RISK ASSESSMENT MITIGATION PHASE – RISK SPEND EFFICIENCY

March 15, 2017

Risk Spend Efficiency Overview

- **Risk Spend Efficiency (RSE):** a ratio developed to quantify and compare the estimated effectiveness of a mitigation at reducing risk to other mitigations for the same risk
- SCG and SDG&E developed the RSE for purposes of **piloting the concept to meet the RAMP requirements** pursuant to D.16-08-018
- SCG and SDG&E's RAMP represents the **first attempt to quantify RSE for identified risks** as a way of measuring the impacts of mitigations
- The concept of **RSE has not been completely developed** and it is not yet clear how it may be applied in the future and whether or not it may be supplemented or replaced
- The RSE in its current state is **used to inform ranking the mitigations within a given risk plan** but is not comparable across risks and cannot be used as the ultimate decision-making tool for funding

How We Developed the RSEs

Review risk information and proposed activities

Aggregate activities into control/mitigation

Aggregation is based on the common triggers and risk reduction they provide.

In general:

- Base controls: maintain the residual risk
- Proposed mitigations: reduce the residual risk

Determine metrics to use to calculate effectiveness of activities

Based on company data or industry data supplemented with SME input

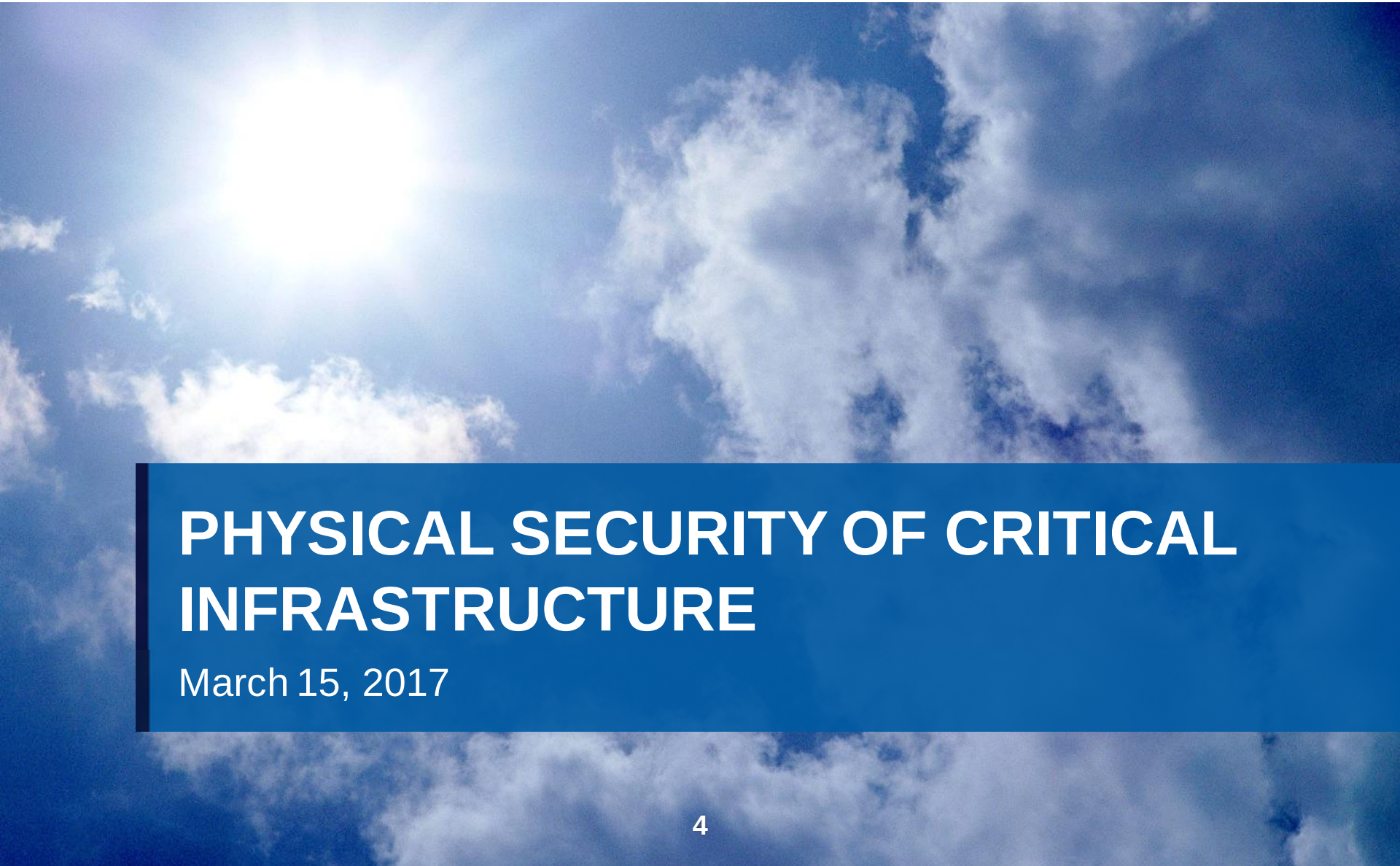
Sample metrics:

- Execution: miles of pipe replaced
- Performance: incident rates

Calculate the RSE of each control/mitigation

- Calculate the forecasted change (%) in frequency/consequence
- Use forecasted frequency/consequence value to recalculate risk score using SCG/SDG&E risk scoring formula
- Calculate the forecasted change in total risk score
- Multiply the change in risk score by the mitigation's life expectancy
- Divide by the total cost

$$RSE = \frac{Risk\ Reduction \times Mitigation's\ Life\ Expectancy}{Total\ Cost}$$



PHYSICAL SECURITY OF CRITICAL INFRASTRUCTURE

March 15, 2017

Risk Spend Efficiency Calculation

$$RSE = \frac{\text{Risk Reduction} * \text{Mitigation's Life Expectancy}}{\text{Total Mitigation Cost}}$$

Risk Spend Efficiency Calculation

$$RSE = \frac{\text{Risk Reduction} * \text{Mitigation's Life Expectancy}}{\text{Total Mitigation Cost}}$$

Risk Overview

- SoCalGas - Physical Security of Critical Infrastructure
- Description
  - The risk of an incident, caused by damage to critical gas infrastructure caused by intentional acts, including but not limited to theft, robbery, burglary, vandalism, disgruntled individuals or groups, terrorism, trespassing, etc., which results in a gas leak, fire, explosion, and/or outages.
- Scope
  - The risk assessment provided focuses on critical gas infrastructure.
  - Mitigations include security measures and operational resiliency.
- Starting Risk Score

Residual Impact				Residual Frequency	Residual Risk Score
Health, Safety, Environmental (40%)	Operational & Reliability (20%)	Regulatory, Legal, Compliance (20%)	Financial (20%)		
5	6	4	4	3	14,087

Mitigations

Current Mitigations

- Physical Security - existing fences, cameras, guards, etc.

