

# In Their Shoes: Flash Flood Decision-Making Under Forecast Uncertainty



*CIROH DevCon – May, 2026*

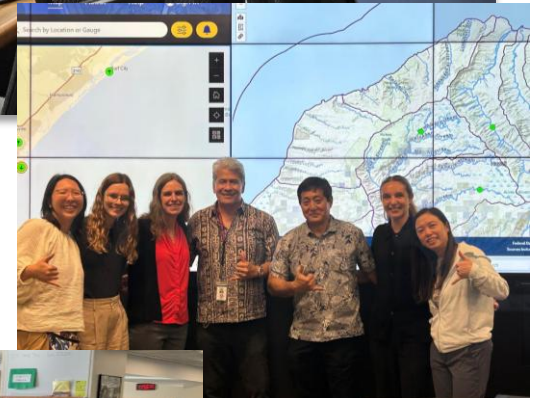
UH: Yu-Fen Huang

RTI: Katie van Werkhoven, Schuyler DeBree



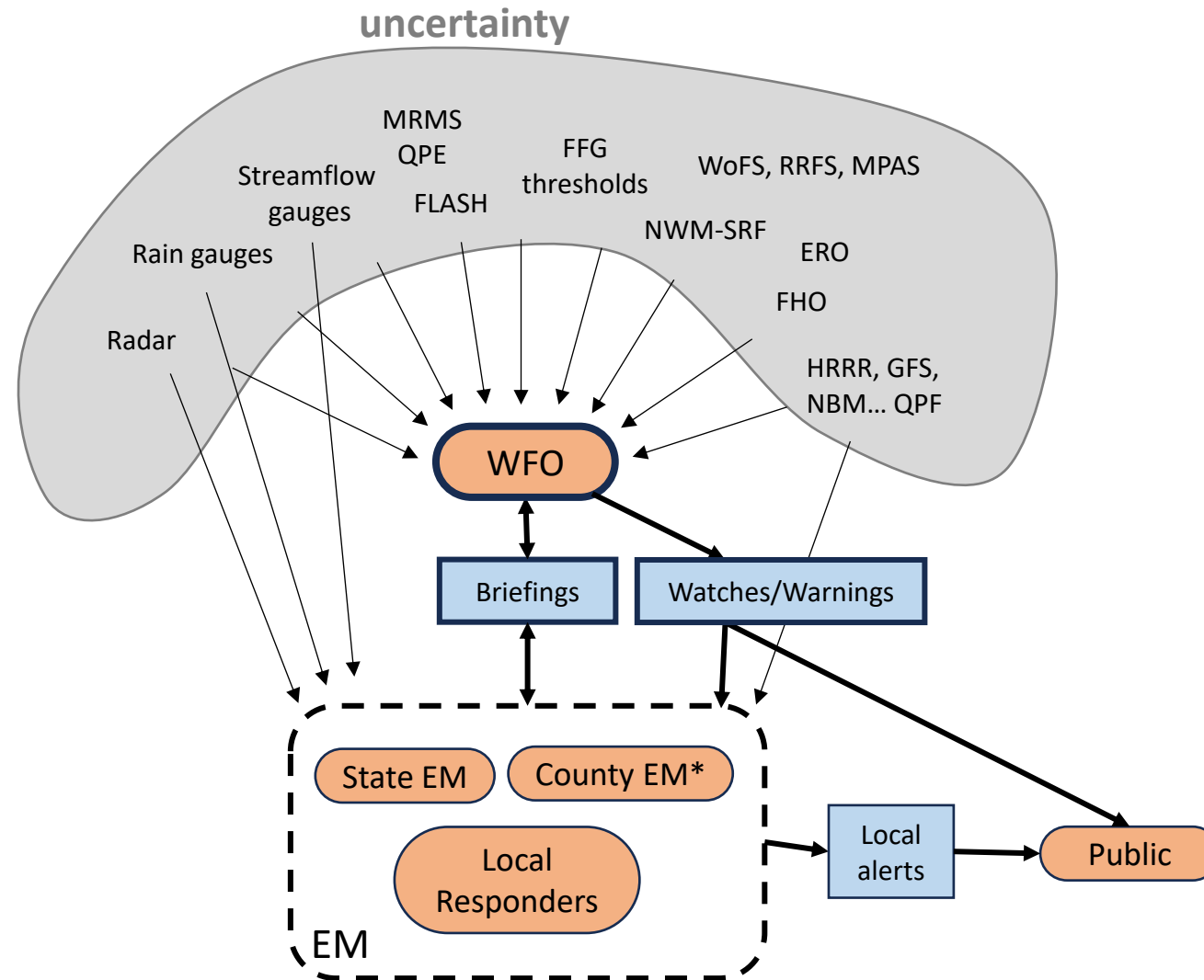
# Inspiration

## WFO



## EM

# Inspiration

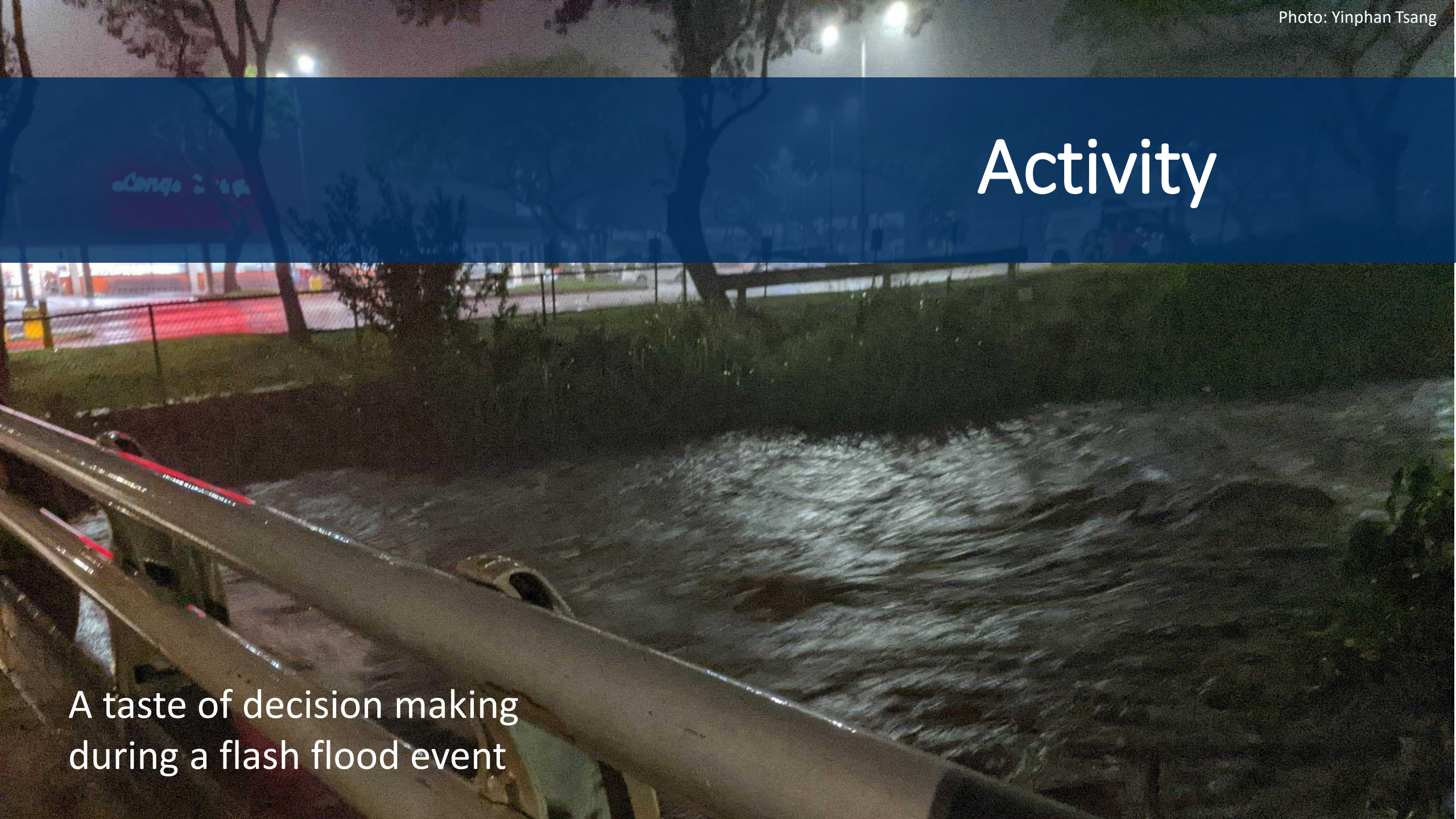


Consequences of  
being wrong



# Activity

A taste of decision making  
during a flash flood event



# Activity – Overview

- **We are aiming to give you a taste of:**
  - Forecast uncertainty
  - High-consequence trade-offs
  - Unclear decision thresholds
  - Spatial variability in the forecast
  - Forecast latency
- **Take note of:**
  - What factors are most influencing your decision?
  - What information do you WISH you had?
  - How confident are you in the information?

# Activity – Overview

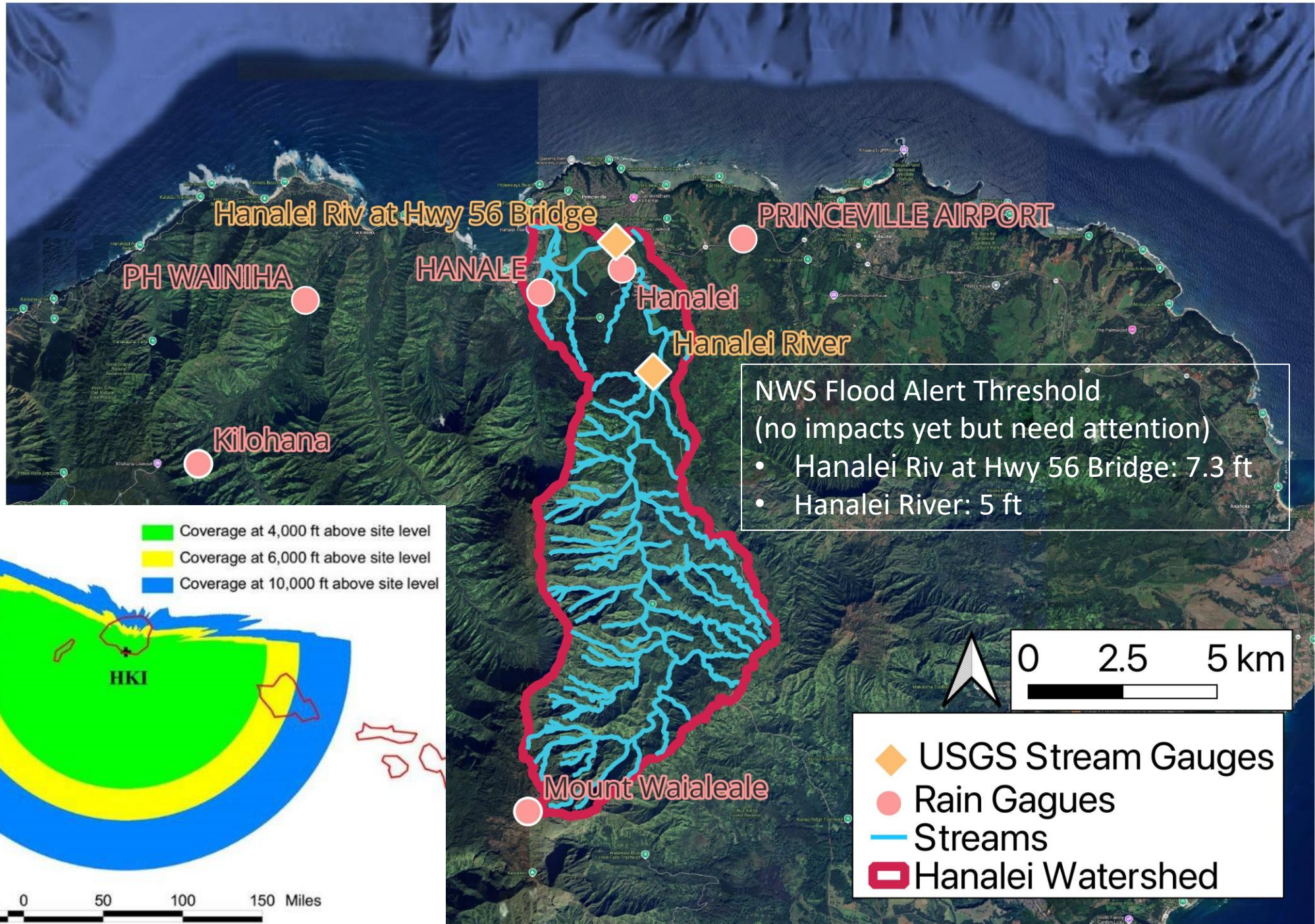
- **Flood context**
  - Brief introduction to the target watershed
- **Get into your role**
  - You will be Weather Forecast Office (WFO) and Emergency Management (EM) staffs.
    - *Break into groups 1) WFOs and 2) EMs*
- **Event scenarios**
  - 2-3 scenarios (activities + session debrief)
- **Debrief & takeaways**

# Activity – Flood Context

- **Hanalei, Kauaʻi (HI)**

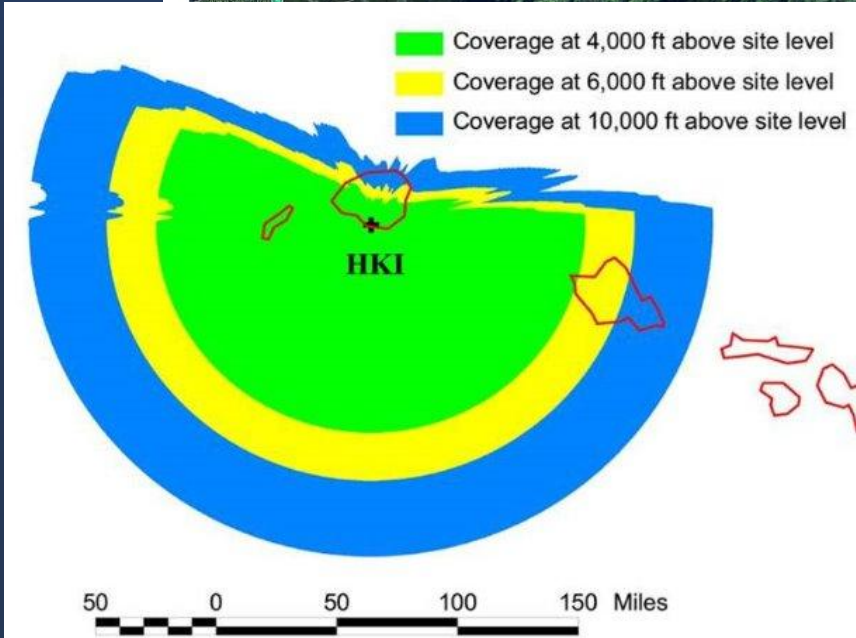
- A remote coastal community on the North Shore of Kauaʻi. Its geography creates a "perfect storm" for flooding:
  - **Isolation:** Kuhio Highway is the ONLY road connecting the town to the rest of the island. There are no alternate routes, and the road relies on small, single-lane bridges.
  - **"Flashy" watershed:** The town sits below steep mountains in a small 49 km<sup>2</sup> (19 mi<sup>2</sup>) basin. Rainwater runs off these slopes almost instantly, causing rivers to rise with very little warning.
  - **Geological risk:** The terrain directly above the only highway is highly unstable and prone to landslides during heavy saturation.
- A small but strong community: 7,500 across the North Shore (Hanalei, Wainiha, and Hāʻena).
- A tourist destination: As a world-famous destination, the daily population can double with visitors who are unfamiliar with the terrain and emergency protocols.





NWS Flood Alert Threshold  
 (no impacts yet but need attention)

- Hanalei Riv at Hwy 56 Bridge: 7.3 ft
- Hanalei River: 5 ft



0 2.5 5 km

- ◆ USGS Stream Gauges
- Rain Gauges
- Streams
- ▭ Hanalei Watershed

# Activity – Your Role (WFO)

## **Continuous monitoring**

- Analyze real-time radar, satellite, and weather forecasts
- Review available hydrological models: NWM short-range, FLASH products, FIM (*future*)

## **Issue NWS severe weather briefings**

- Coordinate with county EMs via briefings
- Communicate the risk level and uncertainty: How confident are you in the forecast?

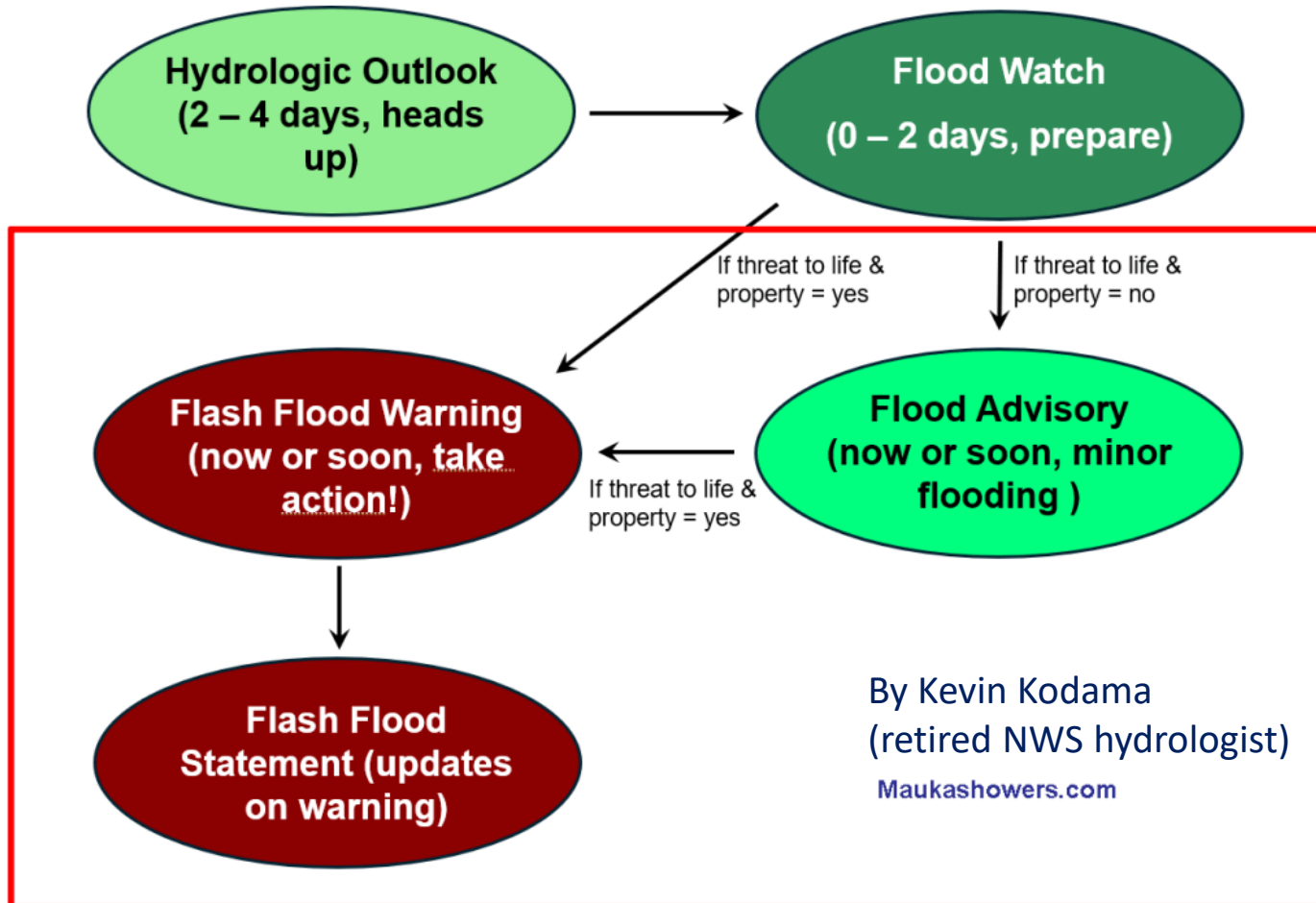
## **Decide when to issue NWS flood products (see WFO reference card):**

- Flash Flood Watch
- Flash Flood Advisory
- Flash Flood Warning

*Key question:* Is there enough confidence to issue Flash Flood Warning BEFORE the rain intensifies?

# Activity – Your Role (WFO)

## NWS Hydrology Products in Hawai'i



# Activity – Your Role (EM)

**Main duty: save lives**

**Decide how to protect lives** (see EM reference card):

- Close Hanalei bridge preemptively
- Prepare for evacuations
- Execute evacuations (e.g., request State/National Guard)

*Key question:* When do you act – and what is the cost of being wrong?

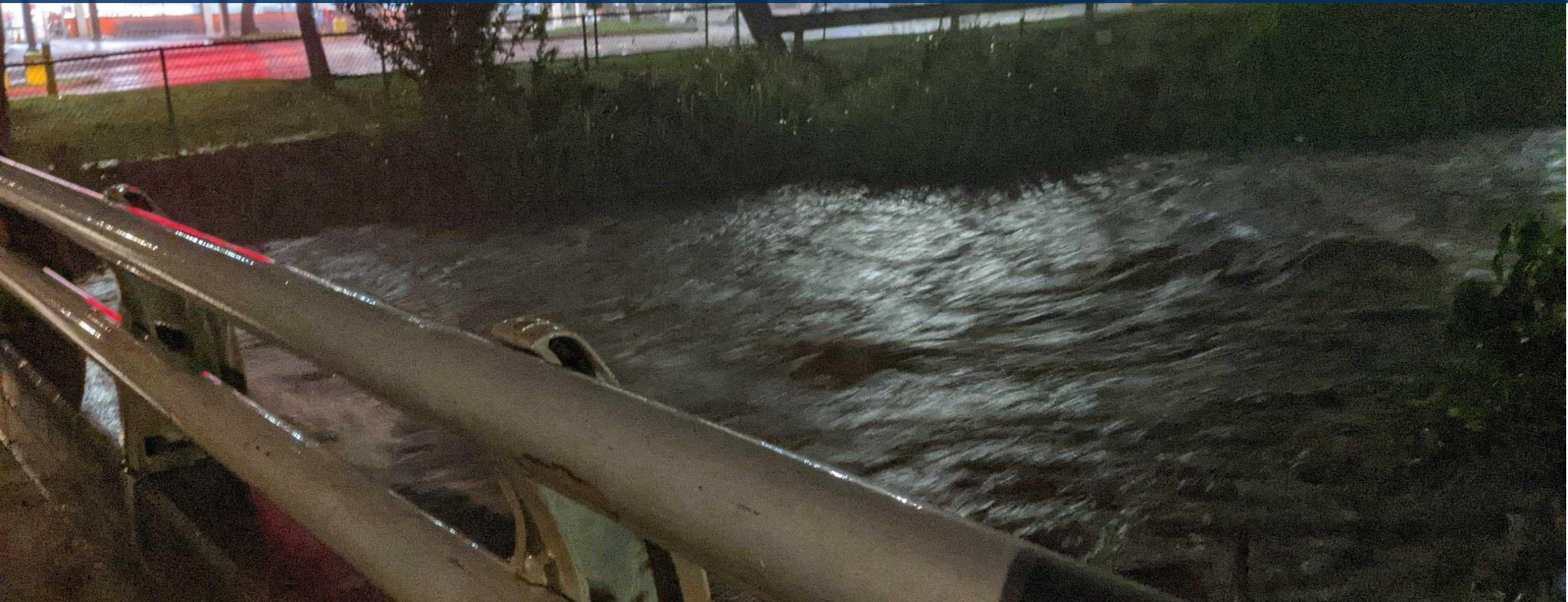


# Activity – Rules

- Each scenarios may have a different # of time steps and decision points
- **At each time step, you will**
  - Look through all the information you have.
  - Jot down:
    - What catches your eye?
    - What info is missing or could be better?
    - How sure are you about the info?
    - (Decision point only) How did you make your decision?
- **At each decision point, you will**
  - Discuss with your group for 4-6 mins
  - WFO passed their decision to paired EM group (secretly).
  - Once EM decide, let Schuyler know. We will show everyone's decisions at the same time.
- **Wildcards:** Sometimes a wildcard pops up that gives the EM team extra info.

Note: Please do NOT open the tape on the materials until instructed.

