Island-wide Outage and Restoration

December 26 and 27, 2008

January 14, 2009 Legislative Briefing

December 26th Event

Presentation Agenda

- Summary of event
- Overview of system
- Definitions
- Lightning data
- Transmission short circuits
- Event chronology
- Restoration
- Communications
- Post-restoration efforts

The Oahu Electrical System

- Geographically isolated
  - Not interconnected to other grids
  - Self reliant for generation
  - Therefore, if something happens to our equipment, it could result in long, extended outages

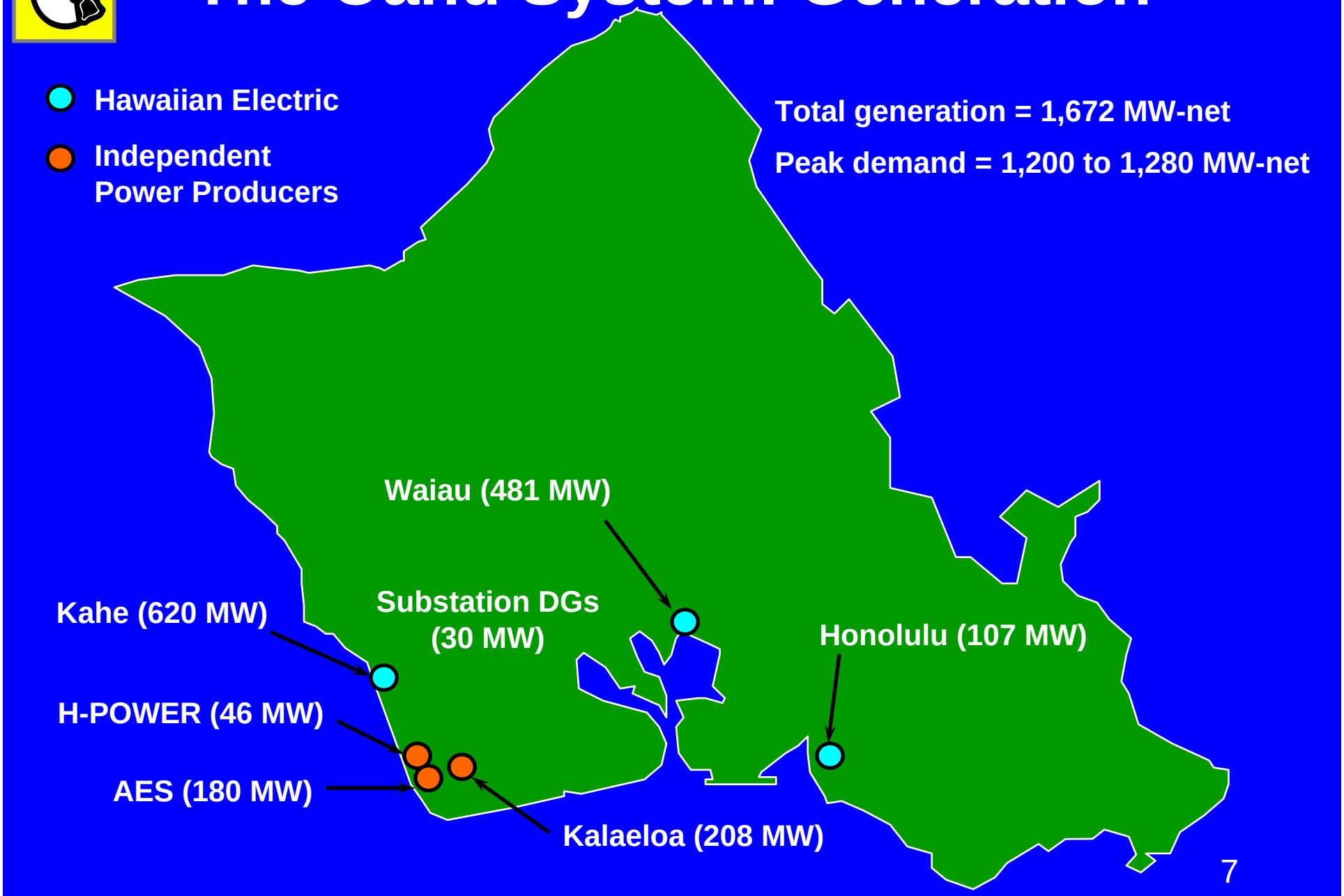
The Oahu Electrical System

- Current generation system
  - Primarily steam generation
  - Benefits
    - Efficient
    - Stable
  - Slower starting
- Planned generation additions
  - New faster starting generator at Campbell Industrial Park
  - Airport Distributed Standby Generator

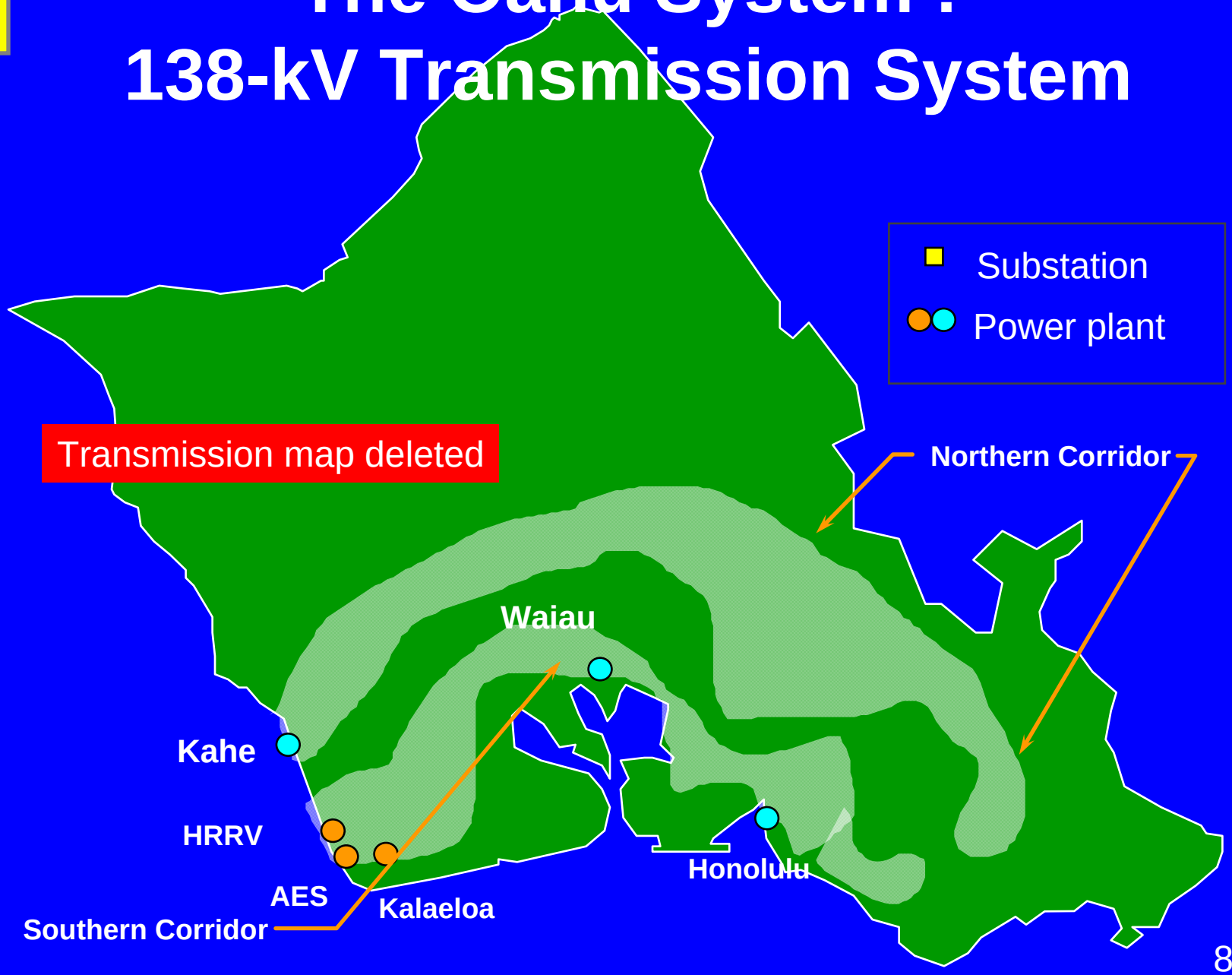
The Oahu Electrical System

- Design and operating philosophy
  - Need to balance two sometimes competing interests:
    - Protect equipment and operate for another day
    - Minimize customer outages
  - How do we accomplish this?
    - Transmission lines and generators have protection equipment to prevent damage
    - Spinning reserve
    - Load shedding to mitigate system instability