Incremental Mitigations

- Physical Security - new or replacement fences, cameras, guards, etc.
- Operational Resiliency - the utility's ability to maintain operations or quickly resume operations

Risk Reduction – Physical Security

Baseline Risk

No Security Measures

Current Risk

Current/Existing Security Measures

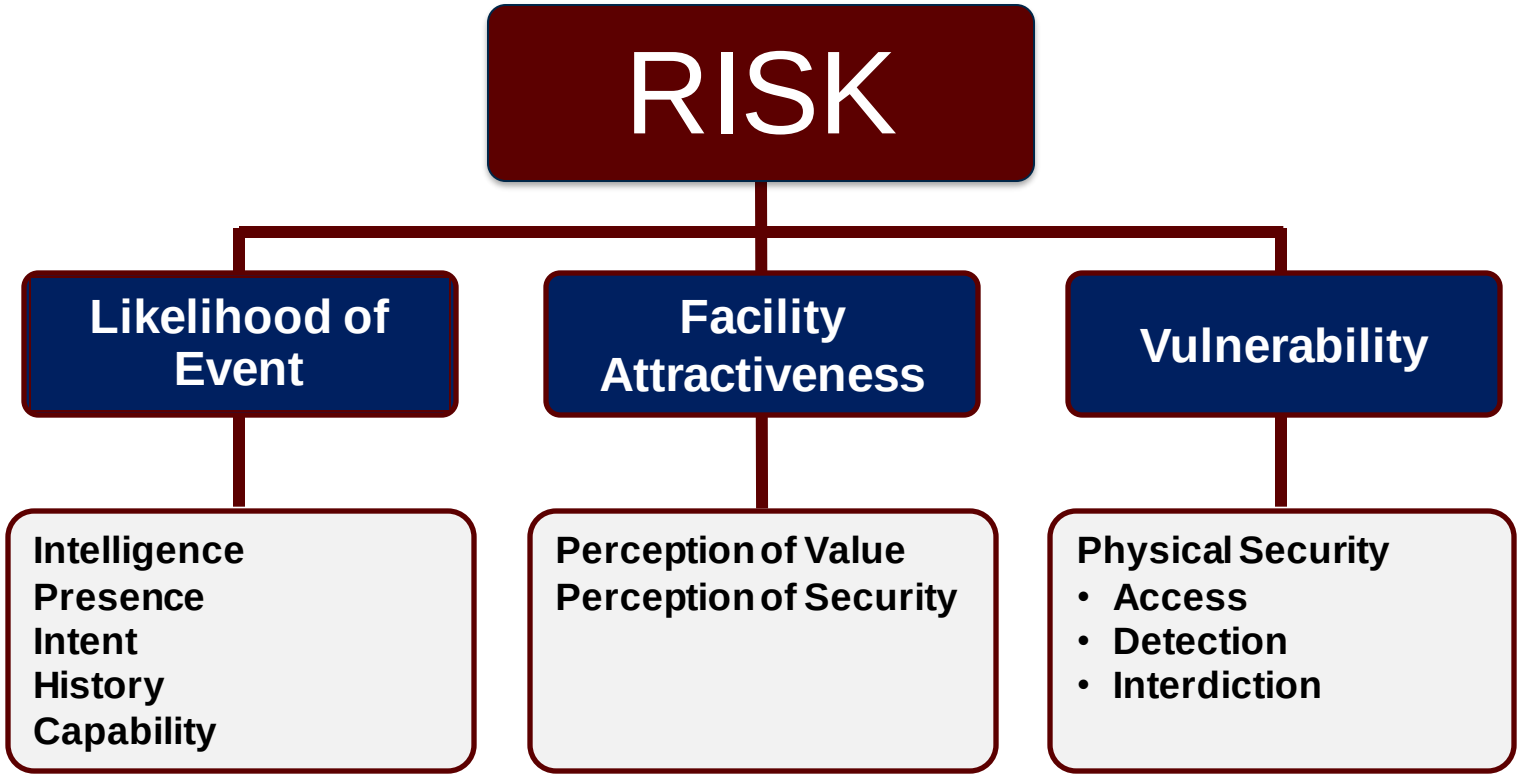
Forecasted Risk

Incremental/Proposed Security Measures

Risk Assessment Methodology

- Risk methodology based from federal risk methodologies
- Facility-based risk assessment
- Threats:
  - Theft
  - Forced Entry
  - Sabotage
  - Small Arms (Shooting)
  - Standoff Weapon
  - Explosive Device – Man Portable
  - Explosive Device – Vehicle Borne Improvised Explosive Device
  - Coordinated Attack
- Includes rating criteria and justifications to ensure the results are reasonable, repeatable, and defensible.

Risk Components



Risk Rating Criteria

LIKELIHOOD OF EVENT
Very High (100)
• **Intelligence** - Credible intelligence has indicated developing plotting. • **Presence** - Group has a large presence in the Southern California region. • **Intent** - Group has made recent public statements or showed signs of intent that may negatively impact SCG. • **History** - Group has recently conducted, planned, or facilitated recent criminal activities against SCG. • **Capability** - Group possesses a high capability or material resources to negatively impact SCG.
Medium (50)
• **Intelligence** – Intelligence may be interpreted in various ways, has alternative views, or the information is credible and plausible, but not corroborated sufficiently to warrant a higher level of confidence. • **Presence** - Group has a moderate presence in the Southern California region or within the Southwestern U.S. • **Intent** - Group has made past public statements or showed signs of intent that may negatively impact SCG. • **History** - Group has previously conducted, planned, or facilitated criminal activities against SCG. • **Capability** - Group possesses a moderate capability or material resources to negatively impact SCG.
Very Low (1)
• **Intelligence** – The information is scant, questionable, or very fragmented and it is difficult to make solid analytical inferences, or there are significant concerns or problems with the sources. • **Presence** - Group has an insignificant presence in the Southwest region. • **Intent** - Group has made not made recent public statements of intent that may negatively impact SCG or the natural gas sector in general. • **History** - Group has conducted, planned, or facilitated minimal or no criminal against SCG or the natural gas sector. • **Capability** - Group possesses a low capability or material resources to negatively impact SCG or the natural gas sector.

Illustrative Risk Assessment Ratings

LOCATION	THREAT VECTOR	Likelihood of Event (LE)	Facility Attractiveness (FA)	Threat (LE x FA)	Vulnerability (CURRENT)	Vulnerability (INCREMENTAL)	RISK (CURRENT)	RISK (INCREMENTAL)
Compressor Station	Theft (Gas)	80	2	**160**	0.4	0.2	**64**	**32**
	Forced Entry (Gas)	90	3	**270**	0.5	0.3	**135**	**81**
	Sabotage	15	2	**30**	0.4	0.2	**12**	**6**
	Small Arms	10	2	**20**	0.9	0.5	**18**	**10**
	Standoff	1	2	**2**	0.9	0.7	**2**	**1**
	Explosives	5	2	**10**	0.9	0.7	**9**	**7**
	VBIED	1	2	**2**	0.9	0.9	**2**	**2**
	Coordinated	1	2	**2**	0.9	0.9	**2**	**2**
Pressure Limiting Station	Theft (Gas)	80	3	**240**	0.5	0.2	**120**	**48**
	Forced Entry (Gas)	90	4	**360**	0.6	0.3	**216**	**108**
	Sabotage	15	3	**45**	0.5	0.2	**23**	**9**
	Small Arms	10	3	**30**	0.9	0.7	**27**	**21**
	Standoff	1	2	**2**	0.9	0.8	**2**	**2**
	Explosives	5	3	**15**	0.9	0.8	**14**	**12**
	VBIED	1	2	**2**	0.9	0.8	**2**	**2**
	Coordinated	1	2	**2**	0.9	0.9	**2**	**2**

Illustrative Risk Assessment Ratings

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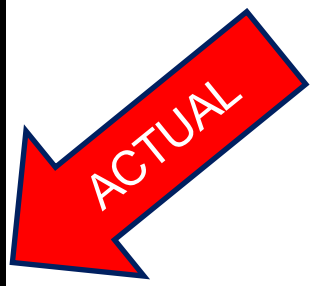
	Small Arms	10	2	20	0.9	0.5	18	10
	Standoff	1	2	2	0.9	0.7	2	1
	Explosives	5	2	10	0.9	0.7	9	7
	VBIED	1	2	2	0.9	0.9	2	2
	Coordinated	1	2	2	0.9	0.9	2	2
Pressure Limiting Station	Theft (Gas)	80	3	240	0.5	0.2	120	48
	Forced Entry (Gas)	90	4	360	0.6	0.3	216	108
	Sabotage	15	3	45	0.5	0.2	23	9
	Small Arms	10	3	30	0.9	0.7	27	21
	Standoff	1	2	2	0.9	0.8	2	2
	Explosives	5	3	15	0.9	0.8	14	12
	VBIED	1	2	2	0.9	0.8	2	2
	Coordinated	1	2	2	0.9	0.9	2	2
					RISK SCORE --->		1545	1146