# Scenario 1



# Scenario 1

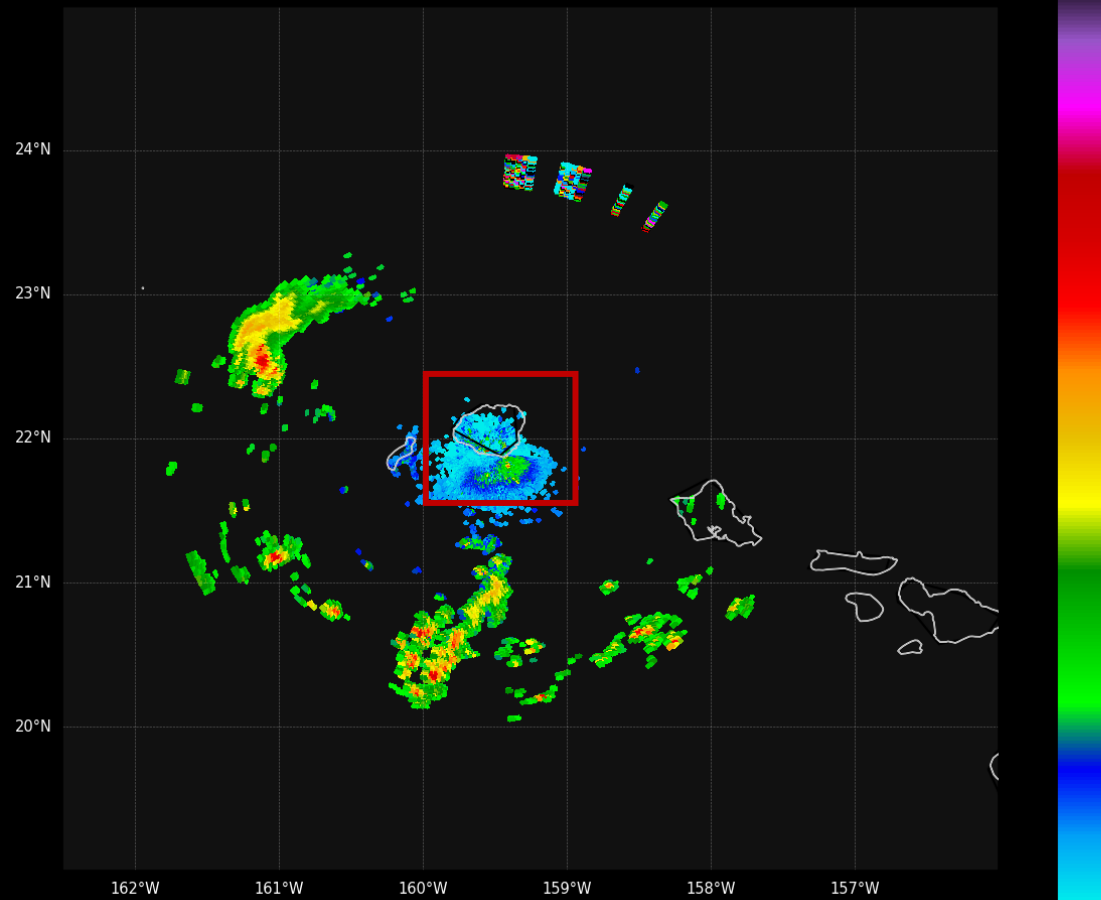
Wednesday, April 11: GFS showing PW > 2.0 inches drawn northward over islands mid-next week, but ECMWF did not show the rain.

**Date: Friday, April 13  
03:00 HST**

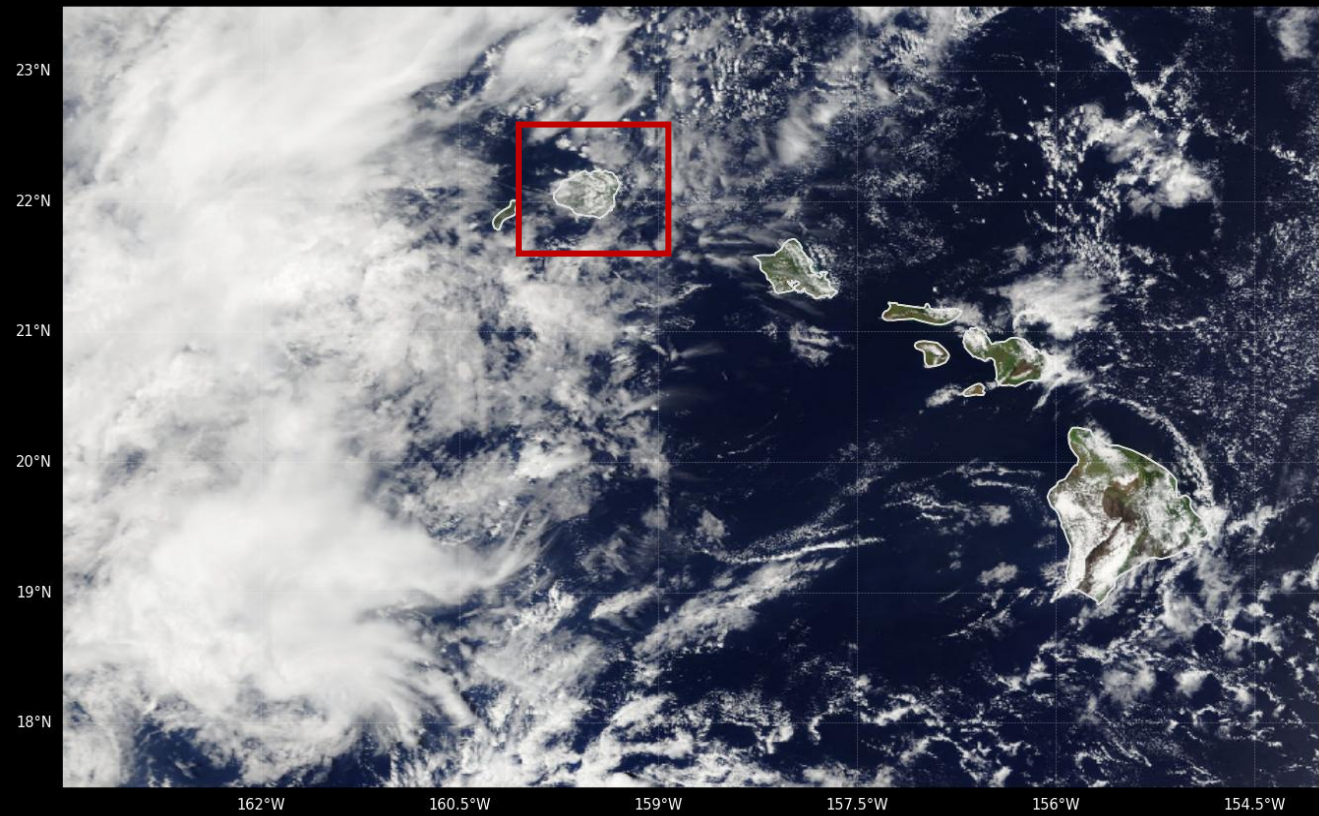
Zonal Forecast Precipitation:

- Windward: Frequent showers, locally rainfall
- Mountain: Frequent showers, locally rainfall

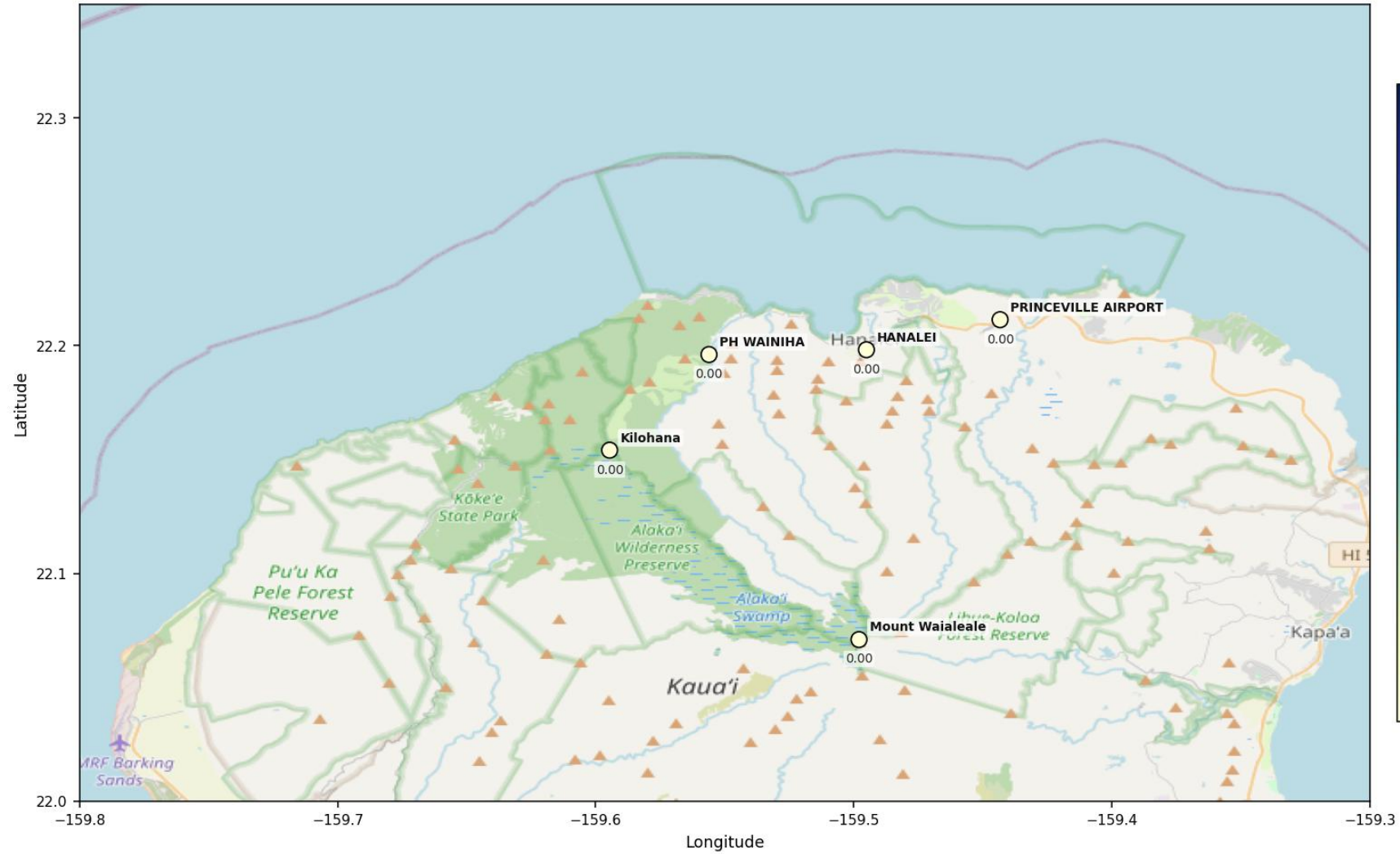
PHKI Digital Hybrid Reflectivity (DHR)



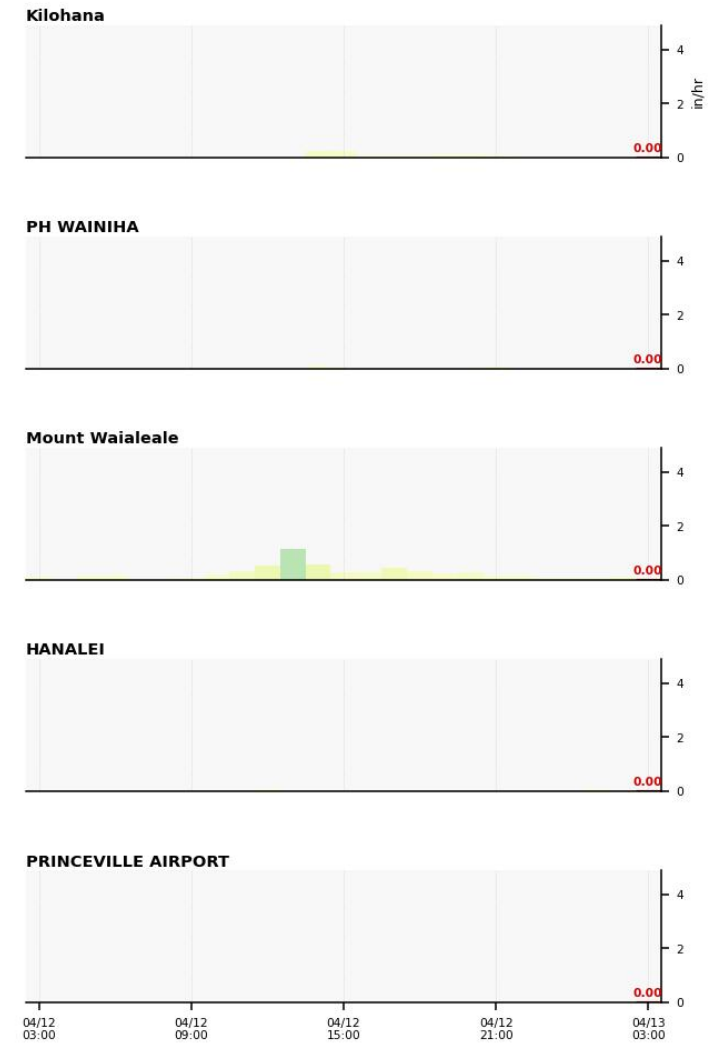
MODIS Terra TrueColor



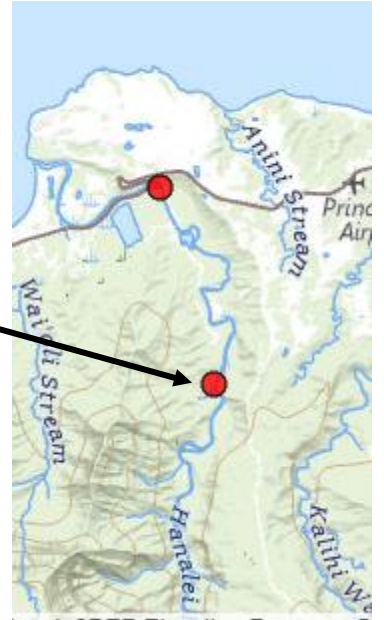
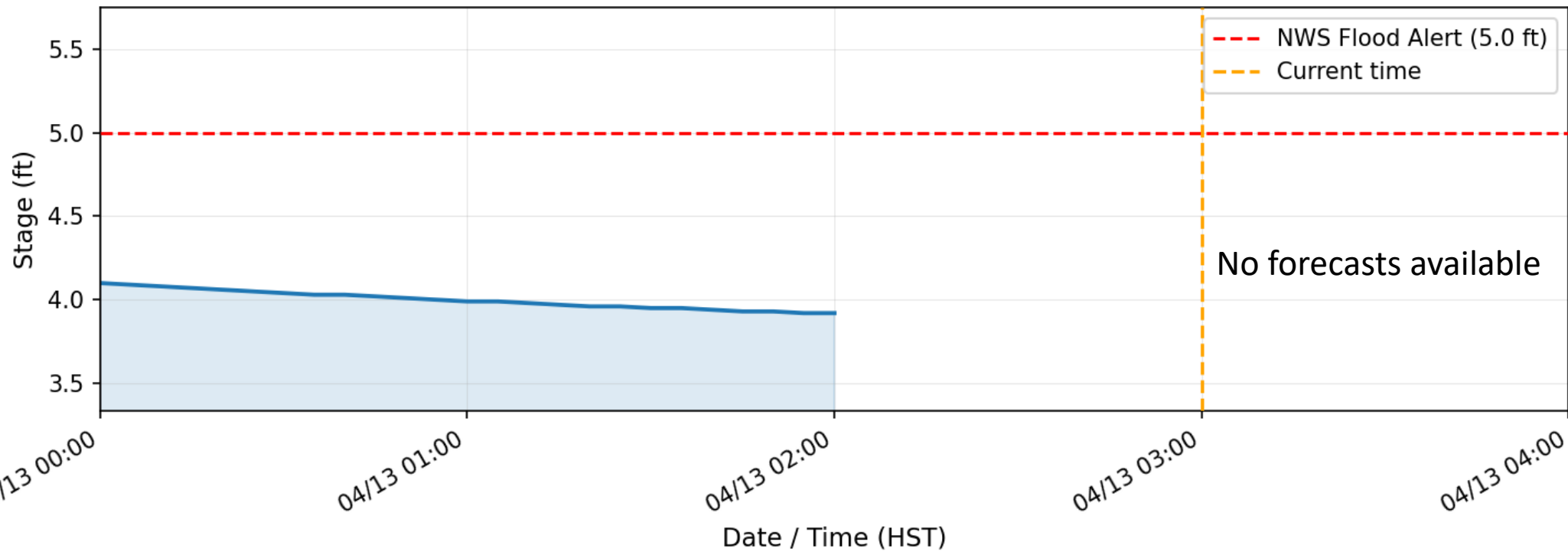
### North Shore Kaua'i — 1-hour Rainfall [04/13 03:00-04:00 HST]



### 24-hr lookback



**USGS 16103000 (Hanalei R nr Hanalei)  
(04/13 03:00 HST)**



# Scenario 1 – Activity

**Date: Friday, April 13  
03:00 HST**

## **WFOs**

Issue severe weather briefing

Communicate to EMs

## **EMs**

Prepare for briefing  
(expectations, questions)

# Scenario 1

**Date: Saturday, April 14  
03:00 HST  
(Decision Point)**

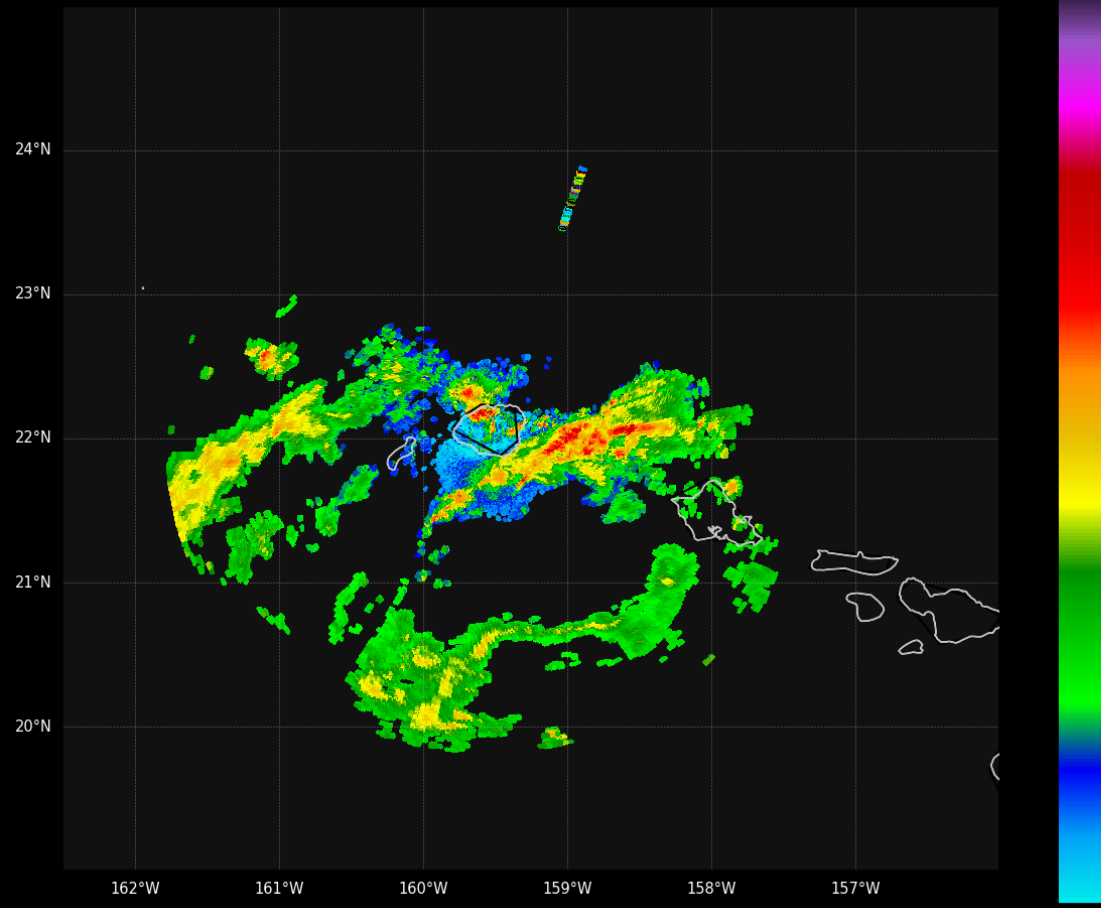
Zonal Forecast Precipitation:

- Windward: Frequent showers, thundershowers
- Mountain: Frequent showers, thundershowers

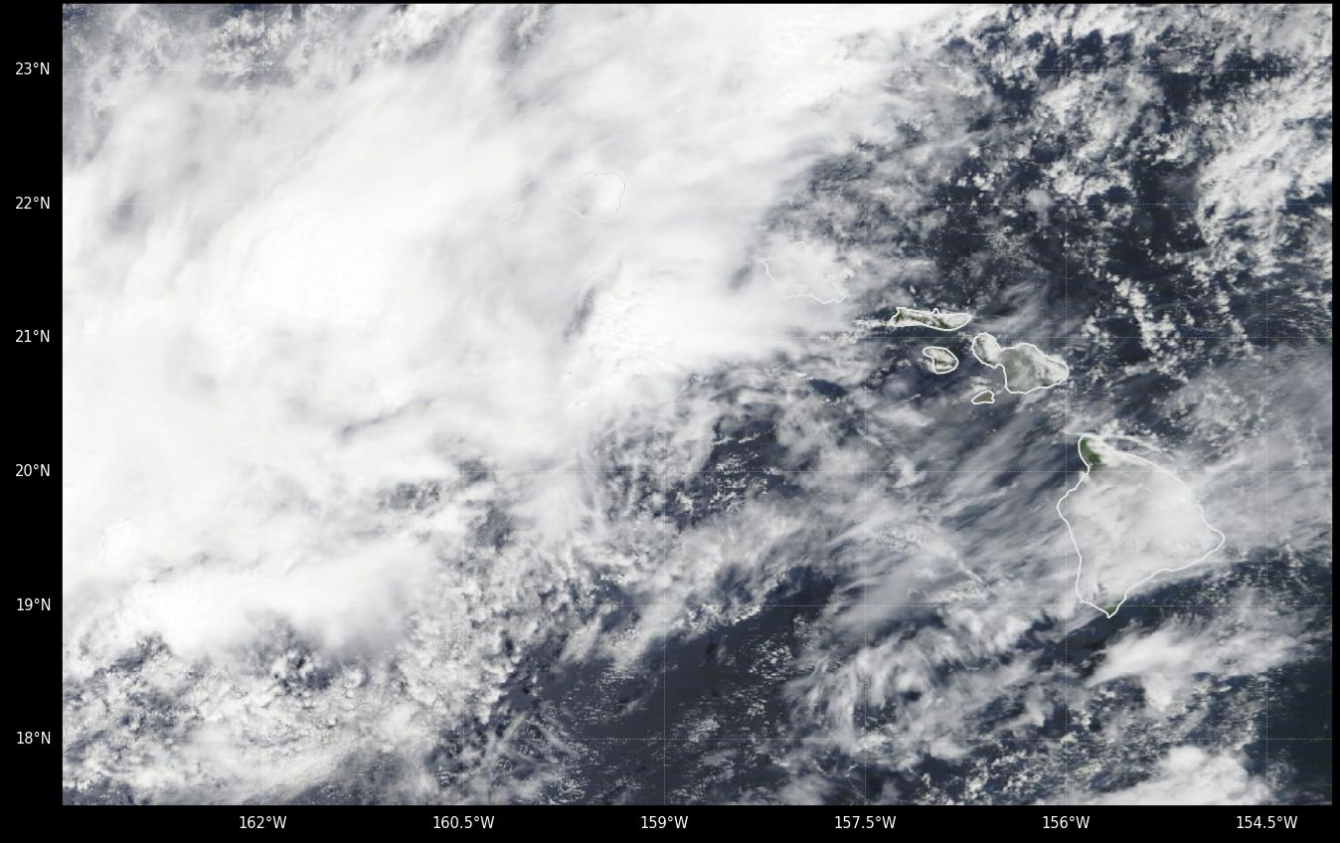
QPF Forecast:

- Kapaa 0.59" / Lihue 0.46" / **Princeville 0.23"** (12hr)