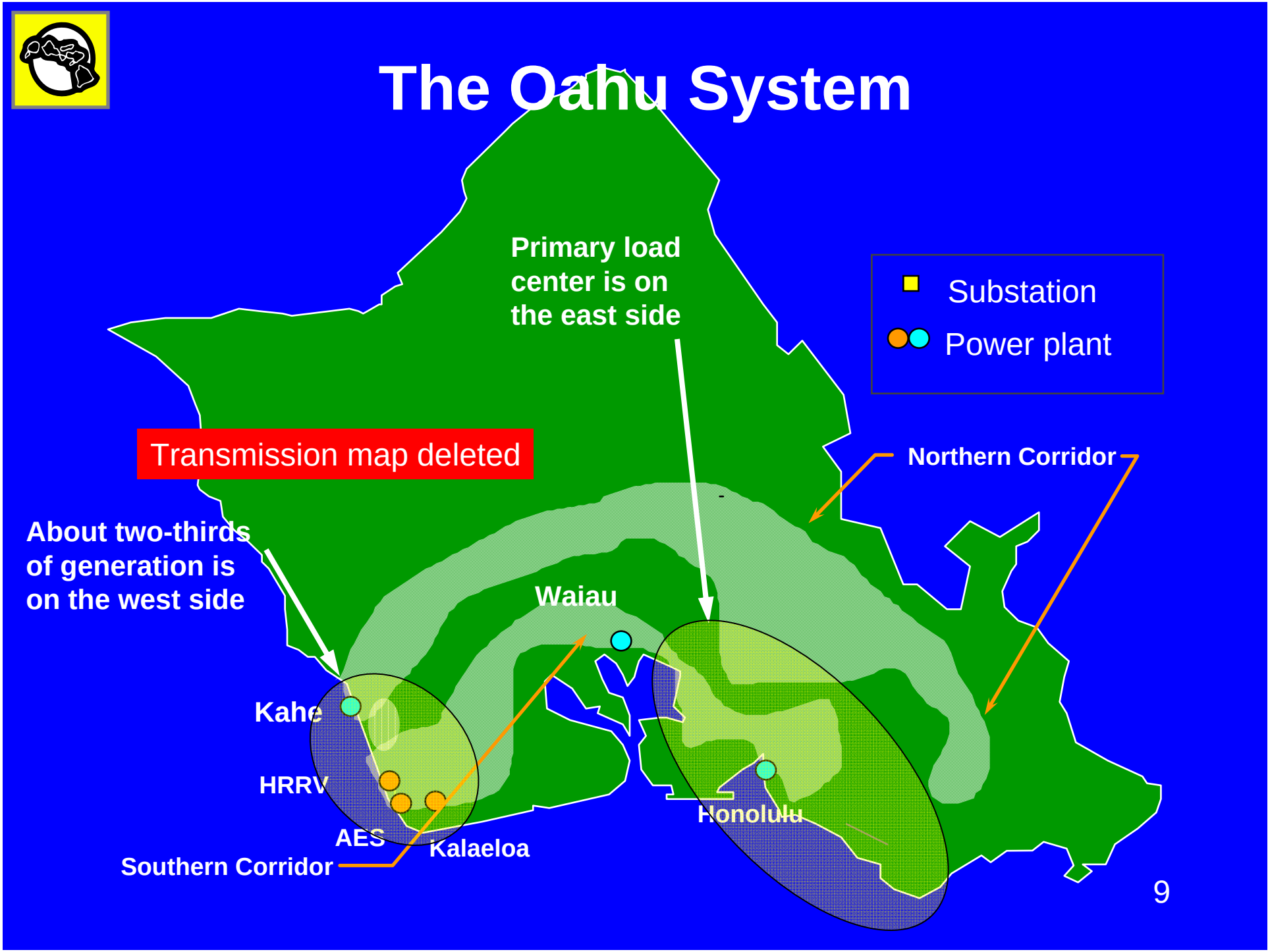
The Oahu System: Generation



The Oahu System : 138-kV Transmission System



The Oahu System

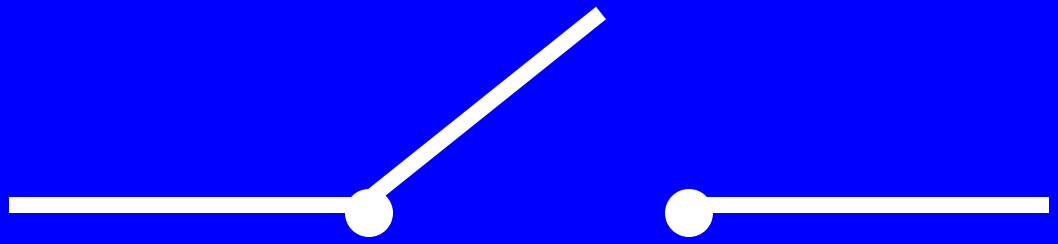


Oahu System Summary

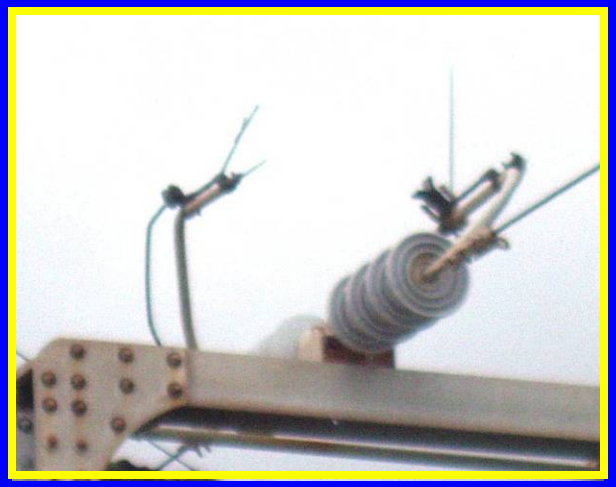
- Geographic isolation
- Primarily steam generation
- Design & operating philosophy a balance of equipment protection and minimizing customer outages
- Power generated flows from west to east on transmission system

Open Circuit

- An “open” or “tripped” circuit is where the transmission line or generator has been cut off or disconnected by automatically or manually opening a breaker.



When a circuit is open, electrical power cannot flow



Open Switch 46kV

Closed Circuit

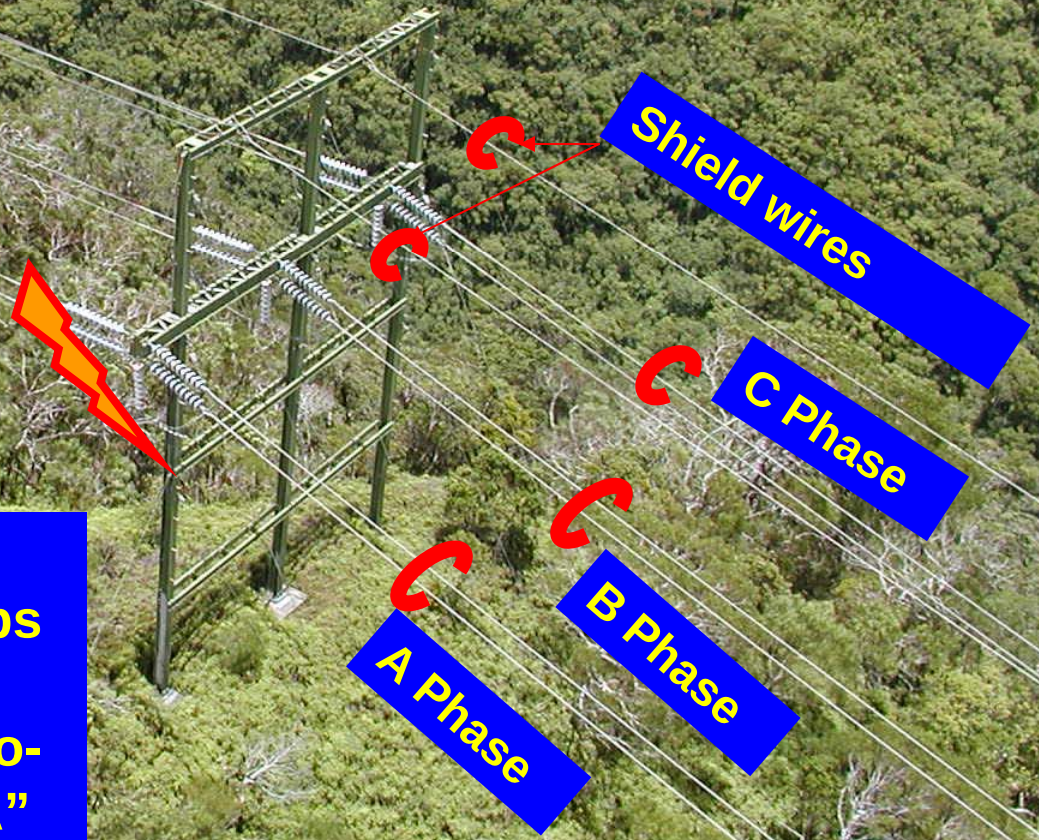
- A “closed” circuit is where the power is flowing through the circuit without interruption.