Risk Reduction – Physical Security

Baseline Risk

No Security Measures

1545

Current Risk

Current/Existing Security Measures

1146

Forecasted Risk

Incremental/Proposed Security Measures

Illustrative Risk Assessment Ratings

LOCATION	THREAT VECTOR	Likelihood of Event (LE)	Facility Attractiveness (FA)	Threat (LE x FA)	Vulnerability (BASELINE)	RISK (BASELINE)
Compressor Station	Theft (Gas)	80	4	320	1.0	320
	Forced Entry (Gas)	90	4	360	1.0	360
	Sabotage	15	4	60	1.0	60
	Small Arms	10	4	40	1.0	40
	Standoff	1	4	4	1.0	4
	Explosives	5	3	15	1.0	15
	VBIED	1	3	3	1.0	3
	Coordinated	1	3	3	1.0	3
Pressure Limiting Station	Theft (Gas)	80	4	320	1.0	320
	Forced Entry (Gas)	90	4	360	1.0	360
	Sabotage	15	4	60	1.0	60
	Small Arms	10	4	40	1.0	40
	Standoff	1	4	4	1.0	4
	Explosives	5	3	15	1.0	15
	VBIED	1	3	3	1.0	3
	Coordinated	1	3	3	1.0	3
					RISK SCORE --->	6072

Illustrative Risk Assessment Ratings

LOCATION	THREAT VECTOR	Likelihood of Event (LE)	Facility Attractiveness (FA)	Threat (LE x FA)	Vulnerability (BASELINE)	RISK (BASELINE)
Compressor Station	Theft (Gas)	80	4	320	1.0	320
	Forced Entry (Gas)	90	4	360	1.0	360
	Sabotage	15	4	60	1.0	60
	Small Arms	10	4	40	1.0	40
	Standoff	1	4	4	1.0	4
	Explosives	5	3	15	1.0	15
	VBIED	1	3	3	1.0	3
	Coordinated	1	3	3	1.0	3
Pressure Limiting Station	Theft (Gas)	80	4	320	1.0	320
	Forced Entry (Gas)	90	4	360	1.0	360
	Sabotage	15	4	60	1.0	60
	Small Arms	10	4	40	1.0	40
	Standoff	1	4	4	1.0	4
	Explosives	5	3	15	1.0	15
	VBIED	1	3	3	1.0	3
	Coordinated	1	3	3	1.0	3
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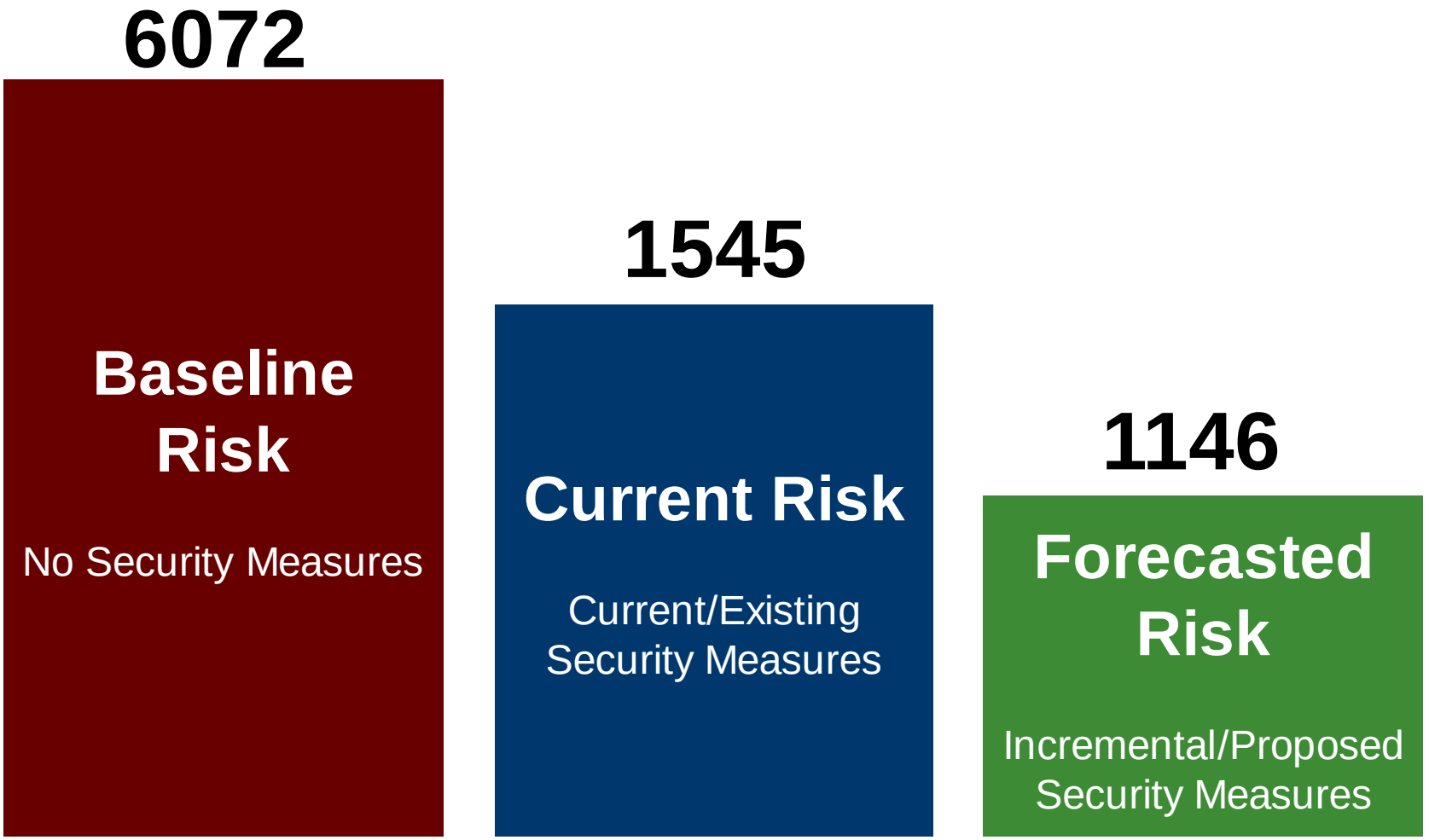
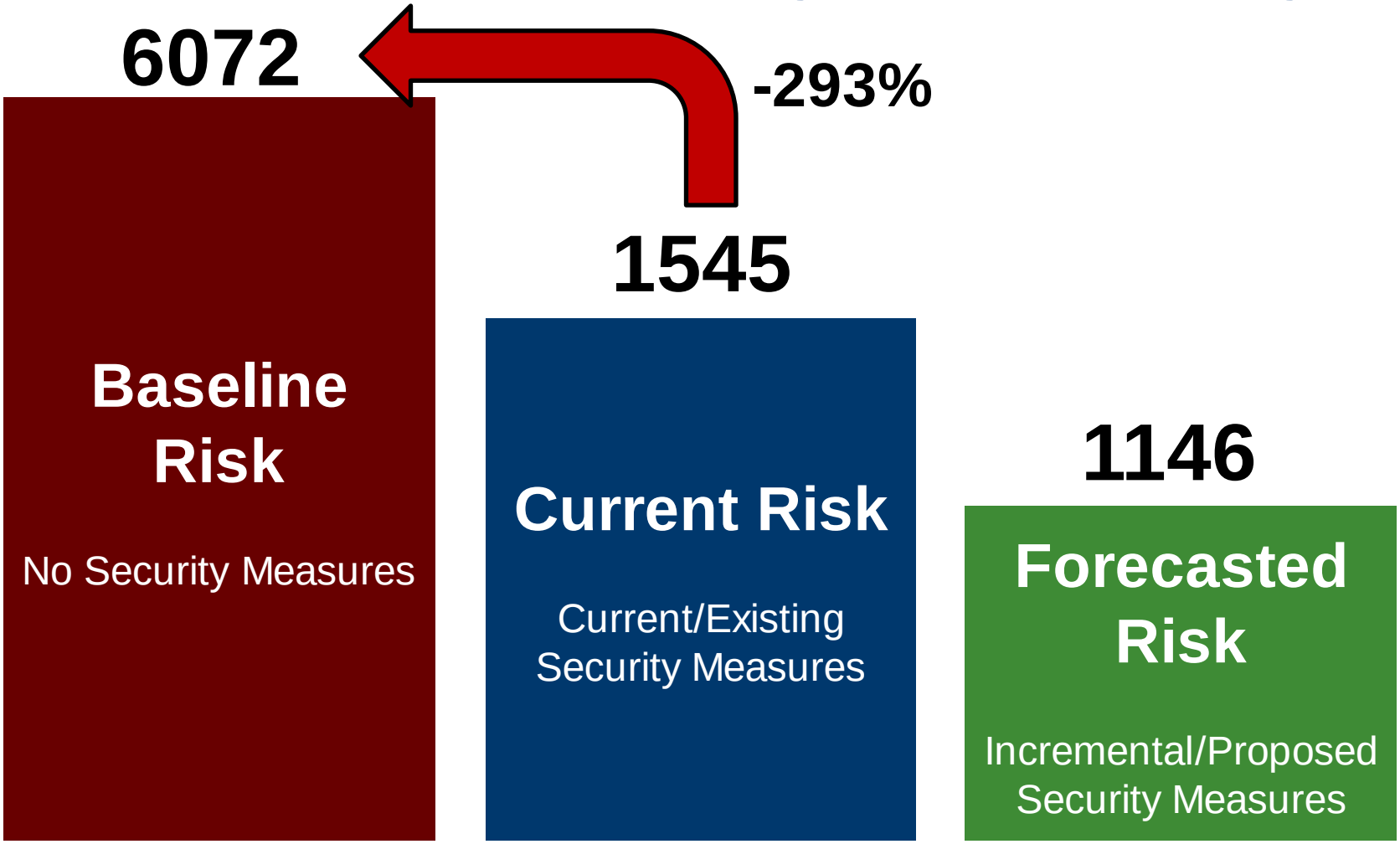
Risk Reduction – Physical Security



