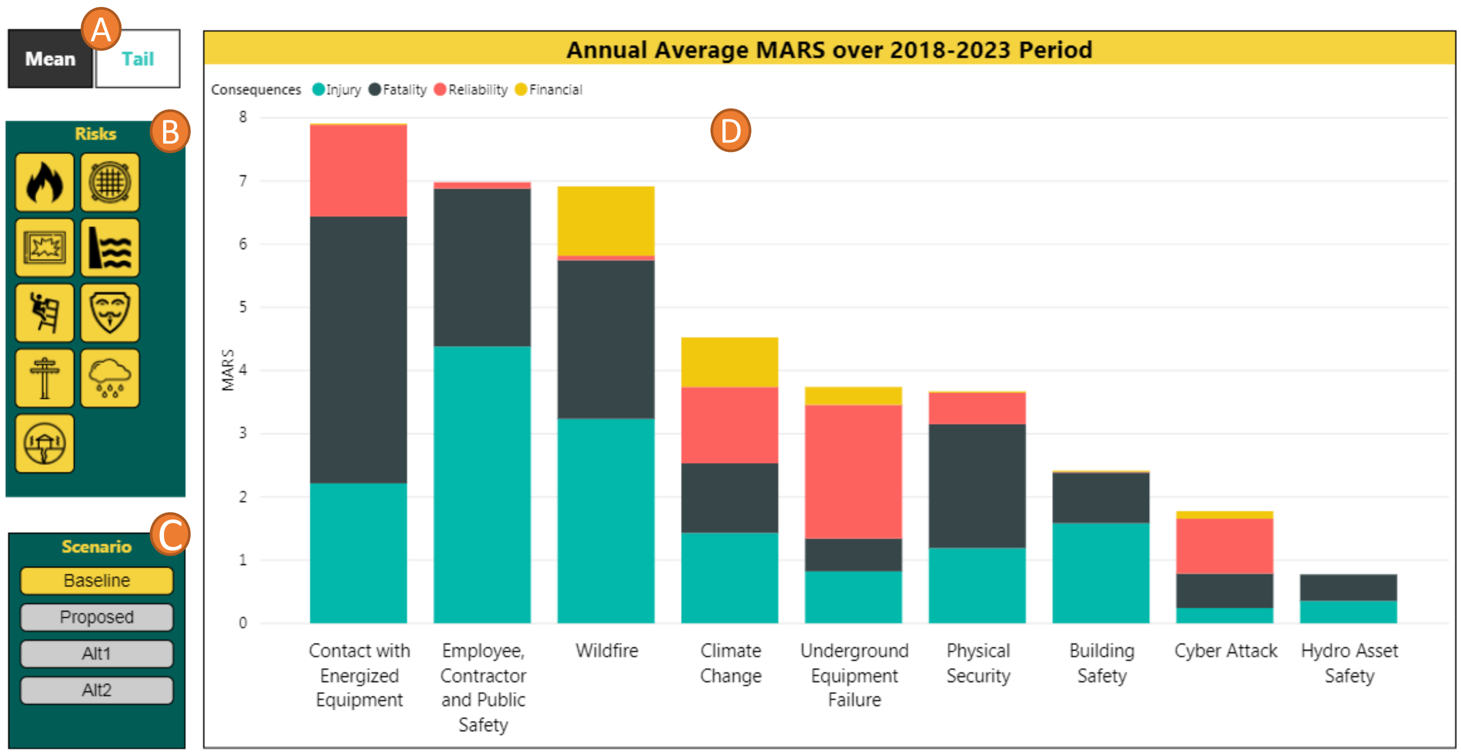
Risk	Total MARS
CEE	7.9
WSA	7.0
WDF	6.9
CMC	4.5
UEF	3.7
PHS	3.7
BUS	2.4
CYB	1.8
HYD	0.8

Description: This report illustrates the 6-year average MARS by risk and scenario

Key Features:

- ***Toggle*** by Mean or Tail Average
- ***Filter*** by Risk and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- Shows stack bar chart of MARS score

MARS Results by Risk and Consequence



E

Risk	Total MARS
CEE	7.9
WSA	7.0
WDF	6.9
CMC	4.5
UEF	3.7
PHS	3.7
BUS	2.4
CYB	1.8
HYD	0.8

Filter Panel

A Mean / Tail Average Toggle - Select ***one.***
Mean is currently selected in this snapshot

B Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

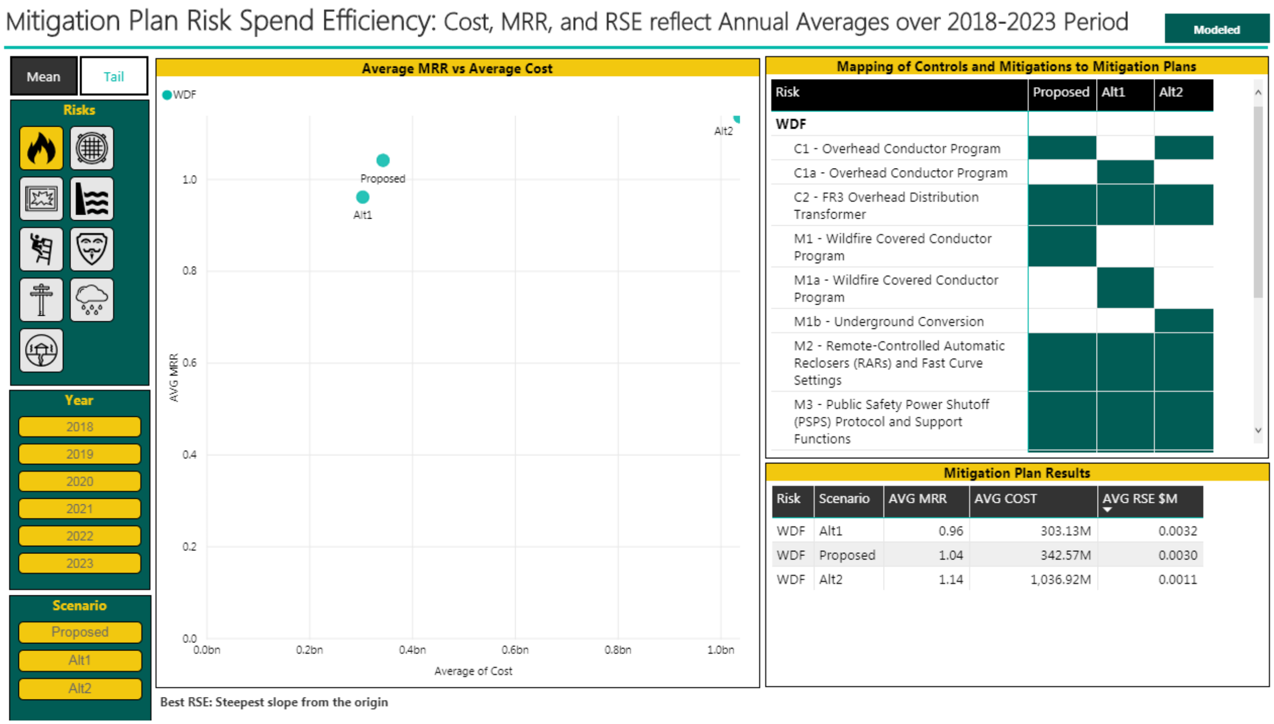
C Scenario Filter – Select ***one.***
[Baseline, Proposed, Alternative-1, Alternative-2]

D Stacked bar chart of consequences in MARS

E Total MARS by risk

Energy for What's Ahead℠ | 21

Report 9: Portfolio Risk Spend Efficiency



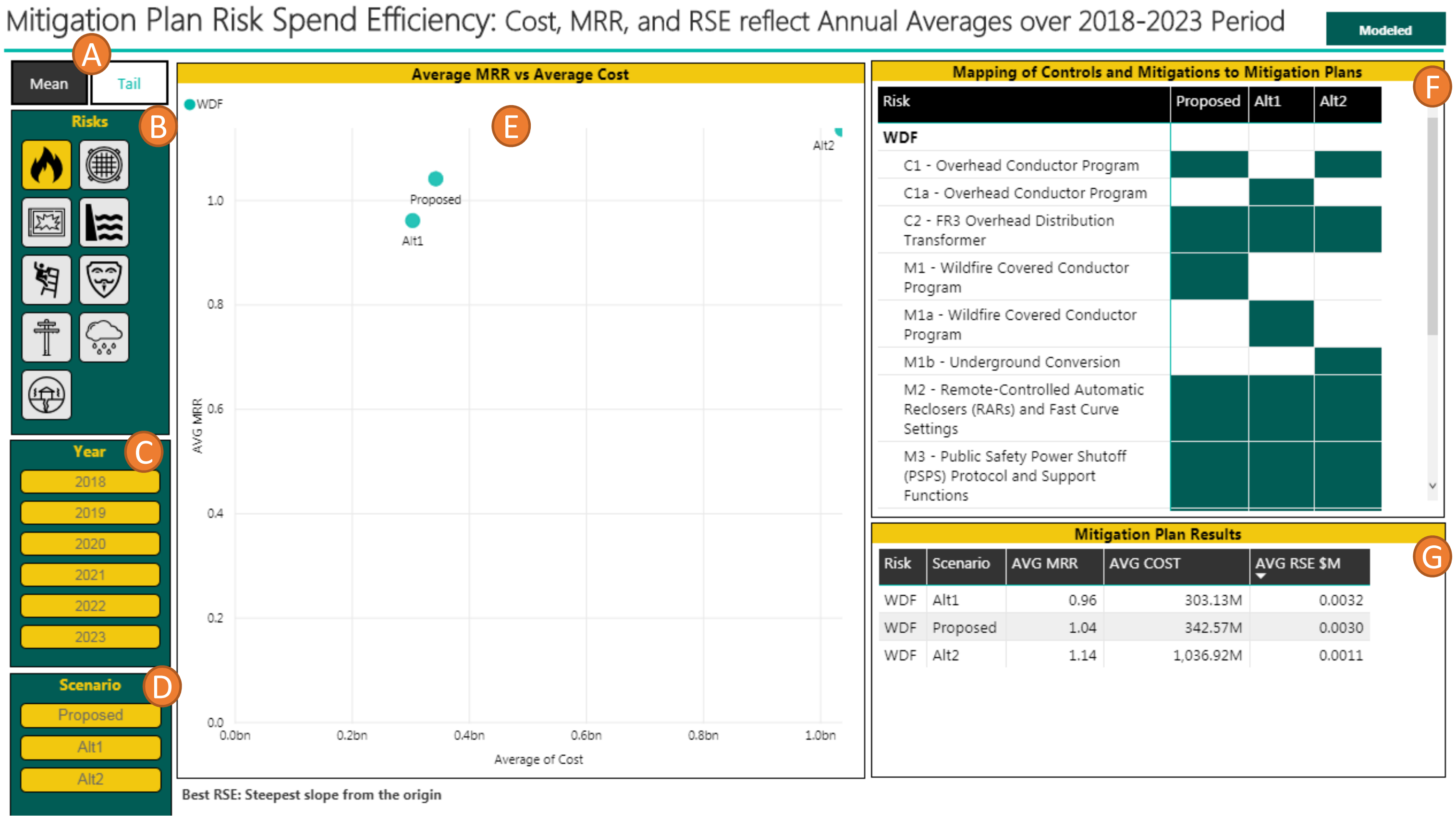
Description: This report illustrates the Risk Spend Efficiency by for each Scenario

Key Features:

- ***Toggle*** by Mean or Tail Average
- ***Filter*** by Risk, Year, and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- Shows which mitigations are mapped to which mitigation portfolio (Baseline, Alternative 1, Alternative 2)
- RSE components and score is plotted and shown in a table

Energy for What's Ahead℠ 22

Mitigation Plan Risk Spend Efficiency: Cost, MRR, and RSE reflect Annual Averages over 2018-2023 Period



Risk	Scenario	AVG MRR	AVG COST	AVG RSE $M
WDF	Alt1	0.96	303.13M	0.0032
WDF	Proposed	1.04	342.57M	0.0030
WDF	Alt2	1.14	1,036.92M	0.0011

Filter Panel

A Mean / Tail Average Toggle - Select ***one*** (Mean is currently selected in this snapshot)

B Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

C Year Filter – Select ***any (one to all)*** of the years

D Mitigation Scenario Filter – Select ***any*** (***one to all)*** [Proposed, Alternative-1, Alternative-2]

E
1) Legend: Each Risk has a different colored circle/dot (Top Left)
2) Y-Axis: Average MRR (average based on selected years)
3) X-Axis: Average Cost (average based on selected years)

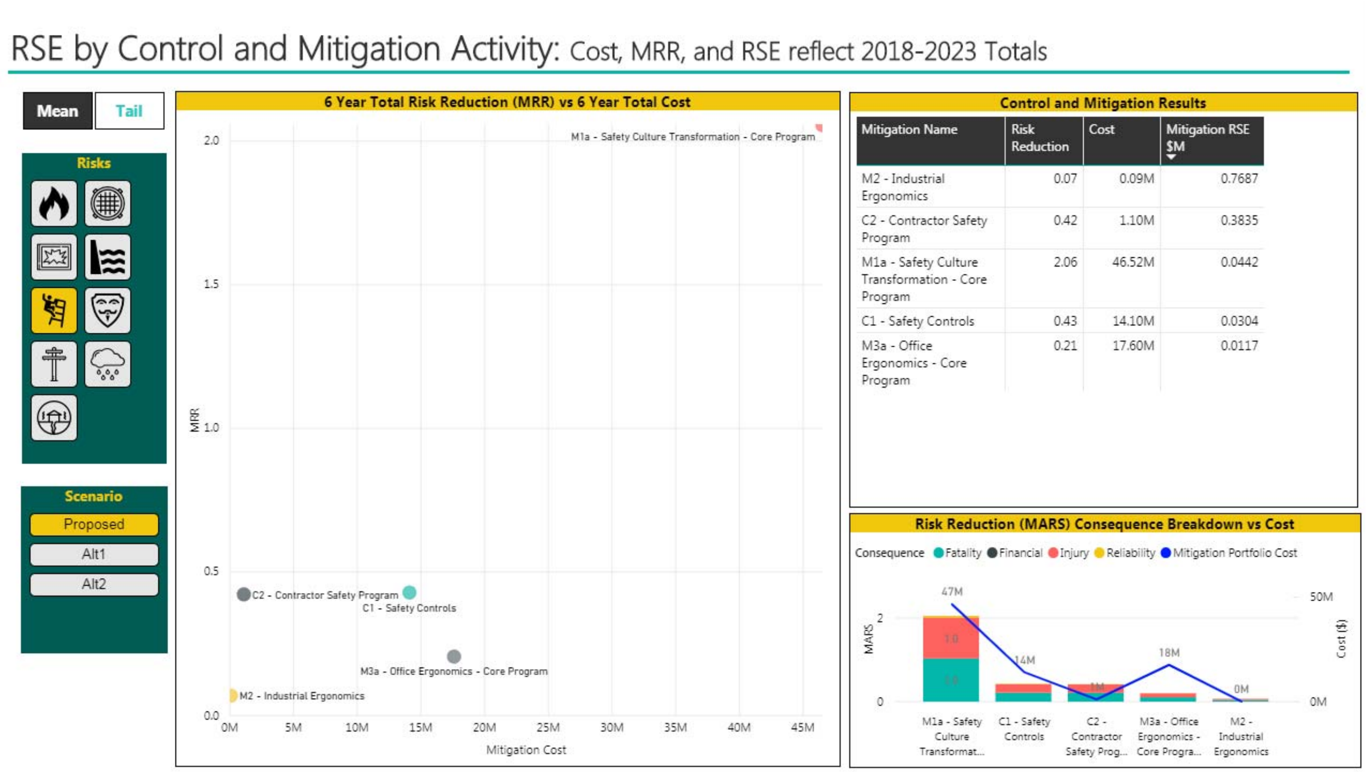
The slope of each dot represents the RSE

F Mitigations mapped to each of the scenarios

G Table containing:
Risk, Scenario, and:
6-year Avg MRR (Risk Reduction)
6-year Avg Cost
Avg RSE (MRR / Cost)

Energy for What's Ahead℠ 23

Report 10: RSE by Mitigation Activity

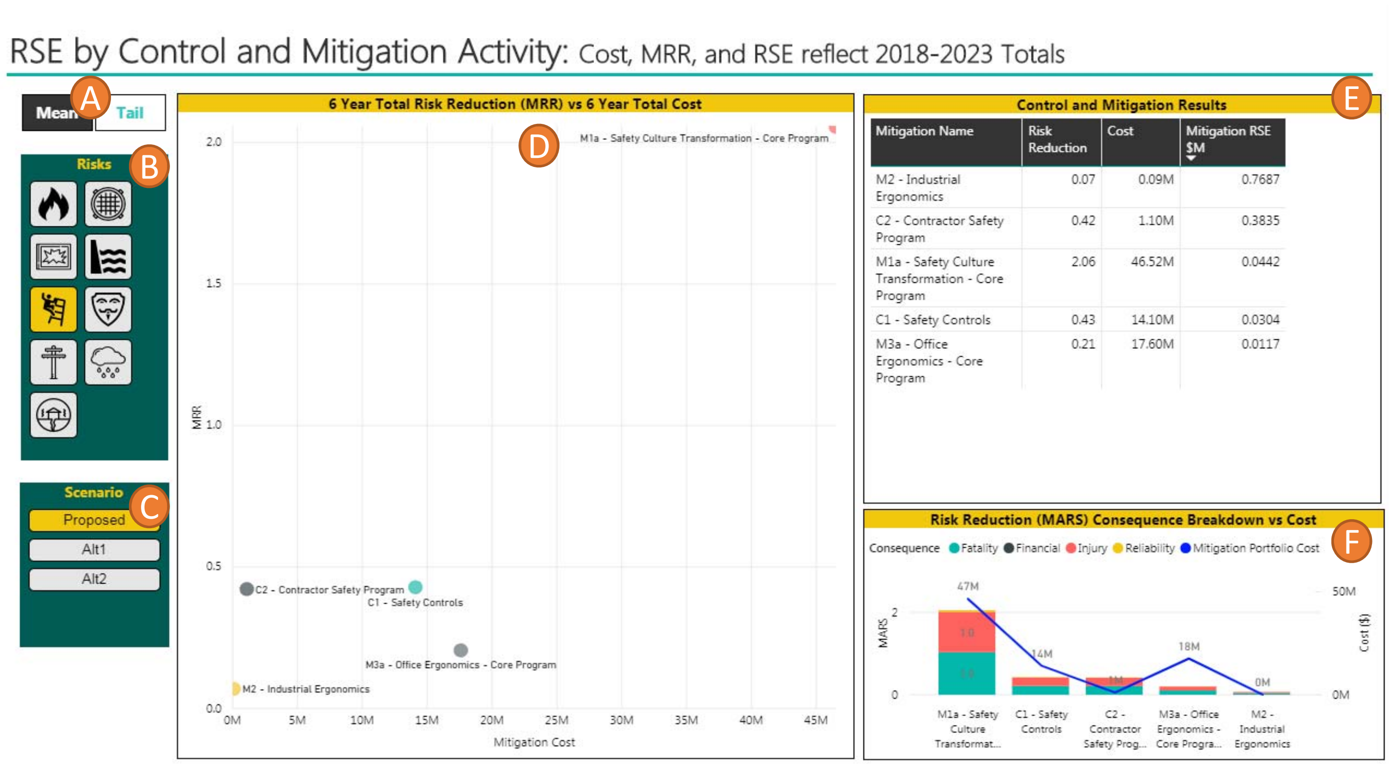


Mitigation Name	Risk Reduction	Cost	Mitigation RSE $M
M2 - Industrial Ergonomics	0.07	0.09M	0.7687
C2 - Contractor Safety Program	0.42	1.10M	0.3835
M1a - Safety Culture Transformation - Core Program	2.06	46.52M	0.0442
C1 - Safety Controls	0.43	14.10M	0.0304
M3a - Office Ergonomics - Core Program	0.21	17.60M	0.0117

Description: This report illustrates the Risk Spend Efficiency for individual mitigations

Key Features:

- ***Toggle*** by Mean or Tail Average
- ***Filter*** by Risk, and Scenario (Baseline, Proposed, Alternative 1, Alternative 2)
- RSE components and score, by individual mitigation, is plotted and shown in a table



Description: This dashboard displays the **RSE** by Mitigation activity (associated with each Risk scenario)

(A) Mean / Tail Average Toggle - Select ***one***
(Mean is currently selected in this snapshot)

(B) Risk Filter – Filter risks by selecting ***one*** of the icons

(C) Scenario Filter – Select ***one***
[Proposed, Alternative-1, Alternative-2]

Filter Panel

(D) 1) Legend: Each mitigation has a different colored dot
2) Y-Axis: 6 year Total MRR (Risk Reduction)
3) X-Axis: 6 year Total Cost
Slope of each dot represents that mitigation's RSE

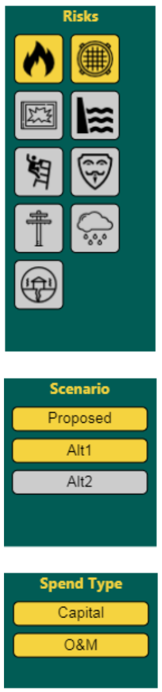
(E) Tabular representation of **(D)**. Click on a column header to sort by that criteria

(F) 1) Left Y-Axis : Risk reduction by mitigation (stacked by consequences)
2) Right Y-Axis: Costs
Mitigation Activity breakdown of Risk reduction by Consequences (6-year Total)

Energy for What's Ahead℠ | 25

Report 11: Mitigation Cost Detail

Mitigation Cost Detail



Risk	ScenarioSort	Spend Type	Mitigation Name	2018	2019	2020	2021	2022	2023	Total
UEF	Proposed	Capital	C1 - Cable Replacement Program (WCR)	117.34M	103.68M	93.37M	93.37M	93.37M	99.70M	600.83M
			C2 - Cable Replacement Program (CIC)	62.22M	64.58M	60.28M	60.28M	60.28M	60.28M	367.91M
			C3 - UG Oil Switch Replacement Program	12.82M	16.69M	17.39M	17.79M	22.02M	23.09M	109.79M
			M1 - Cover Pressure Relief and Restraint (CPRR) Program	0.00M	8.00M	15.00M	15.00M	15.00M	15.00M	68.00M
			Total	**192.38M**	**192.95M**	**186.04M**	**186.43M**	**190.66M**	**198.07M**	**1,146.53M**
		O&M	C1 - Cable Replacement Program (WCR)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C2 - Cable Replacement Program (CIC)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C3 - UG Oil Switch Replacement Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			M1 - Cover Pressure Relief and Restraint (CPRR) Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			Total	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**
		Total		**192.38M**	**192.95M**	**186.04M**	**186.43M**	**190.66M**	**198.07M**	**1,146.53M**
	Alt1	Capital	C1 - Cable Replacement Program (WCR)	117.34M	103.68M	93.37M	93.37M	93.37M	99.70M	600.83M
			C2 - Cable Replacement Program (CIC)	62.22M	64.58M	60.28M	60.28M	60.28M	60.28M	367.91M
			C3 - UG Oil Switch Replacement Program	12.82M	16.69M	17.39M	17.79M	22.02M	23.09M	109.79M
			Total	**192.38M**	**184.95M**	**171.04M**	**171.43M**	**175.66M**	**183.07M**	**1,078.53M**
		O&M	C1 - Cable Replacement Program (WCR)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C2 - Cable Replacement Program (CIC)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C3 - UG Oil Switch Replacement Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			Total	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**
		Total		**192.38M**	**184.95M**	**171.04M**	**171.43M**	**175.66M**	**183.07M**	**1,078.53M**
	Total			**384.76M**	**377.90M**	**357.07M**	**357.87M**	**366.32M**	**381.14M**	**2,225.07M**
WDF	Proposed	Capital	C1 - Overhead Conductor Program	21.45M	30.93M	18.42M	5.14M	13.54M	12.86M	102.35M
			C2 - FR3 Overhead Distribution Transformer	12.45M	12.88M	13.29M	13.72M	14.12M	14.52M	80.98M
			M1 - Wildfire Covered Conductor Program	32.11M	42.41M	194.59M	236.54M	296.12M	359.15M	1,160.92M
			M2 - Remote-Controlled Automatic Reclosers (RARs) and Fast Curve Settings	0.00M	9.09M	19.29M	0.00M	0.00M	0.00M	28.38M

Description: This report provides the estimated costs for each control/mitigation, split by O&M and Capital.

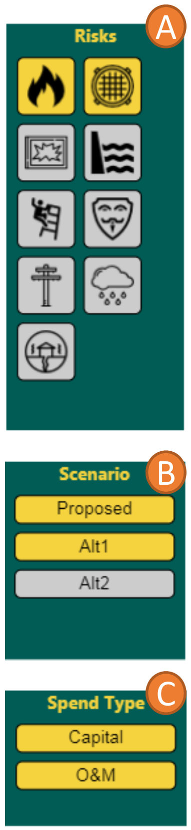
Key Features:

- ***Filter*** by Risk, Year and Scenario (Proposed, Alternative 1, Alternative 2)
- Mitigation cost by year and by risk
- Mitigation cost split into Capital vs O&M

Note: The same mitigation can span multiple risks.
Please refer to Ch. 1 - RAMP Overview for further details

Energy for What's Ahead℠ | 26

Mitigation Cost Detail



D

Risk	ScenarioSort	Spend Type	Mitigation Name	2018	2019	2020	2021	2022	2023	Total
UEF	Proposed	Capital	C1 - Cable Replacement Program (WCR)	117.34M	103.68M	93.37M	93.37M	93.37M	99.70M	600.83M
			C2 - Cable Replacement Program (CIC)	62.22M	64.58M	60.28M	60.28M	60.28M	60.28M	367.91M
			C3 - UG Oil Switch Replacement Program	12.82M	16.69M	17.39M	17.79M	22.02M	23.09M	109.79M
			M1 - Cover Pressure Relief and Restraint (CPRR) Program	0.00M	8.00M	15.00M	15.00M	15.00M	15.00M	68.00M
			Total	**192.38M**	**192.95M**	**186.04M**	**186.43M**	**190.66M**	**198.07M**	**1,146.53M**
		O&M	C1 - Cable Replacement Program (WCR)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C2 - Cable Replacement Program (CIC)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C3 - UG Oil Switch Replacement Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			M1 - Cover Pressure Relief and Restraint (CPRR) Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			Total	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**
		Total		**192.38M**	**192.95M**	**186.04M**	**186.43M**	**190.66M**	**198.07M**	**1,146.53M**
	Alt1	Capital	C1 - Cable Replacement Program (WCR)	117.34M	103.68M	93.37M	93.37M	93.37M	99.70M	600.83M
			C2 - Cable Replacement Program (CIC)	62.22M	64.58M	60.28M	60.28M	60.28M	60.28M	367.91M
			C3 - UG Oil Switch Replacement Program	12.82M	16.69M	17.39M	17.79M	22.02M	23.09M	109.79M
			Total	**192.38M**	**184.95M**	**171.04M**	**171.43M**	**175.66M**	**183.07M**	**1,078.53M**
		O&M	C1 - Cable Replacement Program (WCR)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C2 - Cable Replacement Program (CIC)	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			C3 - UG Oil Switch Replacement Program	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M	0.00M
			Total	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**	**0.00M**
		Total		**192.38M**	**184.95M**	**171.04M**	**171.43M**	**175.66M**	**183.07M**	**1,078.53M**
	Total			**384.76M**	**377.90M**	**357.07M**	**357.87M**	**366.32M**	**381.14M**	**2,225.07M**
WDF	Proposed	Capital	C1 - Overhead Conductor Program	21.45M	30.93M	18.42M	5.14M	13.54M	12.86M	102.35M
			C2 - FR3 Overhead Distribution Transformer	12.45M	12.88M	13.29M	13.72M	14.12M	14.52M	80.98M
			M1 - Wildfire Covered Conductor Program	32.11M	42.41M	194.59M	236.54M	296.12M	359.15M	1,160.92M
			M2 - Remote-Controlled Automatic Reclosers (RARs) and Fast Curve Settings	0.00M	9.09M	19.29M	0.00M	0.00M	0.00M	28.38M

A Risk Filter – Filter risks by selecting ***any (one to all)*** of the icons

B Scenario Filter – Select ***any (one to all)*** [Proposed, Alternative-1, Alternative-2]

C Cost Type – Capital vs O&M, select one or both

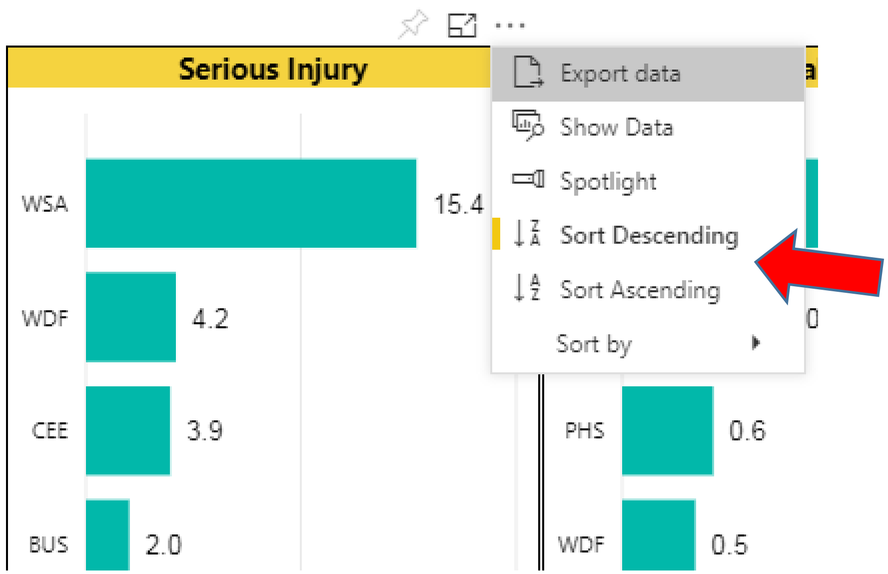
Filter Panel

D Cost by Year – Total costs by mitigation, for Capital or O&M. Totals provided by total Capital, O&M, and Scenario (Portfolio)

Energy for What's Ahead℠ 27

Additional Power BI Capabilities and Options

Sorting a chart



Click on the "…" on the upper right of the chart and a selection box will show.

Can choose ascending or descending sort or other criteria (sort by…)

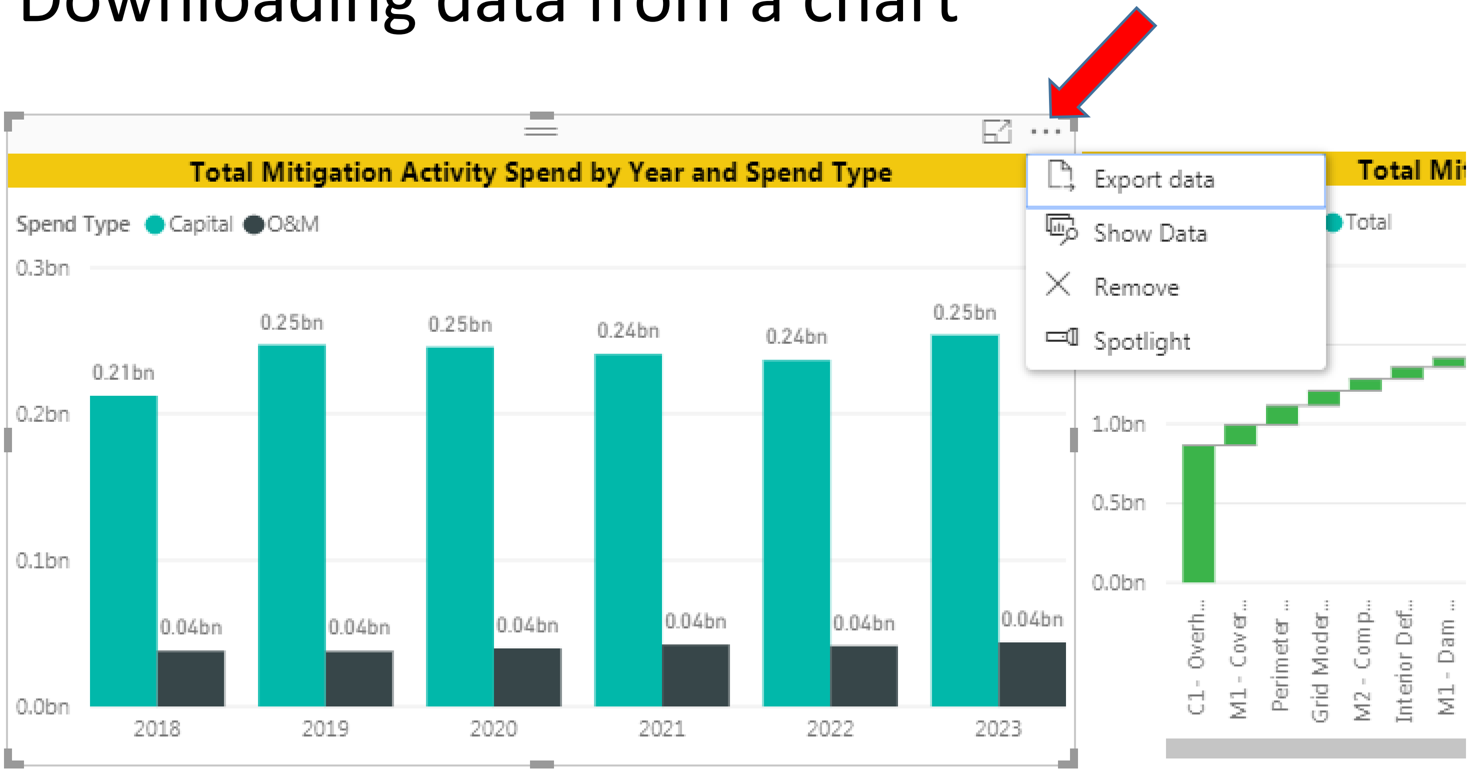
Sorting a table

Mitigation RSE

Mitigation Name	Risk Reduction	Cost	Mitig SE $M
M2 - Industrial Ergonomics	0.07	0.09M	0.7687
C2 - Contractor Safety Program	0.42	1.10M	0.3835
M1a - Safety Culture Transformation - Core Program	2.06	46.52M	0.0442
C1 - Safety Controls	0.43	14.10M	0.0304
M3a - Office Ergonomics - Core Program	0.21	17.60M	0.0117

Click on the column header to sort by that column

Downloading data from a chart

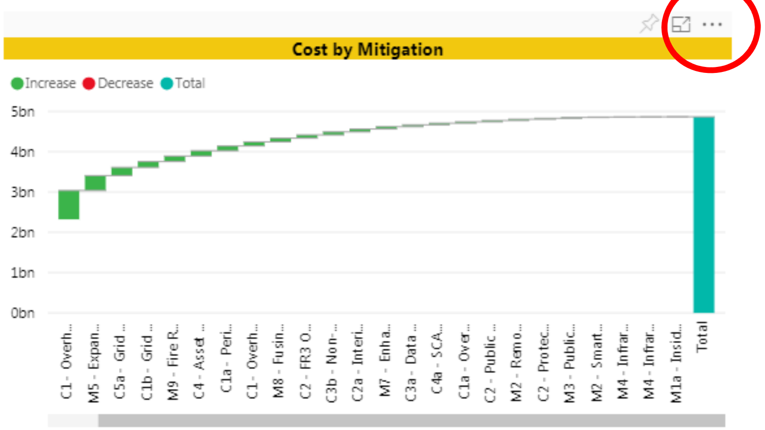


Click on the "…" on the upper right of any of the charts and a selection box will pop up.

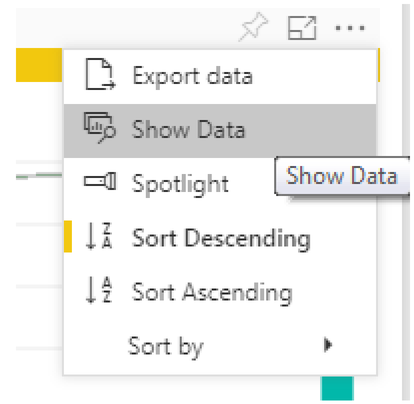
Select "Export data" and the data will be saved as a CSV file.

Zoom in on a chart and show data

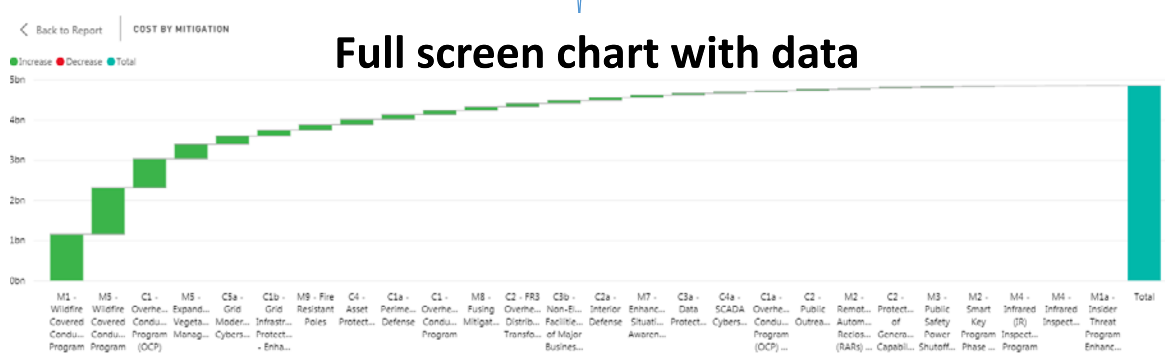
Current chart



Click on "…" and choose "Show Data"



Full screen chart with data



Mitigation Name Unsort	Value
M1 - Wildfire Covered Conductor Program	1,160,916,712.63
M5 - Wildfire Covered Conductor Program	1,160,916,712.63
C1 - Overhead Conductor Program (OCP)	715,132,259.30
M5 - Expanded Vegetation Management	370,194,856.20
C5a - Grid Modernization Cybersecurity	202,995,551.87
C1b - Grid Infrastructure Protection - Enhanced	145,447,851.71
M9 - Fire Resistant Poles	137,046,107.32
C4 - Asset Protection	133,125,577.56
C1a - Perimeter Defense	115,711,049.41
C1 - Overhead Conductor Program	102,345,778.72
M8 - Fusing Mitigation	91,814,569.99
C2 - FR3 Overhead Distribution Transformer	80,976,665.87
C3b - Non-Electric Facilities/Protection of Major Business Functions - Enhanced	74,959,034.99
C2a - Interior Defense	71,555,523.18
M7 - Enhanced Situational Awareness	56,800,418.75
C3a - Data Protection	47,418,095.14
C4a - SCADA Cybersecurity	39,682,231.36
C1a - Overhead Conductor Program (OCP) Utilizing Targeted Covered Conductor	34,380,060.11

…or What's Ahead℠ | 32

Occupational Safety & Health Committee

Serious Injury & Fatality Criteria (SIF)

Revision Date: January, 2017

What is a SIF?

SIF was developed to be a metric that better facilitates the prevention of fatalities and serious injuries that are life threatening or life changing for the employee. The metric should reflect the extent of serious injury to employee(s) from events within the control of the employee and/or the employer.

Criteria

SIF's are work related and serious injuries that occur within the control of the employee and/or employer as defined below.

Defining Work Related

As the General Rule, work related injuries may result from:

- Activities included within the scope of employment **or**
- Activities related to a condition of employment.

If we pass the General Rule criteria, ask:

- Is this injury OSHA Recordable?
- Was the injured worker being paid for work or performing work on behalf of the employer at the time of the event or exposure?
- Was the injured worker's presence at the place of the injury exposure related to a condition of employment?
- Was the cause of the incident within the control of the employee and/or the employer?

If the answer to all of these questions is "Yes," consider the injury to be work-related.

EEI Edison Electric INSTITUTE

Occupational Safety & Health Committee

Frequently Asked Questions

i. If an employee is injured while walking, should these be considered work-related?

The case should be evaluated to consider whether circumstances within the control of the employee or the employer caused or contributed to the injury. It is the intent to count cases where the employee trips, slips, stumbles, falls, or is injured by a hazard in the workplace. It is not the intent to count cases that are outside of the control of the employer, such as a heel break.

ii. Are dog bites in the control of the employer or employee?

Dog bite cases should be evaluated to consider whether the employee was a victim of an unanticipated attack or whether the employee failed to take appropriate actions to prevent the injury. If the employee was clearly a victim, it should not be considered work-related.

Examples of Work Related Events

- Injuries that occur while the employee is performing a work task (e.g., production employee engaged in construction work and operations)
- Injuries that occur while the employee is engaged in normal activities that happen at work between specific work tasks (talking to supervisor, selecting tools, etc.)
- Injuries that occur while injured worker is engaged in work-related travel as defined by current OSHA Recordkeeping Standards
- Injuries resulting from employee slips or trips from a hazard within the work place including employer parking lots and decks
- Injuries that occur during charitable events endorsed by the employer

Examples of Non-Work Related Events

- Injuries that occur on company property or while the worker is engaged in a work activity but *would have occurred at the same time and at the same level of severity even if the employee was not engaged in a work activity* (epileptic seizure, diabetic seizure, heart attacks, sudden joint failure, etc.)
- Injuries that are related to commuting to or from a place of employment outside of work hours
- Injuries that result *solely* from normal body movements unrelated to work (sneezing, coughing, bending over to tie a shoe, walking, etc.)

Occupational Safety & Health Committee

- Injuries that result *solely* from personal tasks performed outside of assigned work hours (retrieving ice for personal use, holding community meeting at employer premises, etc.)
- Injuries that occur in a travel hotel unrelated to work
- Injuries that occur where the employee is present at the site as a member of the general public, unrelated to his or her employment status
- Injuries that result from voluntary participation in wellness, medical, or fitness programs, or recreational activity (team building events)
- Injuries where symptoms surface at work from a known non-work-related event or exposure (yard work, sporting events, etc.)
- Injuries that result from eating/drinking or preparing food/drink for personal consumption (food/drink not provided by employer)
- Injuries that result from personal grooming, self-medication for a non-work-related condition, or intentionally self-inflicted injuries
- Injuries that result from non-preventable vehicle accidents

Identifying and Classifying Serious Injuries

When the work-related criteria have been met, compare the employee injury to the Serious Injury criteria listed below to determine if the injury is deemed "Serious." (Each case should be counted only once. In cases with multiple injuries, assign the case to the category representing the most severe injury.)

1. Fatalities

2. Amputations (involving bone)

3. Concussions and/or cerebral hemorrhages

Occupational Safety & Health Committee

4. Injury or trauma to internal organs

   Frequently Asked Question

   i. When should a case of organ damage be classified as serious, such as an exposure to chemical substance?

      Injuries should be classified as serious if objective medical evidence indicates significant or sustained (beyond initial event, acute treatment and testing) organ damage, or progressive changes in organ function or anatomy. This criterion does not include rapidly dissipating signs and symptoms from the acute event (such as irritation or localized redness) and their associated treatment, or injury from long term or repetitive exposures.

      Only cases that involve relatively short term events should be included in the serious metric, even if the result is an illness (example, reactive upper-dysfunction syndrome resulting from chlorine exposure event). Illnesses that develop from exposure over long periods of time (years) are not to be captured in this metric (example, fibrosis of the lung from asbestos exposure).

   ii. Is a hernia considered a severe case?

      A hernia by itself would not be classified as a severe case. However, if the hernia causes damage to an internal organ such as a strangulated colon, it would be classified as a severe case.

5. Bone fractures with the following considerations:
   a. Include fractures of the fingers and toes only if they are open, compound, or comminuted (crushing)
   b. Include all bone fractures of the face, skull, or navicular wrist bone
   c. Exclude any hairline fractures unless described above

   Frequently Asked Questions

   i. Are all hairline fractures excluded?

      Hairline fractures in the face, skull, or navicular wrist bone are considered a serious injury. All other hairline fractures are excluded.

   ii. Are nasal fractures included as a serious injury in bone fracture criteria?

      Typical nasal cartilage-only fractures are not likely to cause life altering or life threatening injuries, unless other facial bone fractures are involved. If the employee has a "broken nose" that involves facial bone fractures, the injury should be included as a serious injury. Nasal cartridge-only fractures should not be included as a serious injury.

Occupational Safety & Health Committee

iii. Are broken teeth considered a severe case?

No, unless there were other injuries in addition that meet the criteria (Example: Broken Jaw)

6. Complete tendon, ligament and cartilage tears of the major joints (e.g., shoulder, elbow, wrist, hip, knee, and ankle).

Frequently Asked Questions

i. Are partial tendon, ligament and cartilage tears included?

No. Partial tears are not to be classified as a serious injury.

7. Herniated disks (neck or back)

8. Lacerations resulting in severed tendons and/or a deep wound requiring internal stitches

Frequently Asked Question

i. Does a puncture that requires internal sutures meet the laceration criteria?

Yes

9. 2nd (10% body surface) or 3rd degree burns

10. Eye injuries resulting in eye damage or loss of vision

Frequently Asked Questions

i. Does a corneal abrasion constitute eye damage injury?

No. Corneal abrasions and/or scratches due to foreign bodies are considered minor and usually heal quickly.

ii. What are some examples of "eye damage" that meet the criteria?

Examples of eye damage would be cases where the eyeball is penetrated or damaged by a significant foreign body.

Occupational Safety & Health Committee

iii. Does loss of vision mean total loss or is some degradation of vision all that is required to meet the serious injury criteria?

Loss of vision means any permanent change in the employee's vision or change that requires corrective lenses.

11. Injections of foreign materials (e.g. hydraulic fluid)

12. Severe heat exhaustion and all heat stroke cases (Severe heat exhaustion cases are those where all of the following symptoms are present: profuse sweating, nausea, and confusion). If confirmed fainting occurs due to the heat exposure, this is an automatic severe case.

   a. Exclude cases where confirmed personal medical conditions or medications significantly contributed to heat exhaustion

Frequently Asked Question

i. If an employee receives an IV for heat exhaustion, does this make it a severe case?

The application of an IV does not necessarily indicate a severe case; further investigation should be conducted to determine if the criteria for severe heat exhaustion were met (profuse sweating, nausea, and confusion or confirmed fainting).

13. Dislocation of a major joint (hip, shoulder, elbow, etc.)

14. The Other Injuries" category should only be selected for reporting injuries not identified in the existing categories. A Description box is also provided to briefly describe the nature of the injury.

Other Terms and Definitions

1. Serious Injury Incidence Rate (SIIR)

The Serious Injury Incidence Rate (SIIR) is calculated using the formula (# cases x 200,000/hours worked). The calculation of the SIIR uses the same hours worked number as your calculation of the Recordable Incidence Rate.

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 2
Risk Model Overview

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 2
Risk Model Overview

Index of Workpapers

I. Workpaper: Chapter 2 – Risk Model Lessons Learned – Additional Detail

A. Interdependence Assumptions in Mitigation Effectiveness Modeling

SCE gained greater insight into the increased challenges of modeling mitigation effectiveness for a comprehensive mitigation portfolio versus for individual mitigations.

For example, in the Contact with Energized Equipment chapter, both the Proposed Plan and Alternative Plan #2 include the C1 (Overhead Conductor Program (OCP)). However, Alternative Plan #2 also includes M2 (Comprehensive Branch Line Fusing), while the Proposed Plan does not. If these mitigations are truly independent, the modeling of C1 effectiveness can be identical in both plans. However, if they are not completely independent, then there needs to be two representations of C1 (OCP): one with M2 and one without M2.

In general, overlapping interactions among non-independent mitigations is difficult to model for a number of reasons. For example, there are typically more mitigation options than there are mitigation plans. Therefore, the interactions of mitigations within a plan are typically not limited to any two individual mitigations but can involve, potentially, all mitigations under consideration.

The interactions between non-independent mitigations also depend not only on the mitigations themselves but also on their respective rates of deployment. The very question of asking how much more (or less) effective one mitigation becomes in the presence of another is an overly simplified question; that effectiveness relationship may likely change depending on not only the presence of each mitigation but the deployment rates for each mitigation as well.

Mitigation effectiveness modeling also considers "targeting benefits" for those mitigations where scoping tenets target specific assets rather than assets at random. For example, SCE would not apply covered conductor as part of C1a (OCP Utilizing Covered Conductor) through random identification of in-scope OCP spans. SCE would instead apply covered conductor to those in-scope OCP spans that would yield the greatest benefit specific to covered conductor, namely spans with the greatest frequency of faults associated with contact from foreign objects such as animals, metallic balloons, and vegetation. Again, there will likely be overlap within a high-risk asset base when multiple mitigations in a mitigation plan are considered. Therefore the modeled "targeting benefit" for each mitigation is also subject to the same challenge associated with mitigation independence assumptions.

For purposes of this analysis, SCE assumed all mitigations are strictly independent of all other mitigations. This was the most straightforward way SCE found to model individual mitigation effectiveness factors for purposes of the initial RAMP report. As SCE's risk modeling capabilities grow, we look forward to implementing techniques to model mitigation effectiveness interactions among multiple mitigations in a collective plan.

B. Degrees of Confidence in Mitigation Effectiveness Modeling

There can be a range of degrees of confidence in the modeling of mitigation effectiveness. The methodology used in this RAMP report does simulate some risk uncertainty through probabilistic analysis of consequence distributions; however, it does not at currently describe underlying mitigation effectiveness modeling uncertainty.

Consider, for example, the difference between two controls in Chapter 5 (Contact with Energized Equipment): C1 (OCP) and C2 (Public Outreach). In comparing the analysis results, OCP was found to have an RSE approximately one-third of the RSE of Public Outreach. However, there is a wide difference in the degrees of confidence of the underlying assumptions of these two mitigations.

For example, the modeling of OCP was informed by a large amount of asset data and refinement of previous detailed risk analyses. In contrast, the modeling of Public Outreach mitigation effectiveness was based on very little data and was largely informed by educated estimates. In other words, SCE is convinced of the direction of risk reduction benefit for Public Outreach, but is less certain of the exact magnitude of the benefit. A direct comparison of the RSEs of these two controls, without visibility of the underlying degrees of confidence, can lead to incorrect interpretations of the results.

SCE will evaluate ways to evaluate and convey these underlying uncertainties in future RAMP risk analyses. This may add meaningful context when interpreting risk model outputs.

C. Benefits of Mitigations that Span Multiple Risk Statements

SCE developed the risk statements in this RAMP report in a manner that preserved their “independence.” For example, Chapter 10 (Wildfire) analyzes risks associated with wildfire ignition, but does not analyze risks associated with contact with energized conductor. Likewise, Chapter 5 (Contact with Energized Equipment) analyzes risks associated with human contact with energized conductor, but does not analyze risks associated with wildfire ignition. Ultimately, however, some of the mitigations applied for the former risk statement have benefits for the latter. For example, application of covered conductor in the high fire risk area will not only have benefits for reducing drivers of wildfire, but also in reducing consequences associated with human contact with energized equipment.

While evaluating the benefits of each mitigation only with respect to the specific chapter it is in avoids double-counting of benefits, it can present a challenge for how to treat the costs of each mitigation. For mitigations that span multiple chapters, SCE includes the full costs in RSE calculations in both chapters. At this point, SCE does not have a clear methodology for accurately dividing the cost of programs that are expected to provide benefits across multiple independent risk statements. In essence, RSE calculations for covered conductor assumed only *some of the expected benefits* (i.e., benefits specific to each chapter) but *all of the expected costs* (i.e., the full program cost in both chapters). The net effect of this is that calculated RSEs for mitigations like covered conductor – i.e., mitigations that provide benefits that span independent risk statements – were understated in each of these two chapters.

This Page Intentionally Left Blank

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 3
Safety Culture, Performance, and Compensation Policies tied to Safety

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter #3
Safety Culture & Compensation Policies tied to Safety

Index of Workpapers

Safety Culture Transformation Roadmap

September 28, 2017

Energy for What's Ahead℠

SOUTHERN CALIFORNIA EDISON®

Topics:

1. Program Update
2. Workstream Overviews
3. 90 Day Plan and Risks / Issues

Energy for What's Ahead℠

SOUTHERN CALIFORNIA EDISON®

2

Desired Outcomes

ESC ***input*** and ***guidance*** required on key decisions to drive the Safety Culture change.

The goal should **be** to have **directional alignment** with **agile execution** to course correct.

1. **REVIEW** workstream recommendations to drive desired shift from "Public Compliance" to "Private Compliance"

2. **COMMIT** to supporting directly the Safety Culture Transformation program:
   - Role for executives
   - Workstream ownership

3. **APPROVE** 90 Day Plan

We are seeking executive agreement and sponsorship of the new Safety Culture Transformation Program

SOUTHERN CALIFORNIA EDISON® | 3

Executive Summary

The Safety Culture Transformation incorporates a comprehensive 18-month enterprise strategy.

Plateaued Safety Performance. Increasing serious injury & fatalities

Series of targeted & aligned work streams to mature culture and improve program effectiveness

- Safety Leadership
- Safety Culture
- Governance
- Communications
- Hazard Awareness
- Talent
- Programs & Systems
- Data Strategy
- Change Management

Future State

- **"I am responsible for my safety choices"**
- **Individual accountability in changing behaviors and personal choices**
- **Tight union collaboration to own safety**
- **Cross-functional strategic reinforcement of initiatives and desired outcomes**
- **Data driven root causes reviews driving a learning mindset**

Safety Culture Assessment → **System-wide Transformation** → **Continuous Improvement and Sustainable Change**

These transformational work streams are critical in driving the desired Safety Culture Change to Private Compliance.

SOUTHERN CALIFORNIA EDISON®

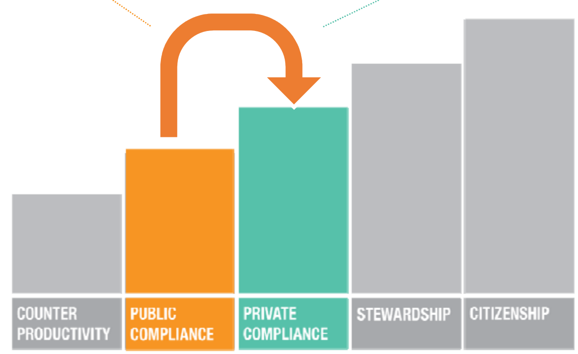
4

Culture Transformation Goal

In order to achieve higher levels of performance, the Safety Culture needs to shift from Public Compliance to Private Compliance on the way to Stewardship and Citizenship.

Current State: Public Compliance

- Imposed
- Compliance Focused
- Meet the minimum standard
- Low involvement
- Peer Pressure
- Managed hazards
- Reactive to injuries
- Safety programs, initiatives and campaigns
- Lagging indicators
- Cost Conflicts with Safety



Future State: Private Compliance

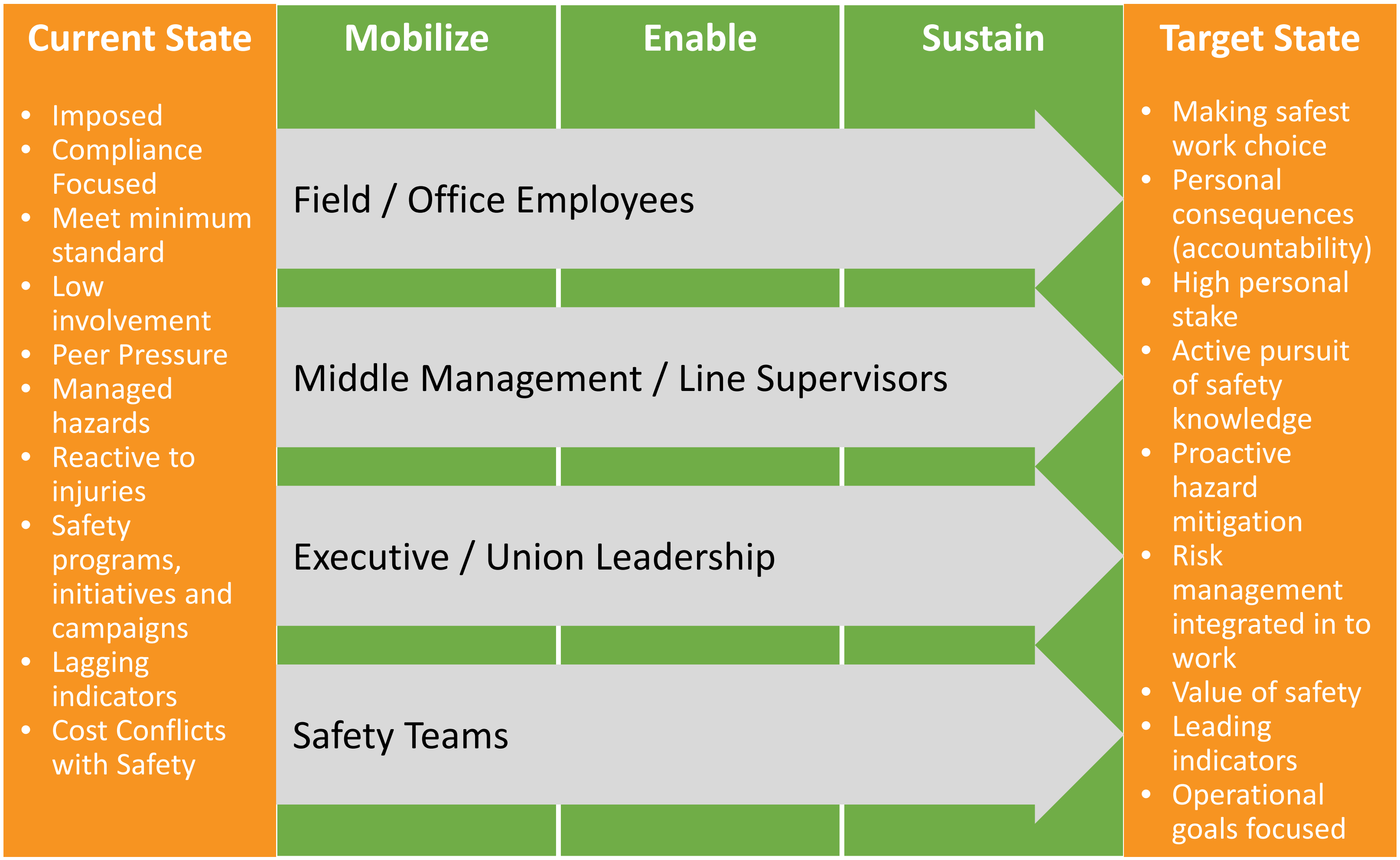
- Making safest work choice
- Personal consequences (accountability)
- High personal stake
- Active pursuit of safety knowledge
- Proactive hazard mitigation
- Risk management integrated in to work
- Value of safety
- Leading indicators
- Operational goals focused

Interventions need to be stage-matched to drive the right shifts in performance, factoring in the attitudes of employees, leadership attributes and safety programs.

SOUTHERN CALIFORNIA EDISON® 5

SCE Safety Culture Transformation Engagement

Framework organizes thinking and communications to help employees understand where we are in the journey and what to expect for their role.



SOUTHERN CALIFORNIA EDISON

SCE Safety Culture Transformation Engagement

Each step builds toward raising awareness, building safety competencies, and ensuring that gains are sustained.

