Hawaiian Electric

Wildfire Safety Strategy (WSS) Preparation

Wildfire Risk Model – Detailed Walkthrough

November 6, 2024

Today's Discussion Topics

- Wildfire Risk Modeling Introduction
- Wildfire Risk Model Walkthrough
- Preliminary Results **(DRAFT Results – Work in Progress)**

Ground Rules

- Chatham House Rule will apply – no personal or organizational attribution will be made to any comments/feedback provided during the meeting by any participant nor in written documentation. Recordings and/or artificial intelligence transcriptions of meetings are prohibited.
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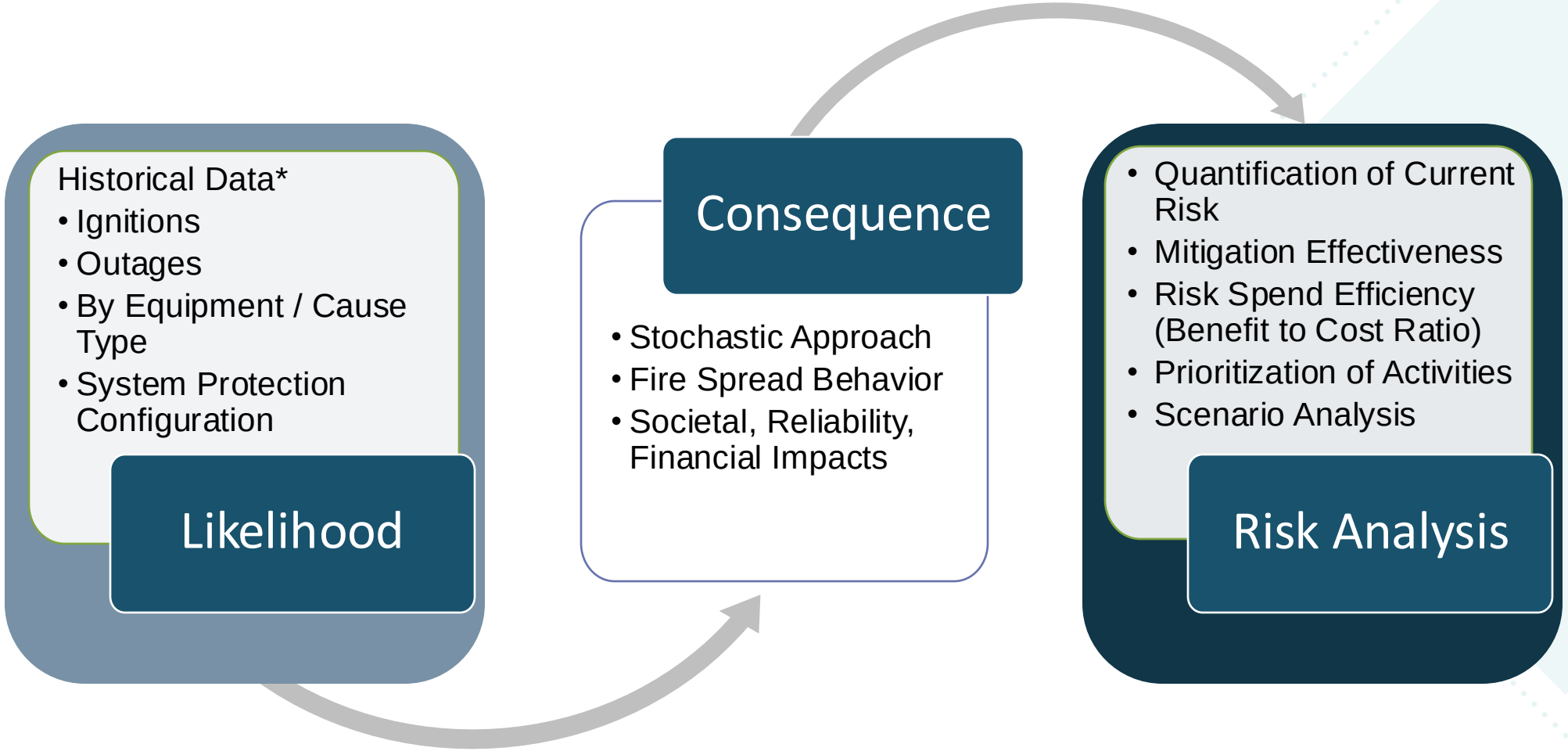
Measuring Wildfire Risk Reduction Progress and Effectiveness in the State