When a circuit is closed, electrical power can flow

Closed Switch 46kV

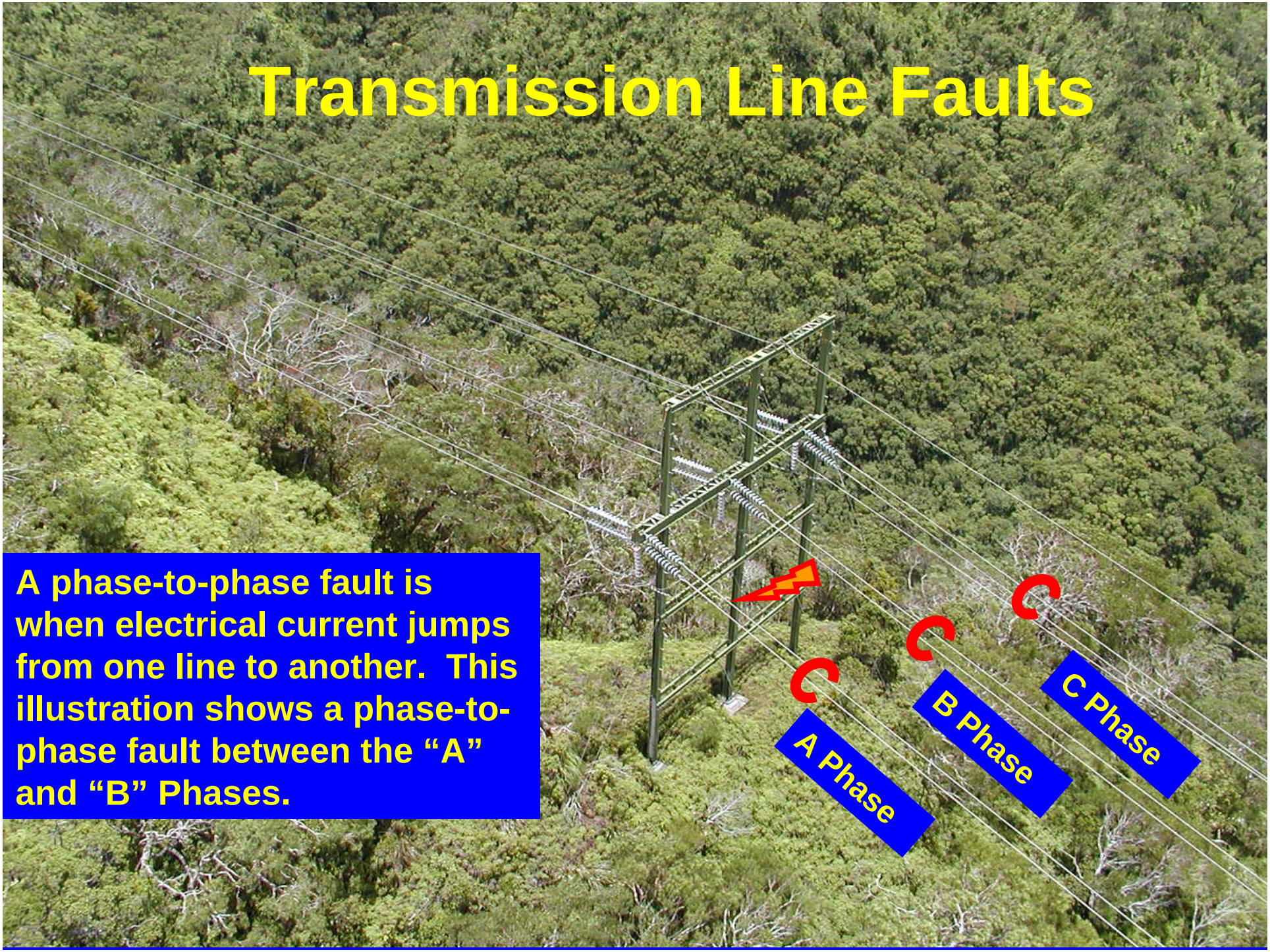
Transmission Line Fault

A fault is what causes a line to trip off. It is a "short circuit."



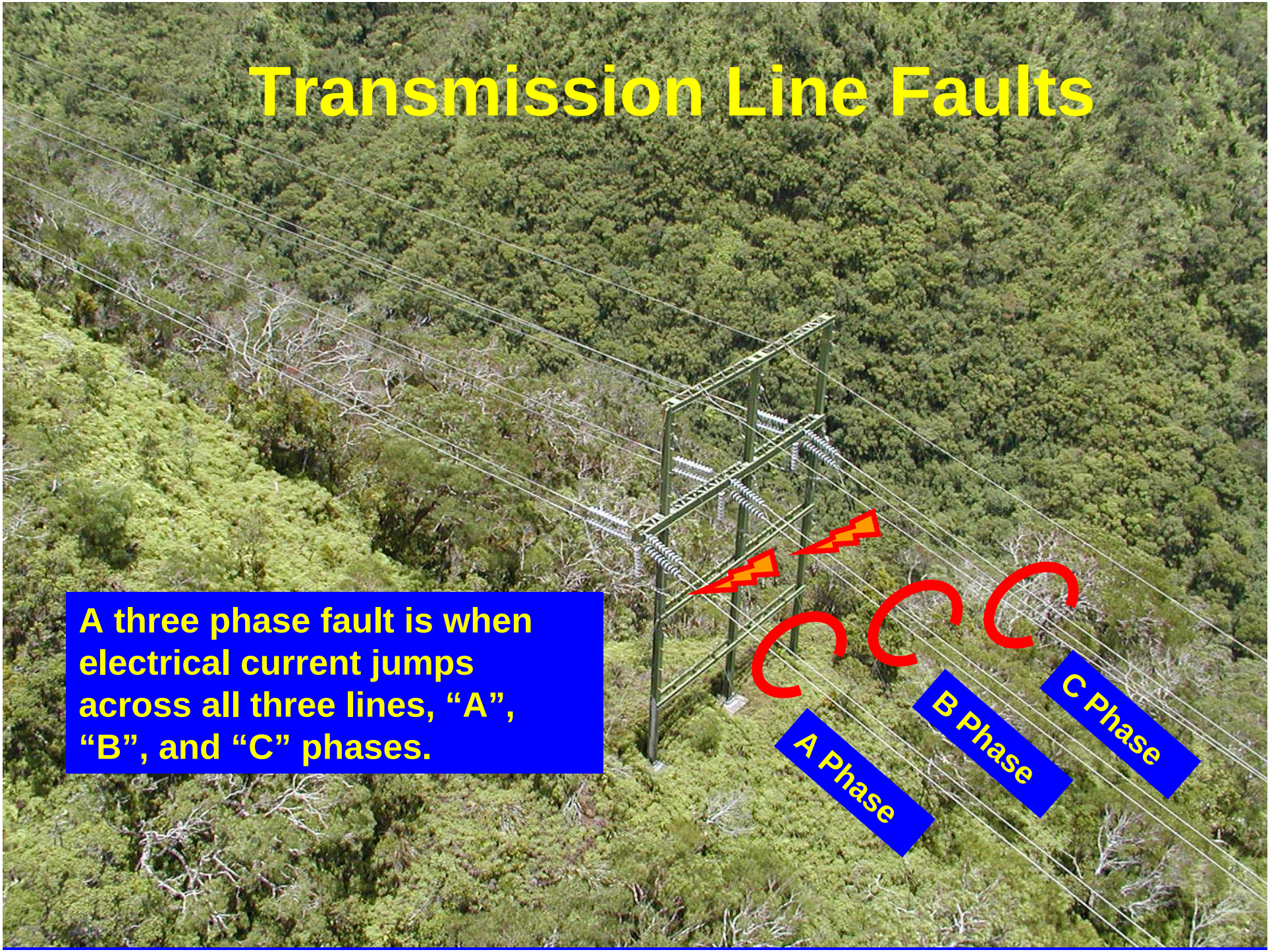
A phase-to-ground fault is when electrical current jumps from a line to ground. This illustration shows a phase-to-ground fault between the "A" phase and the transmission structure.

Transmission Line Faults



A phase-to-phase fault is when electrical current jumps from one line to another. This illustration shows a phase-to-phase fault between the "A" and "B" Phases.

Transmission Line Faults



A three phase fault is when electrical current jumps across all three lines, “A”, “B”, and “C” phases.