Risk Reduction – Physical Security



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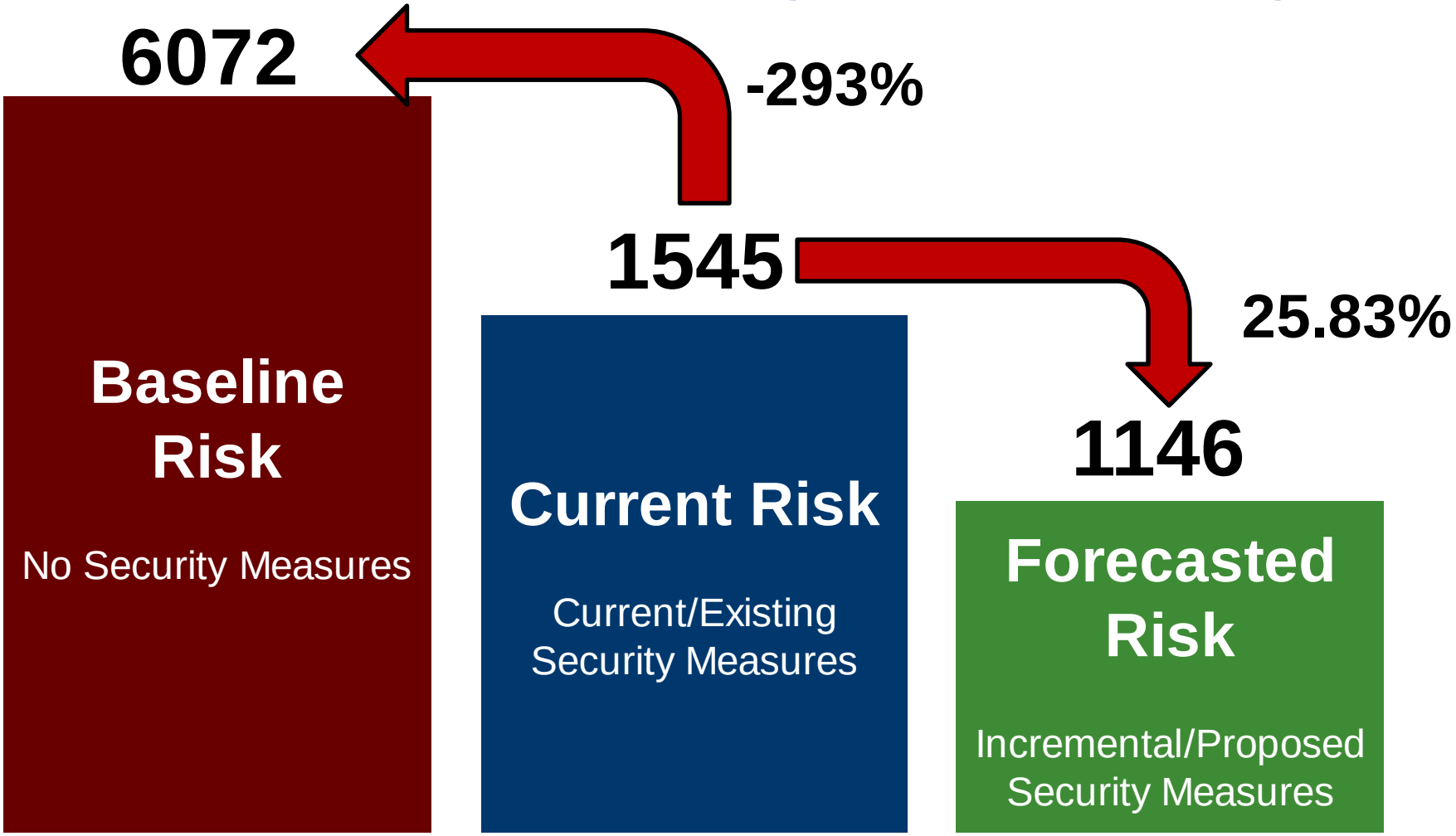


Risk Spend Efficiency Calculation

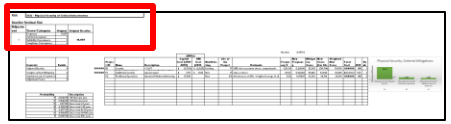
$$RSE = \frac{\text{Risk Reduction} * \text{Mitigation's Life Expectancy}}{\text{Total Mitigation Cost}}$$

INTERPRETING THE RISK SPEND EFFICIENCY (RSE) WORK PAPERS

EXAMPLE: SCG – 6: PHYSICAL SECURITY OF CRITICAL GAS INFRASTRUCTURE

Note: This presentation uses animation. Please view this presentation as a slideshow.

Residual Risk Score



» The analyst selects the risk from a dropdown list. The frequency and consequence scores are pulled from the Reference tab.

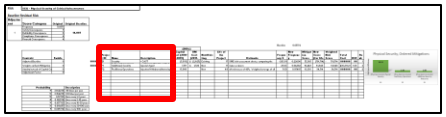
Risk	SCG - Physical Security of Critical Infrastructure

Baseline Residual Risk

Score Category	Original	Original Baseline
Frequency	0.0577	
Safety Consequence	5	
Reliability Consequence	6	**14,087**
Compliance Consequence	4	
Financial Consequence	4	

» The frequency and consequence scores for the selected risk, determined during the 2015 risk assessment process, and the resultant original baseline score populate the table. These values are the same as those shown in the Risk Score section of the risk chapter.

Analysis: Description of Mitigations



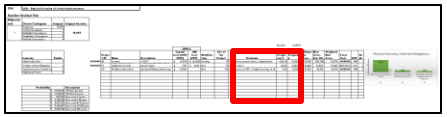
» These columns show the individual mitigations by name, along with a short description. If a mitigation comprises a group of projects, each is listed. More detail on these mitigations is provided in the Baseline Risk Mitigation Plan section of the Risk Chapter.

Name	Description
(Phys Sec) Current Physical Security	• Physical Security Systems • CAST • Investigations • Contract Security • Site Security Reviews • Security Awareness Training • Law Enforcement Liaison and Trade Groups • CA Utilities Liaison • Business Resumption Plan
(Phys Sec) Incremental Additional Security Resources	• Additional guards, Analyst, Special Agent
(Phys Sec) Incremental Resilliency Operations	AC-Injection/Withdrawal/metering

The mitigation names are listed here.

Components of a mitigation are listed here.