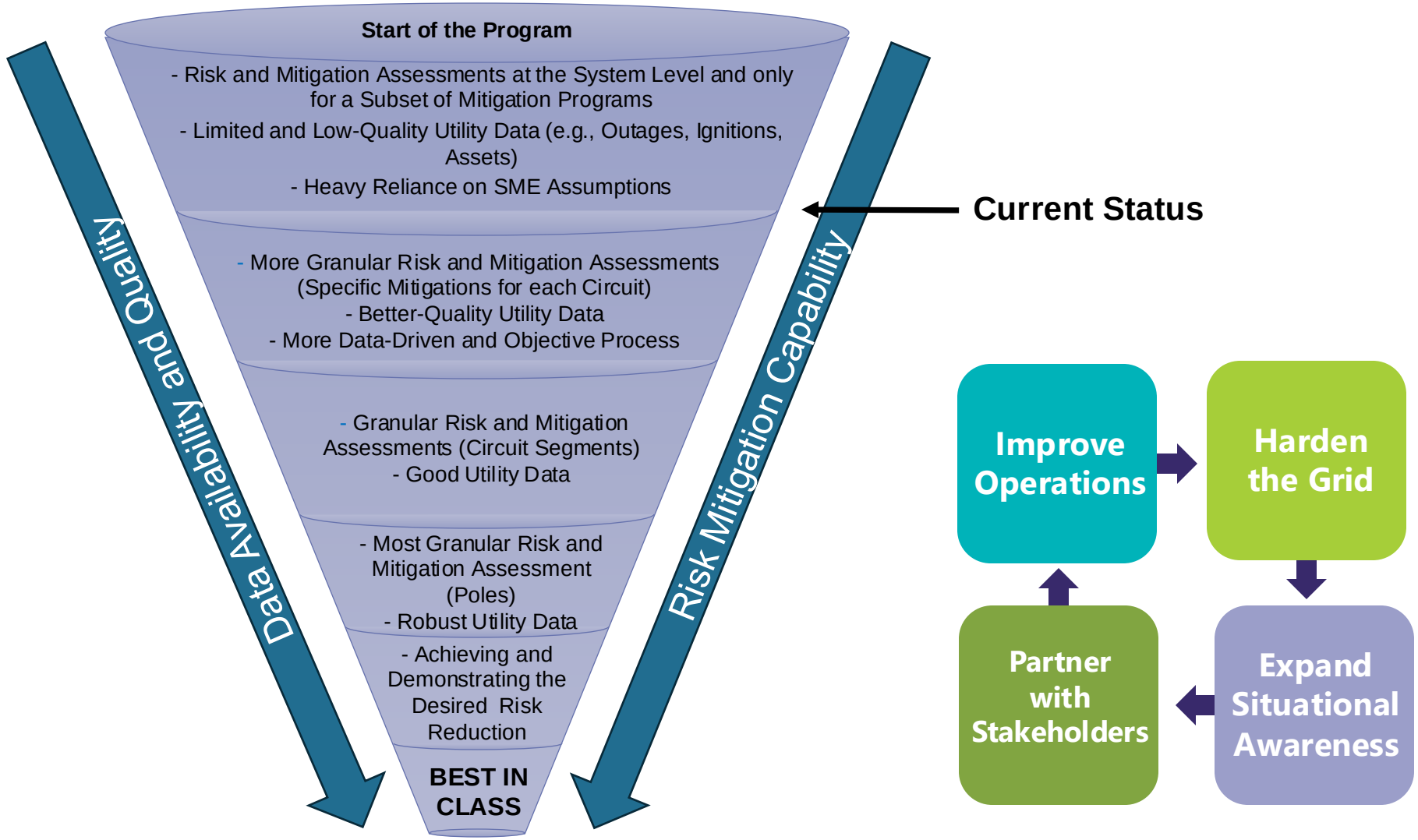
Source: HWMO, Hawaiian Electric Wildfire Safety Symposium, April 2024

Requirements and capabilities for the model



* Data gaps and improvement opportunities have been identified.

Wildfire Risk Mitigation Maturity Journey



A Wildfire Risk Model Informs Risk Mitigation Decisions and Strategies

Wildfire Risk Model Provides:

- Risk ranking of circuits
- Risk Spend Efficiency (RSE) of wildfire risk mitigants
- Estimated effectiveness of system hardening measures
- Informed deployment of operational mitigations
- Insight into data collection improvements to drive future risk assessment improvements

- Model output reviewed by subject matter experts
- Qualitative adjustments (e.g., for public safety) applied
- Resource and execution constraints considered

Wildfire Mitigation Strategy

- Implementation of most effective wildfire mitigations in reducing risk
- Informed by available data (asset data, inspection and maintenance information, ignitions, and outages) and customized risk analyses
- Supporting operational mitigations correlated to risk areas (mapping)
- Support improvements to inspection (asset, vegetation management, outage, etc.) and QA/QC programs

Model Methodology

The term “Risk Model” refers to a collection of analyses containing:

- A framework to estimate wildfire risk for Hawaiian Electric for every distribution circuit and in aggregate for each island and in total across all five islands
- Individual analyses of potential mitigations and how they reduce wildfire risk
- Identification of a portfolio of operational and infrastructure solutions that provides the lowest cost solution to achieve an overall risk reduction target
- A method to compare various mitigations (Risk Spend Efficiency or “RSE”)

$$RSE = \frac{(Annual\ Risk\ Reduction)\ x\ (Project\ Life)}{Cost\ of\ Project}$$

Hawaiian Electric’s Risk Models developed in a collaborative manner:

- Hawaiian Electric’s partners are an integral part of the team
- Data requirements and structure are discussed and defined
- Wildfire risk quantification incorporates historical fire information, risk mapping, and estimated wildfire behavior
- Risk reduction is estimated from potential mitigations through RSE analysis

Risk Assessments are Conducted at the Feeder Level

- Maximum risk at each feeder is used to estimate Risk Spend Efficiency (RSE) for the entire circuit
- It's assumed that the mitigations will address sections of the circuit that are in Tier 3 (high risk) and Tier 2 (medium risk)
- No subcircuit-level risk assessments at this point
- For engineering, design, planning, and execution, more detailed assessment, including field verification, will be necessary after the Wildfire Safety Strategy (WSS) filing

Summary of Mitigation Key Assumptions

- California utilities data were used as a starting point, then adjusted for Hawaiian Electric where better information and data were available
- Mitigation Ordering – Assumed Enhanced Fast Trop (EFT) and Public Safety Power Shutoff (PSPS) first, followed by grid hardening mitigations

Mitigation	Effectiveness	Asset Life	Cost
Enhance Fast Trip (EFT)	40%	30	$175k
PSPS (Existing)	40%	N/A	N/A
PSPS (New)	30%	N/A	$250k
Vegetation Management	35%	N/A	TBD
Covered Conductor (CC) with EFT	82.7%[1]	30	$1.25M/mile
Undergrounding (UG)	95%	55	$11M/mile

1- Average effectiveness, it varies for each feeder.

Qualitative Assessment

Professional judgment, input from subject matter experts, and other difficult to quantify considerations also influence prioritization decisions.

- The WF risk model is not a decision maker – but is a tool for risk-informed decision-making
  - Uncertainty of inputs is large, improving over time as data and experiences evolve
- The custom model will allow for the screening of potential mitigants that need to be informed by Hawaiian Electric's experts and stakeholders:
  - Capacity, budget, and rate impacts
  - Customer and employee satisfaction
  - Staffing requirements
  - Implementation time and other constraints
- Additional prioritization based on qualitative safety consideration

Qualitative Prioritization Model Attributes

In addition to quantitively assessing wildfire risk, the following attributes are being utilized to prioritize investments:

1. Egress – High / Low
2. Social Vulnerability – High / Medium / Low
3. Critical Habitat – High / Low
4. Critical Facility Density – High / Medium / Low
5. Reliability Benefit – High / Medium / Low
6. PSPS Reduction Impact – High / Medium / Low

