California's Earthquake Early Warning System (CEEWS) Benefit Cost Assessment

PEER Researcher's Meeting

August 15, 2024

Cal OES
GOVERNOR'S OFFICE
OF EMERGENCY SERVICES

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CEEWS BCA Research Questions & Objective

1. Who, what, and how do Californians experience EEW benefits and costs?

2. Where, when, and how often will these benefits and costs occur?

→ Identify high potential opportunities to increase system reach and impacts

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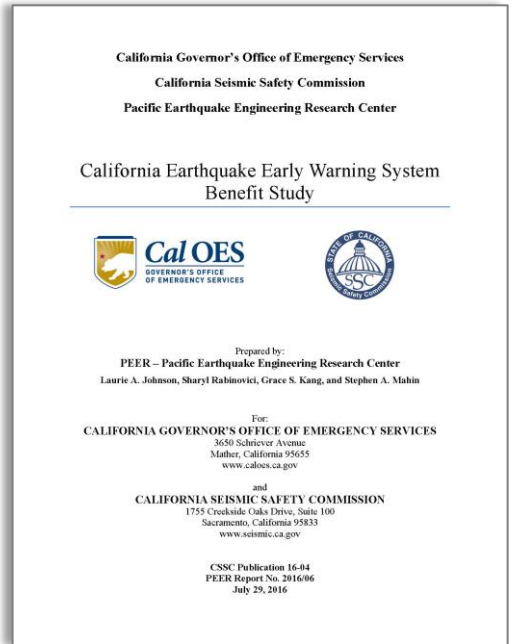
CEEWS BCA Knowledge Progression

2016

PEER + consultants

Scope: Build Framework

* Literature Scan
* 14 Sector Focus
* 24 User interviews
* BCA concepts & framework



California Governor's Office of Emergency Services
California Seismic Safety Commission
Pacific Earthquake Engineering Research Center

California Earthquake Early Warning System Benefit Study

Cal OES GOVERNOR'S OFFICE OF EMERGENCY SERVICES

Prepared by:
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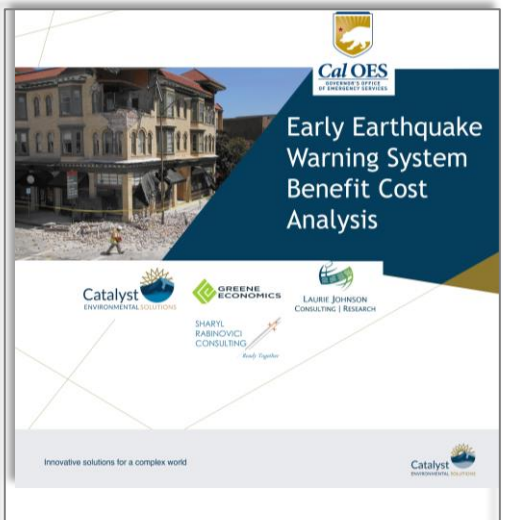
CSSC Publication 16-04
PEER Report No. 2016/06
July 29, 2016

2019-2020

RFP: Catalyst + consultants

Scope: Operationalize w/#s

* Best available data and assumptions
* 11 use cases evaluated
* Excel-Based BCA Tool
* Quantitative BCA Ratios



2024 – This Project

PEER + SRC subconsultants

Scope: "Update & Uptake"

* Scan for & incorporate new data & experiences
* Operator & user interviews
* Update BCA ratios
* Identify needs & recommend opportunities to increase uptake and impact

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Outline

- ☑ Research team
- ☑ Project context
- ☑ CEEWS BCA goals
- ☐ Approach
- ☐ Getting the findings used

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Integrated Study Elements & Stages

Qualitative Assessment

Quantitative Assessment

Preliminary Findings

Stakeholder Workshop

Final Insights & Recommendations Report

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BCA Strategy Crafted to Address Program Needs

Benefit Cost Ratio (BCR)

Overarching value (“One Big Number”)