Example of a Three Phase Fault Caused by Lightning

Source: EPRI

What We Know of Transmission line faults

Transmission line faults can be caused by any of the following:

1. The shield wire snapping and falling on the transmission line
2. Foreign object (such as trees, branches, or other types of debris) falling across or being blown (high wind gusts) into the transmission line
3. Transmission tower structure failure
4. Lightning strikes

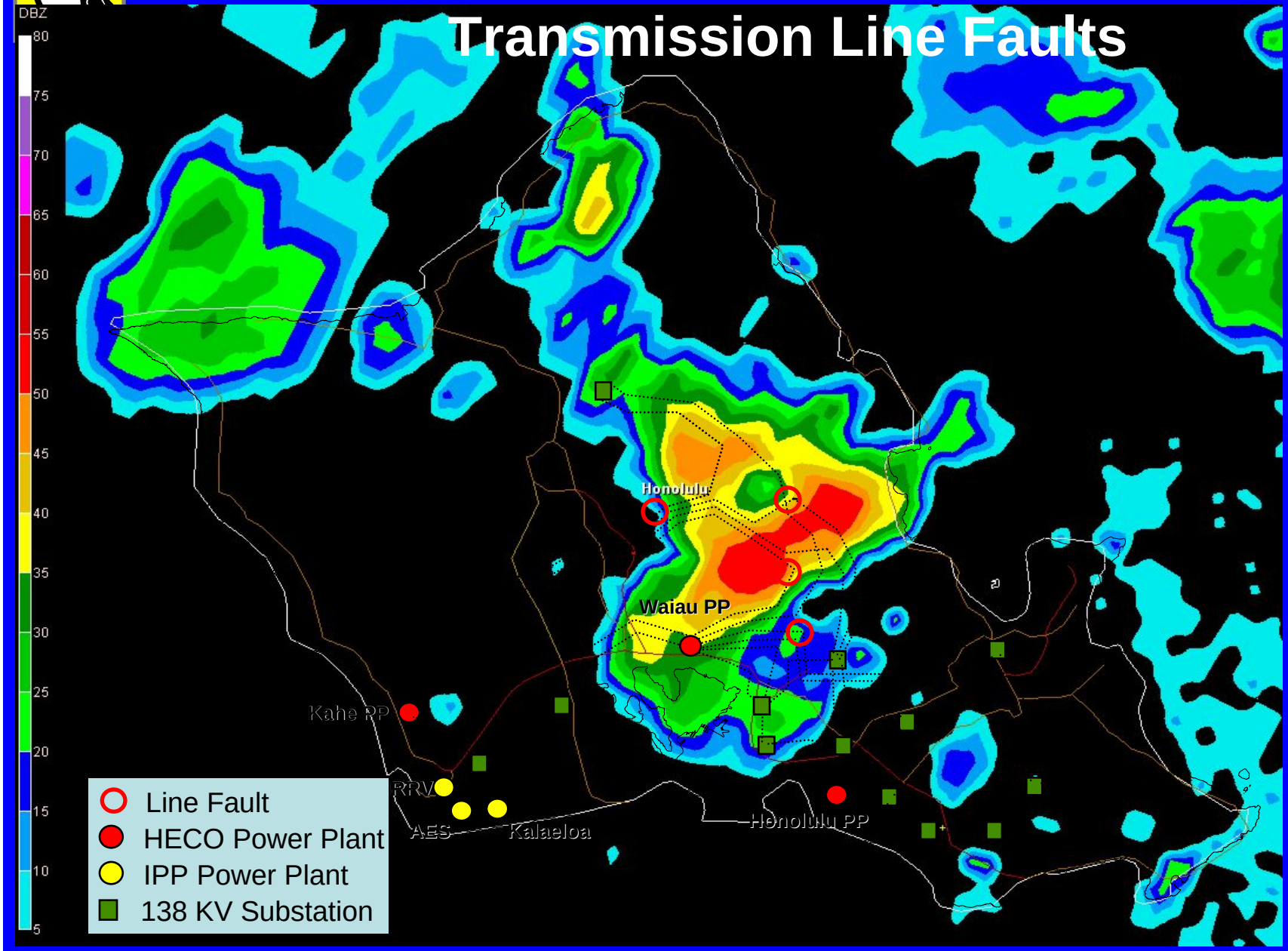
Inspections to date have eliminated Nos. 1, 2, and 3…and evidence of what appears to be a lightning strike has been found on the Kahe-Waiau line

What Lightning Experts are Telling Us

- Finding the actual place of a lightning strike on a line is like “finding a needle in a haystack” since the actual point of contact may not show any visible signs on the outside of the line.
- A lightning strike near a power line can trigger a line fault just as a direct strike on the line itself by making the air between the phases of the transmission line more conductive to electricity.

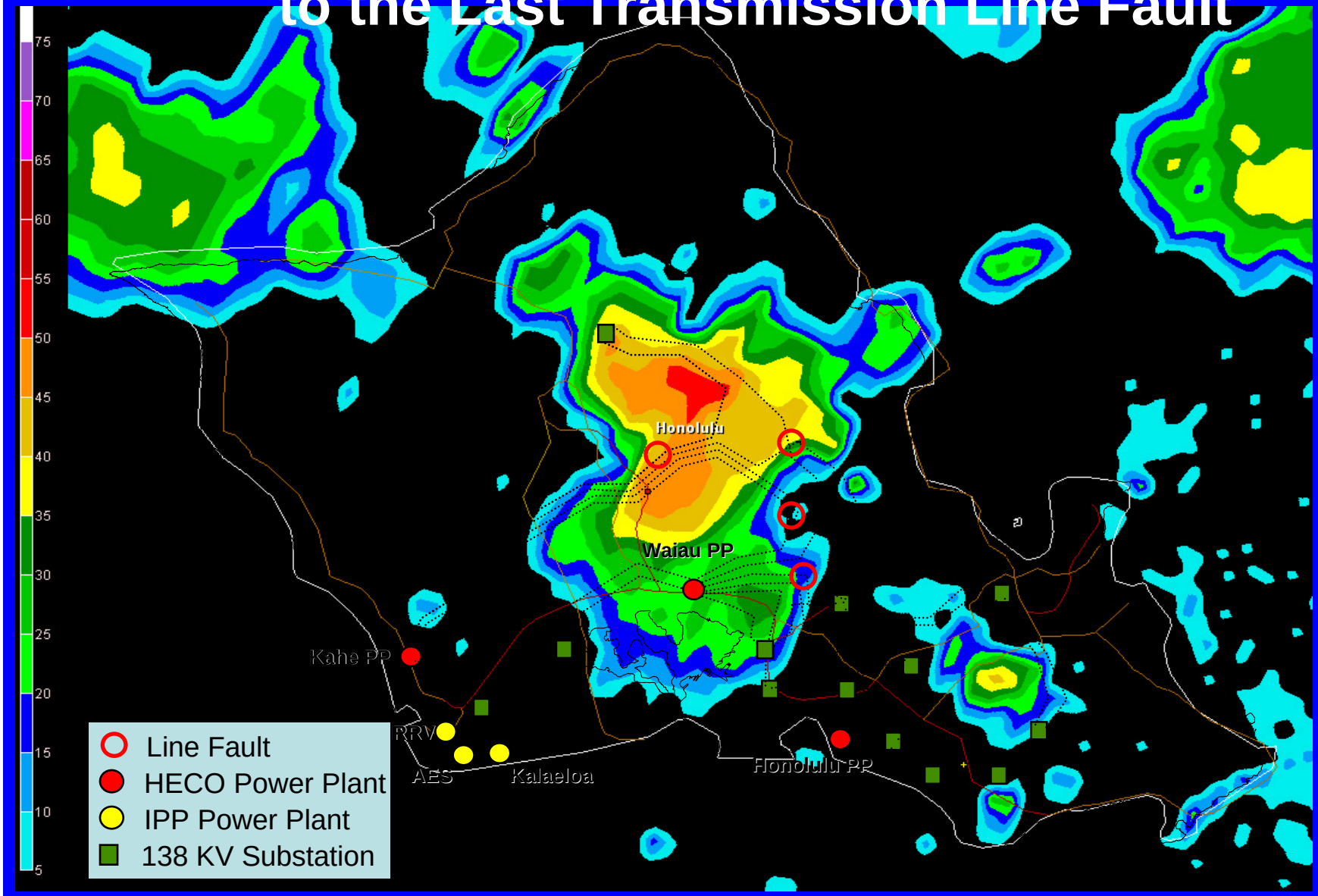
Source: Electric Power Research Institute (EPRI)

Doppler Radar @ 18:25, Prior to a Series of Transmission Line Faults



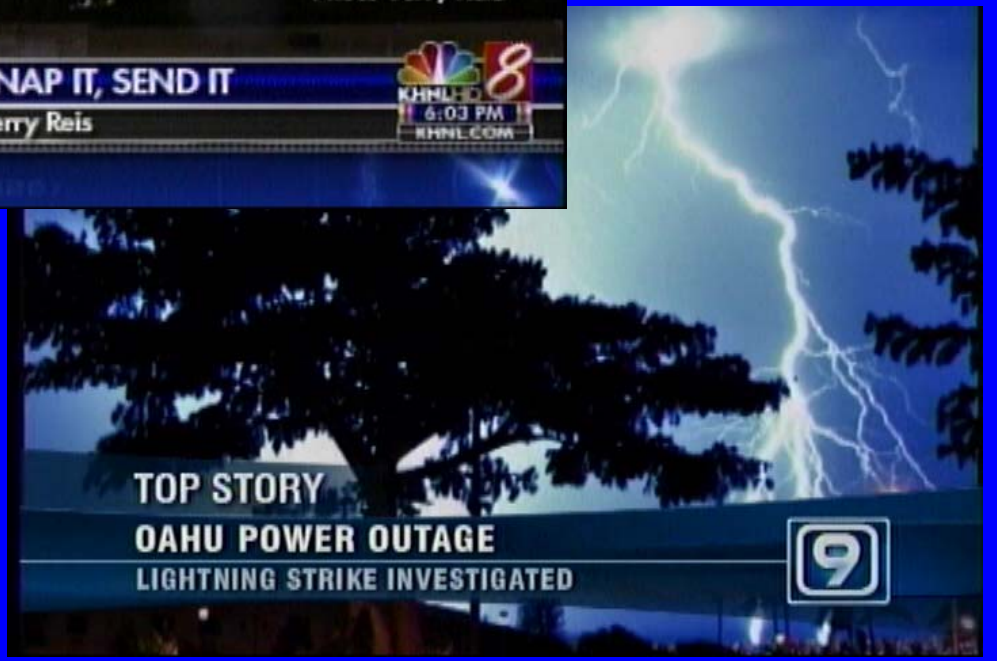
Source: National Weather Service Honolulu