Prioritization Model Attributes

Attribute	Definition	Methodology
Egress	Egress refers to the safe evacuation or exit routes for populations during emergencies, particularly in areas at risk from natural disasters like wildfires	A feeder is assessed based on the overlay with egress zones.
Social Vulnerability Index (SVI)	Social vulnerability, as defined by FEMA, refers to the susceptibility of specific social groups to the adverse impacts of natural hazards, including disproportionate risks of death, injury, livelihood disruption, and property loss.	SVI values are determined based on the Census tracts where each feeder is located. HECO utilized two critical aspects of SVI - socioeconomic status and household composition.
Critical Facility (CF) Density	Critical facilities, which are essential to public safety, include key infrastructure such as emergency services, government facilities, healthcare, energy, water and wastewater, communications, and transportation sectors.	A feeder is assessed based on the density of CFs within a defined buffer zone.
Critical Habitat	Specific areas within the geographical range of a species that contain essential physical or biological features for the species' conservation. Specific areas outside the species' occupied range, if deemed essential for its survival and conservation.	Data from the Hawaii Statewide GIS Program, which included all CH layers provided by the USFWS, was overlaid by feeder locations.
Reliability Benefit	Hardening mitigations can have an additional benefit of reliability.	Estimated reliability benefit from hardening work.
PSPS Reduction Impact	Reducing potential PSPS reduction events.	The ability of a mitigation to reduce the potential of a PSPS event is considered in prioritization

Resource Balancing and Implementation Timing

Careful consideration is being taken to evaluate resource availability and implementation timing to achieving wildfire risk reduction

Mitigation Type Examples	EFT	Covered Conductor	Undergrounding
Duration Considerations	Enable Fast Trip Enable Fast Trip Toggle Add SCADA-controlled switch Add SCADA control via SEL relay	Accessibility Regulatory Approval RFP Requirements Permitting Requirements Material Availability	Regulatory Approval Permitting
Resource Considerations	Protection Engineer Substation Supv Relay Technician Relay Engineer	T&D Engr CSS Engr Project Analyst T&D Drafting Resource Planner OH Crew T&D Ops OH Supv PTM OH Crew T&D Ops OH Supv	T&D Engr Project Analyst T&D Drafting Resource Planner OH / UG Crews T&D Ops OH / UG T&D Ops Supv PTM Inspector

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Overview of Wildfire Risk Modeling Methodology

Top-Down Analysis

Estimate System-Level Risk

Bottom-Up Analysis

Estimate Risk at Each Feeder

- Likelihood of an Ignition
- Potential Consequence of Fire

Combine Top-Down and Bottom-Up Analysis

- Allocate Bottom-Up to Equal Risk of Top-Down

Feeder-Level Risk Modeling Process (High-Level)

Identification of a portfolio of operational and infrastructure solutions that provides the lowest cost solution to achieve an overall risk reduction target

Feeder Attributes (Step 1)

Feeder Attributes

Distribution	Island	FEEDER_ID	OH (mile)	UG (mile)	Tier 1 %	Tier 2 %	Tier 3 %
Distribution	Maui	Feeder 1	24	23	0%	0%	100%
Distribution	Maui	Feeder 2	61	20	0%	0%	100%
Distribution	Hawaii	Feeder 3	5	35	0%	0%	100%
Distribution	Maui	Feeder 4	19	4	0%	0%	100%
Distribution	Hawaii	Feeder 5	141	0	4%	96%	0%
Distribution	Oahu	Feeder 6	19	12	34%	29%	37%

Risk analysis is done at the distribution feeder level

Overhead conductors are the potential source of ignition

Mitigations will focus on Tier 3 (high risk) and Tier 2 (medium risk)

Ignition Proxy for each Feeder (Step 2)

Feeder			Step Outage Data and Calculations						
Distribution	Island	FEEDER_ID	Annualized SAIDI Actual	Annualized Outage Actual	Annualized Outage Adjusted	Outages Per Mile	Annualized Ignition Proxy	Normalized Ignition Proxy	Ignitions Proxy Per Mile
Distribution	Maui	Feeder 1	1.9	27	14	0.6	0.4	0.1	0.00
Distribution	Maui	Feeder 2	1.7	35	18	0.4	0.4	0.1	0.00
Distribution	Hawaii	Feeder 3	0.2	4	4	0.1	0.2	0.1	0.02
Distribution	Maui	Feeder 4	2.3	46	23	2.0	0.0	0.1	0.00
Distribution	Hawaii	Feeder 5	2.2	17	17	0.1	0.0	0.1	0.00
Distribution	Oahu	Feeder 6	0.7	12	12	0.4	0.2	0.1	0.01

Historical outage data to estimate the likelihood of ignitions (outages leading to ignition)

Ignition proxy to estimate the likelihood of ignition at each feeder

Consequence and Risk Estimation (Step 3)

Feeder			Consequence and Risk Calculations			
Distribution	Island	FEEDER_ID	% (>100 Structure Destroyed)	Dryness Index	WF Spread Model: Raw_Adj ($M)	WF Risk $: Calibrated Annual (Pre) ($M)
Distribution	Maui	Feeder 1	23%	2.1	$1,851	$22
Distribution	Maui	Feeder 2	65%	2.1	$1,808	$21
Distribution	Hawaii	Feeder 3	59%	1.8	$1,661	$19
Distribution	Maui	Feeder 4	26%	2.3	$1,381	$15
Distribution	Hawaii	Feeder 5	45%	1.9	$946	$8
Distribution	Oahu	Feeder 6	13%	1.7	$450	$5

Estimating the percentage of large consequences that will be potentially associated with a feeder

Dryness index is used to better estimate the potential fire spread and consequences

Estimating the annual potential wildfire consequences

Risk Reduction Estimates of Mitigations Executed before WSS (Step 4)

Feeder			Between Aug 2023 and WSS submission						
Distribution	Island	FEEDER_ID	EFT Enabled	EFT WF Annual Risk Reduction (Enabled) ($M)	PSPS WF Annual Risk Reduction (T3) ($M)	VM Reliability Risk Reduction2 ($M)	VM Program WF Annual Risk Reduction ($M)	IAP WF Annual Risk Reduction ($M)	Feeder WF annual residual after EFT, PSPS, VM ($M)
Distribution	Maui	Feeder 1	3/4/2024	$9	$5	$0	$2	$1	$5
Distribution	Maui	Feeder 2	3/4/2024	$8	$5	$0	$1	$1	$5
Distribution	Hawaii	Feeder 3	11/21/2023	$8	$5	$0	$0	$1	$6
Distribution	Maui	Feeder 4	3/4/2024	$6	$4	$0	$1	$1	$3
Distribution	Hawaii	Feeder 5	-	$0	$0	$0	$1	$0	$6
Distribution	Oahu	Feeder 6	2/11/2024	$2	$1	$0	$0	$0	$2