SOUTHERN CALIFORNIA EDISON® | 7

SCE Safety Culture Transformation Engagement

Each person's role in the safety culture transformation has specific expectations.

Current State	Mobilize	Enable	Sustain	Target State
• Imposed • Compliance Focused • Meet minimum standard • Low involvement • Peer Pressure • Managed hazards • Reactive to injuries • Safety programs, initiatives and campaigns • Lagging indicators • Cost Conflicts with Safety	**Field / Office Employees** Aware of reason to change personal safety habits	Learn new safety behaviors	Personal action plans	• Making safest work choice • Personal consequences (accountability) • High personal stake • Active pursuit of safety knowledge • Proactive hazard mitigation • Risk management integrated in to work • Value of safety • Leading indicators • Operational goals focused
	Middle Management / Line Supervisors Aware of reason to change style of management	Reinforcing learned behaviors; new style of mgmt	On-going coaching; Data feedback	
	Executive / Union Leadership Shape case for change; provide resources	Communicate; collaborate to refine program	Hold everyone accountable	
	Safety Teams Secure approvals, resourcing for program	Provide training, communications; support teams	Data gathering, reporting; refinements	

SOUTHERN CALIFORNIA EDISON®

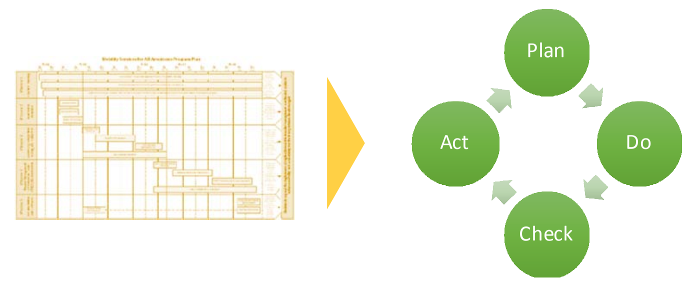
8

Two key differences in approach

To achieve the desired Culture Change, best practices demonstrate the importance of two key alternative leadership and governance approaches.

Incremental Improvements vs. Transformational Change

Waterfall vs. Agile Program Management



Ask: Embrace a different delivery approach new leadership expectations, namely that decisions are made on rolling 90-day plans.

SOUTHERN CALIFORNIA EDISON®

9

Evolving Safety Culture Emphasis

Safety Responsibilities[1]	Past two years	Path forward
Look Out for One Another	Ask employees to motivate others to be safe	Develop sense of personal importance and value of safety
Always Do the Right Thing	Reset expectations for Stop Work Responsibility	Provide tools to better identify risk situations in which to stop work
Be Visible	Told leaders to be visible	Set expectation for leaders time in field
Coach & Reinforce Safety	Set requirements for use of safety observation program	Focus on quality observations instead of numerical targets
Be a Safety Culture Leader	Safety first emphasis to raise awareness	Safety is integral to every decision, not considered in isolation
Master Safety	Focus on awareness of rules and procedures	Enhance job hazard analysis skills so employees can adapt as work situations change

Safety strategy is shifting focus from telling people what to do to helping them demonstrate the personal value of safety

[1] Safety Roles & Responsibilities rolled out to employees in recent "Safety Leader in Me" campaign

SOUTHERN CALIFORNIA EDISON | 10

How executive roles will change

Executives will play a pivotal role in transformation execution by increasing visibility and explaining the future state for safety.

Note: similar safety expectations will be created for each role

Safety is foundational to executive leadership. Leaders must commit to **invest time visibly** in safety. This may mean reducing other commitments.

Coaching	• One-on-one safety coaching conversations • Cognitive tools and techniques to influence mindset & shift behavior (ZIP) • Reward learning & sharing of information
Visibility	• Field presence - engaging employees at the worksite, straight talk, felt leadership & recognition • Leadership by example • Engaging team members in safety strategy & improvements • Foster collaboration, learning & embedding across teams • Remove silos & boundaries in team dialogues
Reinforcement	• Consistent, steady role as a change agent in transformation efforts • Constant reinforcement & repetition on safety priority • Incorporation of reinforcing stories and experiences

Ask: Provide executive support and change personal behaviors for safety

SOUTHERN CALIFORNIA EDISON® | 11

Topics:

1. Program Update

2. Workstream Overviews

3. 90 Day Plan and Risks / Issues

Energy for What's Ahead℠

SOUTHERN CALIFORNIA EDISON®

Strategy 1: Launch common understanding for safety culture change

1 Findings

- Decision making to improve safety performance sits firmly in the space of discrete activities perceived to have a "fix" in mind.
- The organization perceives itself to be reactionary to injuries, and implementing "quick fixes" not the system-level contributing and causal factors of potential and actual harm.

2 Causation

- Competing priorities distract focus from safety
- Solutions developed to address specific issues rather than systemic, cultural needs. Incremental projects often with siloed lens.
- Not everyone feels engaged and empowered to solve safety issues
- Safety is felt as driven as an externally motivated business priority not as a value

3 Approach

- Change management & communication strategies need to shift thinking that safe work is both a value and the goal
- Focus on behaving and responding differently to safety issues, especially when under pressure – does not preclude running current safety operations
- Detailed stakeholder analysis & engagement

Desired Outcome

- **Leadership practices and operational decisions** to realize safety culture and performance improvements.
- **Faster acceptance and adoption of change efforts**.

SOUTHERN CALIFORNIA EDISON®

Strategy 2: Improve safety leadership competencies

1 Findings

- The words and actions of leaders are a significant influencer of the safety choices and actions of their direct reports.
- Established safety leadership competencies should inform recruitment, selection, onboarding, development, performance management, rewards, and promotion for all leadership roles.

2 Causation

- Safety leadership and influencing skills are limited and do not drive the right attitude shifts for field employees
- Insufficient "felt leadership" in the field
- Perceived risks in making a mistake inhibit organizational learning
- Leaders are not trained to meet new behavioral expectations

3 Approach

- Redefine safety leadership competencies - knowledge, skills & attitudes.
- Create individualized development goals and provide 1:1 coaching.
- Engage leaders in cognitive behavior training.
- Establish expectations for leader engagement – time in field tools & support.

Desired Outcome

- **Increase in effective safety leadership**
- Shift **attitudes & beliefs** of employees towards safety through their direct leaders
- Demonstrate commitment to safety through **leader time invested in safety**.

Strategy 3: Increase hazard awareness & risk management skills

1 Findings

- Lack of knowledge and understanding of hazard awareness tools & value
- Protective actions shield the company from litigation, reduce the ability to understand contributing factors associated with fatalities and serious injuries.
- Regulatory and legal risk intolerance leads to a defensive narrative and consequently a public compliance posture.

2 Causation

- Complete root cause analysis inhibited by concern for mitigating business liability
- Employees lack sufficient hazard awareness and mitigation knowledge
- Organization lacks robust learning abilities and processes *(See opportunities | Solve them | Share & Embed learnings)*

3 Approach

- Cognitive behavior training to better identify task-based hazards & knowledge on methods to mitigate hazards
- Implement cause evaluations with systems thinking on contributing factors
- Introduce new processes and capabilities:
  - **Risk assessment** tools
  - **Critical risk** management
  - **Human performance** approach
  - **Time in field** standards
- Redesign pre-work briefing process and expectations

Desired Outcome

- Employees have working knowledge of ownership & accountability of how and why injuries occur; risk awareness, identification and mitigation
- Employees use risk-informed judgment to go beyond rules, standards and policies to protect their personal well-being

SOUTHERN CALIFORNIA EDISON® | 15

Strategy 4: Rethink safety communications

1 Findings

- Safety is perceived as "overkill", in part because of the perception there is a constant stream of communications.
- "Not enough shared" about serious incidents and fatalities in an effort to "protect the business".
- Very little feedback or analysis received from provided data.

2 Causation

- Insufficient strategic focus on safety communications
- Too many safety communications dilutes impact of most important messages
- Over-emphasis of awareness campaigns
- Most serious incident learnings are not effectively shared to limit company liability

3 Approach

- Assessment of safety communications to reduce "noise" and ensure clarity and conciseness of messaging.
- Development of a strategic communication strategy to address the largest issues including serious incidents and fatalities.
- Establish governance and align safety communications to improve consistency

Desired Outcome

- Safety communication process that reaches the hearts and minds of the workforce
- Focus placed on personal motivators to stay safe and move individuals towards private compliance

SOUTHERN CALIFORNIA EDISON® | 16

Strategy 5: Leverage talent management processes

1 Findings

- The words and actions of foremen, supervisors, managers and above are a significant predictor of their direct reports' safety attitudes.
- Limited accountability and influence across leadership levels, particularly through middle management.
- Training does not inspire new thinking about a personal motivation to stay safe.

2 Causation

- Performance management & employee lifecycle practices do not effectively reinforce safety behaviors
- Accountability for safety leadership is secondary to fears of making ineffective decisions
- Safety leadership and influencing skills are limited and do not drive the right attitude shifts for field employees

3 Approach

- Safety competencies and expectations clearly defined and integrated into all Talent Management practices.
- Safety attitudes, knowledge and skills embedded in recruitment, selection, onboarding, training, performance management & promotion of all roles.
- Pilot cognitive-based training to enhance leadership skills.

Desired Outcome

- A workforce that embodies the values, motivation, knowledge and skills to work safely
- Measurable shift in attitudes and behaviors to demonstrate Private Compliance

SOUTHERN CALIFORNIA EDISON®

17

Strategy 6: Implement safety data strategy

1 Findings

- A data strategy will improve the ability to analyze data at both the tactical and organizational strategic level to perform both trend and predictive analysis.
- A strategic approach to prevention will require collaboration across the entire business, and may best be served with a change in the organization's safety structure.

2 Causation

- Safety data infrastructure and strategy are ineffective
- Organizational silos impede development of overarching data structure & architecture
- Data, reporting and management operating system do not support a learning organization's needs for information

3 Approach

- Develop a single comprehensive safety data strategy for the entire organization.
- Consolidate & streamline safety data systems, reporting tools, processes and analysis efforts across the organization.
- Drive consistency across all OUs in cause evaluation/incident investigation methodology.

Desired Outcome

- Safety Data Strategy that links numbers to personal communication
- Meaningful Key Performance Indicators (KPIs) and drivers of safety performance
- Ability to use data to inform personalized safety development plans; predict, prevent and eliminate injuries.

SOUTHERN CALIFORNIA EDISON®

Strategy 7: Optimize the safety structure & governance

1 Findings

- Parallel safety organizations run independently, duplicate efforts/communications and reduce overall effectiveness.
- The CDSP is positively regarded but can be updated to improve results and include management in craft discussions.

2 Causation

- Organizational silos reinforce local solutions rather than company-wide best practices
- Strained labor relations limit union collaboration despite the agreed common objective of improved safety
- Little true accountability for safety programs because of disparate initiatives and ownership

3 Approach

- Restructure the safety organizations to eliminate duplication, knowledge gaps, inconsistencies and lack of alignment.
- Evolve Craft-Driven Safety Program (CDSP). Develop the change story: focused on protecting workers from harm and reliant on proactive peer support, fact gathering, learning to do so.
- Strengthen & consolidate safety program governance.

Desired Outcome

- Increase in knowledge sharing and best practice transfer, consistency.
- Reduced duplication, repetition of messages to improve efficiency of communication.
- Tight governance & alignment on the direction for Safety Culture.

SOUTHERN CALIFORNIA EDISON® | 19

Strategy 8: Enhance safety programs

1 Findings

- Safety programs have limited effectiveness and ROI due to:
  - abundance of programs;
  - the volume launched in a short period of time;
  - organizational infrastructure;
  - technology infrastructure;
  - cultural maturity;
  - ambitious timelines.

2 Causation

- Safety programs have a piece-meal approach rather than an integrated, cultural view
- Action-orientation puts more emphasis on doing rather than ensuring the right things are being done
- Ineffective safety programs due to independent leadership

3 Approach

- Evaluate and reset key programs based on culture maturity:
  - provide clear ownership,
  - data management,
  - strategy,
  - program evaluation and effectiveness;
- Remove observation and recognition program numerical targets
- Tighten communications and change management strategy for such changes.

Desired Outcome

- Integrated safety program supporting overall strategy with increased levels of effectiveness and adoption
- Ability to monitor and measure the impact of desired safety behaviors

SOUTHERN CALIFORNIA EDISON®

Topics:

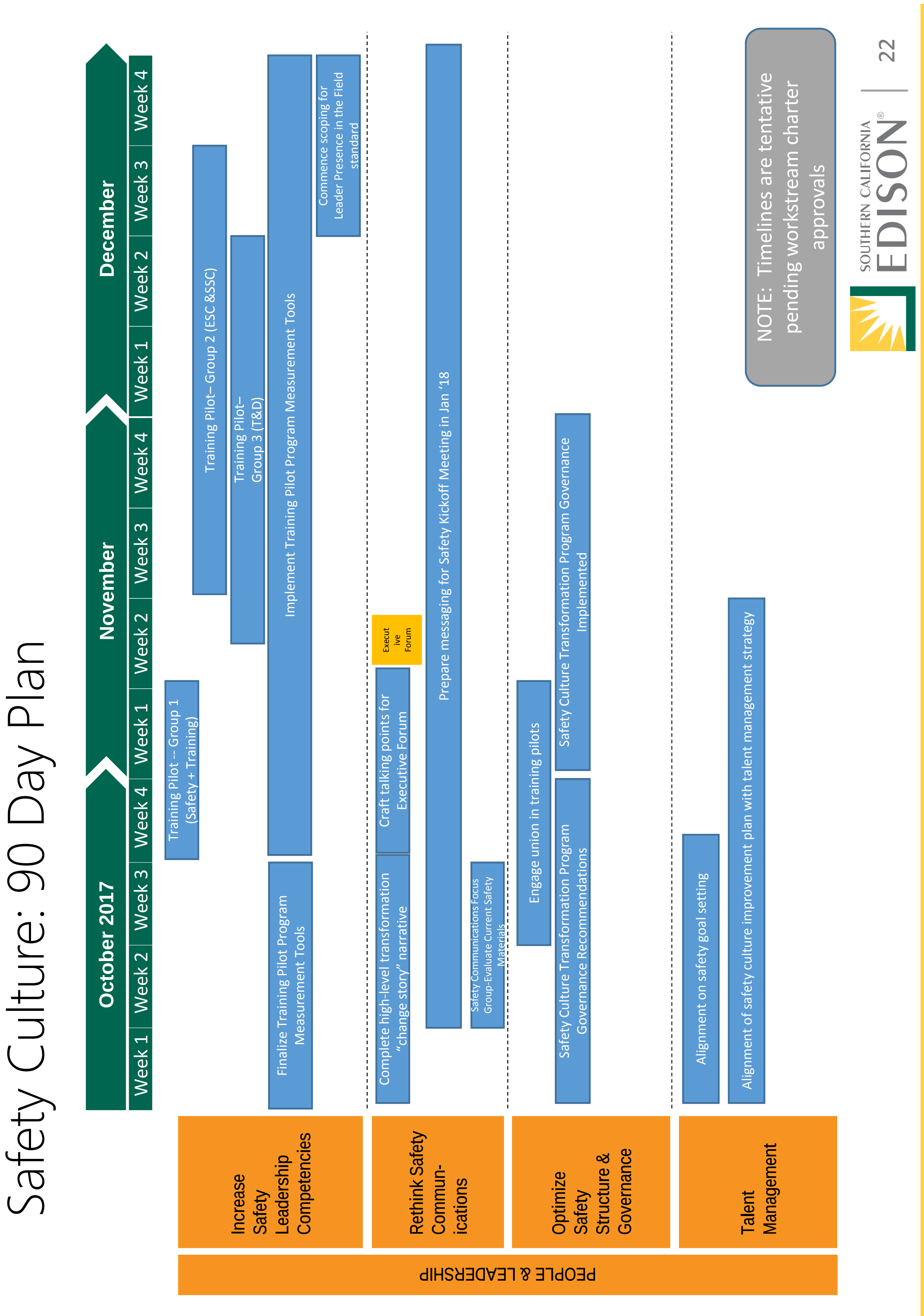
1. Program Update

2. Workstream Overviews

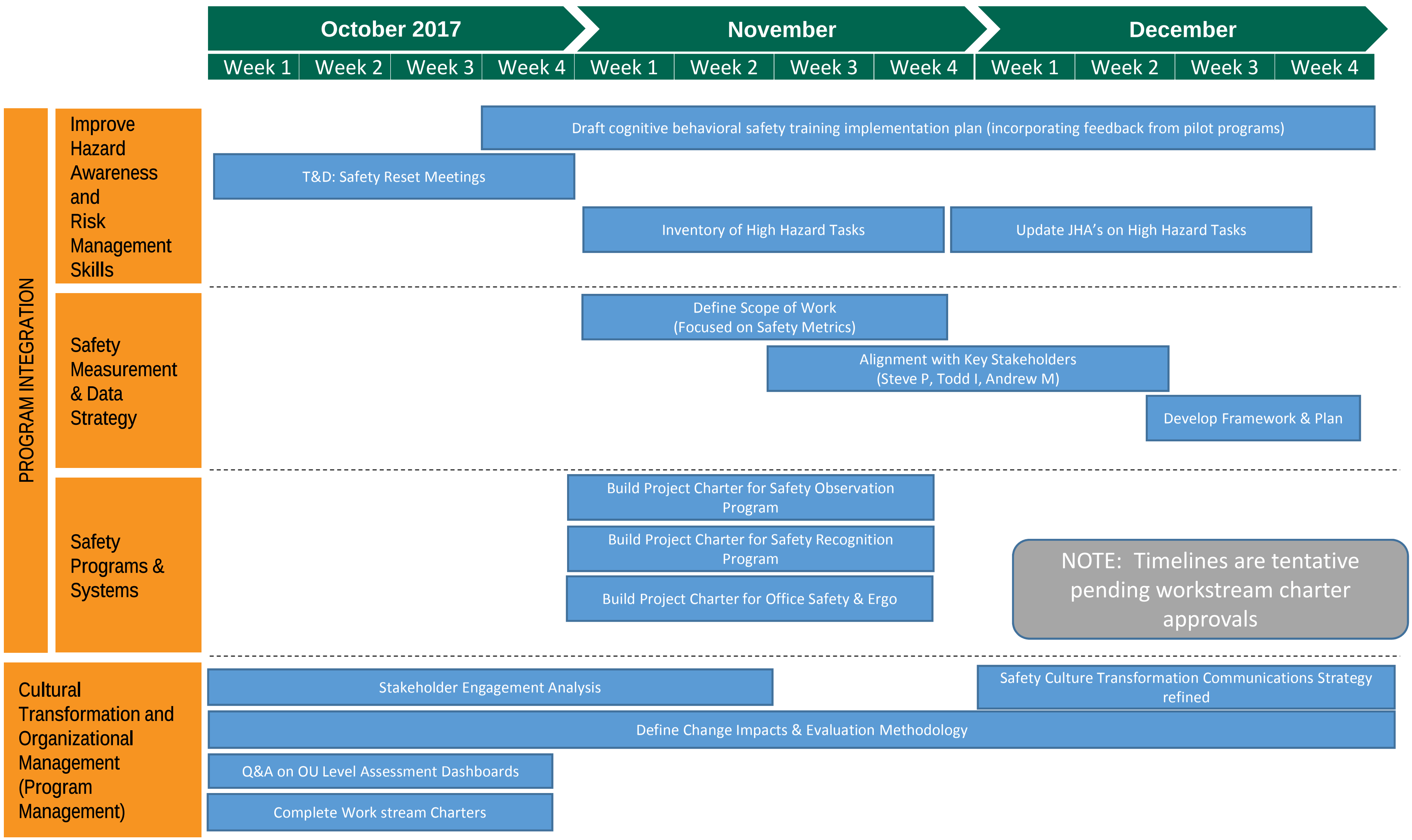
3. 90 Day Plan and Risks / Issues

Energy for What's Ahead℠

SOUTHERN CALIFORNIA EDISON


Safety Culture: 90 Day Plan
October 2017
November
December
Week 1
Week 2
Week 3
Week 4
PEOPLE & LEADERSHIP
Increase Safety Leadership Competencies
Finalize Training Pilot Program Measurement Tools
Training Pilot -- Group 1 (Safety + Training)
Implement Training Pilot Program Measurement Tools
Training Pilot– Group 2 (ESC &SSC)
Training Pilot– Group 3 (T&D)
Commence scoping for Leader Presence in the Field standard
Rethink Safety Commun-ications
Complete high-level transformation "change story" narrative
Craft talking points for Executive Forum
Execut ive Forum
Prepare messaging for Safety Kickoff Meeting in Jan '18
Safety Communications Focus Group-Evaluate Current Safety Materials
Optimize Safety Structure & Governance
Engage union in training pilots
Safety Culture Transformation Program Governance Recommendations
Safety Culture Transformation Program Governance Implemented
Talent Management
Alignment on safety goal setting
Alignment of safety culture improvement plan with talent management strategy
NOTE: Timelines are tentative pending workstream charter approvals
SOUTHERN CALIFORNIA EDISON
22

Safety Culture: 90 Day Plan



SOUTHERN CALIFORNIA EDISON | 23

Program risks / issues

The following primary program risks & issues have been identified. Progress through these and any potential future risks will be monitored by the Program team and managed through the appropriate governing bodies.

ID	Risk	Mitigation
1	Competing priorities distract from ability to execute.	Executive champions prioritize initiatives in order to ensure the right level of support to drive Safety Culture Change.
2	Employees and/or management may not internalize the messaging of change or may resist efforts to change current processes.	Develop change management & communication strategy with opportunities for shared stories with a focus on ownership and personal incentive.
3	Union engagement and support might not reach desired levels of engagement to drive workforce adoption.	Executive Leadership to drive a significant emphasis in securing Union Leadership support.
4	Decisions on key deliverables or successive steps may not be made in a timely manner or may experience conflicts in opinion that delay or reduce the effectiveness of planned deliverables.	Improve & tighten governance structure. Maintain open formal and informal communication channels to execute decision-making quickly. Build consensus around larger themes and identify executive champions to drive transformation.
5	Internal key resources may not have the insights or the skills to develop the workstream deliverables they are listed as responsible for in the plan.	Identify needs and develop & implement supporting strategies to secure needed transformational knowledge. Identify SMEs and Sentis support for key areas of focus.
6	Workstream deliverables may not be completed within a timely manner due to daily operational needs and activities.	Develop clarity around time to implement and identify this time as separate from operational activities. Executive reinforcement of Safety Culture as a critical priority.
7	Timelines for deliverables may be too aggressive for satisfactory completion.	Leverage an agile implementation approach and discuss deliverables, milestones and identify opportunities for increased resources/assistance.

SOUTHERN CALIFORNIA EDISON

25

Appendix

Energy for What's Ahead℠

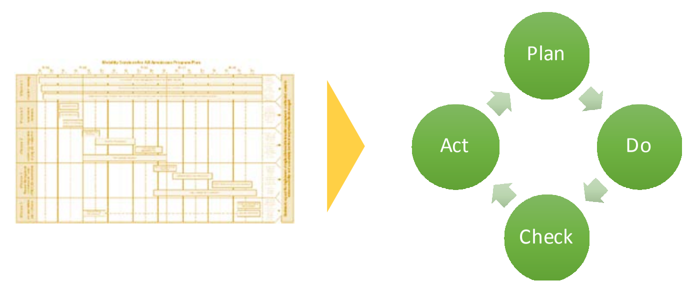
Two key differences in approach

To successfully achieve the desired Culture Change, best practices demonstrate that these alternative implementation approaches driver the greatest probability of success. This is essential to the success of the program but does introduce different leadership and governance expectations.

Incremental Improvements vs. Transformational Change

Transformational Change requires the strong and unwavering commitment of senior leaders to a long term objective and a pursuit of actions that are directly aligned to that desired end outcome.

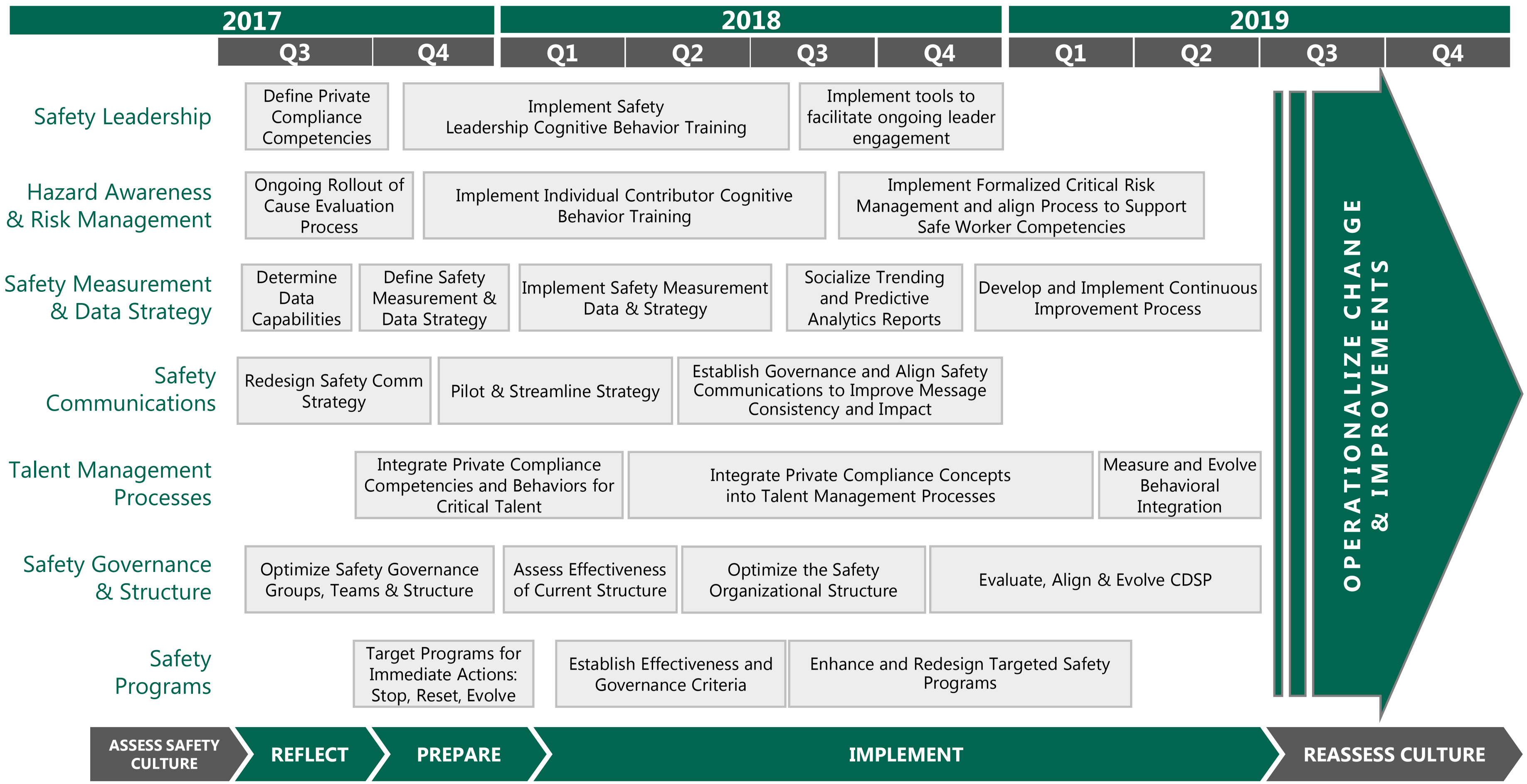
Waterfall vs. Agile Program Management



Traditional Program Implementations have detailed multi-year implementation plans. To drive the right level of Culture Change, we require an agreement on high-level direction for key program stages but sign-offs will need to be made on rolling 90-day implementation cycles that factor in learnings from current execution.

SOUTHERN CALIFORNIA EDISON | 26

Safety Culture Improvement Plan



SOUTHERN CALIFORNIA EDISON® | 27

90 Day Plan: Schedule of Deliverables

Workstream	October	November	December
Increase Safety Leadership Competencies	• Pilot Safety Leader Training – Group 1 • Training Pilot Program Measurements Tool	• Pilot Safety Leader Training – Groups 2 & 3 • Private Compliance Competencies Definition	• Pilot Training Feedback • “Time In Field” Strategy
Improve Hazard Awareness & Risk Management		• Inventory / list of high-risk tasks / jobs	• Updated / new JHA’s on high-risk tasks
Safety Measurement & Data Strategy			• Safety Measurement & Data Strategy
Rethink Safety Communications	• Change Story Narrative • New Monthly Safety Comms – Private Compliance • Evaluation of current safety communications materials	• Executive Forum talking points • New Monthly Safety Comms – Private Compliance	• Jan ‘18 Safety Kickoff messages • New Monthly Safety Comms – Private Compliance
Talent Management	• Safety goal setting alignment		
Safety Governance & Structure	• Transformation Program Governance recommendation	• Safety Culture Transformation Governance implementation	
Safety Programs & Systems		• Enterprise Safety Program Strategy	
Change Management	• Stakeholder Engagement Analysis Plan	• Stakeholder Engagement Analysis • Target State definition	• Culture Communication Strategy • Change Impact Evaluation Methodology
Program Management	• Workstream Charters finalized, approved at Oct ESC		

SOUTHERN CALIFORNIA EDISON®

Linking Themes & Solution Paths

Focus Area	Addresses Assessment findings					
	So my leader goes, so goes the culture	Inadequate skills, motivation or courage to speak up for safe work	Regulation then risk thinking	Input is not always turning to Action	Protecting the business interferes with protecting workers	Safety Communication overkill
Launch new common understanding for safety culture change	Y		Y		Y	
Increase Safety Leadership competencies	Y	Y	Y	Y		Y
Increase Hazard Awareness & Risk Management skills		Y	Y	Y	Y	
Rethink Safety communications			Y			Y
Implement Safety Data Strategy			Y	Y		
Optimize the Safety Structure & Governance	Y			Y	Y	Y
Leverage Talent Management processes	Y	Y	Y			
Enhance Corporate Safety Programs			Y	Y	Y	

SOUTHERN CALIFORNIA EDISON® | 29

Linking Causes & Solution Paths

Causes / Workstreams	#1: Common understanding	#2: Leadership competencies	#3: Hazard Awareness	#4: Commun-ications	#5: Talent Management	#6: Data Strategy	#7: Structure & Governance	#8: Safety Programs
Competing Priorities & Distraction of focus	●	◔		◑	◑	◔	◑	◔
Specific solutions prevent from addressing systemically	●	◔	◑		◔		◔	◕
Lack of engagement to solve safety issues	●	◑	◔		◔			◔
Organizational silos	◑			◔		◔	●	◕
Safety driven by external motivation not value	●			◑				
Safety leadership & influence skills	◔	●			◕			
Lack of "felt leadership"	◔	●			◔			
Perceived risks in making a mistake		◕		◔	◔			
Desire to mitigate business risk	◑		◑	◔				
Hazard awareness & mitigation skills			●					
Lack robust organizational learning abilities		◔	◕	◔	◔			
Too much communications dilutes messaging				●				
Perform. mgmt & lifecycle doesn't reinforce safety behaviors					●			
Insufficient Accountability for safety leadership	◕	◕	◔		●	◔	◑	
Ineffective safety data infrastructure & strategy						●		
Data, reporting & MOS don't reinforce earning org						●		
Strained labor relations	●			◑			●	

SOUTHERN CALIFORNIA EDISON | 30

2014 CPUC Reportable Public Fatality & Serious Injury Events

#	Location	Cause	Category	Injury Type
1	Tustin	A person made contact with an overhead powerline while climbing a tree and was taking pictures and video.	Line Contact (Overhead)	Fatality
2	Malibu	A tree trimmer made contact with an overhead powerline while using a long pruning pole.	Line Contact (Overhead)	Fatality
3	Rosemead	A person had an anxiety attack due to driving near a powerline as it relayed from a heavy winter storm.	Other	Injury
4	Victorville	A person threw a coaxial wire (metallic) over a SCE substation fence and made contact with energized components inside the substation.	Theft/Vandalism	Injury
5	La Mirada	A bicyclist made contact with a downed powerline following a nearby auto accident.	Downed Line	Injury
6	Fullerton	A metallic balloon caused a downed powerline. The area was coned off. A member of the public was pushing a shopping cart entered the area and made contact with the line.	Downed Line	Fatality
7	San Bernardino	A car hit pole caused a downed powerline. Damage to the infrastructure resulted in a house fire with two elderly occupants inside.	Downed Line	Fatality & Injury
8	Santa Fe Springs	A person vandalized a padmount transformer at a substation cut the primary cable and sustained injuries.	Theft/Vandalism	Injury
9	Whittier	A person made contact with a downed conductor in a backyard. He heard a loud noise and went outside to see what it was.	Downed Line	Fatality
10	San Gabriel	A structure fire caused a service drop to fall onto a chain link fence, energizing the fence. A firefighter received an electrical shock when he touched energized fence.	Downed Line	Injury
11	Santa Paula	A helicopter struck an overhead powerline and crashed.	Line Contact (Overhead)	Fatality
12	Colton	Two firefighters were injured when an apparatus ladder made contact with an overhead powerline.	Line Contact (Overhead)	2 Injuries
13	Carson	During training at fire station, ladder raised into 66kV line, firefighter was shocked.	Line Contact (Overhead)	Injury

1 Energy for What's Ahead℠

2014 CPUC Reportable Public Fatality & Serious Injury Events (Continued)

#	Location	Cause	Category	Injury Type
14	Commerce	A person received burn injuries as a result of using an axe to cut into energized primary underground cable housed in a conduit while stealing copper.	Theft/Vandalism	Injury
15	West Hollywood	A concrete worker that was working on a rooftop sustained burns when his aluminum tool struck the conductor.	Line Contact (Overhead)	Injury
16	Agua Dulce	An airplane struck a distribution powerline.	Line Contact (Overhead)	2 Injuries
17	Los Angeles	While painting a building, the elevated boom made contact with a conductor.	Line Contact (Overhead)	Fatality
18	Santa Clarita	Previous vandalism caused damage to a pole. A car subsequently made contact with a downed powerline. A person reported chest pain and hypertension and emotional distress. (The event occurred in 2012, but injury was reported to SCE in 2014.)	Downed Line	Injury
19	Victorville	A plumber was digging and inadvertently cut an underground line.	Line Contact (Underground)	Injury
20	Santa Ana	Two people were burned after cutting underground secondary and primary cable.	Theft/Vandalism	2 Injuries
21	Corona	A tree trimmer inadvertently made contact with overhead powerline.	Line Contact (Overhead)	Fatality
22	Irvine	An individual climbed a lattice tower and jumped to his death.	Fall (Suicide)	Fatality
23	El Cerrito	During suppression efforts, two firefighters were shocked after they made contact with a downed conductor.	Downed Line	2 Injuries
24	San Bernardino	While standing on the ground, a window washer extended a pool upward and made contact with a transmission line.	Line Contact (Overhead)	Injury
25	Rowland Heights	A person climbed a tower, called 911 and jumped.	Fall (Suicide)	Fatality
26	Simi Valley	A tree trimmer made contact with an overhead powerline while using an aluminum tool.	Line Contact (Overhead)	Fatality

2015 CPUC Public Fatality & Serious Injury Events

#	Location	Cause	Category	Injury Type
1	Calabasas	A painter was moving a metal ladder and made contact with an overhead powerline	Line Contact (Overhead)	Injury
2	Los Angeles	A person climbed a steel lattice pole and made contact with the powerline resulting in a flash.	Fall (Apparent Suicide)	Injury
3	Woodlake	A forklift operator struck a pole in an orchard which resulted in downed primary conductor. As the individual was exiting the forklift, they made contact with downed powerline and received flash burns to their arm.	Downed line	Injury
4	Fontana	An individual climbed a transmission tower and jumped.	Fall (Apparent Suicide)	Fatality
5	West Hollywood	A person climbed a pole, made contact with the energized powerline, was shocked and fell to the ground	Line Contact (Overhead)	Fatality
6	Cathedral City	A person sustained burn injuries while performing underground construction when he cut through an SCE conduit. **(Report rescinded)**	Line Contact (Underground)	Injury
7	San Bernardino	A hang glider made contact with an overhead power line.	Line Contact (Overhead)	Injury
8	Moreno Valley	A transient cut a primary riser which caused a flash.	Theft/Vandalism	Injury
9	29 Palms	While riding an ATV, the person made contact with a downed conductor after a heavy storm and sustained injuries to their neck.	Downed Line	2 Injuries
10	La Mirada	Individual made contact with cable while attempting to vandalize a padmount transformer.	Theft/Vandalism	Fatality

2015 CPUC Reportable Fatality & Serious Injury Events for Public People **(continued)**

#	Location	Cause	Category	Injury Type
11	Claremont	A person slipped and fell into an open manhole when she approached SCE Contractors who were engaged in performing underground maintenance and repair work and.	Slip/Trip/Fall	Injury
12	Newport Beach	A construction worker dug up and contacted an underground cable section of the Snead 12 kV distribution line out of Lafayette Substation.	Line Contact (Underground)	Injury
13	Tulare	An employee of the City of Tulare Water Department, was using a jack-hammer that contacted and damaged underground electrical facilities resulting in burn injuries to both hands.	Electrical Contact	Injury
14	San Bernardino	An individual was admitted to Arrowhead Regional Hospital for burns to his hands and face by a damaged (cut) conduit containing primary cable	Electrical Contact	Injury
15	Kern	An foreman of High Sierra Crane suffered burns to his arms and experienced a cardiac event as a result of contacting a section of the Faye 12 kV distribution circuit out of Weldon Substation from an elevated position in a bucket truck while trimming trees	Electrical Contact (Trimming Trees)	Injury
16	Fullerton	An individual had accessed energized equipment within the Basta Substation and suffered severe burn injuries.	Electrical Contact	Fatality

2016 CPUC Reportable Fatality & Serious Injury Events for Public People

#	Location	Cause	Category	Injury Type
1	Moreno Valley	One individual sustained injuries while engaged in tree trimming activities	Electrical Contact	Injury
2	Redlands	One individual sustained injuries while engaged in agricultural activities	Electrical Contact	Injury
3	Cabazon	One individual sustained fatal injuries coming into contact with a downed conductor from a car-hit-pole incident	Electrical Contact	Fatality
4	Chino	One individual sustained fatal injuries in an apparent suicide from a Transmission tower	Suicide	Fatality
5	Newbury Park	A cable television technician sustained injuries when he contacted an energized bus bar in a secondary pedestal.	Line Contact (Underground)	Injury
6	Calabasas	One individual sustained injuries while engaged in excavation activities	Electrical Contact	Injury
7	Santa Paula	Two individuals were fatally injured when their aircraft flew into overhead conductors	Aircraft	2 Fatalities
8	Lancaster	One individual sustained fatal injuries when their medical equipment failed during a power outage	Outage	Fatality
9	Fullerton	One individual sustained injuries while engaged in tree trimming activities	Electrical Contact	Injury
10	Victorville	One individual sustained fatal injuries when an energized cable was in cut in an apparent metal theft attempt.	Electrical Contact	Fatality
11	Malibu	One individual sustained injuries while engaged in tree trimming activities	Electrical Contact	Injury
12	San Marino	One individual sustained burn injuries to both hands while engaged in tree trimming activities	Electrical Contract	Injury
13	Santa Clarita	One individual sustained head injuries contacted overhead primary conductor with his hard hat, causing his head to strike the side of the bucket	Overhead Contact	Injury

2017 CPUC Reportable Fatality & Serious Injury Events for Public People

#	Location	Cause	Category	Injury Type
1	Laguna Woods	One individual sustained fatal injuries in an apparent suicide from a Transmission tower	Suicide	Fatality
2	Corona	One individual employed by Select Electric was in the process of setting a streetlight pole when the crane was elevated and contacted overhead electrical facilities	Electrical Contact	Injury
3	Santa Ana	A person sustained injuries after removing the cover of a secondary pedestal which made contact with UG cable connections.	Live Contact (Underground)	Injury
4	Hawthorne	Trespassing at unmanned Yukon substation, one individual lost balance and fell to the ground while climbing SCE equipment or facility racks.	Fall from Elevation	Injury
5	Costa Mesa	One individual worker sustained burn injuries on a scaffold when the contact occurred.	Electrical Contract	Injury
6	Tulare	A vehicle struck a pole, the line fell onto her vehicle, the driver exited the vehicle and she sustained burn injuries.	Electrical Contact	Injury
7	Santa Rosa Valley	The Ventura County Fire Department reported two male subjects died when an aircraft identified as a single engine Piper crashed in the Santa Rosa Valley area of Ventura County. The downed aircraft erupted into flames and the fire was extinguished by residents in the area. Preliminary information indicates the aircraft may have contacted SCE overhead electrical facilities prior to ground impact. There was no circuit activity and no damage to SCE overhead electrical facilities requiring repair. The NTSB responded to the scene and the investigation is on-going.	Aircraft Crash	2 Fatalities
8	Huntington Beach	One individual sustained fatal injuries after making contact with downed line.	Electrical Contact	Fatality
9	Santa Barbara	One individual sustained burn injuries after making contact with downed conductor.	Electrical Contact	Injury
10	San Gabriel	One individual employed by Ace Sheet Metal was ascending an aluminum ladder and holding a rain gutter that contacted an overhead primary conductor. He sustained injuries as a result of the electrical contact and fell from the ladder.	Electrical Contact	Injury
11	Oxnard	A foreman electrician employed by Light and Power company sustained 3rd degree burn injuries after cutting into an underground primary cable.	Electrical Contact	Injury
12	Somis	Two skydivers came into contact with the conductor	Electrical Contact	2 Injuries

2018 CPUC Reported Public Safety Incidents

#	Location	Cause	Category	Injury Type
1	Agua Dulce	A Cirrus VK-30 crashed in the Agua Dulce area and all four individuals (two adult males, an adult female, and a child) aboard the aircraft died in the incident. It appears that the subject aircraft struck an overhead conductor on the Santa Clara-Vincent 220 kV circuit prior impacting the ground. There was no circuit activity associated with this event and no downed conductors.	Aircraft Crash	4 Fatalities
2	Camarillo	One individual sustained fatal injuries while engaged in tree trimming activities. There was no circuit activity and no damage to the involved SCE facilities.	Electrical Contact	Fatality
3	Rosemead	One individual climbed a utility pole which was part of the Forbid 16kV Circuit out of Rush Substation and reached the level of the potheads and lightning arrestors when she made contact and fell	Electrical Contact	Injury
4	Manhattan Beach	One construction worker for the Blois Company, was using a digging device when he compromised an underground, concrete encased cable which was part of the Salmon 16 kV circuit	Electrical Contact	Injury
5	Pomona	One individual was involved in an electrical contact during a tree trimming activity	Electrical Contact	Injury
6	Hesperia	Two individuals sustained fatal injuries when an aircraft crashed following departure from Hesperia Airport. The aircraft reportedly experienced some type of failure and was returning to the airport when it lost altitude and crashed on Summit Valley Road. It appears during the descent the aircraft contacted and damaged two overhead primary conductors in a span.	Aircraft Crash	2 Fatalities
7	Lynwood	One individual was using hand tools to cut a primary riser on a pole. The individual made electrical contact and was thrown approximately 30 feet and suffered burns on neck, arm, face, and hair.	Electrical Contact	Injury
8	Hemet	A metallic balloon contacted and damaged overhead electrical facilities resulting in a relay on the Cambridge 12 kV circuit out of Mayberry Substation. An overhead primary conductor consisting of No. 4 ACSR was downed and in contact with a chain link fence. One individual reportedly touched the subject fence and sustained injuries.	Electrical Contact	Injury

2018 CPUC Reported Public Safety Incidents

#	Location	Cause	Category	Injury Type
9	La Habra	One unidentified individual was obtaining soil samples for a City of La Habra project and excavated without a dig ticket. The individual suffered burns injuries of unknown severity when he dug into a section of La Fonda 12kV circuit. The person was transported to UC! Medical Center.	Electrical Contact	Injury
10	Pasadena	SCE conducted a planned and noticed outage in the 3200 Block of Barhite St. in Pasadena. The purpose of the outage was to perform re-conductor work in connection with the upgrading of a 4 kV distribution circuit to a 16 kV circuit. Shortly after the utility-provided power was interrupted, the SCE contract crews on scene were notified by a citizen who informed them a resident passed away. SCE has initiated an investigation into this event.	Unknown	Fatality
11	West Hollywood	LADWP employees were excavating for a non-SCE water line project when an employee using a jack hammer contacted an underground cable on the Crescent 4kV Circuit out of Fairfax Substation. The circuit interrupted and a flashover occurred. Two LADWP employees were transported via ambulance to a local hospital with unspecified injuries	Electrical Contact	Injury
12	Fullerton	SCE de-energized the Holloway 4 kV distribution circuit out of District Substation to safely make emergency repairs. Preliminary information indicates the power was restored within six minutes at 4:21 PM. SCE received a call on October 26, 2018, from a customer who advised a relative passed away within that timeframe. SCE has initiated an investigation into this event. Please note this information is preliminary and may change as additional information is gathered.	Unknown	Fatality

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 4
Building Safety

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 4
Building Safety

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Building Safety
Workpaper:	Baseline Risk Modeling Inputs

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Likely	Max
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Earthquake of 6.0 or Greater	0.344	0.344	0.344	0.344	0.344	0.344	Simulations performed by a consultant using both building locations and the US Geological Survey Uniform California Earthquake Rupture Forecast Version 3, Time-Dependent (UCERF3-TD) are used to estimated the annual rate for an earthquake of Magnitude 6.0 or greater to cause potentially damaging ground motions (peak ground accelerations of 0.05 g or greater) at one or more of SCE's 170 occupied buildings.
	D2	Failure of Building Electrical Systems	13.4	13.4	13.4	13.4	13.4	13.4	SCE used a building estimation model (CostLab) to estimate the total number of electrical components per building based on building function. SCE estimated a failure rate of 0.5% per component based on SME judgement and considering existing compliance activities. SCE calculated event frequency as a function of the probability of failure multiplied by the number of electrical components within the 170 buildings in scope.
	D3	Extreme Wind	12.2	12.2	12.2	12.2	12.2	12.2	Historical wind speed data was reviewed to count the number of times that wind speeds exceeded 75mph (the lower threshold for Category 1 hurricane wind speeds) at the building sites in scope for the chapter. The timeframe of historical review varied by data availability at individual locations, but went back to 1987 or 1999 in the majority of cases. The average historical occurrences were used to forecast future frequency.

	ID	Name	2018	2019	2020	2021	2022	2023	Source/Justification
Triggering Event Frequency	TEF	Building Potentially Compromised	26.0	26.0	26.0	26.0	26.0	26.0	The TEF is the sum of the driver frequencies.

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Building Struck by Object(s)	47.0%	12.198	The predicted number of wind events is divided by the TEF to obtain the outcome probability.
	O2.1	Power Out	50.9%	13.211	Based on United States Fire Administration (USFA) data on nonresidential building fire trends, the annual average number of non-residential building fires started by electrical malfunction between 2012 and 2016 is estimated at 7,420. Based on the most recent US Energy Information survey (2012), there were 5.6 million estimated commercial buildings in the U.S. Hence the ratio is 0.0013 fires per building per year. For SCE's portfolio of 170 occupied buildings, the expected annual number of fires is 0.2. The remainder of the 13.4 average annual occurrences of failure of building electrical systems are assumed to result in power out (13.2). These figures are divided by the TEF to obtain the outcome probabilities.
	O2.2	Fire or Flare-Up	0.8%	0.208	
	O3	Moderate Earthquake (6.0 to 6.7)	0.8%	0.208	Simulations performed by a consultant using UCERF3-TD seismic source model are used to estimated the annual rate for earthquakes of magnitude 6.0 to 6.7 and earthquakes of magnitude greater than 6.7 to cause potentially damaging ground motions (peak ground accelerations of 0.05 g or greater) at one or more of SCE's 170 occupied buildings. The rates were divided by the TEF to obtain the outcome probabilities.
	O4	Catastrophic Earthquake (>6.7)	0.5%	0.130	

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
	O1	Serious Injuries	Poisson	0.002	N/A	N/A	Serious injuries are scaled from O1 fatalities at 2:1 ratio. Ratio was determined by comparing the rate of reported injuries to fatalities for historical events found in the National Center for Environmental Information (NOAA) storm events database, for California. The NOAA data provided data from 2013 to 2017 high wind, strong wind, and thunderstorm wind events.
		Fatalities	Poisson	0.001	N/A	N/A	Due to a lack of prior wind-related fatalities for building occupants, SCE utilized SME judgement to derive an estimated frequency of fatality to be 1-in-100 years. The 1/100 year frequency is the divided by annual frequency of O1 to obtain the mean input for the Poisson distribution.

Consequences		Financial	Exponential	$3,000	N/A	N/A	According to historical records, SCE expects to spend approximately $35K for window repairs in an average year. SCE then divided this annual cost by the expected number of wind events to reach the per-event cost.
	O2.1	Financial	Exponential	$93,258	N/A	N/A	SCE selected an exponential model to forecast a per-event cost based on 2016-2017 expenditures for electrical repair costs incurred for building types in scope.
	O2.2	Serious Injuries	Poisson	0.014	N/A	N/A	SCE used an average injury rate of .014 per incident. This represents an average of the injury per fire ratios found in data from Federal Emergency Management Association (FEMA) and the National Fire Protection Agency (NFPA). FEMA documented approximately 1,550 injuries over 96,800 fires for a ratio of .016 injuries per fire; NFPA documented 190 injuries over 14,760 fires for ratio of .013 injuries per fire.
		Fatalities	Poisson	0.001	N/A	N/A	We used a fatality rate of .0014 based on the average rates found in the FEMA and NFPA sources mentioned above (O2.2 serious injuries). FEMA documented approximately 145 fatalities over 96,800 fires for ratio of .0015 fatalities per fire; NFPA documented 20 fatalities over 14,760 fires for ratio of .0013 fatalities per fire.
		Reliability	Exponential	4,608,295	N/A	N/A	Reliability impacts are only expected for the 31 buildings in scope that include bulk electric system control rooms. Using SME judgment, SCE estimated the CMI impacts according to the following scenarios: 0 – 6M CMI (substation down less than one day), 73%; 6M – 18M (substation down 1-3 days), 25%; 18M – 30M (substation down 3-6 days), 2%; 30M+ (substation down 6+ days), >1%.
		Financial	Lognormal	$738,906	$5,409,584	N/A	Based on SME judgement and historical costs, SCE developed data for this consequence along the following scenarios: $0 - $250k, replacing equipment that failed without additional damage, 68%; $250k - $1M localized fire, 20%; $1M - $5M major damage, this would likely require temp lease space, 10%; $5M - $30M significant non-structural building upgrade and/or re-construction, this would likely require temp lease space, 2%; above $30M replacement cost for entire building, this would likely require temp lease space, >1%.

O3	Serious Injuries	Lognormal	2.554	56.327	N/A	Simulation performed by a consultant using the UCERF3-TD seismic source model, models for the 170 occupied SCE buildings based on the FEMA Hazus-MH software and SCE occupancy data are used to develop a lognormal distribution for serious injuries per occurrence. Each building is modeled on construction type, age, height, and location.
	Fatalities	Lognormal	0.096	2.110	N/A	The same simulation was performed for fatalities as was performed for O3 Serious Injuries.
	Reliability	Exponential	201,000	N/A	N/A	Simulation performed by a consultant using the UCERF3-TD seismic source model, models for 31 Bulk Electrical System (BES) substations included in the 170 occupied SCE buildings based on the FEMA Hazus-MH software and SME estimate that collapse of a BES substation could result in 6M CMI per day until a short-term workaround could be implemented.
	Financial	Lognormal	$2,020,000	$4,680,000	N/A	Extent of building damage and collapse results from a simulation performed by a consultant using the UCERF3-TD seismic source model, which include models for the 170 occupied SCE buildings based on the FEMA Hazus-MH software. Repair/replacement costs are based on a combination of SME judgement and project costs for building types in scope.
O4	Serious Injuries	Lognormal	11.963	101.050	N/A	This consequence was calculated using the same method as in Outcome 3, except for earthquakes of magnitude greater than 6.7
	Fatalities	Lognormal	0.598	5.050	N/A	This consequence was calculated using the same method as in Outcome 3, except for earthquakes of magnitude greater than 6.7
	Reliability	Exponential	1,273,000	N/A	N/A	This consequence was calculated using the same method as in Outcome 3, except for earthquakes of magnitude greater than 6.7
	Financial	Lognormal	$12,090,000	$14,300,000	N/A	This consequence was calculated using the same method as in Outcome 3, except for earthquakes of magnitude greater than 6.7

Chapter	Building Safety

Drivers	
ID	Name
D1	Earthquake > 6.0
D2	Failure of Building Electrical Systems
D3	Extreme Wind

Outcomes	
ID	Name
O1	Building Struck by Objects
O2.1	Loss of Building Electrical Function (Power Out)
O2.2	Fire or Flare-Up in Building
O3	Moderate Earthquake (6.0 to 6.7)
O4	Catastrophic Earthquake (>6.7)

Controls & Mitigations	
ID	Name
C1	Seismic Building Safety Program
C2	Facility Emergency Management Program
M1	Fire Life Safety Portfolio Assessment
M2	Electrical Inspections
M3	Wind-Borne Debris Protection
M4	Work(er) Relocation
M5	Building Replacement

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Seismic Building Safety Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Building Struck by Objects	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.1 Loss of Building Electrical	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2 Fire or Flare-Up in Building	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Moderate Earthquake (6.0 to 6.7)	Serious Injuries	7.35%	14.70%	22.05%	29.40%	36.75%	44.10%	The baseline risk for this outcome (see Baseline Risk Assessment Workpaper) is used as a starting point. SCE then reclassifies each building that is within scope of C1 to reflect its upgraded seismic capacity after C1 is applied. The model is then run again to show the portfolio-wide impacts with C1 in place. Hence it is essentially a "before and after" comparison that measures the difference due to the implementation of C1. As more buildings are addressed over each year, the reduction reflects the increased impact.
	Fatalities	7.35%	14.70%	22.05%	29.40%	36.75%	44.10%	See O3 above.
	Reliability	0.00015%	0.00030%	0.00045%	0.00060%	0.00075%	0.00090%	See O3 above.
	Financial	3.15%	6.30%	9.45%	12.60%	15.75%	18.90%	See O3 above.
O4 Catastrophic Earthquake (>6.7)	Serious Injuries	4.50%	9.00%	13.50%	18.00%	22.50%	27.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude (>6.7).
	Fatalities	4.50%	9.00%	13.50%	18.00%	22.50%	27.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude (>6.7).
	Reliability	3.60%	7.20%	10.80%	14.40%	18.00%	21.60%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude (>6.7).
	Financial	2.55%	5.10%	7.65%	10.20%	12.75%	15.30%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude (>6.7).

Name	C2 Facility Emergency Management Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.**
D1	Earthquake > 6.0	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.**
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Building Struck	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
by Objects	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Loss of	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
Electrical	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2	Serious Injuries	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	Although these types of emergency management programs have a "common sense" appeal and a large organization such as SCE would be remiss to not have such a program, SCE was unable to identify research-based findings to measure the impact of such programs. SCE subject matter experts used the value of 5% as a conservative approach that allows C2 to be modeled without attempting to overstate its impact.
Fire or Flare-	Fatalities	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	See O2.2 above.
Up in Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	See O2.2 above.
Moderate	Fatalities	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	See O2.2 above.
Earthquake	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
(6.0 to 6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O4	Serious Injuries	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	See O2.2 above.
Catastrophic	Fatalities	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	See O2.2 above.
Earthquake (	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
>6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M1 Fire Life Safety Portfolio Assessment

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Building Struck	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
by Objects	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Loss of	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
Electrical	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2	Serious Injuries	inactive	3.60%	7.20%	10.80%	14.40%	18.00%	The scope is focused on the buildings without sprinklers (40 out of 170), which are then assumed to be addressed at a pace of 3 per year. An article by the Society of Fire Protection Engineers (https://www.sfpe.org/page/2014_Q4_4/Effectiveness-and-Reliability-of-Fire-Protection-Systems.htm) states that fire-extinguishing systems (wet or dry) reduce casualties by 80%. This incremental benefit per building is then measured in terms of overall risk reduction across the entire portfolio.
Fire or Flare-	Fatalities	inactive	3.60%	7.20%	10.80%	14.40%	18.00%	Same as O2.2 above.
Up in Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Moderate	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Earthquake	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
(6.0 to 6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Catastrophic	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Earthquake (	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
>6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M2 Electrical Inspections

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	18.00%	33.00%	43.00%	48.00%	48.00%	48.00%	The pace of inspections is assumed to address 20% of the portfolio each year, and for each inspection to reduce driver frequency by 90% at the inspected building in the year of the inspection. In each year following the inspection, the driver frequency at the inspected building is assumed to increase to reflect the potential for new issues to arrive due to the passage of time and continued use of the electrical equipment. The percentage decrease changes to 75% in year 2, 50% in year 3, 25% in year 4, and 0% in year 5.
D3	Extreme Wind	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Probability	-10.25%	-20.54%	-28.54%	-32.95%	-32.95%	-32.95%	This adjustment to outcome probability is a necessary mathematical step to right-size the outcome probability after the reduction to D2 frequency is applied. Without this adjustment, the reduction of D2 would mean that O1 has the same share of a smaller number of triggering events, and hence a smaller number of outcomes, even though this mitigation has no connection to O1.
Building Struck by Objects	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.1	Probability	9.60%	19.24%	26.73%	30.87%	30.87%	30.87%	See O1 above.
Loss of Building Electrical Function	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2	Probability	9.60%	19.24%	26.73%	30.87%	30.87%	30.87%	See O1 above.
Fire or Flare-Up in Building	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Probability	-10.25%	-20.54%	-28.54%	-32.95%	-32.95%	-32.95%	See O1 above.
Moderate Earthquake (6.0 to 6.7)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O4	Probability	-10.25%	-20.54%	-28.54%	-32.95%	-32.95%	-32.95%	See O1 above.
Catastrophic Earthquake (>6.7)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M3 Wind-Borne Debris Protection

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	inactive	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	inactive	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	inactive	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	inactive	90.00%	90.00%	90.00%	90.00%	90.00%	Based on product specifications from 3M, a prominent maker of protective window film, the window film is designed to withstand up to 350 lb/in of force. This substantially reduces the risk of injury or fatality that could occur in unprotected glass. SMEs estimated this would result in a reduction to this consequence of 90%.
Building Struck	Fatalities	inactive	90.00%	90.00%	90.00%	90.00%	90.00%	See O1 above.
by Objects	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	inactive	50.00%	50.00%	50.00%	50.00%	50.00%	Based on product specifications from 3M, the film does not prevent the glass from breaking. The film holds the glass in place, and results in a lower repair cost because the damage is localized the window (as opposed to extending into the building). SCE SMEs estimate the reduction percentage as 50%.
O2.1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Loss of	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
Electrical	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Fire or Flare-	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Up in Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Moderate	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Earthquake	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
(6.0 to 6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Catastrophic	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Earthquake (	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
>6.7)	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M4 Work(er) Relocation

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	inactive	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	inactive	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	inactive	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Building Struck	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
by Objects	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Loss of	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
Electrical	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2.2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
Fire or Flare-	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
Up in Building	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	inactive	2.00%	4.00%	4.00%	4.00%	4.00%	Similar to the method used in C1, the baseline risk for this outcome (see Baseline Risk Assessment Workpaper) is used as a starting point. SCE then reclassifies each building that is within scope of M4 to reflect its upgraded seismic capacity after M4 is applied. The model is then run again to show the portfolio-wide impacts with M4 in place. Hence it is essentially a "before and after" comparison that measures the difference due to the implementation of M4.
Moderate	Fatalities	inactive	2.00%	4.00%	4.00%	4.00%	4.00%	See O3 above.
Earthquake	Reliability	inactive	1.50%	3.00%	3.00%	3.00%	3.00%	See O3 above.
(6.0 to 6.7)	Financial	inactive	0.50%	1.00%	1.00%	1.00%	1.00%	See O3 above.
O4	Serious Injuries	inactive	1.00%	2.00%	2.00%	2.00%	2.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
Catastrophic	Fatalities	inactive	1.00%	2.00%	2.00%	2.00%	2.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
Earthquake (	Reliability	inactive	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
>6.7)	Financial	inactive	0.25%	0.50%	1.00%	1.00%	1.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.