Doppler Radar @ 18:40, Two Minutes Prior to the Last Transmission Line Fault



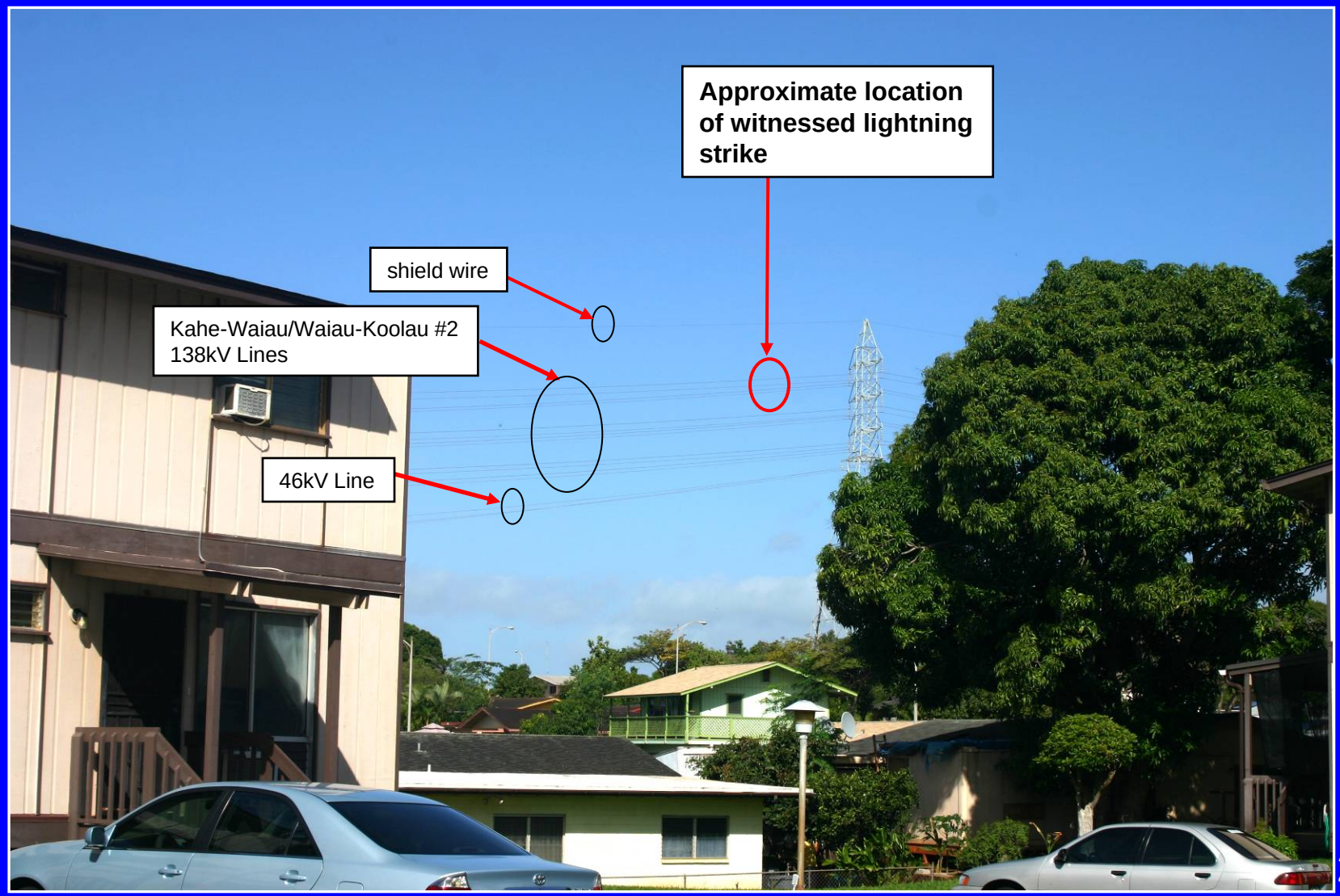
Source: National Weather Service Honolulu

Lightning Strikes Were Reported in the Central Oahu Area



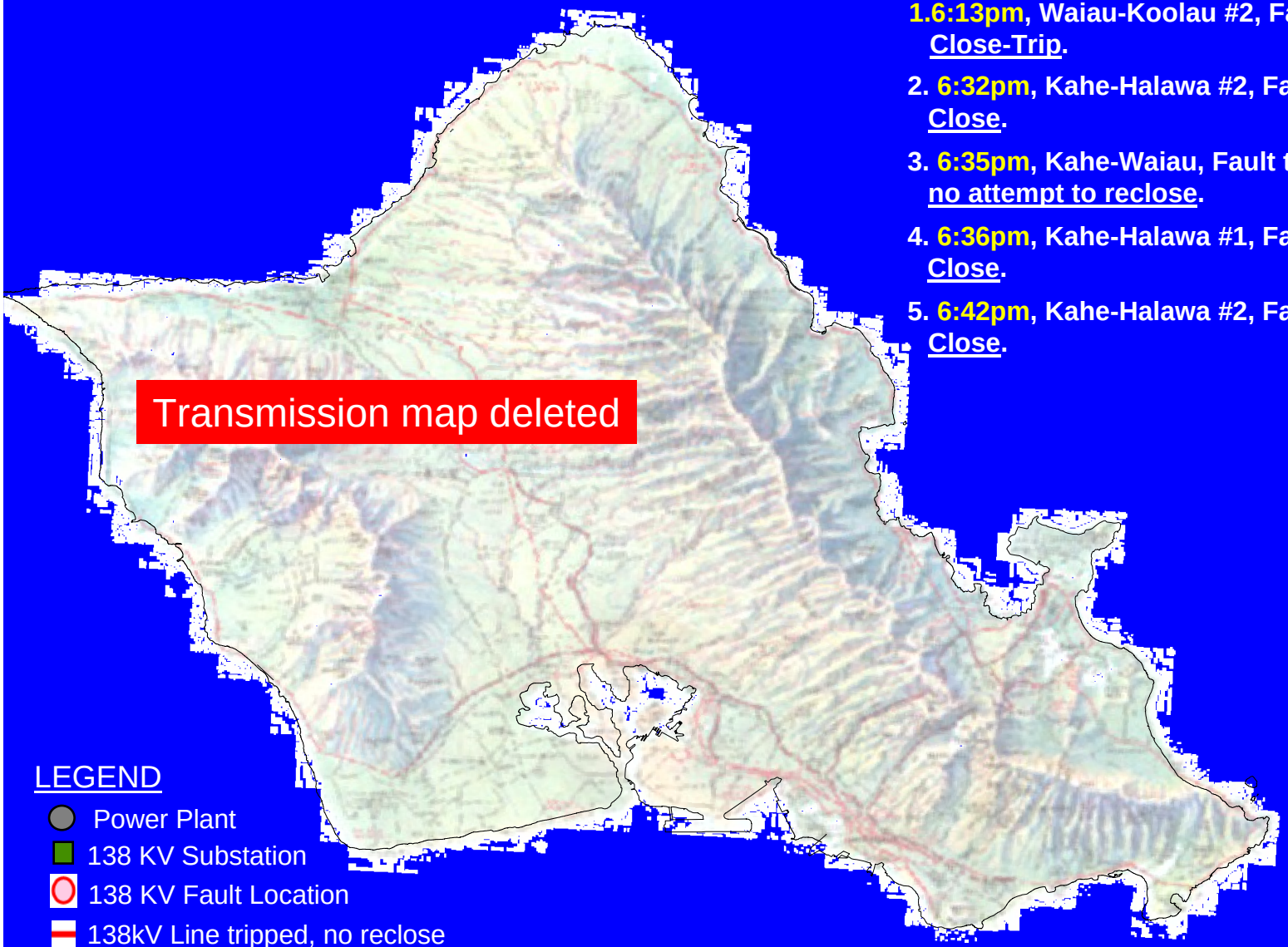
Eyewitness Report of Lightning near our Transmission Lines (Koa Ridge Ranch area)

Eyewitness Report of Lightning near our Transmission Lines (Waiau Subdivision)



138kV Transmission Line Fault Locations

1. 6:13pm, Waiau-Koolau #2, Fault type: C-Gnd, Trip-Close-Trip.
2. 6:32pm, Kahe-Halawa #2, Fault type: A-Gnd, Trip-Close.
3. 6:35pm, Kahe-Waiau, Fault type: A-B-C, Trip-no attempt to reclose.
4. 6:36pm, Kahe-Halawa #1, Fault type: C-Gnd, Trip-Close.
5. 6:42pm, Kahe-Halawa #2, Fault type: A-Gnd, Trip-Close.