Risk reduction of implemented Enhanced Fast Trip (EFT)

Risk reduction of Public Safety Power Shutoff (PSPS)

Risk reduction of wildfire vegetation management program

Risk reduction of Immediate Action Plans (IAP)

Risk Estimates at each Feeder (Step 5)

Feeder			Total Risk			
Distribution	Island	FEEDER_ID	Reliability Risk $ ($M)	Total: Wildfire+ Reliability Consequence ($M)	Rank WF Risk	Rank Total Risk
Distribution	Maui	Feeder 1	$0	$5	2	5
Distribution	Maui	Feeder 2	$0	$6	3	4
Distribution	Hawaii	Feeder 3	$0	$6	4	3
Distribution	Maui	Feeder 4	$0	$4	5	6
Distribution	Hawaii	Feeder 5	$1	$7	7	1
Distribution	Oahu	Feeder 6	$1	$2	8	8

Total wildfire and reliability risk at each feeder

Feeder rank order based on wildfire risk only

Feeder rank order based on wildfire and reliability risk

RSE Estimates of New Operational Mitigation (Step 6)

Feeder				Future Enhanced Fast Trip (EFT) & PSPS					WF Residual Risk
Distribution	Island	FEEDER_ID	PSPS , EFT or Both	Estimated Recloser Units	New EFT & PSPS WF Annual Risk Reduction ($M)	New EFT & PSPS Risk Reduction over Project Life ($M)	New EFT & PSPS Cost ($M)	New EFT & PSPS WF RSE (New)	Feeder WF annual residual after PSPS & EFT (new) ($M)
Distribution	Maui	Feeder 1	-	-	$0	$0	$0	0.0	$5
Distribution	Maui	Feeder 2	-	-	$0	$0	$0	0.0	$5
Distribution	Hawaii	Feeder 3	-	-	$0	$0	$0	0.0	$6
Distribution	Maui	Feeder 4	-	-	$0	$0	$0	0.0	$3
Distribution	Hawaii	Feeder 5	PSPS and EFT	14	$4	$112	$2	70.3	$3
Distribution	Oahu	Feeder 6	-	-	$0	$0	$0	0.0	$2

Mitigation Type (no value means that PSPS and EFT have already been implemented)

Annual risk reduction estimate of mitigations at each feeder

RSE estimates for new operational mitigations

Residual risk after operational mitigations

RSE Estimates of Covered Conductor (CC) Combined with Operational Mitigations (Step 7)

Feeder			New EFT, PSPS and Covered Conductor (CC)					
Distribution	Island	FEEDER_ID	CC Reliability Annual Risk Reduction ($M)	New EFT, PSPS and CC WF Annual Risk Reduction ($M)	New EFT, PSPS and CC Risk Reduction over Project Life ($M)	New EFT, PSPS and CC Cost ($M)	New EFT, PSPS and CC WF RSE	New EFT, PSPS and CC RSE
Distribution	Maui	Feeder 1	$0	$4	$123	$30	3.9	4.1
Distribution	Maui	Feeder 2	$0	$3	$108	$77	1.3	1.4
Distribution	Hawaii	Feeder 3	$0	$3	$94	$6	15.3	15.4
Distribution	Maui	Feeder 4	$0	$2	$83	$24	3.1	3.5
Distribution	Hawaii	Feeder 5	$0	$5	$169	$178	0.9	1.0
Distribution	Oahu	Feeder 6	$0	$1	$37	$23	1.1	1.6

Reliability benefit of CC (incremental to wildfire benefits)

Risk reduction of operational mitigation and CC over project life

RSE without reliability benefits

RSE Estimates of Undergrounding (UG) Combined with Operational Mitigations (Step 8)

Feeder			New EFT, PSPS and Undergrounding (UG)					
Distribution	Island	FEEDER_ID	New EFT, PSPS and UG Reliability Annual Risk Reduction ($M)	New EFT, PSPS and UG WF Annual Risk Reduction ($M)	New EFT, PSPS and UG Risk Reduction over Project Life ($M)	New EFT, PSPS and UG Cost ($M)	New EFT, PSPS and UG WF RSE	New EFT, PSPS and UG RSE
Distribution	Maui	Feeder 1	$0	$5	$266	$262	1.0	1.0
Distribution	Maui	Feeder 2	$0	$5	$281	$675	0.4	0.4
Distribution	Hawaii	Feeder 3	$0	$5	$299	$53	5.6	5.6
Distribution	Maui	Feeder 4	$0	$3	$193	$212	0.8	0.9
Distribution	Hawaii	Feeder 5	$0	$6	$350	$1,551	0.2	0.2
Distribution	Oahu	Feeder 6	$0	$1	$106	$206	0.4	0.5

Reliability benefit of operational mitigations and UG

Risk reduction of operational mitigation and UG over project life

RSE without reliability benefits

Proposed Mitigation Portfolio (Step 9)

Feeder			Mitigation Ranking				
Distribution	Island	FEEDER_ID	EFT & PSPS (new)?	Highest RSE	Preferred Mitigation	$ Cost of Preferred Mitigation ($M)	WF Risk Reduction (annual) ($M)
Distribution	Maui	Feeder 1		3.9	EFT, PSPS and CC	$30	$4
Distribution	Maui	Feeder 2		1.3	EFT, PSPS and CC	$77	$3
Distribution	Hawaii	Feeder 3		15.3	EFT, PSPS and CC	$6	$3
Distribution	Maui	Feeder 4		3.1	EFT, PSPS and CC	$24	$2
Distribution	Hawaii	Feeder 5	EFT and PSPS	70.3	EFT & PSPS	$2	$4
Distribution	Oahu	Feeder 6		1.1	EFT, PSPS and CC	$23	$1