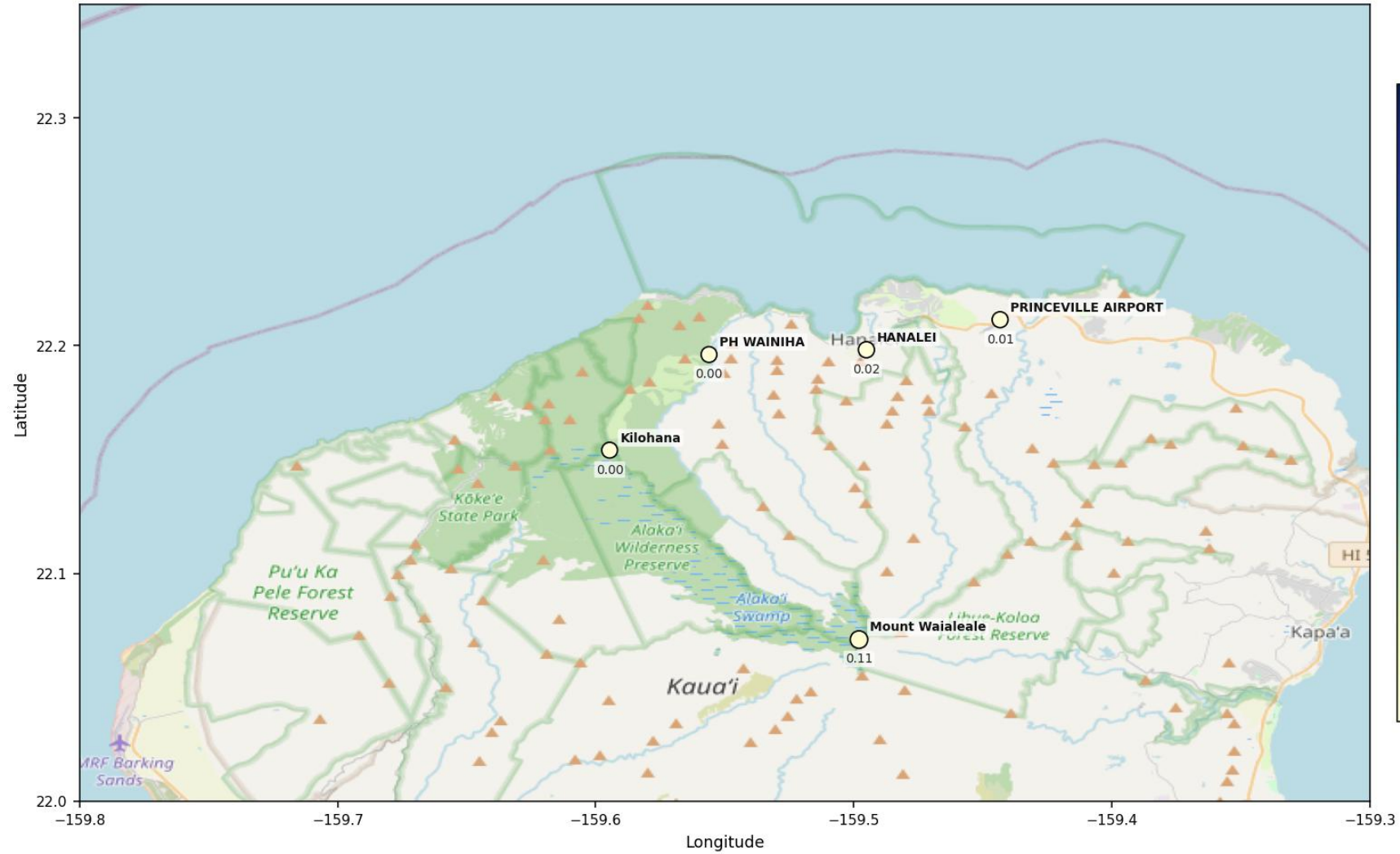
PHKI Digital Hybrid Reflectivity (DHR)



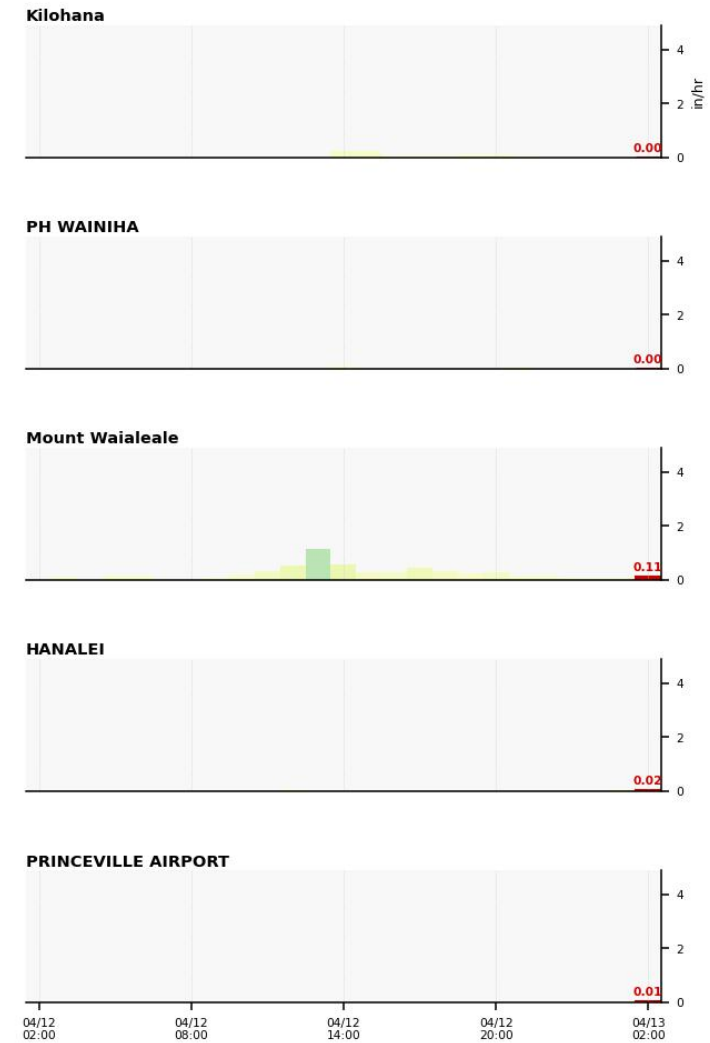
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/13 02:00-03:00 HST]

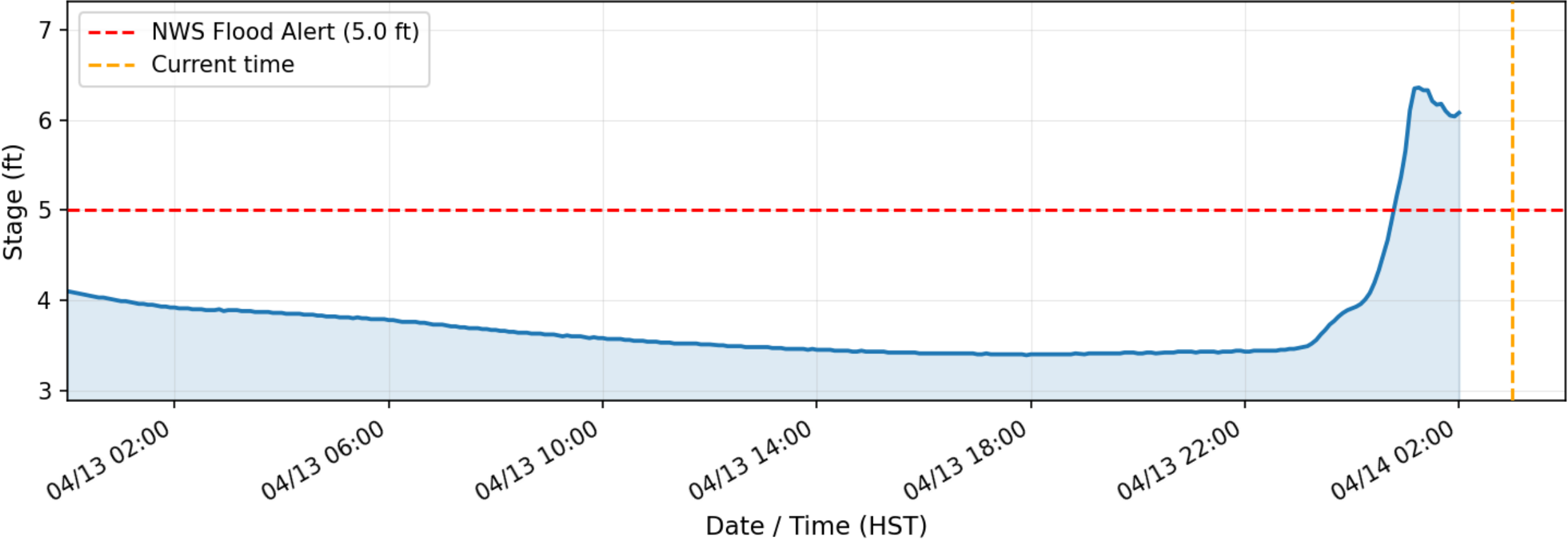


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/14 03:00 HST)**



# Scenario 1 – Decision 1

**Date: Saturday, April 14  
03:00 HST**

## **WFOs**

Issue flood product

## **EMs**

Close the bridge

Prepare for evacuation

Evacuate areas at risk

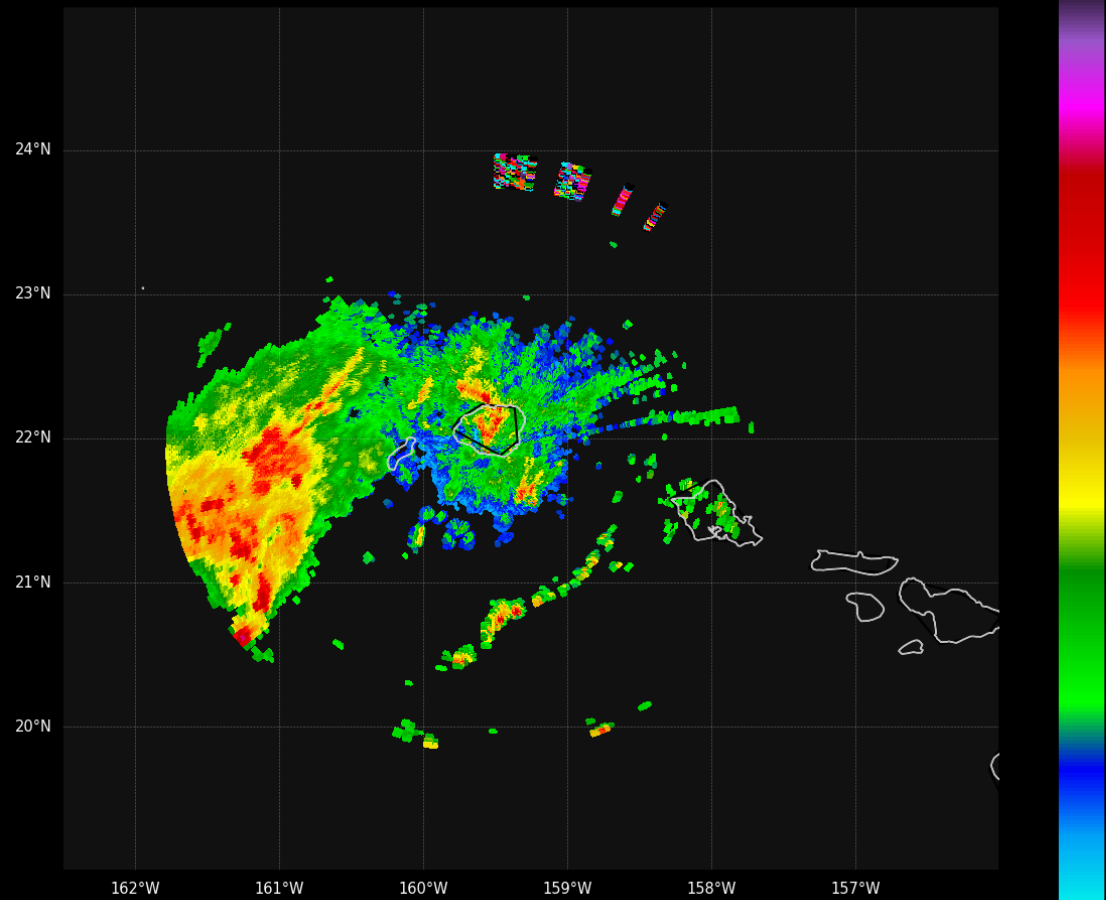
# Scenario 1

**Date: Saturday, April 14  
15:00 HST**

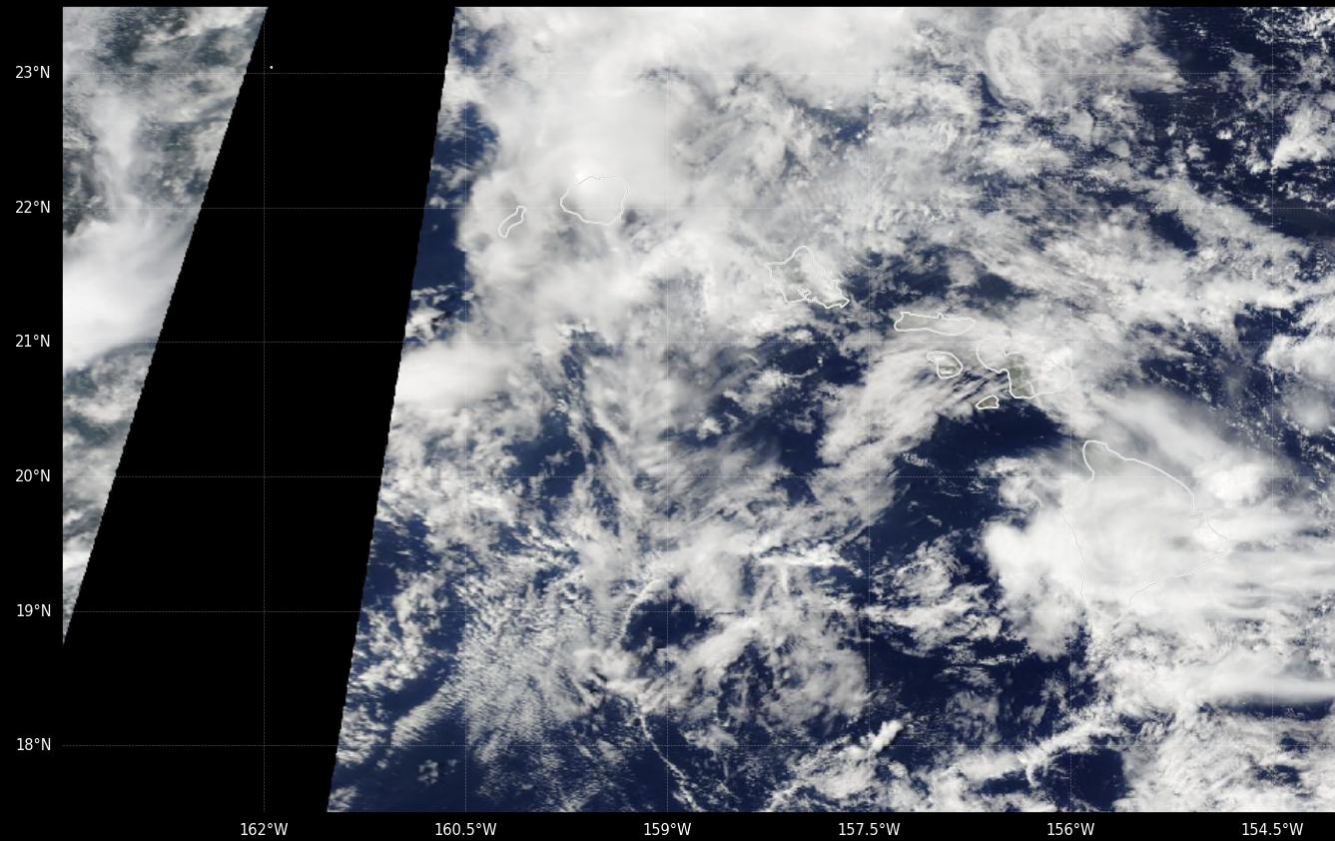
Zonal Forecast Precipitation:

- Windward: Frequent showers, thundershowers
- Mountain: Frequent showers, thundershowers

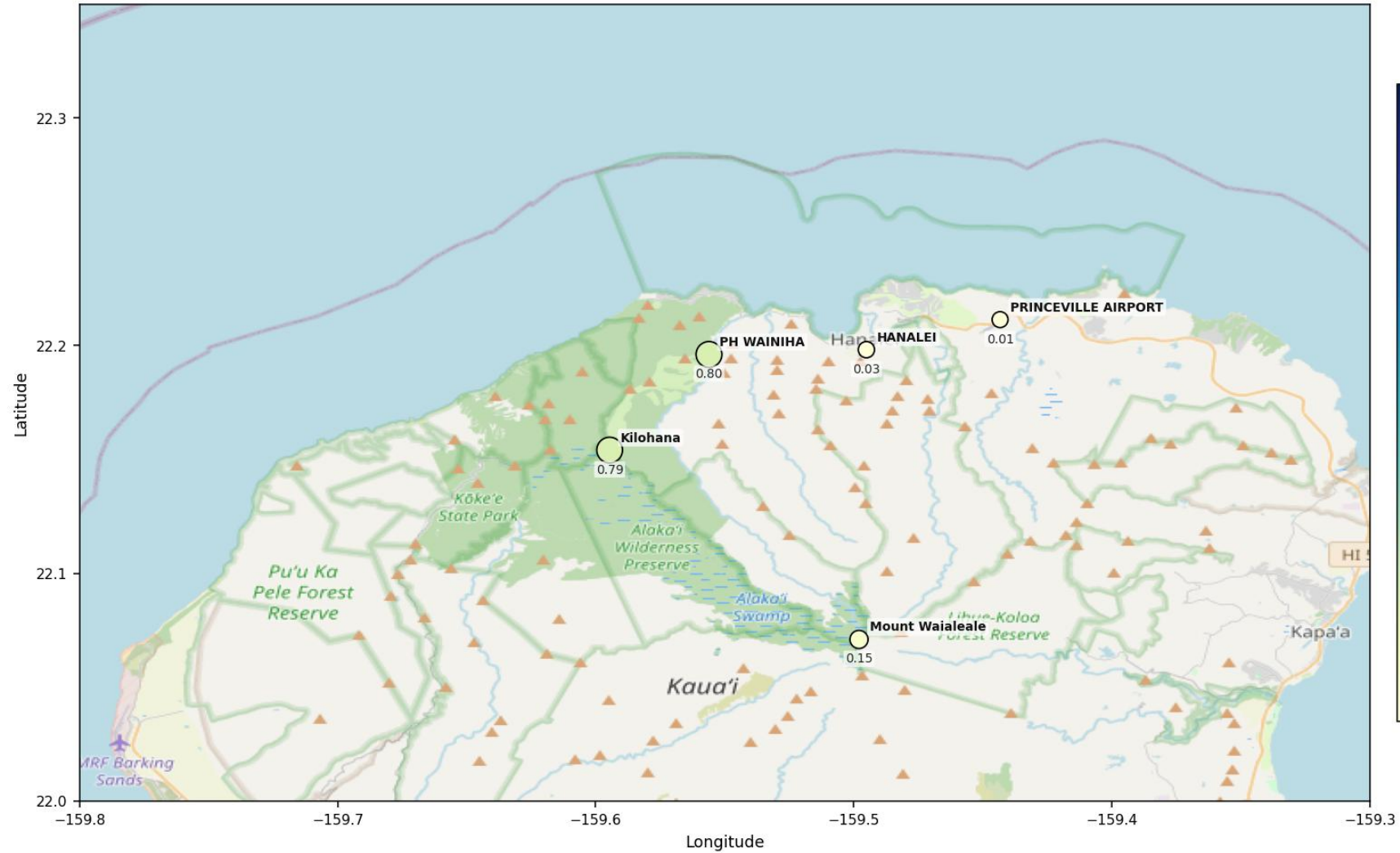
PHKI Digital Hybrid Reflectivity (DHR)



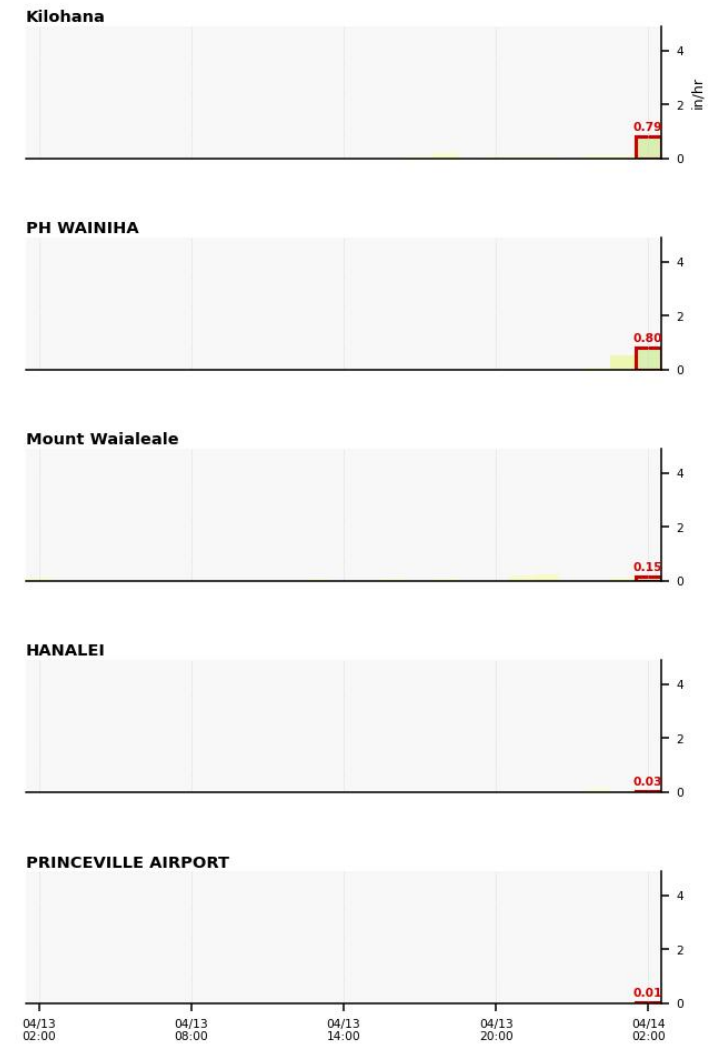
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/14 02:00-03:00 HST]

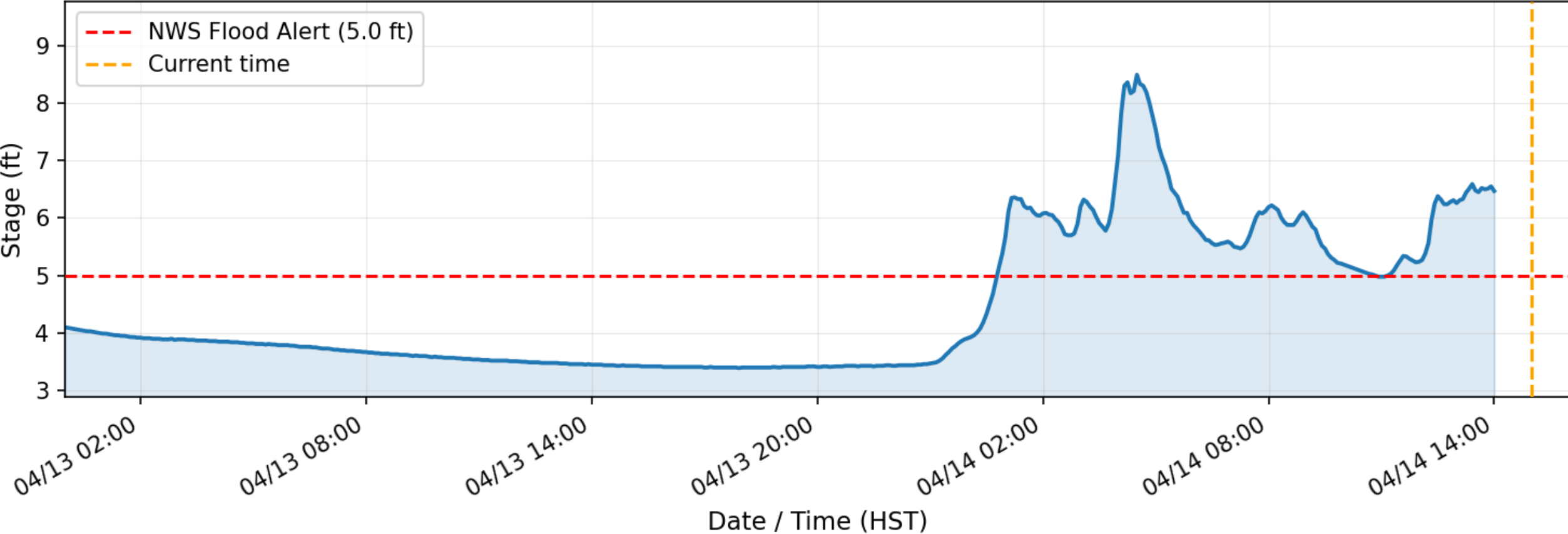


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/14 15:00 HST)**



# Scenario 1

**Date: Saturday, April 14  
21:00 HST**

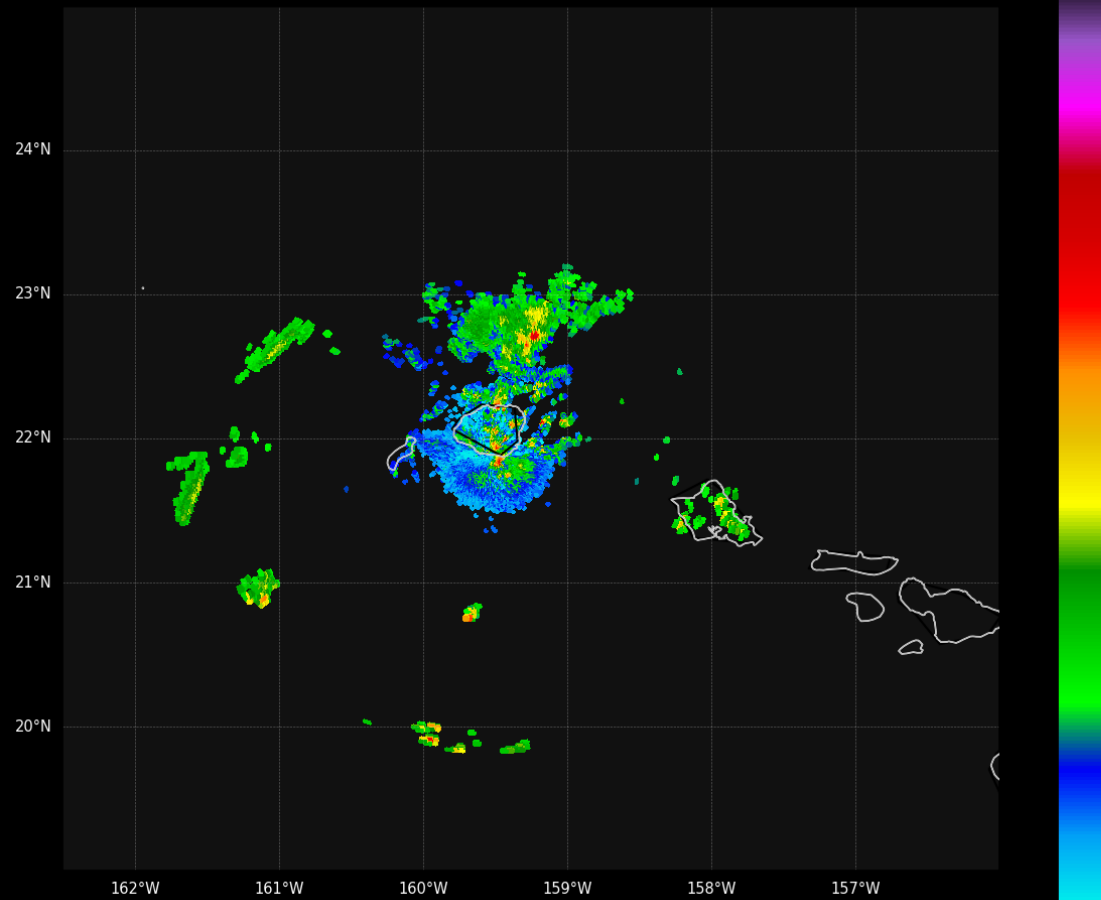
Zonal Forecast Precipitation:

- Windward: Frequent showers, thundershowers ~100%
- Mountain: Frequent showers, thundershowers, and heavy rain

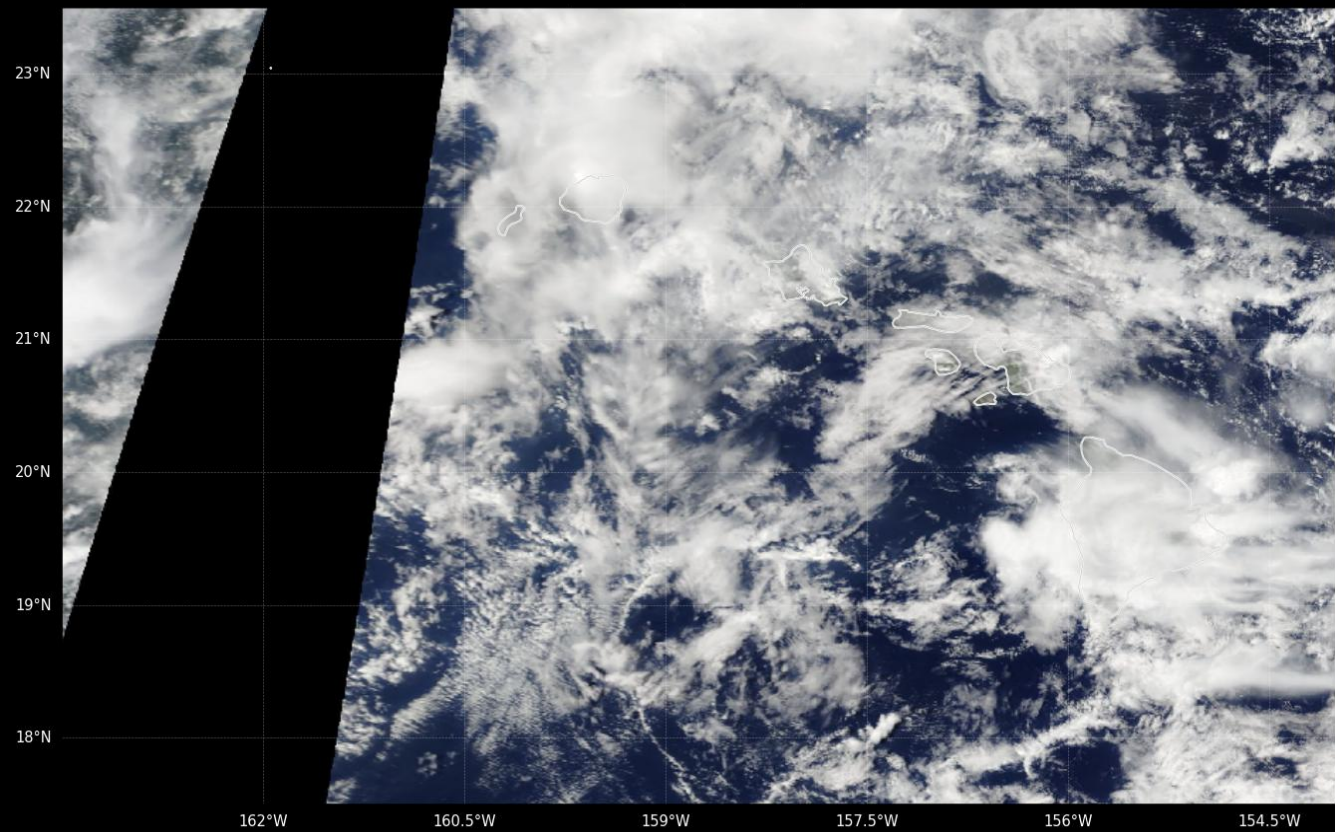
QPF Forecast:

- Kapaa 0.30" / Lihue 0.29" / **Princeville 0.20"** (12hr)

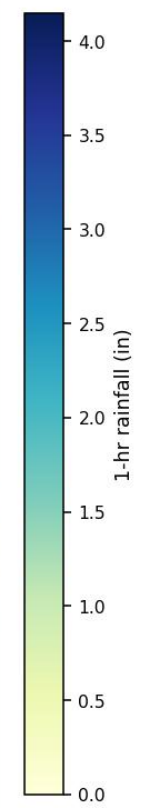
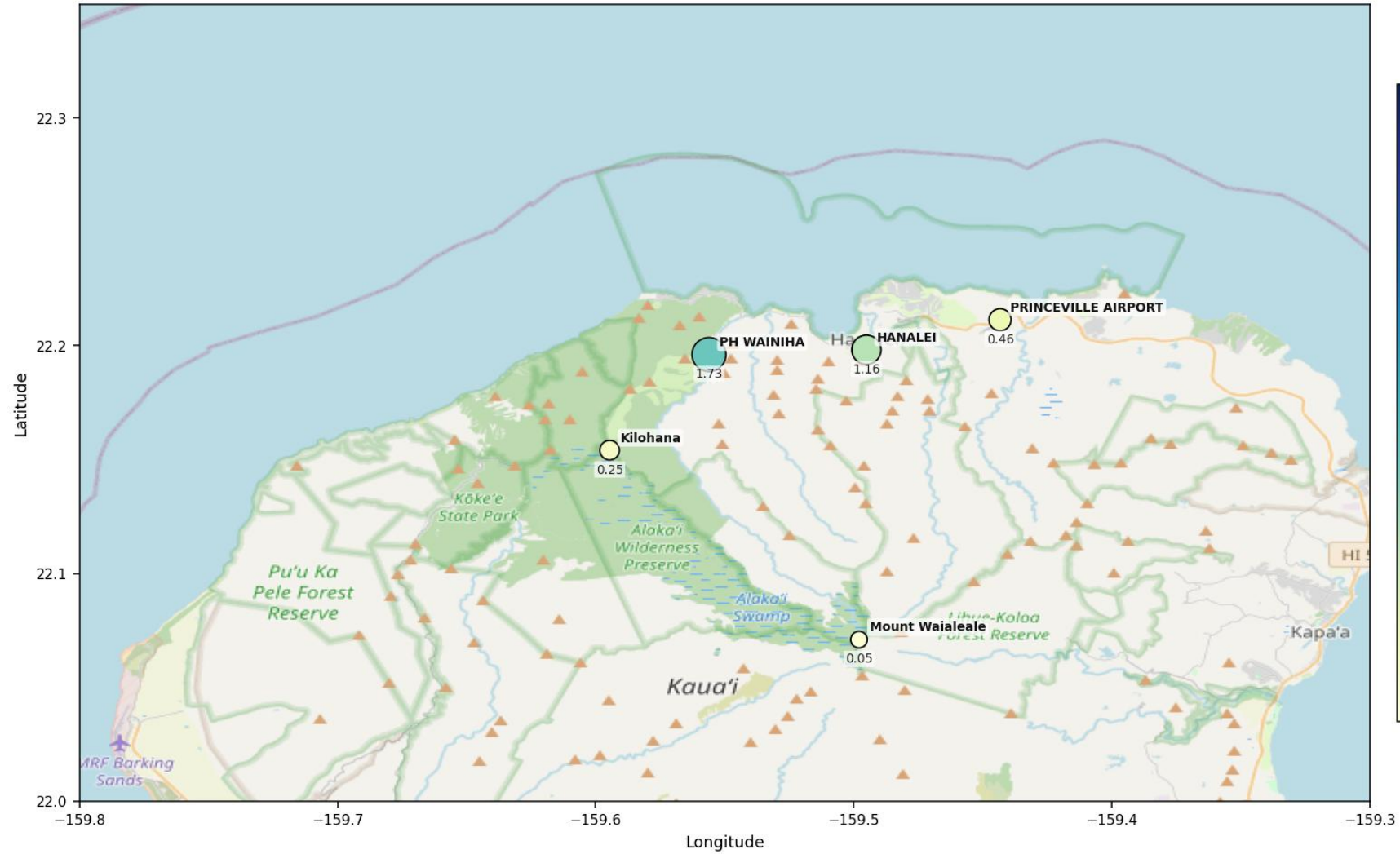
PHKI Digital Hybrid Reflectivity (DHR)



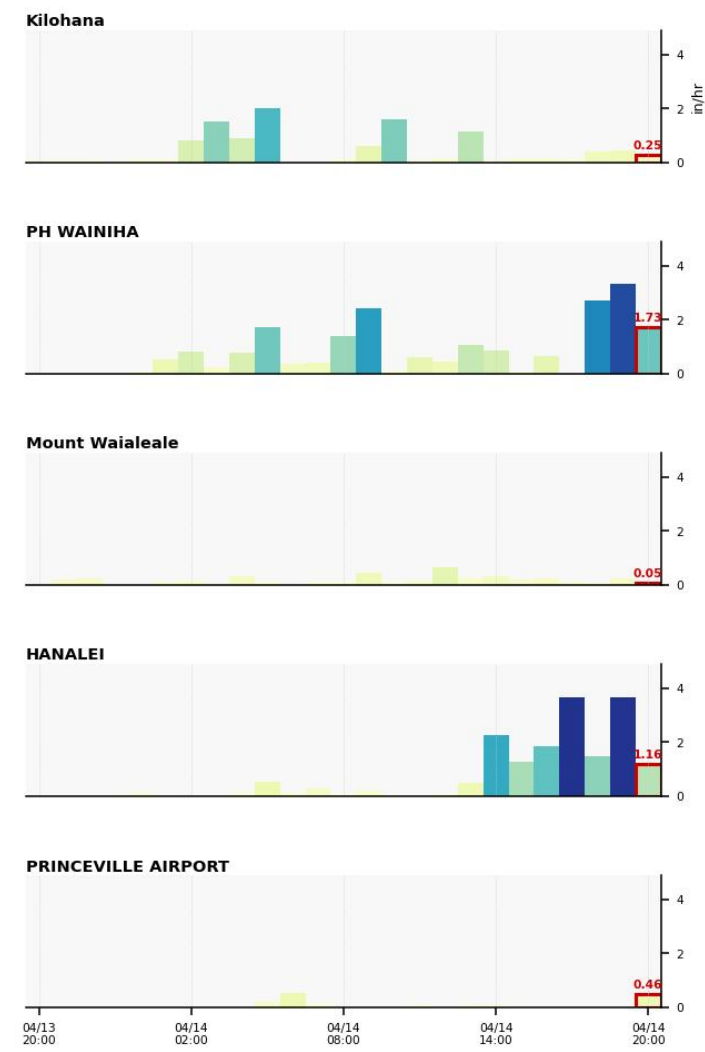
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/14 20:00-21:00 HST]

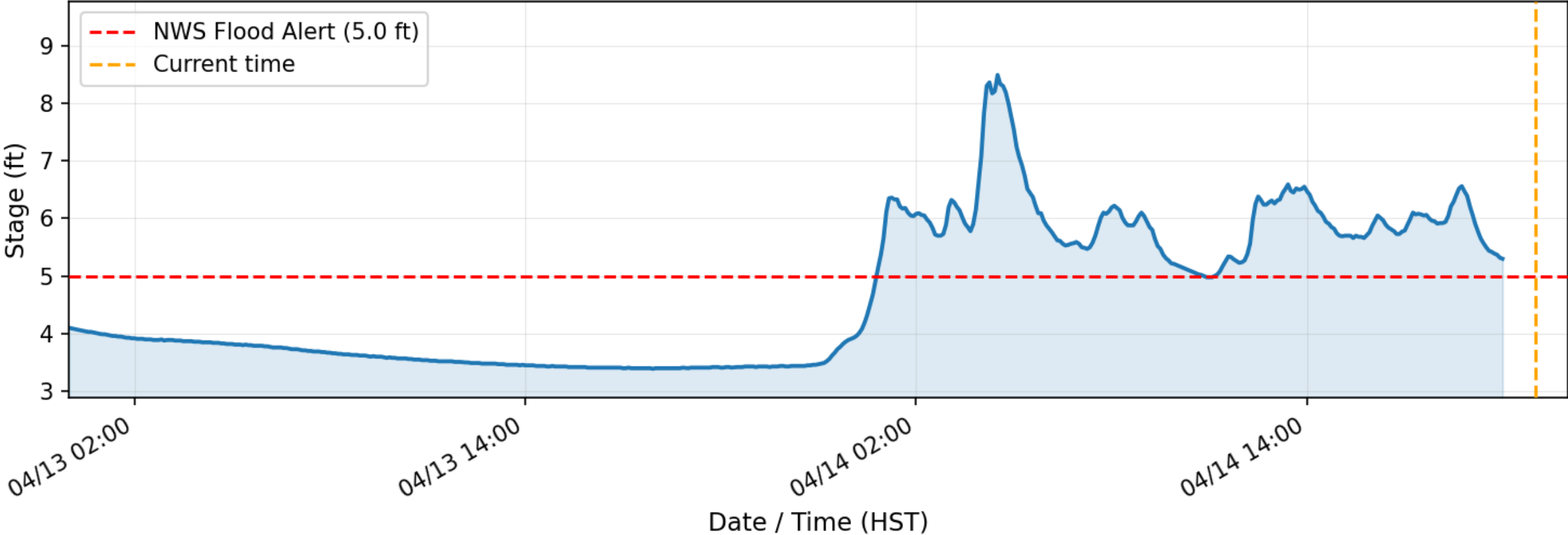


#### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/14 21:00 HST)**



# Scenario 1



**Date: Sunday, April 15  
00:00 HST**

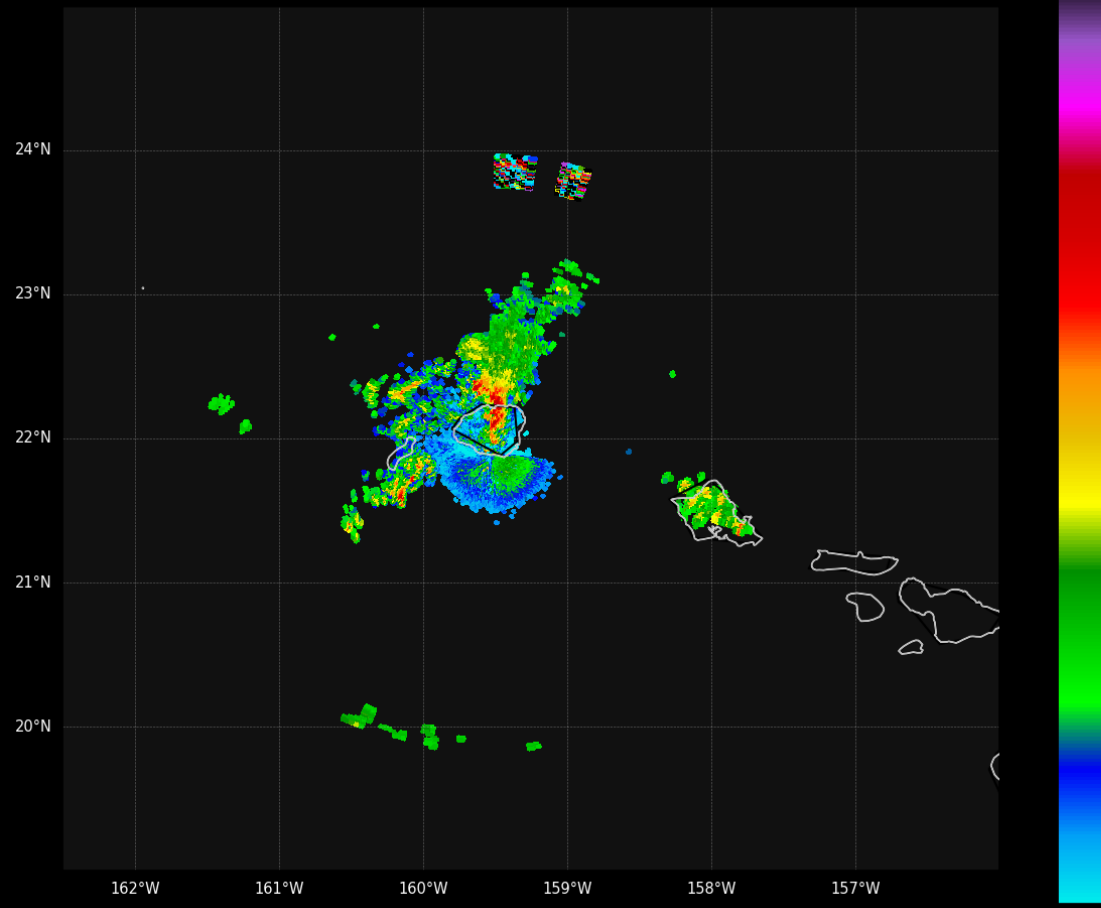
Zonal Forecast Precipitation:

- Windward: Frequent showers, thundershowers ~100%
- Mountain: Frequent showers, thundershowers, and heavy rain

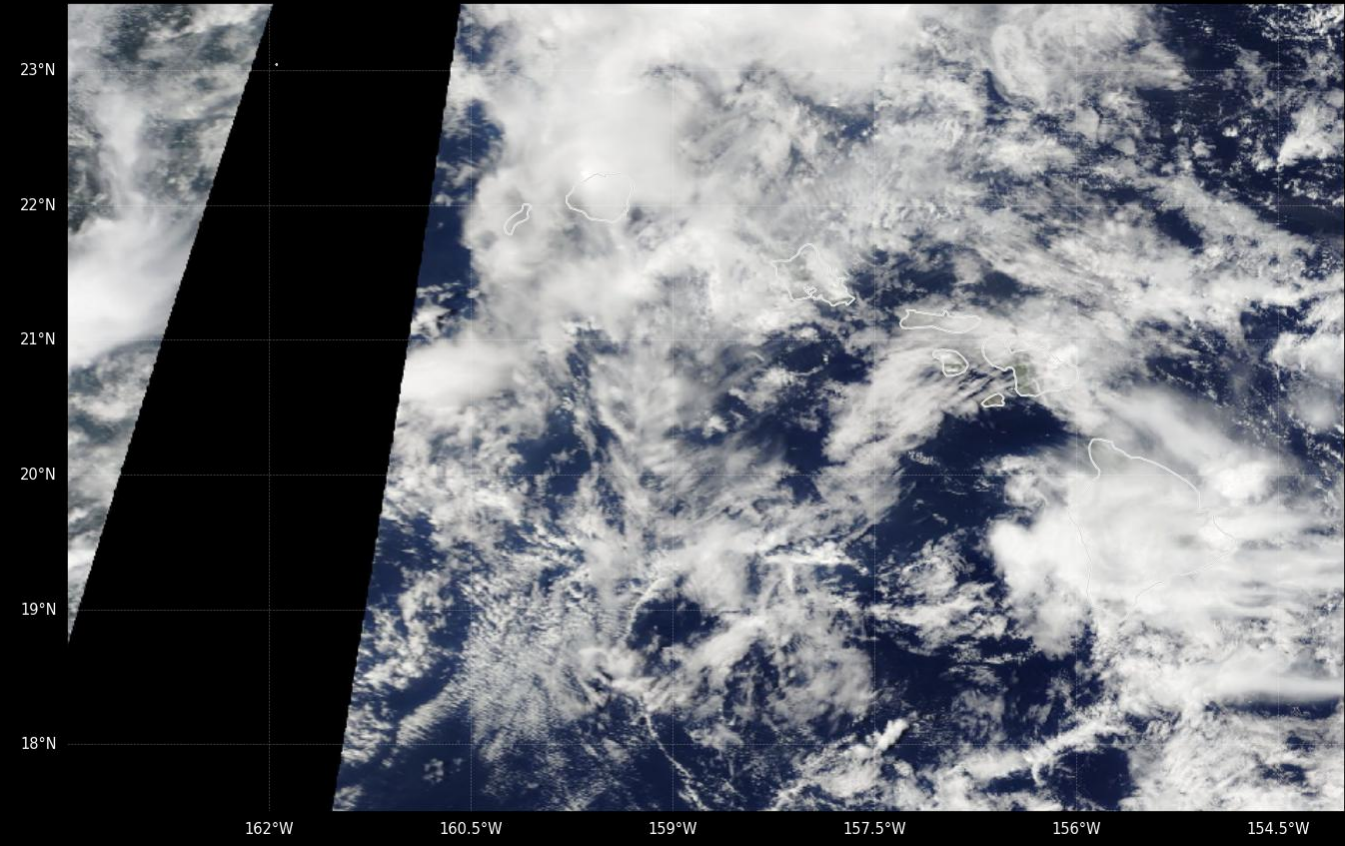
QPF Forecast:

- Kapaa 0.08" / Lihue 0.06" / **Princeville (missing)** (12hr)