Eyewitness Report of Lightning near our Transmission Lines

Transmission map deleted

A

A

B

B

LEGEND

- Power Plant
- 138 KV Substation
- 138 KV Fault Location
- 138kV Line tripped, no reclose
- 138kV Line tripped and reclosed
- Witness accounts of lightning strike

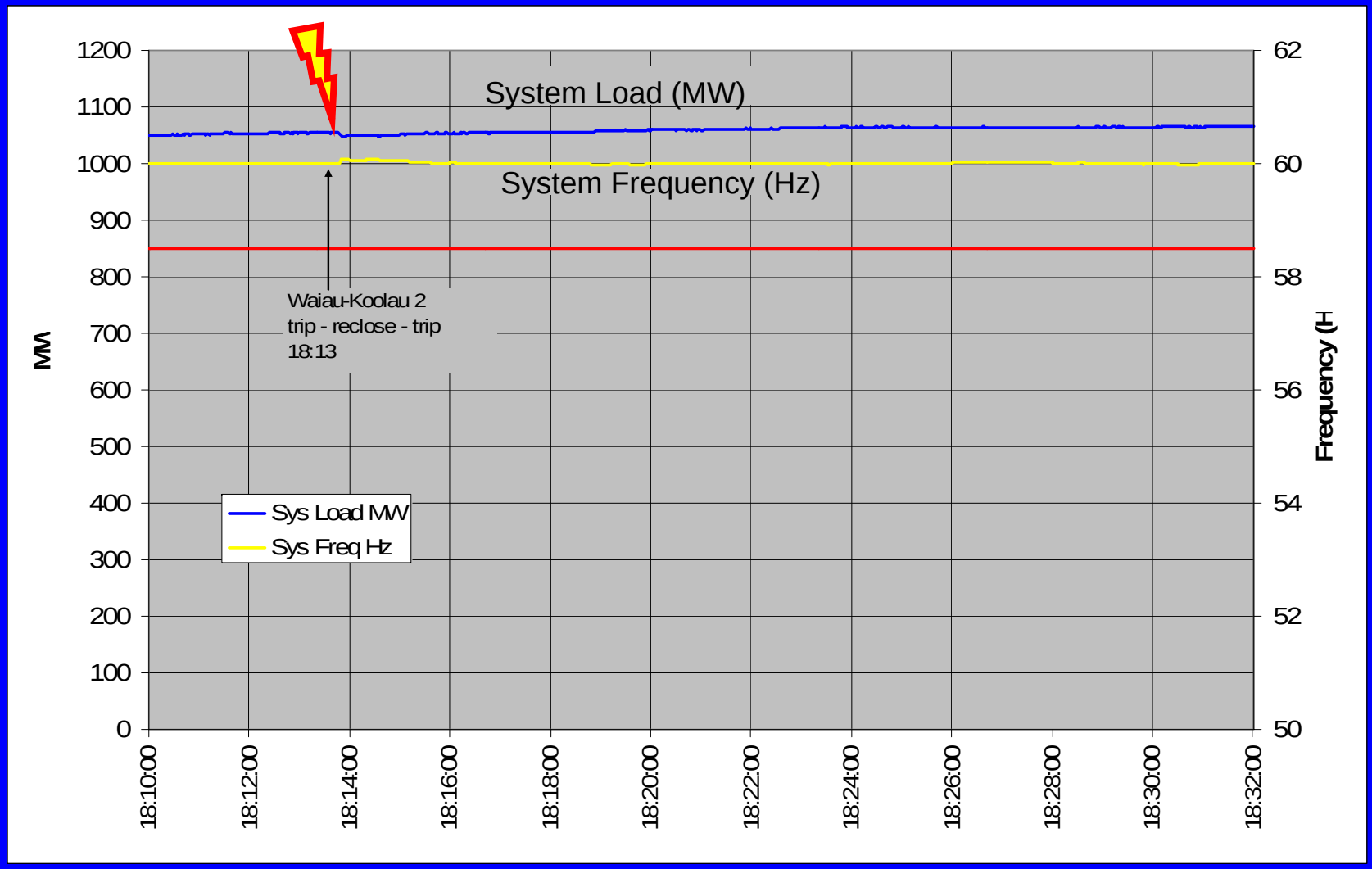
HECO Relay Times Match Detected Lightning Strikes

- Protective relays trip off multiple transmission lines at same time lightning detected by Pacific Lightning Detection Network (PacNet)

Transmission Line	HECO Relay Date & Times	PacNet Detects Lightning Strikes Date & Times
Kahe-Waiau	12/26/08 - **18:35:30 HST**	12/26/08 - **18:35:30 HST**
Kahe Halawa #1	12/26/08 - **18:36:22 HST**	12/26/08 - **18:36:22 HST**