RSE of the proposed mitigation portfolio

Proposed portfolio

Estimated cost of the proposed portfolio

Estimated annual wildfire risk reduction of the proposed portfolio

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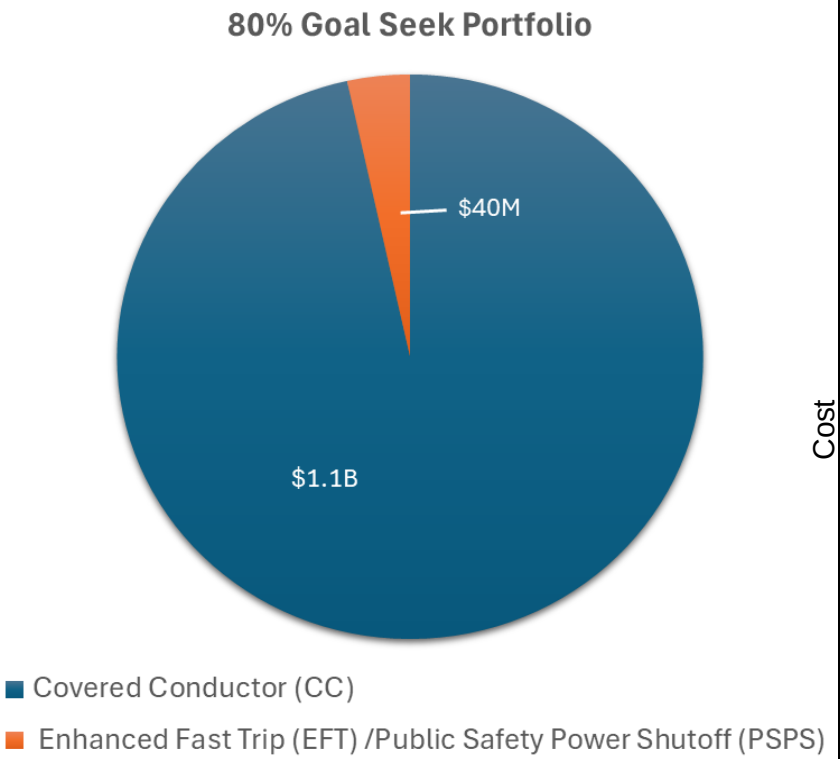
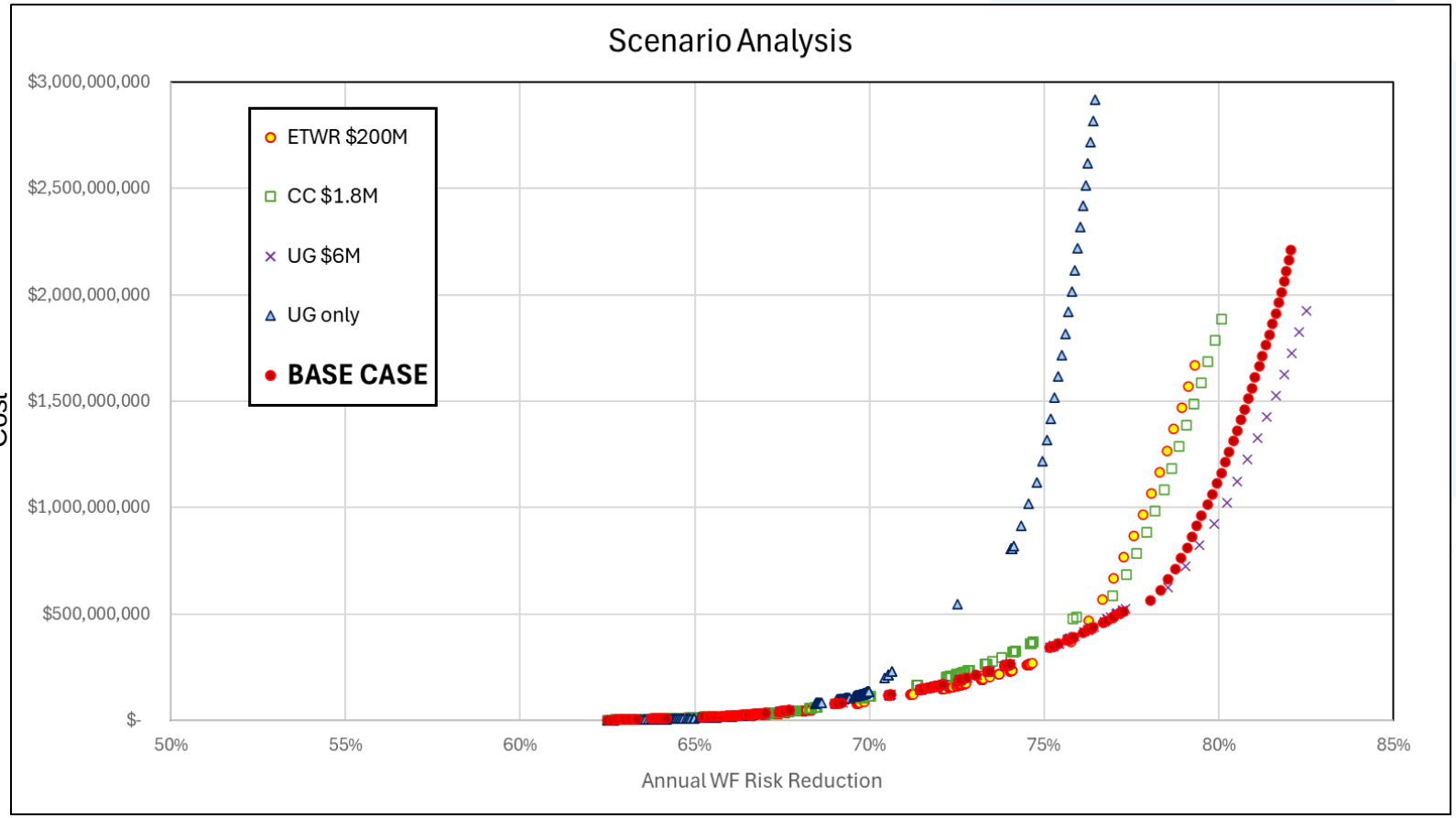
DRAFT Results – Work in Progress

All Scenarios (Except Undergrounding[1]) Achieve ~77.5% Risk Reduction with ~$500M Spend