Name	M5 Building Replacement

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Earthquake > 6.0	inactive	no impact	no impact	no impact	no impact	no impact	
D2	Failure of Building Electrical Systems	inactive	no impact	no impact	no impact	no impact	no impact	
D3	Extreme Wind	inactive	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	
Building Struck	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	
by Objects	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	
O2.1	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	
Loss of	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	
Building	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	
Electrical	Financial	inactive	no impact	no impact	no impact	no impact	no impact	
O2.2	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	
Fire or Flare-	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	
Up in Building	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	inactive	2.10%	4.20%	6.30%	8.40%	10.50%	This is modeled identically to C1, with the exception that the "after" view of the outcome reflects this mitigation's action to replace certain buildings, as opposed to retrofitting them. Likewise, the buildings that are in scope for M5, but not in scope for C1, are changed in the seismic model per the process explained for C1. The reduction effectiveness is applied to the RAMP period on the assumption of addressing two buildings per year.
Moderate	Fatalities	inactive	2.10%	4.20%	6.30%	8.40%	10.50%	See O3 above.
Earthquake	Reliability	inactive	0.40%	0.80%	1.20%	1.60%	2.00%	See O3 above.
(6.0 to 6.7)	Financial	inactive	0.40%	0.80%	1.20%	1.60%	2.00%	See O3 above.
O4	Serious Injuries	inactive	1.10%	2.20%	3.30%	4.40%	5.50%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
Catastrophic	Fatalities	inactive	1.10%	2.20%	3.30%	4.40%	5.50%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
Earthquake (	Reliability	inactive	0.00001%	0.00002%	0.00003%	0.00004%	0.00005%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.
>6.7)	Financial	inactive	0.60%	1.20%	1.80%	2.40%	3.00%	See O3 above, with the difference that in this case, the model is based on earthquakes of higher magnitude.

Workpaper – SME Qualifications

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgment is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Building Safety**
Risk Analysis Component	Development of baseline risk assessment and mitigation effectiveness values.
Does historical data exist at SCE to support the evaluation of this risk analysis component?	In most cases, SME judgment was utilized in conjunction with historical or present-day data (e.g. D2 frequency, O1 fatalities, O2.2 reliability and financial, O3 reliability and financial, O4 reliability and financial, and M3 effectiveness values). In two cases, little or no data was available (C2 and M2 effectiveness values).
Additional back-up or sources used by the SME(s) to inform/validate guidance	In addition to the data sources described in the Mitigation Effectiveness Workpaper and the Baseline Risk Assessment Workpaper, SMEs engaged in discussions with fire-life safety (FLS) and electrical vendors, with peers through the International Facility Management Association (IFMA) network, and with CBRE (CBRE is SCE's service provider for facility maintenance services).
SME(s) who have contributed to this analysis	• Director, SCE Commercial Real Estate (CRE) • Principal Manager, SCE CRE • Senior Advisors, SCE CRE • Consulting Engineer, SCE Generation • Engineer 3, SCE Transmission & Distribution (T&D)
Relevant Experience of SME(s)	• The CRE SMEs collectively have over 75 years of experience in facilities management, mechanical and building engineering, operational maintenance of all building components including FLS and electrical systems, and architectural design and structural construction management experience (including coordination of structural, mechanical, electrical and FLS systems). • CRE Director has over 20 years of experience establishing capital construction budgets. • CRE Principal Manager and Senior Advisor SMEs are active members of IFMA, possess professional certifications such as Certified Facility Manager (CFM), and engage in benchmarking with other utilities via the Western Utilities Group. • Generation SME has 18 years of research and professional experience in the area of seismic risk, including seismic source characterization, probabilistic seismic hazard modeling, finite-element modeling of the seismic response of structures, and probabilistic loss estimation. • T&D SME has 10 years of experience in substation engineering, including 3 years of experience in seismic analysis.

This Page Intentionally Left Blank

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 5
Contact with Energized Equipment

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 5
Contact with Energized Equipment

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Contact with Energized Equipment
Workpaper:	Baseline Risk Modeling Inputs

Legend

Distribution	Input 1	Input 2	Input 3
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

The data and descriptions below represent an aggregation of the two bowties described in the testimony.

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Equipment Cause	206.0	206.0	206.0	206.0	206.0	206.0	SCE annualized data for wire down events (drivers D1 through D5) is based on SCE's Wire-Down database covering years 2015-2017. SCE annualized data for Third Party Contact events (driver D6) is based on SCE internal records regarding injuries or fatalities involving overhead equipment collected from 2008 - 2016.
	D2	Equipment/ Facility Contact	773.0	773.0	773.0	773.0	773.0	773.0	
	D3	SCE Work/ Operation	7.0	7.0	7.0	7.0	7.0	7.0	
	D4	Unknown	168.0	168.0	168.0	168.0	168.0	168.0	
	D5	Downstream Equipment	0.0	0.0	0.0	0.0	0.0	0.0	
	D6	Third Party Contact	5.1	5.1	5.1	5.1	5.1	5.1	

	ID	Name	2018	2019	2020	2021	2022	2023	Source/ Justification
Triggering Event Frequency	TEF	Potential Contact with Energized Equipment	1159.1	1159.1	1159.1	1159.1	1159.1	1159.1	The TEF is the sum of the driver frequencies.

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Energized Wire-Down	31.3%	362.80	SCE created two outcomes O1 & O2, based on SCE's Wire Down Database covering years May 2014 through 2017.
	O2	De-Energized Wire-Down	68.3%	791.67	SCE assumed that where energized status was unknown, 60% were allocated towards Energized & 40% were allocated towards De-Energized wire down events.

	O3	Intact Energized Wire Contact	0.4%	4.64	SCE created one outcome O3 based on SCE internal records regarding injuries or fatalities involving overhead equipment collected from 2008 through 2016.

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences	O1	Serious Injuries	Triangular	0.000	0.000	0.00919	SCE chose a triangular distribution since this is not a long "tail" consequence. SCE reviewed internal records regarding injuries involving overhead equipment (wire-down) collected from 2008 - 2016. The distribution was scaled to match the annual mean.
	O1	Fatalities	Triangular	0.000	0.000	0.00738	SCE chose a triangular distribution since this is not a long "tail" consequence. SCE reviewed internal records regarding fatalities involving overhead equipment (wire-down) collected from 2008 - 2016. The distribution was scaled to match the annual mean.
	O1	Reliability	Exponential	100,539	N/A	N/A	SCE reviewed ODRM and Wire-Down database records to identify reliability consequences associated with wire down events.
	O1	Financial	Lognormal	$4,033.00	$1,339.00	N/A	Due to limited data availability, for purposes of this modeling effort, SCE developed a preliminary estimated distribution of financial consequences associated with equipment repair costs, where the mean was $4,033. The distribution was developed based on a low/medium/high estimate of the repair cost of a wire down.
	O2	Reliability	Exponential	100,539	N/A	N/A	See O1 - Reliability
	O2	Financial	Lognormal	$4,033.00	$1,339.00	N/A	See O1 - Financial
	O3	Serious Injuries	Triangular	0.000	0.000	1.68677	SCE chose a triangular distribution since this is not a long "tail" consequence. SCE reviewed internal records regarding injuries involving overhead equipment (contact with intact conductor) collected from 2008 - 2016. The distribution was scaled to match the annual mean.
	O3	Fatalities	Triangular	0.000	0.000	1.17647	SCE chose a triangular distribution since this is not a long "tail" consequence. SCE reviewed internal records regarding fatalities involving overhead equipment (contact with intact conductor) collected from 2008 - 2016. The distribution was scaled to match the annual mean.

Chapter	Contact with Energized Equipment

Drivers	
ID	Name
D1	Equipment Cause
D2	Equipment / Facility Contact
D3	SCE Work / Operation
D4	Unknown
D5	Downstream Equipment
D6	Third Party Contact

Outcomes	
ID	Name
O1	Energized Wire Down
O2	De-Energized Wire Down
O3	Energized Wire Contact

Controls & Mitigations	
ID	Name
C1	Overhead Conductor Program (OCP)
C1a	Overhead Conductor Program (OCP) Utilizing Targeted Covered Conductor
C2	Public Outreach
M1	Overhead Conductor Program (OCP) Utilizing Covered Conductor
M2	Comprehensive Branch Line Fusing
M3	Targeted Underground Conversion
M4	Infrared Inspections
M5	Wildfire Covered Conductor Program

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Overhead Conductor Program (OCP)

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	10.9%	21.7%	31.7%	39.7%	47.5%	55.9%	See Page 1 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	3.0%	6.0%	8.8%	11.0%	13.2%	15.5%	See Page 1 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Energized Wire	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Down	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
De-Energized	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Wire Down	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Energized Wire	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Contact	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	C1a Overhead Conductor Program (OCP) Utilizing Targeted Covered Conductor

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.0%	0.0%	0.0%	0.6%	1.2%	1.9%	See Page 2 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	0.0%	0.0%	0.0%	0.4%	0.8%	1.2%	See Page 2 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	See Page 8 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
Energized Wire Down	Fatalities	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	See Page 8 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
De-Energized Wire Down	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Energized Wire Contact	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	C2 Public Outreach

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	0.6%	1.2%	1.8%	2.4%	3.0%	3.6%	See Page 9 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total.
Energized Wire Down	Fatalities	0.6%	1.2%	1.8%	2.4%	3.0%	3.6%	See Page 9 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
De-Energized Wire Down	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3	Serious Injuries	0.6%	1.2%	1.8%	2.4%	3.0%	3.6%	See Page 9 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total.
Energized Wire Contact	Fatalities	0.6%	1.2%	1.8%	2.4%	3.0%	3.6%	See Page 9 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M1 Overhead Conductor Program (OCP) Utilizing Covered Conductor

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	6.0%	12.0%	17.5%	22.5%	27.3%	32.4%	See Page 3 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	3.7%	7.4%	10.8%	13.8%	16.8%	19.9%	See Page 3 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	0.9%	1.8%	2.7%	3.4%	4.2%	4.9%	See Page 10 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
Energized Wire Down	Fatalities	0.9%	1.8%	2.7%	3.4%	4.2%	4.9%	See Page 10 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
De-Energized Wire Down	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
Energized Wire Contact	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M2 Comprehensive Branch Line Fusing

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.0%	0.0%	0.7%	1.3%	2.0%	2.6%	See Page 4 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total based on year-by-year deployment rates beginning in 2020.
D2	Equipment / Facility Contact	0.0%	0.0%	0.8%	1.6%	2.4%	3.3%	See Page 4 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linearly increasing to the 2023 total based on year-by-year deployment rates beginning in 2020.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 De-Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3 Energized Wire Contact	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M3 Targeted Underground Conversion

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.1%	0.3%	0.4%	0.5%	0.6%	0.8%	See Page 5 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	0.1%	0.3%	0.4%	0.5%	0.6%	0.8%	See Page 5 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D3	SCE Work / Operation	0.1%	0.3%	0.4%	0.5%	0.6%	0.8%	See Page 5 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D4	Unknown	0.1%	0.3%	0.4%	0.5%	0.6%	0.8%	See Page 5 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2 De-Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3 Energized Wire Contact	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M4 Infrared Inspections

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	7.3%	14.6%	21.8%	29.1%	36.4%	43.7%	See Page 6 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 De-Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3 Energized Wire Contact	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M5 Wildfire Covered Conductor Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.2%	0.5%	1.8%	3.4%	5.1%	7.5%	See Page 7 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Equipment / Facility Contact	0.1%	0.3%	1.1%	2.1%	3.1%	4.6%	See Page 7 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D3	SCE Work / Operation	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	Downstream Equipment	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	Third Party Contact	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Energized Wire Down	Serious Injuries	0.2%	0.3%	1.2%	1.5%	1.8%	2.2%	See Page 11 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Fatalities	0.2%	0.3%	1.2%	1.5%	1.8%	2.2%	See Page 11 of "WP Ch. 5 - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 De-Energized Wire Down	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O3 Energized Wire Contact	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Control C1: Overhead Conductor Program (OCP) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
C1: Overhead Conductor Program (OCP)	1,965 OH circuit miles reconductored in 2018 - 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	5.5%	90%	4.9%	12.5	61.3%	50	55.9%
		D1b	Equipment Cause - Other	65	5.5%	80%	4.4%	12.5	54.5%	30	
		D1c	Equipment Cause - Pole	11	5.5%	0%	0.0%	12.5	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	5.5%	55%	3.0%	12.5	37.3%	33	15.5%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	5.5%	32%	1.8%	12.5	22.0%	87	
		D2c	Equipment/Facility Contact - Other	39	5.5%	46%	2.5%	12.5	31.0%	27	
		D2d	Equipment/Facility Contact - Vegetation	171	5.5%	24%	1.3%	12.5	16.0%	144	
		D2e	Equipment/Facility Contact - Vehicle	206	5.5%	0%	0.0%	12.5	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	5.5%	28%	1.5%	12.5	18.9%	157	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the C1: Overhead Conductor Program (OCP), a total of 1,965 OH circuit miles will be reconductored by 2023. The 5.5% deployment value is calculated by taking the ratio of expected OH circuit miles to be reconductored (1,965) against the total OH circuit miles in SCE's distribution system (36,040). 1,965 OH circuit miles completed ÷ 36,040 OH circuit miles = ~5.5% deployment
Note 3	The Mitigation Effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. There are five (5) broad categories of assumptions that SMEs used to develop mitigation effectiveness: 1. Arcing & melting are the two failure modes for overhead conductor. 2. Reconductoring is assumed to be 50% effective against arc failures and 90% effective against melt failures. 3. Branch Line Fusing (BLF) is assumed to be 0% effective against arc failures and 90% effective against melt failures. 4. SCE made different assumptions for the mix of failure modes for each individual driver. 5. As needed, further adjustments were made to account for the deployment of both reconductoring and BLF mitigations in order to avoid double counting of benefits. The net effect of all the assumptions listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Based on previous risk analysis, the expected risk reduction for the scope considered under this program (1,965 OH circuit miles representing ~5.5% of SCE's distribution system) would be approximately 20% of baseline wir down risk. This 20% risk reduction was based on analysis considering frequency reduction only. SCE estimated that a driver reduction of 235 would reasonably approximate a 20% frequency reduction. Therefore the targeting benefit was adjusted until the difference between Column A and Column G was 235. Because the mitigation effectiveness is not the same for all sub-drivers, the 20% frequency reduction was not achieved by an explicit targeting multiplier but by an aggregate 235 driver reduction. The targeting benefit was adjusted until the difference between Column A and Column G was 235 events. This final "equivalent targeting multiplier" was approximately 12.5.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied l the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C1a: Covered Conductor (10% within OCP Scope) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
C1a: Covered Conductor (10% within OCP Scope)	80 OH circuit miles reconductored with covered conductor in 2018 - 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	0.2%	90%	0.2%	10.5	2.1%	127	1.9%
		D1b	Equipment Cause - Other	65	0.2%	75%	0.2%	10.5	1.7%	64	
		D1c	Equipment Cause - Pole	11	0.2%	0%	0.0%	10.5	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	0.2%	100%	0.2%	10.5	2.3%	52	1.2%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	0.2%	100%	0.2%	10.5	2.3%	108	
		D2c	Equipment/Facility Contact - Other	39	0.2%	32%	0.1%	10.5	0.7%	39	
		D2d	Equipment/Facility Contact - Vegetation	171	0.2%	100%	0.2%	10.5	2.3%	167	
		D2e	Equipment/Facility Contact - Vehicle	206	0.2%	0%	0.0%	10.5	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	0.2%	18%	0.0%	10.5	0.4%	192	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the C1a: Covered Conductor (CC) mitigation program, OCP projects will not incorporate CC replacements until 2021 and beyond. Beginning in 2021 and each year after, 10% of OCP scope will include CC replacements. A total of 80 OH circuit miles will be recoductored with CC by 2023. The 0.2% deployment value is calculated by taking the ratio of expected OH circuit miles to be reconductored with CC (80) under the C1a: CC program against the total OH circuit miles in SCE's distribution system (36,040). 80 OH circuit miles completed ÷ 36,040 OH circuit miles = ~0.2% deployment
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. There are four (4) broad categories of assumptions that SMEs used to develop mitigation effectiveness: 1. Arcing & melting are the two failure modes for overhead conductor. 2. Reconductoring with covered conductor is assumed to be 50% effective against arc failures and 90% effective against melt failures. 3. If no arcing occurs when non-electric materials contact the covered conductor, mitigation effectiveness would be 100% 4. SCE made different assumptions for the mix of failure modes for each individual driver.D22 The net effect of all the assumptions listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Based on previous risk analysis, the expected risk reduction for the scope considered under this program (80 OH circuit miles representing ~0.2% of SCE's distribution system) would be approximately 2% of baseline wire down risk. This 2% risk reduction was based on analysis considering both frequency reduction and consequence reduction; for the purposes of this analysis, SCE allocated approximately 1% to frequency. SCE estimated that a driver reduction of 13 would reasonably approximate a 1% frequency reduction. Therefore the targeting benefit was adjusted until the difference between Column A and Column G was 13. Because the mitigation effectiveness is not the same for all drivers and sub-drivers, the 1% risk reduction was not achieved by an explicit targeting multiplier but by an aggregate 1% driver reduction. The targeting benefit was adjusted until the difference between Column A and Column G was 13 events. This final "equivalent targeting multiplier" was approximately 10.5.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M1: Covered Conductor (100% within OCP Scope) - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column E	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M1a: Covered Conductor (100% within OCP Scope)	1,749 OH circuit miles reconductored with covered conductor by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	4.9%	90%	4.4%	8.3	36.3%	83	32.4%
		D1b	Equipment Cause - Other	65	4.9%	75%	3.6%	8.3	30.2%	45	
		D1c	Equipment Cause - Pole	11	4.9%	0%	0.0%	8.3	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	4.9%	100%	4.9%	8.3	40.3%	32	19.9%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	4.9%	100%	4.9%	8.3	40.3%	66	
		D2c	Equipment/Facility Contact - Other	39	4.9%	32%	1.5%	8.3	12.7%	34	
		D2d	Equipment/Facility Contact - Vegetation	171	4.9%	100%	4.9%	8.3	40.3%	102	
		D2e	Equipment/Facility Contact - Vehicle	206	4.9%	0%	0.0%	8.3	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	4.9%	18%	0.9%	8.3	7.3%	179	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the M1a: Covered Conductor (CC) mitigation program, 100% of the Overhead Conductor Program (OCP) scope will be replaced with CC per ongoing year of the program. A total of 1,749 OH circuit miles will be reconductored by 2023. The 4.9% deployment value is calculated by taking the ratio of expected OH circuit miles to be replaced (1,749) under the M1a: CC program against the total OH circuit miles in SCE's distribution system (36,040). 1,749 OH circuit miles completed ÷ 36,040 OH circuit miles = ~4.9% deployment
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. There are four (4) broad categories of assumptions that SMEs used to develop mitigation effectiveness: 1. Arcing & melting are the two failure modes for overhead conductor. 2. Reconductoring with covered conductor is assumed to be 50% effective against arc failures and 90% effective against melt failures. 3. If no arcing occurs when non-electric materials contact the covered conductor, mitigation effectiveness would be 100% 4. SCE made different assumptions for the mix of failure modes for each individual driver. The net effect of all the assumptions listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Based on previous risk analysis, the expected risk reduction for the scope considered under this program (1,749 OH circuit miles representing ~4.9% of SCE's distribution system) would be approximately 23% of baseline wir down risk. This 23% risk reduction was based on analysis considering both frequency reduction and consequence reduction; for the purposes of this analysis, SCE allocated approximately 19% to frequency. SCE estimated that a driver reduction of 221 would reasonably approximate a 19% frequency reduction. Therefore the targeting benefit was adjusted until the difference between Column A and Column G was 221. Because the mitigation effectiveness is not the same for all drivers and sub-drivers, the 19% frequency reduction was not achieved by an explicit targeting multiplier but by an aggregate 19% driver reduction. The targeting benefit was adjusted until the difference between Column A and Column G was 221 events. This final "equivalent targeting multiplier" was approximately 8.3.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M2: Comprehensive Branch Line Fusing - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M2: Comprehensive Branch Line Fusing	15,000 OH circuit miles fused by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	41.6%	0%	0.0%	1.0	0.0%	130	2.6%
		D1b	Equipment Cause - Other	65	41.6%	20%	8.4%	1.0	8.4%	60	
		D1c	Equipment Cause - Pole	11	41.6%	0%	0.0%	1.0	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	41.6%	25%	10.5%	1.0	10.5%	47	3.3%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	41.6%	0%	0.0%	1.0	0.0%	111	
		D2c	Equipment/Facility Contact - Other	39	41.6%	20%	8.5%	1.0	8.5%	36	
		D2d	Equipment/Facility Contact - Vegetation	171	41.6%	10%	4.1%	1.0	4.1%	164	
		D2e	Equipment/Facility Contact - Vehicle	206	41.6%	0%	0.0%	1.0	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	41.6%	12%	4.8%	1.0	4.8%	184	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the M2: Comprehensive Branch Line Fusing mitigation program, 3,750 OH circuit miles will be fused per year beginning in 2020 until 2023. A total of 15,000 OH circuit miles will be fused by 2023. The 41.6% deployment value is calculated by taking the ratio of OH circuit miles that will be fused (15,000) under the M2: Comprehensive Branch Line Fusing program against the total OH circuit miles in SCE's distribution system (36,040). 15,000 OH circuit miles completed ÷ 36,040 OH circuit miles = ~41.6% deployment
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. There are three (3) broad categories of assumptions that SMEs used to develop mitigation effectiveness: 1. Arcing & melting are the two failure modes for overhead conductor. 2. Branch Line Fusing (BLF) is assumed to be 0% effective against arc failures and 90% effective against melt failures. 3. SCE made different assumptions for the mix of failure modes for each individual driver: The net effect of all the assumptions listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). A targeting benefit of 1.0 assumes that there is no targeting benefit associated.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M3: Underground Cable (10% of OCP) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M3: Underground (UG) Cable (10% of OCP)	27 OH circuit miles converted to UG circuit miles by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	0.1%	100%	0.1%	10.0	0.8%	129	0.8%
		D1b	Equipment Cause - Other	65	0.1%	100%	0.1%	10.0	0.8%	65	
		D1c	Equipment Cause - Pole	11	0.1%	100%	0.1%	10.0	0.8%	11	
		D2a	Equipment/Facility Contact - Animal	53	0.1%	100%	0.1%	10.0	0.8%	53	0.8%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	0.1%	100%	0.1%	10.0	0.8%	110	
		D2c	Equipment/Facility Contact - Other	39	0.1%	100%	0.1%	10.0	0.8%	39	
		D2d	Equipment/Facility Contact - Vegetation	171	0.1%	100%	0.1%	10.0	0.8%	170	
		D2e	Equipment/Facility Contact - Vehicle	206	0.1%	100%	0.1%	10.0	0.8%	204	
		D2f	Equipment/Facility Contact - Weather	193	0.1%	100%	0.1%	10.0	0.8%	192	
		D3	SCE Work/Operation	7	0.1%	100%	0.1%	10.0	0.8%	7	0.8%
		D4	Unknown	168	0.1%	100%	0.1%	10.0	0.8%	167	0.8%
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the M3: Underground (UG) Cable mitigation program, 10% of the Overhead Conductor Program (OCP) scope will be converted to UG circuit miles per ongoing year of the program. A total of 27 OH circuit miles will be converted to UG circuit miles by 2023. The 0.1% deployment value is calculated by taking the ratio of OH circuit miles that will be converted to UG circuit miles (27.4) under the M3: UG Cable program against the total OH circuit miles in SCE's distribution system (36,040). 27.4 OH circuit miles completed ÷ 36,040 OH circuit miles = ~0.1% deployment
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. SMEs develope the mitigation effectiveness on the program scope based on the assumption below: 1. Undergrounding is assumed to be 100% effective against wire downs. The net effect of all the assumption listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Based on the "equivalent targeting benefit" calculated for C1a, SCE estimated that an "equivalent targeting benefit" for M3 would be comparable for the small amount of scope assumed. For this purpose, SCE assumed a 10.0 "equivalent targeting benefit" for M3. Based on this, the difference between Column A and Column G was 9 events, or an overall driver reduction of ~0.8%.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M4: Infrared Scanning - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M4: Infrared scanning	15000 OH circuit miles located in Non High Fire Areas (NHFA) infrared scanned twice by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	200.0%	35%	69.2%	1.0	69.2%	40	43.7%
		D1b	Equipment Cause - Other	65	200.0%	0%	0.0%	1.0	0.0%	65	
		D1c	Equipment Cause - Pole	11	200.0%	0%	0.0%	1.0	0.0%	11	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles, where 15,000 OH circuit miles are located in Non High Fire Areas (NHFA) that need to be infrared scanned. Under the M4: Infrared Scanning mitigation program, 5,000 OH circuit miles will be scanned per year; totaling to 30,000 OH circuit miles scanned by 2023. SCE's NHFA will be scanned twice upon completion of the program. The 200% deployment value is calculated by taking the ratio of OH circuit miles that will be infrared scanned (30,000) under the M4: Infrared Scanning program against the total OH circuit miles in SCE's distribution system located in NHFA that need to be scanned (15,000). 30,000 OH circuit miles completed ÷ 15,000 NHFA OH circuit miles = 200% deployment
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. SMEs develope the mitigation effectiveness on the program scope based on the assumption below: 1. Based on results from SCE's initial program pilot, infrared scanning OH equipment for hot components in NHFA is expected to avoid an average of 45 wire down events associated with Equipment Cause - Connector/Splice/Wire drivers. 45 failures avoided ÷130 failures per year = 35% mitigation effectiveness.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). A targeting benefit of 1.0 assumes that there is no targeting benefit associated.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M5: Wildfire Covered Conductor Program - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M5: Wildfire Covered Conductor Program (WCCP) SCD scope	945 OH circuit miles reconductored with covered conductor by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	2.6%	90%	2.4%	2.0	4.7%	124	4.2%
		D1b	Equipment Cause - Other	65	2.6%	75%	2.0%	2.0	3.9%	62	
		D1c	Equipment Cause - Pole	11	2.6%	0%	0.0%	2.0	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	2.6%	100%	2.6%	2.0	5.2%	50	2.6%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	2.6%	100%	2.6%	2.0	5.2%	105	
		D2c	Equipment/Facility Contact - Other	39	2.6%	32%	0.8%	2.0	1.7%	38	
		D2d	Equipment/Facility Contact - Vegetation	171	2.6%	100%	2.6%	2.0	5.2%	162	
		D2e	Equipment/Facility Contact - Vehicle	206	2.6%	0%	0.0%	2.0	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	2.6%	18%	0.5%	2.0	1.0%	191	
M5: Wildfire Covered Conductor Program (WCCP) CFO scope	1,481 OH circuit miles reconductored with covered conductor by 2023	D1a	Equipment Cause - Connector/Splice/Wire	130	4.1%	90%	3.7%	1.0	3.7%	125	3.3%
		D1b	Equipment Cause - Other	65	4.1%	75%	3.1%	1.0	3.1%	63	
		D1c	Equipment Cause - Pole	11	4.1%	0%	0.0%	1.0	0.0%	11	
		D2a	Equipment/Facility Contact - Animal	53	4.1%	100%	4.1%	1.0	4.1%	51	2.0%
		D2b	Equipment/Facility Contact - Mylar Balloon	111	4.1%	100%	4.1%	1.0	4.1%	106	
		D2c	Equipment/Facility Contact - Other	39	4.1%	32%	1.3%	1.0	1.3%	38	
		D2d	Equipment/Facility Contact - Vegetation	171	4.1%	100%	4.1%	1.0	4.1%	164	
		D2e	Equipment/Facility Contact - Vehicle	206	4.1%	0%	0.0%	1.0	0.0%	206	
		D2f	Equipment/Facility Contact - Weather	193	4.1%	18%	0.7%	1.0	0.7%	192	
										D1 combined (D1 SCD + D1 CFO)	7.5%
										D2 combined (D2 SCD + D2 CFO)	4.6%
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The Initial Driver Frequency values are reflective upon a 3 year historical average from 2015-2017 and are derived from the SCE Wire Down Database, which contains descriptive records of all wire down incidents. The values are associated with Distribution wire down incidents involving only 'Primary' line type classifications. Distribution wire down incidents associated with other line type classifications such as 'Secondary' and 'Unknown' are excluded.
Note 2	The Deployment value represents the overall percentage of mitigation / control program execution at full deployment across the 6 year 2018 - 2023 timeframe. SCE's distribution system is composed of approximately 36,040 overhead (OH) circuit miles. Under the M5: Wildfire Covered Conductor Program (WCCP), a total of 2,426 OH circuit miles will be reconductored with covered conductor by 2023. This consists of 945 OH circuit miles targeting short circuit duty (SCD) associated risk areas and 1,481 OH circuit miles targeting contact from object (CFO) associated risk areas. The SCD ~2.6% deployment value is calculated by taking the ratio of expected OH circuit miles to be replaced (945) under the M5: WCCP (SCD) program against the total OH circuit miles in SCE's distribution system (36,040). 945 OH circuit miles completed ÷ 36,040 OH circuit miles = ~2.6% deployment (SCD) The SCD ~4.1% deployment value is calculated by taking the ratio of expected OH circuit miles to be replaced (1,481) under the M5: WCCP (CFO) program against the total OH circuit miles in SCE's distribution system (36,040). 1,481 OH circuit miles completed ÷ 36,040 OH circuit miles = ~4.1% deployment (CFO)
Note 3	The mitigation effectiveness percentage values per driver are based on SCE Distribution Engineering's subject matter expert (SME) informed input on overall effectiveness for when the mitigation is deployed. There are four (4) broad categories of assumptions that SMEs used to develop mitigation effectiveness: 1. Arcing & melting are the two failure modes for overhead conductor. 2. Reconductoring with covered conductor is assumed to be 50% effective against arc failures and 90% effective against melt failures. 3. If no arcing occurs when non-electric materials contact the covered conductor, mitigation effectiveness would be 100% 4. SCE made different assumptions for the mix of failure modes for each individual driver. The net effect of all the assumptions listed above resulted in the percentages shown under Column C.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation / control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). The SCD targeting benefit of 2.0 assumes a higher targeting benefit compared to 'Random Walk' because the program is targeting SCD associated risk areas directly. The CFO targeting benefit of 1.0 assumes that there is no targeting benefit applied from this program.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A - (Column A * Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C1a: Covered Conductor (10% within OCP Scope) - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Consequence	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Consequence)
C1a: Covered Conductor (10% within OCP Scope)	80 OH circuit miles reconductored with covered conductor in 2018 - 2023		Modeled as a consequence mitigation against energized wire down risk outcome affecting the safety (injury / fatality) risk dimensions **~0.2% reduction in safety consequence of Energized Wire Down (O1)**								
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note	Under the C1a: Covered Conductor program, 10% within OCP scope will be reconductored with covered conductor. Covered conductor is expected to mitigate the energize wire down risk outcome and to provide consequence mitigation benefits across the safety (injury / fatality) risk dimensions. At 10% of OCP scope, approximately 80 OH circuit miles are expected to be reconductored with covered conductor within the 6 year time frame. SCE's distribution system is composed of approximately 36,040 OH circuit miles. Within the system, there is approximately an SCD equivalent of 21,250 affected OH circuit miles. 80 OH circuit miles completed ÷ 21,250 OH circuit miles = ~0.4% deployment The mitigation effectiveness is SME-informed and tied to the ability of covered conductor to mitigate the consequence of energized wire downs within SCE's service territory. For purposes of modeling this mitigation, the overall effectiveness was assumed to be tied to its deployment pattern. At full deployment, it was assumed that covered conductor could, at most, mitigate energized wire down consequences by 60%. As such, the overall reduction in consequence is calculated by taking the deployment value and multiplying it by the mitigation effectiveness: ~0.4% deployment * 60% mitigation effectiveness = ~0.2% reduction in consequence

Control C2: Public Outreach - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver	Consequence	Initial Driver	Deployment	Mitigation	Mitigation Percent	Targeting Benefit	Mitigation Percent	Final Driver	Mitigation
C2: Public Outreach	Promote electric utility hazard awareness and prevention education among affected at-risk audiences		Modeled as a consequence mitigation against energized wire down and intact energized wire contact risk outcomes affecting the safety (injury / fatality) risk dimensions **~3.6% reduction in safety consequence of Energized Wire Down (O1) and Intact Energized Wire Down Contact (O3)**								

Note	The C2: Public Outreach control program will promote electric utility hazard awareness and prevention education among affected at-risk audiences; thereby helping to reduce incidents, prevent injury, and save lives. At-risk audiences consist of utility employees, 3rd party contractors, etc. whom have high influence in experiencing risks such as energized wire down or contact with energized downed wire events. This program is effective against the energized wire down and intact energized wire contact risk outcomes, which correspondingly affects both the safety injury / fatality risk dimensions. A ~3.6% reduction in consequence is expected at the end of 6 years in program implementation. Reduction in consequence for this program is modeled after survey data collected by the Culver Company, a company focused on developing public outreach programs for utility companies, who SCE has partnered with to execute this program. Below is collected data used for the program's effectiveness calculation: 1. The U.S Utilities average for At-Risk workers to recall safety messages after receiving mailing is 26% 2. The U.S Utilities average for At-Risk workers to identify safety hazards from retention of outreach material unaided is 14% Program effectiveness is calculated as: 26% recall * 14% unaided recall = ~3.6% mitigation percent by 2023

Mitigation M1: Covered Conductor (100% within OCP Scope) - Consequence Analysis

Mitigation	Mitigation Scope	Driver ID	Consequence	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Consequence)
M1a: Covered Conductor (100% within OCP Scope)	1,749 OH circuit miles reconductored with covered conductor by 2023		Modeled as a consequence mitigation against energized wire down risk outcome affecting the safety (injury / fatality) risk dimensions **~4.9% reduction in safety consequence of Energized Wire Down (O1)**								

Note	Under the C1a: Covered Conductor program, 10% within OCP scope will be reconductored with covered conductor. Covered conductor is expected to mitigate the energize wire down risk outcome and to provide consequence mitigation benefits across the safety (injury / fatality) risk dimensions. At 100% of OCP scope, approximately 1749 OH circuit miles are expected to be reconductored with covered conductor within the 6 year time frame. SCE's distribution system is composed of approximately 36,040 OH circuit miles. Within the system, there is approximately an SCD equivalent of 21,250 affected OH circuit miles. The mitigation effectiveness is SME-informed and tied to the ability of covered conductor to mitigate the consequence of energized wire downs within SCE's service territory. For purposes of modeling this mitigation, the overall effectiveness was assumed to be tied to its deployment pattern. At full deployment, it was assumed that covered conductor could, at most, mitigate energized wire down consequences by 60%. As such, the overall reduction in consequence is calculated by: (1,749 OH circuit miles completed ÷ 21,250 OH SCD equivalent circuit miles) * 60% mitigation effectiveness = ~4.9% reduction in consequence

Mitigation M5: Wildfire Covered Conductor Program - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Consequence	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Consequence)
M5: Wildfire Covered Conductor Program (WCCP)	2,426 total OH circuit miles reconductored with covered conductor by 2023		Modeled as a consequence mitigation against energized wire down risk outcome affecting the safety (injury / fatality) risk dimensions **~2.2% reduction in safety consequence of Energized Wire Down (O1)**								

Note	Under M5 (WCCP), covered conductor is expected to provide consequence mitigation benefits across the safety (injury / fatality) risk dimensions for wire down events. SCE's distribution system is composed of approximately 36,040 OH circuit miles. Within the system, there is approximately an SCD equivalent of 21,250 affected OH circuit miles. By the end of year 5, WCCP will have reconductored 1707 miles, and an additional 709 miles will be reconductored in year 6 (2,426 miles total). The mitigation effectiveness is SME-informed and tied to the ability of covered conductor to mitigate the consequence of energized wire downs within SCE's service territory. For purposes of modeling this mitigation, the overall effectiveness was assumed to be tied to its deployment pattern. At full deployment, it was assumed that covered conductor could, at most, mitigate energized wire down consequences by 60%. The Y6 reduction in consequence is calculated by: 719 OH circuit miles completed in Y6 ÷ (21,250 OH SCD equivalent circuit miles - 1,707 OH SCD circuit miles mitigated through Y5) * 60% mitigation effectiveness = 2.2% reduction in consequence

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 6
Cyberattack

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 6
Cyberattack

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

Chapter:	Cyberattack
Workpaper:	Baseline Risk Modeling Inputs

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	External Actor	5.95	6.74	7.62	8.63	9.77	11.06	SCE sourced control system intrusions resulting from the Triggering Event to each of the three drivers based on knowledge of where cyber-attacks generally originate today. SCE has found that in many cases, applicable and available industry reports differ in their sourcing of cyber-attack incidents. Therefore, SCE has leveraged subject matter expertise and the qualitative assertions of industry reports to estimate the incident source by SCE driver for 2018 (for example, Idaho National Laboratory 2016 report on Cyber Threat and Vulnerability Analysis of the U.S. Electric Sector. (https://www.energy.gov/sites/prod/files/2017/01/f34/Cyber%20Threat%20and%20Vulnerability%20Analysis%20of%20the%20U.S.%20Electric%20Sector.pdf) . SCE applied annualized growth rates to each driver as follows: D1 – External Actor: 13% annual growth rate consistent with the overall linear trending growth rate for ICS-CERT incidents, adjusted to account for unreported events and growth in frequency if SCE were to stop implementing existing cyber controls over the RAMP period. D2 – Insider Threat: SCE projects the annual growth rate to remain flat, as we expect this risk driver in the context of the utility industry will remain relatively the same over the RAMP time period. D3 – Supply Chain: 20% annual growth rate (1.5 times the rate of growth of External Actor), as attackers are focusing more attention on supply chain cybersecurity as a means to start an attack, and to provide greater detection avoidance relative to a direct cyberattack against the utility.
	D2	Insider Threat	0.70	0.70	0.70	0.70	0.70	0.70	
	D3	Supply Chain	0.35	0.42	0.50	0.60	0.72	0.86	

	ID	Name	2018	2019	2020	2021	2022	2023	Source/Justification

Triggering Event Frequency	**TEF**	Compromise of SCE System Controls	7.0	7.9	8.8	9.9	11.2	12.6	SCE obtained the number of reported critical infrastructure incidents by year from National Coordinating Center for Communications Integration Center (NCCIC) and Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) Annual Review Reports (https://ics-cert.us-cert.gov/Other-Reports). These organizations operate under the direction of the Department of Homeland Security (DHS). SCE then filtered this data for incidents within the Energy Sector. SCE then used data from these reports, as well as information substantiated through the SANS - Securing Industrial Control Systems 2017 Report, to determine that approximately 12% of ICS/SCADA security incidents result in the actual intrusion into control systems (https://www.sans.org/reading-room/whitepapers/analyst/securing-industrial-control-systems-2017-37860).

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	No impact to service or data	84.0%	5.88	To develop the probability of occurrence of each outcome, SCE surveyed internal and external experts who have extensive knowledge of utility cyber attacks. These experts considered historical events and forecast potential future impacts of cyber attacks facing the electric sector to define these probabilities over the RAMP period.
	O2	Exfiltration of ICS/SCADA/CEII data	11.0%	0.77	
	O3	Loss of control with denial of use of electrical systems	3.5%	0.25	
	O4	Adversary control with disruption to electrical systems	1.0%	0.07	
	O5	Adversary control with physical damage to /destruction of electrical system	0.5%	0.04	

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
	O1	Financial	Uniform	$0	$52,600	N/A	The financial consequences for this outcome are based on the estimated approximate costs to remediate a cyber breach. The 2017 "Cost of Cyber Crime" study was developed by Ponemon Institute LLC and Accenture (https://www.accenture.com/t20170926T072837Z__w__/us-en/_acnmedia/PDF-61/Accenture-2017-CostCyberCrimeStudy.pdf). According to the study, the utilities and energy industry sector had an average annualized cost of $17.2 million for such breaches (see p. 20). Using the 2017 ICS-CERT forecast incident count of 327, which is based on a simple trend analysis, this creates an average annualized cost per incident of $52,600.

Consequences	O2	Financial	Uniform	$3,620,000	$7,400,000	N/A	The financial consequence of this more serious outcome was based on evaluating the estimated costs to remediate a breach and exfiltration of data from our systems. According to a report by the Ponemon Institute (https://public.dhe.ibm.com/common/ssi/ecm/se/en/sel03130wwen/security-ibm-security-services-se-research-report-sel03130wwen-20180122.pdf) and a related Data Risk Calculator from IBM (https://databreachcalculator.mybluemix.net/), the cost for a data breach in the Energy Industry ranges from $3.4 million to $7.4 million depending on the number of compensating controls in-place for the specific energy utility. These costs include direct expenses such as hardware, software, and services remediation costs, hiring external data forensics and cybersecurity experts to determine the scope of breach and data compromised, and indirect expenses related to internal investigations and additional audit and assessment activity surrounding the breach.
	O3	Reliability	Exponential	81,000,000	N/A	N/A	To evaluate the reliability consequences of this outcome, SCE leveraged the impacts of the 2015 Ukrenergo power distribution system cyber-attack. This attack, which aligns to the attack paths of this outcome, resulted in approximately 6 hours of electrical outage to 225,000 customers, or 81,000,000 CMI (customer minutes of interruption).
		Financial	Uniform	$3,303,507	$33,035,068	N/A	SCE estimated the cost to recover and/or replace the IT hardware and software systems that would likely be affected after an attack of this magnitude. For this outcome, SCE modeled a range of costs required to repair/replace between 1% and 10% of SCE's server infrastructure.
	O4	Reliability	Exponential	81,000,000	N/A	N/A	To evaluate the reliability consequences of this outcome, SCE leveraged the impacts of the 2015 Ukrenergo power distribution system cyber-attack. This attack, which aligns to the attack paths of this outcome, resulted in approximately 6 hours of electrical outage to 225,000 customers, or 81,000,000 CMI (customer minutes of interruption).
		Financial	Uniform	$3,303,507	$66,070,136	N/A	SCE estimated the cost to recover and/or replace the IT hardware and software systems that would likely be affected after an attack of this magnitude. For this outcome, SCE modeled a range of costs required to repair/replace between 1% and 20% of SCE's server infrastructure.

[redacted]	O5	Serious Injuries	Poisson	1.0	N/A	N/A	SCE evaluated two potential cyber attack scenarios where an adversary obtains control of our grid assets and causes physical damage to, or destruction of, the electrical system. These scenarios include an attack on our hydroelectric system, as well as a coordinated attack on multiple substations. SCE's cybersecurity efforts are focused on protecting critical infrastructure. Therefore, a secure process for disclosing detailed tactics, techniques, and procedures is necessary to help ensure continued security and protection. In an effort to provide the Commission access to the information needed to answer specific questions regarding the cybersecurity risk, mitigations, and cost forecasts, as mentioned above SCE can provide an in-person briefing in a closed setting to provide further information as needed, if needed.
		Fatalities	Poisson	1.0	N/A	N/A	
		Reliability	Exponential	711,403,200	N/A	N/A	
		Financial	Uniform	$47,000,000	$300,000,000	N/A	

Workpaper – Subject Matter Expert Qualifications

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgement is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Cyber**
Risk Analysis Component	• Baseline risk assessment (Drivers, Outcomes, Consequences) • Control and mitigation effectiveness
Does historical data exist at SCE to support the evaluation of this risk analysis component?	SCE and our external partner (Revolutionary Security) leveraged our understanding of the attacks facing the electric utility grid and SCE to inform the estimates used in this chapter. However, SCE-specific historical data was not explicitly used in this analysis.
Additional back-up or sources used by the SME(s) to inform/validate guidance	There are a number of external cybersecurity-related research studies, reports, and analyses that were leveraged to inform this analysis.
SME(s) who have contributed to this analysis	**Internal SCE SMEs:** • Director of Cybersecurity & Compliance • Principal Manager, Cybersecurity • Senior Manager, Cybersecurity • Various Advisors within the Cybersecurity organization **External SMEs from Revolutionary Security:** • President & CEO • Director, Security Assessments & Strategy • Principal Security Consultant, IT & OT Services • Consultants within the Security Assessments & Strategy Practice

Relevant Experience of SME(s)	**Internal SME Experience:** These SMEs have a combined 58 years of experience in the field of information technology with expertise in information security, cybersecurity intelligence and engineering, technology analysis, incident response and forensics, policy development and compliance, security strategy development, risk assessment, and vulnerability management. SMEs collectively possess various professional training, certifications and degrees, including: CRISC (Certified in Risk and Information System Control), CISSP (Certified Information Systems Security Professional) Certifications, technical training in the U.S Navy, and Bachelor's degrees. **External SME Experience:** These SME’s have a combined 63 years of experience in the fields of software engineering, system & network architecture, cybersecurity policy & governance, information security & cybersecurity development and practice, threat intelligence, threat modeling, risk management, vulnerability assessment, penetration testing, and regulatory & compliance within the electric utility, oil & gas, manufacturing, defense contracting, and pharmaceutical industries. SMEs collectively possess various professional training, certifications and degrees, including: GICSP (Global Industrial Cyber Security Professional), CISSP (Certified Information Systems Security Professional), C|EH (Certified Ethical Hacker), Security+, and Network+ certifications, and various Bachelor of Science and Art and Master Degrees.

Summary

SCE partnered with Revolutionary Security, LLC (RevSec),[1] a cybersecurity services firm, to develop a method to assess the risk reduction capabilities of the proposed and alternative controls and mitigations in this RAMP report. This method is based on evaluating how well these controls and mitigations would perform against the various scenarios of cyberattacks contemplated in the Cyberattack RAMP Chapter. The team aligned the steps of those attack scenarios with existing SCE cybersecurity projects to predict their effectiveness in stopping future attack campaigns. This method is based on how controls and mitigations are applied to specific each of the five outcomes in the RAMP chapter, to determine the amount of risk reduced. SCE then took these results and applied then to SCE's RAMP model by modifying the likelihood of each outcome occurring.

Controls & Mitigations

SCE employs a defense-in-depth cybersecurity strategy, which uses multiple layers of protection to prevent unauthorized access and controls of its systems. This strategy involves deploying several programs, implementing processes, and implementing a variety of proactive vulnerability testing, training, and education programs. SCE organizes its cybersecurity defense into six program areas:

- Perimeter Defense
- Interior Defense
- Data Protection
- SCADA Cybersecurity
- Grid Modernization Cybersecurity
- NERC CIP Compliance[2]

Each of these programs protects our business against cyberattacks in different ways. Each program area consists of different projects, each of which was arbitrarily assigned a code for RAMP filing purposes to not disclose sensitive SCE information. One new project (V) was added that applies only to the Alternative Mitigation Plan #2 to address the risk of hardware vulnerabilities similar to Spectre and Meltdown (this is referred to as M1 – Accelerated Hardware Refresh in the chapter).

Program Area	Project Code	Program Area	Project Code
Data Protection	A	Perimeter Defense	L
Data Protection	B	Perimeter Defense	M
Data Protection	C	Perimeter Defense	N
Interior Defense	D	Perimeter Defense	O
Interior Defense	E	SCADA Protection	P
Interior Defense	F	GridMod	Q
Interior Defense	G	GridMod	R

[1] See https://www.revsec.com/ for more information on this firm.
[2] Since NERC CIP compliance is considered a compliance-based control, we did not model this control in the RAMP model.

Program Area	Project Code	Program Area	Project Code
Interior Defense	H	GridMod	S
Interior Defense	I	GridMod	T
Perimeter Defense	J	GridMod	U
Perimeter Defense	K	Accelerated Hardware Refresh	V

Table 1: Program to Project Mapping

Outcomes

SCE identified a range of outcomes that would occur should control systems be compromised. Historical examples of relevant cyber attacks were used to generate the Financial, Reliability, and Safety impacts of each outcome. The examples for Outcomes 1 through 4 are based on real-world events, while Outcome 5 uses two contrived examples based on real-world events. One that focuses on Safety was translated into a hydro-electric power generation environment. The second focuses on Reliability and Financial was based on physical attack against SCE substations and transformers but was translated to a cyber-attack. SCE's Dam Security personnel were consulted in the creation of this Outcome.

Number	Outcome	Examples of Real-World Events
Outcome 1	**No impact to service or data**	Bowman Ave Dam (NY)
Outcome 2	**Exfiltration of CEI data**	BlackEnergy Part of Ukraine 2015
		Ponemon Institute
Outcome 3	**Loss of control with denial of use of electrical systems**	Merck (NotPetya)
		Maersk (NotPetya)
Outcome 4	**Adversary control with disruption to electrical systems**	2015 Ukraine Attack
Outcome 5	**Adversary control with physical damage to /destruction of electrical system**	Cyber Attack on SCE dam resulting in uncontrolled rapid release of water flooding a powerhouse and campground

Table 2: Outcomes & Examples

Risk Reduction Model

The historical examples used as basis for the Outcomes were each deconstructed into a series of attack steps that the adversary performed to achieve their goal. Each attack step was mapped to a current SCE Program Area and Project Code. RevSec Subject Matter Experts (SME) graded the estimated effectiveness of a project at addressing that attack step for each Outcome. This was done using the following scale: 1 (low impact), 2 (minimum effectiveness for attack mitigation), or 3 (highly effective). The following table shows the attack steps for Outcome 1, which has both the shortest number of attack steps and the least impact to SCE operations (financial consequence only).

Attack Number	Attack Step	Control Area	Project Code	Estimated Effective - Mitigation Plan		
				Prop	Alt 1	Alt 2
AD-1	Social engineering (via phishing)	Perimeter Defense	Project J	3	1	3
			Project O	1	1	2
AD-2	Social engineering (via physical implant)	Interior Defense	Project D	3	1	3
AD-3	Malware establishes C2 via some external channel, scales from ftp->http->soap/api->https etc	Perimeter Defense	Project K	3	1	3
			Project L	3	1	3
AD-4	Endpoint is compromised, privilege escalation to system for memory access	Interior Defense	Project H	1	1	2
			Project I	3	1	3
		Accel HW Refresh	Project V	0	0	3
AD-5	End of Scenario	N/A	N/A	N/A	N/A	N/A

Table 3: Outcome 1 Attack Path

The team then aggregated the effectiveness of each control in addressing each outcome. This was used as an input to the RAMP model. The estimated effectiveness for each of the mitigations plans for each Outcome were also totaled, then divided by the maximum value of matched Project Codes to create the percentage of estimated effectiveness shown in the table below.

Estimated Effectiveness as Percentage of Max Value of Outcome Outcome Value / Max Value for Outcome			
Outcome	**Prop**	**Alt #1**	**Alt #2**
O1	71%	29%	92%
O2	71%	31%	90%
O3	65%	31%	90%
O4	64%	31%	94%
O5	70%	31%	94%
Average	**68%**	**31%**	**92%**

Table 4: Percentage of Estimated Effectiveness per Outcome

This Page Intentionally Left Blank

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 7
Employee, Contractor & Public Safety

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 7
Employee, Contractor, and Public Safety

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Employee, Contractor, and Public Safety
Workpaper:	Baseline Risk Modeling Inputs

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	**D1**	Incorrect Operations: System Operation	344.2	344.2	344.2	344.2	344.2	344.2	SCE used historical incident rates over the 2014-2017 period related to SCE field employees and Tier 1 contractors to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D2	Incorrect Operations: Other	159.3	159.3	159.3	159.3	159.3	159.3	SCE used historical incident rates over the 2014-2017 period related to SCE employees and Tier 1 and Tier 2 contractors to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D3	Hazard Identification Failure	106.6	106.6	106.6	106.6	106.6	106.6	SCE used historical incident rates over the 2014-2017 period related to SCE employees and Tier 1 and Tier 2 contractors to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D4	Incorrect Operations: Vehicle Operation	18.5	18.5	18.5	18.5	18.5	18.5	SCE used historical incident rates over the 2014-2017 period related to SCE employees and Tier 1 and Tier 2 contractors to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D5	Process/System Design Failure	7.4	7.4	7.4	7.4	7.4	7.4	SCE used historical incident rates over the 2014-2017 period related to SCE employees to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D6	Fitness for Duty Issues	1.0	1.0	1.0	1.0	1.0	1.0	SCE used historical incident rates over the 2014-2017 period related to SCE employees to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.
	D7	Lack of Skills and Qualifications	0.5	0.5	0.5	0.5	0.5	0.5	SCE used historical incident rates over the 2014-2017 period related to SCE employees to estimate the number of incorrect operations resulting in adverse outcomes over the 2018-2023 period.

	ID	Name	2018	2019	2020	2021	2022	2023	Source/Justification
Triggering Event Frequency	TEF	An Act Performed	637.4	637.4	637.4	637.4	637.4	637.4	The TEF is the sum of all driver frequencies for each year.

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Incidents Not Resulting in Fatalities or Reportable Injuries	97.5%	621.5	We used the same historical data as the drivers to derive outcome likelihood percentages. Drivers were mapped to each outcome to determine the likelihood for each outcome to occur. SCE maintained the same probability each year of the 2018-2023 RAMP period.
	O2	Field without Electrical Incident	1.6%	10.2	
	O3	Field with Electrical Incident	0.8%	5.1	
	O4	Office Incident	0.1%	0.6	
	O5	Vehicle Incident	0.0%	0.3	

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
	O1	Reliability	Exponential	12,218.0	N/A	N/A	53% of the incidents that result in this outcome are due to incorrect system operations that lead to reliability impacts. The average CMI due to such incidents over 2014-2017 was 23,062 CMI per event. To model this outcome, the 23,062 was multiplied by 53% to account for the fact that this outcome will not always result in a reliability impact due to the presence of incidents not related to incorrect system operations.
	O1	Financial	Exponential	38.3	N/A	N/A	SCE evaluated approximately 2,000 vehicle incidents to estimate the cost per incident resulting from this outcome. Of these 2,000 incidents, the average cost to repair was ~$1,400. SCE modeled this average cost using an exponential distribution with a mean of $38.3 to reflect the large volume of incidents with lower repair costs.
		Serious Injuries	Poisson	0.95	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 0.95 OSHA reportable serious injuries per year for this outcome. This number was used as the mean input for the Poisson distribution.

Consequences	O2	Fatalities	Exponential	0.05	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 0.05 fatalities per year for this outcome. This number was used as the mean input for the Poisson distribution.
		Reliability	Reliability	23,062.0	N/A	N/A	SCE used internal Outage Management System (OMS) data from 2014-2017 to estimate the average CMI per incident associated with worker errors. There were 1,234 incidents over this period, resulting in an estimated average of 23,062 CMI per event for this outcome.
	O3	Serious Injuries	Uniform	0.0	2.0	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 1.0 OSHA reportable serious injury per year for this outcome. SCE modeled this consequence using a uniform distribution in order to account for the variation number of counts over the 2013-2023 period.
		Fatalities	Exponential	0.1	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 0.1 fatalities per year for this outcome. This number was used as the mean input for the exponential distribution.
		Reliability	Exponential	23,062.0	N/A	N/A	SCE used internal Outage Management System (OMS) data from 2014-2017. We calculated the average for this outage consequence per incident. Over this time period, we evaluated 1,234 incidents and estimated an average of 23,062.0 CMI per event for this outcome.
	O4	Serious Injuries	Triangular	0.3	0.6	0.9	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an annual average of 0.6 EEI serious injuries for this outcome. There were no OSHA reportable serious injuries during this timeframe for either contractor or employee; therefore, SCE used EEI serious injury data as a proxy.

		Fatalities	Poisson	0.0	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an annual average of 0.0 fatalities for office incidents.
	O5	Serious Injuries	Poisson	1.0	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 1.0 OSHA reportable serious injury per year for this outcome. This number was used as the mean input for the Poisson distribution.
		Fatalities	Poisson	0.0	N/A	N/A	SCE evaluated incident, injury, and incident cause evaluation data from 2014-2017 for SCE employees and contractors. This data suggests an average of 0.0 fatalities per year for this outcome. This number was used as the mean input for the Poisson distribution.
		Financial	Exponential	1400.0	N/A	N/A	SCE used the same data set modeled in the Financial consequence for Outcome 1 (approximately 2,000 vehicle incidents with an average cost to repair of ~$1,400) to model the Financial consequence for Outcome 5. However, instead of using a mean of $38 for the exponential distribution (which was used to reflect the large volume of incidents with lower repair costs), SCE modeled this consequence using an exponential distribution with a mean of $1,400 to reflect the likely higher cost of repairs associated with vehicle incidents that result in serious injury or fatality.

Chapter	Employee, Contractor & Public Safety

Drivers

ID	Name
D1	Incorrect Operations: System Operation
D2	Incorrect Operations: Other
D3	Hazard Identification Failure
D4	Incorrect Operations: Vehicle Operation
D5	Process/System Design Failure
D6	Fitness for Duty Issues
D7	Lack of Skills and Qualifications

Outcomes

ID	Name
O1	Incidents Not Resulting in Fatalities or Reportable Injuries
O2	Field without Electrical Incident
O3	Field with Electrical Incident
O4	Office Incident
O5	Vehicle Incident

Controls & Mitigations

ID	Name
C1	Safety Controls
C2	Contractor Safety Program
M1a	Safety Culture Transformation – Core Program
M1b	Safety Culture Transformation – Expanded Training & Electronic Tailboards
M2	Industrial Ergonomics
M3a	Office Ergonomics – Core Program
M3b	Office Ergonomics – Additional Software
M4a	Driver Safety Training – Full Training Population
M4b	Driver Safety Training – Limited Training Population

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Safety Controls

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforce positive behaviors and safe practices, hence reducing incidents. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D2	Incorrect Operations: Other	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. Additionally, FMS reduces driver frequency for this driver by providing customized assessments for individuals to perform work safely with an improved understanding of their physical abilities. FMS has already seen some improvements in 2018. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D3	Hazard Identification Failure	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. Additionally, FMS reduces driver frequency for this driver by providing customized assessments for individuals to perform work safely with an improved understanding of their physical abilities. FMS has already seen some improvements in 2018. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D5	Process/System Design Failure	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D7	Lack of Skills and Qualifications	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will implement programs that minimize the occurrence of all drivers. These programs are meant to increase the skill-sets of workers and reinforcing positive behaviors and safe practices, hence reducing incidents. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O5 Vehicle Incident	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	C2 Contractor Safety Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model**
D1	Incorrect Operations: System Operation	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D2	Incorrect Operations: Other	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D3	Hazard Identification Failure	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D5	Process/System Design Failure	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D6	Fitness for Duty Issues	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety and the potential for eliminating any fitness for duty issues based on the screening processes of our safety programs. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.
D7	Lack of Skills and Qualifications	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this control will improve processes and practices related to contractor Safety and the potential for eliminating any issues related to lack of skills and qualifications based on the screening processes of our safety programs. This includes a range of activities related to establishing qualification requirements for contractors, continually evaluating contractor safety performance, and making field-based assessments and observations. The targeted population that this control will impact is our contractor workforce (Tier I Contractor), which we assume will remain constant through the RAMP period.