Analysis: Frequency Change



- The frequency % is the percentage change to the initial baseline frequency for this risk attributable to each mitigation. Positive numbers indicate a frequency reduction, negative numbers indicate an increase.
- The rationale for the frequency reduction explains how the analysis team arrived at the frequency % or new frequency.
- The new frequency is the resultant frequency after the percentage changes are applied.

Rationale	Frequency %	New Frequency
The frequency adjustment was derived from SME risk assessment sheets, comparing the total risk scores before and after mitigation. For the life of the project, the team assumed that long term items, such as fencing, have a life expectancy of 30 years. Shorter term items, such as electronics, have a life of 5 years. This yields a weighted average of ~17 years.	-293.01	0.22690
Same as above	25.83	0.04282
2 facilities out of 10 critical remedied with effectiveness of 40%. Weighted average of all facilities.	5.00	0.05485

This refers to the SME assessment (not shown for confidentiality):

- Site attractiveness score with existing mitigations = 1545
- Site attractiveness score without existing mitigations = 6072
- % reduction in score from existing mitigations = (1545-6072)/1545=-293.01%

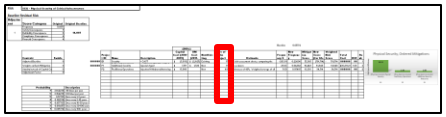
The resultant new frequencies are used to determine a new risk score for each mitigation.

- Baseline frequency = 0.0577
- % change = -293.01%
- Resultant new frequency = 0.0577*(1-(-293.01%))=0.2269

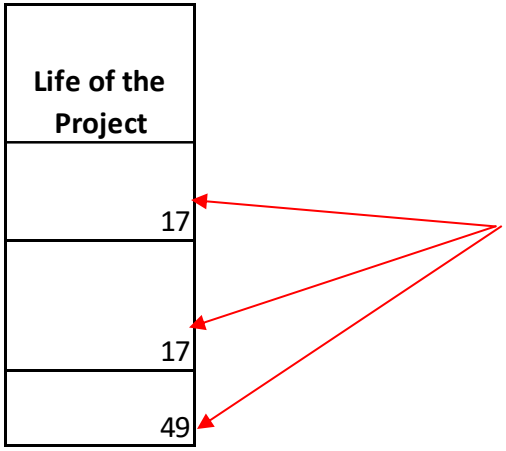
SDGE A Sempra Energy utility®

SoCalGas A Sempra Energy utility®

Analysis: Life of Project

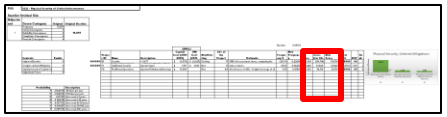


- The life of the project is the number of years over which the mitigation is expected to yield risk reduction. This value is intrinsically tied to the cost of this mitigation. An annual O&M expenditure yields one year of risk reduction, while a large capital expenditure buys multiple years of risk reduction benefit.
- In calculating the expenditure for the mitigation (the denominator in the RSE calculation), the capital component is added to the total O&M expenditure for the life of the project. *Total Cost = CapEx + Life_of_Project*O&M*



These mitigations consist of a mix of physical security items (such as fencing) and shorter term items (such as electronics) that have a life of 5 years. This mitigation consists of major updates to structures. Expected life of the upgrades that have a life expectancy of 30 years were not known, so the SMEs indicated the number of years of expected risk reduction corresponding to this mitigation's expenditure. This yields an average of ~17 years.

Analysis: New Score Calculation



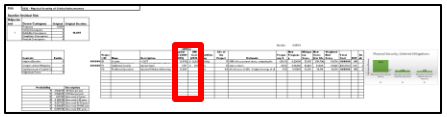
- The Mitigation Score is the score change attributable to each mitigation resulting from the new frequency.
- The Score Change (for life of project) is the difference between the baseline residual risk score and the new mitigation score multiplied by the life of project.

Mitigation Score	Score Change (for life of project)
55,365	- 701,714
10,449	61,848
13,383	34,514

Mitigation Score Calculation:

- Baseline Residual Risk Score = 14,087
- Mitigation Score = 0.2269 * (.4*10^5 + .2*10^6+.2*10^4+.2*10^4) = 55,365
- Score Change for life of project = (14,087 – 55,365)*17 = -701,714
- Note that figures in this example have been rounded prior to calculation

Analysis: Costs



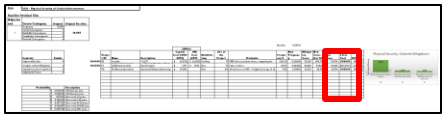
- These columns show the costs for each mitigation. Units are in thousands of dollars. The costs used in the analysis represent the midpoint costs for the ranges provided in the Summary of Mitigations section of the Risk Chapter.

(000s)	
Capital Cost (2017-2019)	OM Cost (2017-2019 average)
$ (5,033)	$ (2,625)
$ 7,571	$ 1,720
$ 15,000	

For the analysis, the cost(s) of current mitigation(s) are entered as negative values (to indicate the cost savings if these mitigations were defunded or discontinued).

The cost(s) of incremental mitigations are entered as positive values (representing the costs required to achieve this mitigation's risk reduction).

Analysis: RSE Calculation



- As noted previously, the total cost is a function of the capital cost, O&M, and life of the project:

*Total Cost = CapEx + Life_of_Project*O&M*

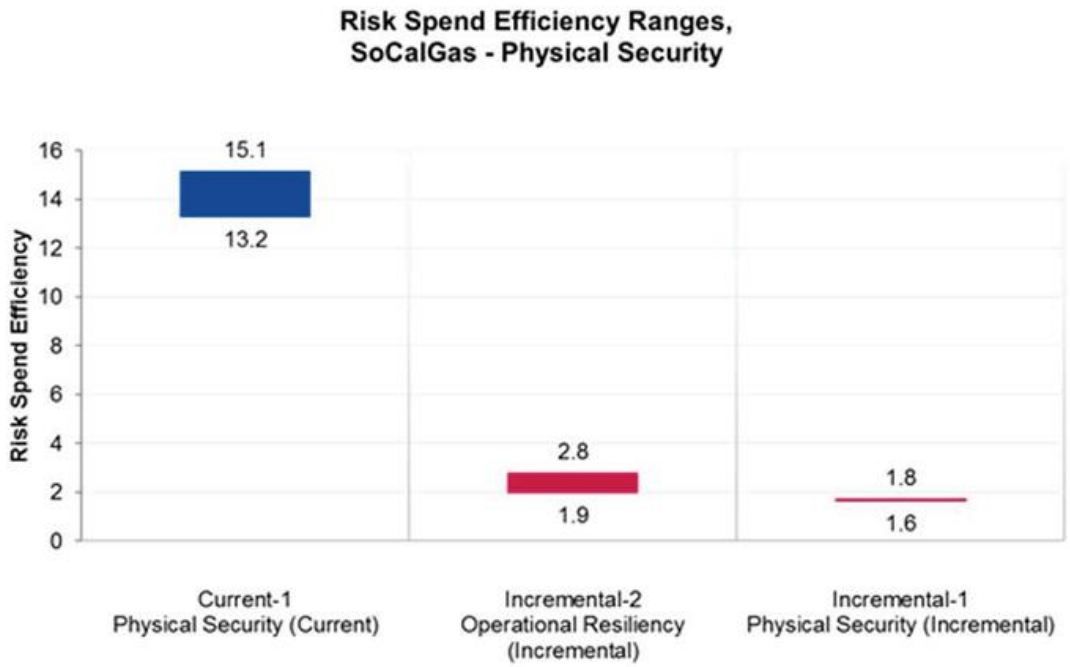
- The RSE is calculated by dividing the new score for life of project (weighted, if applicable) by the total cost.

$$Risk\ Spend\ Efficiency = \frac{Risk\ Reduction * Number\ of\ Years\ of\ Expected\ Risk\ Reduction}{Total\ Mitigation\ Cost\ (in\ thousands)}$$

Score Change (for life of project)	Total Cost	RSE
- 701,714	-$49,651.59	14.13
61,848	$36,811.21	1.68
34,514	$15,000.00	2.30

RSEs in the Risk Chapters

- For the calculation of the RSEs shown in the RAMP Risk Chapters, a low and high range of costs were used to derive a high and low RSE range, respectively. These cost ranges are shown in the Summary of Mitigations section of the Risk Chapter.
- The Weighted New Score from the work papers is used for the numerator and the calculated low and high costs for the denominator.