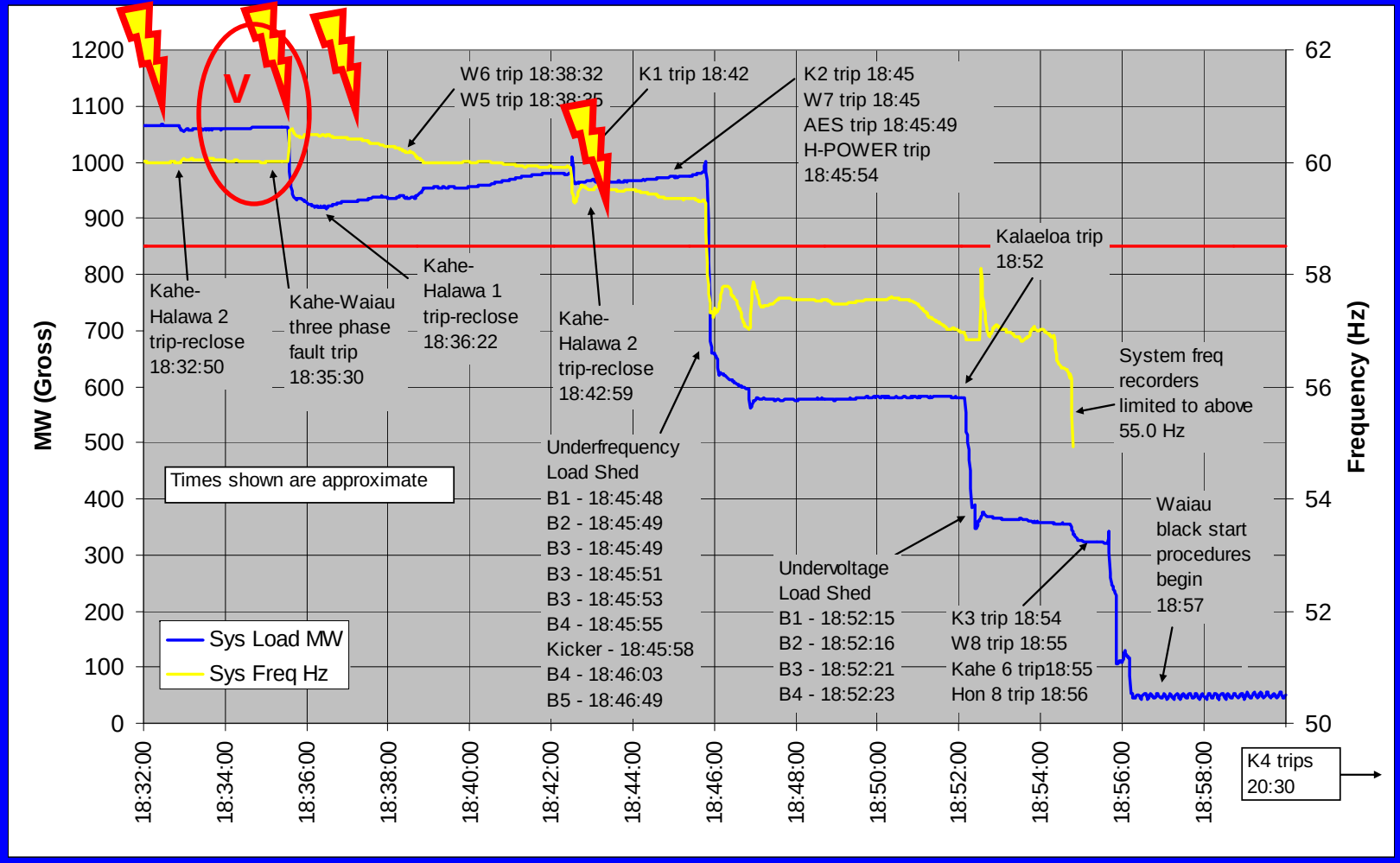
System Generation & Freq. vs. Time

Friday, December 26, 2008, 18:10-18:32



System Generation & Freq. vs. Time

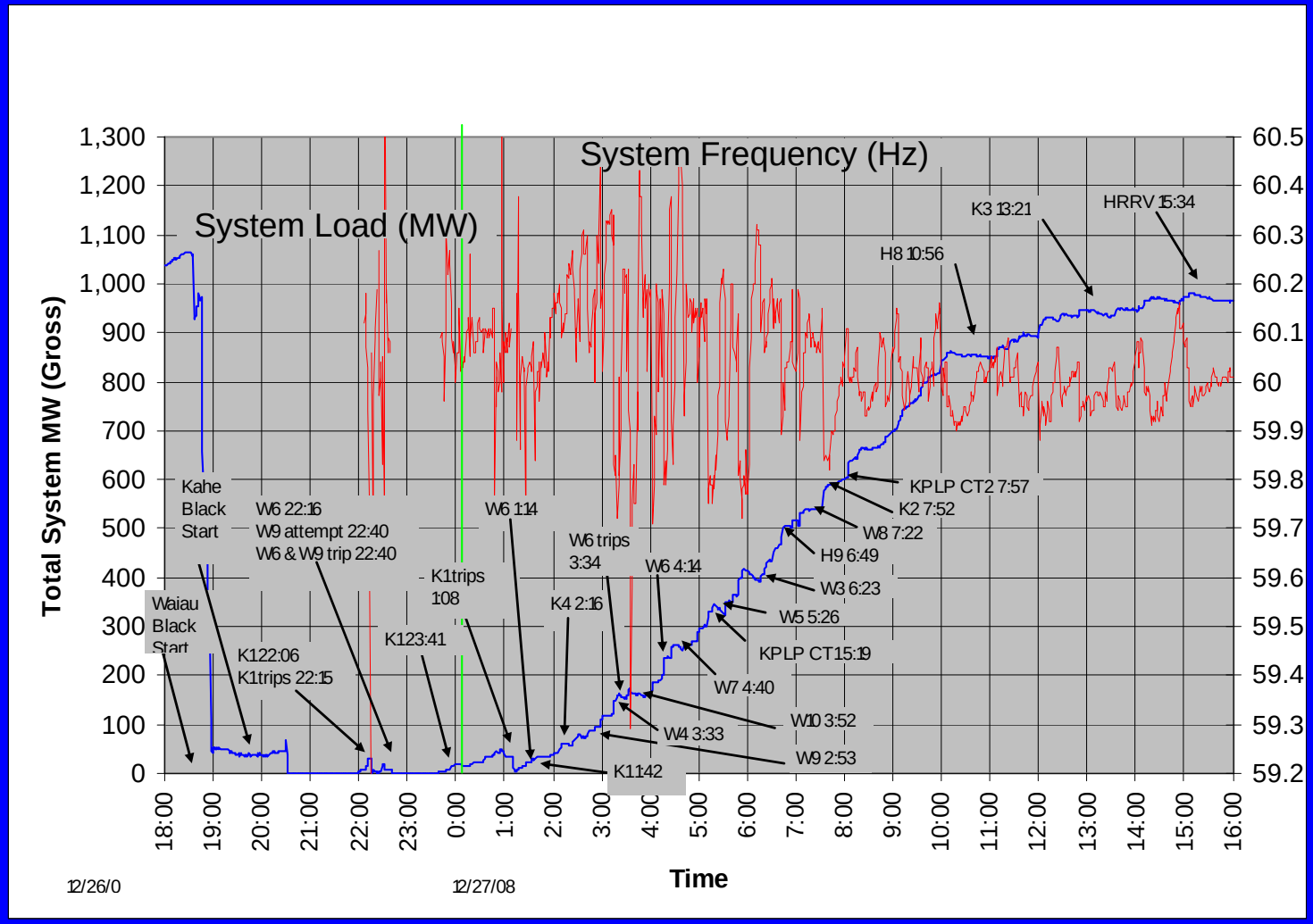
Friday, December 26, 2008, 18:32-19:00



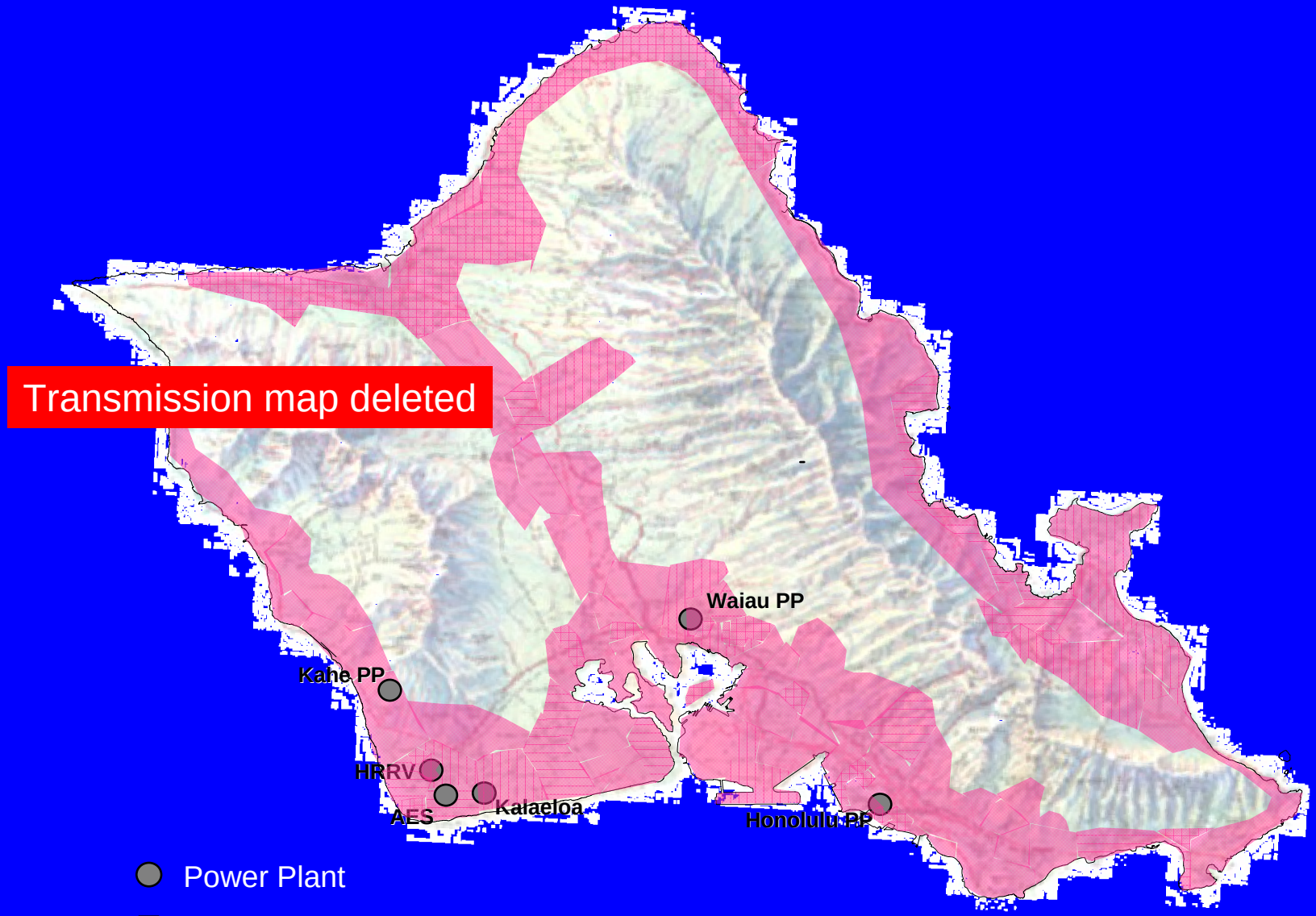
Event Summary

- Severe and unusual lightning strikes caused multiple short circuits on the transmission system, resulting in increasing system instability
- This instability caused a significant amount of customer load to shut down followed by a series of generation shut downs and the eventual island-wide outage