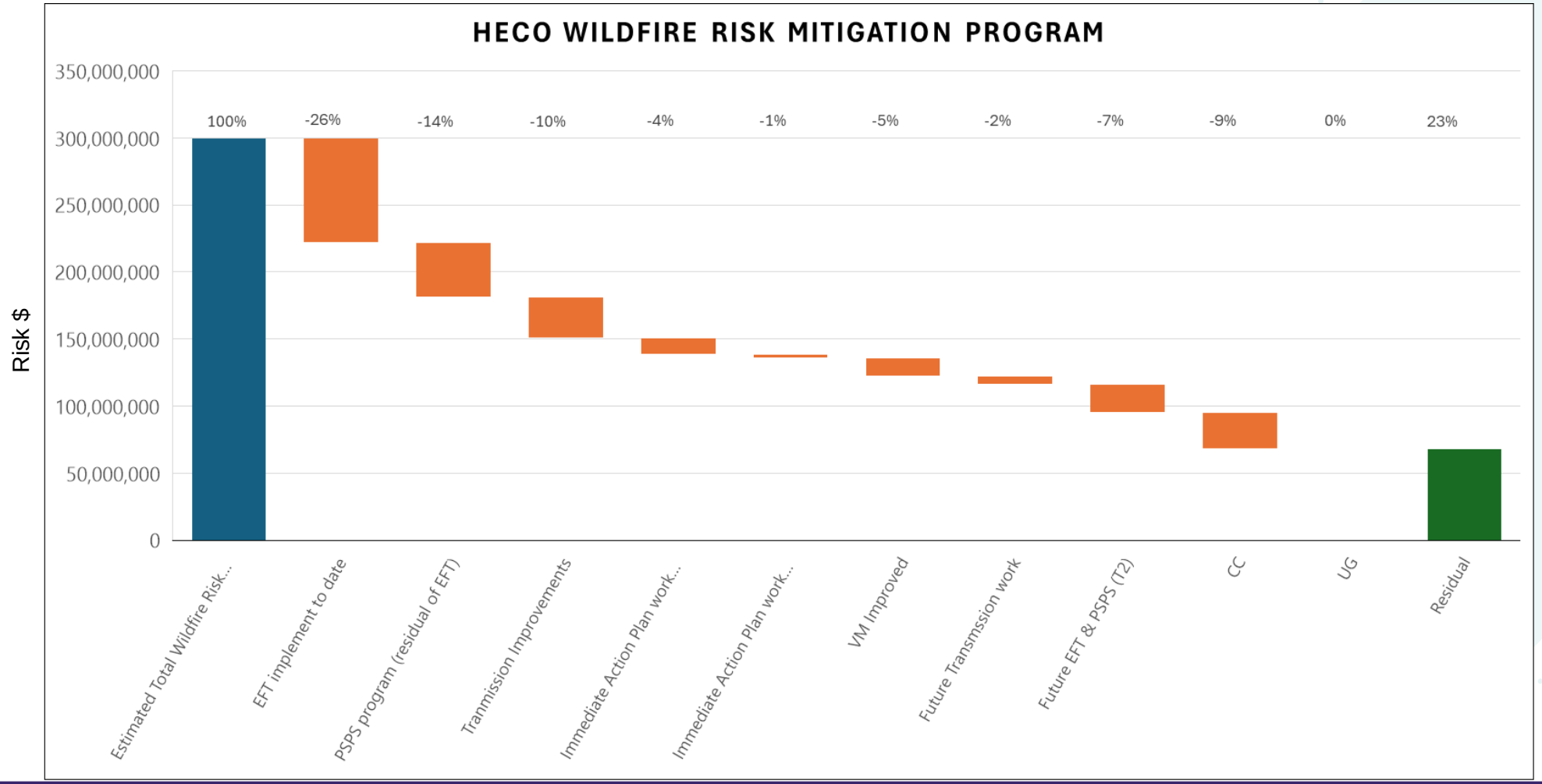




1- Undergrounding results in significantly higher cost, >$10B to achieve 80% risk reduction.

DRAFT Results – Work in Progress

Hawaiian Electric Wildfire Risk Reduction Estimates By Mitigation Program



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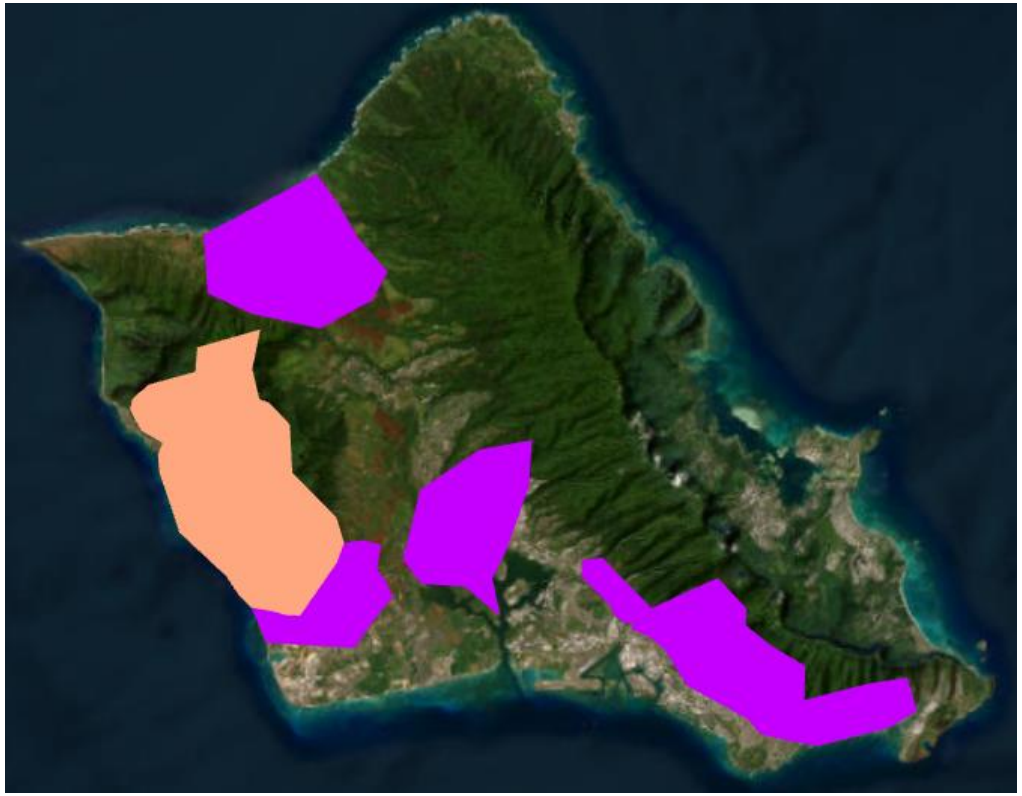
Maps – Oahu