SOCAL GAS HIGH PRESSURE PIPELINE FAILURE

March 15, 2017

Risk Overview

- Description
  - A natural gas high pressure pipeline failure in a populated residential area resulting in fatalities, injuries and property damage. Incident results in reliability concerns in the surrounding gas network threatening curtailment and loss of core customers.
- Scope:
  - HP Natural Gas pipeline system operating at pressure greater than 60 psig.
- Starting Risk Score

Residual Impact				Residual Frequency	Residual Risk Score
Health, Safety, Environmental (40%)	Operational & Reliability (20%)	Regulatory, Legal, Compliance (20%)	Financial (20%)		
6	5	5	6	3	36,950

Mitigations Overview

Mitigation	Capital Costs (Sum 2017-2019, $000)	O&M Cost Estimate (2019, $000)
Integrity management – Transmission Integrity Management Program is closely monitored and audited.	$147,900 - $213,000	$47,000 - $52,500
PSEP – Approved PSEP program to test or replace High Consequence Area High Pressure pipelines that do not meet current records criteria. Program has continuous monitoring and prioritizing of lines with timely completion of remediation.	$365,300 - $608,800	$13,500 - $110,000
Technical Training – Employees are comprehensively trained (e.g., operator qualified) to perform compliance inspections. Policies in place to comply with Federal and State regulations regarding inspections, repair schedules, and repair methods.	$29 - $32	$2,300 - $2,600
Compliance Activities – Systems are in place to monitor and manage compliance activity schedules.	$33,100 - $36,600	$22,300 - $24,700

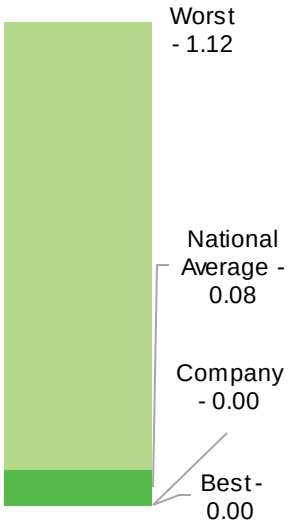
Note: The proposed mitigations are primarily based on Code of Federal Regulation (CFR) Part 192; General Order (GO) 112 state requirements; and Public Utility Code Sections 957 and 958

RSE – Integrity Mgmt

Assumption:

1. Incidents causes impacted by mitigation are Corrosion, Material/weld failure
2. If integrity management mitigation is not funded, Incident rate for causes impacted by mitigation shifts to worst on the chart (for the proportion of the assets that was to be mitigated)

2010-2016 PHMSA incidents: Corrosion, material/weld failure



Inputs:

- Miles addressed per year **500** out of **3,485** mi
  Or Assets being mitigated over 3 years= **3/7**
- SCG current incident rate per MM for corrosion, material/weld/pipe = **0**
- Projected Incident rate per MM (worst on the chart) = **1.12**
- Local population = **21.6MM**
- Current Incidents per year from all causes = 1.1
- Life of the mitigation 7 years

Calculation ΔFreq %:

Projected incidents increase per year at highest incident rate = (1.12-0)*21.6 = **24.2**

Δ Freq% =Projected incidents increase/Current incident rate * proportion of Assets Remedied = (24.2/1.1) * 3/7 = 966.8% = **9.7 X residual**

Calculation RSE:

Total change in risk over life of mitigation= **357,257 * 7 = 2,500,657**
Total cost over life of mitigation **= 528,889**

RSE= 4.73

Mitigation Detail – PSEP

Assumptions:
1. Mitigated incident causes: corrosion, equipment, material, other
2. If mitigation not funded Incident rate shifts to national average

Inputs:
- Miles addressed per year **100** out of **1,100** SCG miles at risk or Proportion of Assets being mitigated over 3 years= **3/11**
- SCG incident rate per MM for corrosion or material/weld/pipe or equipment or other = **0**
- Incident rate per MM of national average = **0.193**
- Local population = **21.6MM**
-Current Incidents per yr from all causes = **1.1**
- Life of the Mitigation = 64 years

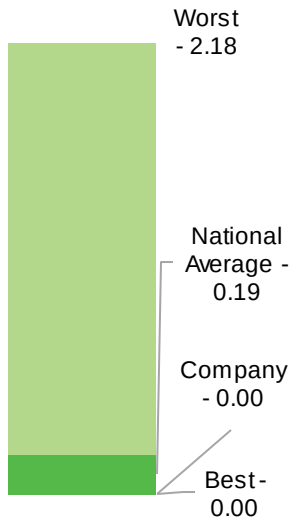
Calculation Δ Freq %:
Projected incidents increase per yr at National average incident rate = (0.193-0)*21.6 = **4.2**

Δ Freq % = Projected incidents increase/ Current incidents * Proportion of Assets Remedied = (4.2/1.1) * 3/11 = **106% = 1.06 X residual**

Calculation RSE:
Total change in risk over life of mitigation = **39,079 * 64 = 2,501,005**
Total cost over life of mitigation **= 4,439,000**

RSE= 0.56

2010-2016 PHMSA incidents: corrosion, equipment, material, other



Mitigation Detail – Technical Training

Assumption:
1. Mitigated incident causes: Incorrect Operation
2. If mitigation not funded Incorrect operations goes to 1/3 of worst state.

Inputs:
- SCG incident rate per MM for incorrect operations = **0.015**
- Incident rate per MM of worst state = **0.152**
- Local population = **21.6MM**

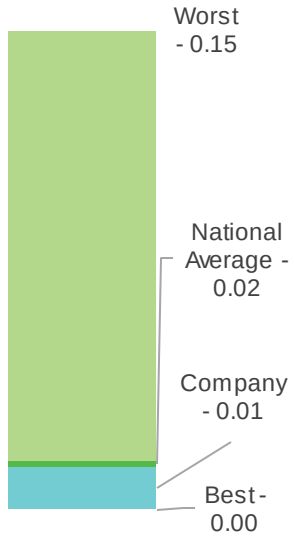
Calculation Δ Freq %:
Projected incidents increase per yr. at highest incident rate = (0.152-0.015)*21.6 = **3**
Current Incidents per yr from all causes = **1.1**

ΔFreq % = Projected incidents increase/ Current incidents = (3 / 1.1) * 1/3 = **91.45% = 0.91 X residual**

Calculation RSE:
Total change in risk = **33,791 * 1 = 33,791**
Total cost **= 2,464**

RSE= 13.71

2010-2016 PHMSA incidents: Incorrect Operations



Mitigation Detail – Compliance

Assumption:
1. Applicable cause codes: corrosion, material, equipment, excavation, other
2. If mitigation not funded performance drift to worst state

Inputs:
- SCG incident rate per MM where cause is corrosion, material, equipment, other, excavation = **0.04**
- Incident rate per MM of worst state = **2.29**
- Local population = **21.6MM**

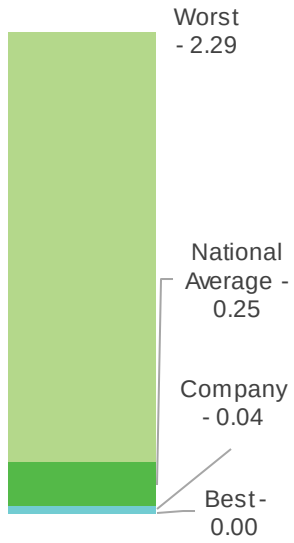
Calculation Δ Freq %:
Projected incidents increase per yr at highest incident rate = (2.29-0.04)*21.6 = **48.6**
Current Incidents per yr. from all causes = **1.1**

ΔFreq % = Projected incidents / Current incidents
= (48.6/1.1) = **4,513.98% = 45.14 X residual**