Outcomes		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model**
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M1a Safety Culture Transformation – Core Program

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D2	Incorrect Operations: Other	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D3	Hazard Identification Failure	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, use of hazard awareness and error prevention tools, effective sharing of lessons learned, and consistent leader reinforcement of safety behaviors, values and attitudes. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D5	Process/System Design Failure	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through a more efficient and aligned safety organizational model, predictive analytics to drive proactive measures, and industrial ergonomics technology to make data-driven decisions and improvements. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced as personal safety ownership is adopted and safety behaviors evolve. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D7	Lack of Skills and Qualifications	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through skills obtained in Switch, Engage and Connect trainings, identifying leadership skills through profile assessments, and identifying and hiring top talent aligned with our safety culture. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M1b Safety Culture Transformation – Expanded Training & Electronic Tailboards

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. Additionally, for this mitigation, our experts assessed incremental risk reduction due to the availability of information in the field via tablets and apps. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D2	Incorrect Operations: Other	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. Additionally, for this mitigation, our experts assessed the incremental risk reduction due to the availability of information in the field via tablets and apps. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D3	Hazard Identification Failure	24.0%	24.0%	24.0%	24.0%	24.0%	24.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, use of hazard awareness and error prevention tools, effective sharing of lessons learned, and consistent leader reinforcement of safety behaviors, values and attitudes. Additionally, for this mitigation, our experts assessed the incremental risk reduction due to the availability of information in the field via tablets and apps. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through cognitive-based skills obtained in Switch training, effective sharing of lessons learned, use of hazard awareness and error prevention tools, availability of trends and predictive analytics to drive decision-making, and consistent leader reinforcement of safety behaviors, values and attitudes. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D5	Process/System Design Failure	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through a more efficient and aligned safety organizational model, predictive analytics to drive proactive measures, and industrial ergonomics technology to make data-driven decisions and improvements. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced as personal safety ownership is adopted and safety behaviors evolve. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.

D7	Lack of Skills and Qualifications	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	These percentages were developed by our safety experts (see workpaper for SME qualifications) and results from the 2017 Safety Culture Assessment. Experts considered how the safety culture transformation efforts are expected to lead to performance improvements and a reduction in all drivers. This driver will be reduced through skills obtained in Switch, Engage and Connect trainings, identifying leadership skills through profile assessments, and identifying and hiring top talent aligned with our safety culture. Additionally, for this mitigation, our experts assessed the incremental risk reduction due to the availability of information in the field via tablets and apps. The targeted population is all SCE employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M2 Industrial Ergonomics

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Incorrect Operations: Other	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how improvements are expected to help with skills and qualifications and process/hazard identification issues and a reduction in all drivers. The adoption of the Set Up. Perform. Recover. approach by employees will reduce the frequency of this driver as it relate to industrial ergonomics practices. The targeted population is SCE field employees, which we assume will be held constant through the RAMP period.
D3	Hazard Identification Failure	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how improvements are expected to help with skills and qualifications and process/hazard identification issues and a reduction in all drivers. The adoption of the Set Up. Perform. Recover. approach by employees will reduce the frequency of this driver as it relate to industrial ergonomics practices. The targeted population is SCE field employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D5	Process/System Design Failure	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how improvements are expected to help with skills and qualifications and process/hazard identification issues and a reduction in all drivers. Wearable technology will provide data to inform specific solutions that should reduce the frequency of this driver. The targeted population is SCE field employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D7	Lack of Skills and Qualifications	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how improvements are expected to help with skills and qualifications and process/hazard identification issues and a reduction in all drivers. Through workshops and training, employee knowledge of ergonomic risk factors will improve and the frequency of this driver will be reduced. The targeted population is SCE field employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M3a Office Ergonomics – Core Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Incorrect Operations: Other	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Hazard Identification Failure	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how self-assessments and ergonomic training will improve employee knowledge of ergonomic risk factors and increase skills around ergonomic hazard identification, which should mitigate strain and sprain risks. Office ergonomic improvements are expected to provide benefit in reducing frequency of this driver. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D5	Process/System Design Failure	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how Sit-to-stand desks will enable employees to adjust their own workstations to their ergonomic needs. Office ergonomic improvements are expected to provide benefit in reducing frequency of this driver. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D7	Lack of Skills and Qualifications	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how self-assessments and ergonomic training will improve employee knowledge of ergonomic risk factors and increase skills around ergonomic hazard identification, which should mitigate strain and sprain risks. Office ergonomic improvements are expected to provide benefit in reducing frequency of this driver. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M3b Office Ergonomics – Additional Software

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Incorrect Operations: Other	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Hazard Identification Failure	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this software will complement the overall ergonomics program by providing individual data and trends, reducing the frequency of this driver. This mitigation in combination with M3a is estimated to provide an incremental 3% benefit on top of benefits from M3a. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D5	Process/System Design Failure	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this software will complement the overall ergonomics program by providing individual data and trends, reducing the frequency of this driver. At both the individual and aggregate levels, this data and these trends will enable proactive improvements in processes, communications and behaviors, reducing the frequency of this driver. This mitigation in combination with M3a is estimated to provide an incremental 3% benefit on top of benefits from M3a. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.
D6	Fitness for Duty Issues	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D7	Lack of Skills and Qualifications	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how this software will complement the overall ergonomics program by providing individual data and trends, reducing the frequency of this driver. This mitigation in combination with M3a is estimated to provide an incremental 3% benefit on top of benefits from M3a. The targeted population is SCE office employees, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Incidents Not Resulting in Fatalities or	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2 Field without Electrical Incident	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3 Field with Electrical Incident	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4 Office Incident	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5 Vehicle Incident	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

Name	M4a Driver Safety Training – Full Training Population

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	inactive	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Incorrect Operations: Other	inactive	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Hazard Identification Failure	inactive	5.0%	5.0%	5.0%	5.0%	5.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders or workers who are assigned to SCE vehicles, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	inactive	10.0%	10.0%	10.0%	10.0%	10.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders or workers who are assigned to SCE vehicles, which we assume will be held constant through the RAMP period.
D5	Process/System Design Failure	inactive	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D6	Fitness for Duty Issues	inactive	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D7	Lack of Skills and Qualifications	inactive	2.0%	2.0%	2.0%	2.0%	2.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders or workers who are assigned to SCE vehicles, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how training focuses on driving and vehicle safety, which improves a driver's ability to respond safely should an incident occur. This mitigation is expected to minimize catastrophic outcomes form vehicle events. The targeted population is all Class A license holders or workers who are assigned to SCE vehicles, which we assume will be held constant through the RAMP period.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.

Name	M4b
	Driver Safety Training – Limited Training Population

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Incorrect Operations: System Operation	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Incorrect Operations: Other	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Hazard Identification Failure	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders only, which we assume will be held constant through the RAMP period.
D4	Incorrect Operations: Vehicle Operation	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders only, which we assume will be held constant through the RAMP period.
D5	Process/System Design Failure	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D6	Fitness for Duty Issues	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D7	Lack of Skills and Qualifications	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how the training is expected to improve driving skills, abilities, and hazard avoidance. This mitigation is expected to provide benefit in reducing frequency of this driver. The targeted population is all Class A license holders only, which we assume will be held constant through the RAMP period.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incidents Not	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Resulting in	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Fatalities or	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field without	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Field with	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Electrical	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Incident	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Office Incident	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O5	Serious Injuries	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	These percentages were developed by our safety experts (see workpaper for SME qualifications). Experts considered how training focuses on driving and vehicle safety, which improves a driver’s ability to respond safely should an incident occur. This mitigation is expected to minimize catastrophic outcomes form vehicle events. The targeted population is all Class A license holders only, which we assume will be held constant through the RAMP period.
Vehicle	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.
Incident	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this consequence.

WP Ch. 7 - RAMP Mitigation Reduction Workpaper.xlsx

14 of 14

Workpaper – Risk Evaluation Memo

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgement is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Employee, Contractor & Public Safety**
Risk Analysis Component	Mitigation Evaluation – Development of mitigation effectiveness values.
Does historical data exist at SCE to support the evaluation of this risk analysis component?	No, SCE does not have historical data to perform this analysis. SME judgement was utilized to forecast the benefits of new mitigations.
Additional back-up or sources used by the SME(s) to inform/validate guidance	SMEs has regular interactions and discussions with colleagues at various utilities that have experienced this risk event and who have deployed similar mitigations. These interactions typically take place through professional conferences and through direct conversations. SCE SMEs used this information as a resource in the design of our own system, and leveraged that information to help inform the SME guidance to the mitigation effectiveness found in this chapter.
SME(s) who have contributed to this analysis	• Director, Corporate Health & Safety • Principal Manager, Safety Programs & Compliance • Advisor, Health & Safety
Relevant Experience of SME(s)	These SMEs have a combined 51 years of professional safety and business experience within the electric utility environment. SMEs collectively possess various professional certifications and advanced degrees, including: Certified Safety Professionals (CSP), Juris Doctor, Master's degree in Business Administration, and Bachelor's degrees in Business Administration, and Project Management Certification.

Safety Volume	Type (definitions below)	Compliance	Regulatory Body	Notes
Automated External Defibrillator (AED) Standard	Standard	Yes	CA Emergency Medical Services Authority CA Civil Code CA Health & Safety Code	Organizations that provide AEDs must have a standard to meet regulatory requirements
Accident Prevention Manual	Manual	Yes	California OSHA / Federal OSHA	Contains rules and safe work practices, the majority of which are based on regulatory requirements
Asbestos Management for Construction Related Activities	Program	Yes	California OSHA / Federal OSHA Air Quality Mgmt. District	Program implemented to establish safe work practices of asbestos management when performing construction related activities (e.g. constructing, altering, repairing, maintaining, or renovating asbestos-containing structures or substrates)
Bloodborne Pathogens (BBP) Exposure Control Standard	Standard	Yes	California OSHA / Federal OSHA	BBP Exposure Control Manual accompanies the standard and explains how to accomplish the standard requirements
Company Vehicle and Driver Policy	Policy	Yes	CA Department of Transportation CA Air Resource Board rules	Also includes non-compliance-related rules and guidelines (e.g. telematics, or GPS vehicle monitoring)
Confined Space Program	Program	Yes	California OSHA / Federal OSHA	The purpose of this program is to ensure the protection of workers from the hazards associated with confined space entry
Other Confined Space (Enclosed Space) Operations Program	Program	Yes	California OSHA / Federal OSHA	Specific to utility vaults. Will be updated to "Enclosed Space" in Q4 2018, in line with CA regulation changes
Contractor Safety Management Standard	Standard	Yes	CPUC California OSHA / Federal OSHA	The EHS Handbook for Contractors outlines how to accomplish the standard requirements
Electric and Magnetic Fields (EMF)	Program	Yes	CPUC	Inform customers and employees about potential EMF health effects, provide free EMF measurements, and use EMF-minimizing designs on new and rebuilt power lines and substations
Ergonomic Program	Program	Yes	California OSHA / Federal OSHA	Part of Injury and Illness Prevention Program to identify and mitigate ergonomic hazards
Fall Protection Standard	Standard	Yes	California OSHA / Federal OSHA	Fall Protection Manual outlines how to accomplish the standard requirements
Fire Prevention Program	Program	Yes	California OSHA / Federal OSHA	Part of SCE's safety management system; defines requirements and responsibilities around fire prevention plans
First Aid Response Guidelines	Guidelines	Yes	California OSHA / Federal OSHA	Electrical workers are required to be trained in CPR/First Aid. Guidelines are available for inspection, replenishment and requests for changes to the contents of SCE First Aid Kits
Hazard Communication & Chemical Management Standard	Standard	Yes	California OSHA / Federal OSHA	Standard provides criteria for classification of chemical hazards, and approach to safe labeling of such material (e.g., Safety Data Sheets)
Hazardous Energy Control – Lockout/Tagout (LOTO) Program	Program	Yes	California OSHA / Federal OSHA	"Lockout/tagout" refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities
Hearing Conservation Program	Program	Yes	California OSHA / Federal OSHA	Used to protect workers from hearing problems due to noise exposure
Hexavalent Chromium Program	Program	Yes	California OSHA / Federal OSHA	Program established to maintain worker exposure below the permissible limits
Hot Work Program	Program	Yes	California OSHA / Federal OSHA	This program is designed to prevent injury and loss of property from fire or explosion as a result of hot work (e.g. welding, brazing, soldering, etc.)
Injury and Illness Prevention Program	Program	Yes	California OSHA / Federal OSHA	Program focused on prevention of injury and illness
Lead Management Program	Program	Yes	California OSHA / Federal OSHA	The purpose of this program is to ensure the protection of workers from the hazards associated with lead exposure
Medical Support for Remote Operations	Directive	Yes	California OSHA / Federal OSHA	Program to provide workers with medical support when working a remote location
Radio Frequency Energy Safety Program	Program	Yes	California OSHA / Federal OSHA	Program established to maintain worker exposure below the permissible limits
Respirable Crystalline Silica Management Standard	Standard	Yes	California OSHA / Federal OSHA	This standard protects workers from exposure to respirable crystalline silica, which is a common material found in construction material such as sand, concrete, stone, etc.
Respiratory Protection Program	Program	Yes	California OSHA / Federal OSHA	The Respiratory Protection Handbook outlines how to accomplish the program requirements
Safety Incident Management Standard	Standard	Yes	California OSHA / Federal OSHA	This standard defines requirements and responsibilities for notification and evaluation of safety incidents (injuries, illnesses or close calls) involving employees conducting company business and/or members of the public
Safety Observation Program	Program	Yes	California OSHA / Federal OSHA	Meets requirement that supervisors observe employees in workplace at least once/year to identify hazards. SCE provides tool available to all employees, which also enables peer-to-peer observations

Governance Documents:

Policy: A corporate policy articulates the boundaries of business behavior and personal conduct. A corporate policy outlines who has specific authority or assigned accountability and what actions are required in specific situations. Corporate policies are a principal control to manage compliance risks and demonstrate compliance to regulators. A corporate policy applies across the enterprise unless a company or a specific group of individuals has been exempted by the Edison International General Counsel.

Program: A corporate program is a set of related measures, events or activities with a particular long term aim. A corporate program may be related or unrelated to regulatory requirements. Compliance to a corporate program is based on applicability. A corporate program is typically documented in a corporate program document.

Directive: An official instruction, or set of instructions, regarding a specific topic.

Guidelines: Advice or guidance on a particular topic or work practice.

Implementation Documents:

Standard: A corporate standard describes a minimum set of requirements for a method, material, or practice which, when followed, leads to consistent results. Corporate standards are usually governed by a corporate policy, program or charter

Manual: A manual typically accompanies a Standard document and provides details regarding how to accomplish the Standard requirements

This Page Intentionally Left Blank

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 8
Hydro Asset Safety

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 8
Hydro Asset Safety

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Hydro Asset Safety
Workpaper:	Baseline Risk Modeling Inputs

Legend			
Distribution	Input 1	Input 2	Input 3
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Low	Likely	High
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Earthquake	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	SCE Dam & Public Safety (D&PS) Risk Assessments. 230 Potential Failure Modes (PFMs) have been assigned likelihood of dam failure through Risk Assessment Workshops attended by SCE, outside consultants, and representatives of regulatory agencies (FERC and DSOD). Likehood categories are converted to lognormal distributions on frequency (see Tab "D&PS Category Conversions"). Each PFM is mapped to one of the three drivers , then the mean of the distributions of all PFMs mapped to the driver are summed to obtain the mean frequency of occurrence for each driver (see Tab "Frequency Calculation").
	D2	Flood	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	
	D3	Failure Under Normal Operations	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Triggering Event Frequency	TEF	Uncontrolled Rapid Release of Water	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	The TEF is the sum of driver frequencies per year

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Hydro Facility Inoperable; No Significant Inundation	2.0%	0.0001	SCE Dam & Public Safety (D&PS) Risk Assessments. 230 Potential Failure Modes (PFMs) have been assigned consequences of dam failure through Risk Assessment Workshops attended by SCE, outside consultants, and representatives of regulatory agencies (FERC and DSOD). Each PFM is mapped to one of the outcomes based on the severity of the consequences (see Tab "D&PS Category Conversions"). The mean frequencies for each of the mapped PFMs (see above) are summed then divided by the triggering event frequency to obtain the probability (see Tab "Outcome Calculation")
	O2	Hydro Facility Inoperable; Inundation of Unpopulated Area	33.4%	0.0019	
	O3	Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	64.6%	0.0037	

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences	O1	Reliability	Lognormal	154,088	131,993	N/A	SCE Transmission Planning assessments shows that from 2009-2017 indicates that area north of Bishop Control substation is "islanded" from the grid an average of 3.25 times per year. The assessment also shows that from 2005-2016 the average duration of line outages in this area is 1300 minutes. If the plants serving June Lake (Rush Creek) or Lee Vining (Poole, Lundy) are unavailable during such an outage, the local population would suffer an interruption. 2010 census data indicates that the June Lake has 290 households and Lee Vining has 85. These values are used to estimate a lognormal distribution for customer minutes' of interruption that are mapped to PFMs associated with dams affecting these power plants. The distributions are combined with the frequency distributions for each PFM (see "Driver Frequency") to develop a lognormal distribution for reliability loss. The distribution is divided by the mean frequency of occurence of O1 to give the per-occurence reliability consequence distribution (see Tab "O1 Consequence Calculation")
	O1	Financial	Lognormal	$1,712,653	$915,359	N/A	Annual Generation data for each plant from 1997-2018 (see Tab "Annual Generation by Plant") was used to develop a lognormal distribution for lost generation from one year of non-operation for each dam, based on a price of $25 per megawatt-hour (see Tab "Lost Generation Revenue per Dam"). The distributions are combined with the frequency distributions for each PFM (see "Driver Frequency") to develop a lognormal distribution financial loss. The distribution is divided by the mean frequency of occurence of O1 to give the per-occurence financial consequence distribution (see Tab "Consequence Calculation")
	O2	Reliability	Lognormal	39,044	27,974	N/A	Calculation as per O1, except mapped to PFMs associated with O2 (see Tab "Consequence Calculation").
	O2	Financial	Lognormal	$19,042,085	$19,095,903	N/A	Loss of generation is calculated as per O1, except mapped to PFMs associated with O2. Additionally, losses due to inundation are estimated for each PFM based on the severity of the consequences as assigned during SCE Dam & Public Safety (see Tab "D&PS conversion"). The financial losses from loss of generation and inundation are combined for each PFM, combined with the frequencies distributions and summed over all PFMs mapped to O2 to obtain a lognormal distribution financial consequence distribution, then divided by the mean frequency of occurence of O2 to obtain a per-occurence consequence distribution (see Tab "Consequence Calculation").

	O3	Serious Injuries	Lognormal	27.03	14.67	N/A	SCE Dam & Public Safety (D&PS) Risk Assessments. A lognormal distribution for fatalities is assigned to each PFM based on the Consequence categories assigned in Risk Assessment Workshops, which is then multiplied by a scaling factor that increases with the severity of the event (see Tab "D&PS Category Conversion") based on FEMA guidance document "Assessing the Consequences of Dam Failure: A How-To Guide". The distributions for PFMs mapped to O3 are combined with the associated frequency distributions and summed to obtain a lognormal distribution for serious injuries, which is then divided by the mean frequency of occurence of O3 to obtain a per-occurence consequence distribution (see Tab "Consequence Calculation")
		Fatalities	Lognormal	7.65	3.92	N/A	SCE Dam & Public Safety (D&PS) Risk Assessments. A lognormal distribution for fatalities is assigned to each PFM based on the Consequence categories assigned in Risk Assessment Workshops attended by SCE, outside consultants, and representatives of regulatory agencies (see Tab "D&PS Category Conversion"). The distributions for PFMs mapped to O3 are combined with the associated frequency distributions and summed to obtain a lognormal distribution for fatalities, which is then divided by the mean frequency of occurence of O3 to obtain a per-occurence consequence distribution (see Tab "Consequence Calculation")
		Reliability	Lognormal	904,562	1,020,387	N/A	Reliability impacts due to loss of redundancy are calculated as per O1 and O2, except mapped to PFMs associated with O3. Additionally, there are dams where the inundation could damage electrical infrastructure, leading to an outage for local communities. It's estimated that the restoration of service through a temporary work-around would take approximately one week. Reliability impacts due to inundation are combined with impacts due to loss of redundancy for all PFMs mapped to O3 and then combined with the frequency distribution to obtain a lognormal distribution for reliability impacts, which is then divided by the mean frequency of occurrence of O3 to obtain a per-occurence consequence distribution (see Tab "Consequence Calculations")
		Financial	Lognormal	$125,405,046	$109,110,720	N/A	Calculation as per O2, except mapped to PFMs associated with O3 (see Tab "Consequence Calculation").

Chapter	Hydro Asset Safety

Drivers	
ID	Name
D1	Earthquake
D2	Flood
D3	Failure Under Normal Operations

Outcomes	
ID	Name
O1	Hydro Facility Inoperable; No Significant Inundation
O2	Hydro Facility Inoperable; Inundation of Unpopulated Area
O3	Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)

Controls & Mitigations	
ID	Name
C1	Seismic Retrofit
C2	Dam Surface Protection
C3	Spillway Remediation & Improvement
C4	Low Level Outlet Improvements
C5	Seepage Mitigation
C6	Instrumentation & Communication Improvements
M1	Proactive Dam Removal
M2	Relocation of Campgrounds
M3	Purchase of Private Residences

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Seismic Retrofit

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	1.00%	1.00%	1.00%	1.00%	1.00%	2.40%	Proposed capital improvement projects are estimated to reduce the likelihood of targeted PFMs by 70%. While the design intent of the mitigations would likely translate to a mitigation effectiveness of 90% or more, given uncertainties in materials, construction, etc, 70% was judged by SMEs to be a reasonably conservative estimate. The aggregated affect over the portfolio for the driver is calculated to obtain the overall reduction percentage (see Tab "C1 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	C2 Dam Surface Protection

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	0.07%	0.07%	0.07%	0.07%	0.07%	0.14%	Proposed capital improvement projects are estimated to reduce the likelihood of targeted PFMs by 70%. While the design intent of the mitigations would likely translate to a mitigation effectiveness of 90% or more, given uncertainties in materials, construction, etc, 70% was judged by SMEs to be a reasonably conservative estimate. The aggregated affect over the portfolio for the driver is calculated to obtain the overall reduction percentage (see Tab "C2 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	
	C3 Spillway Remediation & Improvement

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	12.20%	24.40%	36.60%	48.80%	61.00%	61.00%	Proposed capital improvement projects are estimated to reduce the likelihood of targeted PFMs by 70%. While the design intent of the mitigations would likely translate to a mitigation effectiveness of 90% or more, given uncertainties in materials, construction, etc, 70% was judged by SMEs to be a reasonably conservative estimate. The aggregated affect over the portfolio for the driver is calculated to obtain the overall reduction percentage (see Tab "C3 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	
	C4 Low Level Outlet Improvements

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	0.28%	0.56%	0.84%	0.84%	0.84%	1.12%	Proposed capital improvement projects are estimated to reduce the serious injury, fatality and financial consequences associated with inundation of targeted PFMs by 10%. While executing in controlled drain of the reservoir behind a dam through LLOs could substantially reduce the consequences of a dam failure, SMEs judged that the 10% figure was appropriate based on uncertainties with successfully identifying potential failures and successfully executing a drain to reduce impacts. The aggregated affect over the portfolio for the impacted consequences are calculated to obtain the overall reduction percentages (see Tab "C4 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	0.18%	0.36%	0.54%	0.54%	0.54%	0.72%	See discussion for Outcome O1 financial impacts.
	Fatalities	0.26%	0.53%	0.79%	0.79%	0.79%	1.06%	See discussion for Outcome O1 financial impacts.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	0.25%	0.50%	0.76%	0.76%	0.76%	1.01%	See discussion for Outcome O1 financial impacts.

Name	C5 Seepage Mitigation

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	inactive	6.03%	12.07%	18.10%	24.14%	24.14%	Proposed capital improvement projects are estimated to reduce the likelihood of targeted PFMs by 70%. While the design intent of the mitigations would likely translate to a mitigation effectiveness of 90% or more, given uncertainties in materials, construction, etc, 70% was judged by SMEs to be a reasonably conservative estimate. The aggregated affect over the portfolio for the driver is calculated to obtain the overall reduction percentage (see Tab "C5 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	C6
	Instrumentation & Communication Improvements

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3	Serious Injuries	inactive	11.12%	22.24%	33.35%	44.47%	44.47%	Proposed capital improvement projects are estimated to reduce the serious injury and fatality of targeted PFMs by 45%. While data from past dam failures shows that adequate warning reduces casaulties by 90% or more, SMEs judged that the mitigation effectiveness should be reduced by half (to 45%) to account for the uncertainty in whether warning could be successfully issued to the downstream population in time. The aggregated effect over the portfolio for the impacted consequences are calculated to obtain the overall reduction percentages (see Tab "C6 Calculation"). The mitigation impact is applied in years the capital work is forecast to take place.
Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Fatalities	inactive	11.02%	22.03%	33.05%	44.07%	44.07%	See discussion for Serious Injuries.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M1 Proactive Dam Removal

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	inactive	inactive	inactive	2.60%	5.10%	7.70%	Removal of a dam reduces the likelihood of all associated PFMs by 100%. The aggregated affect over the portfolio for the driver is calculated to obtain the overall reduction percentage (see Tab "M1 Calculation"). The mitigation impact is applied in years the removals are forecast to take place.
D2	Flood	inactive	inactive	inactive	28.60%	57.30%	86.00%	See discussion for Driver D1.
D3	Failure Under Normal Operations	inactive	inactive	inactive	8.20%	16.29%	24.48%	See discussion for Driver D1.

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M2 Relocation of Campgrounds

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	inactive	inactive	inactive	inactive	4.12%	8.23%	Relocation of campgrounds is assumed to reduce the serious injury and fatality consequences for all PFMs associated with dams upstream of the relocated sites by 70% (even if campsites are removed, there may still be some day use of the site). The aggregated effect over the portfolio for the impacted consequences are calculated to obtain the overall reduction percentages (see Tab "M2 Calculation"). The mitigation impact is applied in years the relocations are forecast to take place.
	Fatalities	inactive	inactive	inactive	inactive	3.69%	7.38%	See discussion for Serious Injuries.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Name	M3 Purchase of Private Residences

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Earthquake	no impact	no impact	no impact	no impact	no impact	no impact	
D2	Flood	no impact	no impact	no impact	no impact	no impact	no impact	
D3	Failure Under Normal Operations	no impact	no impact	no impact	no impact	no impact	no impact	

Outcomes		2018	2019	2020	2021	2022	2023	For the purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1 Hydro Facility Inoperable; No Significant Inundation	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O2 Hydro Facility Inoperable; Inundation of Unpopulated Area	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	
O3 Hydro Facility Inoperable; Inundation of Unpopulated & Populated Area(s)	Serious Injuries	inactive	inactive	inactive	0.21%	0.42%	0.63%	Purchase of private residences is assumed to reduce the serious injury and fatality consequences for all PFMs associated with the dam upstream of the purchased sites by 90%. The mitigation effectiveness reflects the judgement of SMEs that a small percentage of owners would be unwilling to sell. The aggregated effect over the portfolio for the impacted consequences are calculated to obtain the overall reduction percentages (see Tab "M3 Calculation"). The mitigation impact is applied in years the purchases are forecast to take place.
	Fatalities	inactive	inactive	inactive	0.37%	0.75%	1.12%	See discussion for Serious Injuries.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	

Workpaper – Risk Evaluation Memo

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgement is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Building Safety**
Risk Analysis Component	Development of baseline risk assessment and mitigation effectiveness values.
Does historical data exist at SCE to support the evaluation of this risk analysis component?	SCE does not have any historical incidents of failure of a high hazard dam. Other data, such as field investigations and instrumentation records, is used to inform SME judgement.
Additional back-up or sources used by the SME(s) to inform/validate guidance	SMEs consider design documents, drawings, construction and inspection reports, field investigations, surveillance and monitoring data, inundation mapping, seismic and hydrologic hazard assessments, stability analyses and all other available technical studies on dams. Semi-Quantitative Risk Assessments are performed in facilitated workshops involving participants from SCE, external consultants, and representatives from federal and state dam safety regulators.
SME(s) who have contributed to this analysis	• Senior Manager, SCE Dam & Public Safety • Consulting Engineer, SCE Dam & Public Safety • Senior Geologist, SCE Dam & Public Safety • Engineer 3, SCE Dam & Public Safety
Relevant Experience of SME(s)	• Senior Manager has 16 years of experience with dams, including computer modeling, field testing, instrumentation and risk assessment. He has extensive experience interfacing with senior leaders at state and dam federal regulators, and with other dam owners. • Consulting Engineer has 18 years of research and professional experience in seismic risk analysis, including seismic source modeling, seismic hazard analysis, and computer modeling of structural response, and ten years of experience in dam safety, including coordinating and implement risk assessment and risk management. • Senior Geologist has 29 years of experience as an engineering geologist, including 15 years spent supporting dam safety and other hydropower-related projects, including construction, damage assessment and repair, and coordinating collection, evaluation and reporting of dam surveillance data. • Engineer 3 has 10 years of experience in dam safety, including hydrology and hydraulic analyses, flooding risk assessment, and probabilistic flood analysis.

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 9
Physical Security

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 9
Physical Security

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Physical Security
Workpaper	Baseline Risk Modeling Input Sources and Assumptions

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	Std. Dev.	
Normal	Mean	Std. Dev.	
Triangular	Low	Mean	High
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Security Systems Bypass/ Breach	92.14	115.07	131.95	150.31	170.19	191.64	SCE used internal data (from our NAVEX database) from 2016-2017, FBI active shooter data from 2014-2017, and 2017 U.S Bureau of Labor and Statistics (BLS). SCE used both internal data and a scaled version of national data to develop a more robust data set by which to estimate future driver frequencies. SCE combined internal physical security incidents with scaled national incidents (from FBI data) to develop annualized incident rates. SCE scaled national level FBI incident data to SCE's service area, based on SCE's workforce relative to that of the US (SCE employee and contractor count of 20,875 was divided by total workforce of 155 million from the U.S. BLS). Then, SCE appropriated these annualized incidents to each of the drivers to estimate the frequency of each driver in 2018. SCE then applied growth rates to each driver based on: (1) Growth in the risk itself. Over the 2013-2017 period, SCE experienced an average annual growth rate in physical security incidents of about 7%. (2) In addition, SCE applied growth to each driver to account for the removal of controls and mitigations over the RAMP period. For example, the baseline risk for this chapter contemplates the removal of fixed security officers at our facilities, no further maintenance of fences, cameras and alarms, and no further maintenance of access controls.
	D2	Human/ Process Failure	58.50	75.35	87.55	100.92	115.51	131.35	The same method in D1 was used for D2
	D3	Insider Threat	0.68	0.81	0.92	1.03	1.14	1.27	The same method in D1 was used for D3

Triggering Event Frequency	ID	Name	2018	2019	2020	2021	2022	2023	Units
	TEF	Compromise of SCE Physical Security	151	191	220	252	287	324	The triggering event frequency is the sum of the driver frequencies.

Outcomes	ID	Name	Probability	# of Events	Source / Justification
	O1	Theft	53.0%	80.14	SCE mapped each event captured in the Driver analysis one of the four outcomes. We then and assigned percentages for each outcome based on the total number of events.
	O2	Trespassing	46.9%	71.00	
	O3	Workplace Violence	0.1%	0.14	
	O4	Coordinated Substation Attack	0.0%	0.03	

Consequences	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
	O1	Reliability	Exponential	16,248	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. This evaluated theft data from SCE's internal NAVEX database over 2016-2017. The resulted in an exponential distribution with a mean input of 16,248.
		Financial	Lognormal	$11,982	$20,889	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. This evaluated theft data from SCE's internal NAVEX database over 2016-2017. The resulted in a lognormal distribution with a median input of $11,982 and a standard deviation of $20,889.
	O2	Financial	Exponential	$2,188	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. This evaluated theft data from SCE's internal NAVEX database over 2016-2017. This resulted in an exponential distribution with a mean input of $2,188.
	O3	Serious Injuries	Exponential	3.674	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. This evaluated workplace violence data from SCE's internal NAVEX database over 2011, 2016, and 2017, and FBI data from 2014-2017. The "Pulse Nightclub" and "Route 91 Harvest Festival" incidents were excluded from the dataset because they extreme outliers that skewed our distribution fitting. This resulted in an exponential distribution with a mean input of 3.674.
		Fatalities	Exponential	2.281	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. This evaluated workplace violence data from SCE's internal NAVEX database over 2011, 2016, and 2017, and FBI data from 2014-2017. The "Pulse Nightclub" and "Route 91 Harvest Festival" incidents were excluded from the dataset because they extreme outliers that skewed our distribution fitting. This resulted in an exponential distribution with a mean input of 2.281.
		Serious Injuries	Exponential	6.000	N/A	N/A	SCE used an exponential distribution to model this consequence, consistent with how we have modeled safety consequences in other outcomes. SCE physical security experts leveraged Grid Security exercises (Grid-Ex) performed by NERC to develop an estimate for the mean input of this distribution (6).

[redacted]	O4	Fatalities	Exponential	2.000	N/A	N/A	SCE used an exponential distribution to model this consequence, consistent with how we have modeled safety consequences in other outcomes. SCE physical security experts leveraged Grid Security exercises (Grid-Ex) performed by NERC to develop an estimate for the mean input of this distribution (2).
		Reliability	Exponential	711,403,200	N/A	N/A	SCE used an exponential distribution to model this consequence. SCE physical security experts leveraged Grid Security exercises (Grid-Ex) performed by NERC to develop an estimate for the mean input of this distribution (711,403,200 CMI).
		Financial	Uniform	$40,000,000	$60,000,000	N/A	SCE used uniform distribution to model this consequence. SCE physical security experts leveraged Grid Security exercises (Grid-Ex) performed by NERC to develop an estimate for the range input of this distribution ($40 to $60 million).

Workpaper – Risk Evaluation Memo

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgment is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Physical Security**
Risk Analysis Component	• Control and Mitigation Evaluation – Development of mitigation effectiveness values. • Outcome Evaluation – Development of frequency and consequence estimates for coordinated attack on multiple substations outcome
Does historical data exist at SCE to support the evaluation of this risk analysis component?	While there is no historical data at SCE to support this part of the analysis, comparisons were drawn with actual events across the United States: Metcalf attack on PG&E, substation attacks on other utilities over the previous 10 years, and NERC GRIDEX 2015 simulation exercise.
Additional back-up or sources used by the SME(s) to inform/validate guidance	SMEs hold membership and collaborate regularly with members of the North American Transmission Forum (NATF) and various professional organizations. They actively participate in peer benchmarking activities and working groups across the industry. In addition, SMEs held discussions with colleagues at SDG&E and PG&E who experienced similar risk events, and who have deployed similar mitigations. These include: Concrete/block walls, cameras, lights, alarms, and security officers. SMEs utilize this input and compared it to the physical characteristics of SCE target facilities, the risk tolerances/safety culture at SCE and industry best practices. This information was utilized to design the system outlined and to inform the SME guidance to the mitigation effectiveness found in this chapter.
SME(s) who have contributed to this analysis	• Principal Manager, Corporate Security • Principal Manager, Grid Operations • Senior Advisor, Corporate Security • Security Specialist 2, Corporate Security • Technical Specialist/Scientist 3

Relevant Experience of SME(s)	These SMEs have over 150 years combined of experience in risk mitigation, intelligence operations, law enforcement, security management and operations, threat analysis, risk assessment, physical security standards, workplace violence protection and emergency preparedness. SMEs serve on the Department of Homeland Security Critical Infrastructure Partnership Advisory Council as the Chair of the Dam Sector Coordinating Council. SMEs collectively possess various professional certifications and advanced degrees, including: Doctorate in Law, Master's degrees in Business Administration, Criminal Justice Management, Security Management, and have graduated from Georgetown University International Security Management Association Senior Executive Leadership Program. SME's are active members of the American Society of Industrial Security. This is the preeminent security organization in the world, recognized by governments and private industries as a standard for security protocols. Certifications include: Certified Information Privacy Professional, and the following ASIS certifications: Certified Protection Professional, Professional Certified Investigator and Physical Security Professional.

Chapter	Physical Security

Drivers	
ID	Name
D1	Security System Bypass/ Breach
D2	Human/ Process Failure
D3	Insider Threat

Outcomes	
ID	Name
O1	Theft
O2	Trespassing
O3	Workplace Violence
O4	Coordinated Substation Attack

Controls & Mitigations	
ID	Name
C1B	Grid Infrastructure Protection - Enhanced
C1A	Grid Infrastructure Protection - Base
C2	Protection of Generation Capabilities
C3B	Non-Electric Facilities/Protection of Major Business Functions - Enhanced
C3A	Non-Electric Facilities/Protection of Major Business Functions - Base
C4	Asset Protection
M1B	Insider Threat Program Enhancement & Information Analysis - Enhanced
M1A	Insider Threat Program Enhancement & Information Analysis - Base
M2	Smart Key Program Phase 1 - Listed BR/CS Critical Sites
M3	Smart Key Phase 2 - Electrical Sites
M4	Smart Key Phase 3 - Remaining Non-Electric

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1A Grid Infrastructure Protection - Base

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, adding physical barriers such as walls and gates, as well as video surveillance and/or improved lighting, can reduce the frequency of System Security Breach/Bypass.
D2	Human/ Process Failure	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how updating security processes and access management systems can reduce frequency of Human/Process Failure.
D3	Insider Threat	1%	2%	3%	4%	5%	6%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how access restrictions for employees can reduce the frequency of D3 (Insider Threat) by granting access to only those areas where the employee specifically needs access to accomplish job duties.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
	Financial	3%	7%	10%	13%	16%	19%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
Workplace Violence	Fatalities	3%	7%	10%	13%	16%	19%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
Coordinated Substation Attack	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	2%	3%	5%	7%	8%	10%	
	Financial	2%	3%	5%	7%	8%	10%	

Name	C2 Protection of Generation Capabilities

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, this control will reduce the frequency of System Security Breach/Bypass by making it more difficult to penetrate our security perimeter. For instance, barbed wire fencing could deter individuals from entering a hydro facility.
D2	Human/ Process Failure	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control reduces the frequency of Human/Process Failure by implementing access control, which will prevent and reduce the frequency of unauthorized access.
D3	Insider Threat	1%	3%	4%	5%	6%	8%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how access control reduces the frequency of Insider Threat by restricting access to only those employees who should have it.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control deploys similar measures as C1 (Grid Infrastructure Protection), it similarly effects each outcome and consequence. The physical security measures in C2 are tailored to the needs of each generation facility, and reduce the magnitude of impact associated with each outcome by deploying early detection technologies and faster response techniques.
	Financial	2%	4%	6%	9%	11%	13%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control deploys similar measures as C1 (Grid Infrastructure Protection), it similarly effects each outcome and consequence. The physical security measures in C2 are tailored to the needs of each generation facility, and reduce the magnitude of impact associated with each outcome by deploying early detection technologies and faster response techniques.
O3	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control deploys similar measures as C1 (Grid Infrastructure Protection), it similarly effects each outcome and consequence. The physical security measures in C2 are tailored to the needs of each generation facility, and reduce the magnitude of impact associated with each outcome by deploying early detection technologies and faster response techniques.
Workplace Violence	Fatalities	4%	7%	11%	14%	17%	20%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control deploys similar measures as C1 (Grid Infrastructure Protection), it similarly effects each outcome and consequence. The physical security measures in C2 are tailored to the needs of each generation facility, and reduce the magnitude of impact associated with each outcome by deploying early detection technologies and faster response techniques.
Coordinated Substation Attack	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	2%	4%	6%	9%	11%	13%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	C1B Grid Infrastructure Protection - Enhanced

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	4%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, adding physical barriers such as walls and gates, as well as video surveillance and/or improved lighting, can reduce the frequency of System Security Breach/Bypass.
D2	Human/ Process Failure	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how updating security processes and access management systems can reduce frequency of Human/Process Failure.
D3	Insider Threat	2%	4%	6%	9%	11%	12%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how access restrictions for employees can reduce the frequency of D3 (Insider Threat) by granting access to only those areas where the employee specifically needs access to accomplish job duties.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
	Financial	4%	7%	11%	14%	17%	20%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
O3	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
Workplace Violence	Fatalities	4%	7%	11%	14%	17%	20%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes. For example, the early detection and mitigation of suspicious and criminal activity in and around facilities is improved with security cameras and other technology (e.g., gunshot detection). This aids in rapid deployment of security officers and law enforcement, thereby reducing the consequences associated with all outcomes. This control allows SCE to respond to incidents more rapidly and effectively. Furthermore, this control helps conceal the most critical assets within substations to reduce injury, theft, or damage (to the assets or associated assets).
Coordinated Substation Attack	Fatalities	3%	7%	10%	13%	16%	19%	
	Reliability	2%	4%	6%	9%	11%	13%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	C3A Non-Electric Facilities/Protection of Major Business Functions - Base

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, access control affected through uniformed security officers can reduce the frequency of Security System Bypass/Breach.
D2	Human/ Process Failure	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, updating security processes and access management systems can reduce the frequency of Human/Process Failure.
D3	Insider Threat	1%	3%	4%	5%	6%	8%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, access restrictions for employees can reduce the frequency of Insider Threat by only granting employees access to authorized and as-needed areas.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, uniformed security patrols are likely to deter individuals from stealing company assets, thereby we assumed reduction in the financial consequences associated with Theft.
	Financial	2%	4%	6%	9%	11%	13%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how access control (such as using badge readers) reduces the number of unauthorized accesses; this reduction in turn reduces the number of Trespassing events.
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how early detection of suspicious and criminal activity in and around non-electrical facilities is improved with video surveillance and duress alarms. This aids in rapidly deploying security officers and law enforcement, thereby reducing the consequences associated with Workplace Violence.
Workplace Violence	Fatalities	3%	7%	10%	13%	16%	19%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how early detection of suspicious and criminal activity in and around non-electrical facilities is improved with video surveillance and duress alarms. This aids in rapidly deploying security officers and law enforcement, thereby reducing the consequences associated with Coordinated Attack on Multiple Substations.
Coordinated Substation Attack	Fatalities	3%	7%	10%	13%	16%	19%	
	Reliability	2%	3%	5%	7%	8%	10%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	C3B Non-Electric Facilities/Protection of Major Business Functions - Enhanced

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, access control affected through uniformed security officers can reduce the frequency of Security System Bypass/Breach.
D2	Human/ Process Failure	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, updating security processes and access management systems can reduce the frequency of Human/Process Failure.
D3	Insider Threat	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, access restrictions for employees can reduce the frequency of Insider Threat by only granting employees access to authorized and as-needed areas.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, uniformed security patrols are likely to deter individuals from stealing company assets, thereby we assumed reduction in the financial consequences associated with Theft.
	Financial	4%	7%	11%	14%	17%	20%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how access control (such as using badge readers) reduces the number of unauthorized accesses; this reduction in turn reduces the number of Trespassing events.
O3	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how early detection of suspicious and criminal activity in and around non-electrical facilities is improved with video surveillance and duress alarms. This aids in rapidly deploying security officers and law enforcement, thereby reducing the consequences associated with Workplace Violence.
Workplace Violence	Fatalities	4%	7%	11%	14%	17%	20%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how early detection of suspicious and criminal activity in and around non-electrical facilities is improved with video surveillance and duress alarms. This aids in rapidly deploying security officers and law enforcement, thereby reducing the consequences associated with Coordinated Attack on Multiple Substations.
Coordinated Substation Attack	Fatalities	4%	7%	11%	14%	17%	20%	
	Reliability	2%	4%	6%	9%	11%	13%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	C4 Asset Protection

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, deploying security officers to deter violence and property crimes, observe and report security incidents, control access to facilities, and provide immediate response capability.
D2	Human/ Process Failure	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, deploying security officers to deter violence and property crimes, observe and report security incidents, control access to facilities, and provide immediate response capability.
D3	Insider Threat	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, The Insider Threat program reduces the frequency of Insider Threat by identifying potential threats before they materialize.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes and their associated consequences. This control implements the principal components of the program so that SCE can respond to risks and incidents more rapidly and effectively. Safety, reliability, and financial consequences will be reduced when each outcome occurs.
	Financial	4%	7%	11%	14%	17%	20%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes and their associated consequences. This control implements the principal components of the program so that SCE can respond to risks and incidents more rapidly and effectively. Safety, reliability, and financial consequences will be reduced when each outcome occurs.
O3	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes and their associated consequences. This control implements the principal components of the program so that SCE can respond to risks and incidents more rapidly and effectively. Safety, reliability, and financial consequences will be reduced when each outcome occurs.
Workplace Violence	Fatalities	4%	7%	11%	14%	17%	20%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this control impacts all outcomes and their associated consequences. This control implements the principal components of the program so that SCE can respond to risks and incidents more rapidly and effectively. Safety, reliability, and financial consequences will be reduced when each outcome occurs.
Coordinated Substation Attack	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	2%	4%	6%	9%	11%	13%	
	Financial	2%	3%	5%	7%	8%	10%	

Name	M1A Insider Threat Program Enhancement & Information Analysis - Base

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	1%	2%	3%	4%	5%	6%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how the Insider Threat program will impact Security System Bypass/Breach by conducting awareness training focusing in: • Being alert to detect suspicious behavior from internal or external actors; • Adopting best practices for maintaining security protections; and • Having ongoing awareness training so that physical security procedures are reinforced on an annual basis.
D2	Human/ Process Failure	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how the Insider Threat program will impact Human/Process Failure by conducting awareness training focusing in: • Being alert to detect suspicious behavior from internal or external actors; • Adopting best practices for maintaining security protections; and • Having ongoing awareness training so that physical security procedures are reinforced on an annual basis.
D3	Insider Threat	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation impacts Insider Threat by preventing high-risk individuals from joining the SCE workforce, and identifying and addressing existing high-risk workers before they can commit malicious acts against SCE.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, Theft is reduced when unusual behavior patterns from internal actors are identified, investigated and ended.
	Financial	2%	3%	5%	7%	8%	10%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	1%	3%	4%	5%	6%	8%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how financial consequences associated with Trespassing events are reduced when employees are trained to detect and report suspicious behavior from potential intruders.
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how Workplace Violence is reduced as SCE hires lower-risk workers.
Workplace Violence	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how financial and reliability consequences associated with Coordinated Attack on Multiple Substations events are reduced when employees are trained to detect and report suspicious behavior from potential intruders.
Coordinated Substation Attack	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	2%	3%	5%	7%	8%	10%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	M1B Insider Threat Program Enhancement & Information Analysis - Enhanced

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how the Insider Threat program will impact Security System Bypass/Breach by conducting awareness training focusing in: • Being alert to detect suspicious behavior from internal or external actors; • Adopting best practices for maintaining security protections; and • Having ongoing awareness training so that physical security procedures are reinforced on an annual basis.
D2	Human/ Process Failure	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how the Insider Threat program will impact Human/Process Failure by conducting awareness training focusing in: • Being alert to detect suspicious behavior from internal or external actors; • Adopting best practices for maintaining security protections; and • Having ongoing awareness training so that physical security procedures are reinforced on an annual basis.
D3	Insider Threat	4%	7%	11%	14%	17%	20%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation impacts Insider Threat by preventing high-risk individuals from joining the SCE workforce, and identifying and addressing existing high-risk workers before they can commit malicious acts against SCE.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how, for example, Theft is reduced when unusual behavior patterns from internal actors are identified, investigated and ended.
	Financial	2%	4%	6%	9%	11%	13%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how financial and reliability consequences associated with Trespassing events are reduced when employees are trained to detect and report suspicious behavior from potential intruders.
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the opinion of our safety experts (see workpaper for SME qualifications) and applied the methodology described in the Control or Mitigation Effectiveness Workpaper. The opinion of our experts considered how
Workplace Violence	Fatalities	3%	7%	10%	13%	16%	19%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how financial and reliability consequences associated with Coordinated Attack on Multiple Substations events are reduced when employees are trained to detect and report suspicious behavior from potential intruders.
Coordinated Substation Attack	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	2%	4%	6%	9%	11%	13%	
	Financial	2%	4%	6%	9%	11%	13%	

Name	M2 Smart Key Program Phase 1 - Listed BR/CS Critical Sites

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security System Bypass/Breach by helping prevent unauthorized access and providing greater accountability for the use of keys.
D2	Human/ Process Failure	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security Human/Process Failure by helping prevent unauthorized access and providing greater accountability for the use of keys.
D3	Insider Threat	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how Smart Keys reduce the frequency of Insider Threat events by limiting access permissions to only those individuals who have a justified business need. Smart keys can also detect unauthorized access attempts; such detection can alert SCE to concerning behavior that is subject to investigation and disciplinary action.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. Smart Key technology reduces potential Theft events.
	Financial	3%	7%	10%	13%	16%	19%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. This mitigation prevents and reduces Trespassing events because access permissions are only assigned to authorized users that have a legitimate work reason for possessing access.
O3	Serious Injuries	3%	7%	10%	13%	16%	19%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.
Workplace Violence	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	2%	3%	5%	7%	8%	10%	These percentages were based on the opinion of our safety experts (see workpaper for SME qualifications) and applied the methodology described in the Control or Mitigation Effectiveness Workpaper. The opinion of our experts considered how this
Coordinated Substation	Fatalities	2%	3%	5%	7%	8%	10%	
	Reliability	2%	3%	5%	7%	8%	10%	

Attack	Financial	2%	3%	5%	7%	8%	10%	mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.

Name	M3 Smart Key Phase 2 - Electrical Sites

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security System Bypass/Breach by helping prevent unauthorized access and providing greater accountability for the use of keys.
D2	Human/ Process Failure	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security Human/Process Failure by helping prevent unauthorized access and providing greater accountability for the use of keys.
D3	Insider Threat	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how Smart Keys reduce the frequency of Insider Threat events by limiting access permissions to only those individuals who have a justified business need. Smart keys can also detect unauthorized access attempts; such detection can alert SCE to concerning behavior that is subject to investigation and disciplinary action.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. Smart Key technology reduces potential Theft events.
	Financial	2%	4%	6%	9%	11%	13%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. This mitigation prevents and reduces Trespassing events because access permissions are only assigned to authorized users that have a legitimate work reason for possessing access.
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.
Workplace Violence	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
O4	Serious Injuries	1%	3%	4%	5%	6%	8%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.
Coordinated	Fatalities	1%	3%	4%	5%	6%	8%	
Substation	Reliability	2%	3%	5%	7%	8%	10%	

Attack	Financial	1%	3%	4%	5%	6%	8%	

Name	M4 Smart Key Phase 3 - Remaining Non-Electric

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Security System Bypass/ Breach	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security System Bypass/Breach by helping prevent unauthorized access and providing greater accountability for the use of keys.
D2	Human/ Process Failure	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact Security Human/Process Failure by helping prevent unauthorized access and providing greater accountability for the use of keys.
D3	Insider Threat	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how Smart Keys reduce the frequency of Insider Threat events by limiting access permissions to only those individuals who have a justified business need. Smart keys can also detect unauthorized access attempts; such detection can alert SCE to concerning behavior that is subject to investigation and disciplinary action.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Theft	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. Smart Key technology reduces potential Theft events.
	Financial	2%	4%	6%	9%	11%	13%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
Trespassing	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	2%	3%	5%	7%	8%	10%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. This mitigation prevents and reduces Trespassing events because access permissions are only assigned to authorized users that have a legitimate work reason for possessing access.
O3	Serious Injuries	2%	4%	6%	9%	11%	13%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.
Workplace Violence	Fatalities	2%	4%	6%	9%	11%	13%	
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	mitigation does not affect this outcome.

O4	Serious Injuries	1%	2%	3%	4%	5%	6%	These percentages were based on the methodology described in the Control or Mitigation Effectiveness Workpaper. SCE Physical Security experts considered how this mitigation will impact all outcomes and associated consequences. For example, traditional keys turn into unrestrained keys once they are reported as lost or stolen. However, Smart Keys allow us to track and control keys efficiently and effectively by disabling them or promptly removing associated access permissions. The use of Smart Key technology reduces events related to Workplace Violence and Coordinated Attack at Multiple Substations. This technology helps identify unusual behavior patterns in use of the Smart Key, so that SCE can investigate and end threats.
Coordinated Substation Attack	Fatalities	1%	3%	4%	5%	6%	8%	
	Reliability	1%	2%	3%	4%	5%	6%	
	Financial	1%	2%	3%	4%	5%	6%	

SCE estimates how effective each control and mitigation will be at reducing the frequency of each driver, the probability of occurrence for each outcome, and the severity of each consequence.

The Physical Security risk is unique in that each facility we protect has a different risk profile based on its size, function, criticality, vulnerabilities, prior security work performed, etc. As such, to perform the RAMP risk analysis and protect the disclosure of confidential security information, SCE used the following approach which allowed us to show the effects of the controls and mitigations on the risk without disclosing critical security information. SCE relied on internal physical security experts[1] and prior evaluations of each of our sites' criticality, threats, vulnerabilities, and activities implemented, to do this.

1) First, our physical security experts estimated how effective a control or mitigation is at reducing risk at a facility (or grouping of similar facilities). Because not every facility has the same risk exposure, the actual set of physical security measures at each facility may vary. Therefore, our experts assessed each facility type independently (for example, different sizes and complexities or substations, different administrative office building functions, etc.). SCE assigned an estimated reduction value to each driver and consequence based on the control/mitigation's ability to affect each type or grouping of facilities. For example, a SME may estimate that deploying uniformed security guards at electric substation facilities would reduce the frequency of driver D1 (Security System Bypass/Breach) at those types of facilities by 80%.

2) Second, we estimated the risk for the facilities being evaluated for security enhancements over the RAMP period. SCE prioritizes which facilities (out of more than 1,300) are treated with security enhancements. This is estimated to be about 100 facilities. In most cases, an enhancement will be deployed at the highest-impact facilities first. Based on SCE's internal evaluation of the risks associated with each facility, SCE estimated that the facilities in scope for treatment during the RAMP period represent approximately 25% of the total company-wide physical security baseline risk.[2]

[1] See the 'SME Qualifications' workpaper for more detail on these experts.

[2] For purposes of this analysis, our portfolio of controls/mitigations is expected to enhance security at roughly 100 facilities out of SCE's ~1300 total facilities (7.7%). SCE is enhancing the facilities with the highest expected impact, measured by expected driver frequency and/or consequence severity. The majority of facilities are not critically essential to large-scale grid reliability, and do not contain very significant materials of value. As a result, they have

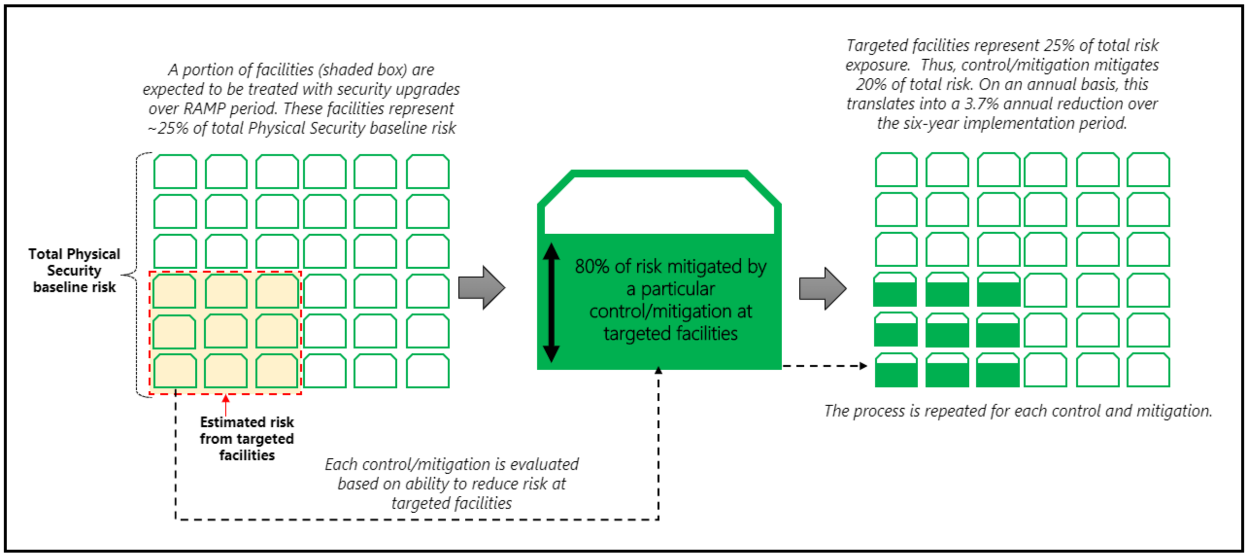
3) Third, we calculate the percentage reduction of each control/mitigation on the total physical security baseline risk. To do this, SCE applied the percentage in Step 1 to the percentage in Step 2: For our example, security guards are expected to reduce frequency of security breach by 80% at targeted facilities, and this control is applied to facilities representing 25% of the total physical security risk exposure. Thus, the risk reduction effectiveness of the security guard program would be 20% (i.e., 80% x 25% = 20%). This 20% represents the risk reduction over six years. Therefore, we apportioned the reduction over the six year period.[3]

The graphic below illustrates these three steps:

a low likelihood of being targeted or a low impact as the result of attack. As such, SCE assumes that facilities targeted for enhancement represent a risk exposure three times greater than the average; three times 7.7% leads us to 25% risk exposure at these facilities. For the purposes of this analysis, SCE is making the simplifying assumption that each control is addressing 25% of SCE's total physical security risk exposure.

[3] This equates to a risk reduction for D2 of 3.7% in 2018.