Risk reduction is achieved by expanding the deployment of operational mitigations (EFT and PSPS) in various other medium tier areas and by implementing Covered Conductor on Waianae Coast



Covered Conductor

EFT / PSPS only

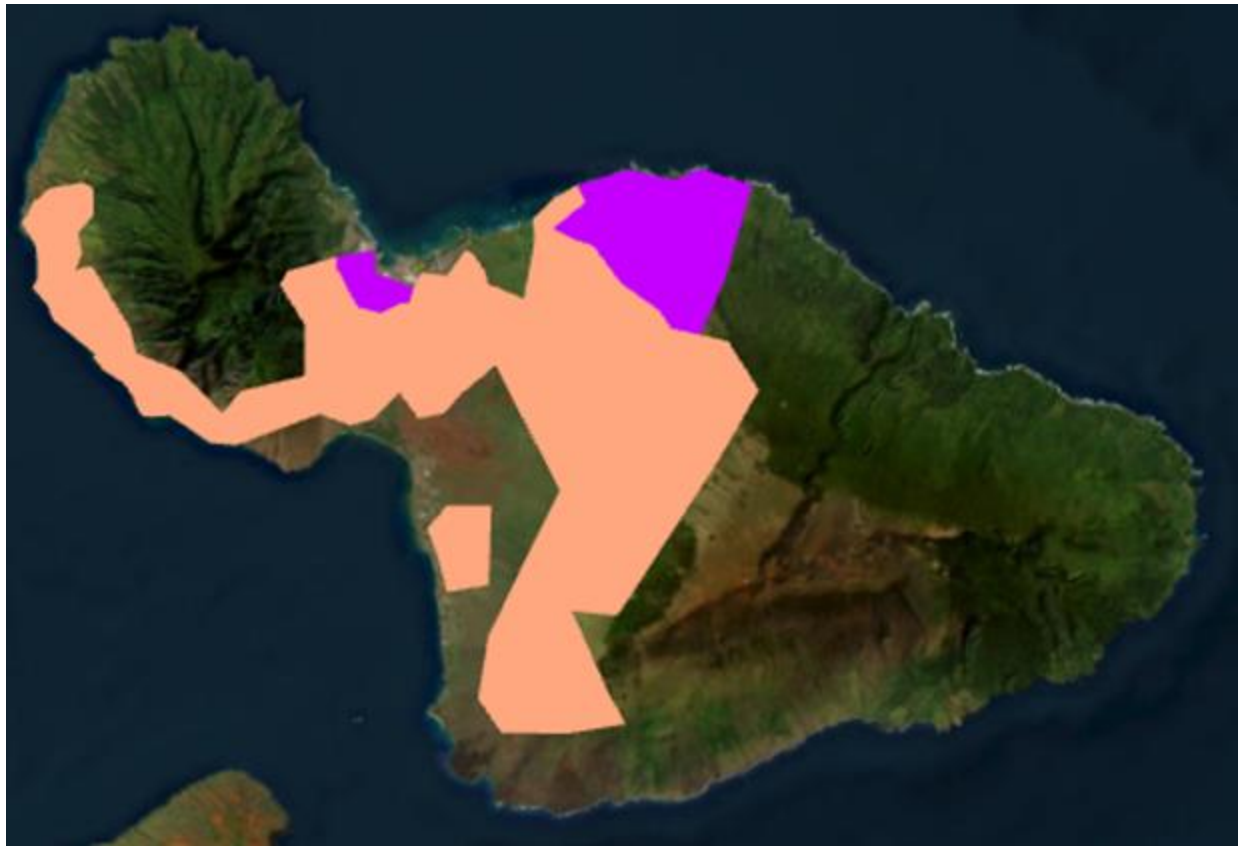
~150 miles Covered Conductor

Note: These are high level visualizations of risk model output. **NOT** meant to be precise.

DRAFT Results – Work in Progress

Maps - Maui

Covered Conductor across most of High-Risk Tier, EFT/PSPS in medium risk areas



Covered Conductor

EFT / PSPS only

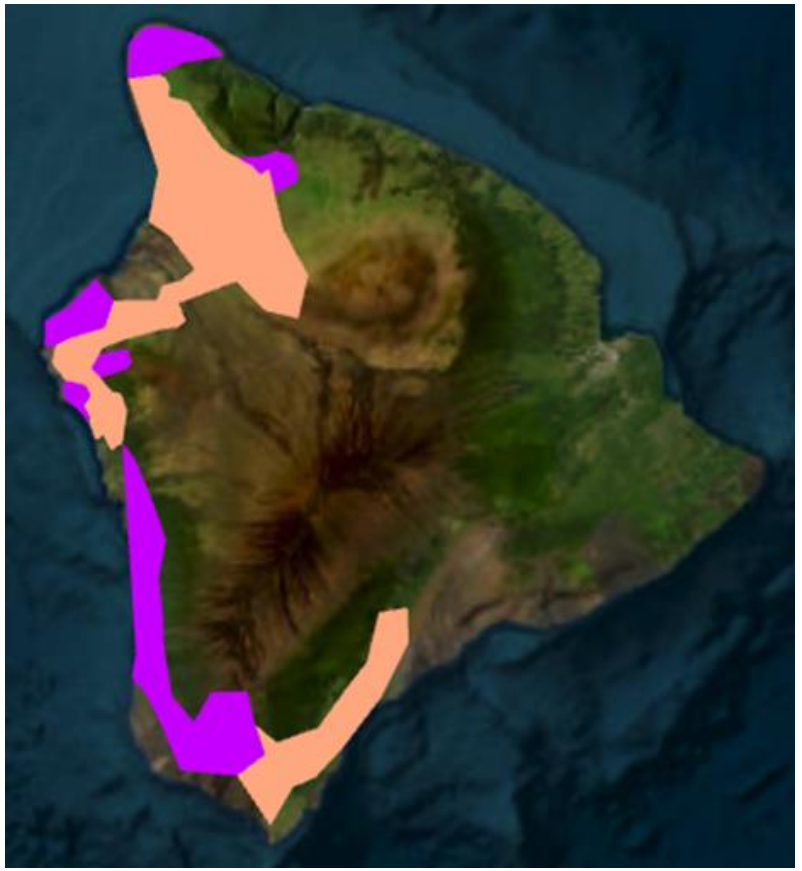
~250 miles Covered Conductor

Note: These are high level visualizations of risk model output. **NOT** meant to be precise.