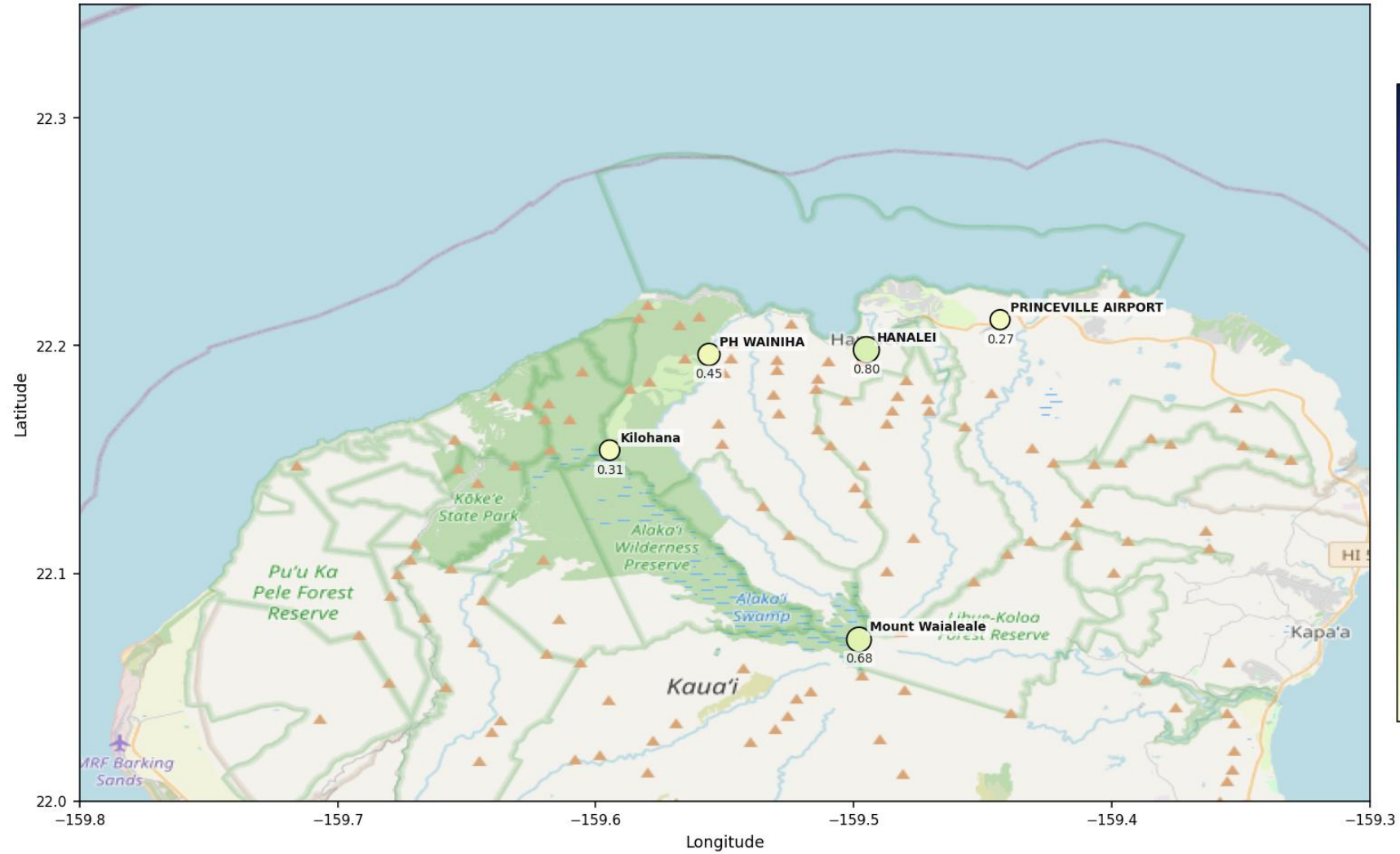
PHKI Digital Hybrid Reflectivity (DHR)



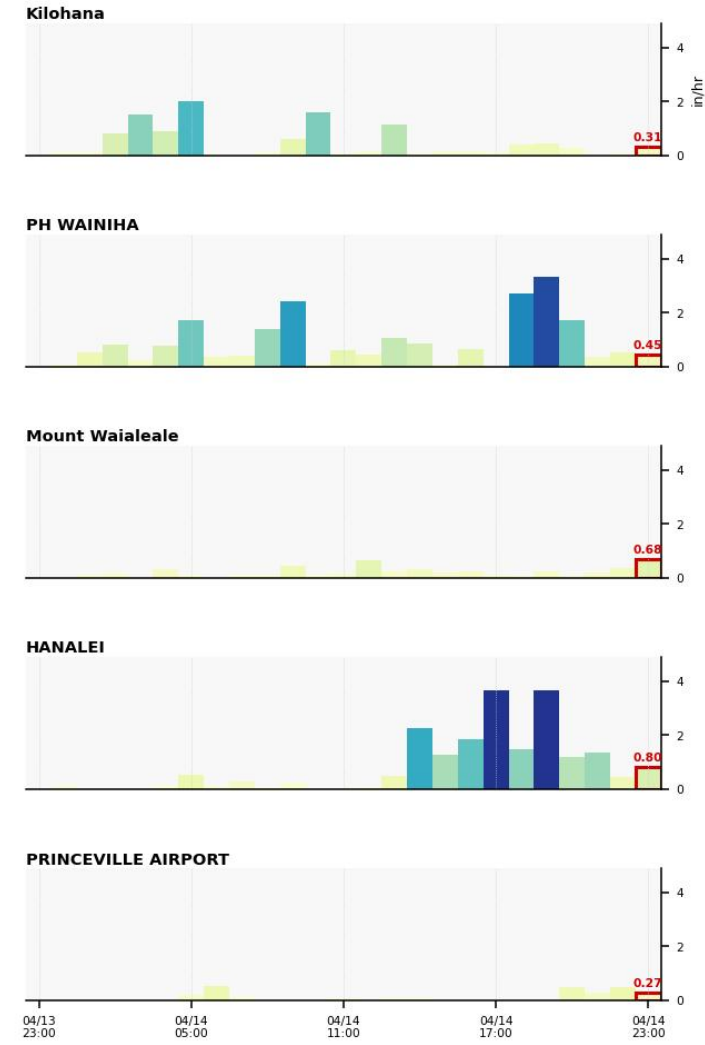
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/14 23:00-00:00 HST]

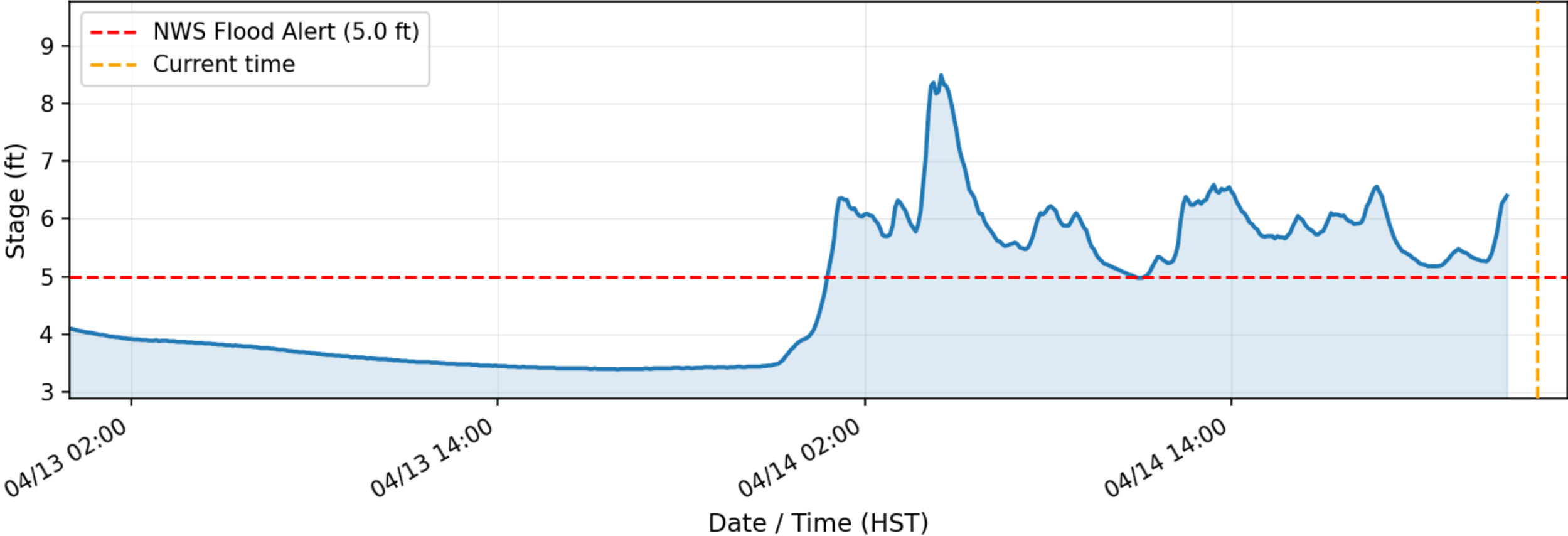


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/15 00:00 HST)**



# Scenario 1

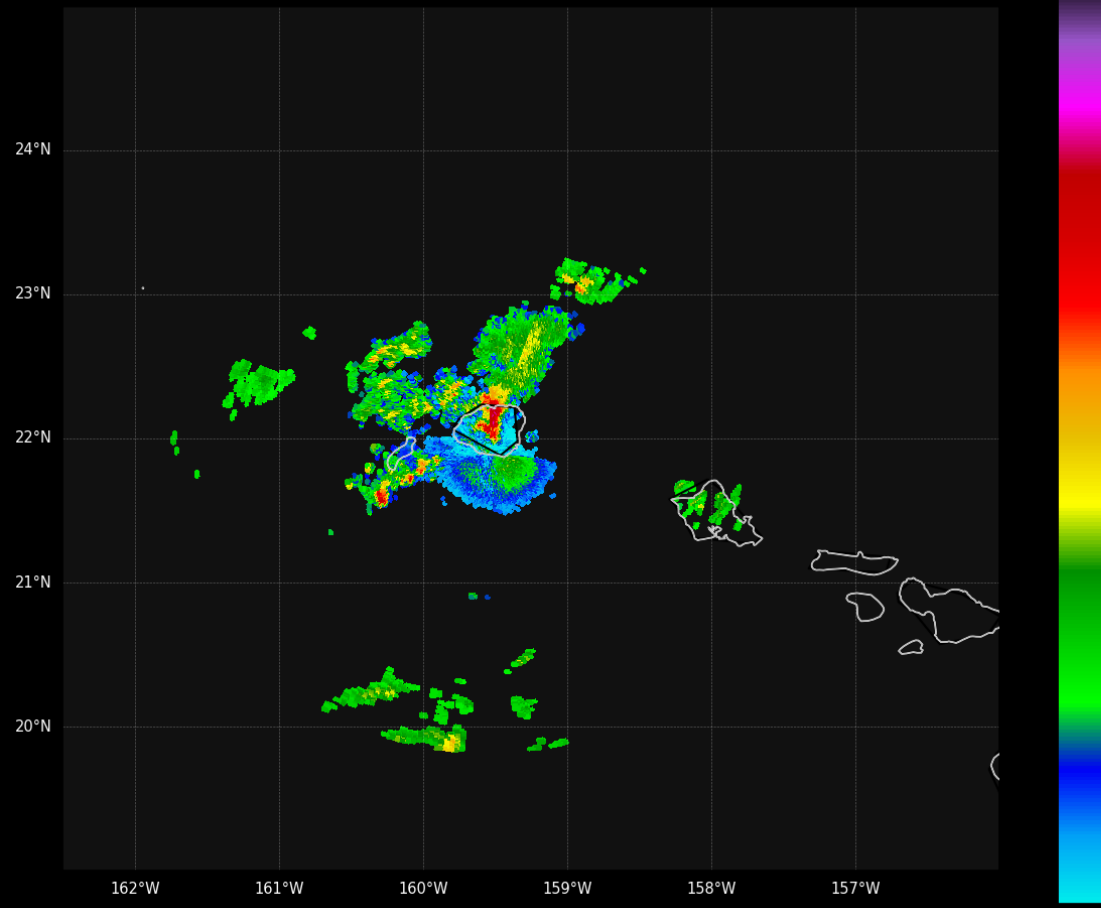


**Date: Sunday, April 15  
01:00 HST  
(Decision Point)**

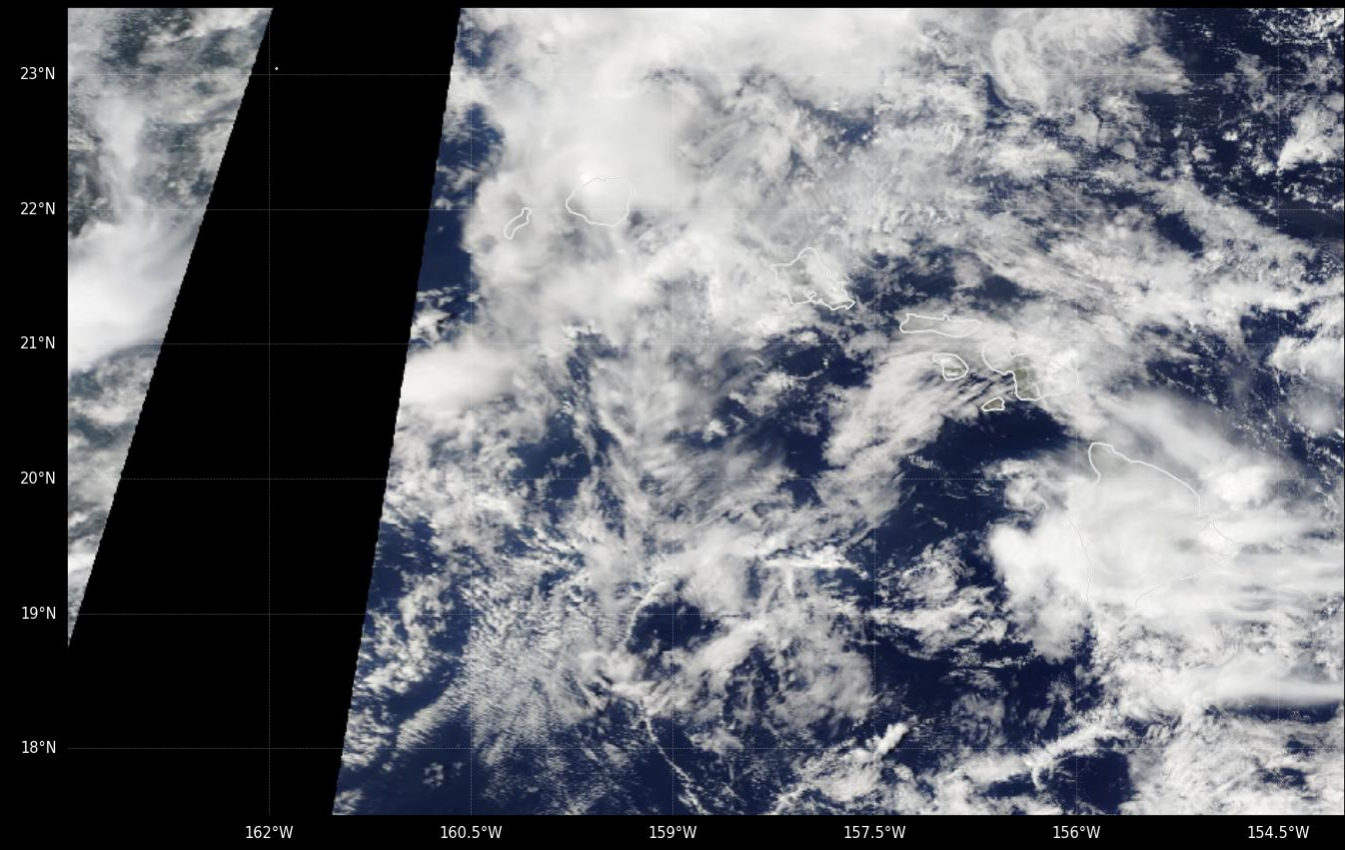
Zonal Forecast Precipitation:

- Windward: Frequent thundershowers ~100%
- Mountain: Frequent thundershowers ~100%

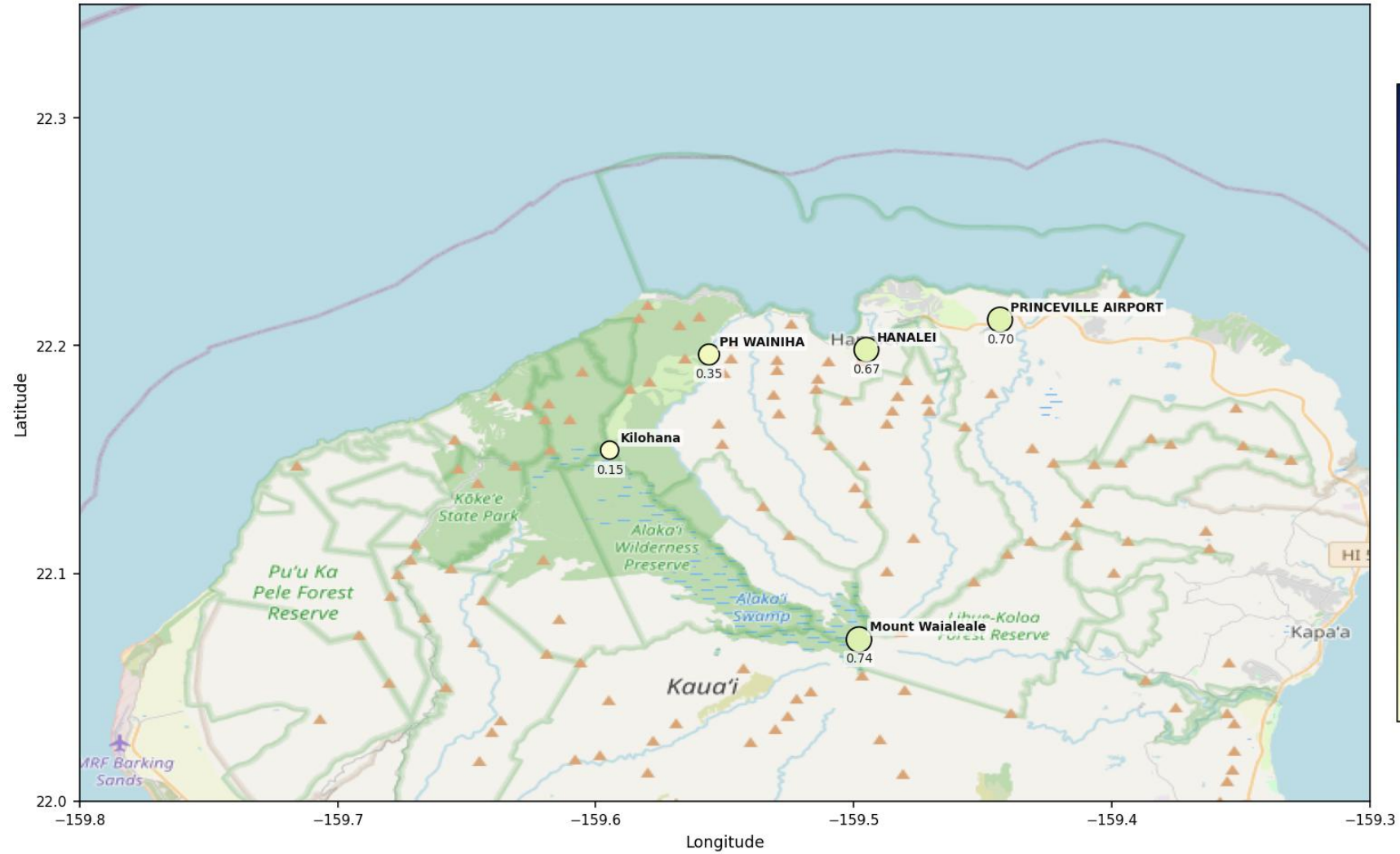
PHKI Digital Hybrid Reflectivity (DHR)



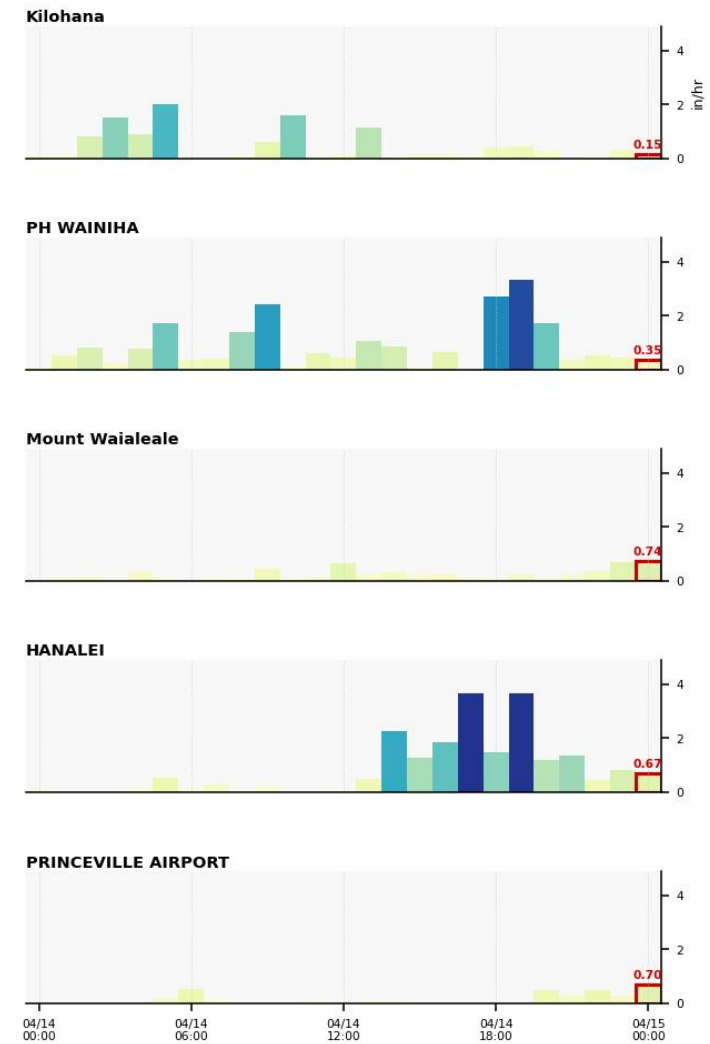
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/15 00:00-01:00 HST]