Figure 1 – Risk Mitigation Effectiveness Methodology



The results of this process, for all controls and mitigations evaluated in this chapter, are shown in the tables below:

Controls & Mitigations

ID	Controls/Mitigations	Description	Portfolios: Proposed Plan	Portfolios: Alternative Plan #1	Portfolios: Alternative Plan #2
C1a	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Baseline	Continue baseline Risk Mitigation security controls, including targeted metal theft abatement, security system refresh / break fix, security officer program, access control, and critical infrastructure protection.			X
C1b	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Enhanced	Continuing baseline Risk Mitigation security controls, plus: enhanced visitor/access management processes and controls (e.g., smart key), tiered critical facility program.	X	X	
C2	Electric Facilities Blanket/Protection of Generation Capabilities (Capital)	Continuing baseline Risk Mitigations security controls as a focused Generation Protection strategy, including risk-based Facility security controls, and access management / controls.	X	X	X
C3a	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Baseline	Continue baseline Risk Mitigation security controls as a business capability-focused protection strategy, e.g., risk-based security controls for critical facilities protection based on enterprise Business Impact Analysis.			X
C3b	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Enhanced	Continuing baseline Risk Mitigation security controls as a focused protection strategy, plus: comprehensive risk-based Facilities security controls, and enhanced visitor / access management processes / controls (e.g., smart key).	X	X	
C4	Asset Protection - Workforce Protection and Insider Threat (O&M)	Continuing current Risk Mitigation security controls, plus focus on emerging Workplace violence risks, rising active shooter threats, and the people and environmental risks associated with increasing transient encampments.	X	X	X
M1a	Insider Threat Program Enhancement - Information analysis (Capital/O&M) - Low	Enterprise insider risk analysis program using internal resources, practices, procedures, training, and jointly leveraging SCE internal technology capabilities across key stakeholders.	X		X
M1b	Insider Threat Program Enhancement - Information analysis (Capital/O&M) - High	Implementation of comprehensive Enterprise Insider Threat program, including enhanced identity management, utilizing primarily external contracted assets to analyze risk based on internal and external inputs to evaluate employee risk probability, identify high risk employees, and report on areas and issues of concern.		X	
M2	Smart Key Program Phase 1 - Listed BR/CS Critical Sites and CS Tier Sites	Smart Key - Deployment at targeted sites restores master key accountability and helps close perimeter security vulnerabilities.	X	X	
M3	Smart Key Program Phase 2 - Remaining Electrical Sites	Smart Key - Deployment at remaining electrical sites restores master key accountability and helps close perimeter security vulnerabilities.		X	
M4	Smart Key Program Phase 3 Remaining Non Electric Sites	Smart Key - Deployment at remaining non electrical sites restores master key accountability and helps close perimeter security vulnerabilities.		X	

% Reduction – Total Physical Security Baseline Risk

		Drivers			O1 - Theft Consequences		O2 - Trespassing Consequences	O3 - Workplace Violence Consequences		O4 - Coordinated Substation Attack			
ID	Controls/Mitigations	D2 – Human / Process Failure	D1 – Security System Bypass/ Breach	D3 – Insider Threat	Reliability	Financial	Financial	Fatalities	Injuries	Fatalities	Injuries4	Reliability	Financial
		%	%	%	%	%	%	%	%	%	%	%	%
C1a	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Baseline	2%	2%	1%	2%	3%	3%	3%	2%	2%	2%	2%	2%
C1b	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Enhanced	3%	4%	2%	4%	4%	4%	4%	3%	3%	3%	2%	2%
C2	Electric Facilities Blanket/Protection of Generation Capabilities (Capital)	2%	2%	1%	3%	2%	4%	4%	3%	2%	2%	2%	2%
C3a	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Baseline	2%	2%	1%	2%	2%	2%	3%	2%	3%	2%	2%	2%
C3b	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Enhanced	3%	4%	2%	3%	4%	4%	4%	3%	4%	3%	2%	2%
C4	Asset Protection - Workforce Protection and Insider Threat (O&M)	2%	3%	2%	4%	4%	3%	4%	3%	2%	2%	2%	2%
M1a	Insider Threat Program Enhancement - Information analysis (Capital/O&M) - Low	2%	1%	3%	2%	2%	1%	2%	2%	2%	2%	2%	2%
M1b	Insider Threat Program Enhancement - Information analysis (Capital/O&M) - High	2%	2%	4%	2%	2%	2%	3%	2%	2%	2%	2%	2%
M2	Smart Key Program Phase 1 - Listed BR/CS Critical Sites and CS Tier Sites	2%	3%	2%	3%	3%	2%	2%	3%	2%	2%	2%	2%
M3	Smart Key Program Phase 2 - Remaining Electrical Sites	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	2%	1%
M4	Smart Key Program Phase 3 Remaining Non Electric Sites	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%	1%

5

% Reduction – Targeted Facilities Only

25%	Universal value for risk exposure at targeted facilities	Drivers			O1 - Theft Consequences		O2 - Trespassing Consequences	O3 - Workplace Violence Consequences		O4 - Coordinated Substation Attack			
ID	Controls/Mitigations	D2 – Human / Process Failure	D1 – Security System Bypass/ Breach	D3 – Insider Threat	Reliability	Financial	Financial	Fatalities	Injuries	Fatalities	Injuries4	Reliability	Financial
		%	%	%	%	%	%	%	%	%	%	%	%
C1a	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Baseline	40%	50%	25%	50%	75%	75%	75%	50%	50%	50%	40%	40%
C1b	Electric Facilities Blanket/Grid Infrastructure Protection (Capital) - Enhanced	75%	80%	50%	80%	80%	80%	80%	75%	75%	75%	50%	50%
C2	Electric Facilities Blanket/Protection of Generation Capabilities (Capital)	50%	50%	30%	75%	50%	80%	80%	75%	50%	50%	50%	50%
C3a	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Baseline	40%	40%	30%	50%	50%	50%	75%	50%	75%	50%	40%	50%
C3b	Non-electric Facilities Blanket/Protection of Major Business Functions (Capital) - Enhanced	75%	80%	50%	75%	80%	80%	80%	75%	80%	75%	50%	50%
C4	Asset Protection (O&M)	50%	75%	50%	80%	80%	75%	80%	75%	50%	50%	50%	40%
M1b	Insider Threat Program Enhancement Information analysis (Capital/O&M) - High	50%	50%	80%	50%	50%	40%	75%	50%	50%	50%	50%	50%
M1a	Insider Threat Program Enhancement Information analysis (Capital/O&M) - Low	50%	25%	75%	50%	40%	30%	50%	50%	50%	50%	40%	50%
M2	Smart Key Program Phase 1 - Listed BR/BIA Critical and CS Tier Sites	50%	75%	50%	75%	75%	50%	50%	75%	40%	40%	40%	40%
M3	Smart Key Program Phase 2 - Remaining Electrical Sites	40%	50%	40%	50%	50%	50%	50%	50%	30%	30%	40%	30%
M4	Smart Key Program Phase 3 Remaining Non Electric Sites	40%	40%	40%	50%	50%	40%	50%	50%	30%	25%	25%	25%

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 10
Wildfire

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 10
Wildfire

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Wildfire
Workpaper:	Baseline Risk Modeling Inputs

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Contact From Object	23.0	23.0	23.0	23.0	23.0	23.0	Driver frequencies are based on the annual average CPUC Reportable incidents from 2015-2017, per D.14-02-015 which defines reportable incidents as including fires that travel greater than one linear meter from the ignition point. The 2015-2017 data was filtered to those incidents identified as starting in SCE's HFRA, and associated with SCE's distribution infrastructure. For purposes of this analysis, HFRA includes the most recent CPUC High Fire Threat District maps with Tier 2 and Tier 3 designations, plus areas previously identified by SCE as high fire risk areas prior to the release of the most recent CPUC maps.
	D2	Equipment/ Facility Failure	14.0	14.0	14.0	14.0	14.0	14.0	
	D3	Other (Wire-to-Wire Contact/ Contamination	2.0	2.0	2.0	2.0	2.0	2.0	
	D4	Unknown/ Unspecified	5.0	5.0	5.0	5.0	5.0	5.0	

	ID	Name	2018	2019	2020	2021	2022	2023	Source/Justification
Triggering Event Frequency	TEF	Ignition associated with SCE in HFRA	44.0	44.0	44.0	44.0	44.0	44.0	The TEF is the sum of the annual driver frequencies

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Wildfire Red Flag Warning In Effect; Fire Greater Than 5,000	0.8%	0.4	The following data sources were used: SCE overlaid Red Flag Day data on CPUC reportable incidents for distribution infrastructure across SCE's service territory from 2015-2017.
	O2	Wildfire Red Flag Warning In Effect; Fire Less Than 5,000	31.0%	13.6	
	O3	Wildfire Red Flag Warning Not In Effect; Fire Greater Than	0.2%	0.1	
	O4	Wildfire Red Flag Warning Not In Effect; Fire Less Than 5,000	68.1%	30.0	

	ID	Name	Distribution (see	Input 1	Input 2	Input 3	Source / Justification
Consequences	O1	Serious Injuries	Exponential	22.161	N/A	N/A	Serious injury data related to wildfires was not readily available among data reviewed, therefore a
		Fatalities	Exponential	2.670	N/A	N/A	SCE reviewed fatalities associated with CalFire data for fires statewide >300 acres from 2007-
		Reliability	Exponential	1,138,799	N/A	N/A	
		Financial	Exponential	$530,464,210	N/A	N/A	Financial consequence was estimated based on several factors:
	O2	Serious Injuries	Exponential	0.007	N/A	N/A	Based on CalFire 2010-2017 dataset, received through data request to CalFire. Filtered on < 5,000
		Fatalities	Exponential	0.001	N/A	N/A	Imputed from the Mean of Serious Injuries using the 8.3 ratio
		Reliability	Exponential	125,506	N/A	N/A	
		Financial	Exponential	$50,630	N/A	N/A	Based on CalFire 2010-2017 dataset, received through data request to CalFire. Filtered on < 5,000
	O3	Serious Injuries	Exponential	8.300	N/A	N/A	Serious injury data related to wildfires was not readily available among data reviewed, therefore a
		Fatalities	Exponential	1.000	N/A	N/A	Please see O1 - Fatalities.
		Reliability	Exponential	1,138,799	N/A	N/A	Same distribution as O1
		Financial	Exponential	$477,798,167	N/A	N/A	Please see O1 - Financial.
	O4	Serious Injuries	Exponential	0.007	N/A	N/A	Same as O2
		Fatalities	Exponential	0.001	N/A	N/A	Same as O2
		Reliability	Exponential	125,506	N/A	N/A	Same as O2
		Financial	Exponential	$50,630.00	N/A	N/A	Same as O2

Chapter:	Wildfire
Workpaper:	Baseline Risk Modeling Inputs - O1 O3 - Fatalities

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

		Fatalities	Exponential	2.670	N/A	N/A	SCE reviewed fatalities associated with CalFire data for fires statewide >300 acres from 2007-2016, inclusive of several data modifications: SCE also included several 2017 wildfires that were described within CalFire press releases as caused by "Power Lines". SCE removed the 2015 Valley Fire, which was reported by CalFire with a cause listed as "Electrical Power". CalFire investigation reports indicated that the fire was caused by faulty residential wiring, therefore this fire was removed from analysis. SCE added the 2007 Witch Fire, which was classified in CalFire RedBooks as "Equipment Cause". SCE included this fire to be consistent with Cal Fire investigations, which indicated "Electric Power" cause. http://www.fire.ca.gov/fire_protection/fire_protection_fire_info_redbooks http://calfire.ca.gov/communications/communications_newsreleases SCE overlaid Red Flag Day data on CalFire incidents described above. The Red Flag data provided was from the Iowa State University Mesonet GIS Page. https://mesonet.agron.iastate.edu/request/gis/watchwarn.phtml
		Fatalities	Exponential	1.000	N/A	N/A	Please see O1 - Fatalities.

O1 - Wildfire (Red Flag Days) >5,000 Acres 2007-2016, Power Lines

year	Fire Name	Acres Total	Fatality
2007	Witch Fire	197990	2
2017	Norrbom, Ado	56556	3
2017	Atlas	51624	6
2017	Redwood	36523	9
2017	Pocket	17357	0
2013	DEER	11429	0
2017	Cherokee	8417	0
2017	La Porte Fire	8417	0

Distribution Detail
- •Fitted historical fatality (by event) using @RISK
- •Exponential Distribution with mean of 2.67

O3 - Wildfire (Not Red Flag Days) >5,000 Acres, Power Lines

year	Fire Name	Acres Total	Fatality
2015	BUTTE	70868	2
2013	MOUNTAIN	27531	0

Distribution Detail
- •2 data points not enough to fit a distribution

•Assumed same distribution as O1 (i.e. Exponential) and the mean would be the average, in this case 1.

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

Chapter:	Wildfire
Workpaper:	Baseline Risk Modeling Inputs - O2 O4 Serious Injury

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences	O2	Serious Injuries	Exponential	0.007	N/A	N/A	Based on Calfire 2010-2017 dataset, received through data request to CalFire. Filtered on < 5,000 acres, electrical cause, codes 141,142,143. Attempted to match with Red Flag day data, however Calfire dataset does not have the incidents by county. Performed a match on date (best information available).
	O4	Serious Injuries	Exponential	0.007	N/A	N/A	Same as O2

O2 - Wildfire (Red Flag Days) < 5,000 Acres
Distribution Detail:
•1,377 rows of data
•Total of 9 injuries (assumed Serious)
•Distribution Fitting using @RISK
•Exponential , mean = 0.006531
Note: Since County Information was not available within the CalFire data set, approximated Red Flag designation by searching the date of the fire and if it matched any date from the

O4 - Wildfire (Not Red Flag Days) < 5,000 Acres

Across 190 rows of assumed non-red flag day fires, zero injuries were recorded. A zero value seemed unlikely given a large number of fires, and based on the injury rate listed above
Spot checks of larger fires (>5,000 acres) could not match data against CalFIre redbook data. Data integrity concerns were noted.

Chapter:	Wildfire
Workpaper:	Baseline Risk Modeling Inputs - O1 O3 Financial

Legend

Distribution	Input 1	Input 2	Input 3
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences	O1	Financial	Exponential	$530,464,210	N/A	N/A	Financial consequence was estimated based on several factors: Damage Claims: SCE used CalFire's destroyed structure counts from reported Power Line fire incidents statewide >300 acres from 2007-2016, and partial year 2017. SCE applied a cost per structure of $819,472 based on insurance industry property claims data for fires in California, in constant 2017 dollars. https://www.iii.org/fact-statistic/facts-statistics-wildfires Suppression Costs: SCE used acreage count from CalFire reported Power Line fire incidents statewide >300 acres from 2007-2016, and partial year 2017. A unit cost of $248.39 was applied per acre suppression based on nationally reporet suppression costs, in constant 2017 dollars. https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf Land Restoration Costs: SCE used acreage count from CalFire reported Power Line fire incidents statewide >300 acres from 2007-2016, and partial year 2017. A unit cost of $1,227 was applied per acre restoration based on public agency research papers. https://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf Data modifications to CalFire data were consistent with the methodology described in O1 - Fatalities description above. http://www.fire.ca.gov/fire_protection/fire_protection_fire_info_redbooks http://calfire.ca.gov/communications/communications_newsreleases
	O3	Financial	Exponential	$477,798,167	N/A	N/A	Please see O1 - Financial. Costs were calculated based on actual data described in O1 - Financial, for non Red Flag Days SCE Used Red Flag Data to identify incidents not occurring on Red Flag Days. The Red Flag data provided was from the Iowa State University Mesonet GIS Page. https://mesonet.agron.iastate.edu/request/gis/watchwarn.phtml

Property Claims Cost per structure in 2017 dollars	Per Acre Restoration cost in 2017 dollars	Per Acre Estimated Firefighting cost in 2017 dollars
$819,472	$1,227	$248.39

PROPERTY CLAIMS
https://www.iii.org/fact-statistic/facts-statistics-wildfires
California Fires only

Rank	Date	Name, Location	Dollars when occurred	In 2016 dollars (2)	2017 Inflation Multiplier	In 2017 Dollars (millions)	# Structures (Calfire Redbooks)	# Acres (Calfire Redbooks)	Property Claims Cost per structure in 2017 dollars
1	Oct. 20-21, 1991	Oakland Hills Fire, CA	1,700	2,746	1.02	$2,804	2,900	1,600	
2	Oct. 21-24, 2007	Witch Fire, CA	1,300	1,488	1.02	$1,520	1,650	197,990	
3	Oct. 25-Nov. 4, 2003	Cedar Fire, CA	1,060	1,362	1.02	$1,391	2,820	273,246	
4	Oct. 25-Nov. 3, 2003	Old Fire, CA	975	1,253	1.02	$1,280	1,003	91,281	
~~5~~	~~Nov. 28-30, 2016~~	~~Great Smoky Mountains Fire, TN~~							
6	Sep. 12-14, 2015	Valley Fire, CA	921	933	1.02	$953	1,955	76,067	
7	Nov. 2-3, 1993	Topanga Fire, CA	375	578	1.02	$590	323	18,000	
~~8~~	~~Sep. 4-9, 2011~~	~~Bastrop County Complex Fire, TX~~							
9	Oct. 27-28, 1993	Laguna Canyon Fire, CA	350	540	1.02	$552	441	14,437	
~~10~~	~~Jun. 24-28, 2012~~	~~Waldo Canyon Fire, CO~~							
						$9,090	11,092		$819,472

(1) Property coverage only for catastrophic fires. Effective January 1, 1997, ISO's Property Claim Services (PCS) unit defines catastrophes as events that cause more than $25 million in insured property damage and that affect a significant number of insureds and insurers. From 1982 to 1996, PCS used a $5 million threshold in defining catastrophes. Before 1982, PCS used a $1 million threshold. Does not include wildfires in 2017.

(2) Adjusted for inflation through 2016 by ISO using the GDP implicit price deflator.
Source: The Property Claim Services® (PCS®) unit of ISO®, a Verisk Analytics® company

Suppression Costs
https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf
Federal Firefighting Costs (Suppression Only)

Year	Fires	Acres	Forest Service	DOI Agencies	Total	CPI Inflation In	2017 Dollar Total	$/acre in 2017 dollars
1985	82,591	2,896,147.00	$161,505,000	$78,438,000	$239,943,000	49.33	$546,774,665	188.7938235
1986	85,907	2,719,162.00	$111,625,000	$91,153,000	$202,778,000	50.27	$453,477,006	166.7708678
1987	71,300	2,447,296.00	$253,657,000	$81,452,000	$335,109,000	52.11	$722,919,942	295.3953843
1988	72,750	5,009,290.00	$429,609,000	$149,317,000	$578,926,000	54.23	$1,199,967,021	239.5483233
1989	48,949	1,827,310.00	$331,672,000	$168,115,000	$499,787,000	56.85	$988,230,018	540.8113663
1990	66,481	4,621,621.00	$253,700,000	$144,252,000	$397,952,000	59.92	$746,571,810	161.5389514
1991	75,754	2,953,578.00	$132,300,000	$73,820,000	$206,120,000	62.46	$370,977,533	125.6027547
1992	87,394	2,069,929.00	$290,300,000	$87,166,000	$377,466,000	64.35	$659,396,427	318.559925
1993	58,810	1,797,574.00	$184,000,000	$56,436,000	$240,436,000	66.25	$407,976,271	226.9593747
1994	79,107	4,073,579.00	$757,200,000	$161,135,000	$918,335,000	67.98	$1,518,649,975	372.8048419
1995	82,234	1,840,546.00	$367,000,000	$110,126,000	$477,126,000	69.88	$767,491,587	416.9912553
1996	96,363	6,065,998.00	$547,500,000	$153,683,000	$701,183,000	71.93	$1,095,783,773	180.6436094
1997	66,196	2,856,959.00	$179,100,000	$105,048,000	$284,148,000	73.61	$433,912,819	151.8792602
1998	81,043	1,329,704.00	$306,800,000	$109,904,000	$416,704,000	74.76	$626,607,909	471.2386431
1999	92,487	5,626,093.00	$361,100,000	$154,416,000	$515,516,000	76.39	$758,595,630	134.8352454
2000	92,250	7,383,493.00	$1,076,000,000	$334,802,000	$1,410,802,000	78.97	$2,008,218,341	271.987573
2001	84,079	3,570,911.00	$683,122,000	$269,574,000	$952,696,000	81.20	$1,318,850,414	369.3316393
2002	73,457	7,184,712.00	$1,279,000,000	$395,040,000	$1,674,040,000	82.49	$2,281,250,798	317.5145779
2003	63,629	3,960,842.00	$1,023,500,000	$303,638,000	$1,327,138,000	84.36	$1,768,376,065	446.4646822
2004	65,461	8,097,880.00	$726,000,000	$281,244,000	$1,007,244,000	86.62	$1,307,130,837	161.4164247
2005	66,753	8,689,389.00	$524,900,000	$294,054,000	$818,954,000	89.56	$1,027,906,959	118.2945037
2006	96,385	9,873,745.00	$1,280,419,000	$424,058,000	$1,704,477,000	92.45	$2,072,509,737	209.9010798
2007	85,705	9,328,045.00	$1,149,654,000	$470,491,000	$1,620,145,000	95.09	$1,915,330,562	205.3303304
2008	78,979	5,292,468.00	$1,193,073,000	$392,783,000	$1,585,856,000	98.74	$1,805,480,020	341.1414145
2009	78,792	5,921,786.00	$702,111,000	$218,418,000	$920,529,000	98.39	$1,051,751,842	177.6072019
2010	71,971	3,422,724.00	$578,285,000	$231,214,000	$809,499,000	100.00	$909,970,432	265.8614695
2011	74,126	8,711,367.00	$1,055,736,000	$318,789,000	$1,374,525,000	103.16	$1,497,840,506	171.9409257
2012	67,774	9,326,238.00	$1,436,614,000	$465,832,000	$1,902,446,000	105.29	$2,031,093,757	217.7827498
2013	47,579	4,319,546.00	$1,341,735,000	$399,199,000	$1,740,934,000	106.83	$1,831,826,749	424.0785373
2014	63,212	3,595,613.00	$1,195,955,000	$326,194,000	$1,522,149,000	108.57	$1,576,052,083	438.3263948
2015	68,151	10,125,149.00	$1,713,000,000	$417,543,000	$2,130,543,000	108.70	$2,203,377,025	217.6142816
2016	67,595	5,503,538.00	$1,603,806,000	$371,739,000	$1,975,545,000	110.07	$2,017,626,282	366.6053149
2017	71,499	10,026,286.00	$2,410,165,000	$508,000,000	$2,918,165,000	112.41	$2,918,165,000	291.0514422
2018								
		172,468,518.00					$42,840,089,796	$ 248.39

The Department of Interior agencies include: Bureau of Indian Affairs, Bureau of Land Management; National Park Service; and U.S. Fish and Wildlife Service. The U.S. Forest Service is an agency of the Department of Agriculture.

Annual fires and total acres include all private, state and federal lands in the United States.

Costs are not adjusted for inflation.

RESTORATION COSTS

https://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf

Fire Name	Suppression Costs	Other Direct Costs	Rehabilitation Cost	Indirect Costs	Additional Costs	Total Costs	Total / Suppression	Suppression	Acres	Year	CPI Index	2017 CPI	2017 rehab	Cost per acres
Canyon Ferry Complex (MT 200	$9,544,627	$400,000	$8,075,921	$55,310	n/a	$18,075,858	1.9	53%	43,944	2000	78.97072	112.4116	$11,495,740	$262
Cerro Grande (NM 2000)	$33,500,000	$864,500,000	$72,388,944	n/a	n/a	$970,388,944	29	3%	42,873	2000	78.97072	112.4116	$103,042,670	$2,403
Hayman (CO 2002)	$42,279,000	$93,269,834	$39,930,000	$2,691,601	29529614	$207,700,049	4.9	20%	137,759	2002	82.49047	112.4116	$54,413,481	$395
Missionary Ridge(CO 2002)	$37,714,992	$52,561,331	$8,623,203	$50,499,849	3404410	$152,803,785	4.1	25%	70,000	2002	82.49047	112.4116	$11,751,027	$168
Rodeo-Chedeski (AZ 2002)	$46,500,000	$122,500,000	$139,000,000	$403,000	n/a	$308,403,000	6.6	15%	462,614	2002	82.49047	112.4116	$189,418,330	$409
Old, Grand Prix,Padua (CA 2003)	$61,335,684	n/a	$534,593,425	$681,004,114	n/a	$1,276,933,224	20.8	5%	125,000	2003	84.36308	112.4116	$712,331,511	$5,699
COST CATEGORY									882,190			112.4116	$1,082,452,759	$1,227

https://fred.stlouisfed.org/series/CPALTT01USA661S
FRED Graph Observations
Federal Reserve Economic Data
Link: https://fred.stlouisfed.org
Help: https://fred.stlouisfed.org/help-fa
Economic Research Division
Federal Reserve Bank of St. Louis

CPALTT01USA661S Consumer Price Index: Total All Items for the United States, Index 2010=100, Annual, Not Seasonally Adjust

Frequency: Annual

observation_date		CPALTT01USA661S
1960-01-01	1960	13.5630607803976
1961-01-01	1961	13.7082837473334
1962-01-01	1962	13.8726149993923
1963-01-01	1963	14.0445895655005
1964-01-01	1964	14.2242074456579
1965-01-01	1965	14.4496852101109
1966-01-01	1966	14.8853541109182
1967-01-01	1967	15.2980930695778
1968-01-01	1968	15.9515964207889
1969-01-01	1969	16.8229342224036
1970-01-01	1970	17.8051000777325
1971-01-01	1971	18.5694314826577
1972-01-01	1972	19.1770749495732
1973-01-01	1973	20.3617886272073
1974-01-01	1974	22.6127446147120
1975-01-01	1975	24.6802610650347
1976-01-01	1976	26.0980958211709
1977-01-01	1977	27.7949115401048
1978-01-01	1978	29.9159311887723
1979-01-01	1979	33.2828110274678
1980-01-01	1980	37.7923663165264
1981-01-01	1981	41.6980997956942
1982-01-01	1982	44.2547883451690
1983-01-01	1983	45.6764447583299
1984-01-01	1984	47.6407764689876
1985-01-01	1985	49.3299488738723
1986-01-01	1986	50.2662548449057
1987-01-01	1987	52.1082935307754
1988-01-01	1988	54.2331348364675
1989-01-01	1989	56.8509698983363
1990-01-01	1990	59.9197604891109
1991-01-01	1991	62.4573407534626
1992-01-01	1992	64.3490609806524
1993-01-01	1993	66.2484245218916
1994-01-01	1994	67.9758134970225
1995-01-01	1995	69.8828203523109
1996-01-01	1996	71.9312285175104
1997-01-01	1997	73.6127576083459
1998-01-01	1998	74.7554330587090
1999-01-01	1999	76.3911022652490
2000-01-01	2000	78.9707207568715
2001-01-01	2001	81.2025684592531
2002-01-01	2002	82.4904668765520
2003-01-01	2003	84.3630788186188
2004-01-01	2004	86.6216781201728
2005-01-01	2005	89.5605323721102
2006-01-01	2006	92.4497050827274
2007-01-01	2007	95.0869923788516
2008-01-01	2008	98.7374773853445
2009-01-01	2009	98.3864199710624
2010-01-01	2010	100.0000000000000
2011-01-01	2011	103.1568415686220
2012-01-01	2012	105.2915045328670
2013-01-01	2013	106.8338488748660
2014-01-01	2014	108.5669321189640
2015-01-01	2015	108.6957219606930
2016-01-01	2016	110.0670089342700
2017-01-01	2017	112.4115573023080

Legend			
Distribution	Input 1	Input 2	Input 3
Poisson	Mean		
Exponential	Mean		
Lognormal	Median	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Mode	Max
Uniform	Min	Max	

Chapter:	Wildfire
Workpaper:	Baseline Risk Modeling Inputs - O2 O4 Financial

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences		Financial	Exponential	$50,630	N/A	N/A	Based on Calfire 2010-2017 dataset, received through data request to CalFire. Filtered on < 5,000 acres, electrical cause, codes 141,142,143. Attempted to match with Red Flag day data, however Calfire dataset does not have the incidents by county. Performed a match on date (best information available). SCE applied the unit costs described in O1 for $/acres suppression and restoration, and $/structures destroyed to form a distribution of costs
		Financial	Exponential	$50,630.00	N/A	N/A	Same as O2

Property Claims Cost per structure in 2017 dollars	Per Acre Restoration cost in 2017 dollars	Per Acre Estimated Firefighting cost in 2017 dollars
$819,472	$1,227	$248.39

See Workpaper "Baseline Risk Modeling Inputs - O1 O3 Financial" for detail supporting these unit costs.

O2 - Wildfire (Red Flag Days) < 5,000 Acres

Distribution Detail:

- 1,377 rows of data
- Used Unit costs for Acre Suppression, Restoration Costs, and Structures destroyed
- Distribution fitting using @RISK
- Exponential, Mean = $49K

O4 - Wildfire (Not Red Flag Days) < 5,000 Acres

See Above

Chapter	Wildfire

Drivers

ID	Name
D1	Contact From Object
D2	Equipment / Facility Failure
D3	Other (Wire to Wire Contact / Contamination)
D4	Unknown / Unspecified

Outcomes

ID	Name
O1	Red Flag day, > 5,000 Acres
O2	Red Flag Day , < 5,000 Acres
O3	Non Red Flag Day, > 5,000 Acres
O4	Non Red Flag Day, < 5,000 Acres

Controls & Mitigations

ID	Name
C1	Overhead Conductor Program
C1a	Overhead Conductor Program
C2	FR3 Overhead Distribution Transformer
M1	Wildfire Covered Conductor Program
M1a	Wildfire Covered Conductor Program
M1b	Wildfire Covered Conductor Program
M2	Remote-Controlled Automatic Reclosers and Fast Curve Settings
M3	PSPS Protocol and Support Functions
M4	Infrared Inspection Program
M5	Expanded Vegetation Management
M6	Microgrids
M7	Enhanced Situational Awareness
M8	Fusing Mitigation
M9	Fire Resistant Poles
M9a	Fire Resistant Poles

M9b	Fire Resistant Poles

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	
	C1 Overhead Conductor Program

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	0.1%	0.3%	0.4%	0.4%	0.5%	0.5%	See Page 1 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in
D2	Equipment / Facility Failure	0.3%	0.8%	1.1%	1.2%	1.3%	1.5%	interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, >	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	C1a Overhead Conductor Program

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	0.3%	0.8%	1.1%	1.2%	1.3%	1.5%	See Page 2 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, >	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	C2 FR3 Overhead Distribution Transformer

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	0.2%	0.4%	0.7%	0.9%	1.1%	1.3%	See Page 3 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, >	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M1 Wildfire Covered Conductor Program

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	1.2%	2.6%	9.2%	16.9%	26.3%	37.4%	See Page 4 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D2	Equipment / Facility Failure	0.5%	1.1%	3.8%	7.0%	10.9%	15.4%	
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, >	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M1a Wildfire Covered Conductor Program

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	0.9%	2.1%	7.2%	13.3%	20.7%	29.4%	See Page 5 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D2	Equipment / Facility Failure	0.4%	0.9%	3.0%	5.6%	8.7%	12.4%	
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, > 5,000 Acres	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day , < 5,000 Acres	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag Day, > 5,000 Acres	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag Day, < 5,000 Acres	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M1b Wildfire Covered Conductor Program

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	1.2%	2.8%	9.9%	18.2%	28.2%	40.1%	See Page 6 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D2	Equipment / Facility Failure	0.7%	1.7%	5.8%	10.7%	16.7%	23.7%	
D3	Other (Wire to Wire Contact / Contaminatio	0.5%	1.1%	3.7%	6.8%	10.6%	15.1%	
D4	Unknown / Unspecified	0.5%	1.1%	3.7%	6.8%	10.6%	15.1%	

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M2
	Remote-Controlled Automatic Reclosers and Fast Curve Settings

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	See Page 7 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for details.
Red Flag day, >	Fatalities	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
5,000 Acres	Reliability	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
	Financial	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
O2	Serious Injuries	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
Red Flag Day ,	Fatalities	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
< 5,000 Acres	Reliability	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
	Financial	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M3 PSPS Protocol and Support Functions

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminati	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	See Page 8 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for details.
Red Flag day, >	Fatalities	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
5,000 Acres	Reliability	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
	Financial	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M4 Infrared Inspection Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	1.2%	2.4%	3.5%	4.7%	5.9%	7.1%	See Page 9 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as linear increase to the 2023 total.
D3	Other (Wire to Wire Contact / Contaminatic	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M5 Expanded Vegetation Management

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	0.0%	0.8%	2.3%	3.9%	5.4%	7.0%	See Page 10 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag day, >	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Red Flag Day ,	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
< 5,000 Acres	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, > 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Non Red Flag	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Day, < 5,000	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
Acres	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M6 Microgrids

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	See Page 11 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2020 are assumed zero, and years 2021-2023 are modeled as linearly increasing to the 2023 total.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M7 Enhanced Situational Awareness

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.**
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.**
O1 Red Flag day, > 5,000 Acres	Serious Injuries	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	See Page 12 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2020. Percentages in interim years 2018-2020 are modeled as increasing to the 2020 total based on relative year-by-year deployment rates, and same percentage assumed to be maintained for years 2021-2023.
	Fatalities	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Reliability	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Financial	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Fatalities	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Reliability	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Financial	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Fatalities	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Reliability	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Financial	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Fatalities	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Reliability	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	
	Financial	1.3%	3.2%	4.5%	4.5%	4.5%	4.5%	

Name	M8 Fusing Mitigation

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	0.5%	2.6%	4.1%	4.1%	4.1%	4.1%	See Page 13 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2020. Percentages in interim years 2018-2020 are modeled as increasing to the 2020 total based on relative year-by-year deployment rates, and same percentage assumed to be maintained for years 2021-2023.
D3	Other (Wire to Wire Contact / Contaminatio	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D5	#N/A	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D6	#N/A	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D7	#N/A	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M9 Fire Resistant Poles

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contaminatic	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	See Page 14 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
	Fatalities	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Reliability	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Financial	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Fatalities	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Reliability	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Financial	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Fatalities	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Reliability	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Financial	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Fatalities	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Reliability	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	
	Financial	0.0%	0.3%	1.5%	3.0%	4.8%	6.9%	

Name	M9a Fire Resistant Poles

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contamination)	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	See Page 15 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
	Fatalities	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Reliability	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Financial	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Fatalities	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Reliability	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Financial	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Fatalities	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Reliability	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Financial	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Fatalities	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Reliability	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	
	Financial	0.0%	0.2%	1.3%	2.6%	4.2%	6.0%	

Name	M9b Fire Resistant Poles

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Contact From Object	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Equipment / Facility Failure	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Other (Wire to Wire Contact / Contamination)	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D4	Unknown / Unspecified	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
O1 Red Flag day, > 5,000 Acres	Serious Injuries	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	See Page 16 of Wildfire (WDF): Mitigation Effectiveness Workpaper.xlsx for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on relative year-by-year deployment rates.
	Fatalities	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Reliability	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Financial	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
O2 Red Flag Day , < 5,000 Acres	Serious Injuries	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Fatalities	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Reliability	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Financial	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
O3 Non Red Flag Day, > 5,000 Acres	Serious Injuries	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Fatalities	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Reliability	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Financial	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
O4 Non Red Flag Day, < 5,000 Acres	Serious Injuries	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Fatalities	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Reliability	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	
	Financial	0.0%	0.1%	0.6%	1.2%	1.7%	2.8%	

Control C1: OCP (bare and covered) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
C1: OCP (bare and covered)	~253 OH circuit miles reconductored	D1a	Contact From Object - Animal	5.0	0.7%	99%	0.6%	1.0	0.6%	5.0	0.5%
		D1b	Contact From Object - Balloons	5.0	0.7%	99%	0.6%	1.0	0.6%	5.0	
		D1c	Contact From Object - Unspecified	3.0	0.7%	77%	0.5%	1.0	0.5%	3.0	
		D1d	Contact From Object - Vegetation	7.0	0.7%	99%	0.6%	1.0	0.6%	7.0	
		All other D1	various	3.0	0.7%	0%	0.0%	1.0	0.0%	3.0	
		D2b	Equipment/Facility Failure - Conductor	4.0	2.6%	90%	2.3%	1.5	3.5%	3.9	1.5%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	2.6%	90%	2.3%	1.0	2.3%	2.9	
		All other D2	various	7.0	2.6%	0%	0.0%	1.0	0.0%	7.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value represents the total amount of OH conductor to be replaced within the HFRA over the 6 year time frame; there are two figures because covered conductor (which affects driver category D1) will only be deployed from 2021-2023. It is expected that 253 miles of OH primary will be replaced, and 65 miles of that will be covered conductor in 2021-2023. The total amount of OH primary is 9,825 miles within the HFRA. 65 OH circuit miles completed ÷ 9,825 OH circuit miles = ~0.7% deployment (D1 only) 253 OH circuit miles completed ÷ 9,825 OH circuit miles = ~2.6% deployment (D2 only)
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every mile of bare conductor replaced with covered conductor, the covered conductor is assumed to be 99% effective against the specific contact from object drivers shown (D1a, D1b, D1d). For every mile of small bare conductor replaced with covered conductor, the covered conductor is assumed to be 90% effective against the specific equipment failure drivers shown (D2b, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, OCP aims to address areas of the system with susceptibility to short circuit duty (SCD) failure. As such, SMEs judged it to have a 2.0 targeting benefit for D2b Equipment/Facility Failure - Conductor (i.e. it is twice as effective in preventing this specific driver than executing the program on a random basis). All other drivers were modeled as 1.0 targeting benefit (i.e. no targeting).
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C1a: OCP (bare) - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
C1a: OCP (bare)	~253 OH circuit miles reconductored	D2b	Equipment/Facility Failure - Conductor	4.0	2.6%	90%	2.3%	1.5	3.5%	3.9	1.5%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	2.6%	90%	2.3%	1.0	2.3%	2.9	
		All other D2	various	7.0	2.6%	0%	0.0%	1.0	0.0%	7.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value represents the total amount of OH conductor to be replaced within the HFRA over the 6 year time frame. It is expected that 253 miles of OH primary will be replaced, and for this control it is assumed to be entirely bare conductor. The total amount of OH primary is 9,825 miles within the HFRA. 253 OH circuit miles completed ÷ 9,825 OH circuit miles = ~2.6% deployment
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every mile of small bare conductor replaced with larger bare conductor, the larger bare conductor is assumed to be 90% effective against the specific equipment failure drivers shown (D2b, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, OCP aims to address areas of the system with susceptibility to short circuit duty (SCD) failure. As such, SMEs judged it to have a 2.0 targeting benefit for D2b Equipment/Facility Failure - Conductor (i.e. it is twice as effective in preventing this specific driver than executing the program on a random basis). All other drivers were modeled as 1.0 targeting benefit (i.e. no targeting).
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C2: FR3 Transformer Replacement - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
C2: FR3 Transformer Replacement	~36k transformers replaced	D2g	Equipment/Facility Failure - Transformer	1.0	20.6%	90%	18.5%	1.0	18.5%	0.8	1.3%
		All other D2	various	13.0	20.6%	0%	0.0%	1.0	0.0%	13.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value is an estimate of the total amount of distribution transformers that would be replaced through other means within the HFRA over a 6 year time frame. This is based on an assumption of approximately ~6k transformers replaced per year (~36k over six years), out of a total estimate of ~175k overhead transformers in HFRA. (6 years x 6,000 OH transformers replaced per year) ÷ 175,000 OH transformers = ~20.6% deployment
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every distribution transformer replaced, a new FR3 transformer is assumed to be 90% effective against driver D2g Equipment/Facility Failure - Transformer. For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, the deployment strategy for FR3 transformers is to replace transformers on a reactive basis. As such, no targeting benefit is assumed.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M1: WCCP (covered) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M1: WCCP (covered)	**SCD Specific Scope** ~945 miles by 2023	D1a	Contact From Object - Animal	5.0	9.6%	99%	9.5%	1.0	9.5%	4.5	8.0%
		D1b	Contact From Object - Balloons	5.0	9.6%	99%	9.5%	1.0	9.5%	4.5	
		D1c	Contact From Object - Unspecified	3.0	9.6%	77%	7.4%	1.0	7.4%	2.8	
		D1d	Contact From Object - Vegetation	7.0	9.6%	99%	9.5%	1.0	9.5%	6.3	
		All other D1	various	3.0	9.6%	0%	0.0%	1.0	0.0%	3.0	
		D2b	Equipment/Facility Failure - Conductor	4.0	9.6%	90%	8.7%	2.0	17.3%	3.3	8.7%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	9.6%	90%	8.7%	2.0	17.3%	2.5	
		All other D2	various	7.0	9.6%	0%	0.0%	1.0	0.0%	7.0	
M1: WCCP (covered)	**CFO Specific Scope** ~1,481 miles by 2023	D1a	Contact From Object - Animal	5.0	15.1%	99%	14.9%	2.0	29.9%	3.5	29.4%
		D1b	Contact From Object - Balloons	5.0	15.1%	99%	14.9%	1.0	14.9%	4.3	
		D1c	Contact From Object - Unspecified	3.0	15.1%	77%	11.6%	1.0	11.6%	2.7	
		D1d	Contact From Object - Vegetation	7.0	15.1%	99%	14.9%	4.0	59.7%	2.8	
		All other D1	various	3.0	15.1%	0%	0.0%	1.0	0.0%	3.0	
		D2b	Equipment/Facility Failure - Conductor	4.0	15.1%	90%	13.6%	1.0	13.6%	3.5	6.8%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	15.1%	90%	13.6%	1.0	13.6%	2.6	
		All other D2	various	7.0	15.1%	0%	0.0%	1.0	0.0%	7.0	
										D1 combined (sum of D1 SCD and D1 CFO)	37.4%
										D2 combined (sum of D2 SCD and D2 CFO)	15.4%
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area). Note, the driver frequency data is duplicated for each specific scope selection (SCD and CFO).
Note 2	This value represents the total amount of OH conductor to be replaced within the HFRA over the 6 year time frame; there are two figures because SCD-targeted scope will be deployed on ~945 miles by 2023 and CFO-targeted scope will be deployed on ~1,481 miles by 2023. The total amount of OH primary is 9,825 miles within the HFRA. 945 OH circuit miles completed ÷ 9,825 OH circuit miles = ~9.6% deployment (SCD-targeted scope) 1,481 OH circuit miles completed ÷ 9,825 OH circuit miles = ~15.1% deployment (CFO-targeted scope)
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every mile of bare conductor replaced with covered conductor, the covered conductor is assumed to be 99% effective against the specific contact from object drivers shown (D1a, D1b, D1d). For every mile of small bare conductor replaced with covered conductor, the covered conductor is assumed to be 90% effective against the specific equipment failure drivers shown (D2b, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, the WCCP mitigation aims to address areas of the system with a history of vegetation-related faults. An analysis showed that the circuits targeted were 3.6 times as likely to have experienced a vegetation-related fault as compared to the system average. As such, a 3.6 targeting multiplier was assigned to the CFO-Vegetation driver for the CFO-targeted scope. Similarly, SMEs considered the prioritization scheme to also benefit areas with a history of animal-related faults, but to a lesser degree. As such, a 1.8 multiplier was assumed (half of the assumed vegetation targeting benefit). The WCCP mitigation was assumed to have a 2.0 targeting multiplier for conductor failure related drivers (the same value as OCP). It is important to note that the targeting multipliers are different between the two different scope categories, as they fundamentally target different portions of the system.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G

Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H Final RAMP model input (in 2023) for M1 was sum of SCD results and CFO results for each D1 and D2.

Mitigation M1a: WCCP (bare and covered) - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M1a: WCCP (bare)	**SCD Specific Scope** ~945 miles by 2023	D2b	Equipment/Facility Failure - Conductor	4.0	9.6%	90%	8.7%	1.5	13.0%	3.5	5.6%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	9.6%	90%	8.7%	1.0	8.7%	2.7	
		All other D2	various	7.0	9.6%	0%	0.0%	1.0	0.0%	7.0	
M1a: WCCP (Covered)	**CFO Specific Scope** ~1,481 miles by 2023	D1a	Contact From Object - Animal	5.0	15.1%	99%	14.9%	2.0	29.9%	3.5	29.4%
		D1b	Contact From Object - Balloons	5.0	15.1%	99%	14.9%	1.0	14.9%	4.3	
		D1c	Contact From Object - Unspecified	3.0	15.1%	77%	11.6%	1.0	11.6%	2.7	
		D1d	Contact From Object - Vegetation	7.0	15.1%	99%	14.9%	4.0	59.7%	2.8	
		All other D1	various	3.0	15.1%	0%	0.0%	1.0	0.0%	3.0	
		D2b	Equipment/Facility Failure - Conductor	4.0	15.1%	90%	13.6%	1.0	13.6%	3.5	6.8%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	15.1%	90%	13.6%	1.0	13.6%	2.6	
		All other D2	various	7.0	15.1%	0%	0.0%	1.0	0.0%	7.0	
										D1 CFO only	29.4%
									D2 combined (sum of D2 SCD and D2 CFO)		12.4%
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area). Note, the driver frequency data is duplicated for each specific scope selection (SCD and CFO).
Note 2	This value represents the total amount of OH conductor to be replaced within the HFRA over the 6 year time frame; there are two figures because SCD-targeted scope will be deployed on ~945 miles by 2023 and CFO-targeted scope will be deployed on ~1,481 miles by 2023. The total amount of OH primary is 9,825 miles within the HFRA. 945 OH circuit miles completed ÷ 9,825 OH circuit miles = ~9.6% deployment (SCD-targeted scope) 1,481 OH circuit miles completed ÷ 9,825 OH circuit miles = ~15.1% deployment (CFO-targeted scope)
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every mile of bare conductor replaced with covered conductor, the covered conductor is assumed to be 99% effective against the specific contact from object drivers shown (D1a, D1b, D1d). For every mile of small bare conductor replaced with covered conductor, the covered conductor is assumed to be 90% effective against the specific equipment failure drivers shown (D2b, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, the WCCP mitigation aims to address areas of the system with a history of vegetation-related faults. An analysis showed that the circuits targeted were 3.6 times as likely to have experienced a vegetation-related fault as compared to the system average. As such, a 3.6 targeting multiplier was assigned to the CFO-Vegetation driver for the CFO-targeted scope. Similarly, SMEs considered the prioritization scheme to also benefit areas with a history of animal-related faults, but to a lesser degree. As such, a 1.8 multiplier was assumed (half of the assumed vegetation targeting benefit). The WCCP mitigation was assumed to have a 2.0 targeting multiplier for conductor failure related drivers (the same value as OCP). It is important to note that the targeting multipliers are different between the two different scope categories, as they are fundamentally targeting different portions of the system.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G

Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H Final RAMP model input (in 2023) for M1a was sum of SCD results and CFO results for each D1 and D2.

Mitigation M1b: WCCP (bare and covered) - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M1b: WCCP (covered)	**SCD Specific Scope** ~945 miles by 2023	D1a	Contact From Object - Animal	5.0	9.6%	99%	9.5%	1.0	9.5%	4.5	8.0%
		D1b	Contact From Object - Balloons	5.0	9.6%	99%	9.5%	1.0	9.5%	4.5	
		D1c	Contact From Object - Unspecified	3.0	9.6%	77%	7.4%	1.0	7.4%	2.8	
		D1d	Contact From Object - Vegetation	7.0	9.6%	99%	9.5%	1.0	9.5%	6.3	
		All other D1	various	3.0	9.6%	0%	0.0%	1.0	0.0%	3.0	
		D2b	Equipment/Facility Failure - Conductor	4.0	9.6%	90%	8.7%	2.0	17.3%	3.3	8.7%
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	9.6%	90%	8.7%	2.0	17.3%	2.5	
		All other D2	various	7.0	9.6%	0%	0.0%	1.0	0.0%	7.0	
M1b: WCCP (OH to UG Conversion)	**CFO Specific Scope** ~1,481 miles by 2023	D1a	Contact From Object - Animal	5.0	15.1%	100%	15.1%	2.0	30.2%	3.5	32.1%
		D1d	Contact From Object - Vegetation	7.0	15.1%	100%	15.1%	4.0	60.3%	2.8	
		All other D1	various	11.0	15.1%	100%	15.1%	1.0	15.1%	9.3	
		All D2	various	14.0	15.1%	100%	15.1%	1.0	15.1%	11.9	15.1%
		D3	Other (Wire to Wire Contact / Contamination)	2.0	15.1%	100%	15.1%	1.0	15.1%	1.7	15.1%
		D4	Unknown / Unspecified	5.0	15.1%	100%	15.1%	1.0	15.1%	4.2	15.1%
										D1 combined (sum of D1 SCD and D1 CFO)	40.1%
										D2 combined (sum of D2 SCD and D2 CFO)	23.7%
										D3 CFO only	15.1%
										D4 CFO only	15.1%
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area). Note, the driver frequency data is duplicated for each specific scope selection (SCD and CFO).
Note 2	This value represents the total amount of OH conductor to be replaced within the HFRA over the 6 year time frame; there are two figures because SCD-targeted scope will be deployed on ~945 miles by 2023 and CFO-targeted scope will be deployed on ~1,481 miles by 2023. The total amount of OH primary is 9,825 miles within the HFRA. 945 OH circuit miles completed ÷ 9,825 OH circuit miles = ~9.6% deployment (SCD-targeted scope) 1,481 OH circuit miles completed ÷ 9,825 OH circuit miles = ~15.1% deployment (CFO-targeted scope)
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every mile of bare conductor replaced with covered conductor, the covered conductor is assumed to be 99% effective against the specific contact from object drivers shown (D1a, D1b, D1d). For every mile of small bare conductor replaced with covered conductor, the covered conductor is assumed to be 90% effective against the specific equipment failure drivers shown (D2b, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%. For every mile of bare conductor converted to underground cable, the underground cable is expected to be 100% effective against all drivers and sub-drivers.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, the WCCP mitigation aims to address areas of the system with a history of vegetation-related faults. An analysis showed that the circuits targeted were 3.6 times as likely to have experienced a vegetation-related fault as compared to the system average. As such, a 3.6 targeting multiplier was assigned to the CFO-Vegetation driver for the CFO-targeted scope. Similarly, SMEs considered the prioritization scheme to also benefit areas with a history of animal-related faults, but to a lesser degree. As such, a 1.8 multiplier was assumed (half of the assumed vegetation targeting benefit). The WCCP mitigation was assumed to have a 2.0 targeting multiplier for conductor failure related drivers (the same value as OCP). It is important to note that the targeting multipliers are different between the two different scope categories, as they fundamentally target different portions of the system.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F

Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H Final RAMP model input (in 2023) for M1b was sum of SCD results and CFO results for each D1 through D4.

Mitigation M2: RAR / CB Settings - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M2: RAR / CB Settings	~1,300 circuits with "fast curve settings" during 'red flag' conditions	n/a	Modeled as a consequence mitigation given operational nature specific to one set of outcomes ('red flag conditions only') **5% reduction of all consequences (O1, O2)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note	Remote Automatic Recloser (RAR) / Circuit Breaker (CB) Fast Curve settings are expected to mitigate against all drivers. However, these settings will only be in place during 'red flag' conditions. Due to the constraints of the RAMP model, this mitigation cannot be modeled as only affecting certain outcomes (i.e. an outcome percentage shift). Therefore, due to the model limitations, this mitigation is modeled as a consequence reduction only for red flag specific outcomes. Every circuit with exposure to the HFRA is capable of enabling fast curve settings, either at the RAR or CB, during red flag conditions. As such, these fast curve settings are expected to have 100% coverage of the HFRA. When considering drivers, the RAMP model focuses ignition events. Fast curve settings are designed to limit the fault energy observed by the system. Given the limited understanding of what level of fault energy is likely to result in an ignition, it is difficult to quantify how effective fast curve settings are likely to be in reducing ignitions. As such, this mitigation was assigned a conservative value of 5%. This was assumed to be a 5% reduction of all consequence distributions for outcomes O1 and O2. The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.…) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M3: PSPS - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M3: PSPS	De-energization of specific circuits under severe wildfire conditions	n/a	Modeled as a consequence mitigation given operational nature specific to one outcome ('red flag conditions, >5,000 acres') **10% reduction in all consequences (O1 only)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note	Public Safety Power Shutoffs (PSPS), when conducted, are expected to reduce wildfire drivers. However, this mitigation is only being considered in the most severe wildfire conditions. For the purposes of the RAMP model, the PSPS mitigation is therefore modeled as mitigation for the worst wildfires, namely those occurring during 'red flag' conditions and exceeding 5,000 acres. Therefore, due to the constraints in the ability to model (i.e. inability to reduce drivers for a specific outcome only), SCE chose to model this as a reduction in consequences for a specific outcome only. As a modeling assumption, SCE assumed a 10% reduction in the consequences associated with "red flag" fires greater than 5000 acres (i.e. O1). The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M4: IR Inspection Program - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M4: IR Inspection Program	Bi-annual IR inspection of specific HFRA assets	D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3.0	100.0%	33%	33.0%	1.0	33.0%	2.0	7.1%
		All other D2	various	11.0	100.0%	0%	0.0%	1.0	0.0%	11.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value represents the total amount of the HFRA that is expected to be scanned in the six year time frame. This program is designed to complete a scan of the HFRA every two years. Therefore, for purposes of modeling, M4 is assumed 100% deployment within RAMP window.
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. For this specific mitigation, given it's focus on connectors and continual sweep timing, it is assumed to reduce the overall ignition count as a result of splices/clamps/connector failure (D1f) by 1 at the end of the six year time frame. This is equivalent to a 33% mitigation effectiveness value within RAMP window. For all other sub-drivers, the mitigation effectiveness is assumed to be 0%
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). In this case, given that the entire area is to be inspected, no targeting benefit is assumed.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M5: Expanded Vegetation Management - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M5: Expanded Vegetation Management	~135,000 trees by 2023	D1d	Contact From Object - Vegetation	7	13.5%	85%	11.47500%	2.0	23.0%	5.4	7.0%
		All other D1	various	16	13.5%	0%	0.0%	1.0	0.0%	16.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value represents the total amount of high risk trees, as a percentage of all high risk trees, expected to be removed by this program in the six year time frame. Specifically, approximately 135,000 trees out of 1,000,000 are expected to be removed, or approximately 13.5%. The year-by-year deployment is assumed 15,000 trees in 2019 and 30,000 trees each year 2020-2023.
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, if all high risk trees within the HFRA were removed, it is assumed that this would be 85% effective against the drivers shown (D1d, CFO-Vegetation). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Current program strategy is to target the highest risk tree areas first, therefore a value of 2.0 is assumed.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M6: Microgrids - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M6: Microgrids	Installation of 3 microgrids / year starting in 2021	n/a	Modeled as a reliability consequence mitigation for for the PSPS mitigation; limited to circuits that are likely to receive microgrid installations **0.1% reliability consequence reduction (O1)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note	microgrids are expected to be deployed on circuits most likely to execute the PSPS mitigation. As such, they are expected to provide reliability benefits (i.e. mitigate reliability risk) for circuits affected by the PSPS mitigation, and therefore a consequence mitigation, albeit one for a different mitigation that is expected to mitigate wildfire drivers. 9 microgrids are expected to be deployed from 2018-2023. In total, there are 270 specific circuits targeted for microgrid deployment, tied to the 270 circuits considered most likely for PSPS deployment. As such, the expected deployment by 2023 is 3.3% of the system, or 9 divided by 270. The mitigation effectiveness is tied to a microgrid's ability to mitigate the additional reliability risk introduced by the PSPS mitigation. This is a conservative approach - it is highly likely that microgrids could be effective in providing reliability benefits in wildfire situations themselves (as opposed to limiting the reliability "cost" of the PSPS mitigation). The mitigation effectiveness value is SME-informed and based on the expected deployment profile of PSPS, namely 4 executions affecting 15 circuits per year. Given that these executions could be on any of the 270 circuits, the effectiveness must be appropriately discounted. Furthermore, microgrids, as currently considered, are expected to only provide power to a subset of the customers on the circuit, assumed to be a conservative 10% of customers. Therefore, if fully deployed on all 270 circuits, the mitigation effectiveness is expected to be approximately 2%, or [(4 executions multiplied by 15 circuits) / (270 PSPS circuits)] x [10% customers mitigated]. Overall mitigation percent is based on 3.3% deployment and 2% mitigation effectiveness: 3.3% deployment * 2% mitigation effectiveness = ~0.1% mitigation percent by 2023 The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M7: HD Cameras / Weather Stations - Consequence Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M7: HD Cameras / Weather Stations	~50 HD Cameras / ~280 weather stations per year until 2020	n/a	Modeled as a consequence mitigation across all risk dimensions (safety, reliability, financial) for all wildfire outcomes. **4.5% reduction in all consequences (O1-O4)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note	
	HD Cameras and Weather Stations are expected to be deployed throughout the HFRA. However, as they do not prevent ignitions themselves, they are expected (and modeled) as a consequence mitigation. They are expected to provide consequence mitigation benefits across all risk dimensions (safety, reliability, financial) for all outcomes. Approximately 150 HD Cameras and 850 weather stations are expected to be deployed by 2020. These are expected to provide coverage for approximately 90% of the HFRA. The mitigation effectiveness is SME-informed and tied to the ability of these technologies to mitigate the consequence of wildfires within SCE's service territory. The assumed mitigation effectiveness is 5% for modeling purposes. This is potentially a conservative figure. Based on the limited experiences with the HD camera at Santiago Peak and the multiple testimonials from firefighting agencies received to date, it is possible that these technologies are more effective at targeting resources to limit the damage of wildfires. Overall mitigation percent is based on 90% deployment and 5% mitigation effectiveness: 90% deployment * 5% mitigation effectiveness = 4.5% mitigation percent by 2020 The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M8: Fusing Mitigation - Driver Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
M8: Fusing Mitigation	~5,333 CLFs / year ~16,000 CLFs total	D2b	Equipment/Facility Failure - Conductor	4	63.1%	10%	6.3%	1.0	6.3%	3.7	4.1%
		D2d	Equipment/Facility Failure - Fuse	0	63.1%	10%	6.3%	1.0	6.3%	0.0	
		D2e	Equipment/Facility Failure - Insulator	2	63.1%	10%	6.3%	1.0	6.3%	1.9	
		D2f	Equipment/Facility Failure - Splice/Clamp/Connector	3	63.1%	10%	6.3%	1.0	6.3%	2.8	
		All other D2	various	5	63.1%	0%	0.0%	1.0	0.0%	5.0	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	These annualized driver values are as derived from the 2015-2017 CPUC fire reports, specifically distribution-related within the SCE-designated HFRA (High Fire Risk Area).
Note 2	This value represents the total amount of primary overhead conductor within the HFRA that is expected to be protected by fusing within the 6 year time frame. More specifically, approximately 6,200 circuit miles of 9,825 total circuit miles within the HFRA are expected to be protected by 2020. 6,200 circuit miles protected ÷ 9,825 circuit miles total = ~63% deployment
Note 3	These values represent SME-informed mitigation effectiveness values for wherever the mitigation is deployed. Specifically, for every fuse installed, it is assumed to be 10% effective in mitigating the drivers shown (D2b, D2d, D2e, D2f). For all other sub-drivers, the mitigation effectiveness is assumed to be 0%.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is derived by taking the expected Deployment value of the mitigation or control multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation or control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Current program strategy is to install or replace fuses at all possible locations within the HFRA. As such, no targeting benefit is assumed.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (100% - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M9: Fire-resistant Poles - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M9: Fire-resistant Poles	Assumed to be performed in conjunction with CC (M1)	n/a	Modeled as a consequence mitigation across all risk dimensions (safety, reliability, financial) for all wildfire outcomes. **6.9% reduction in all consequences (O1-O4)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note	Fire-resistant (FR) poles are expected to be deployed in conjunction with covered conductor work. However, as they do not prevent ignitions themselves, they are expected (and modeled) as a consequence mitigation. They are expected to provide consequence mitigation benefits across all risk dimensions (safety, reliability, financial). Approximately 27,500 fire-resistant poles are expected to be deployed within the 6 year time frame. There are approximately 400,000 distribution poles within the HFRA. Therefore, this represents 6.9% of the total asset population within the HFRA. 27,500 poles replaced ÷ 400,000 total poles = ~6.9% deployment SCE has assumed that replacement of 40,000 poles (i.e. 10% deployment) could be associated with 10% reduction in consequences associated with outcomes O1-O4. Therefore, for any deployment less than 10%, the consequence reduction would be identical to the deployment percentage. In this case, since SCE is assuming 6.9% deployment, SCE has chosen to model a 6.9% consequence reduction for all outcomes (O1-O4). The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M9a: Fire-resistant Poles - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M9a: Fire-resistant Poles	Assumed to be performed in conjunction with CC (M1a)	n/a	Modeled as a consequence mitigation across all risk dimensions (safety, reliability, financial) for all wildfire outcomes. **6.0% reduction in all consequences (O1-O4)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note	
	Fire-resistant (FR) poles are expected to be deployed in conjunction with covered conductor work. However, as they do not prevent ignitions themselves, they are expected (and modeled) as a consequence mitigation. They are expected to provide consequence mitigation benefits across all risk dimensions (safety, reliability, financial). Approximately 23,900 fire-resistant poles are expected to be deployed within the 6 year time frame. There are approximately 400,000 distribution poles within the HFRA. Therefore, this represents 6.0% of the total asset population within the HFRA. 23,900 poles replaced ÷ 400,000 total poles = ~6.0% deployment SCE has assumed that replacement of 40,000 poles (i.e. 10% deployment) could be associated with 10% reduction in consequences associated with outcomes O1-O4. Therefore, for any deployment less than 10%, the consequence reduction would be identical to the deployment percentage. In this case, since SCE is assuming 6.0% deployment, SCE has chosen to model a 6.0% consequence reduction for all outcomes (O1-O4). The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Mitigation M9b: Fire-resistant Poles - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M9b: Fire-resistant Poles	Assumed to be performed in conjunction with CC (M1b)	n/a	Modeled as a consequence mitigation across all risk dimensions (safety, reliability, financial) for all wildfire outcomes. **2.8% reduction in all consequences (O1-O4)**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note	Fire-resistant (FR) poles are expected to be deployed in conjunction with covered conductor work. However, as they do not prevent ignitions themselves, they are expected (and modeled) as a consequence mitigation. They are expected to provide consequence mitigation benefits across all risk dimensions (safety, reliability, financial). Approximately 11,100 fire-resistant poles are expected to be deployed within the 6 year time frame. There are approximately 400,000 distribution poles within the HFRA. Therefore, this represents 2.8% of the total asset population within the HFRA. 11,100 poles replaced ÷ 400,000 total poles = ~2.8% deployment SCE has assumed that replacement of 40,000 poles (i.e. 10% deployment) could be associated with 10% reduction in consequences associated with outcomes O1-O4. Therefore, for any deployment less than 10%, the consequence reduction would be identical to the deployment percentage. In this case, since SCE is assuming 2.8% deployment, SCE has chosen to model a 2.8% consequence reduction for all outcomes (O1-O4). The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

Workpaper: Chapter 10 – Wildfire
Circuit Deployment Prioritization

Introduction

SCE developed a deployment prioritization methodology for its Wildfire Covered Conductor Program (WCCP) to guide the deployment of covered conductor in place of existing bare distribution primary conductor in high fire risk areas (HFRA). This methodology prioritizes deploying covered conductor on circuits posing the greatest wildfire risk, focusing on ignition consequence and ignition frequency. This methodology also took into consideration the mitigation effectiveness of covered conductor as deployed in specific areas of high fire risk. Within each factor category, individual attributes were selected and subsequently assigned a weighting, as shown below.