DRAFT Results – Work in Progress

Maps – Hawaii

Covered Conductor in Kohala and south, EFT and PSPS in various medium tier areas



Covered Conductor

EFT / PSPS only

~400 miles Covered Conductor

Note: These are high level visualizations of risk model output. **NOT** meant to be precise.

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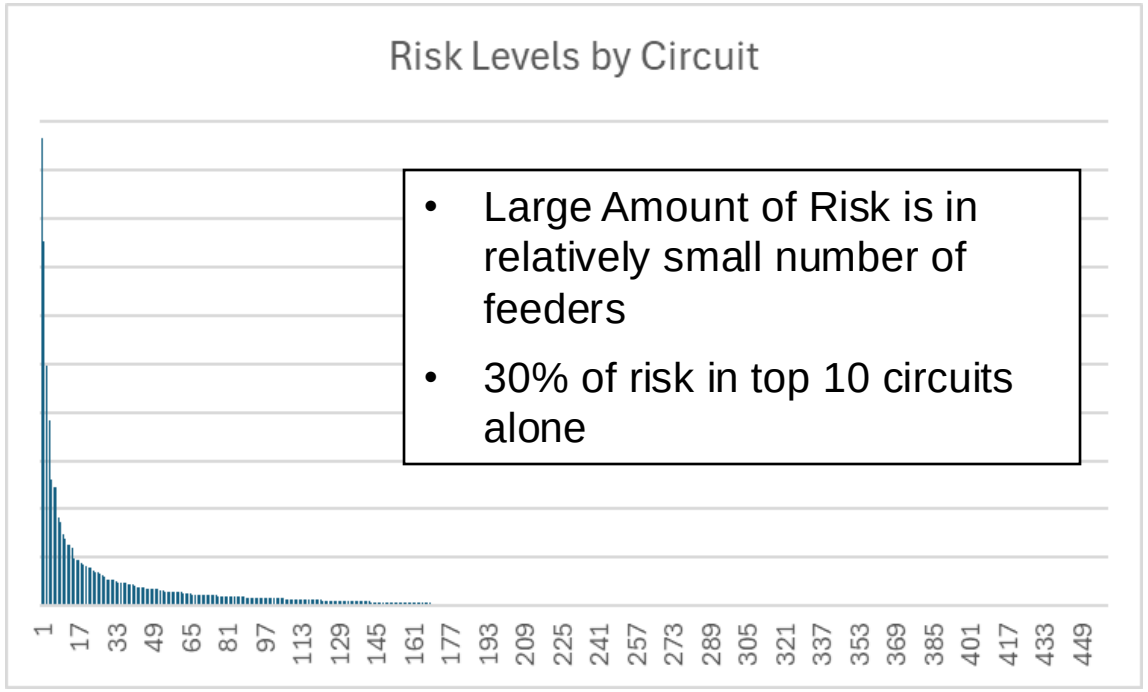
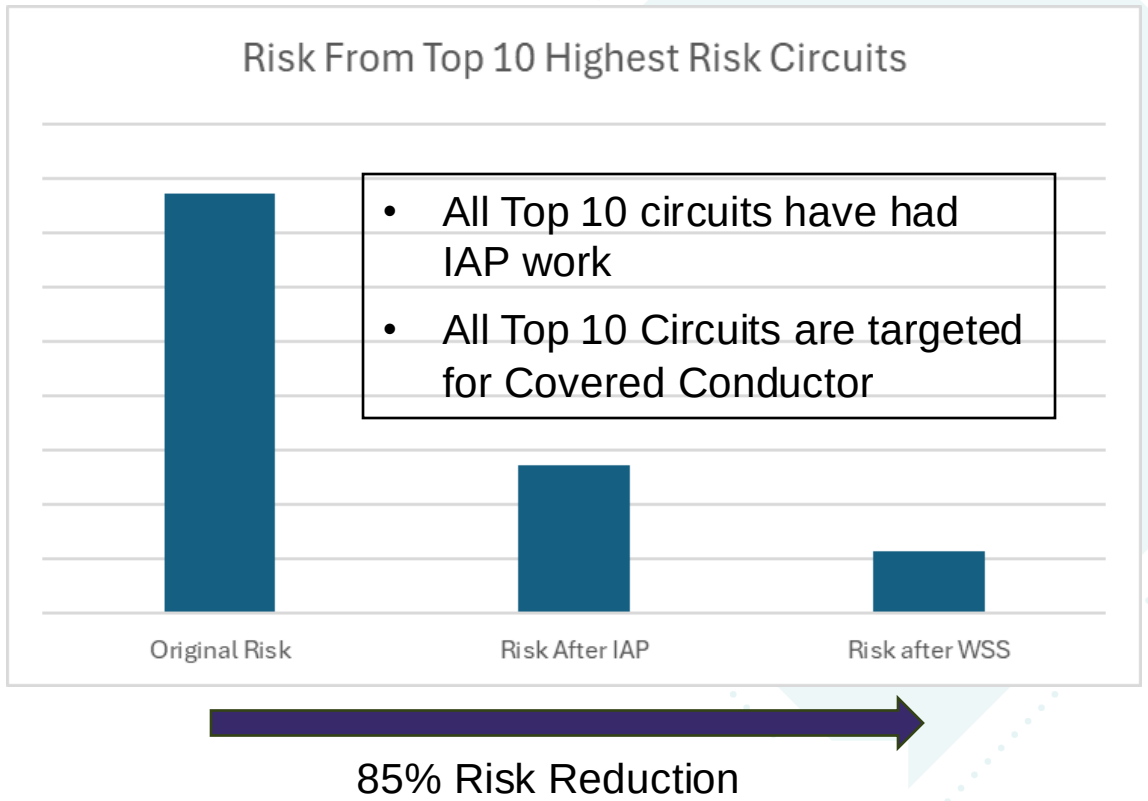
Highest Risk Circuits

Being addressed: First Through IAP then WSS



- Large Amount of Risk is in relatively small number of feeders
- 30% of risk in top 10 circuits alone



- All Top 10 circuits have had IAP work
- All Top 10 Circuits are targeted for Covered Conductor

Feel free to provide any additional feedback

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WFS WG Webpage: https://www.hawaiianelectric.com/safety-and-outages/wildfire-safety/wildfire-safety-working-group-documents

Mahalo!