Focus on *high-confidence* estimation

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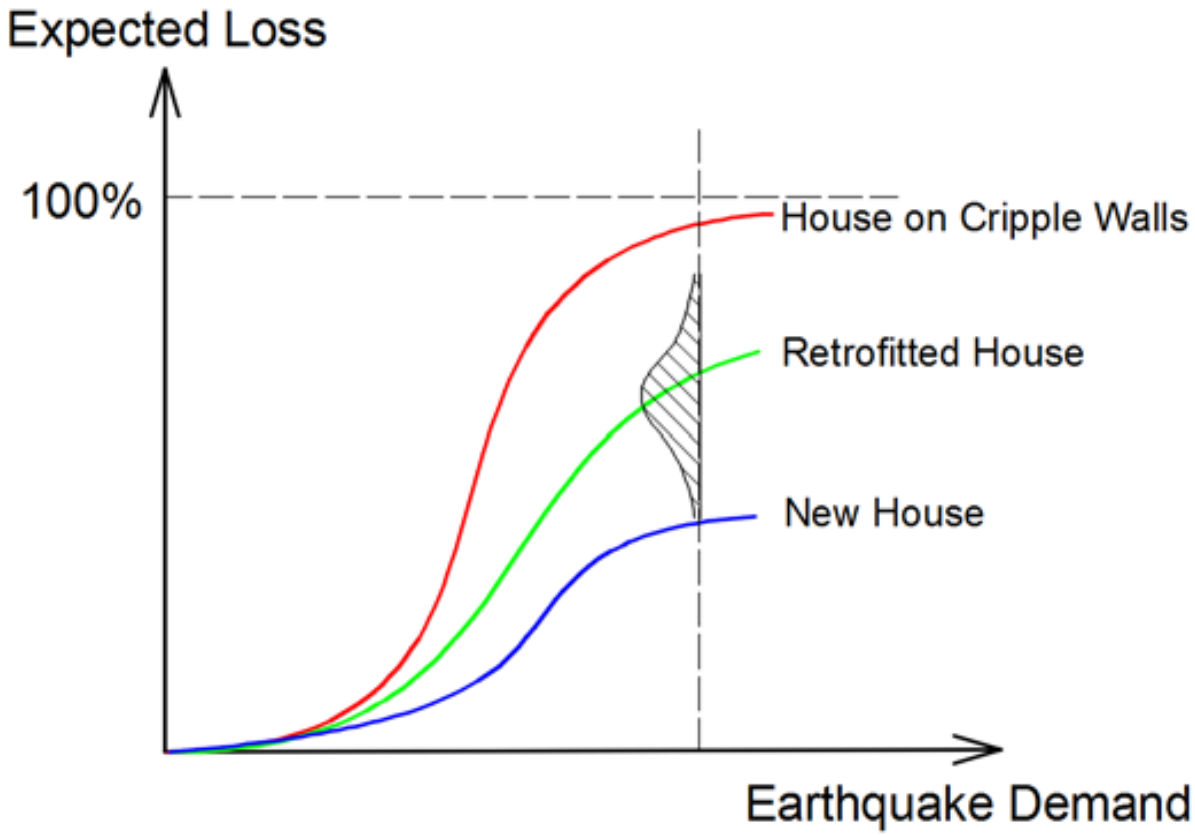
Estimating Potential EEW Benefits: A Fragility Curve Analogy



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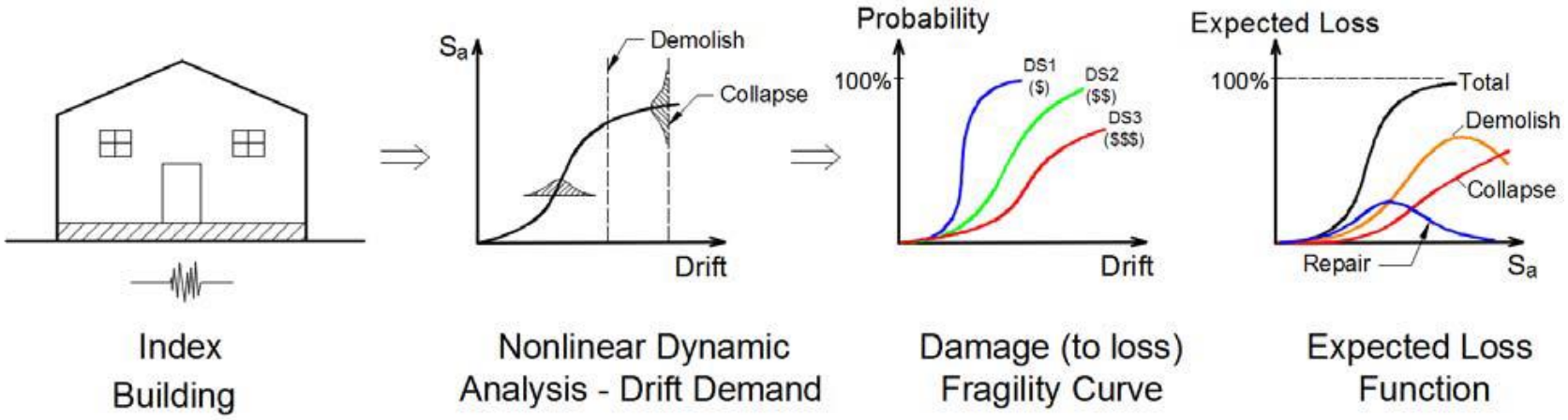
Estimating Potential EEW Benefits: The Fragility Curve Analogy