Category	Total Category Weighting	Attribute	Individual Attribute Weighting
Ignition Consequence Factors	50%	Circuit Length in Tier 3	25%
		Circuit Length in Tier 2	15%
		Circuit Length in High Wind within HFRA	10%
Ignition Frequency Factors	30%	Historic Vegetation Faults in HFRA	15%
		Historic Wire Down Events	10%
		Circuit Length of Vintage Small Conductor	5%
Mitigation Effectiveness Factor	20%	Estimated number of mitigated faults in proportion to circuit length in HFRA	20%

Development of Methodology

SCE conducted a comprehensive process to determine how best to prioritize covered conductor deployment within the HFRA. SCE initially considered deploying covered conductor on any circuit located in CPUC Tier 3 HFRA. This approach was rejected, however, in favor of a more nuanced analysis that took into account other contributing factors to wildfire risk in order to provide for a more effective and efficient deployment strategy.

Given the variety of circumstances that could lead to a fire, SCE considered how best to leverage additional datasets to develop a more sophisticated approach to its prioritization methodology. For this effort, SCE formed a cross-function team to assess attributes best representing the potential for wildfire risk. These internal stakeholders included representatives from SCE's Transmission and Distribution Engineering, Business Resiliency and Risk Management organizations. Three general categories were determined to best inform SCE's prioritization methodology: ignition consequence, ignition frequency and mitigation effectiveness.

In order to determine the relative value between each category, SCE used a comparative approach. When considering ignition consequence and ignition frequency, SCE recognized that not all ignitions result in catastrophic wildfires. Therefore, placing greater priority on high consequence areas of our system would likely address greater risk. As such, the ignition consequence attributes, in aggregate, were given greater value than ignition frequency attributes.

Similarly, in determining the relative value of mitigation effectiveness compared to the other two general categories, SCE recognized that this factor—while valuable—would place greater emphasis on deploying covered conductor in areas where it is likely to be most effective and efficient, as opposed to areas where there is the greatest fire risk. SCE therefore gave this category a lower value than the other two, in order to maintain appropriate emphasis on deploying covered conductor in high fire risk areas and recognizing that covered conductor provides overall substantial benefits for mitigating fire risk, as discussed in the RAMP Report.

Ultimately, an aggregate 50% weighting was assigned to ignition consequence, an aggregate 30% weighting was assigned to ignition frequency, and an aggregate 20% weighting was assigned to mitigation effectiveness.

Ignition Consequence Factors

In sum, the ignition consequence factors account for 50% of the total prioritization weighting. As noted in the table above, this category has three attributes. In determining how to divide this 50% among the three attributes, SCE relied on subject matter input to best inform the weightings of the individual attributes, with validating analyses to further confirm the relative weightings where possible.

Circuit length in Tier 2 and Tier 3: SCE has approximately 4,500 distribution circuits in its service area. Approximately 1,300 of these circuits have at least some portion located within HFRA, which includes CPUC Tier 2 and Tier 3 areas.[1] In prioritizing these circuits for the WCCP, SCE placed a weight of 25% to the circuit length in a Tier 3 area and a weight of 15% to the circuit length in a Tier 2 area to reflect the greater risk associated with Tier 3 areas relative to Tier 2. This means that circuits with the longest length in Tier 3 are generally given priority over circuits of comparable length in Tier 2. Under certain circumstances, however, circuits with considerable length in Tier 2 could be prioritized over circuits with a short length in Tier 3.

In order to further validate these relative weightings, SCE reviewed the 2015-2017 fire history as reported to the CPUC. A majority of fires at distribution voltages up to 33kV were determined to occur within the Tier 3 area, providing further justification for Tier 3 receiving a greater weighting than Tier 2.

Wind Load Considerations in HFRA: Wind plays an important role in many contact-related faults, including contact with tree limbs and palm fronds. In addition, high wind speeds are a known contributor to larger fires. SCE understands that wind loading is considered as part of the CPUC's Tier 2 and Tier 3 designations; however, SCE decided to undertake an additional review of wind conditions on its system to further inform its deployment of covered conductor. For this effort, SCE utilized GIS data mapping and existing data from its Pole Loading program to map the estimated wind load on the portions of its circuits in HFRA and has also used this data in prioritizing circuits for WCCP.

[1] HFRA refers to areas designated as Tier 2 or Tier 3 in recent CPUC mapping proceedings or SCE HFRA not in CPUC Tiers.

This factor (wind load) was assigned a weight of 10% as part of SCE's WCCP circuit prioritization methodology. This means that circuits with greater exposure to high wind conditions within the HFRA are generally given priority over circuits with minimal high wind exposure. Because wind loading is also taken into account as part of the CPUC's Tier 2 and Tier 3 designations, SCE assigned this factor a lower relative value, comparatively, within this category of attributes.

Ignition Frequency Factors

In sum, the ignition frequency factors account for 30% of the total prioritization weighting. As noted in the table above, this category has three attributes. In determining how to divide this 30% among the three attributes, SCE relied on subject matter input to best inform the weightings of the individual attributes, with validating analyses to further confirm the relative weightings where possible.

Number of historic vegetation faults in HFRA: Vegetation is a known contributor to ignition events associated with SCE distribution equipment. During the 2015 to 2017 time period, approximately 8% of annual faults associated with HFRA circuits were related to vegetation, yet these faults were associated with approximately 17% of the annual fire events within the HFRA. Since vegetation-related faults pose a heightened fire risk as compared to other fault types and covered conductor is an effective mitigation tool for vegetation driven faults, this attribute was assigned a weight of 15% as part SCE's WCCP circuit prioritization methodology. This means that circuits with a history of vegetation faults within the HFRA are generally given priority over circuits with other historical fault types.

Furthermore, from 2015 to 2017, vegetation represented the leading cause of ignitions associated with SCE distribution equipment within HFRA.[2] This further justifies this attribute receiving the highest individual attribute weighting within this category.

Number of historic wire-down events: Wire-down events in HFRA also pose an ignition frequency risk. Therefore, circuits with a history of wire-down events are likely to indicate an area of outsized ignition risk. This attribute was assigned a weight of 10% as part SCE's WCCP circuit prioritization methodology. This means that circuits with a history of wire-down events are generally given priority over circuits without a history of wire-down events.

Similar to the above, from 2015 to 2017, conductor-related fires represented one of the leading cause of ignitions associated with SCE distribution equipment within the HFRA.[3] Historical wire-down events are considered to be a proxy for conductor-related ignitions. This provides further justification for this attribute being included, albeit at a lower attribute weighting compared to vegetation.

Circuit length of vintage small conductor: Vintage small conductor could be subject to damage under fault conditions and is at risk of a wire-down event and posing an ignition risk. In addition, smaller conductor is likely to be older than other parts of our system, and potentially

[2] This analysis refers only to those ignition events recorded at voltage levels up to 33kV.
[3] This analysis refers only to those ignition events recorded at voltage levels up to 33kV.

exposed to corrosive conditions and degradation for a longer period. Under normal operating conditions, however, vintage small conductor is considered to be of limited risk of leading to an ignition event. Consequently, this attribute was assigned a weight of 5% as part of SCE's WCCP circuit prioritization methodology. This means that circuits with longer lengths of vintage small conductor are generally given priority over circuits with less vintage small conductor.

Mitigation Effectiveness Factor

Mitigation effectiveness accounts for 20% of the total prioritization weighting. SCE relied on subject matter input to determine this weighting value, and whether additional attributes were necessary. No other attributes were determined to further assist in determining which areas covered conductor would provide the greatest benefits when deployed.

Estimated number of faults mitigated in proportion to circuit length in HFRA: In conjunction with the analysis of the 2015-2017 fault history in ODRM, SCE utilized the data on each circuit's fault history to estimate the relative mitigation effectiveness of installing covered conductor. More specifically, a comparative value was calculated by dividing the number of historical faults within the HFRA potentially mitigated through covered conductor by the circuit's length within the HFRA. This factor was assigned a weight of 20% as part of SCE's WCCP circuit prioritization methodology. This weighting, all else being equal, prioritizes circuits with a greater recorded rate of potentially mitigated faults per circuit length, compared to circuits with faults not expected to be addressed by covered conductor.

Results and Review

This methodology resulted in a prioritized listing of approximately 1,300 HFRA circuits with overhead conductor exposure. Circuits intended to be remediated within the 2018-2020 time period generally have greater Tier 3 and Tier 2 exposure, indicators of potential concerns with overall asset health, such as the historical number of wire-down events, and a history of faults that are likely to be mitigated by covered conductor.

The final prioritized results also underwent a review by stakeholders to help ensure the areas selected for initial deployment of covered conductor were indicative of areas of highest risk. In particular, the reviews focused on making sure that areas historically affected by wildfires were highly prioritized relative to other areas, while also recognizing that future wildfires may not occur in the same areas as the past.

Chapter 10 Workpaper: Comparison of GS&RP and RAMP

Conductor Effectiveness Comparison

Executive Summary

- Different methodologies are used in GS&RP and RAMP to compare effectiveness of different conductor types in mitigating wildfire risk
  - GS&RP Mitigation-Cost Ratios compare effectiveness of conductor types in reducing % of potential ignitions across all HFRA per dollar spent (per mile)
  - RAMP effectiveness (Risk Spend Efficiency) is the ratio of risk reduction (using Multi Attribute Risk Scoring) over cost of mitigation at the program level
- When RAMP modeling inputs are matched exactly to GS&RP inputs, the resulting effectiveness comparison of conductors is similar in RAMP and GS&RP
- RAMP analysis includes further refinements to inputs, including number of miles, implementation timing, targeting effectiveness, and combination with other mitigation activities

Comparable GS&RP and RAMP Analyses Produce Similar Relationship amongst Risk Reduction to Cost Ratios of Various Conductor Types

GS&RP Methodology

- GS&RP presents a Mitigation-Cost Ratio for Bare, Covered, and UG conductor options, assuming full deployment of conductor in HFRA
- ***Result:* Covered conductor is shown to have ~ 2.8x better Mitigation-Cost ratio vs. Bare conductor**

Mitigation Option	Relative Mitigation Effectiveness Factor	Cost per Mile ($ million)	Mitigation-Cost Ratio
Re-conductor – Bare	0.15	0.30	0.50
Re-conductor – Covered	0.60	0.43	1.40
Underground Conversion	1.00	3.00	0.33

- GS&RP analysis estimated the impact of conductor replacement on reducing the potential frequency of ignition (left-side of the Bowtie); RAMP uses the same assumptions and progresses to the right-side of the Bowtie to measure the risk and its consequences

RAMP Methodology

- An equivalent analysis that uses the same potential frequency of ignition and scope assumptions (~4,000 circuit miles) as GS&RP was performed using the RAMP model
- ***Result:* Covered conductor is shown to have ~ 3.3x better RSE vs. Bare conductor on mean basis and ~ 3.4x better RSE on tail average (TA) basis**

2018-2023 Values	Total Cost ($M)	MRR (Mean)	RSE (Mean)	MRR (TA)	RSE (TA)
100% Bare	$1,448	1.63	0.0011	4.27	0.0029
100% Covered	$1,704	6.21	0.0036	16.82	0.0098
100% Underground	$11,933	10.85	0.0009	30.33	0.0025

MRR = Mitigation Risk Reduction

Energy for What's Ahead℠ | 3

Circuit Prioritization Methodologies Result in Additional Risk Spend Efficiency Benefit

SCE intends to use a circuit prioritization methodology which will deploy covered conductor on circuits posing the greatest wildfire risk, focusing on ignition consequence and ignition frequency. SCE anticipates that using a prioritization methodology will provide additional risk reduction benefit.

RAMP Methodology (without prioritization)

- ***Result:*** **Covered conductor is shown to have ~ 3.3x better RSE vs. Bare conductor on mean basis and ~ 3.4x better RSE on tail average (TA) basis**

2018-2023 Values	Total Cost ($M)	MRR (Mean)	RSE (Mean)	MRR (TA)	RSE (TA)
100% Bare	$1,448	1.63	0.0011	4.27	0.0029
100% Covered	$1,704	6.21	0.0036	16.82	0.0098
100% Underground	$11,933	10.85	0.0009	30.33	0.0025

MRR = Mitigation Risk Reduction

RAMP Methodology (with prioritization)

- ***Result:*** **Covered conductor is shown to have ~ 5.1x better RSE vs. Bare conductor on mean basis and ~ 5.1x better RSE on tail average (TA) basis**

2018-2023 Values	Total Cost ($M)	MRR (Mean)	RSE (Mean)	MRR (TA)	RSE (TA)
100% Bare	$1,448	2.08	0.0014	5.60	0.0039
100% Covered	$1,704	12.01	0.0071	33.91	0.0199
100% Underground	$11,933	17.28	0.0014	51.99	0.0044

MRR = Mitigation Risk Reduction

There are several additional inputs applied within RAMP analysis:

- Magnitude of scope analyzed (~ 2,400 miles conductor replacement within RAMP time period)
- Timing of implementation and analysis (6-year view)
- Aggregation of multiple mitigations (e.g., RAMP portfolios combine Covered Conductor, PSPS, and other mitigations)

Energy for What's Ahead℠ 4

RAMP – Conductor Mitigation Portfolios

- RAMP presents different alternatives for implementing conductor across HFRA
  - **M1** – Wildfire Covered Conductor Program (in the Proposed Plan) deploys only covered conductor across ~2,426 circuit miles
  - **M1a** – Wildfire Covered Conductor Program with Bare and Covered Sections (in the Alternative Plan #1) deploys ~1481 circuit miles of covered conductor in ‘Contact From Object’ Areas, and ~945 circuit miles of bare conductor in “Short Circuit Duty” areas (small wire areas)
- RSE for M1 is slightly better than M1a. The similarity of portfolio scope and implementation timing between M1 and M1a results in a less pronounced difference than if the two RAMP mitigations were (1) 100% covered conductor deployment, and (2) 100% bare conductor deployment.

2018 – 2023 totals	Total Cost ($M)	MRR (Mean)	RSE (Mean)	Miles Addressed
M1 **(Proposed Plan)**	$1,161	2.27	0.0020	2,426 covered circuit miles 0 bare 0 underground
M1a **(Alternative Plan #1)**	$947	1.83	0.0019	1,481 covered 945 bare 0 underground
M1b **(Alternative Plan #2)**	$5,399	2.87	0.00053	945 covered 1,481 underground

Workpaper – SME Qualifications

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgment is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Wildfire**
Risk Analysis Component	Reliability (CMI) consequence assumptions for large (outcomes O1, O3) and small (outcomes O2, O4) wildfires
Does historical data exist at SCE to support the evaluation of this risk analysis component?	Partially. ODRM tracks outage events in terms of cause (including a "fire" cause code) but ODRM does not identify specific attributes of the fire itself (i.e., fire name, size, etc.). Therefore, the SME task at hand was to develop a method of filtering ODRM data to reasonably approximate the range of CMI values for large (O1, O3) and small (O2, O4) fires.
Additional back-up or sources used by the SME(s) to inform/validate guidance	Knowledge of how ODRM accrues CMI for multiple-day events (i.e., CMI is accrued to the day an outage is triggered), how Major Event Days (MEDs) are calculated, and knowledge of SCE's SAIDI performance trends for both MED-included and MED-excluded scenarios.
SME(s) who have contributed to this analysis	• Senior Manager, Asset Strategy & Analytics • Senior Engineer, Maintenance, Performance & Reliability
Relevant Experience of SME(s)	• Senior Manager has 16+ years of T&D experience with system reliability studies, including 6+ years of direct experience both performing and reviewing studies regarding system SAIDI metrics. • Senior Engineer has 10+ years T&D experience with system reliability studies, all of which includes direct experience both performing and reviewing studies regarding system SAIDI metrics.

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 11
Underground Equipment Failure

2018 SCE Risk Assessment Mitigation Phase (RAMP)

Chapter 11
Underground Equipment Failure

Index of Workpapers

Excel versions of Workpapers are available online

1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

Chapter:	Underground Equipment Failure
Workpaper:	Baseline Risk Modeling Inputs

Legend			
Distribution	Input 1	Input 2	Input 3
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Min	Most Likely	Max
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Driver Frequency	D1	Major Equipment Cause	1877	1938	2002	2067	2135	2205	Source: 2015-2017 equipment failure from ODRM for underground equipment (excluding "padmounted" equipment). Includes reported failures of Cables, Cable Accessories, BURD Transformers, Switches, and Unknown failures. 2018-2022 assumed a compound annual growth rate (CAGR) of 4%/year for cable and switches (subcategories of D1) to approximate the known relationship between equipment age and probability of failure (for example, weibull relationships for cable and switches shown in 2018 GRC). CAGR assumed 0%/year for BURD transformers (subcategory of D1) and 0%/year for "Unknown" (Subcategory of D2) based on limited data. Net result is assumed 3% CAGR for D1 and 0% CAGR for D2.
	D2	Miscellaneous Equipment Cause	28	28	28	28	28	28	

	ID	Name	2018	2019	2020	2021	2022	2023	Source/Justification
Triggering Event Frequency	TEF	Failure of Underground Electric Equipment	1905	1966	2030	2095	2163	2233	Sum of D1 plus D2.

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1	Explosion in a Manhole or Vault	1.1%	20.65	Outcome likelihood percentages from CPRR tracker, based on 7 months of historical data extrapolated to yearly average. CPRR tracker data shows 20 explosions per year prior to CAGR, which corresponds to a 1.1% probability

	O2	Non-Explosion			98.9%	1883.91	explosions per year prior to CAGR, which corresponds to a 1.1% probability of outcome O1 (and a 98.9% probability of O2). 20.6 events in 2018 includes one year of CAGR.

	ID	Name	Distribution (see legend)	Input 1	Input 2	Input 3	Source / Justification
Consequences	O1	Serious Injuries	Poisson	0.024	N/A	N/A	Due to limited data available pertaining to serious injuries and fatalities associated with this outcome, an estimate was developed for the annual consequences to be one serious injury in two years, based on review of 2014-2016 CPUC SED reports, as well as internal incident tracking. Mean was developed based on 0.5 / 20.6 (1 injury every 2 years divided by 20.6 explosions per year)
		Fatalities	Poisson	0.002	N/A	N/A	Due to limited data available pertaining to serious injuries and fatalities associated with this outcome, an estimate was developed to be one fatality in 25 years. One fatality was observed in Boston area in 2016. Mean was developed based on .04 / 20.6 (1 fatality every 25 years divided by 20.6 explosions per year).
		Reliability	Exponential	81,976	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. ODRM Database for 2015-2017 was reviewed for actual underground equipment-based events.
		Financial	Uniform	$0	$464,000	N/A	Due to limited data available, an estimate was developed based on previous GRC unit costs for underground structural replacements. It was assumed that outcome O1 can result in the need for full structural replacement as well as all equipment within a vault or manhole. As a result, we build a range of costs from $0 to $464K. $464K corresponds to the unit cost for underground structure replacement, as shown in SCE's 2018 GRC filing, (SCE 02 Vol 5 Table I-23, page 36).
	O2	Reliability	Exponential	81,976	N/A	N/A	SCE formed a distribution using the @Risk software "Distribution Fitting" tool. ODRM Database for 2015-2017 was reviewed for actual underground equipment-based events.
		Financial	Uniform	$15,000	$35,000	N/A	Due to limited available data pertaining to the Financial impact of a Non-Explosion, an estimate of $25K per event was developed with a +/- $10K spread based on approximate replacement cost for typical distrubtion apparatus.

Chapter	Underground Equipment Failure

Drivers

ID	Name
D1	Equipment Cause
D2	Unknown

Outcomes

ID	Name
O1	Explosion in a Manhole or Vault
O2	Non-Explosion

Controls & Mitigations

ID	Name
C1	Cable Replacement Program (WCR)
C2	Cable Replacement Program (CIC)
C3	UG Oil Switch Replacement Program
M1	Venting Vault Lids (CPRR)
M2	BURD Transformer Replacement

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Cable Replacement Program (WCR)

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers enter "inactive", "no impact", or % value % value indicates reduction in event freq.		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.6%	1.1%	1.5%	2.0%	2.4%	2.9%	See Page 1 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Unknown	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes enter "inactive", "no impact", or % value % value indicates reduction in outcome consequence		2018	2019	2020	2021	2022	2023	Supporting rationale and data sources. If additional materials (studies, excel sheets, presentations, etc) were used to develop the % values, reference those materials and store them in the RAMP chapter sharepoint folder.
O1 Explosion in a Manhole or Vault	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	0.3%	0.6%	0.8%	1.1%	1.3%	1.6%	See Page 2 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 Non-Explosion	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	0.3%	0.6%	0.8%	1.1%	1.3%	1.6%	See Page 2 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	C2 Cable Replacement Program (CIC)

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers enter "inactive", "no impact", or % value % value indicates reduction in event freq.		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	3.3%	6.9%	10.5%	14.1%	17.7%	21.4%	See Page 3 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Unknown	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes enter "inactive", "no impact", or % value % value indicates reduction in outcome consequence		2018	2019	2020	2021	2022	2023	Supporting rationale and data sources. If additional materials (studies, excel sheets, presentations, etc) were used to develop the % values, reference those materials and store them in the RAMP chapter sharepoint folder.
O1 Explosion in a Manhole or Vault	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 Non-Explosion	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	C3 UG Oil Switch Replacement Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers enter "inactive", "no impact", or % value % value indicates reduction in event freq.		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.2%	0.4%	0.7%	1.0%	1.3%	1.7%	See Page 4 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Unknown	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes enter "inactive", "no impact", or % value % value indicates reduction in outcome consequence		2018	2019	2020	2021	2022	2023	Supporting rationale and data sources. If additional materials (studies, excel sheets, presentations, etc) were used to develop the % values, reference those materials and store them in the RAMP chapter sharepoint folder.
O1 Explosion in a Manhole or Vault	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 Non-Explosion	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M1 Venting Vault Lids (CPRR)

Portfolio Inclusion	
Proposed	x
Alt 1	
Alt 2	

Drivers enter "inactive", "no impact", or % value % value indicates reduction in event freq.		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Unknown	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes enter "inactive", "no impact", or % value % value indicates reduction in outcome consequence		2018	2019	2020	2021	2022	2023	Supporting rationale and data sources. If additional materials (studies, excel sheets, presentations, etc) were used to develop the % values, reference those materials and store them in the RAMP chapter sharepoint folder.
O1 Explosion in a Manhole or Vault	Serious Injuries	0.0%	5.1%	14.8%	24.5%	34.1%	43.8%	See Page 5 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Fatalities	0.0%	5.1%	14.8%	24.5%	34.1%	43.8%	See Page 5 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 Non-Explosion	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

Name	M2 BURD Transformer Replacement

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers enter "inactive", "no impact", or % value % value indicates reduction in event freq.		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model.
D1	Equipment Cause	0.0%	1.1%	2.2%	3.2%	4.1%	5.0%	See Page 6 of "WP Ch. 11 - Underground Equipment Failure (UEF) - Mitigation Effectiveness Workpaper.xlsx" for basis of calculation of "% value" for 2023. Percentages in interim years 2018-2022 are modeled as increasing to the 2023 total based on year-by-year deployment rates.
D2	Unknown	inactive	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes enter "inactive", "no impact", or % value % value indicates reduction in outcome consequence		2018	2019	2020	2021	2022	2023	Supporting rationale and data sources. If additional materials (studies, excel sheets, presentations, etc) were used to develop the % values, reference those materials and store them in the RAMP chapter sharepoint folder.
O1 Explosion in a Manhole or Vault	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
O2 Non-Explosion	Serious Injuries	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Fatalities	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this consequence.

WP Ch. 11 - Mitigation Effectiveness Workpaper.xlsx
Page 1 of 6

Control C1: Cable Replacement Program (WCR) - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
C1: Cable Replacement Program (WCR)	1846 conductor miles replaced from 2018-2023	D1a	Equipment Cause - Connector/Splice/Cable	1770	4.7%	40%	1.9%	1.9	3.6%	1,706	2.9%
		D1b	Equipment Cause - Transformer	328	0%	0%	0.0%	-	0.0%	328	
		D1c	Equipment Cause - Switch	114	0%	0%	0.0%	-	0.0%	114	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	Starting point: 2015-2017 ODRM data filtered for Cable, Cable Splice, Elbow/Junction bar cause codes (D1a), BURD Transformers (D1b), and BURD Switch, Gas Switch and Oil Switch (D1c) 1399/year: D1a average 328/year: D1b average 90/year: D1c average Mitigation effectiveness modeling was based on starting point driver frequency after 6 years of compound annual growth rate (CAGR) assumed @ 4%/year (D1a and D1c) and @ 0%/year (D1b only) Initial Driver Frequency (D1a): 1399*(1.04)^6 = 1770 Initial Driver Frequency (D1b): 328*(1.00)^6 = 328 Initial Driver Frequency (D1c): 90*(1.04)^6 = 114
Note 2	2018 GRC (SCE-02 Vol 08) stated "approximately 13,000 conductor miles, one-fourth of SCE's cable population, is CIC type cable." Based on this, the SCE system would have an estimated 13,000 * 3 = ~39,000 conductor miles of mainline cable 1,846 conductor miles in scope ÷ 39,000 conductor miles in system = 4.7% deployment
Note 3	2015-2017 ODRM data filtered for Cable only; quantity of CB/AR outages vs "Area Out" outages assumed to represent percentage of Mainline vs CIC outages respectively. ODRM data showed 1,482 Mainline outages; 2,046 CIC outages; 3,528 total Cable outages combined. 1,482 Mainline outages ÷ 3,528 total Cable outages = 42% Mitigation Effectiveness at full deployment; rounded to ~40% for purposes of analysis
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation/control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Through review of previous risk analysis results, SCE estimates that 4.7% deployment of WCR would correspond to approximately 17.4% benefit. Therefore 17.4%/4.7% = 3.7 estimated targeting multiplier. However, WCR scoping practice targets both failure frequency and failure severity. Since this calculation applies to only failure frequency, the estimated targeting multiplier is square rooted to represent targeting benefit for frequency only (√3.7 = ~1.9 Targeting Benefit, frequency only).
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (1 - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C1: Cable Replacement Program (WCR) - Consequence Analysis

Mitigation	Mitigation Scope	Driver ID	Driver	Column A Initial Driver Frequency	Column B Deployment	Column C Mitigation Effectiveness	Column D Mitigation Percent (Random Walk)	Column E Targeting Benefit	Column F Mitigation Percent (Sub-Driver)	Column G Final Driver Frequency	Column H Mitigation Percent (Driver)
C1: Cable Replacement Program (WCR)	1846 conductor miles replaced from 2018-2023	n/a	Reliability Consequence mitigation for all outcomes (O1 and O2) **1.6% reduction in reliability consequence for O1 and O2**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note	WCR is also targeted to reduce reliability consequences for underground cable failures. Percent decrease in average consequence was calculated by taking the potential risk mitigation of 17.4% (see note 5 on previous page) times scope deployment of 4.7% (see Note 2 on previous page) times the targeting multiplier of ~1.9 (see note 5 for Control C1: Cable Replacement Program (WCR) - Driver Analysis). 17.4% * 4.7% * 1.9 = ~1.6% reduction in reliability consequences

WP Ch. 11 - Mitigation Effectiveness Workpaper.xlsx
Page 3 of 6

Control C2: Cable Replacement Program (CIC) - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
C2: Cable Replacement Programs (CIC)	600 conductor miles rejuvenated and 900 conductor miles replaced from 2018-2023	D1a	Equipment Cause - Connector/Splice/Cable	1770	10.2%	60%	6.1%	4.4	26.8%	1,296	21.4%
		D1b	Equipment Cause - Transformer	328	0%	0%	0.0%	-	0%	328	
		D1c	Equipment Cause - Switch	114	0%	0%	0.0%	-	0%	114	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	Starting point: 2015-2017 ODRM data filtered for Cable, Cable Splice, Elbow/Junction bar cause codes (D1a), BURD Transformers (D1b), and BURD Switch, Gas Switch and Oil Switch (D1c) 1399/year: D1a average 328/year: D1b average 90/year: D1c average Mitigation effectiveness modeling was based on starting point driver frequency after 6 years of compound annual growth rate (CAGR) assumed @ 4%/year (D1a and D1c) and @ 0%/year (D1b only) Initial Driver Frequency (D1a): 1399*(1.04)^6 = 1770 Initial Driver Frequency (D1b): 328*(1.00)^6 = 328 Initial Driver Frequency (D1c): 90*(1.04)^6 = 114
Note 2	2018 GRC identified approximately 53,701 conductor miles in UG system; as previously shown (see C1 workpaper notes), approximately 39,000 is mainline cable 53,701 conductor miles in system - 39,000 estimated mainline conductor miles = ~14,701 CIC conductor miles in system 600 conductor miles rejuvenated + 900 conductor miles replaced = 1500 conductor miles mitigated 1500 conductor miles mitigated ÷ 14,701 CIC conductor miles in system = ~10.2% deployment
Note 3	2015-2017 ODRM data filtered for Cable only; quantity of CB/AR outages vs "Area Out" outages assumed to represent percentage of Mainline vs CIC outages respectively. ODRM data showed 1,482 Mainline outages; 2,046 CIC outages; 3,528 total Cable outages combined. 2,046 CIC outages ÷ 3,528 total Cable outages = 58% Mitigation Effectiveness at full deployment; rounded to ~60% for purposes of analysis
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation/control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Through review of previous risk analysis results, SCE estimates that 10.2% deployment of CIC would correspond to approximately ~44.6% benefit. Therefore 44.6%/10.2% = ~4.4 targeting multiplier for CIC. Deployment of C2 replacement conductor miles is only meant to decrease failure frequency, so no further reduction of this 4.4 targeting benefit value is necessary.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (1 - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Control C3: UG Oil Switch Replacement Program - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
C3: UG Oil Switch Replacement Program	1,463 switches replaced from 2018-2023	D1a	Equipment Cause - Connector/Splice/Cable	1770	0%	0%	0.0%	-	0.0%	1,770	1.7%
		D1b	Equipment Cause - Transformer	328	0%	0%	0.0%	-	0.0%	328	
		D1c	Equipment Cause - Switch	114	15.4%	100%	15.4%	2.1	32.5%	77	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	Starting point: 2015-2017 ODRM data filtered for Cable, Cable Splice, Elbow/Junction bar cause codes (D1a), BURD Transformers (D1b), and BURD Switch, Gas Switch and Oil Switch (D1c) 1399/year: D1a average 328/year: D1b average 90/year: D1c average Mitigation effectiveness modeling was based on starting point driver frequency after 6 years of compound annual growth rate (CAGR) assumed @ 4%/year (D1a and D1c) and @ 0%/year (D1b only) Initial Driver Frequency (D1a): 1399*(1.04)^6 = 1770 Initial Driver Frequency (D1b): 328*(1.00)^6 = 328 Initial Driver Frequency (D1c): 90*(1.04)^6 = 114
Note 2	1,463 switch replacements in scope ÷ 9,478 Oil switches in system = 15.4% deployment
Note 3	Driver: Replacement of switch fully mitigates reliability risk.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation/control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Through review of previous risk analysis results, SCE estimates that 15.4% deployment of switches would correspond to approximately~32.5% benefit. Therefore 32.5%/15.4% = ~2.1 targeting multiplier for switches. Deployment of C3 replacement switches is only meant to decrease failure frequency, so no further reduction of this 2.1 targeting benefit value is necessary.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (1 - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

Mitigation M1: Venting Vault Lids (CPRR) - Consequence Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Driver)
M1: Venting Vault Lids (CPRR)	4,665 lids replaced from 2019-2023	n/a	Modeled as a Safety Consequence Mitigation for outcome O1 (explosion) **43.8% reduced O1 safety consequences**	n/a	11.7%	90%	10.6%	4.1	43.8% safety consequence for outcome O1	n/a	n/a
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.
Note 2	4,665 lids replaced ÷ population of 40,000 lids = 11.7%
Note 3	Consequence: Replacement of lid mitigates safety risk. SME informed estimation of 90% probability an explosion event will be contained with mitigation.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation/control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Through review of previous risk analysis results, SCE estimates that 11.7% deployment of CPRR lids would correspond to approximately ~48.6% benefit. Therefore 48.6%/11.7% = ~4.1 targeting multiplier for CPRR. Deployment of M1 lids is only meant to decrease failure consequence, so no further reduction of this 4.1 targeting benefit value is necessary.
Note 6	The Mitigation Percent value here is essentially the modeled reduction in safety consequences. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Note that this is a percent reduction in consequences, not drivers. Column D * Column E = Column F
Note 7	The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.
Note 8	The use of "n/a" in this table indicates particular columns (i.e. Driver ID, Initial Driver Frequency, etc.) that were not applicable for consequence-based mitigation effectiveness modeling.

WP Ch. 11 - Mitigation Effectiveness Workpaper.xlsx
Page 6 of 6

Mitigation M2: BURD Transformer Replacements - Driver Analysis

				Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Mitigation	Mitigation Scope	Driver ID	Driver	Initial Driver Frequency	Deployment	Mitigation Effectiveness	Mitigation Percent (Random Walk)	Targeting Benefit	Mitigation Percent (Sub-Driver)	Final Driver Frequency	Mitigation Percent (Consequence)
M2: BURD Transformer Replacements	500 BURD Transformers replaced from 2019-2023	D1a	Equipment Cause - Connector/Splice/Cable	1770	0%	0%	0%	-	0%	1,770	5.0%
		D1b	Equipment Cause - Transformer	328	0.6%	100%	0.6%	55.0	33.5%	218	
		D1c	Equipment Cause - Switch	114	0%	0%	0%	-	0%	114	
				Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8

Note 1	Starting point: 2015-2017 ODRM data filtered for Cable, Cable Splice, Elbow/Junction bar cause codes (D1a), BURD Transformers (D1b), and BURD Switch, Gas Switch and Oil Switch (D1c) 1399/year: D1a average 328/year: D1b average 90/year: D1c average Mitigation effectiveness modeling was based on starting point driver frequency after 6 years of compound annual growth rate (CAGR) assumed @ 4%/year (D1a and D1c) and @ 0%/year (D1b only) Initial Driver Frequency (D1a): 1399*(1.04)^6 = 1770 Initial Driver Frequency (D1b): 328*(1.00)^6 = 328 Initial Driver Frequency (D1c): 90*(1.04)^6 = 114
Note 2	500 transformers replaced ÷ population of ~82,000 transformers = 0.6%
Note 3	Driver: Replacement of transformer fully mitigates reliability risk.
Note 4	The Mitigation Percent (Random Walk) value represents the total program mitigation effectiveness at full deployment against the corresponding driver. The term 'Random Walk' assumes that there is no targeting element involved. The value is calculated by taking the expected Deployment value of the mitigation / control program multiplied by the corresponding Mitigation Effectiveness percentage. Column B * Column C = Column D
Note 5	Targeting Benefit reflects the degree to which this mitigation/control is expected to address the highest risk assets first. This is expressed as the ratio of expected risk reduction (as percentage of total risk) over planned deployment (as percentage of total population). Previous risk analysis was not available for this particular mitigation to estimate targeting benefit like other controls and mitigations. Instead, an analysis performed had estimated that predictive analytics might be able to identify potential failure with a 1 year accuracy of 22%, i.e. 22% of equipment identified for failure will fail within 1 year of identification. Therefore, for RAMP purposes, SCE assumed 22% of the 500 BURD transformer replacements will avoid a failure leading to 22% * 500 = 110 avoided failures and subsequently 110 ÷ 328 = 33.5% less failures at the end of the RAMP window of evaluation. (This essentially assumes that there are "persistent" benefits for BURD transformer replacements, i.e. in Y6, 22 failures are avoided from the Y5 investment, and 88 failures are avoided from the previous years IR investments). For targeting benefit, 33.5% of the total population risk ÷ 0.61% of the asset population = 55. A Targeting Multiplier of 55 is quite high compared to other programs as modeled in RAMP. This disparity is likely due to the lack of risk analysis used to justify the Targeting Multiplier. A lack of a quantitative multiyear predictive accuracy metric in addition to the 1 year accuracy of 22% allows for significant ambiguity whether or not 78% of BURD transformer replacements in the 6 year RAMP time frame would prevent an equipment failure. Deployment of M2 replacement BURD transformers is only meant to decrease failure frequency.
Note 6	The Mitigation Percent (Sub-Driver) value represents the 'targeting benefit' total effectiveness of the mitigation / control program. The value is calculated by taking the Mitigation Percent (Random Walk) value multiplied by the Targeting Benefit value. Column D * Column E = Column F
Note 7	The Final Driver Frequency value represents the expected resulting annualized driver frequency at the end of the 6 year period in implementing the mitigation / control program. The value is calculated by taking the Initial Driver Frequency values and reducing them by their corresponding Mitigation Percent (Sub-Driver) values. Column A * (1 - Column F) = Column G
Note 8	The Mitigation Percent (Driver) is the weighted average of the Mitigation Percent (Sub-Driver) with Initial Driver Frequency as the weighting factors. At each Driver level: (SUM of values in Column A - SUM of values in Column G) ÷ SUM of values in Column A = Column H

(U 338-E)

Southern California Edison Company's Risk Assessment and Mitigation Phase

Workpapers

Chapter 12
Climate Change

SCE 2018 Risk Assessment Mitigation Phase (RAMP)

Chapter 12
Climate Change

Index of Workpapers

Excel versions of Workpapers are available online

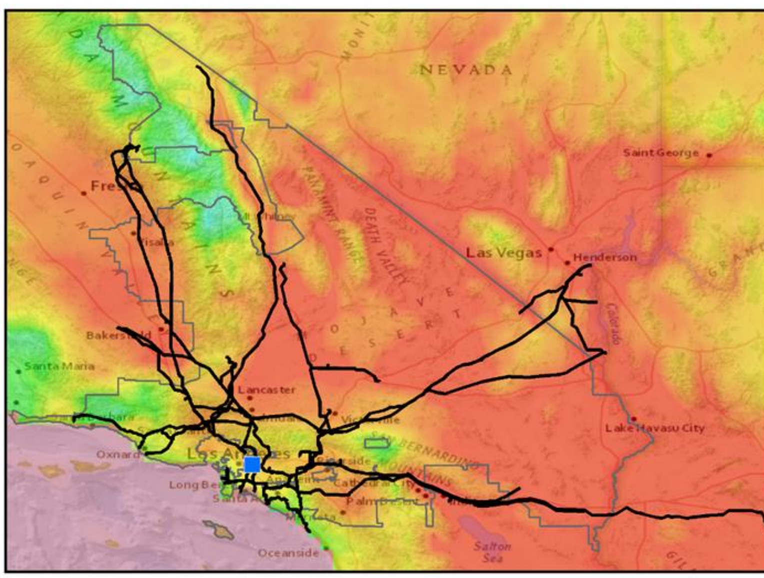
1. Go to www.sce.com/applications
2. Select SCE 2018 RAMP
3. In the new window, select Zipped document

SOUTHERN CALIFORNIA EDISON®

An EDISON INTERNATIONAL® Company

2016

Southern California Edison Climate Impact Analysis and Resilience Planning



Version 01
November 30, 2016

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

In 2015, SCE became one of 17 utilities voluntarily participating in a U.S Department of Energy (DOE) project, Partnership for Energy Sector Climate Resilience, aimed at enhancing energy security by improving the resilience of energy infrastructure against the impacts of extreme weather and climate change. The goal was to understand how the wider trends of climate change on a global scale would translate into local changes in energy system performance.

Building upon research done by the California Energy Commission (CEC) and the scientific community, SCE created an Adaptation Planning Tool, which allowed SCE to analyze the impacts that long-term climate change would have throughout its service territory, down to the local level. In early 2016, the findings of this research were submitted in a report to the DOE and the California Public Utilities Commission (CPUC). This report detailed the impacts that SCE would likely to experience over the next 100 years as a result of global climate change in southern California. Key vulnerabilities impacting SCE over the next 100 years include:

- Increased risk for facility inundation and flooding, especially at 18 at-risk coastal facilities
- Transmission, distribution, and generation systems will operate less efficiently under extreme heat
- Increased demand due to ongoing increased average temperature and extreme heat days
- Disruption of service due to facility and equipment loss following flood and landslide events
- Limited generation capacity due to decreased reservoir levels
- Disruption of service due to facility and equipment loss due to wildfire events
- Employee and public safety and wellbeing impacted by wildfire events
- Increased liability due to higher potential of utility caused fires

Throughout the summer of 2016, SCE held a series of workshops, in which subject matter experts were brought together to identify solutions to the impacts long-term climate change will have on the SCE network. From these workshops numerous mitigation measures were identified and shared throughout the company and will serve as the basis for continued development of a climate change resilience action plan. Summarizing the findings of these workshops, key mitigation efforts would include:

- Design new facilities and equipment utilizing future modeling instead of historical data
- Initiate facility relocation well in advance of coastal inundation at at-risk facilities
- Implement engineering solutions to mitigate facilities at increased risk for inundation, flooding, mudslides, and debris flows
- Install additional equipment to decrease burden on existing equipment
- Increase the use of distributed energy solutions to limit the burden on the transmission system
- Increase the capacity of the existing reservoir system through additional locations and a more robust catchment system
- Mandate all new facilities in at-risk location for wildfires have 2 independent evacuation routes

Work will continue throughout 2017 and 2018 to further refine these proposals to determine the most viable and realistic solutions that will best serve SCE's communities.

The climate is changing, and will continue to change. SCE is committed to working with the DOE, CPUC, and the communities we serve to ensure that together we are prepared for that future. Over the next 3 years, SCE will work closely with subject matter experts to develop an effective resilience action against long-term climate change for implementation into the 2020 general rate case.

2 RESILIENCE PLANNING SCOPE

2.1 RESILIENCE PLANNING GOALS

SCE is a major business and significant contributor to the Southern California economy. SCE's resilience plan goal is to identify strategies that can meet California's regional climate adaptation needs while continuing to ensure that electricity is safe, reliable, and affordable.

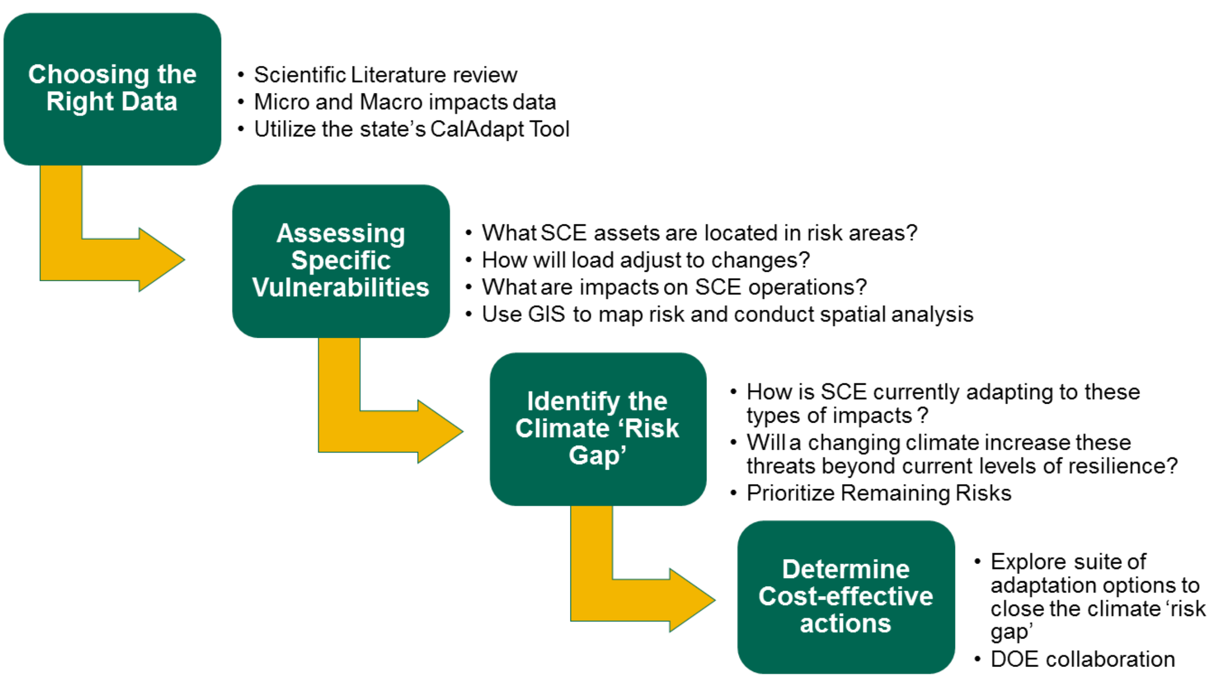
With this goal in mind, SCE joined the DOE's Partnership for Energy Sector Climate Resilience on July 22, 2014. As a Partner, SCE agreed to "identify priority vulnerabilities to energy infrastructure assets and operations from extreme weather and climate change impacts" and to work with the partnership and stakeholders to determine a resilience plan.

2.2 ADAPTATION PLANNING FRAMEWORK

SCE, in conjunction with external stakeholders, created an adaptation-planning framework that functions as its DOE Partnership work plan. Key to this framework is four milestones: Choosing the Right Data, Assessing Specific Vulnerabilities, Identifying the Climate 'Risk Gap', and Determining Cost–effective Actions to address any remaining risks.

In the flow chart below, SCE has highlighted key questions to be answered, and actions to be taken, in order to achieve each milestone. Along with the DOE Partners, SCE has completed the first phase of the DOE partnership represented by the first two milestones and we will be focusing on the final two milestones in the months ahead. At this point SCE has an understanding of the potential impacts, and is now considering where risk mitigation is necessary, and which actions are appropriate to provide reliable, safe, and affordable electric service to our customers.

Figure 1: Four milestones of the adaptation-planning framework



3 CLIMATE CHANGE ANALYSIS

Southern California Edison (SCE) utilized the data from the Cal-Adapt climate change research program as the basis for its long-term impact and vulnerability assessment. The impacts outlined in the Cal-Adapt study were further reviewed and categorized into broad vulnerability categories to allow for the development of more effective mitigation strategies as outlined in Section 3.3 of this document.

3.1 DEVELOP INPUTS ON CLIMATE CHANGE

Identify Climate Change Projections

Attempting to understand how global climate change will affect local communities, researchers have refined methods of modeling global climate change in order to apply those projections to local regions and communities. This progress is allowing climate scientists, state regulators, and now utilities, to speak with added confidence about the impacts Southern California could face in the decades ahead. The trend is clear, more warming can be expected, and with that warming, comes additional variability across a number of weather and natural phenomena.

SCE's internal analysis, and the scientific literature reviewed, both draw from many of the same down-scaled models utilized in research funded by the California Energy Commission (e.g., Westerling and Bryant 2008; Westerling et al. 2009; Cayan et al. 2009; Heberger et al. 2009).

The projections made in this climate impact analysis stem from an emission scenario (called 'A2') created by the Intergovernmental Panel on Climate Change (IPCC). The A2 scenario is considered to represent a medium-high emissions scenario. This scenario describes a world with a large income disparity, slow technological diffusion, and high greenhouse gas emissions. In the A2 scenario, global carbon dioxide (CO2) emissions reach nearly 30 gigatons of carbon (GtC) annually by 2100. SCE utilized this emissions scenario to conduct an internal spatial analysis because SCE is interested in exploring the extent of the climate risk gap (between current preparedness and the extremes of climate change) and also because when viewing the data it appeared more optimistic emission scenarios track relatively near the A2 scenario in the near-term (out to 2030). SCE views this vulnerability analysis as an iterative process, and as more accurate global emissions projections are developed in the future, the tool SCE created can augment its assumptions by using different data sets.

Existing studies were consulted to verify analysis and draw further systemic conclusions. Two studies in particular were drawn upon to cross check SCE's internal analysis. The first was the 'Climate Change in the Los Angeles Region' project run by UCLA. This project is a collection of ongoing studies that began in 2010 and has been funded jointly by the City and County of Los Angeles, the U.S. Department of Energy, and the U.S. National Science Foundation. Another study key to our analysis was 'Estimating Risk to California Energy Infrastructure from Projected Climate Change' funded through the California Energy Commission's Public Interest Energy Research (PIER) Program and authored by researchers at Lawrence Berkeley National Lab (LBNL) and UC Berkeley . When citing potential impacts from previous studies, SCE has also attempted to draw from those works the climate impacts derived from the A2 scenario (or explicitly flag the use of other scenarios) to ensure consistency.

The SCE Adaptation Planning tool was designed to utilize datasets from numerous sources, including the Cal-Adapt climate impact that illustrates climate data over time within SCE's service territory. By utilizing different geospatial analysis processes, this tool extracts detailed climate impact data at each asset location. The tool easily iterates over multiple locations to create a time series impact at each asset location and report impacts in a table, which allows SCE the ability to create an impact analysis by a specific assets as the impact changes into the future. Utilizing the locational aspects allows SCE to draw conclusions from climate projections across our system, as well as focus in on specific facilities and assets. The ability to conduct this type of analytic over SCE's diverse 50,000 square mile territory ensures that SCE will be have geographic specific analysis to inform the effectiveness of mitigation strategies identified in the second phase of this effort.

The SCE Adaption Planning tool was designed for the data sets provided through the State's Cap-Adapt research portal for this initial analysis, but SCE designed the tool to be flexible enough to accept new data when it becomes available, allowing for iterative adaptation planning as the research community refines methods and gathers additional data.

3.2 Climate Change Hazards

SCE's analysis focused on understanding the climate impacts projected to occur to the energy assets that customers most heavily rely upon, and which SCE controls. As mentioned in the overview of SCE's analysis above, this included utility–owned generation, transmission lines greater than 115 kV, all substations, and a high-level look at distribution system impacts.

While there is still significant uncertainty regarding the likelihood of specific downscaled impacts at specific locations, focusing SCE's analysis at the facility (or asset) level has provided insights into trends and specific concerns that require additional analysis. The data breakouts below offer a representative look at how facility-level data can be generated from SCE's Adaptation Planning tool. This facility-level data combined with a thorough review of the scientific literature and a deep understanding of the challenges facing the SCE system, has allowed SCE to prioritize the list of assets being studied and will allow SCE to understand where our system may be vulnerable at the state, regional and facility-level.

These facility-level outputs provide SCE with a large quantity of information that can be analyzed to help better understand climate change hazards. For instance, while the snowpack data for Big Creek Hydro Generation (found in Table 2 below) is only representative of impacts at a specific facility, not the total watershed, further analysis can reveal the total impacts to hydro production for the region. The same type of analysis can be applied to other areas of concern such as extreme heat days and sea level rise.

Example of Facility-level Analysis Outputs

Table 1: Mesa substation facility analysis

Mesa Substation	2030 (2020 for Fire Data)	2050	2085
Avg Air Temp (c) Aug	27	28.3	29.6
Fire Risk Multiplier	0	0	0
Max Air Temp (c) Aug	34.2	35.5	36.8
Min Air Temp (c) Jan	11.9	11.2	6.5
Net Surf Radi (watt per square meter)	25	25.6	28.9
Precipitation (mm per month)	0	35.4	74.2
Runoff (mm per month)	0	1.6	5.1
Snow Water Equiv (mm per month)	0	0	0

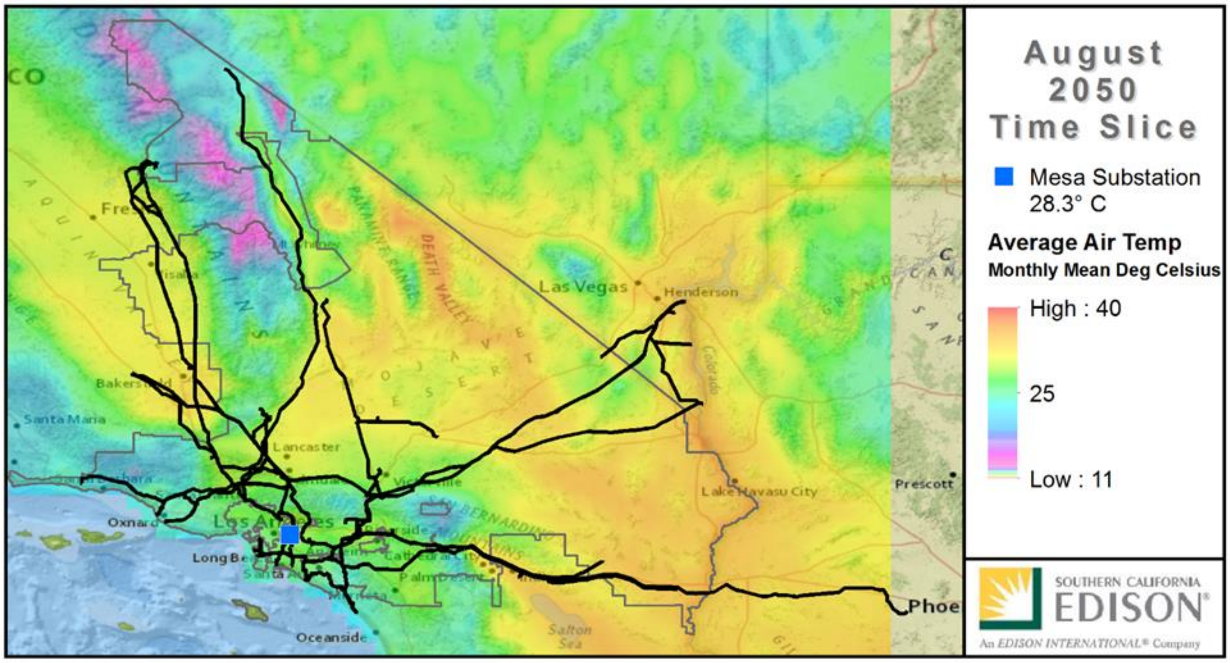
Table 2: Big Creek facility analysis

Big Creek #1- Hydro Generation	2030 (2020 for Fire Data)	2050	2085
Avg Air Temp (c) Aug	18.5	20.2	20.6
Fire Risk Multiplier	1	1.3	1.6
Max Air Temp (c) Aug	24.9	27.9	27.6
Min Air Temp (c) Jan	-0.3	-3.4	-4
Net Surf Radi (watt per square meter)	33.5	27.9	14.3
Precipitation (mm per month)	2	152.9	196.2
Runoff (mm per month)	0	23.6	20.4
Snow Water Equiv (mm per month)	0	68.3	52.3

The following section describes the climate impacts most likely to affect SCE's operations and assets. Drawing upon relevant previous studies and our own analysis, SCE presents below a summary of key findings and climate impact maps for the year 2050. Additional impact maps showing 2030, 2050, and 2085 snapshots side-by-side for reference are located in Appendix B, at end of this update.

1- Warming Temperatures:

According to research conducted by Cayan et al. (2009) mean temperatures in California are expected to warm significantly over the twenty-first century in all widely studied climate scenarios, especially in the summer and in inland areas. At a more regional scale, by mid-century, Hall et al. (2013) find the most likely warming under the business-as-usual scenario is roughly 4.6 degrees Fahrenheit averaged over the LA region's land areas, with a 95% confidence that the warming lies between 1.7 and 7.5 degrees. The high resolution of their projections reveals a pronounced spatial pattern in the warming: High elevations and inland areas separated from the coast by at least one mountain complex warm 20% to 50% more than the areas near the coast or within the Los Angeles basin (Hall 2013)**.** Moving beyond mid-century and urban centers, SCE's analysis finds the eastern border of the service territory may see average monthly ambient air temperature increases between 7 and 12 degrees Fahrenheit in the 2070-2099 period *resulting in decreased efficiency in SCE's current transmission, distribution, and generation systems*. The increase in average temperatures will also drive *an increase in customer demand* as electricity usage goes up during warmer weather. This region hosts five key transmission pathways serving load to southern California.