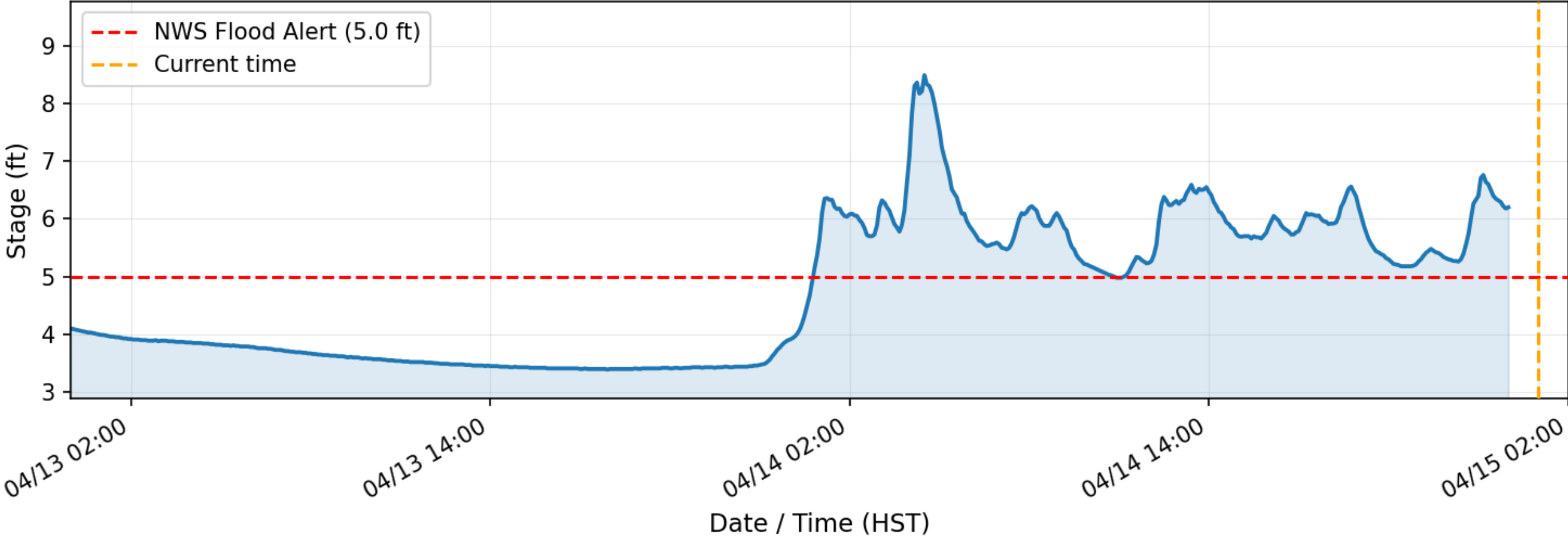


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/15 01:00 HST)**



# Scenario 1 – Decision 2

**Date: Sunday, April 15  
01:00 HST**

## **WFOs**

Issue flood product

## **EMs**

Close the bridge

Prepare for evacuation

Evacuate areas at risk

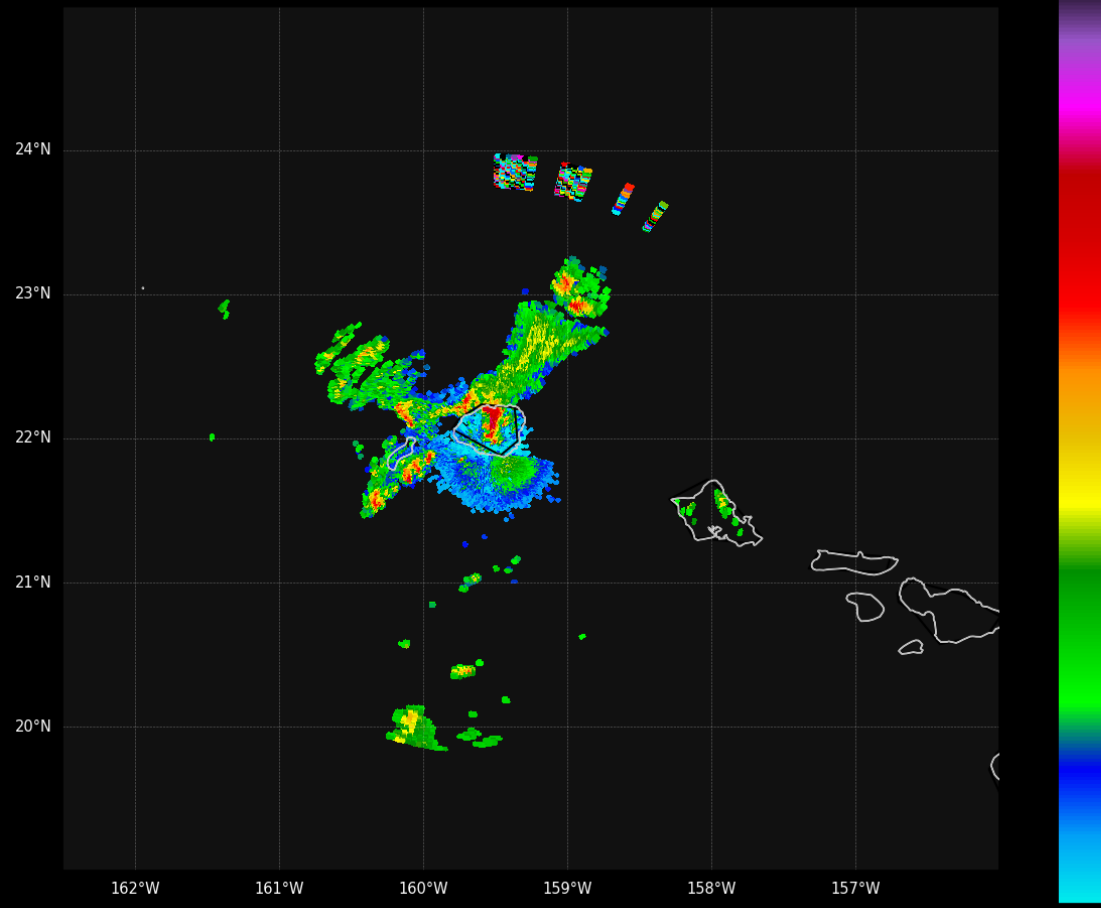
# Scenario 1

**Date: Sunday, April 15  
02:00 HST**

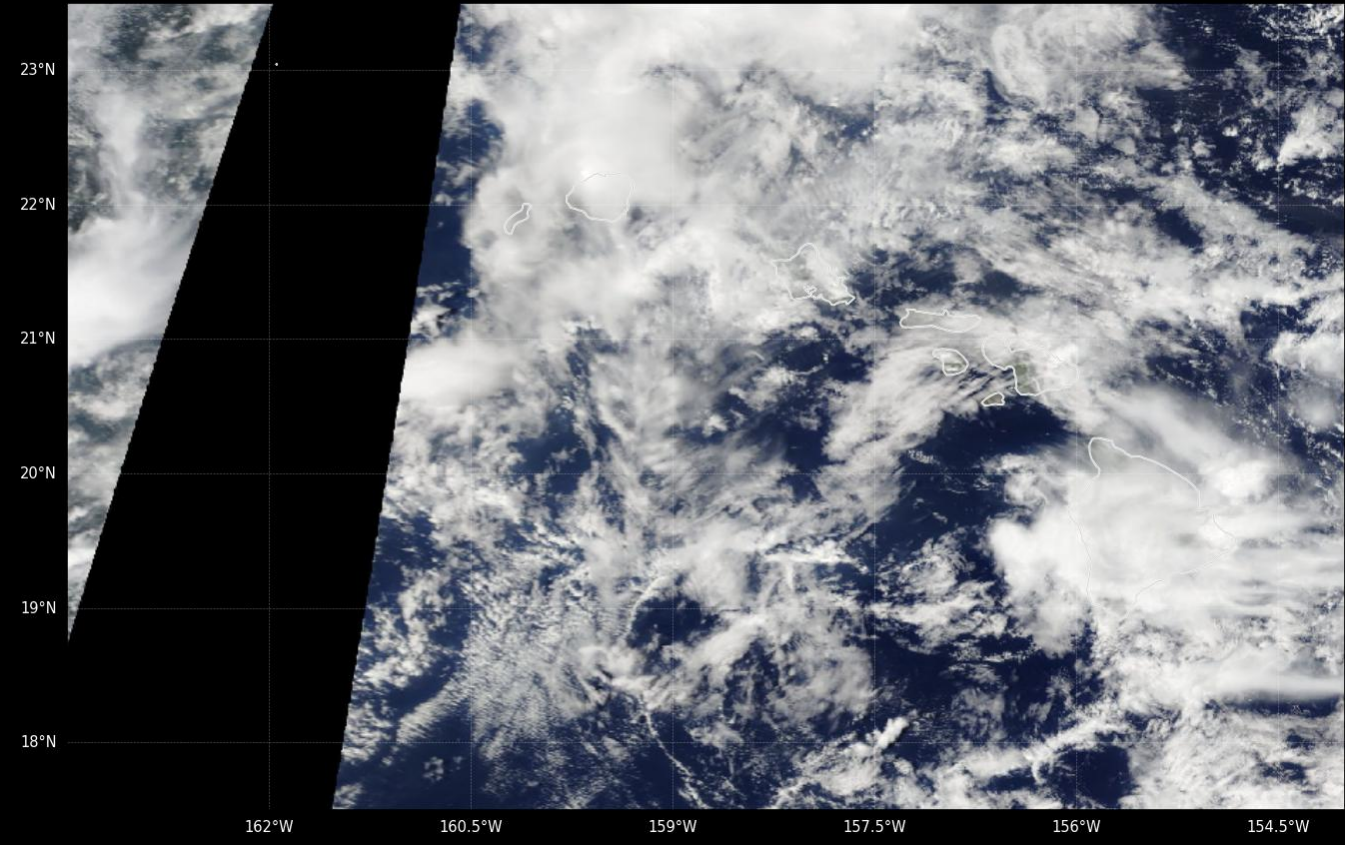
Zonal Forecast Precipitation:

- Windward: Frequent thundershowers ~100%
- Mountain: Frequent thundershowers ~100%

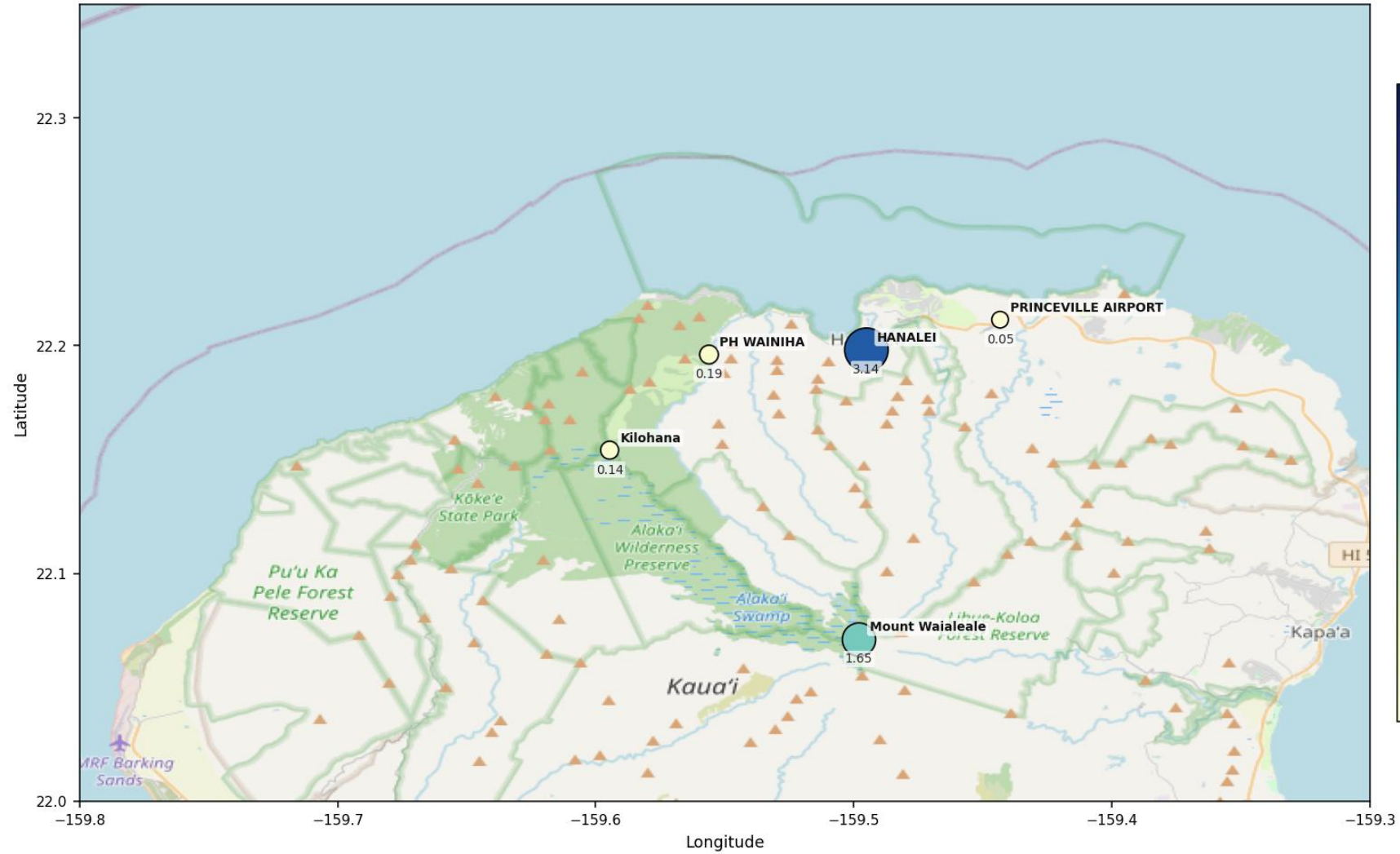
PHKI Digital Hybrid Reflectivity (DHR)



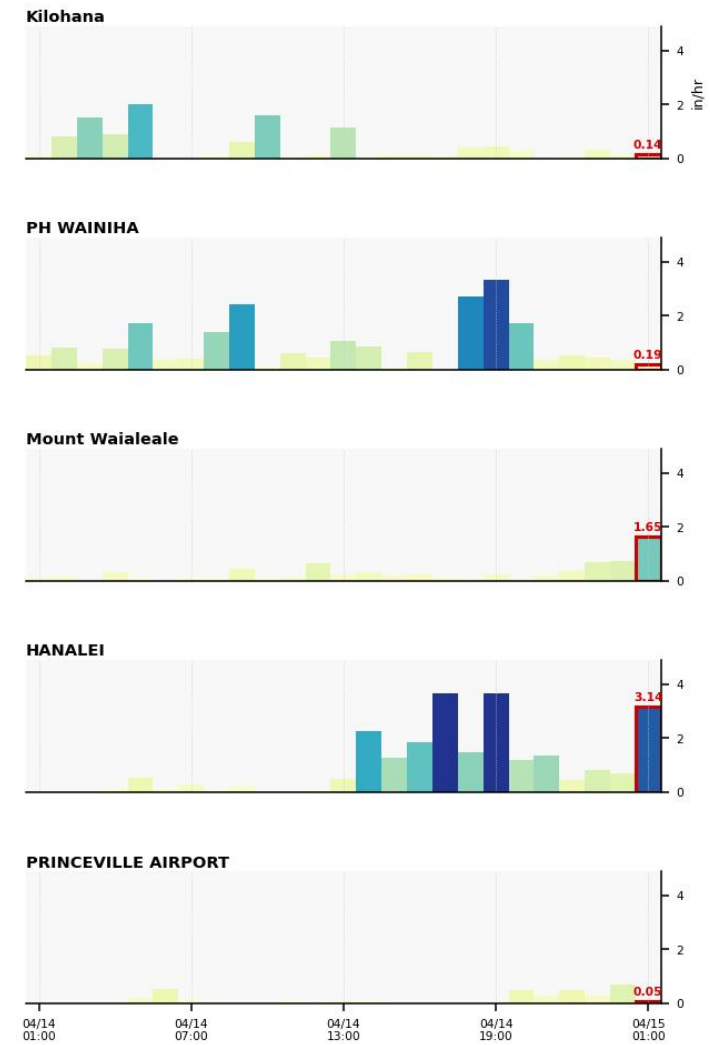
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/15 01:00-02:00 HST]

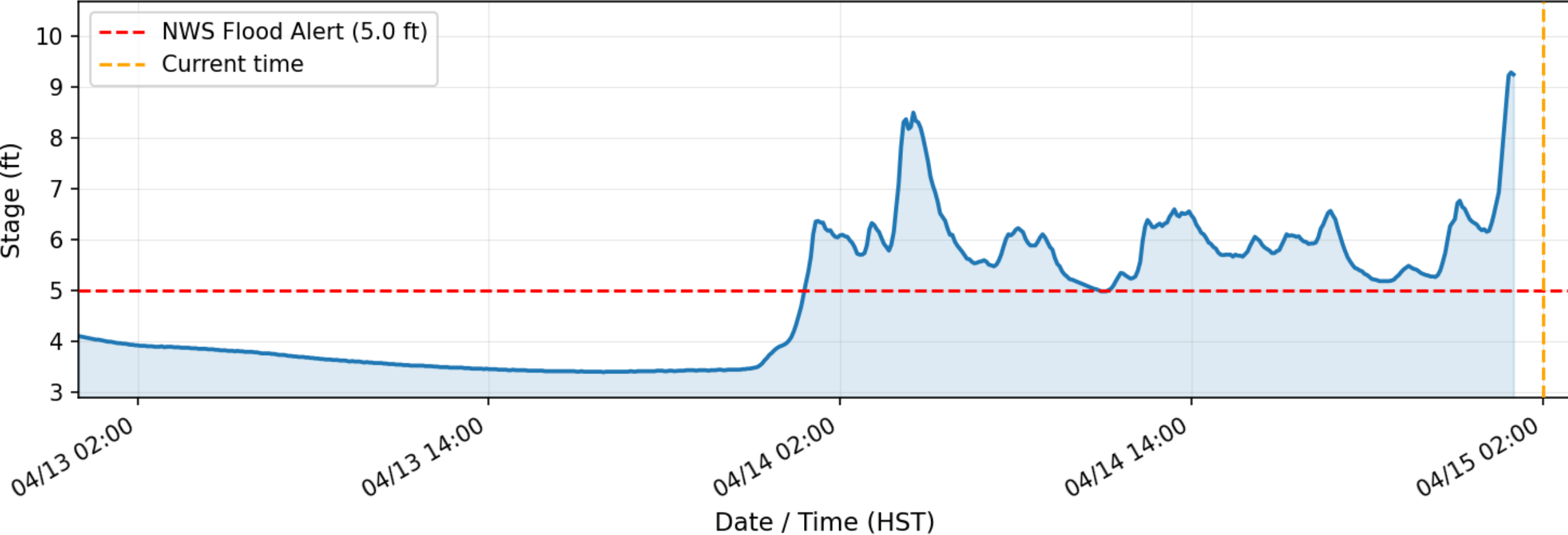


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/15 02:00 HST)**



# Scenario 1

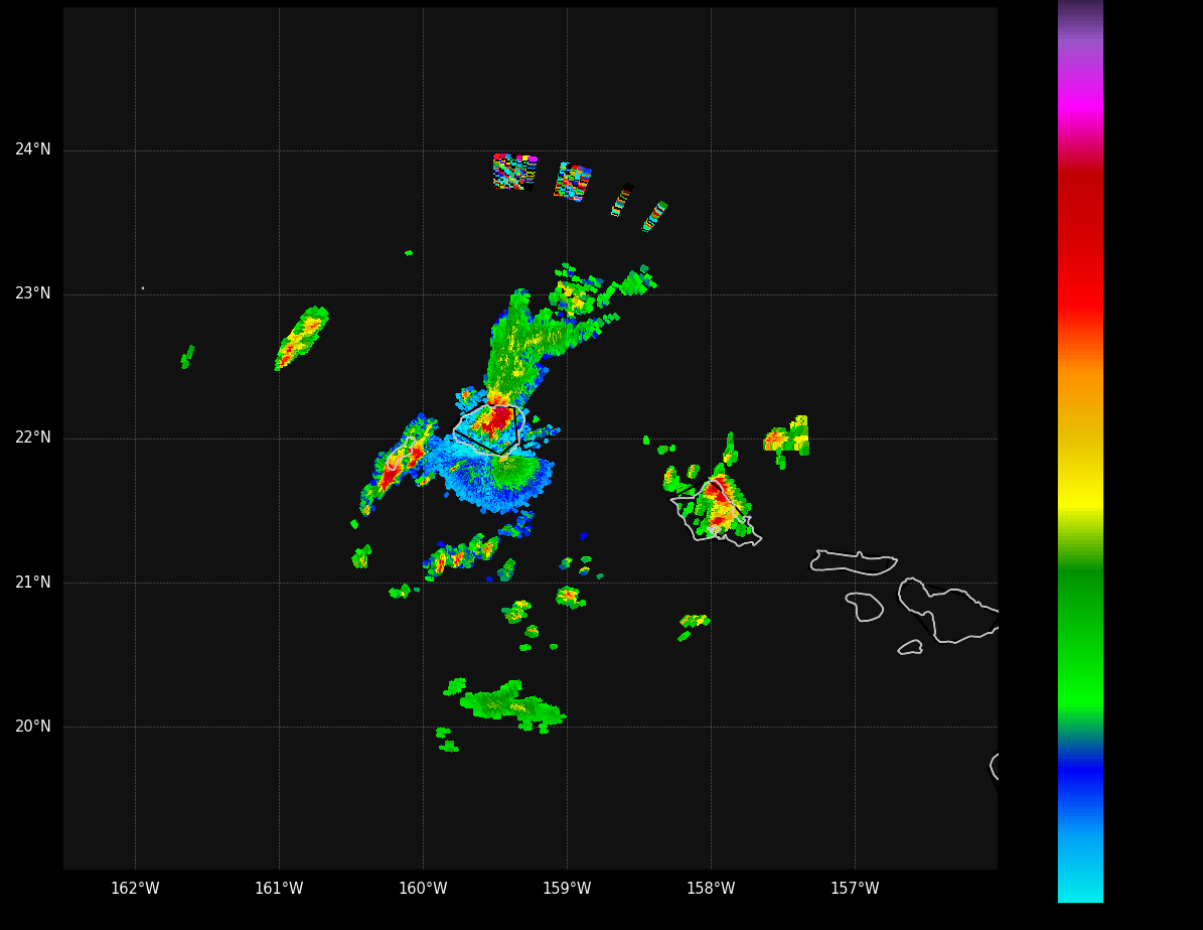


**Date: Sunday, April 15  
04:00 HST  
(Decision Point)**

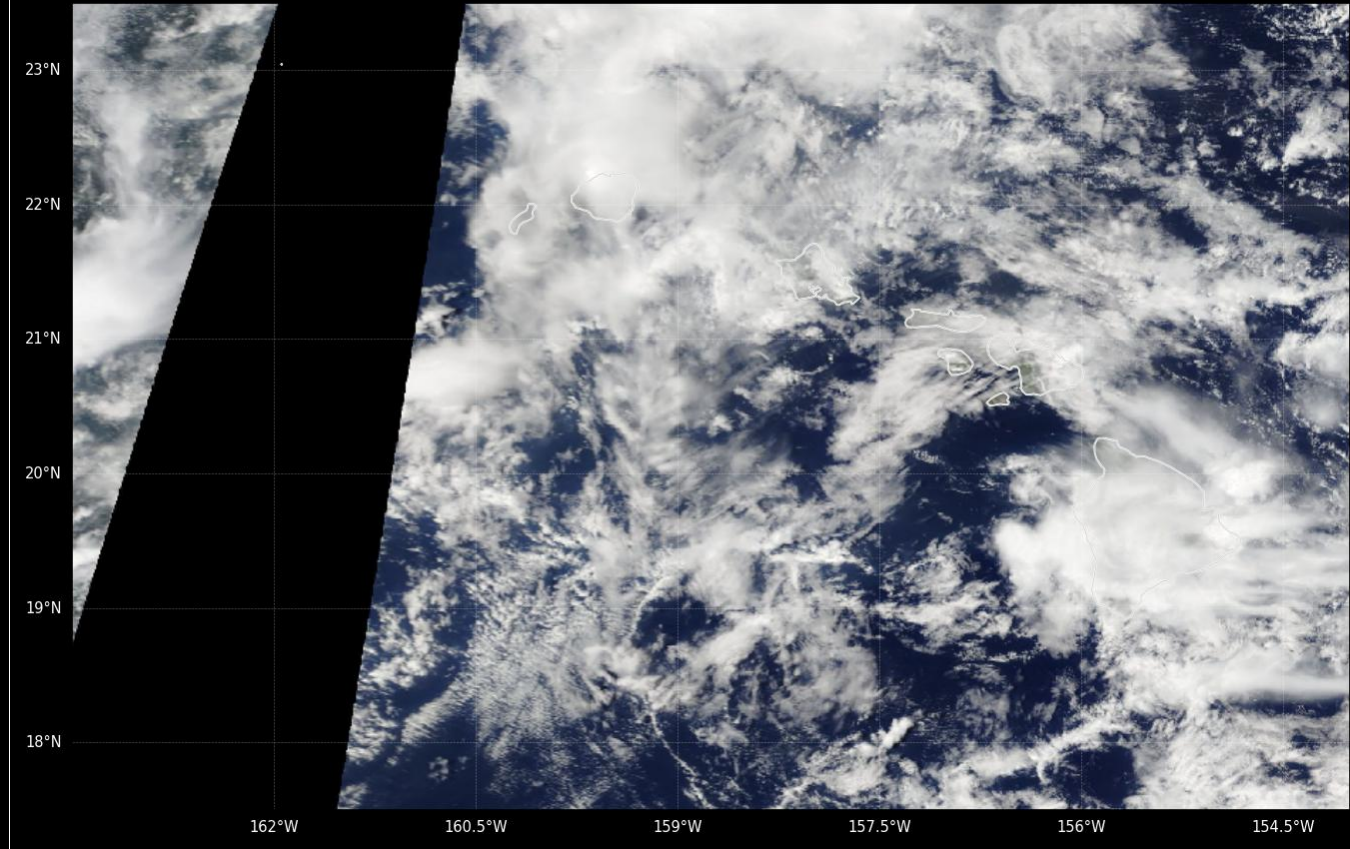
Zonal Forecast Precipitation:

- Windward: Frequent showers, thundershowers
- Mountain: Frequent thundershowers ~100%

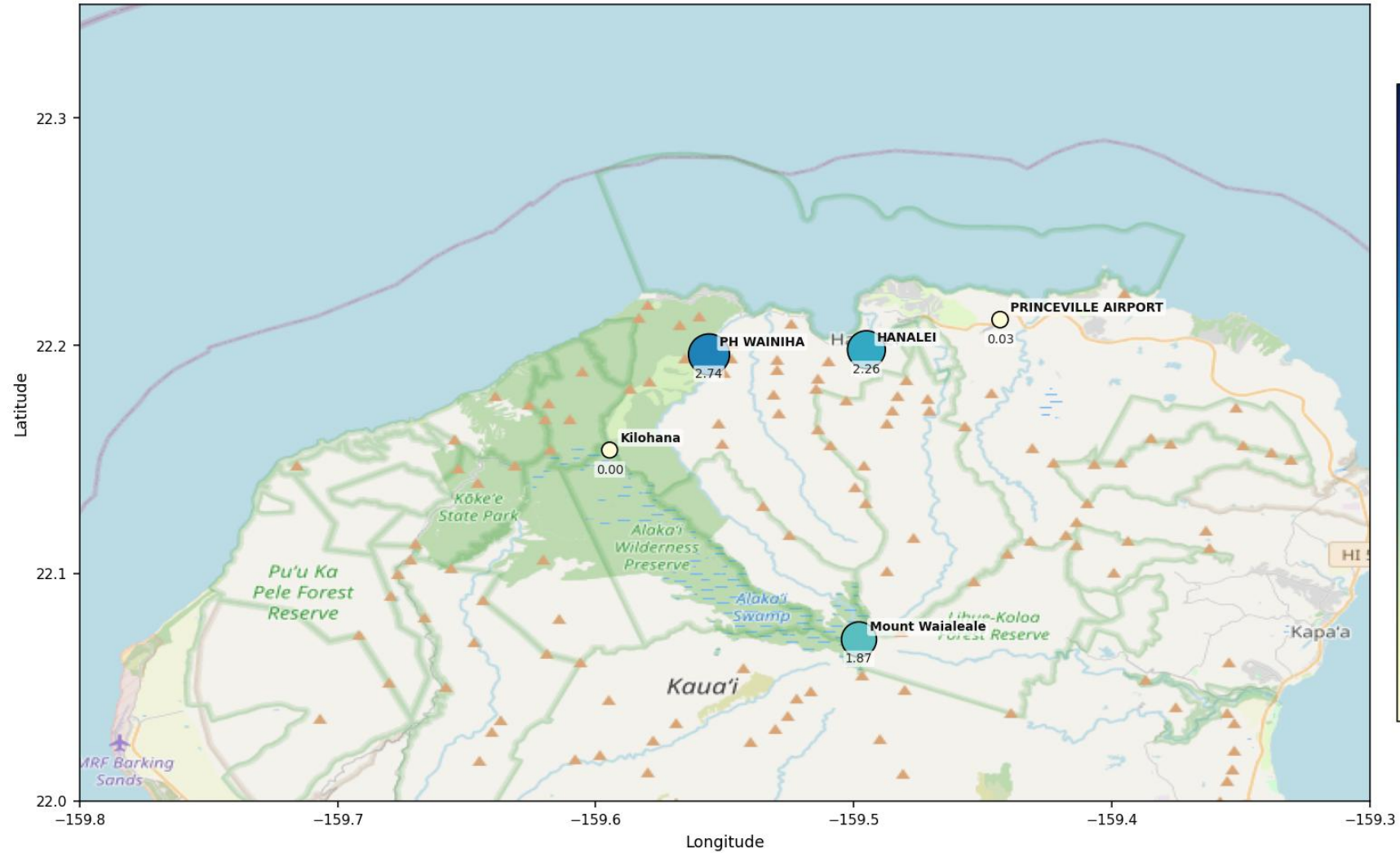
PHKI Digital Hybrid Reflectivity (DHR)