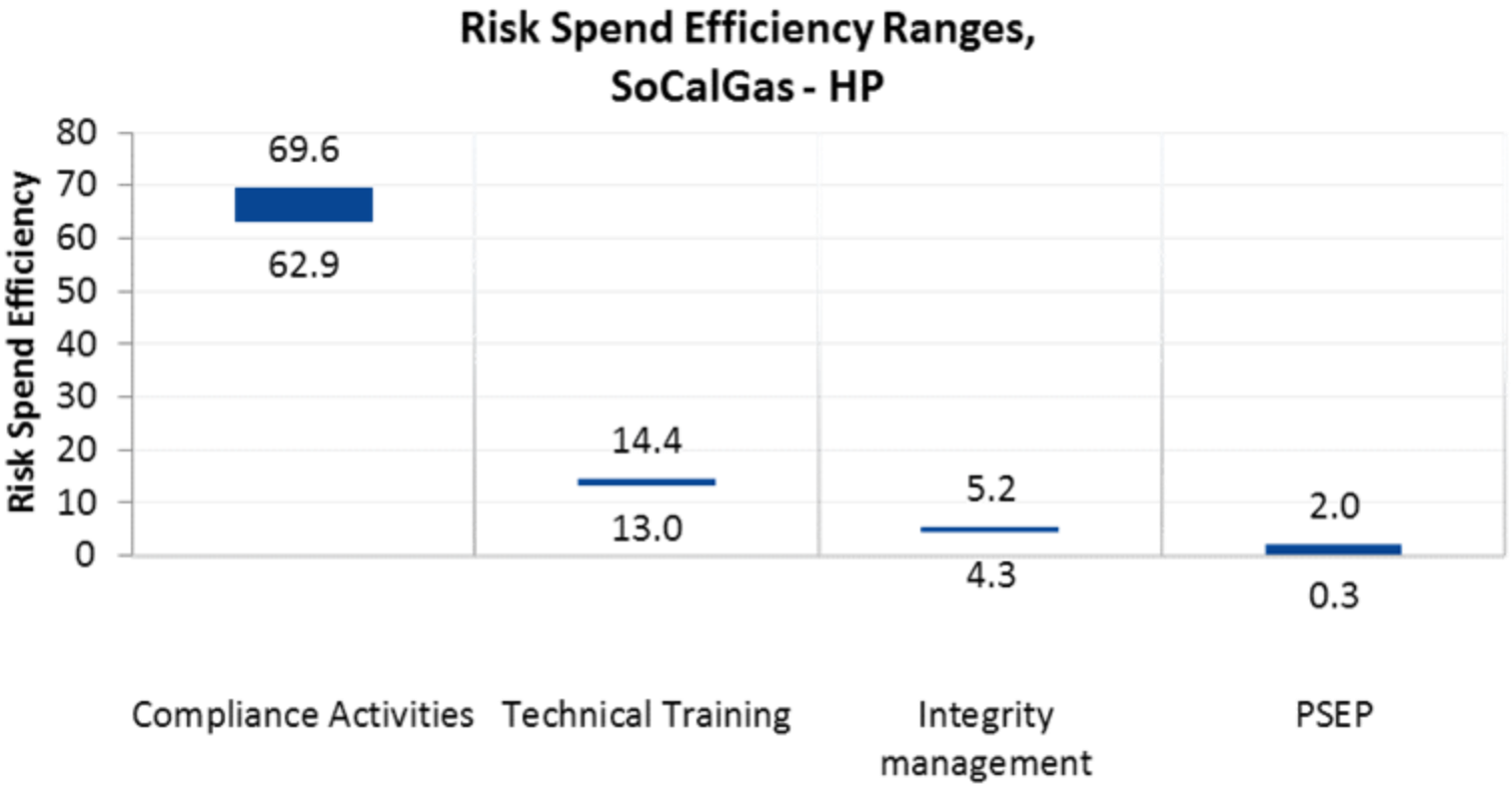
Calculation RSE:
Total change in risk = **1,667,935 * 20 = 33,358,696**
Total cost **= 504,853**

RSE= 66.08

2010-2016 PHMSA incidents: corrosion, material, equipment, other, excavation



Summary of Mitigations



SDG&E WILDFIRE

March 15, 2017

Risk Overview

- Description
  - An ignition coming from an overhead SDG&E electric facility results in a catastrophic wildfire that causes multiple fatalities, numerous injuries, property damage, operational impacts, claims, and litigation
- Scope:
  - The overhead distribution system spans 6,500 miles across the service territory
  - Mitigation activities include:

Current Programs	Incremental Programs
Rapid Response (C-1)	Advanced Protection (I-1)
Vegetation Management (C-2)	**Incremental** System Hardening, Inspection and Repair Programs – **Distribution** (I-2D)
System Hardening (C-3)	
Aviation Protection (C-4)	**Incremental** System Hardening, Inspection and Repair Programs – **Transmission** (I-2T)
Advanced Detection (C-5)	

- Starting Risk Score

Residual Impact					
Health, Safety, Environmental (40%)	Operational & Reliability (20%)	Regulatory, Legal, Compliance (20%)	Financial (20%)	Residual Frequency	Residual Risk Score
7	6	5	6	5	2,551,888

Mitigations Overview

Mitigation	Capital Costs (Sum 2017-2019 $000)	O&M Cost Estimate (2019 $000)
Rapid Response: Helo availability, crew staging, field patrols, etc.	-	$6,400 - $8,300
Vegetation Management: Tree trimming, pole brushing, etc.	-	$23,600 - $30,600
Inspection, Repair, & Hardening – Distribution (Current): Long span inspection and repair, wood to steel, FiRM, CMP etc.	$266,200 - $360,200	$1,300 - $1,600
Aviation Protection: Marker balls, avian protection, mylar balloon.	$1,300 - $1,700	$600 - $700
Advanced Detection: Weather stations, WRRM, FPI components, etc.	$1,400 - $1,800	$1,600 - $2,100
Advanced Protection: Ground Fault Detection, Phasor Measurement Units - Distribution, SCADA Capacitors, etc.	$36,100 - $47,000	-
Inspection, Repair, & Hardening – Distribution (Incremental): CNF	$240,100 - $298,000	-
Inspection, Repair, & Hardening – Transmission: CNF	$388,800 - $505,400	-

Mitigation Detail – Rapid Response (C-1)

Inputs:
SDGE tracks fires triggered by the overhead system (~25 to 30 per year). Fields include size of fire, who suppressed the fire (e.g. SDGE or a fire service), how the fire was triggered, etc.

Assumptions:
25 Fire events per year
10% are suppressed by SDGE crews (Rapid Response) – all or these are less than 0.25 acres
20% of fires which SDGE does not catch develop past 0.25 acres
7% of fires which develop past 0.25 acres spread past 100 acres
5% of fires over 100 acres cause significant property damage

Calculation Δ Freq %:
25 * 10% * 20% * 7% * 5% = 0.0017 reduction in events per year
0.0017/0.5774 = 0.29% reduction

Calculation RSE:
Total change in risk = 2,551,888 * 0.29% = 7,367
Total cost = 6,352

RSE= 1.16

Mitigation Detail – Vegetation Management (C-2)

Inputs:
Prior to implementing enhanced vegetation management specifications, SDGE experienced 420 tree-caused events per year on average. In recent years, this level has dropped to 40. From ongoing log of fire events triggered by the electric system, about 15% of fires are triggered by tree events.