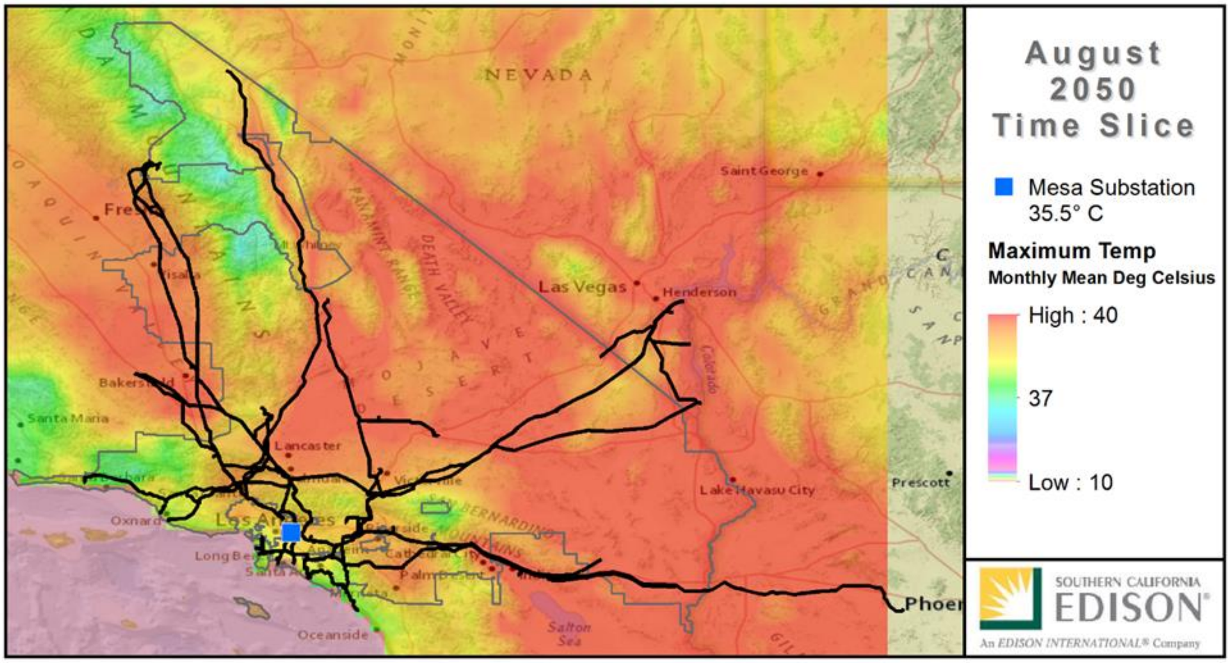
2- Extreme Heat Events:

According to research from Hall et al. (2013),

> "The number of extreme heat days, defined as days in which the high temperature exceeds 95 degrees Fahrenheit, rises everywhere at mid-century under the business-as-usual scenario. The number of extreme heat days in the future follows a similar spatial pattern to that of the warming results, with inland areas seeing much higher totals than coastal areas. For example, Santa Barbara sees average annual extreme heat days rise from 5 in the baseline period to more than 123 at mid-century under business-as-usual. By contrast, Riverside sees an increase from 58 days to 103 days."

Overall, this research finds a tripling of extreme heat days by mid-century in dense urban areas in Los Angeles County, the San Fernando Valley, and San Gabriel Valley.

Historically, most Southern California heat waves have occurred in July and August, but as climate warming occurs, these events appear to begin earlier in the season and could continue through the fall, while summer events become more frequent and more intense. The increasing tendency for multiple hot days in succession – resulting in heat waves that last longer – could cause problems for distribution infrastructure as well as transmission. Especially important may be the lack of nighttime cooling that has characterized recent heat waves in California, which can cause additional stress on the transformers that help serve customer load.



High temperatures can also result in decreased efficiency in generation. The LBNL (2012) study finds that higher temperatures will decrease the capacity of existing natural gas-fired power plants during extreme heat events. While they note that the estimated decrease in capacity varies (by region, emission scenario, climate model, and plant type) the trend is clear. During the hot periods of August at the end of the century, under the high emission scenario, the models used for this study estimate a decrease in natural gas power plant generating capacity of 3 percent to 6 percent in California. To put this phenomenon in perspective, total nameplate Capacity losses at California's gas-fired generating plants could total 10.3 GW on hot days by the end of the century (LBNL 2012). This should be compared with the 1961–1990 maximum coincident loss of 7.6 GW.(LBNL 2012)

The transmission of electricity will also be affected by increased ambient air temperature and extreme heat events. As described in the State of California's Third Climate Change:

> "In addition to reduced efficiency in the electricity generation process at natural gas plants, reduced hydropower generation, losses at substations, and increasing demand during the hottest periods (resulting in more than 17 Gigawatts or 38 percent of additional capacity needed by 2100 due to higher temperatures alone), transmission lines lose 7 percent to 8 percent of transmitting capacity in high temperatures while needing to transport greater loads."

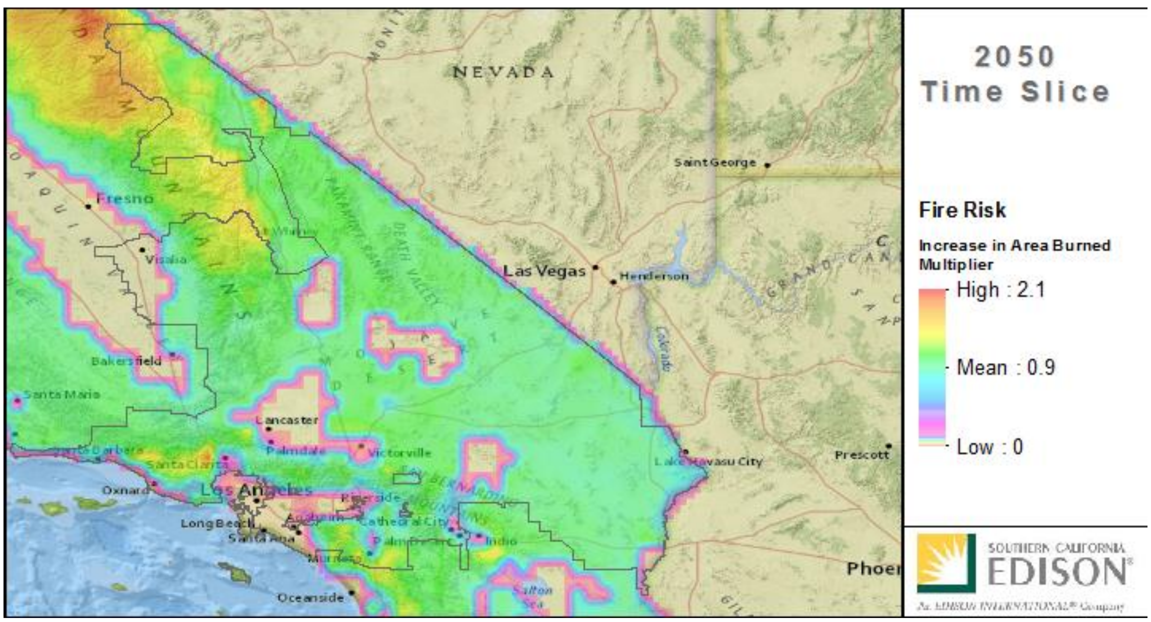
According to SCE analysis and previous studies, average annual air temperature is projected to rise between 7-12 degrees Fahrenheit along the eastern boundary of SCE's Service territory by the end of the century – subjecting at least 5 key transmission pathways to some of the most extreme warming our state will face. (SCE analysis, LBNL 2012) According to the LBNL study, a 9 degree Fahrenheit air temperature increase (the average increase predicted for hot days in August according to the Intergovernmental Panel on Climate Change's A2 scenario) diminishes the capacity of a fully loaded transmission line by an average of 7.5 percent. (LBNL 2012) This warming and increased chance of extreme heat will posing key risk due to the fact that Southern California draws on imports coming east for about one-third of its needs.

3- Increased Wildfire Risk:

Of the most damaging fires in the United States over the last 170 years, more than half occurred in California, and California leads the nation in economic losses from wildfire (Fried et al. 2004; Torn et al. 1998). Southern California wildfires can be a serious threat to electrical transmission and distribution lines, as they can result in increased maintenance costs and reduced line efficiency. As noted in the scientific literature, wildfire risk is influenced by a number of factors, including climate, topography, available fuel, and sources of ignition (Westerling et al. 2009). From studying the data, it seems that climate change will only exacerbate the problem, as increased temperatures, a reduced snowpack, and altered precipitation will lead to increased flammability of fuel for longer periods of time, which will affect the size, frequency, and severity of wildfires (LBNL 2012). The escalation in flammability *increases the liability for all electric utilities due to a higher potential for utility caused fires*.

One study summarized in California's Third Assessment finds, "a 40 percent increase in the probability of wildfire exposure for some major transmission lines, including the transmission line bringing hydropower from the Pacific Northwest into California during peak demand periods" (Third Assessment 2012). These fires will also *heighten the risk to crews working in remote locations with limited evacuation routes*.

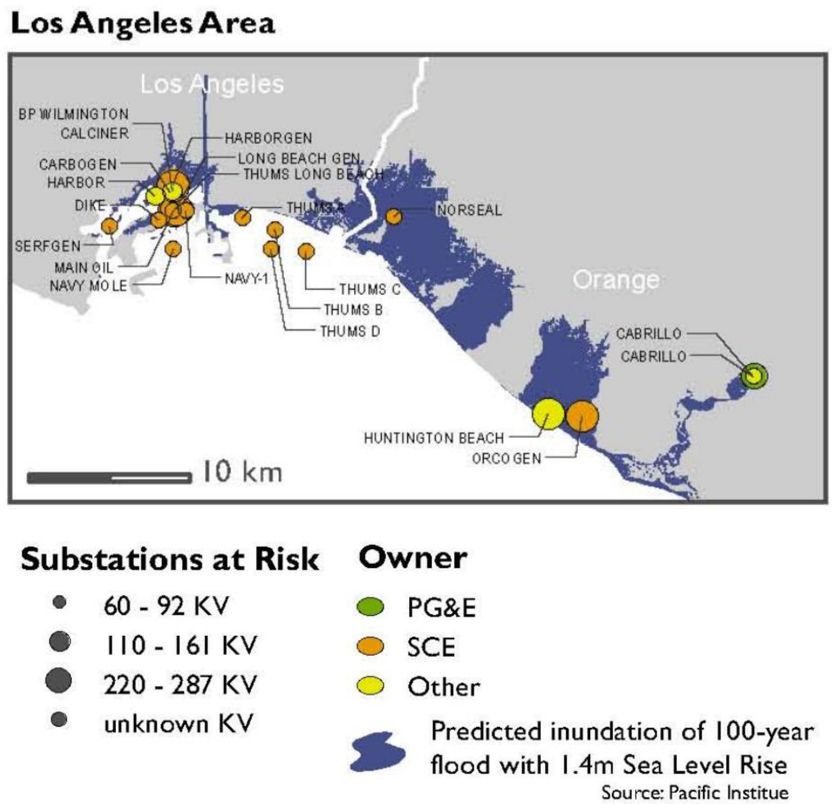
According to SCE's analysis of the data, this could mean *tripling of wildfire risk in extreme cases (ex. near transmission lines serving Santa Barbra)* but also slightly decreasing risk across the southeastern reaches of SCE's service territory (possibly due to vegetation migration) by the end of the century.



SCE currently utilizes CAL FIRE data, and on–the-ground inspections, to assess threats to SCE's system from wildfire. However, CAL FIRE's Fire and Resource Assessment Program Fire Threat Map hasn't included the explicit impacts of increased fire risk due to climate change. SCE will seek to integrate this climate change data into its planning process and risk maps.

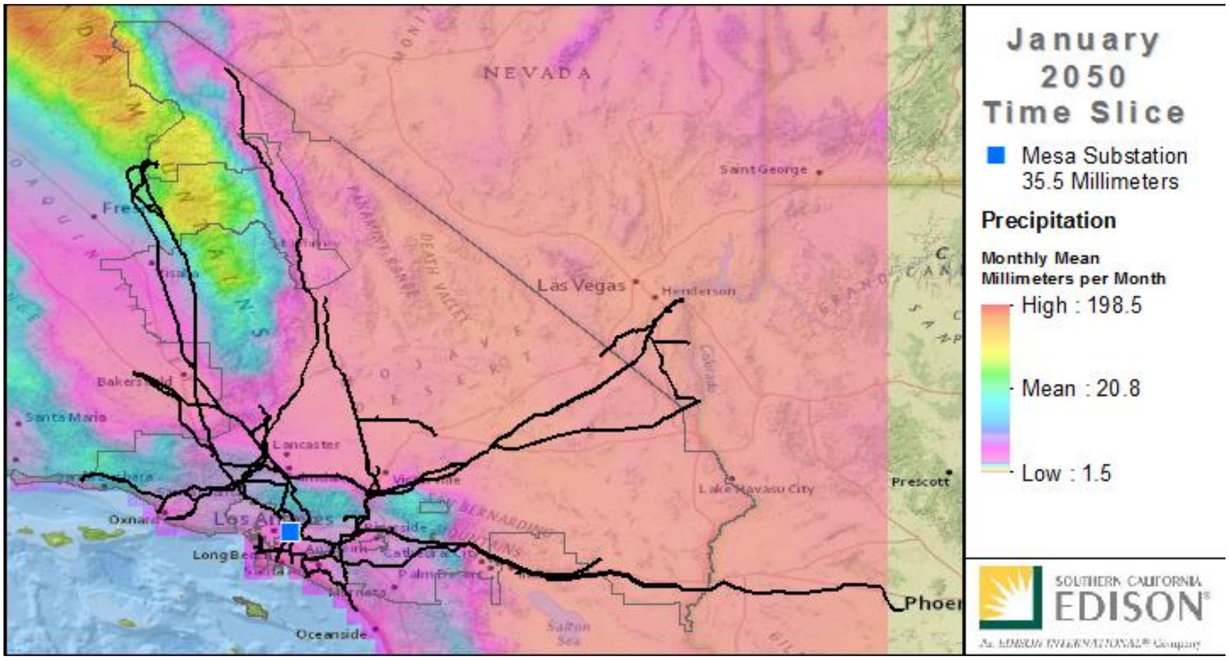
4- Sea Level Rise/ Coastal Inundation:

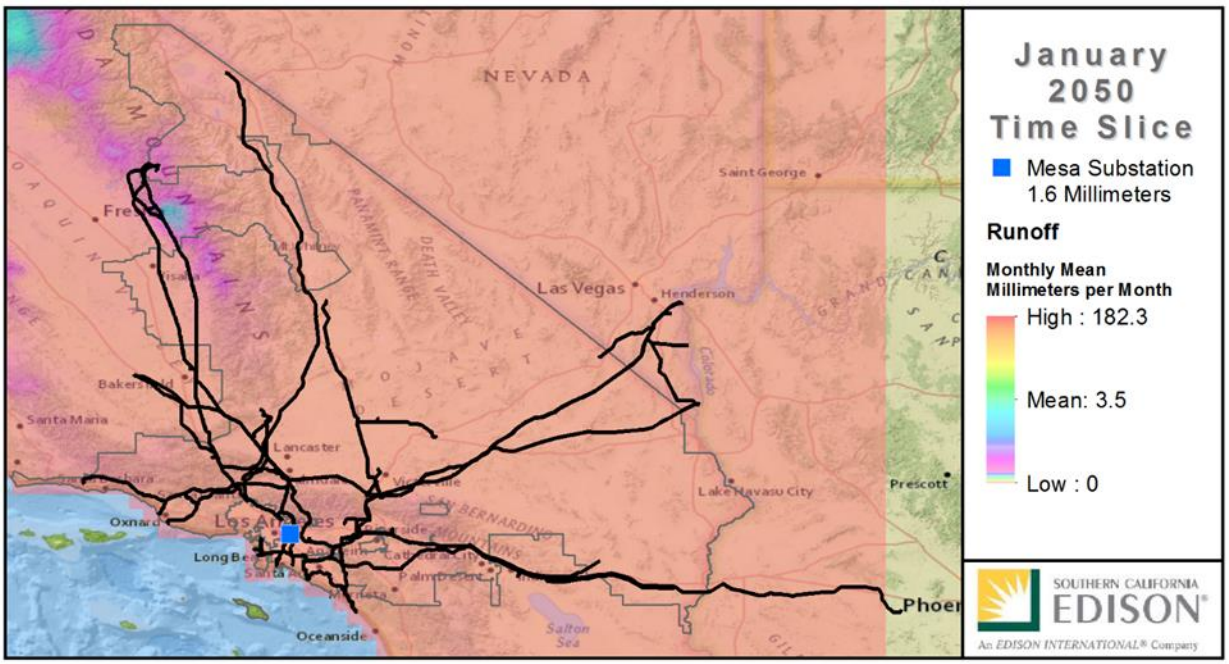
Sea level along California's coast has risen about 17–20 centimeters (cm) over the last century, and many studies anticipate a larger rise over the coming century (Cayan et al. 2009). Researcher studying the impacts of climate change (specifically the low (B1) to medium-high (A2) emissions scenarios) found that, “by 2100 average sea level along the California coast may rise between 1.0 and 1.4 meters (3.3 and 4.6 feet)” (Cayan et al. 2008; Cayan et al. 2009). This magnitude of sea level rise could pose an increasing threat to energy infrastructure along the coast, including power plants, transmission and distribution lines. SCE’s analysis corroborates the findings of other researchers, discovering that *18 SCE-owned substations are at risk from a 100-year flood accompanied by a 1.4-meter sea-level rise* by the end of the century according to the data. (SCE Analysis, LBNL 2012)



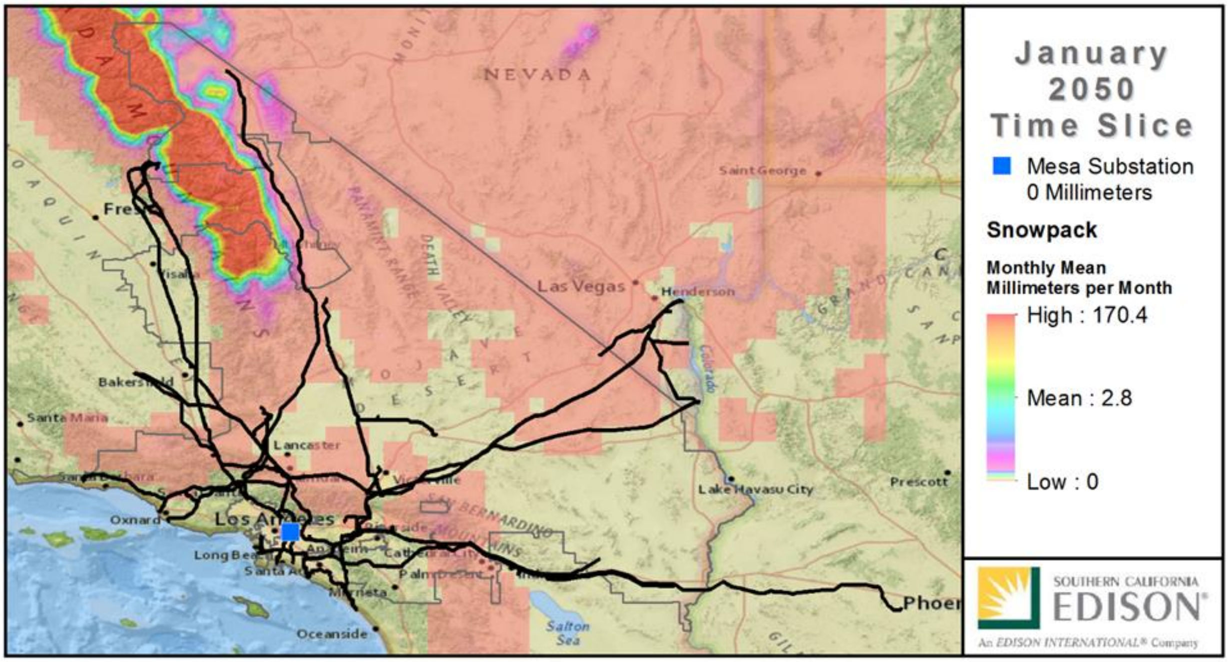
5- Precipitation and Snowpack Changes:

There will be significant challenges to California’s water systems over the next few decades. Paradoxically, “the state may very well experience both drought and increased rainfall simultaneously, with a greater share of precipitation coming from big storm events as was the case in San Diego this past July where, while in the midst of a drought, they received more rainfall in a single month than they had received in the previous 100 Julys combined” (CPUC 2016). Researchers also predict winter precipitation falling as rain instead of snowpack, which will have significant impacts on hydropower generation. The overall decrease in rainfall will result in *limited reservoir capacity available for generation needs*. Alternatively, the intensification in big storm events will *increase the risk of flooding and mudslides damaging critical equipment throughout the SCE service territory*. These projections are echoed in SCE’ analysis of data seen below and in Appendix B.





SCE's internal analysis sees a dramatic rise in January precipitation (+ 151 mm per month) and runoff +23 mm per month) at some of our hydropower facilities between now and mid-century. The impacts on hydropower generation require additional study, because specific data points fail to represent the cumulative watershed impacts of this data set. SCE will engage in this analysis over the coming months.



3.3 Electrical Utility Sector Vulnerabilities

The long-term impacts of climate change were categorized into vulnerability categories to allow for more effective mitigation strategy development. The following vulnerabilities were identified as the greatest risks facing SCE over the next 100 years due to long-term climate change impacts:

- Increased risk for facility inundation and flooding, especially at 18 at-risk coastal facilities
- Transmission, distribution, and generation systems will operate less efficiently under extreme heat
- Increased demand due to ongoing increased average temperature and extreme heat days
- Disruption of service due to facility and equipment loss following flood and landslide events
- Limited generation capacity due to decreased reservoir levels
- Disruption of service due to facility and equipment loss due to wildfire events
- Employee and public safety and wellbeing impacted by wildfire events
- Increased liability due to higher potential of utility caused fires

3.4 Estimate Consequences of Climate Change Impacts

Southern California Edison (SCE) has initiated a study on the indirect and induced costs associated with long-term climate change and the mitigations associated with overcoming them. Completing such a study in a short period is prohibitive due to the complex variables involved and the interrelated nature of associated costs. Every significant impact of climate change results in a cascading financial effect, many of which are difficult to identify and measure.

Completion of an initial impacts cost analysis is anticipated early 2017, with a detailed study slated to be completed mid-2017 to support the mitigation selection process.

Direct Costs of Climate Change Impacts

Measuring the direct costs associated with climate change over the next 100 years will require an extensive analysis of numerous variables. Factors such as increased flood risk, sea-level rise, and diminished capacity of equipment during extreme heat events all result in financial risk to SCE equipment and facilities. In order to effectively project direct costs it will be necessary to incorporate historical data, such as average facility relocation costs, with projected costs like developing technology. The following table provides an example of the direct costs associated with climate change and extreme weather impacts.

Table 3: Direct costs associated with climate change and extreme weather impacts

Climate Impact	Direct Cost of Impacts
Nuisance Flooding (Periodic, Temporary)	• Restoration and repair costs, including parts and labor • Replacement costs for damaged assets, including parts and labor • Administration of restoration and repair activities, including inspections, procurement, and installation/removal of temporary measures like portable substations
Permanent Inundation due to Sea-Level Rise	• Relocation costs, including property, infrastructure, engineering, and installation • Costs to connect relocated assets and supporting infrastructure • Replacement costs for equipment that cannot be relocated
Extreme Storm Surge Event	• Restoration and repair costs, including parts and labor • Replacement costs for damaged assets, including parts and labor • Administrative costs
Wildfire	• Inspection and repair/replacement costs for assets damaged by smoke exposure • Replacement costs for assets damaged by fire
Warmer Temperatures and Extreme Heat Events	• Restoration costs for outages • Replacement costs for equipment needing earlier replacement

Indirect and Induced Costs of Climate Change Impacts

In addition to the direct costs mentioned earlier, we also should be concerned with indirect and induced costs. These costs can have a large impact on our residential, industrial, commercial, agricultural, and infrastructure and public service customers. According to the DOE, some examples of indirect and induced costs by consumer class are shown in the table below. SCE looks forward to a continued analysis with state agencies and stakeholders.

Table 4: Indirect costs associated with climate change and extreme weather impacts

Consumer Class	Indirect Costs to Consumers	Induced Costs to Non-Consumers
Residential	• Inconvenience, lost leisure, stress, etc. • Out-of-pocket costs: – Spoilage – Property Damage • Health and safety effects	• Costs to other households and firms
Industrial, Commercial, and Agricultural	• Opportunity costs of idle resources such as labor, land, and capital • Shutdown and restart costs • Spoilage and damage • Health and safety effects	• Cost on other firms that are supplied by impacted firm (multiplier effect) • Costs on consumers if impacted firm supplies a final good • Health and safety related externalities
Infrastructure and Public Service	• Opportunity cost of idle resources • Spoilage and damage	• Costs to public users of impacted services and institutions • Health and safety effects • Potential for social costs stemming from looting, vandalism

4 DEVELOPING MITIGATION STRATEGIES

4.1 SCE MITIGATION WORKSHOPS

In the summer of 2016, Southern California Edison (SCE) held a series of 'course of action workshops' meant to bring subject matter expertise together to detail specific mitigation strategies to overcome the vulnerabilities outlined in Section 3.3. The mitigation measures will continue to be refined by subject matter experts for future integration into executable mitigation plans, with detailed cost-benefit analyses outlined to facilitate the selection process. These mitigation strategies represent an initial review of the potential impacts of long-term climate change, and will require further study and analysis prior to implementation.

A summary of the mitigation strategies outlined in the course of action workshops are detailed below.

1. **Build to projected impacts**

Current policy dictates that all new facility locations are built using historical flood projects and current 100-year flood plain maps. This policy change would use maps developed using future projections and computer modelling for determining optimal building locations.

Vulnerabilities Mitigated:

- Increased risk for facility inundation and flooding, especially at 18 at-risk coastal facilities
- Disruption of service due to facility and equipment loss following flood and landslide events

Associated Costs:

- Building new facilities may become more expensive due to more stringent location requirements and environmental standards
- More analysis would be required in the planning phase of building new facilities
- This COA would have a much higher potential benefit and much lower cost than other items on this list

Associated Benefits:

- Hardened infrastructure to weather events that will become more frequent in a future climate regime
- The ability to maintain reliable service through a major weather event that would have been interrupted at a previous location

2. **Facility relocation**

Relocate facilities located in projected 100-year flood plain locations 10 years prior to flood plain encroachment.

Vulnerabilities Mitigated:

- Increased risk for facility inundation and flooding, especially at 18 at-risk coastal facilities
- Disruption of service due to facility and equipment loss following flood and landslide events

Associated Costs:

- Decommission and demolish old facilities and repurpose the land

- Cost associated with rebuilding (construction) a new facility in a potentially more costly location
- New environmental and regulatory constraints
- A move to a new location may decrease efficiency or alter how certain facilities interact with Edison infrastructure
- Potential cost associated with moving out of a projected flood plain, but in reality, the flood plain advances beyond the initial projection. This may cause the need to move once again

Associated Benefits:

- Hardened infrastructure to weather events that will become more frequent in a future climate regime
- The ability to maintain reliable service through a major weather event that would have been interrupted at a previous location
- Offers an opportunity to relocate facilities that were not places in ideal locations in the first place

3. Individual facility flood mitigation engineering

Conduct site-specific engineering review to assess the potential need for unique engineering solutions, to include but not limited to:

- Raising each site above flood plain levels
- Place critical equipment on raised or floating platforms
- Place flood berms around facilities and equipment
- Addition of seawalls in impacted communities

Vulnerabilities Mitigated:

- Increased risk for facility inundation and flooding, especially at 18 at-risk coastal facilities
- Disruption of service due to facility and equipment loss following flood and landslide events

Associated Costs:

- Construction and equipment purchase cost associated with upgrading facilities
- Potential failure of certain mitigating engineering solutions resulting in facility failure and lack of reliable service

Associated Benefits:

- Hardened infrastructure to weather events that will become more frequent in a future climate regime
- The ability to maintain reliable service through a major weather event that would have been interrupted at a previous location
- Would eliminate costs of physically moving infrastructure or procuring land

4. Equipment specifications aligned to future weather models

Current policy requires that all equipment be built to specification matching historical weather conditions for its area. This policy change would require all equipment be built to specifications matching the modeled conditions projected for the end of the equipment’s lifespan (i.e. equipment with an 80 year life expectancy would have to operate effectively under the projected conditions 80 years in the future).

Vulnerabilities Mitigated:

- Transmission, distribution, and generation systems will operate less efficiently under extreme heat
- Increased demand due to ongoing increased average temperature and extreme heat days

Associated Costs:

- R&D costs associated with determining appropriately engineered equipment
- Cost of procuring and replacing the outdated equipment
- Cost of replacing equipment to climate forecast standards that may not turn out to be accurate

Associated Benefits:

- Hardened infrastructure to weather events that will become more frequent in a future climate regime
- A more accurate understanding of how your system will behave and endure the new climate and during extreme weather conditions
- Less equipment failures would decrease cost and increase safety
- Equipment that is more efficient would decrease cost in the end

5. Add equipment to reduce increased system stress

As equipment becomes less efficient due to increased temperatures and increased demand, add new equipment to reduce the burden on the existing equipment.

Vulnerabilities Mitigated:

- Limited generation capacity due to decreased reservoir levels
- Increased demand due to ongoing increased average temperature and extreme heat days
- Transmission, distribution, and generation systems will operate less efficiently under extreme heat

Associated Costs:

- R&D costs associated with determining appropriately engineered equipment
- Cost of procuring and replacing the outdated equipment as well as siting new locations for equipment

Associated Benefits:

- Increased reliability due to more contingency infrastructure in case of failure at certain points
- Increase the lifespan of older, overburdened equipment that would be negatively affected by climate change

6. Increase focus on distributed generation availability

As increased demand and decreased generation efficiency occur, focus on increasing the availability of distributed generation capacity and the ability of the grid to perform two directional flow.

Vulnerabilities Mitigated:

- Limited generation capacity due to decreased reservoir levels
- Increased demand due to ongoing increased average temperature and extreme heat days
- Transmission, distribution, and generation systems will operate less efficiently under extreme heat

Associated Costs:

- R&D costs associated with determining appropriately engineered equipment
- Costs associated with upgrading or replacing outdated equipment
- Costs associated with increased need for accurate localized load forecasts

Associated Benefits:

- Increased grid stability and reliability
- Decreases opportunities for equipment failures and costs associated with repairing or replacing the impacted equipment
- Less need for additional traditional generation

7. Increase reservoir locations and capacity

As the frequency of rain becomes less frequent but the intensity increases, the ability to capture runoff to support hydrological generation will decrease. By adding additional reservoir locations and increasing capacity, additional rain can be captured during high intensity periods of rain.

Vulnerabilities Mitigated:

- Limited generation capacity due to decreased reservoir levels

Associated Costs:

- Building new reservoirs as well as increasing the capacity of existing reservoirs would require significant construction spending
- Optimizing reservoirs would require climatological analysis, downstream water user, and environment studies
- A significant change to the system of reservoirs would increase Edison's potential exposure to infrastructure failure as well as environmental issues

Associated Benefits:

- Enhances Edison's ability to maintain hydro generation during periods of extended drought as well as optimizes the system for the anticipated changes in precipitation patterns
- Helps create a more positive public impression for Edison by showing increased water stewardship

8. Align system specifications with modified weather conditions

Model future grid development off of existing U.S. city grid design/specifications that match projected weather conditions (i.e. if 50-year weather projections for the rancho Cucamonga area match current conditions in phoenix, model grid design and requirements off of Phoenix' current design requirements.

Vulnerabilities Mitigated:

- Transmission, distribution, and generation systems will operate less efficiently under extreme heat
- Increased demand due to ongoing increased average temperature and extreme heat days

Associated Costs:

- Could present significant costs in upgrading pre-existing infrastructure and standards
- May provide for somewhat misleading solutions that work better in a different city
- The adjustments might end up being costly in the long term

- Fails to account for changes in technology over time (always looking to historical technology)

Associated Benefits:

- Utilizes pre-existing research and knowledge that may help provide realistic, workable solutions to climate change challenges
- May help to identify additional challenges or best approaches to hardening the grid

9. Increased distributed energy resources at the distribution level

Increase the use of distributed energy resources at the distribution level to reduce the load impact on the bulk transmission system.

Vulnerabilities Mitigated:

- Transmission, distribution, and generation systems will operate less efficiently under extreme heat
- Increased demand due to ongoing increased average temperature and extreme heat days
- Limited generation capacity due to decreased reservoir levels

Associated Costs:

- Significant financial impact to implement new generation capabilities throughout the SCE service territory
    - These costs could be shared across political and industry boundaries and spread out over an extended period of time if demand is forecasted long-term

Associated Benefits:

- Decreases impact on bulk transmission system
- Reduces impact of extreme heat days due to locally produced peak power production
- Greater potential for implementing ‘green’ power solutions

10. Multiple evacuation route policy

Implement a policy change that requires all SCE facilities to have two geographically independent evacuation routes for every Southern California Edison (SCE) facility.

Vulnerabilities Mitigated:

- Employee and public safety and wellbeing impacted by wildfire events

Associated Costs:

- Extremely costly in remote areas to develop a secondary evacuation route if none exists (i.e.; building and maintaining a new road, building a helipad)
- In some areas, the secondary evacuation route may be as vulnerable to fire as the primary evacuation route

Associated Benefits:

- Allows Edison employees to work more safely and confidently in areas of high fire risk
- Could potentially be lifesaving if fire conditions do threaten the facility

5 CHALLENGES

5.1 COMMUNITY ENGAGEMENT

SCE cannot operate independently in preparing for the impacts of global climate change. The interdependencies that exist between the utility industry, emergency management, and local communities require that any broadly implemented resilience strategy must incorporate each of these entities. One significant challenge will be aligning the mitigation strategies of SCE, with the long-term planning of local communities and emergency management organizations. For instance, attempting to move substations that may be inundated due to sea level rise must first take into account how the communities those substations serve will adapt to the same sea level rise. If the community moves, or implements coastal mitigation measures, it will significantly affect how SCE infrastructure will need to service those areas.

5.2 FINANCIAL ANALYSIS

Understanding the financial impacts of long-term climate impacts, and the role mitigation measures may have on those costs, will require extensive research and analysis. The complexity of analyzing financial impacts assessed over 100 years will necessitate the creation of a standardized model for analyzing these economic considerations across all partnering utilities to ensure consistency. At present, there is no mechanism to guide partnering utilities through this analysis.

6 NEXT STEPS

The climate is changing, and will continue changing. SCE is committed to working with the communities we serve to ensure that together we are prepared for that future.

SCE plans to continue active participation in these DOE efforts, and additionally work with state regulators in California to continue the analysis of the energy sector's climate impacts. SCE is specifically interested in pursuing the opportunities to broaden the analysis conducted so far to include California Public Utility Commission's recommendations. These recommendations urge California utilities to:

- Broaden the Definition of Assets
- Assess the System as a Sum of its Assets
- Assess Future System Assets
- Assess Emergency Management Procedures
- Assess the Vulnerability of Customers
- Assess Internal and Operational Vulnerabilities

SCE will work with DOE partners to continue assessing cost-effective mitigation measures that can address the impacts of global climate change on Southern California energy infrastructure. This work will be shared with California energy agencies, stakeholders, and our communities to promote a comprehensive understanding of the risks – and opportunities to mitigate those risks.

6.1 Plans to Monitor, Evaluate, and Reassess

There is a lot of uncertainty around future climate change. Southern California Edison agrees with the DOE that a robust plan should be created to address this uncertainty. Plans should include monitoring progress, evaluation of implementation and reassessing the plan. SCE will have implementation milestones, which are key points that indicate increased level of resilience to a climate threat. Key cost and performance data will also be collected and monitored.

SCE agrees with the DOE that evaluating implementation should take into account new information from outside sources. Outside sources include new climate change assessment and products form our state (ex. Cal-Adapt), US Global Change Research Program reports, DOE reports on climate change resilience planning, and NOAA climate change projections.

Reassessment is a regular part of planning and depends on how new information becomes available, urgency or how different the new information is, and resource constraints. SCE agrees with the DOE guidance that it should occur at least as often as climate change assessment reports are produced. If a change to the plan is needed, it can be individually updated starting with the step most likely to be affected.

6.2 Evaluate and Prioritize Resilience Measures

In mid-2017, SCE will be conducting a mitigation review process to facilitate the selection of defined long-term mitigation strategies that will be adopted across the organization. In order for any long-term mitigation strategies to be effective, they must be integrated into the highest-level of corporate decision-making, therefore, senior executives will be brought in along with subject matter experts to help facilitate the selection criterion.

6.3 Develop a Resilience Action Plan

Once the appropriate mitigation strategies have been identified by the selection committee, a corporate resilience plan will be published, detailing how the mitigation strategies will be built into long-term planning effort across the company.

7 REFERENCES

Cayan, D. R., P. D. Bromirski, K. Hayhoe, M. Tyree, M. D. Dettinger, and R. E. Flick. 2008."Climate Change Projections of Sea Level Extremes Along the California Coast." *Climatic Change* 87 (Suppl. 1), S57–S73.

Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. *Climate Change Scenarios and Sea Level Rise Estimates for the California 2008 Climate Change Scenario Assessment.* CEC-500-2009-014D.

Fried, J., M. Torn, E. Mills. 2004. "The Impact of Climate Change on Wildfire Severity: A Regional Forecast for Northern California." *Climate Change* 64:169–191.

Hall, Alex, et al. 2013. *Climate Change in the Los Angeles Region Project*. http://research.atmos.ucla.edu/csrl/LA_project_summary.html

Heberger, M., H. Cooley, P. Herrera, P. H. Gleick, and E. Moore. 2009. *The Impacts of Sea-LevelRise on the California Coast.* CEC-500-2009-024-D.

LBNL: Sathaye, J. et al., "Estimating risk to California energy infrastructure from projected climate change" (California Energy Commission, Pub. Number: CEC-500-2012-057, 2012).

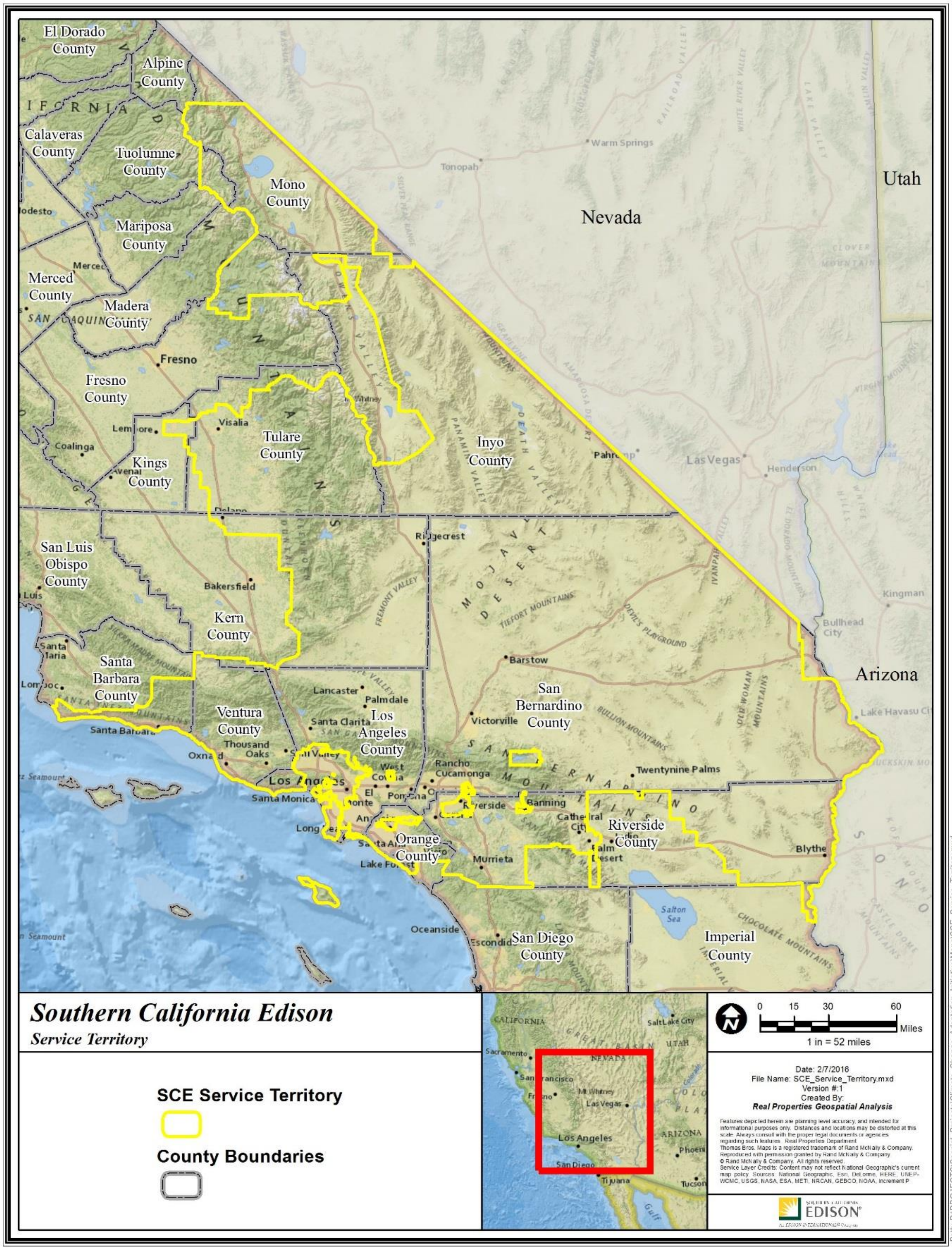
Third Assessment: 'Our Changing Climate" 2012 Vulnerability and Adaptation Study, State of California. 2012.

Torn, M. S., E. Mills, and J. Fried. 1998. *Will Climate Change Spark More Wildfire Damage?* LBNL Report No. 42592.

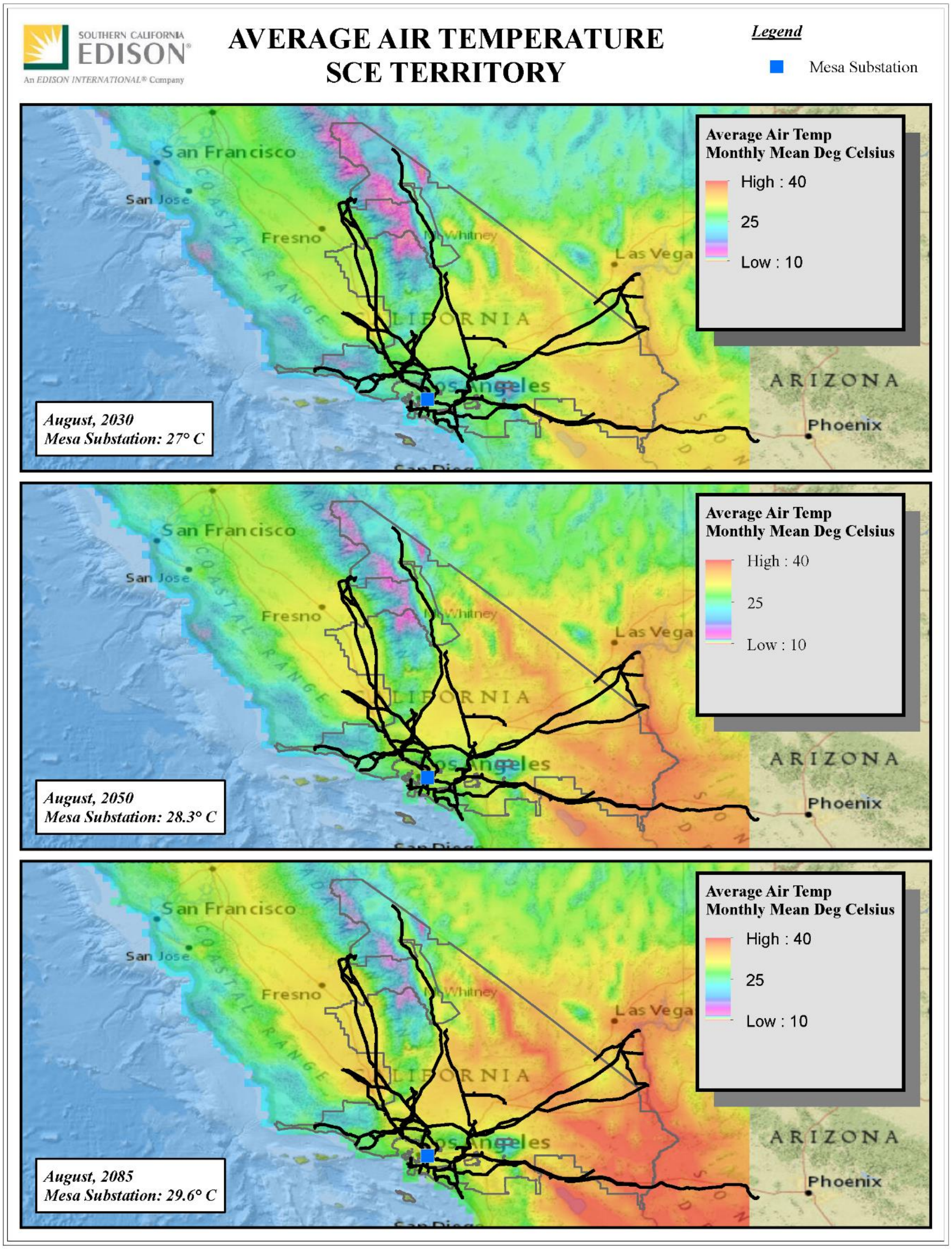
Westerling, A. L., and B. P. Bryant. 2008. "Climate Change and Wildfire in California." *Climatic Change* 87 (Suppl 1): s231–s249.

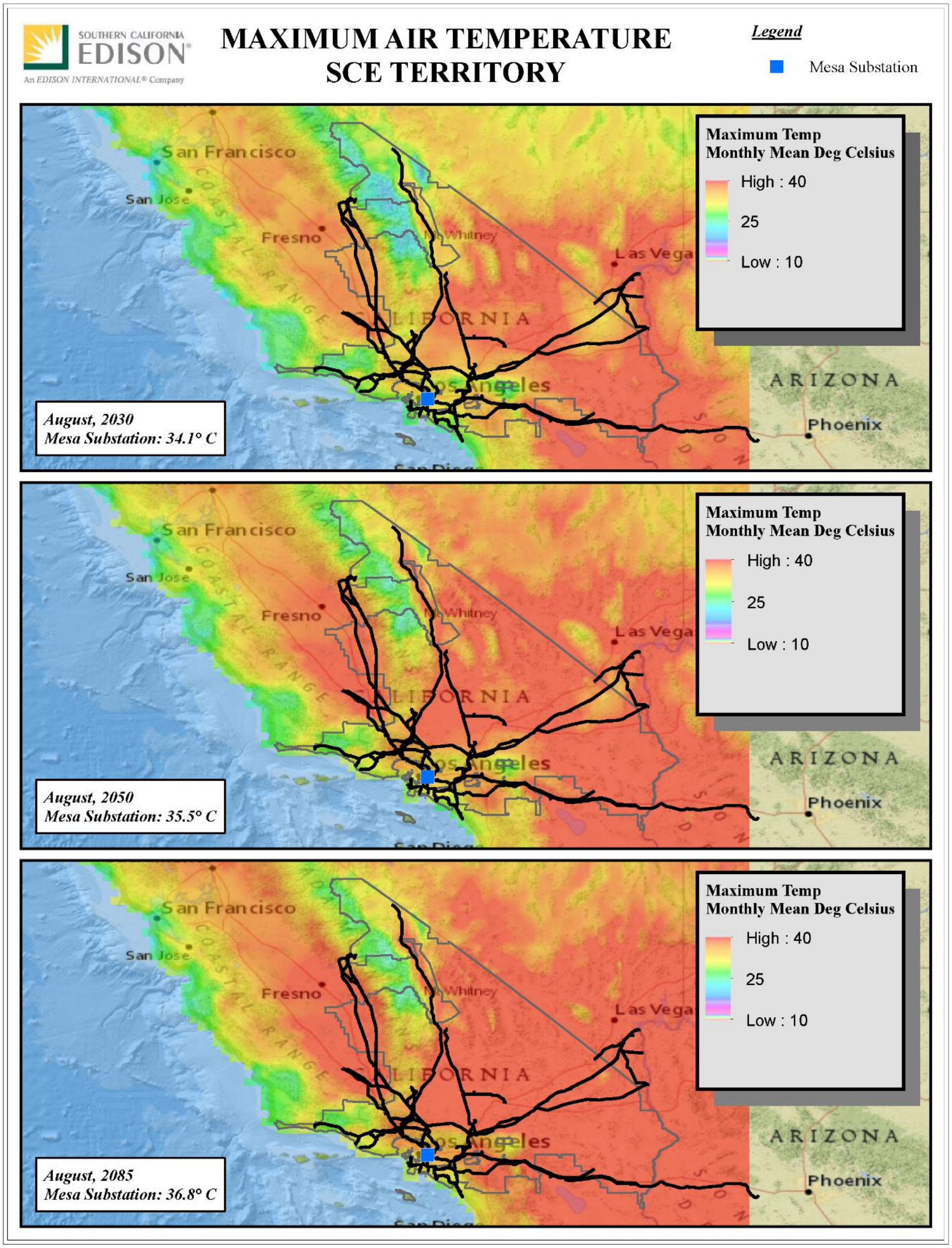
Westerling, A. L., B. P. Bryant, H. K. Preisler, H. G. Hidalgo, T. Das, and S. R. Shrestha. 2009. *Climate Change, Growth and California Wildfire.* CEC-500-2009-046D.

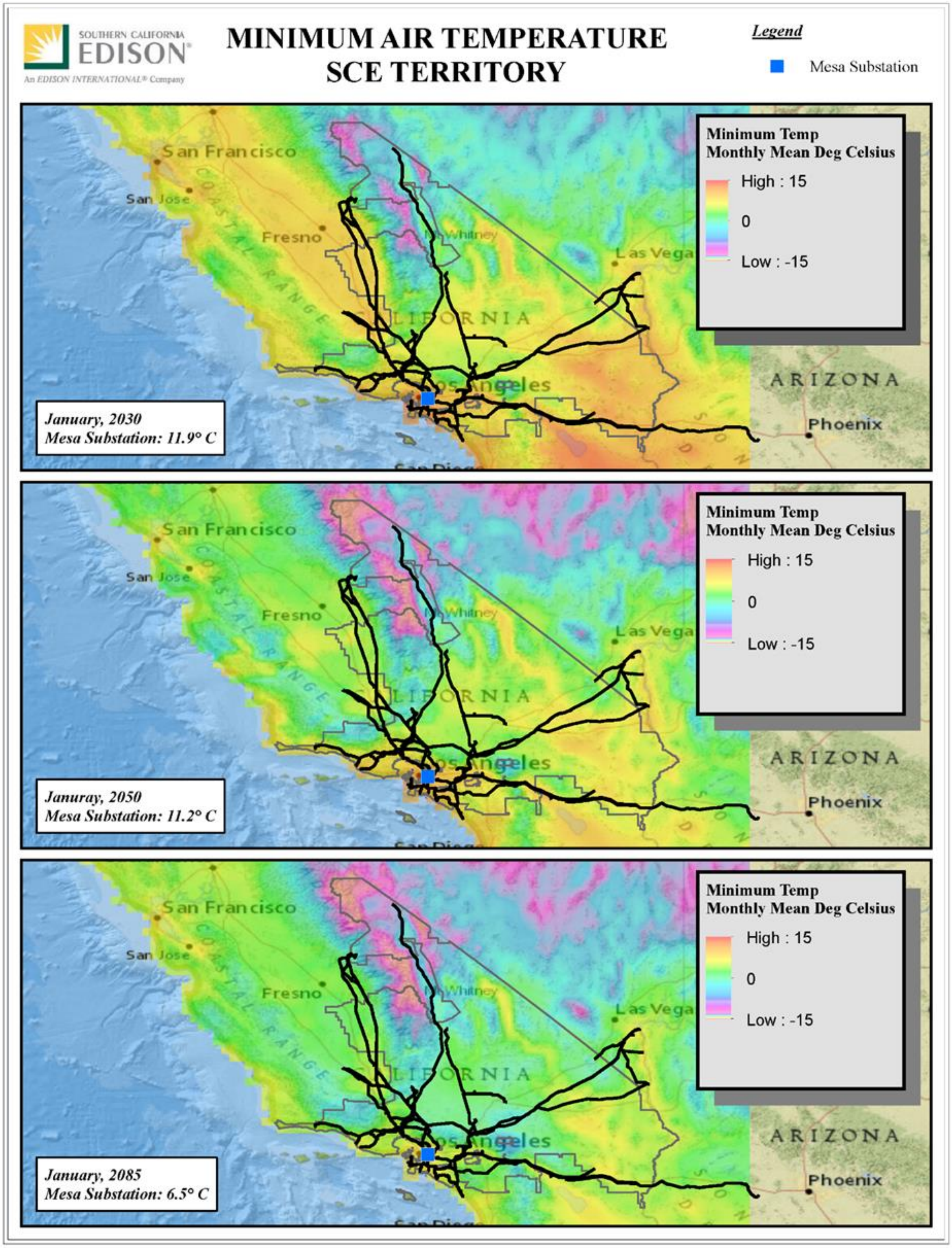
Appendix A: Map of SCE's Service Territory

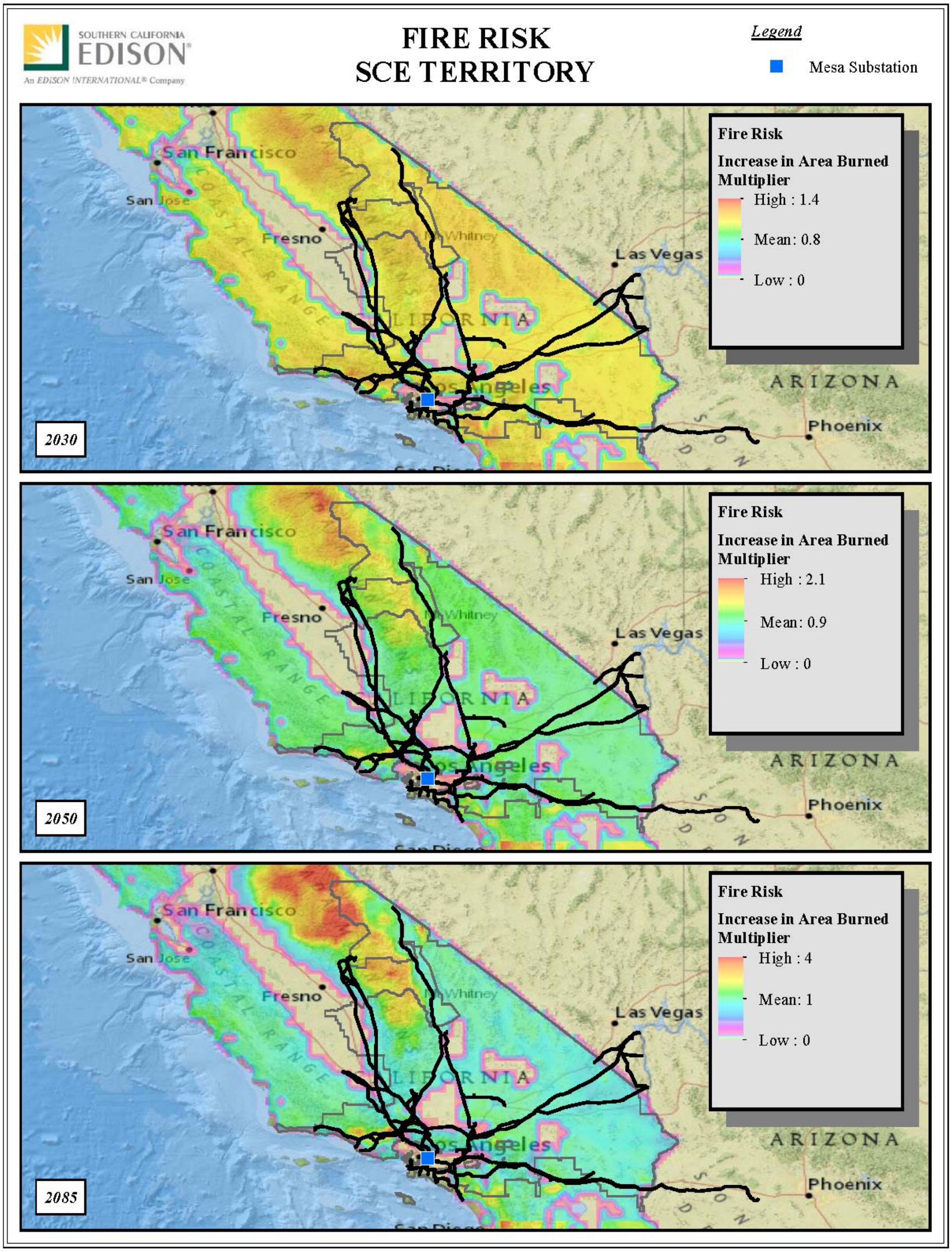


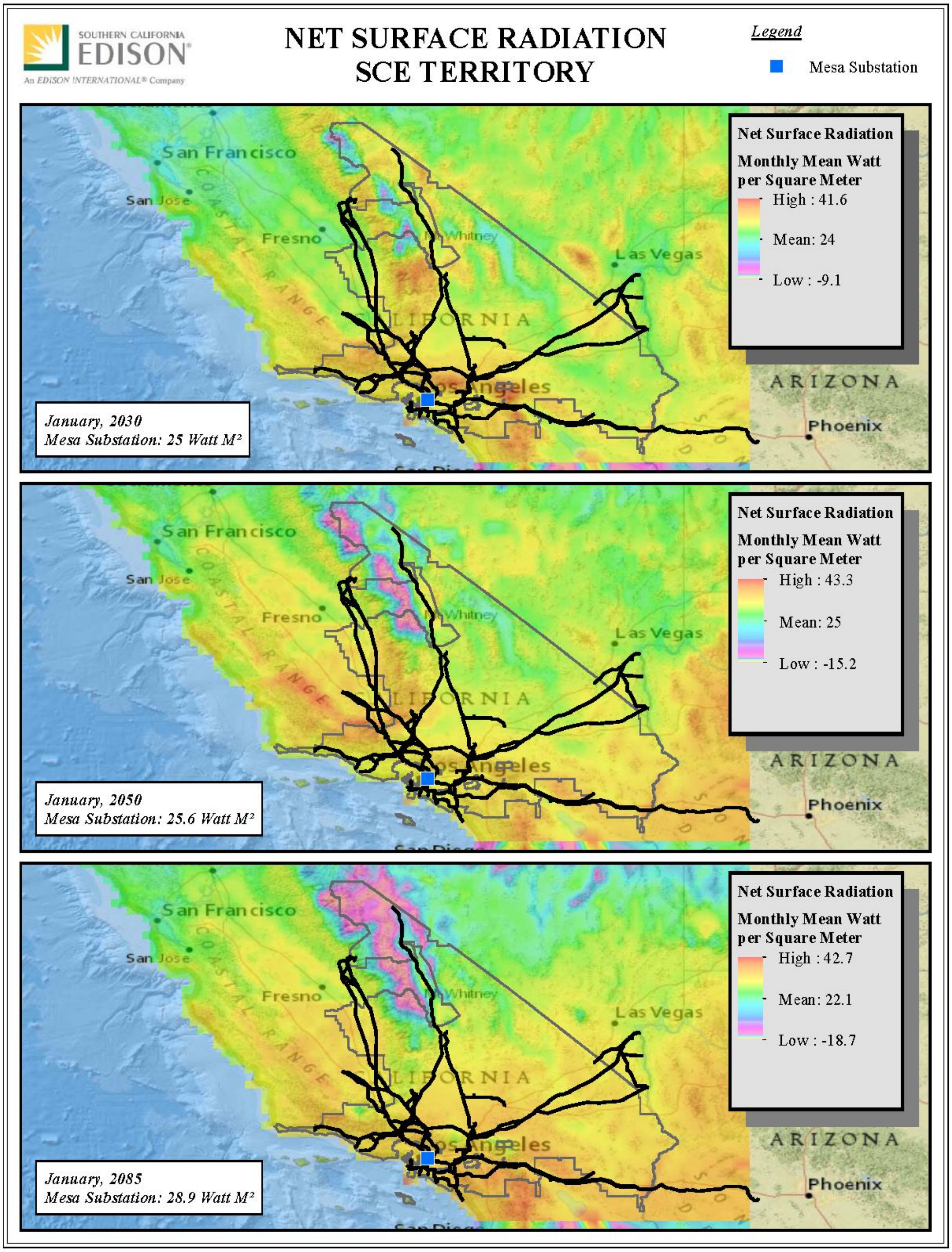
Appendix B: Side-by-side Climate Impact Maps (2030, 2050, 2085)