Index Building

Nonlinear Dynamic Analysis - Drift Demand

Damage (to loss) Fragility Curve

Expected Loss Function

Mappable Units of Analysis	Outcome States & Benefit Metrics	Probabilities With and Without EEW	Valuation of Expected Benefits
• people • track segment • school	• Injury severity • PTSD • Damage	• Warning time required • % risk reduction	• Cost of illness • Earthquake likelihood

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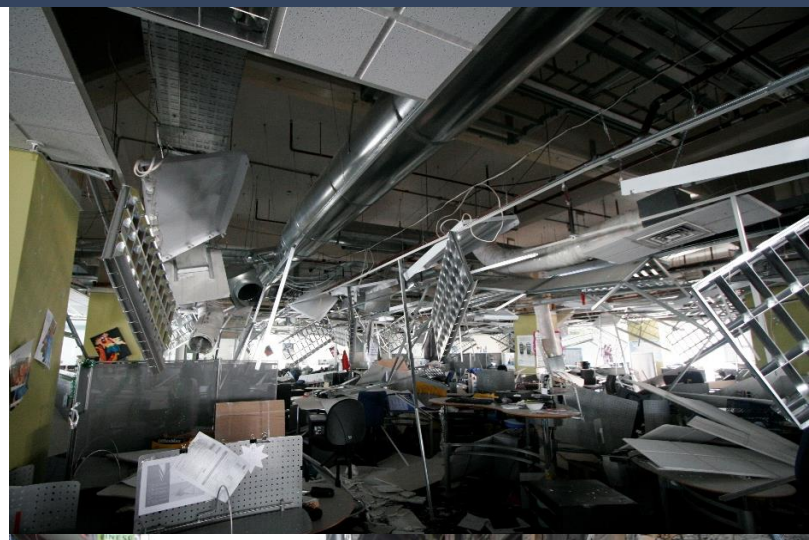
Use Cases and Units of Analysis Requirements

- Geographically-locatable unit of analysis
- Clear EEW delivery pathway
- Risk reduction mechanism and required response time
- Types of benefits
- Types and timing of costs



Types of Benefit$ Considered

Reduced Death, Injuries, & PTSD

Reduced Property Damage

Prevention of Response Time Impediments

Utility Interruption Avoided

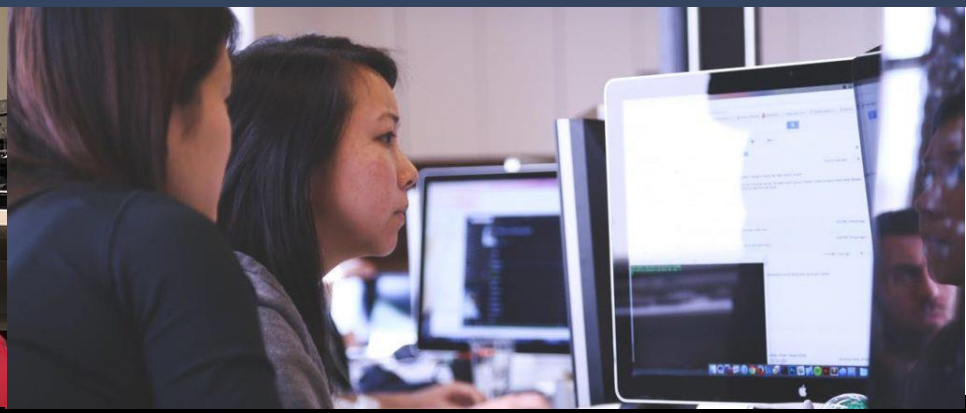
Use Cases by Types of Benefits Considered