Assumptions:
380 tree incidents prevented annually
5% would result in ignition
15% of fire events are attributable to trees

Calculation Δ Freq %:
(380/40) * 5% * 15% = 7.1% reduction

Calculation RSE:
Total change in risk = 2,551,888 * 7.1% * 4 years benefit for each trim= 727,288
Total cost = 94,212

RSE= 7.72

Mitigation Detail – System Hardening, Inspection, Repair (C-3)

Inputs:
Fire Risk Management (FiRM) plan to harden distribution lines in the high threat zone
Wildfire Risk Reduction Management (WRRM) tool for calculating fire risk reduction benefits

Assumptions:
Complete scope of all proposed FiRM projects mitigates 12,857,000 "complex units of risk"
FiRM plan for 2017-2019 addresses 3,641,274 of these points (28.3%)
Complete scope of all proposed FiRM projects would address 90% of fire risk due to Wires Down
Wires down events account for approximately 25% of all fires triggered by SDGE's OH system
4% of hardening benefit attributable Advanced Detection (C-5)
FiRM benefits will last for 20 years

Calculation Δ Freq %:
3,641,274 / 12,857,000 * 90% * 25% * (100%-4%)= 6.1%

Calculation RSE:
Total change in risk = 2,551,888 * 6.1% * 20 years benefit = 3,122,188
Total cost = 301,154

RSE= 10.37

Mitigation Detail – Aviation Protection (C-4)

Inputs:
NTSB statistics - ~1 aircraft vs. wire/tower event per year in California

Assumptions:
SDGE has ~10% of overhead infrastructure in California based on serving ~10% of its population
50% of events would be reduced if all unmarked locations were mitigated
10% of unmarked locations would be addressed in the 2017-2019 period
1% (arbitrarily low – no recent events on record) of SDGE-triggered wildfire events are due to aircraft vs. wire events
Markings would remain effective for a 20 year period

Calculation Δ Freq %:
1 * 10% * 50% * 10% * 1% = 0.005%

Calculation RSE:
Total change in risk = 2,551,888 * 0.005% * 20 years benefit = 2,552
Total cost = 12,771

RSE= 0.20

Mitigation Detail – Advanced Detection (C-5)

Inputs:
System Hardening Benefits

Assumptions:
SDGE's FiRM hardening program (C-3), along with Wood-to-steel and work in the Cleveland National Forest (I-2D & I-2T) are made possible by investments in Advanced Detection
4% of the total value of these programs are attributable to Advanced Detection

Calculation Δ Freq %:
(6.4% + 5.3% + 3.6%) * (4%) = 0.61%

Calculation RSE:
Total change in risk = 2,551,888 * 0.61% = 15,590
Total cost = 2,987

RSE= 5.22

Mitigation Detail – Advanced Protection (I-1)

Inputs:
Log of SDGE system-caused fires
Estimates of scope and effectiveness of technology

Assumptions:
Applicable to 70% of SDGE system-caused events (wires down, tree, vehicle, portions of flash and other)
Program will address 10% of SDGE circuits
Program will address 20% of each covered circuit
Technology is assumed to be 80% effective
Value discounted by 70% to prevent double-counting reductions from other mitigations
Mitigation benefits assumed to last for 20 years

Calculation Δ Freq %:
70% * 10% * 20% * 80% * (100% - 70%) = 0.34%

Calculation RSE:
Total change in risk = 2,551,888 * 0.34% * 20 = 171,487
Total cost = 36,145

RSE= 4.74

Mitigation Detail – Incremental System Hardening, Inspection, Repair (I-2D)

Inputs:
Benefits assumed to be similar to item C-3 (Ongoing System Hardening, Inspection, Repair) in proportion to their relative capital spends

Assumptions:
Reduction from C-3: 6.4%
C-3 Budget: 276,120
I-2D Budget: 230,154
4% of value attributable to C-5
Benefits to last 20 years

Calculation Δ Freq %:
6.4% * 230,154 / 276,120 * 96% = 5.1%

Calculation RSE:
Total change in risk = 2,551,888 * 5.1% * 20 = 2,602,434
Total cost = 230,154

RSE= 11.31

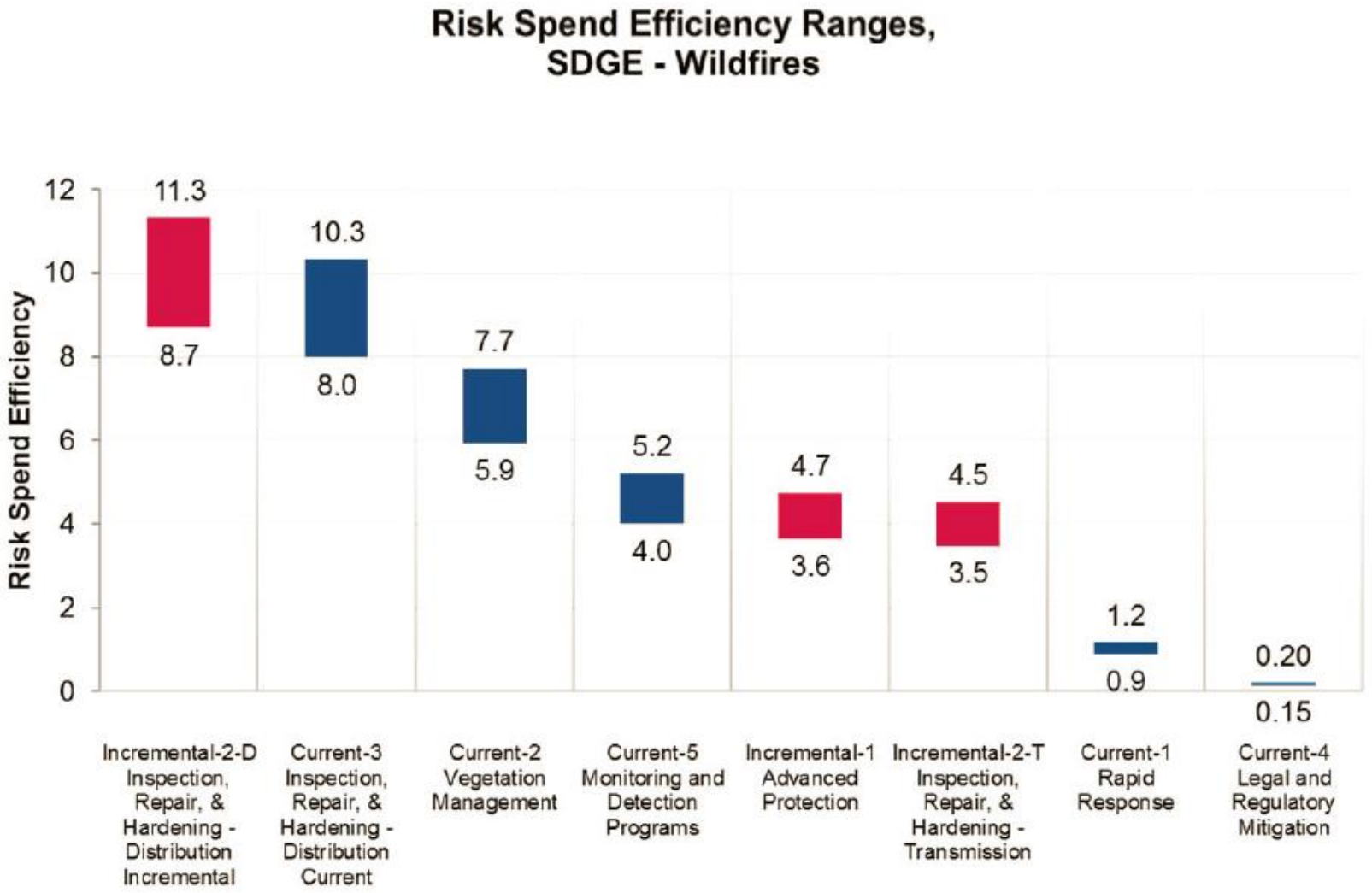
Mitigation Detail – Incremental System Hardening, Inspection, Repair (I-2T)

Inputs:
Benefits assumed to be similar to item C-3 (Ongoing System Hardening, Inspection, Repair) in proportion to their relative capital spends, and downgraded due to reduced rate of fires triggered by transmission system.

Assumptions:
Reduction from C-3: 6.4%
C-3 Budget: 276,120
I-2T Budget: 388,805
Discount by 60% for lower rate of fires triggered by transmission
4% of value attributable to C-5
Benefits to last 20 years

Calculation Δ Freq %:
6.4% * 388,805 / 276,120 * 40% * 96% = 3.45%

Calculation RSE:
Total change in risk = 2,551,888 * 3.45% * 20 = 1,758,543
Total cost = 388,805

RSE= 4.52

Summary of Mitigations