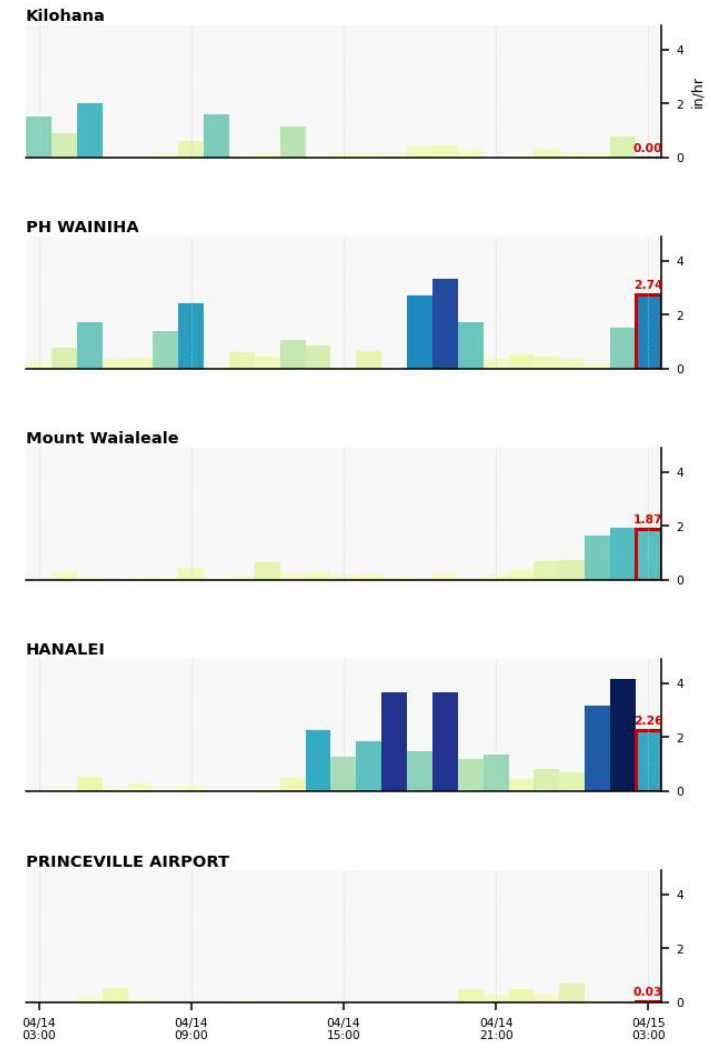
MODIS Terra TrueColor



### North Shore Kaua'i — 1-hour Rainfall [04/15 03:00-04:00 HST]

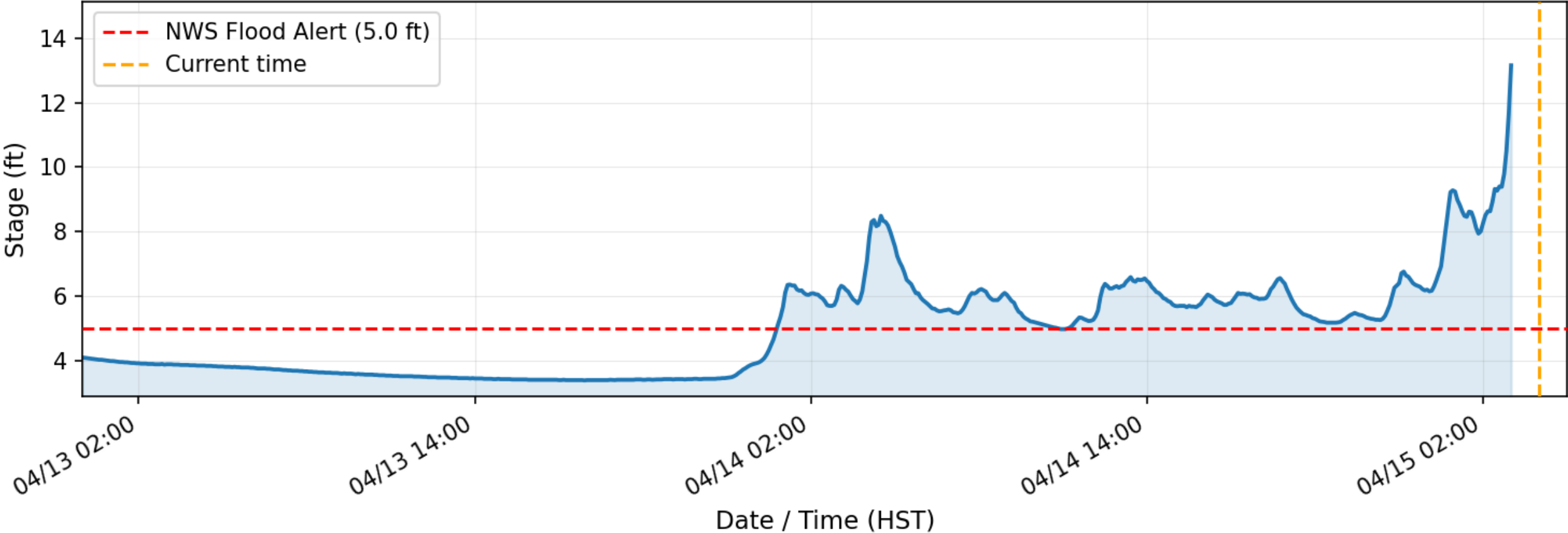


### 24-hr lookback



USGS Observed Stage Data

**USGS 16103000 (Hanalei R nr Hanalei)  
(04/15 04:00 HST)**



# Scenario 1 – Decision 3

**Date: Sunday, April 15  
03:00 HST**

## **WFOs**

Issue flood product

## **EMs**

Close the bridge  
Prepare for evacuation  
Evacuate areas at risk

# Scenario 1 – Decision Outcome and Discussion

- [Real decision timeline](#)
- Share flood outcome
- Discuss the thinking process
  - What factor(s) most influenced your decision?
  - What other information do you WISH you had?
  - How confident did you feel about the information?

# Scenario 1 – What was Really Happened

- The event: April 13-15, 2018
  - A seasonal storm became a record-breaking.
  - Unprecedented rainfall rates:
    - 1 hour: 140 mm (5.51")
    - 6 hours: 496 mm (19.52")
    - **24 hours: 1,262 mm (49.69") — a new U.S. national record.**
  - ⑩ The Hanalei River reached a peak flow of approximately 926 cms (or 32,700 cfs) before the USGS stream gauge washed out in the middle of the event.
- ⑩ Damage and recovery
  - ⑩ Zero fatalities were reported, largely due to community response.
  - ⑩ Infrastructure: 15 landslides buried the only highway, completely cutting off the North Shore from the rest of the island for about 14-months.
  - ⑩ **Property: 532 homes were damaged or destroyed.**
  - ⑩ **Economic Cost: Total damages were estimated between \$125M and \$180M USD.**



# Scenario 2

Switch Roles!



# Scenario 2

## Continue to note

- What factors are most influencing your decision?
- What information do you WISH you had?
- How confident are you in the information?

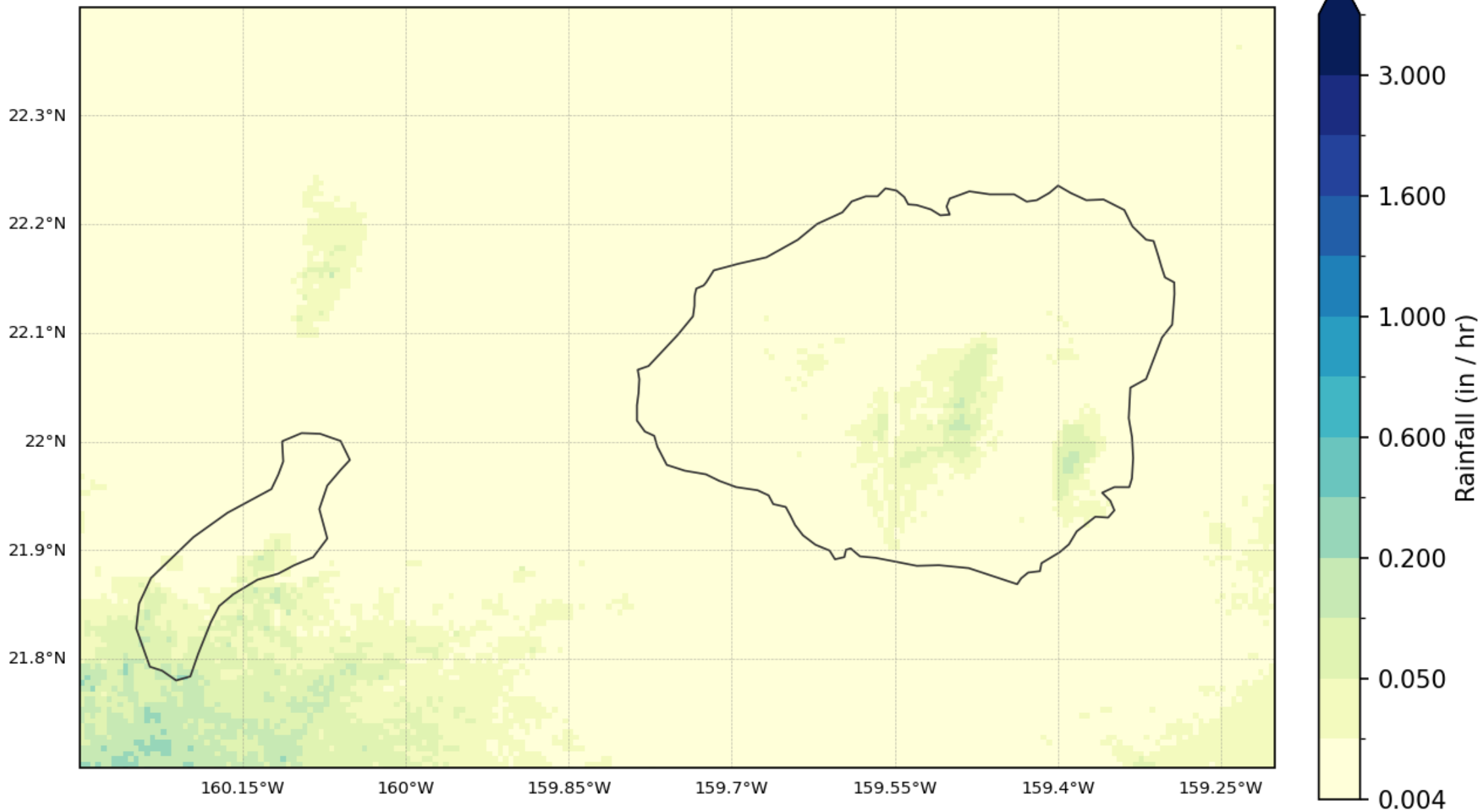
**Date: Wednesday, March 11  
04:30 HST**

Zonal Forecast Precipitation:

- Kauai North: locally heavy rain possible

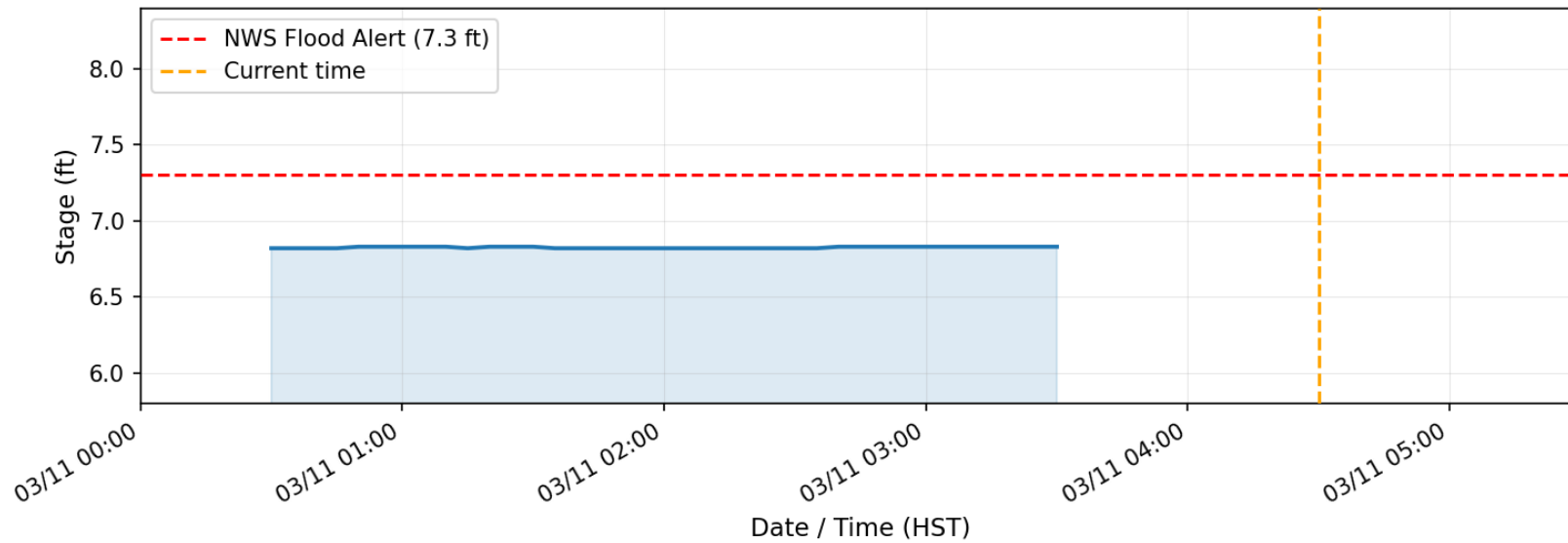
FFA on Oahu, Maui, and Big Island

**MRMS Radar-Only QPE (1-hr rainfall)**  
**March 11 04:30 HST**

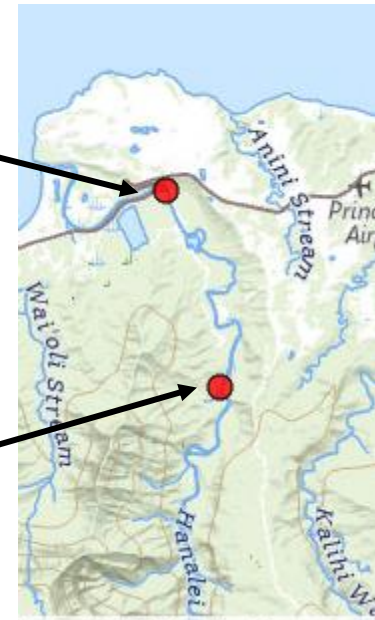
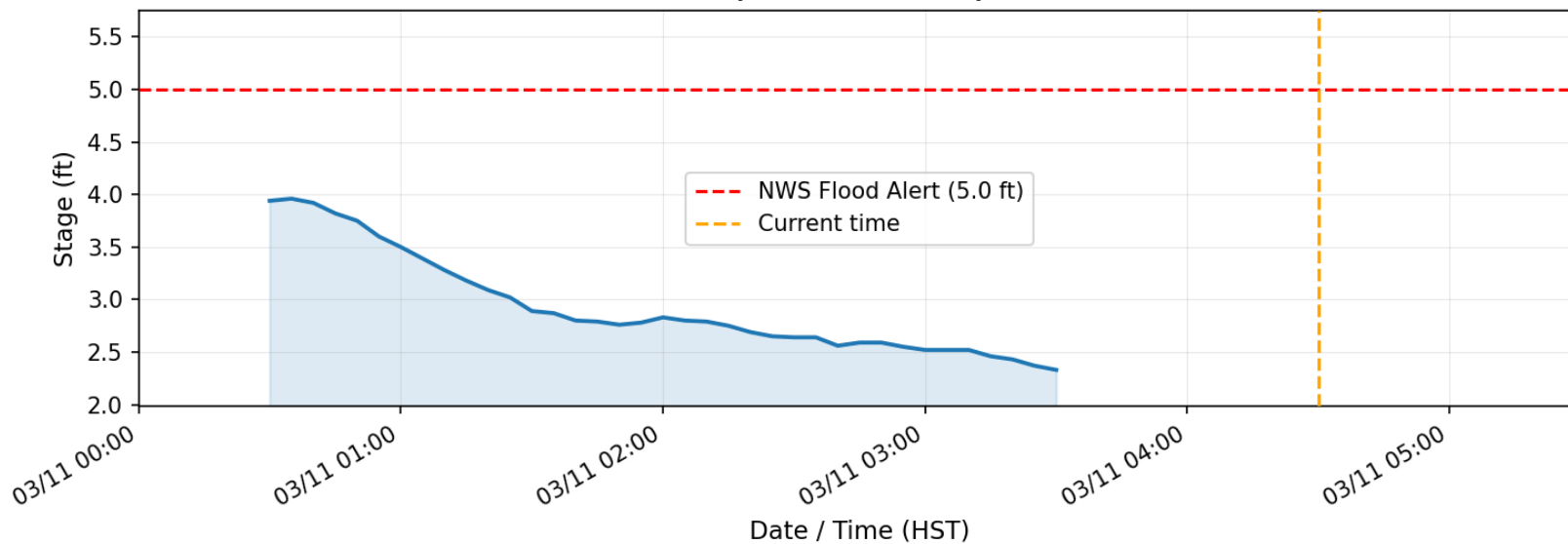


USGS  
Observed  
Stage Data

**USGS 16104200 (Hanalei R at Hwy 56 Bridge nr Hanalei)  
(03/11 04:30 HST)**

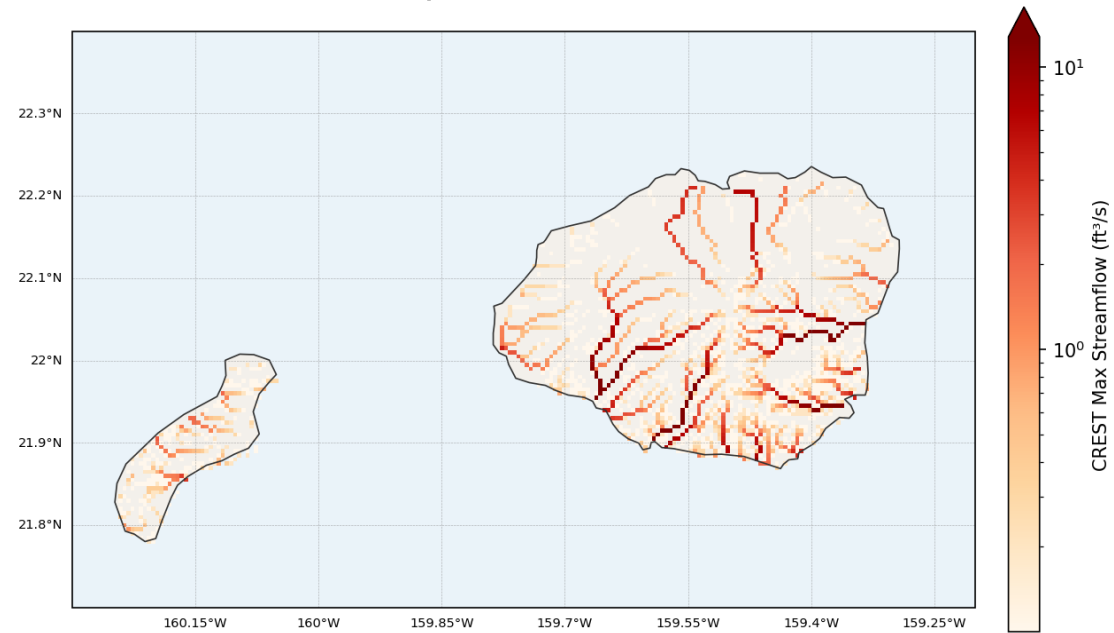


**USGS 16103000 (Hanalei R nr Hanalei)  
(03/11 04:30 HST)**

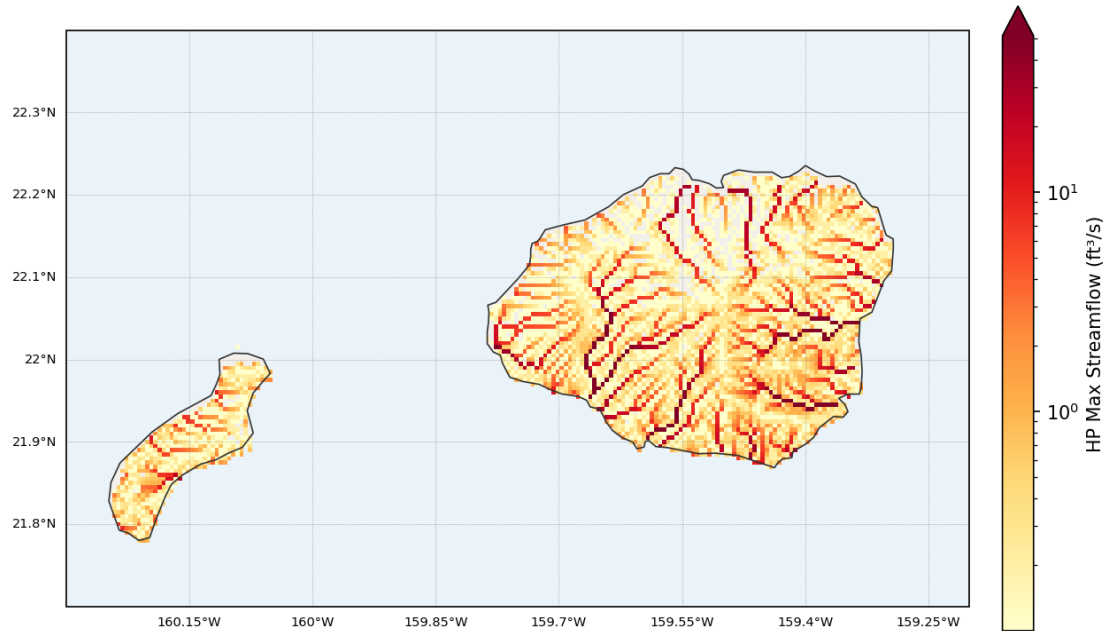


Latest Available  
FLASH products

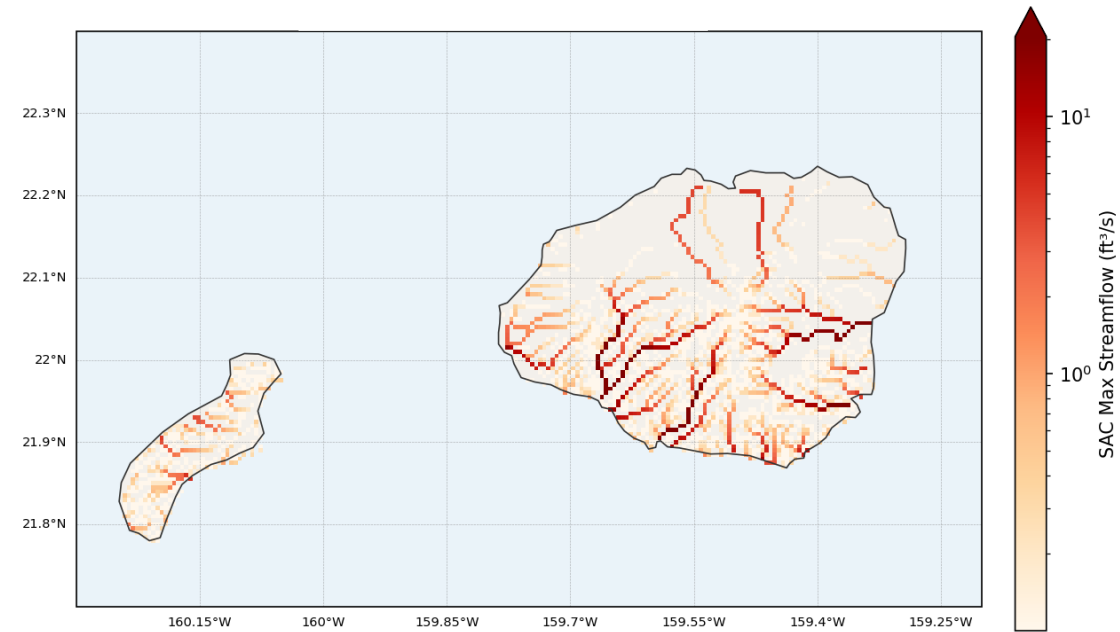
**CREST Max Streamflow (ft<sup>3</sup>/s)**