Use Case	Mortality	Injuries & PTSD	Asset Damage	Response Time	Utility Services
Mass Transit Control	♦	♦	♦		
Personal Protective Action Alerts:					
Smartphone		♦			
School Public Address System		♦			

Elevator Control				♦	
Fire Station Doors				♦	
Automatic Gas Shut-off			♦	♦	
Water Utility Control					♦

Cost$ Considered

EEW Equipment: Installation & Periodic Replacement

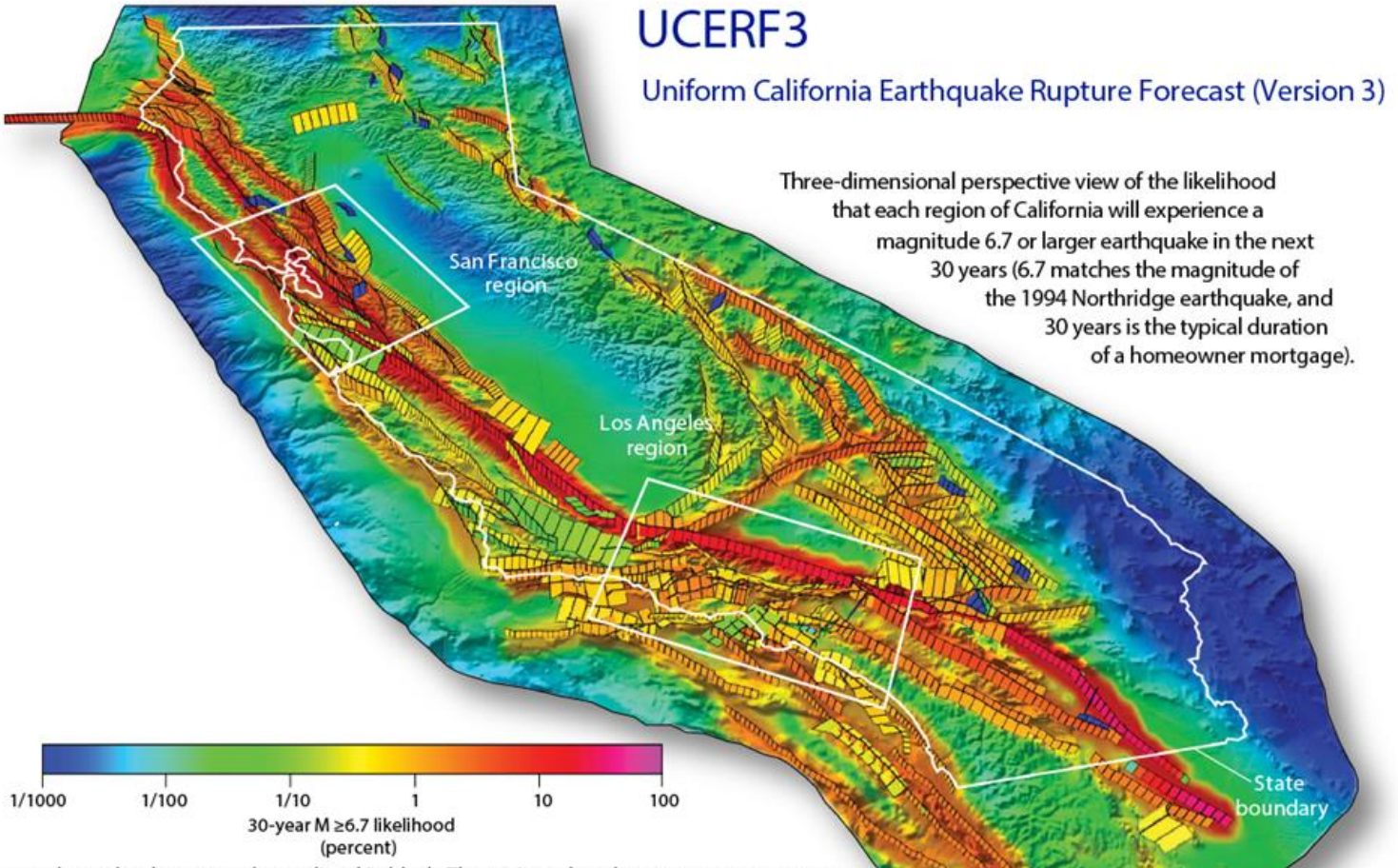


Employee Training

Maintenance & Testing

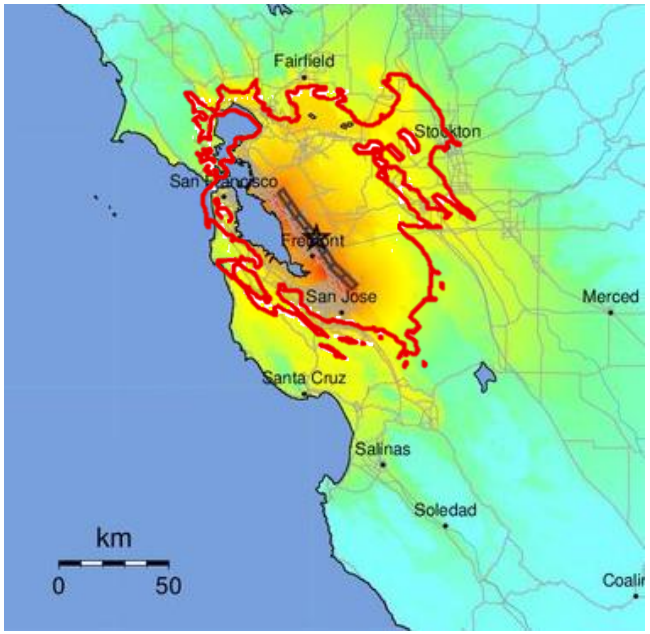
Public Outreach & Education

Addressing Varied Earthquake Intensities, Probabilities and Locations

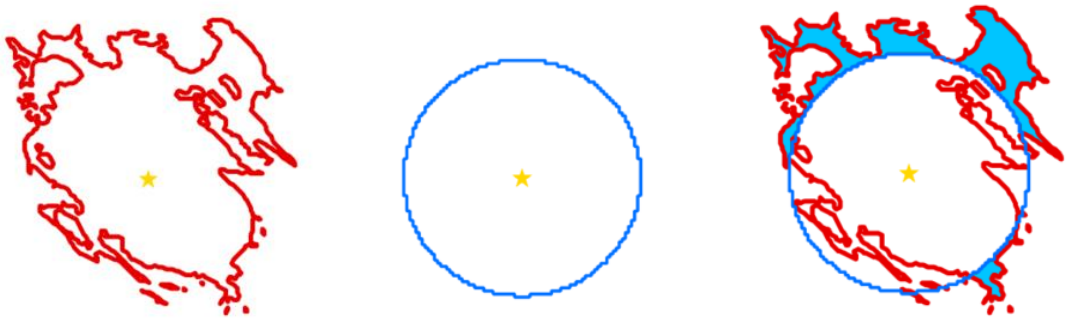


The Beneficial Warning "Footprint"

Earthquake Scenario Shaking Intensity



High Shaking Intensity Zone — **Non-Actionable Zone** = **Beneficial Warning Zone**



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Process to Estimate Expected EEWB for a Use Case in a Region

1. Define a **region** of interest (e.g., the total geographical area of the nine counties in SFBA)

2. Map coordinates of all analysis units in the region

3. Use the **OpenSHA Intensity Measure (IM) calculation tool** and an in-house distance calculation tool to estimate IM, S-wave and warning arrival times for each earthquake (defined as a fault rupture) in **UCERF3** that affects the region

For each unit, if IM value >= harm threshold **AND**

S-wave arrival time >= Alert time + response time,

Count that unit as IN the "Beneficial Warning Zone"

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Integrating the Qualitative Findings & Culminating Stakeholder Workshop

- Report out to and generate interaction among:
  - Private and non-profit end users (potential & current)
  - Researchers
  - USGS ShakeAlert partners
  - Vendors
  - LtOs

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Methodological and Practical Contributions

- Comprehensive, clarified terminology
- Realistically mapped Beneficial Warning Zones
- Scalable, updatable benefit-cost metric equations

- High confidence BCR and NPV estimates
- Integrated qualitative and quantitative insights
- Increased stakeholder interaction and understanding

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Thank you!

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