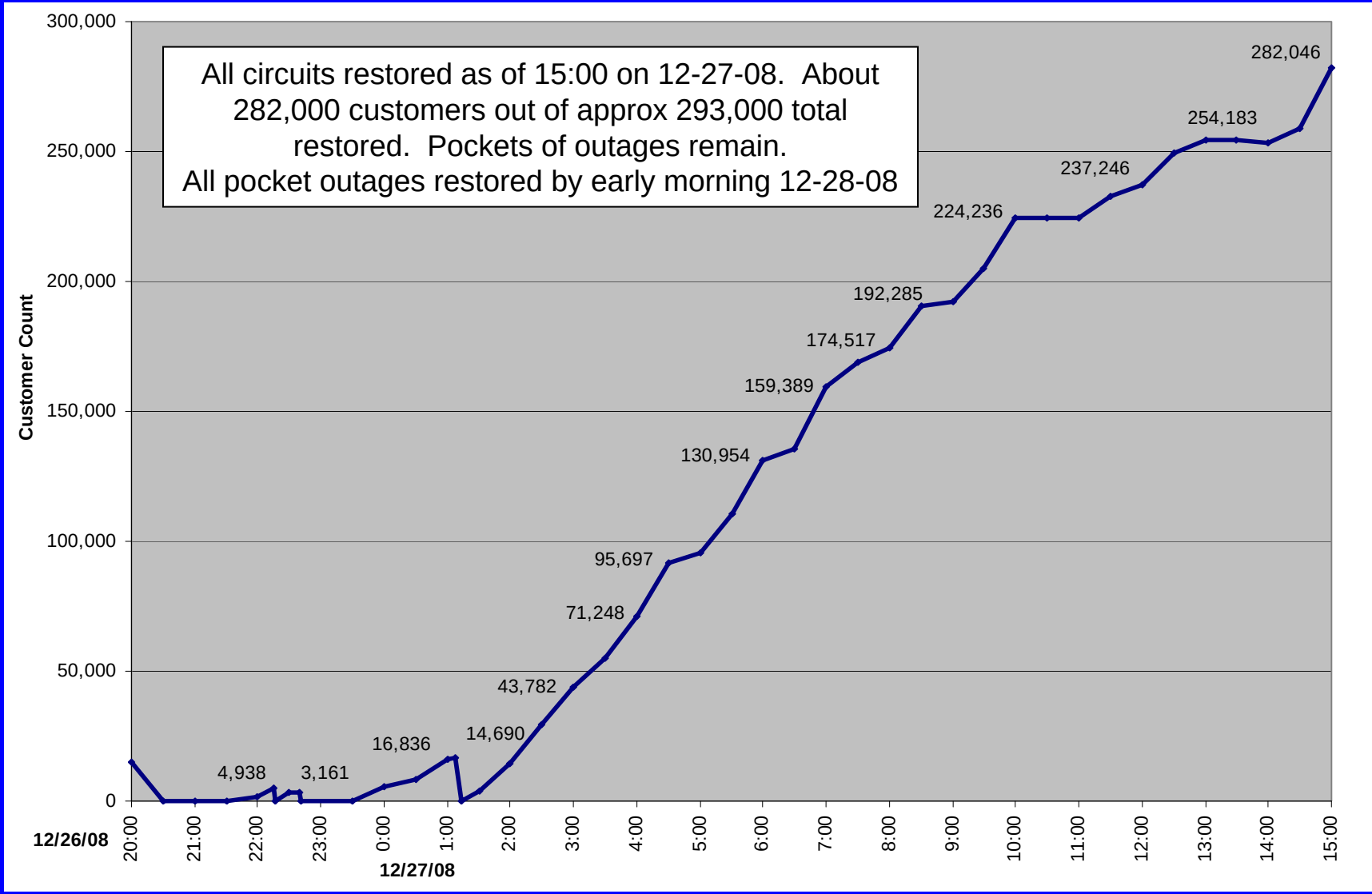
Restoration Timeline
December 26 and 27



Customer Restoration



Customer Restoration



Pocket Outages

- By 3:00pm on December 27th, all distribution circuits were energized
- Crews worked until the early morning of December 28th, to restore customers affected by pocket outages

Restoration Summary

- Restoration is a careful and methodical restoration process
- Rebuilding the HECO system and restoring all customers must initially be in small increments, carefully maintaining voltages and frequency
- Loads are restored around the energized transmission system
- Restoration strategy includes prioritizing critical customers along the way

Communications

- State and County
  - State Civil Defense
  - Oahu Dept. of Emergency Management
  - Honolulu Police Department
  - Governor/Mayor
  - Public Utilities Commission/Consumer Advocate
  - Other government officials

Communications

(continued)

- Public communications
  - Call in to KSSK within 30-minutes after load shedding
  - Company spokesman at KSSK within an hour, providing on-air status reports through the night and for most of the next day
  - Ongoing updates to other local and national media
  - Press conferences (12/27 and 12/28)
  - Customer Service call center fully staffed
    - Supplemented with updated recorded messages
  - Major commercial customer contacts

Post-Restoration Efforts

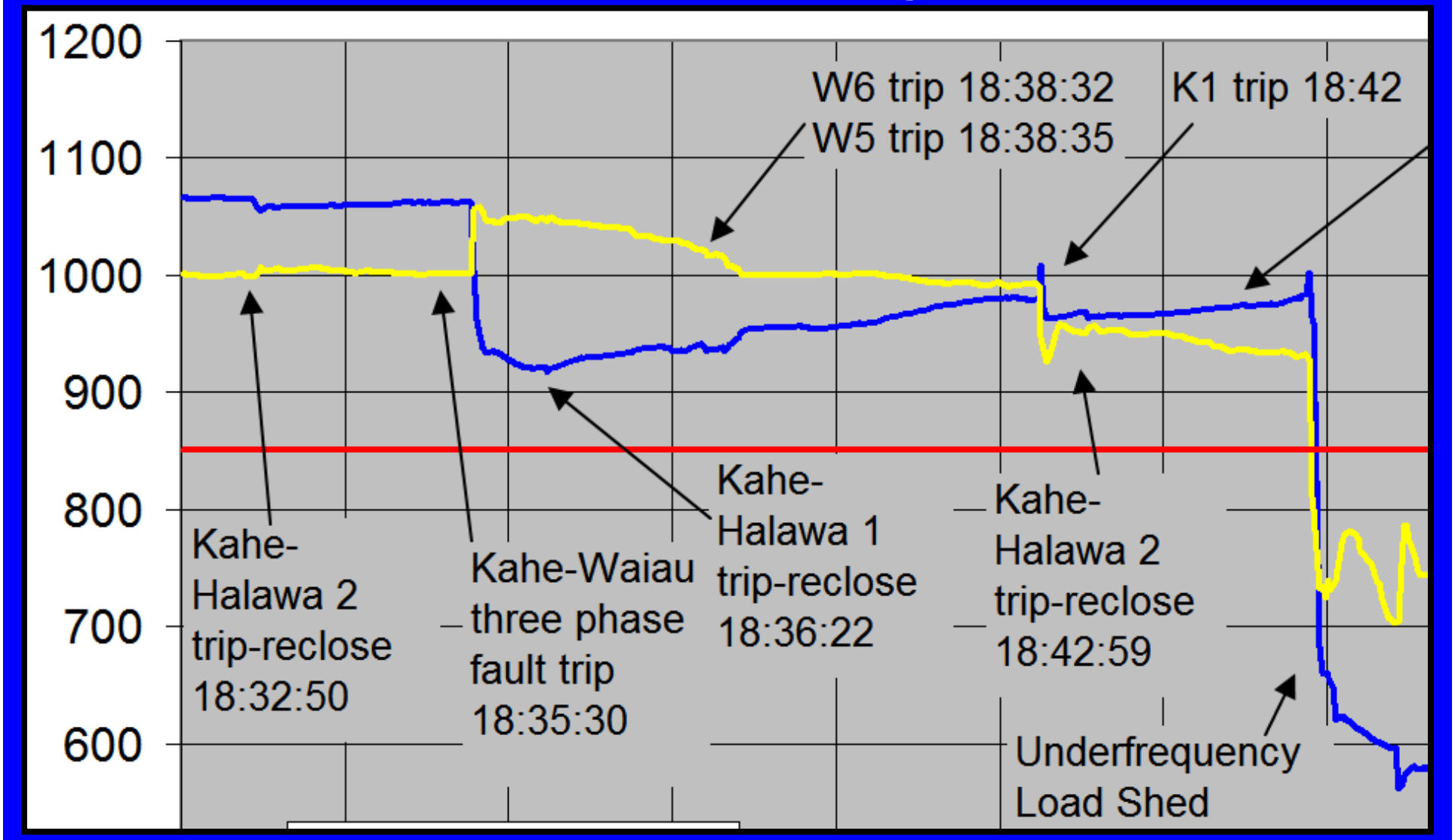
- Continue inspections of equipment
- Expert consultation and review to further determine and confirm what caused system loss and to review restoration efforts

Post-Restoration Efforts

(continued)

- Expert consultation on what, if anything, should be done to further "harden" the system
- Planned generation additions
  - New faster starting generator at Campbell Industrial Park
  - Airport Distributed Standby Generator

Summary


1200
1100
1000
900
800
700
600
W6 trip 18:38:32
W5 trip 18:38:35
K1 trip 18:42
Kahe-
Halawa 2
trip-reclose
18:32:50
Kahe-Waiau
three phase
fault trip
18:35:30
Kahe-
Halawa 1
trip-reclose
18:36:22
Kahe-
Halawa 2
trip-reclose
18:42:59
Underfrequency
Load Shed

Thank You