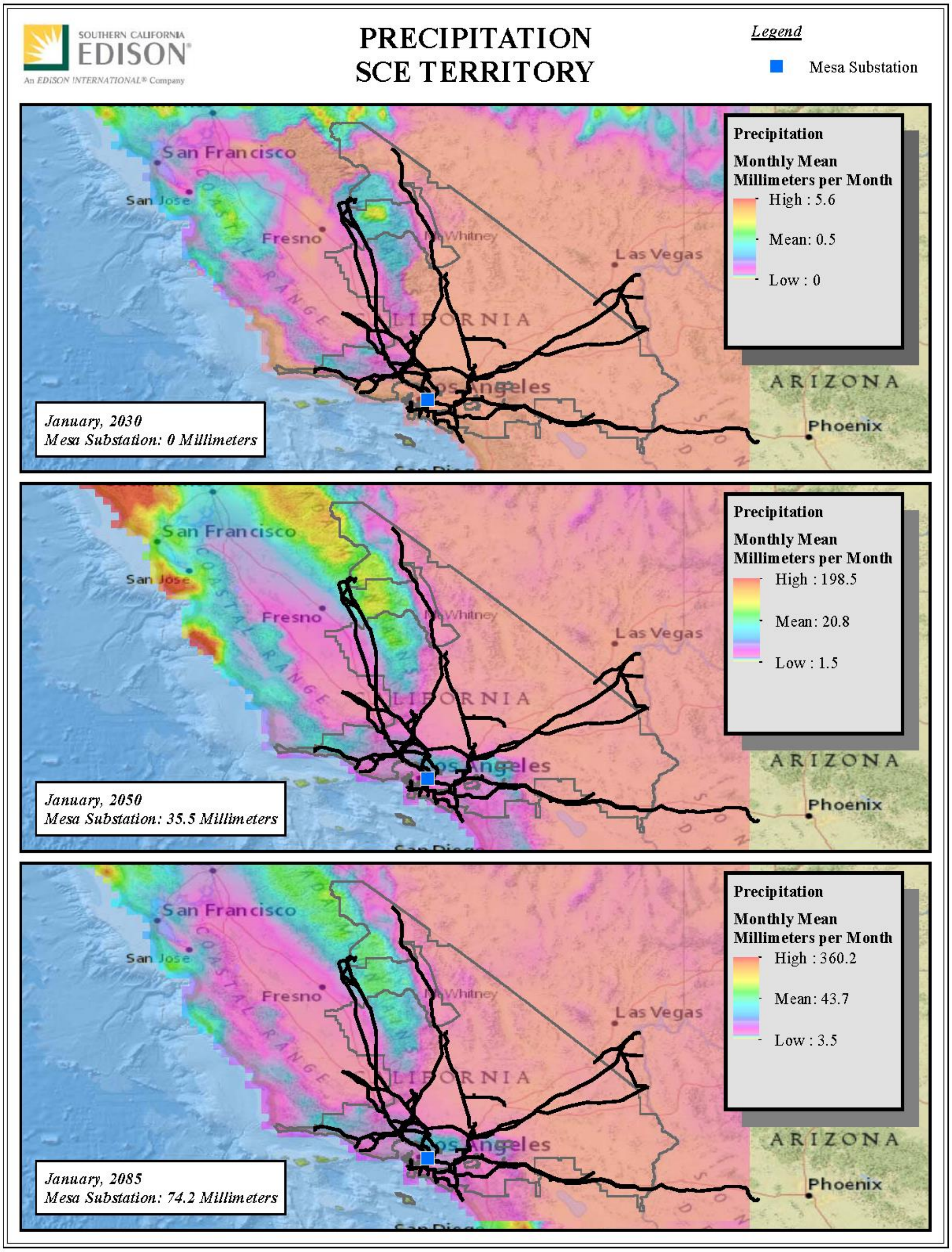


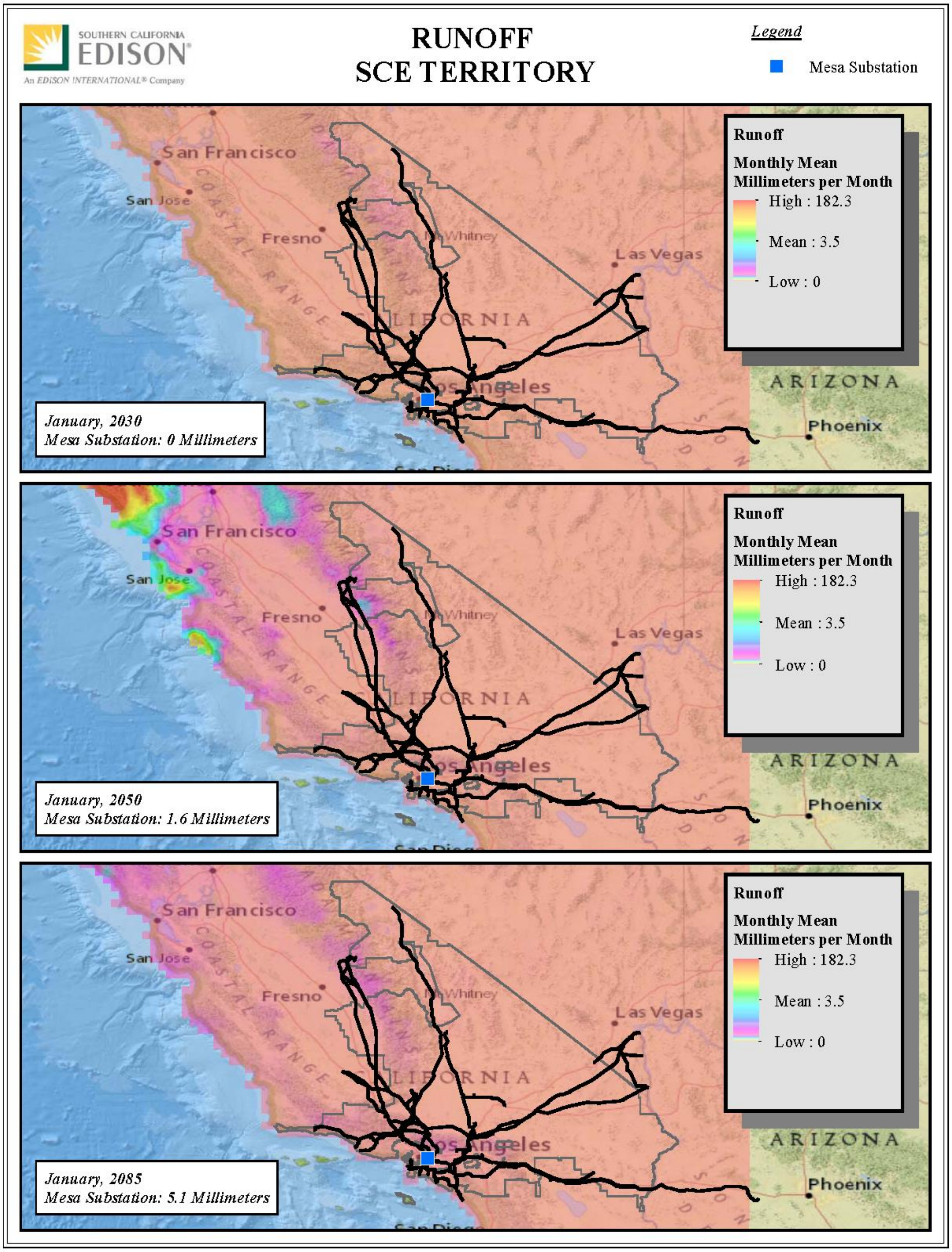

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company
MAXIMUM AIR TEMPERATURE
SCE TERRITORY
Legend
Mesa Substation
Maximum Temp
Monthly Mean Deg Celsius
High : 40
25
Low : 10
August, 2030
Mesa Substation: 34.1° C
August, 2050
Mesa Substation: 35.5° C
August, 2085
Mesa Substation: 36.8° C
San Francisco
San Jose
Fresno
Las Vega
ARIZONA
Phoenix

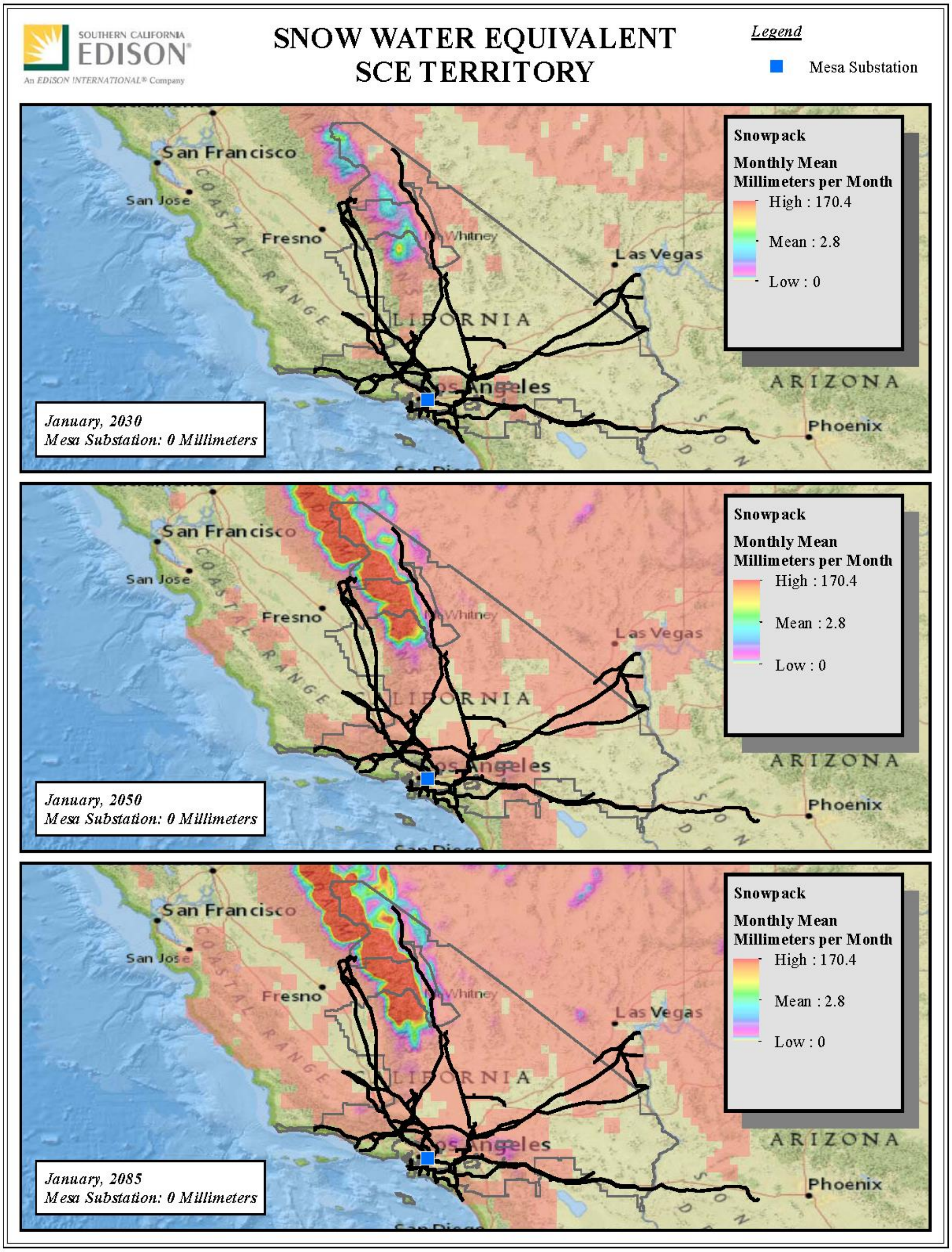

SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL® Company
MINIMUM AIR TEMPERATURE
SCE TERRITORY
Legend
Mesa Substation
Minimum Temp
Monthly Mean Deg Celsius
High : 15
0
Low : -15
January, 2030
Mesa Substation: 11.9° C
Minimum Temp
Monthly Mean Deg Celsius
High : 15
0
Low : -15
Januray, 2050
Mesa Substation: 11.2° C
Minimum Temp
Monthly Mean Deg Celsius
High : 15
0
Low : -15
January, 2085
Mesa Substation: 6.5° C
San Francisco
San Jose
Fresno
Las Vega
ARIZONA
Phoenix


FIRE RISK
SCE TERRITORY
Legend
Mesa Substation
Fire Risk
Increase in Area Burned Multiplier
High : 1.4
Mean: 0.8
Low : 0
2030
Fire Risk
Increase in Area Burned Multiplier
High : 2.1
Mean: 0.9
Low : 0
2050
Fire Risk
Increase in Area Burned Multiplier
High : 4
Mean: 1
Low : 0
2085
San Francisco
San Jose
Fresno
Las Vegas
Los Angeles
ARIZONA
Phoenix


SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company
NET SURFACE RADIATION
SCE TERRITORY
Legend
Mesa Substation
Net Surface Radiation
Monthly Mean Watt per Square Meter
High : 41.6
Mean: 24
Low : -9.1
January, 2030
Mesa Substation: 25 Watt M²
Net Surface Radiation
Monthly Mean Watt per Square Meter
High : 43.3
Mean: 25
Low : -15.2
January, 2050
Mesa Substation: 25.6 Watt M²
Net Surface Radiation
Monthly Mean Watt per Square Meter
High : 42.7
Mean: 22.1
Low : -18.7
January, 2085
Mesa Substation: 28.9 Watt M²
San Francisco
San Jose
Fresno
Las Vegas
Los Angeles
CALIFORNIA
ARIZONA
Phoenix


PRECIPITATION
SCE TERRITORY
Legend
Mesa Substation
Precipitation
Monthly Mean
Millimeters per Month
High : 5.6
Mean: 0.5
Low : 0
January, 2030
Mesa Substation: 0 Millimeters
Precipitation
Monthly Mean
Millimeters per Month
High : 198.5
Mean: 20.8
Low : 1.5
January, 2050
Mesa Substation: 35.5 Millimeters
Precipitation
Monthly Mean
Millimeters per Month
High : 360.2
Mean: 43.7
Low : 3.5
January, 2085
Mesa Substation: 74.2 Millimeters


SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company
RUNOFF
SCE TERRITORY
Legend
Mesa Substation
Runoff
Monthly Mean
Millimeters per Month
High : 182.3
Mean : 3.5
Low : 0
January, 2030
Mesa Substation: 0 Millimeters
January, 2050
Mesa Substation: 1.6 Millimeters
January, 2085
Mesa Substation: 5.1 Millimeters
San Francisco
San Jose
Fresno
Las Vegas
ARIZONA
Phoenix


SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company
SNOW WATER EQUIVALENT
SCE TERRITORY
Legend
Mesa Substation
Snowpack
Monthly Mean
Millimeters per Month
High : 170.4
Mean : 2.8
Low : 0
January, 2030
Mesa Substation: 0 Millimeters
January, 2050
Mesa Substation: 0 Millimeters
January, 2085
Mesa Substation: 0 Millimeters
San Francisco
San Jose
Fresno
Las Vegas
Los Angeles
Phoenix
CALIFORNIA
ARIZONA
COASTAL RANGE

Sample of Rain Events and Storm Declarations

Summary: This workpaper provides examples of rain events that have occurred in SCE service territory, resulting in storm declarations by SCE's Transmission & Distribution organization, due to significant strain on the electric system and number of customers affected.

#	Incident Name	Inches of Rainfall	Storm Opened	Storm Closed	Total Customers Affected	SCE Zone/Area	Comment
1	Storm 1801 - Rain Storm	2.02"	1/8/2018	1/24/2018	73,014	Eastern, Northern, Southern, Western	This was a mild rain storm event with over two inches of rainfall.
2	Storm 1804 - Rain Storm	1.01"	3/2/2018	3/2/2018	5,166	Northern	This was a mild rain storm event with over one inch of rainfall.
3	Storm 1805 - Rain Storm	1.34"	3/20/2018	3/23/2018	29,682	Northern, Western	This was a mild rain storm event with over one inch of rainfall.
4	Storm 1702 Wind/Rain Storm	5.33"	1/19/2017	1/25/2017	369,479	Eastern, Northern, Southern, Western	This was a moderate wind and rain storm event.
5	Storm 1705 Wind/Rain Storm	2.73"	2/17/2017	2/20/2017	301,076	Eastern, Northern, Southern, Western	This was a moderate wind and rain storm event.
6	Storm 1602 Wind/Rain Storm	0.05"	1/31/2016	2/3/2016	425,077	Eastern, Northern, Southern, Western	This was a moderate wind and rain storm event.
7	Storm 1604 Wind/Rain Storm	1.42"	3/6/2016	3/8/2016	164,518	Eastern, Northern, Southern, Western	This was a moderate wind and rain storm event.
8	Storm 1512 Heat/Rain Storm	0.03"	9/8/2015	9/11/2015	239,193	Eastern, Northern, Southern, Western	This was a moderate heat and rain storm event.
9	Storm 1517 Rain/Lightning Storm	0.01"	10/14/2015	10/19/2015	173,723	Eastern, Northern, Southern	This was a moderate lightning and rain storm event.

Chapter:	Climate Change
Workpaper	Baseline Risk Assessment

Legend			
Distribution	**Input 1**	**Input 2**	**Input 3**
Poisson	Mean		
Exponential	Mean		
Lognormal	Mean	StdDev	
Normal	Mean	StdDev	
Triangular	Low	Mean	High
Uniform	Min	Max	

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Drivers	D1	Extreme Rain Events	5.31	5.14	4.98	4.81	4.65	4.48	SCE meterologists collected and evaluated data from 75 weather stations across the Los Angeles/Orange County area. Using this data, we determined that the 99th percentile (extreme) rainfall event is a cumulative 1.5 inches of rain for 3 consecutive days or less. During such events, the electric system experiences significant strain in the form of outages and storm declarations. We used data from 2017 back to 1976 to develop a regression, and project values for the 2018 - 2023 period. The year 1976 is widely acknowledged as the beginning of a "climate shift," where global temperatures began to increase at least partially due to atmospheric greenhouse gas concentrations. SCE includes a supplemental workpaper with details of this analysis.
	D2	Extreme Heat Events	4.20	4.22	4.24	4.26	4.28	4.30	SCE calculated extreme heat events using a weighted average of three consecutive days of heat to calculate effective temperature; three consecutive days of heat is commonly represented as a heatwave. Using effective temperature, we analyzed historical trends across several decades. We used recorded daily maximum temperatures from five weather stations located across Southern California to calculate effective temperature across the service territory. SCE identified 101°F as the 99th percentile value for effective temperature, based on averages of effective temperature data from January 2011 – August 2018. We then used data from 2017 back to 1976 to develop a regression, and project values for the 2018 - 2023 period. SCE includes a supplemental workpaper with details of this analysis.
	D3	Extreme Wildfire Events	1.21	1.21	1.22	1.22	1.23	1.23	Given that there are tens of thousands of wildfires in California per year, SCE elected to consider only large California wildfires (those that exceed 300 acres, a threshold established by CAL FIRE). SCE identified 100,124 acres as the present day 99th percentile wildfire size, based on data from 2011 – 2017. We then used data from 1979 – 2017 to develop a regression, and project values for the 2018 - 2023 period. SCE includes a supplemental workpaper with details of this analysis.

	ID	Name	2018	2019	2020	2021	2022	2023	Source / Justification
Triggering Event Frequency	TEF	Failure to Adapt to Climate Change	10.72	10.57	10.44	10.29	10.16	10.01	The TEF is the sum of driver frequencies above/year.

	ID	Name	Probability	# of Events (2018)	Source / Justification
Outcomes	O1A	Increased Major Weather Events	60.0%	6.43	SCE internal data shows about 6 major weather events occur per year between 2014 and 2017
	O1B	Increased Catastrophic Weather Events	5.0%	0.54	SCE reviewed the threat of potential catastrophic weather events. Based on our experience, this equates to about 1 every 2 years (or 0.5 per year).
	O2A	Higher Energy Procurement Cost	32.5%	3.48	An analysis of energy procurement costs from 2015 - 2018 showed an average of about 3.5 heatwave events/year
	O2B	Exceptional Energy Procurement Cost	2.5%	0.27	An analysis of energy procurement costs from 2015 - 2018 showed an average of 1 case of exceptional energy procurement costs from heatwaves. (0.25 or 1 in 4 years).

	ID	Name	Distribution	Input 1	Input 2	Input 3	Source / Justification

WP Ch. 12 - Baseline Risk Assessment Workpaper.xlsx

Consequences	O1A	Serious Injury	Poisson	0.155	N/A	N/A	SCE reviewed worker injuries resulting from storms over 2015 – 2017. Many of these injuries could have easily turned into serious injuries. Based on this review, SCE applied an estimate of approximately one serious injury occurring each year during the most extreme storms.
		Fatality	Poisson	0.019	N/A	N/A	SCE does not have representative data for fatalities in recent years across the identified major weather events. However, based on recent wildfires, we believe this to be a consequence necessary to include in our model. FOr purposes of this analysis, SCE applied a ratio of injuries to fatalities (8.3:1) based on the number of injuries and fatalities accounted for in the National Fire Protection Association's report on Fire in the U.S., which uses data from 2010 - 2014.
		Reliability	Exponential	4,570,875	N/A	N/A	SCE reviewed data on customer minutes of interruption (CMI) from 2014 - 2017 for weather-related events/storms (e.g., heat days, rain storms, wildfires, etc.). The data for identified storms were utilized as baseline inputs to the model. It is important to note that based on recorded data, SCE experienced about 5-6 major storm events annually.
		Financial	Exponential	$15,834,205	N/A	N/A	SCE reviewed data on storm-related expenses (equipment repair and restoration, logistics for procuring new infrastructure, as well as other storm response and recovery activities) from 2014 - 2017. For example the total storm related expenses totaled $65M in 2016 and $97M in 2017. Based on recorded data, SCE experienced about 5-6 major storm events annually.
	O1B	Serious Injury	Exponential	1.291	N/A	N/A	SCE reviewed the 7 largest wildfires in the past 12 years and observed 1 fatality to a utility worker, or 0.0833 fatalities/event. SCE applied a ratio of (8.3:1) based on the number of injuries and fatalities accounted for in the National Fire Protection Association's report on Fires by Occupancy or Property Type, which uses data from 2010 - 2014, to derive a serious injury value.
		Fatality	Exponential	0.155	N/A	N/A	SCE reviewed the 7 largest wildfires in the past 12 years and observed 1 fatality to a utility worker. This translates to 0.0833 fatalities/event.
		Reliability	Exponential	133,000,000	N/A	N/A	As an example for this outcome, SCE evaluated the impacts from extreme rain events on areas prone to landslides that contain transmission towers. SCE estimated that such extreme rain events occur every 37.5 years, and could result in 453 million minutes of customer interruption on average.
		Financial	Exponential	$20,110,000	N/A	N/A	SCE estimated the cost to restore power and provide backup generation to mitigate the impacts of the outcome. SCE estimated $18-20M dollars for contingency back-up generation.
	O2A	Financial	Exponential	$8,862,849	N/A	N/A	SCE evaluated the differences in daily energy procurement costs during summer heat wave days vs non-heatwave summer days, over the 2015-2017 period. SCE includes a supplemental workpaper with details of this analysis.
	O2B	Financial	Exponential	$68,279,986	N/A	N/A	SCE evaluated the differences in daily energy procurement costs during summer heat wave days vs non-heatwave summer days in 2018, when those days experienced compounding market forces that drove energy prices exceptionally higher than normal. SCE includes a supplemental workpaper with details of this analysis.

Outcomes	Heatwaves per year	Marginal Cost of heatwaves
Outcome 2A (Higher Energy Procurement Cost)	2015 - Heatwave 1	$2,375,683
	2015 - Heatwave 2	$1,480,057
	2015 - Heatwave 3	$10,878,175
	2015 - Heatwave 4	$1,681,911
	2016 - Heatwave 1	$3,746,753
	2016 - Heatwave 2	$1,417,864
	2017 - Heatwave 1	$6,822,763
	2017 - Heatwave 2	$4,829,528
	2017 - Heatwave 3	$28,576,724
	2017 - Heatwave 4	$26,819,032
Outcome 2B (Exceptional Energy Procurement Cost)	2018 - Heatwave 1	$24,773,973
	2018 - Heatwave 2	$91,561,250
	2018 - Heatwave 3	$86,438,044

% Likelihood of Occurrence for Outcomes	Frequency	%	Comment
Outcome 1A (Increased Major Weather Events)	6	60.0%	Occurs about 6 times/year
Outcome 1B (Increased Catastrophic Weather Events)	0.5	5.0%	Occurs about 0.5 times/year
Outcome 2A (Higher Energy Procurement Cost)	3.25	32.5%	Occurs about 3.25 times/year
Outcome 2B (Exceptional Energy Procurement Cost)	0.25	2.5%	Occurs about 0.25 times/year (only occurred once based on available data)
Total	10	100.0%	

Extreme Heatwave Summer Days (101+ EffT)			
2018	2017	2016	2015
7/6/2018	7/8/2017	6/20/2016	8/15/2015
7/7/2018	7/9/2017	7/23/2016	8/16/2015
7/8/2018	7/10/2017		8/28/2015
7/9/2018	8/3/2017		8/29/2015
7/10/2018	8/29/17		9/8/2015
7/24/2018	8/30/17		9/9/2015
7/25/2018	8/31/17		9/10/2015
8/7/2018	9/1/2017		9/11/2015
8/8/2018	9/2/2017		10/11/2015
8/9/2018	9/3/2017		
8/10/2018			

Non-heatwave Summer Days (87.7-88.7 EffT)			
2018	2017	2016	2015
6/12/2018	6/15/2017	6/23/2016	6/19/2015
8/26/2018	6/28/2017	7/11/2016	7/3/2015
8/29/2018	7/3/2017	7/13/2016	7/14/2015
	7/4/2017	7/18/2016	7/17/2015
	8/14/2017	8/10/2016	7/21/2015
	8/22/2017	8/19/2016	7/27/2015
		8/21/2016	8/7/2015
		8/22/2016	8/20/2015
		8/23/2016	8/22/2015
		8/25/2016	10/2/2015
		10/8/2016	

Estimation of Marginal Cost of Heatwaves (2015)										
Step 1			Step 2		Step 3			Step 4	Step 5	
Non-heatwave days 2015			Average cost of Non-heatwave days in 2015 (by month)		Heatwave days 2015			Marginal daily heatwave cost (heatwave day cost - average cost of non-heatwave day. i.e. step 3 - step 2)	Marginal Cost of heatwaves	
Date	Load (MWh)	Net Costs	Month	Average Cost	Date	Load (MWh)	Net Costs		Heatwaves in 2015	Cost
6/19/2015	(253,568)	$2,709,525	July 2015	$ 3,751,056	8/15/2015	(301,336)	$4,244,379	$885,822		
7/3/2015	(239,523)	$2,521,191	August 2015	$ 3,358,558	8/16/2015	(296,608)	$4,848,419	$1,489,861	2015 - Heatwave 1	$ 2,375,683
7/14/2015	(255,836)	$3,681,764	October 2015	$ 3,008,746	8/28/2015	(326,598)	$4,090,566	$732,009		
7/17/2015	(265,498)	$3,798,979			8/29/2015	(288,005)	$4,106,606	$748,048	2015 - Heatwave 2	$ 1,480,057
7/21/2015	(262,609)	$4,182,149			9/8/2015	(291,374)	$5,921,099	$2,562,541		
7/27/2015	(268,705)	$3,341,331			9/9/2015	(322,714)	$6,229,099	$2,870,542		
8/7/2015	(269,688)	$3,706,711			9/10/2015	(340,907)	$6,115,771	$2,757,213		
8/20/2015	(274,870)	$3,368,013			9/11/2015	(333,819)	$6,046,437	$2,687,879	2015 - Heatwave 3	$ 10,878,175
8/22/2015	(251,312)	$3,000,949			10/11/2015	(239,388)	$4,690,658	$1,681,911	2015 - Heatwave 4	$ 1,681,911
10/2/2015	(254,560)	$3,008,746							**Total 2015**	**$ 16,415,827**

WP Ch. 12 - Heatwave vs. Average Summer Temperatures Workpaper.xlsx

Estimation of Marginal Cost of Heatwaves (2016)										
Step 1			Step 2		Step 3			Step 4	Step 5	
Non-heatwave days 2016			Average cost of Non-heatwave days 2016 (by month)		Heatwave days 2016			Marginal daily heatwave cost (heatwave day cost - average cost of non-heatwave day. i.e. step 3 - step 2)	Marginal Cost of heatwaves	
Date	Load (MWh)	Net Costs	Month	Average Cost	Date	Load (MWh)	Net Costs		Heatwaves in 2016	Cost
6/23/2016	(254,891)	$3,131,355	June 2016	$ 3,131,355	6/20/2016	(312,131)	$6,878,109	$3,746,753	2016 - Heatwave 1	$ 3,746,753
7/11/2016	(242,007)	$2,482,649	July 2016	$ 2,940,317	7/23/2016	(302,231)	$4,358,181	$1,417,864	2016 - Heatwave 2	$ 1,417,864
7/13/2016	(256,255)	$3,165,628	August 2016	$ 3,075,715					**Total 2015**	**$ 5,164,617**
7/18/2016	(248,920)	$3,172,673	October 2016	$ 3,423,440						
8/10/2016	(251,349)	$3,014,044								
8/19/2016	(261,181)	$3,769,307								
8/21/2016	(227,895)	$2,962,756								
8/22/2016	(256,188)	$3,137,636								
8/23/2016	(255,296)	$2,834,140								
8/25/2016	(253,795)	$2,736,408								
10/8/2016	(208,618)	$3,423,440								

Estimation of Marginal Cost of Heatwaves (2017)											
Step 1			Step 2		Step 3			Step 4	Step 5	
Non-heatwave days 2017			Average cost of Non-heatwave days in 2017 (by month)		Heatwave days 2017			Marginal daily heatwave cost (heatwave day cost - average cost of non-heatwave day. i.e. step 3 - step 2)	Marginal Cost of heatwaves	
Date	Load (MWh)	Net Costs	Month	Average Cost	Date	Load (MWh)	Net Costs		Heatwaves in 2017	Cost
6/15/2017	(234,127)	$2,070,170	June 2017	$ 2,131,717	7/8/2017	(291,325)	$ 4,420,125	$2,225,555		
6/28/2017	(245,338)	$2,193,265	July 2017	$ 2,194,570	7/9/2017	(276,467)	$ 4,697,351	$2,502,781		
7/3/2017	(221,413)	$2,092,257	August 2017	$ 2,561,041	7/10/2017	(292,375)	$ 5,034,744	$2,840,174	2017 - Heatwave 1	$ 7,568,510
7/4/2017	(215,184)	$2,296,883			8/3/2017	(328,126)	$ 7,390,568	$4,829,528	2017 - Heatwave 2	$ 4,829,528
8/14/2017	(259,549)	$2,132,258			8/29/2017	(343,365)	$13,874,038	$11,312,997		
8/22/2017	(256,197)	$2,989,824			8/30/2017	(344,430)	$ 9,000,909	$6,439,868		
					8/31/2017	(344,307)	$13,384,899	$10,823,858	2017 - Heatwave 3	$ 28,576,724
					9/1/2017	(357,855)	$20,205,194	$17,644,153		
					9/2/2017	(322,667)	$ 8,701,975	$6,140,935		
					9/3/2017	(291,873)	$ 5,594,985	$3,033,945	2017 - Heatwave 4	$ 26,819,032
									Total 2017	**$ 67,793,794**

WP Ch. 12 - Heatwave vs. Average Summer Temperatures Workpaper.xlsx

5 of 7

Estimation of Marginal Cost of Heatwaves (2018)										
Step 1			Step 2		Step 3			Step 4	Step 5	
Non-heatwave days 2018			Average cost of Non-heatwave days in 2018 (by month)		Heatwave days 2018			Marginal daily heatwave cost (heatwave day cost - average cost of non-heatwave day. i.e. step 3 - step 2)	Marginal Cost of heatwaves	
Date	Load (MWh)	Net Costs	Month	Average Cost	Date	Load (MWh)	Net Costs		Heatwaves in 2018	Cost
6/12/2018	(247,888)	$4,236,546	June 2018	$ 4,236,546	7/6/2018	(313,465)	$13,088,026	$8,851,479		
8/26/2018	(222,900)	$2,962,788	August 2018	$ 3,461,537	7/7/2018	(307,489)	$ 9,102,816	$4,866,269		
8/29/2018	(251,399)	$3,960,286			7/8/2018	(300,307)	$ 8,106,860	$3,870,314		
					7/9/2018	(302,173)	$ 6,766,342	$2,529,796		
					7/10/2018	(301,524)	$ 8,375,988	$4,139,441	2018 - Heatwave 1	$ 24,257,300
					7/24/2018	(347,427)	$54,333,309	$50,096,763		
					7/25/2018	(357,985)	$45,701,033	$41,464,487	2018 - Heatwave 2	$ 91,561,250
					8/7/2018	(331,618)	$38,299,770	$34,838,233		
					8/8/2018	(321,310)	$23,925,378	$20,463,841		
					8/9/2018	(322,431)	$21,182,395	$17,720,858		
					8/10/2018	(305,048)	$16,876,649	$13,415,112	2018 - Heatwave 3	$ 86,438,044
									Total 2017	**$ 202,256,594**

Estimation of Marginal Cost of Heatwaves: 2015 - 2018 (Combined Results)

Non-heatwave			Heatwave			
Date	Load (MWh)	Net Costs	Date	Load (MWh)	Net Costs	Marginal daily heatwave cost (heatwave day cost - nonheatwave daily average cost)
6/19/2015	253,568	$ 2,709,525	8/15/2015	301,336	$ 4,244,379	$885,822
7/3/2015	239,523	$ 2,521,191	8/16/2015	296,608	$ 4,848,419	$1,489,861
7/14/2015	255,836	$ 3,681,764	8/28/2015	326,598	$ 4,090,566	$732,009
7/17/2015	265,498	$ 3,798,979	8/29/2015	288,005	$ 4,106,606	$748,048
7/21/2015	262,609	$ 4,182,149	9/8/2015	291,374	$ 5,921,099	$2,562,541
7/27/2015	268,705	$ 3,341,331	9/9/2015	322,714	$ 6,229,099	$2,870,542
8/7/2015	269,688	$ 3,706,711	9/10/2015	340,907	$ 6,115,771	$2,757,213
8/20/2015	274,870	$ 3,368,013	9/11/2015	333,819	$ 6,046,437	$2,687,879
8/22/2015	251,312	$ 3,000,949	10/11/2015	239,388	$ 4,690,658	$1,681,911
10/2/2015	254,560	$ 3,008,746	6/20/2016	312,131	$ 6,878,109	$3,746,753
6/23/2016	254,891	$ 3,131,355	7/23/2016	302,231	$ 4,358,181	$1,417,864
7/11/2016	242,007	$ 2,482,649	7/8/2017	291,325	$ 4,420,125	$2,225,555
7/13/2016	256,255	$ 3,165,628	7/9/2017	276,467	$ 4,697,351	$2,502,781
7/18/2016	248,920	$ 3,172,673	7/10/2017	292,375	$ 5,034,744	$2,840,174
8/10/2016	251,349	$ 3,014,044	8/3/2017	328,126	$ 7,390,568	$4,829,528
8/19/2016	261,181	$ 3,769,307	8/29/2017	343,365	$ 13,874,038	$11,312,997
8/21/2016	227,895	$ 2,962,756	8/30/2017	344,430	$ 9,000,909	$6,439,868
8/22/2016	256,188	$ 3,137,636	8/31/2017	344,307	$ 13,384,899	$10,823,858
8/23/2016	255,296	$ 2,834,140	9/1/2017	357,855	$ 20,205,194	$17,644,153
8/25/2016	253,795	$ 2,736,408	9/2/2017	322,667	$ 8,701,975	$6,140,935
10/8/2016	208,618	$ 3,423,440	9/3/2017	291,873	$ 5,594,985	$3,033,945
6/15/2017	234,127	$ 2,070,170	7/6/2018	313,465	$ 13,088,026	$8,851,479
6/28/2017	245,338	$ 2,193,265	7/7/2018	307,489	$ 9,102,816	$4,866,269
7/3/2017	221,413	$ 2,092,257	7/8/2018	300,307	$ 8,106,860	$3,870,314
7/4/2017	215,184	$ 2,296,883	7/9/2018	302,173	$ 6,766,342	$2,529,796
8/14/2017	259,549	$ 2,132,258	7/10/2018	301,524	$ 8,375,988	$4,139,441
8/22/2017	256,197	$ 2,989,824	7/24/2018	347,427	$ 54,333,309	$50,096,763
6/12/2018	247,888	$ 4,236,546	7/25/2018	357,985	$ 45,701,033	$41,464,487
8/26/2018	222,900	$ 2,962,788	8/7/2018	331,618	$ 38,299,770	$34,838,233
8/29/2018	251,399	$ 3,960,286	8/8/2018	321,310	$ 23,925,378	$20,463,841
			8/9/2018	322,431	$ 21,182,395	$17,720,858
			8/10/2018	305,048	$ 16,876,649	$13,415,112
Total Non-heatwave Load (2015 - 2018)	7,466,560		Total heatwave Load (2015 - 2018)	10,058,678		
Total Non-heatwave cost (2015 - 2018)	$ 92,083,672		Total heatwave cost (2015 - 2018)	$ 395,592,679		

Ratio of non-heatwave load to heatwave load	1.3	which is 1 : 1.3
Ratio of non-heatwave cost to heatwave cost	4.3	which is 1 : 4.3

Heatwaves per year	Marginal Cost of heatwaves
2015 - Heatwave 1	$2,375,683
2015 - Heatwave 2	$1,480,057
2015 - Heatwave 3	$10,878,175
2015 - Heatwave 4	$1,681,911
2016 - Heatwave 1	$3,746,753
2016 - Heatwave 2	$1,417,864
2017 - Heatwave 1	$7,568,510
2017 - Heatwave 2	$4,829,528
2017 - Heatwave 3	$28,576,724
2017 - Heatwave 4	$26,819,032
2018 - Heatwave 1	$24,257,300
2018 - Heatwave 2	$91,561,250
2018 - Heatwave 3	$86,438,044

Year	Marginal cost of heatwaves per year (heatwave period - nonheatwave average cost)
Total 2015	$ 16,415,827
Total 2016	$ 5,164,617
Total 2017	$ 67,793,794
Total 2018	$ 202,256,594

Key	Description
(yellow)	Data from 1/1/15 - 12/31/17
(orange)	Data from 1/1/18 - 9/13/18

Year	Average Non-heatwave cost
2015	$3,331,936
2016	$3,075,458
2017	$2,295,776
2018	$3,719,873

WP Ch. 12 - Heatwave vs. Average Summer Temperatures Workpaper.xlsx

7 of 7

Chapter	Climate Change

Drivers

ID	Name
D1	Extreme Rain Events
D2	Extreme Heat Events
D3	Extreme Wildfire Events

Outcomes

ID	Name
O1A	Increased Major Weather Events
O1B	Increased Catastrophic Weather Events
O2A	Higher Energy Procurement Cost
O2B	Exceptional Energy Procurement Cost

Controls & Mitigations

ID	Name
C1	Emergency Management
C2	Fire Management
M1	Climate Adaptation & Severe Weather Program
M2a	Situational Awareness, Monitoring & Analytics (Optimal)
M2b	Situational Awareness, Monitoring & Analytics (Max)
M3	Distribution System Stress Reduction Program

"inactive" = not active in given year
"no impact" = active in given year but has no impact

Name	C1 Emergency Management

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Extreme Wildfire Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A	Serious Injury	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE business resiliency experts estimate that this control provides a 10% reduction to the safety consequences associated with O1A. This is based on the performance of safety hazard risk assessments, communication of safety and hazard information with workers, first responders, and our communities, etc. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes. Please see workpaper - Subject Matter Expert Qualifications.
Increased Major Weather Events	Fatality	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE business resiliency experts estimate that this control provides a 10% reduction to the safety consequences associated with O1A. This is based on the performance of safety hazard risk assessments, communication of safety and hazard information with workers, first responders, and our communities, etc. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes. Please see workpaper - Subject Matter Expert Qualifications.
	Reliability	17.0%	18.0%	19.0%	20.0%	21.0%	22.0%	SCE compared the Customer Minute of Interruption (CMI) prior to implementation of the Incident Command System (ICS) as part of the Emergency Management control. From 2011 - 2013 (pre-ICS implementation), CMI was 730 million per year on average. After SCE implemented this control in 2013, the average CMI (over 2014-2016) dropped to 606 million. The CMI change after implementation of ICS represents a 17% reduction. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes.
	Financial	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE business resiliency experts estimate that this control provides a 10% reduction to the financial consequences associated with O1A. This is based on the ability for this control to provide efficient operational and financial management of resources to restore power efficiently, order materials, and coordinate logistics related to restoration and remediation efforts. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes.Please see workpaper - Subject Matter Expert Qualifications.
O1B	Serious Injury	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE business resiliency experts estimate that this control provides a 10% reduction to the safety consequences associated with O1B. This is based on the performance of safety hazard risk assessments, communication of safety and hazard information with workers, first responders, and our communities, etc. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes. Please see the workpaper on Subject Matter Expert Qualifications.
Increased Catastrophic Weather Events	Fatality	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE business resiliency experts estimate that this control provides a 10% reduction to the safety consequences associated with O1B. This is based on the performance of safety hazard risk assessments, communication of safety and hazard information with workers, first responders, and our communities, etc. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes. Please see workpaper - Subject Matter Expert Qualifications.
	Reliability	12.0%	13.0%	14.0%	15.0%	16.0%	17.0%	SCE business resiliency experts estimate that this control provides about 12% reduction in reliability consequences. This is based on application of relevant mitigation strategies such as: preparing for and securing backup local generation for vulnerable parts of SCE territory that might experience reliability impacts, prestaging resources, laydown yard and materials to restore power following a catastrophic event. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes. Please see the workpaper on Subject Matter Expert Qualifications.

	Financial	15.0%	16.0%	17.0%	18.0%	19.0%	20.0%	SCE business resiliency experts estimate that this control provides a 15% reduction to the financial consequences associated with O1B. This is based on the ability for this control to provide efficient operational and financial management of resources to restore power efficiently, order materials, and coordinate logistics related to restoration and remediation efforts. SCE assumes a 1% annual increase in the effectiveness of this control each year as we continuously improve and refine our processes.Please see workpaper - Subject Matter Expert Qualifications.
O2A Higher Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2B Exceptional Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

	Fire Management

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.
D3	Extreme Wildfire Events	no impact	no impact	no impact	no impact	no impact	no impact	Control does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A Increased Major Weather Events	Serious Injury	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE fire management personnel respond to several fires per year. These fire management personnel estimate that about 10% of fires can be prevented from impacting SCE assets and thereby reducing safety consequences. This is done through effectively partnering with fire agencies, and by providing notification/hazard advisory to SCE crews to alert those driving in the direction of wildfires. Assumes 1% annual increase in effectiveness based on continuous improvement and lessons learned. Please see workpaper - Subject Matter Expert Qualifications.
	Fatality	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE fire management personnel respond to several fires per year. These fire management personnel estimate that about 10% of fires can be prevented from impacting SCE assets and thereby reducing safety consequences. This is done through effectively partnering with fire agencies, and by providing notification/hazard advisory to SCE crews to alert those driving in the direction of wildfires. Assumes 1% annual increase in effectiveness based on continuous improvement and lessons learned. Please see workpaper - Subject Matter Expert Qualifications.
	Reliability	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE fire management officers coordinate with fire agencies to mitigate impacts by dropping flame retardant to prevent asset damage, cutting linebreaks to limit fire growth, etc. The fire management officers estimate that approximately 10% of reliability impacts will be reduced by these activities . Assumes 1% annual increase in effectiveness. Please see workpaper - Subject Matter Expert Qualifications.
	Financial	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	SCE fire management officers coordinate with fire agencies to mitigate impacts by dropping flame retardant to prevent asset damage, cutting linebreaks to limit fire growth, etc. The fire management officers estimate that approximately 10% of financial impact will be reduced by these activities. Assumes 1% annual increase in effectiveness. Please see workpaper - Subject Matter Expert Qualifications.
O1B Increased Catastrophic Weather Events	Serious Injury	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Fatality	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Reliability	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
	Financial	inactive	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2A Higher Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2B Exceptional Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Name	M1 Climate Adaptation & Severe Weather Program

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Extreme Wildfire Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A	Serious Injury	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	At the time of this analysis, this mitigation is in the early stages of implementation. We estimate that it would provide at least 5% risk reduction. The climate adaptation and severe weather program recently commenced and does not currently have quantitative analysis of effectiveness, however, vulnerabillity assessments and risk mitigation strategies are underway. Additionally, after further analysis and determination of flexible adaptation pathways, this program will propose targeted mitigations to reduce identified impacts.
Increased Major Weather Events	Fatality	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
	Reliability	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
	Financial	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
O1B	Serious Injury	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	At the time of this analysis, this mitigation is in the early stages of implementation. We estimate that it would provide at least 5% risk reduction. The climate adaptation and severe weather program recently commenced and does not currently have quantitative analysis of effectiveness, however, vulnerabillity assessments and risk mitigation strategies are underway. Additionally, after further analysis and determination of flexible adaptation pathways, this program will propose targeted mitigations to reduce identified impacts.
Increased Catastrophic Weather Events	Fatality	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
	Reliability	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
	Financial	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	Same as above
O2A Higher Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2B Exceptional Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

WP Ch. 12 - RAMP Mitigation Reduction Workpaper.xlsx 5 of 10

Name	M2a Situational Awareness, Monitoring & Analytics (Optimal)

Portfolio Inclusion	
Proposed	x
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Extreme Wildfire Events	15.0%	15.0%	17.0%	17.5%	18.0%	18.5%	SCE assumes a 15% reduction in number of small fires that could grow into larger fires due to faster response and deployment of air and ground resources to contain the fire. The effectiveness percentage increases as more HD Cameras and Situational Awareness equipment/tools are deployed. Please see workpaper - Subject Matter Expert Qualifications.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A Increased Major Weather Events	Serious Injury	15.0%	15.5%	16.0%	16.5%	17.0%	17.5%	SCE assumes a 15% risk reduction due to avoidance of accident/injury by utilizing advanced weather models to inform proactive hazardous weather alerts for field crews. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned. Please see workpaper - Subject Matter Expert Qualifications.
	Fatality	15.0%	15.5%	16.0%	16.5%	17.0%	17.5%	SCE assumes a 15% risk reduction due to avoidance of accident/injury by utilizing advanced weather models to inform proactive hazardous weather alerts for field crews. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned. Please see workpaper - Subject Matter Expert Qualifications.
	Reliability	10.0%	10.5%	11.0%	11.5%	12.0%	12.5%	SCE assumes a 10% reduction in reliability consequences associated with fire impacting SCE assets as a result of early fire detection and containment. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Financial	12.5%	13.5%	14.5%	15.5%	16.5%	17.5%	SCE estimates a 12.5% reduction in financial consequences if one major fire is prevented from impacting SCE assets as a result of early fire detection by SCE HD Cameras and rapid containment by fire agencies. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned. See workpaper - Effectiveness of M2a/M2b on Major Weather Events (Financial Consequences).
O1B Increased Catastrophic Weather Events	Serious Injury	7.5%	8.0%	8.5%	9.0%	9.5%	10.0%	SCE assumes a 7.5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Fatality	7.5%	8.0%	8.5%	9.0%	9.5%	10.0%	SCE assumes a 7.5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Reliability	5.0%	5.5%	6.0%	6.5%	7.0%	7.5%	SCE assumes a 5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Financial	6.3%	6.8%	7.3%	7.8%	8.3%	8.8%	SCE assumes a 6.25% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
O2A Higher Energy Procurement Cost	Financial	1.0%	3.0%	5.0%	5.5%	6.0%	6.5%	SCE assumes a range of 1% - 6.5% risk reduction due to better forecasting and modeling capabilities that will provide additional benefits to energy demand forecasting and procurement during heat event days (effectiveness percentage increases with weather modeling capability deployment schedule). Please see workpaper - Subject Matter Expert Qualifications.
O2B Exceptional Energy Procurement Cost	Financial	1.0%	3.0%	5.0%	5.5%	6.0%	6.5%	SCE assumes a range of 1% - 6.5% risk reduction due to better forecasting and modeling capabilities that will provide additional benefits to energy demand forecasting and procurement during heat event days (effectiveness percentage increases with weather modeling capability deployment schedule). Please see workpaper - Subject Matter Expert Qualifications.

Name	M2b Situational Awareness, Monitoring & Analytics (Max)

Portfolio Inclusion	
Proposed	
Alt 1	
Alt 2	x

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Extreme Wildfire Events	16.0%	18.0%	20.0%	20.5%	21.0%	21.5%	SCE assumes a 16% reduction in number of small fires that could grow into larger fires due to faster response and deployment of air and ground resources to contain the fire. The effectiveness percentage increases as more HD Cameras and Situational Awareness equipment/tools are deployed. Please see workpaper - Subject Matter Expert Qualifications.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A Increased Major Weather Events	Serious Injuries	15.0%	15.5%	16.0%	16.5%	17.0%	17.5%	SCE assumes a 15% risk reduction due to avoidance of accident/injury by utilizing advanced weather models to inform proactive hazardous weather alerts for field crews. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Fatalities	15.0%	15.5%	16.0%	16.5%	17.0%	17.5%	SCE assumes a 15% risk reduction due to avoidance of accident/injury by utilizing advanced weather models to inform proactive hazardous weather alerts for field crews. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Reliability	10.0%	10.5%	11.0%	11.5%	12.0%	12.5%	SCE assumes a 10% reduction in reliability consequences associated with fire impacting SCE assets as a result of early fire detection and containment. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Financial	12.5%	13.5%	14.5%	15.5%	16.5%	17.5%	SCE estimates a 12.5% reduction in financial consequences if one major fire is prevented from impacting SCE assets as a result of early fire detection by SCE HD Cameras and rapid containment by fire agencies. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned. See workpaper - Effectiveness of M2a/M2b on Major Weather Events (Financial Consequences).
O1B Increased Catastrophic Weather Events	Serious Injuries	7.5%	8.0%	8.5%	9.0%	9.5%	10.0%	SCE assumes a 7.5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Fatalities	7.5%	8.0%	8.5%	9.0%	9.5%	10.0%	SCE assumes a 7.5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Reliability	5.0%	5.5%	6.0%	6.5%	7.0%	7.5%	SCE assumes a 5% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
	Financial	6.3%	6.8%	7.3%	7.8%	8.3%	8.8%	SCE assumes a 6.25% risk reduction based on this mitigation being half as effective on catastrophic events in O1B compared to major events in O1A. Assumes 0.5% annual increase in effectiveness based on continuous improvement and lessons learned.
O2A Higher Energy Procurement Cost	Financial	1.0%	3.0%	5.0%	5.5%	6.0%	6.5%	SCE assumes a range of 1% - 6.5% risk reduction due to better forecasting and modeling capabilities that will provide additional benefits to energy demand forecasting and procurement during heat event days (effectiveness percentage increases with weather modeling capability deployment schedule)
O2B Exceptional Energy Procurement Cost	Financial	1.0%	3.0%	5.0%	5.5%	6.0%	6.5%	SCE assumes a range of 1% - 6.5% risk reduction due to better forecasting and modeling capabilities that will provide additional benefits to energy demand forecasting and procurement during heat event days (effectiveness percentage increases with weather modeling capability deployment schedule)

Name	M3 Distribution System Stress Reduction Program

Portfolio Inclusion	
Proposed	
Alt 1	x
Alt 2	

Drivers		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
D1	Extreme Rain Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D2	Extreme Heat Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.
D3	Extreme Wildfire Events	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this driver.

Outcomes		2018	2019	2020	2021	2022	2023	For purposes of this RAMP analysis, the following assumptions, data sources, and supporting rationale were used to develop mitigation effectiveness values to input into the model
O1A Increased Major Weather Events	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not mitigate this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not mitigate this outcome.
	Reliability	4.0%	4.5%	5.0%	5.5%	6.0%	6.5%	SCE estimates a marginal risk reduction of 4%. Further studies are required to obtain better precision on risk reduction. Assumes 0.5% annual increase in effectiveness from continuous process improvement.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this outcome.
O1B Increased Catastrophic Weather Events	Serious Injuries	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this outcome.
	Fatalities	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this outcome.
	Reliability	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this outcome.
	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Mitigation does not influence this outcome.
O2A Higher Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.
O2B Exceptional Energy Procurement Cost	Financial	no impact	no impact	no impact	no impact	no impact	no impact	Control does not mitigate this outcome.

Effectiveness of C1 on Major Weather Events (Reliability Consequences)

Definition of terms:
CMI - Customer Minutes of Interruption
C1 - Emergency Management Control
ICS - Incident Command System (national framework for responding to incidents - subcomponent of the Emergency Management Control)

Summary: This workpaper illustrates CMI Reduction from C1 on Major Weather Events.
Source: Data was obtained from SCE outage data and reliability metrics

Table 1: CMI Prior to ICS Implementation

Year	2011	2012	2013	Grand Total	PRE ICS-Annual Average
Sum of CMI	1,145,490,041	535,306,671	510,781,049	2,191,577,762	730,525,920

Table 2: CMI Prior to ICS Implementation

Year	2014	2015	2016	Grand Total	POST ICS- Annual Average	% Reduction
Sum of CMI	561,851,540	577,961,823	680,531,070	1,820,344,432	606,781,477	17%

The difference in average CMI pre and post ICS implementation represents a 17% reduction.

Effectiveness of M2a on Major Weather Events (Financial Consequences)

Summary: This workpaper provides a rationale of percentage risk reduction resulting from early fire detection and containment

Source: Restoration cost for major fire storms obtained from associated storm work orders

2016 Major Fire Storms	Restoration Cost
Storm 1611	$7,449,858
Storm 1614	$16,191,410
2017 Major Fire Storms	**Restoration Cost**
Storm 1716	$247,350
Storm 1720	$46,261,191
Total cost of major fire storms from 2016 -2017	$70,149,808
Average cost of major fire storms from 2016 - 2017	$17,537,452
Percentage reduction if one fire is detected early by **SCE HD Cameras** and also prevented from growing and impacting SCE assets by rapid containment from **fire agencies** (average cost of fires listed above ÷ total cost of fires listed above)	25%
Mitigation effectiveness for M2a (half % risk reduction is attributed to SCE and the other half to responding fire agencies)	12.5%

Workpaper: Number of Weather Stations

Objective: This workpaper shows an approach for determining number of weather stations for SCE HFRA (High Fire Risk Area)

Summary: The following factors were utilized for benchmarking purposes; (i) SDG&E HFRA size (ii) Number of SDG&E weather stations (iii) SCE HFRA size (iv) Ratio of HFRAs for both utilities

Item	Description	Amount	Notes
			SDG&E Data and Assumptions
A	SDG&E territory (sq mi)	4,100	Per SDG&E webpage 8/29 (https://www.sdge.com/more-information/our-company/about-us)
B	Assumed SDG&E % HFRA	70%	estimated @ 65%- 75%
C	SDG&E HFRA sq miles	2,870	4100 sq miles * 0.7
D	SDG&E weather stations	170	Per 2017 Sempra annual report
			SCE Data and Assumptions
E	SCE HFRA (sq mi)	14,297	Per GIS exercise (Tier 2, Tier 3, and related buffered)
F	SCE / SDG&E HFRA ratio	5	= E/C (rounded)
G	**SCE target weather stations**	**850**	**(Number of SDG&E weather stations) * (Ratio of SCE : SDG&E HFRA)**

Workpaper – Subject Matter Expert Qualifications

Purpose: In cases where SCE has relied on SME judgment, we provide additional detail, where applicable, as to why such judgement is prudent and should be used to inform RAMP analyses.

Risk Chapter	**Climate Change**
Risk Analysis Component	Mitigation Evaluation – Development of mitigation effectiveness values.
Does historical data exist at SCE to support the evaluation of this risk analysis component?	No, SCE does not have historical data to perform this analysis.
Additional back-up or sources used by the SME(s) to inform/validate guidance	SMEs had discussions with internal and external colleagues that have experienced risk events similar to those modeled in this chapter, and who have deployed similar types of mitigations. SCE SMEs calibrated this feedback to make expert judgements relating to the design of SCE's system to determine the mitigation effectiveness values used in this chapter.
SME(s) who have contributed to this analysis	• Director, Business Resiliency • Principal Manager, Business Resiliency • Senior Manager, Business Resiliency • Senior Advisor, Fire Management • Senior Advisor, Hazard Assessment & Mitigation • Senior Advisor, Meteorology • Consultant(s), Climate Change Adaptation
Relevant Experience of SME(s)	These SME's have a combined 65+ years of experience in the fields of Business Resiliency, Energy and Climate Policy, Wildfire Management and Prevention, Hazard Assessment and Mitigation, and Disaster Recovery & Meteorology, all within an electric utility environment. SCE's SMEs have performed advanced incident complexity analysis and developed and/or executed emergency action plans and climate adaptation strategies for electric utility systems and processes. SMEs collectively possess various professional qualifications and advanced degrees, including: extensive T&D field experience, Master's degrees in Community and Regional Planning, and a Ph.D. in Ecology.