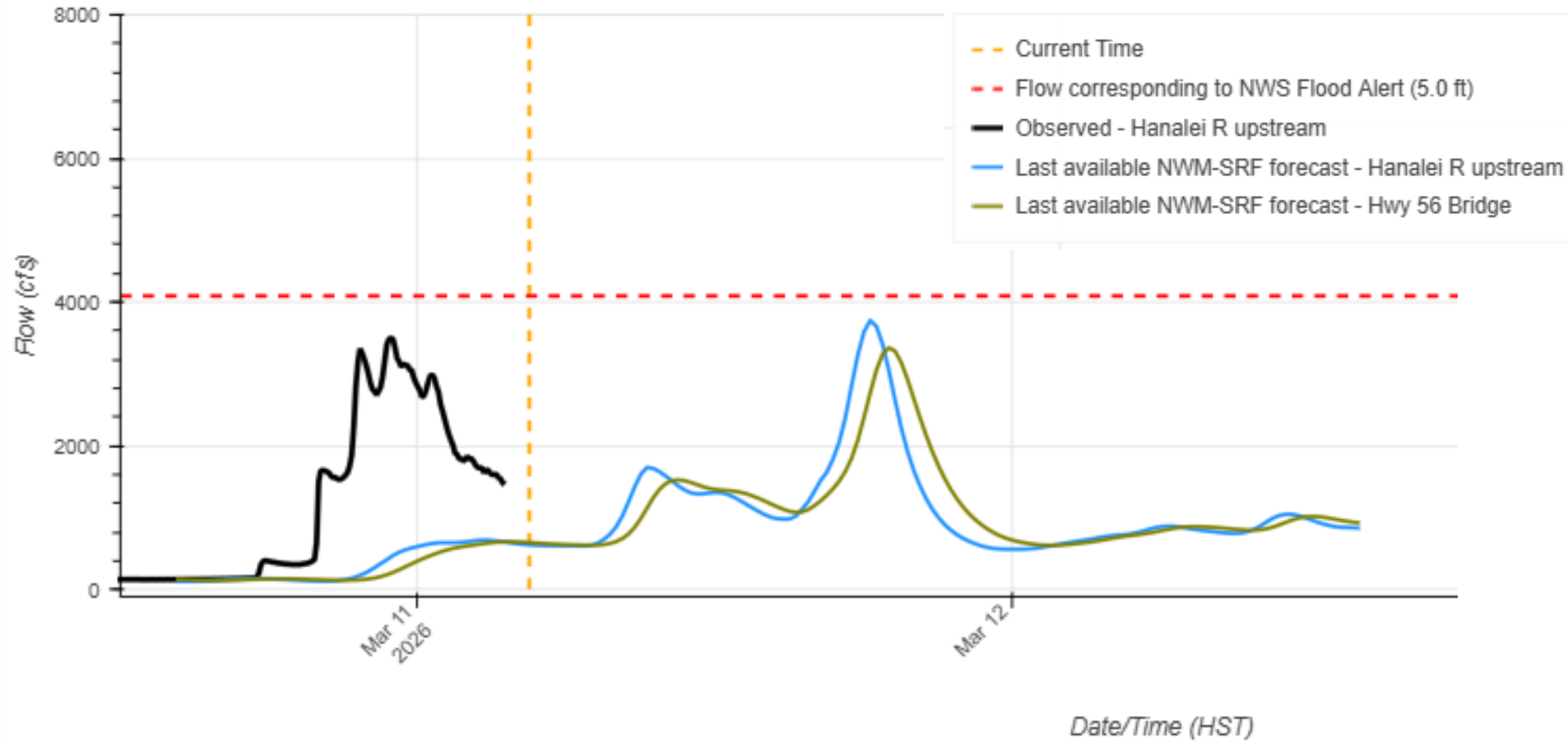
**HP Max Streamflow (ft<sup>3</sup>/s)**



**SAC Max Streamflow (ft<sup>3</sup>/s)**



# Latest Available NWM Short Range Forecasts



# Scenario 2 – Activity

**Date: Wednesday, March 11  
04:30 HST**

## **WFOs**

Issue severe weather briefing

Communicate to EMs

## **EMs**

Prepare for briefing  
(expectations, questions)

# Scenario 2

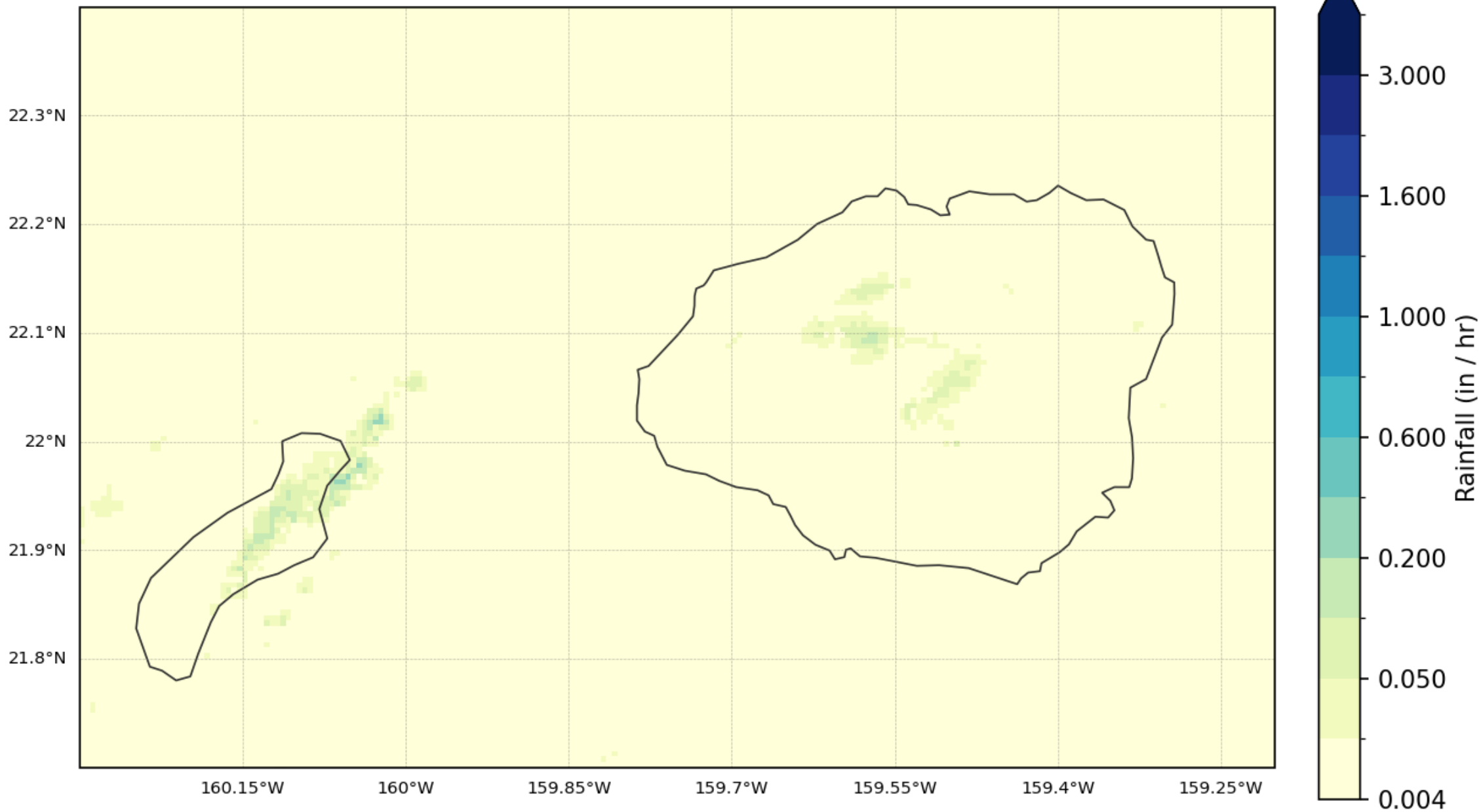
**Date: Thursday, March 12  
04:30 HST**

Zonal Forecast Precipitation:

- Kauai North: locally heavy rain possible, gust to 60 mph

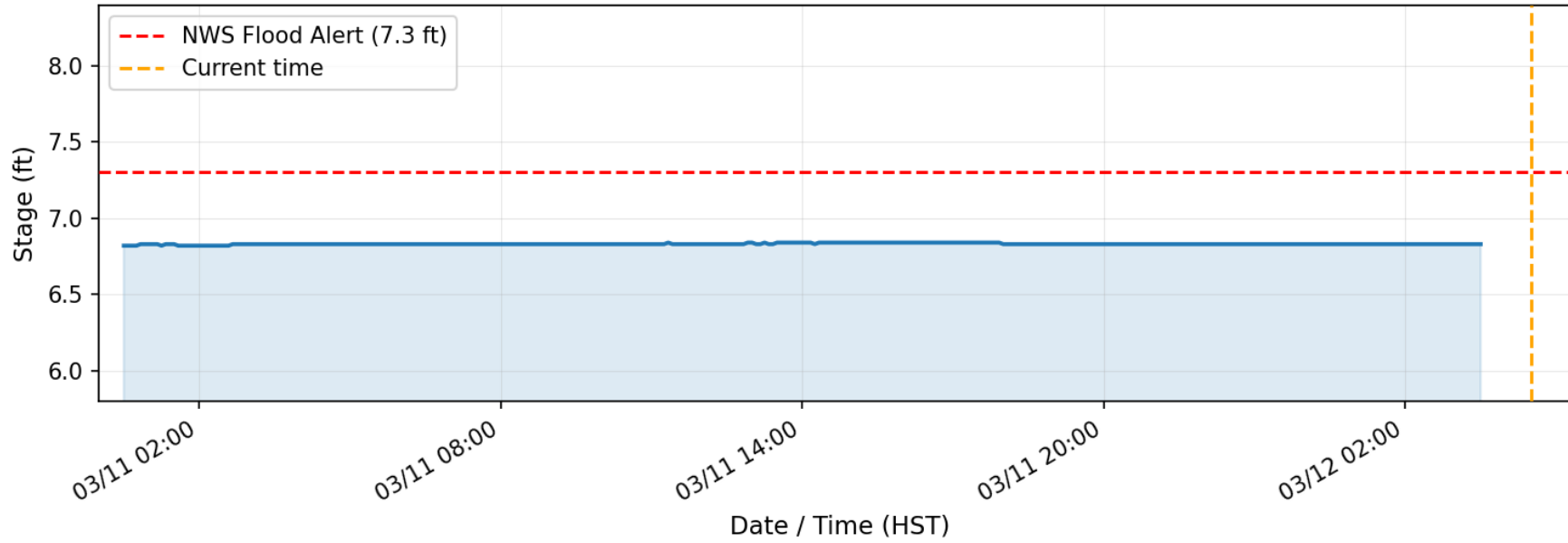
FFW on Oahu; FFA on Maui and Big Island

**MRMS Radar-Only QPE (1-hr rainfall)**  
**March 12 04:30 HST**

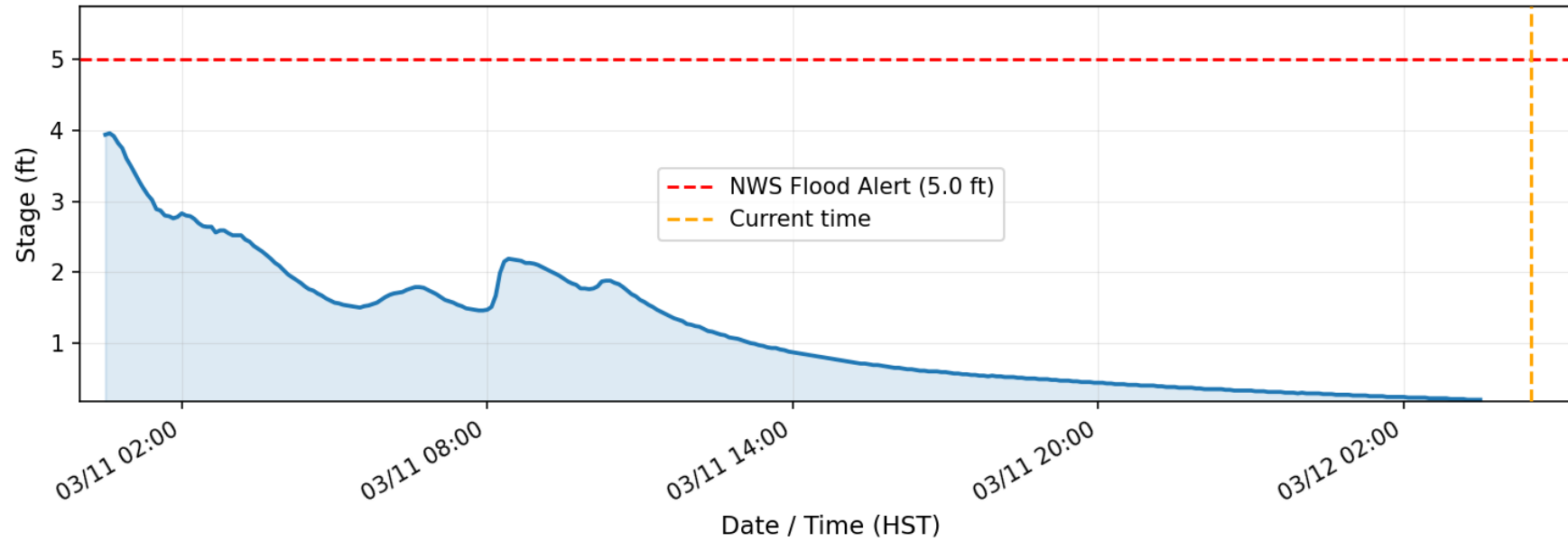


USGS  
Observed  
Stage Data

**USGS 16104200 (Hanalei R at Hwy 56 Bridge nr Hanalei)  
(03/12 04:30 HST)**

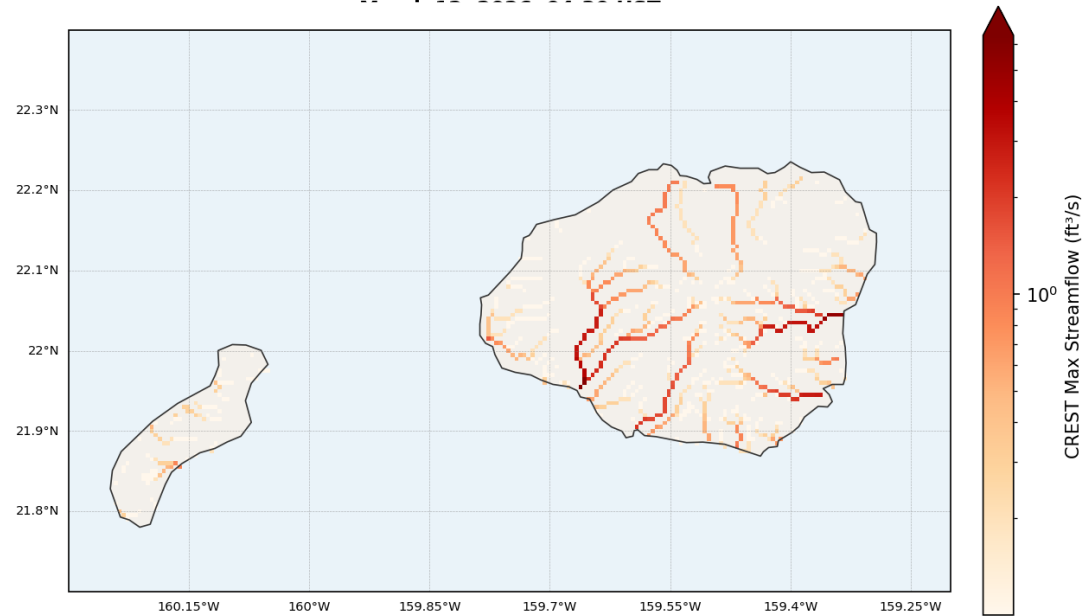


**USGS 16103000 (Hanalei R nr Hanalei)  
(03/12 04:30 HST)**

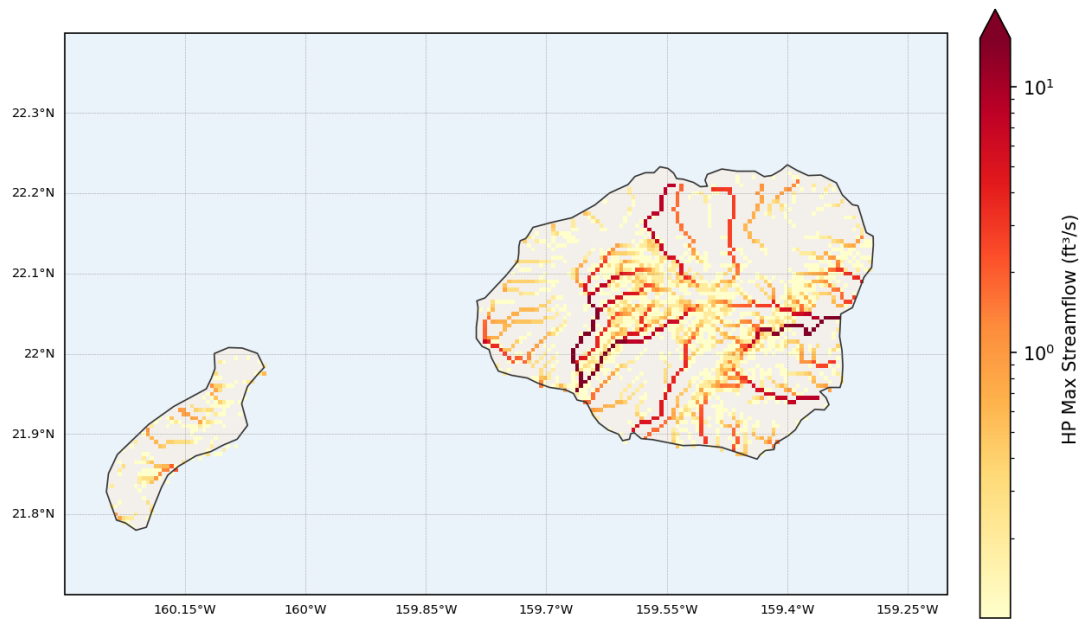


Latest Available  
FLASH products

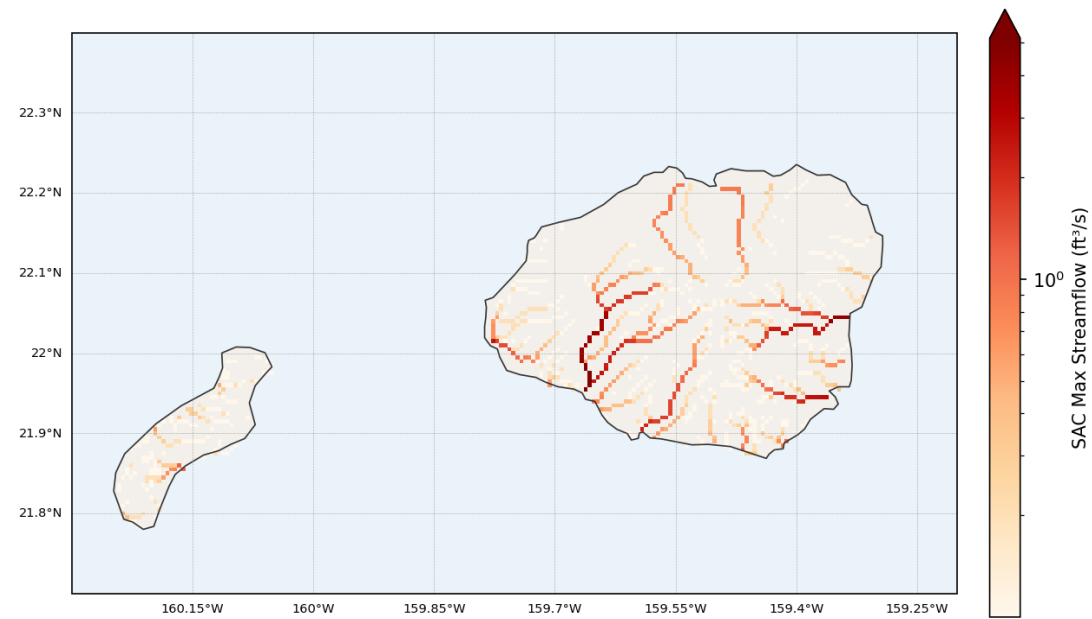
**CREST Max Streamflow (ft<sup>3</sup>/s)**



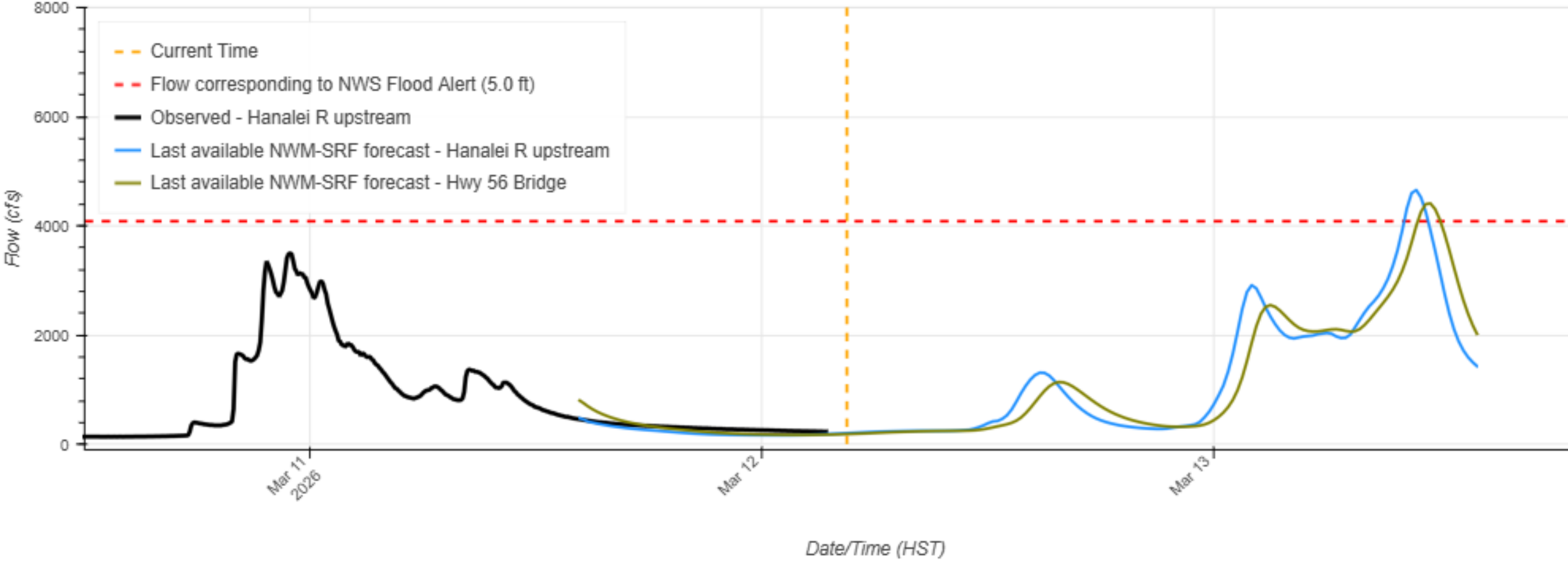
**HP Max Streamflow (ft<sup>3</sup>/s)**



**SAC Max Streamflow (ft<sup>3</sup>/s)**



# Latest Available NWM Short Range Forecasts



# Scenario 2

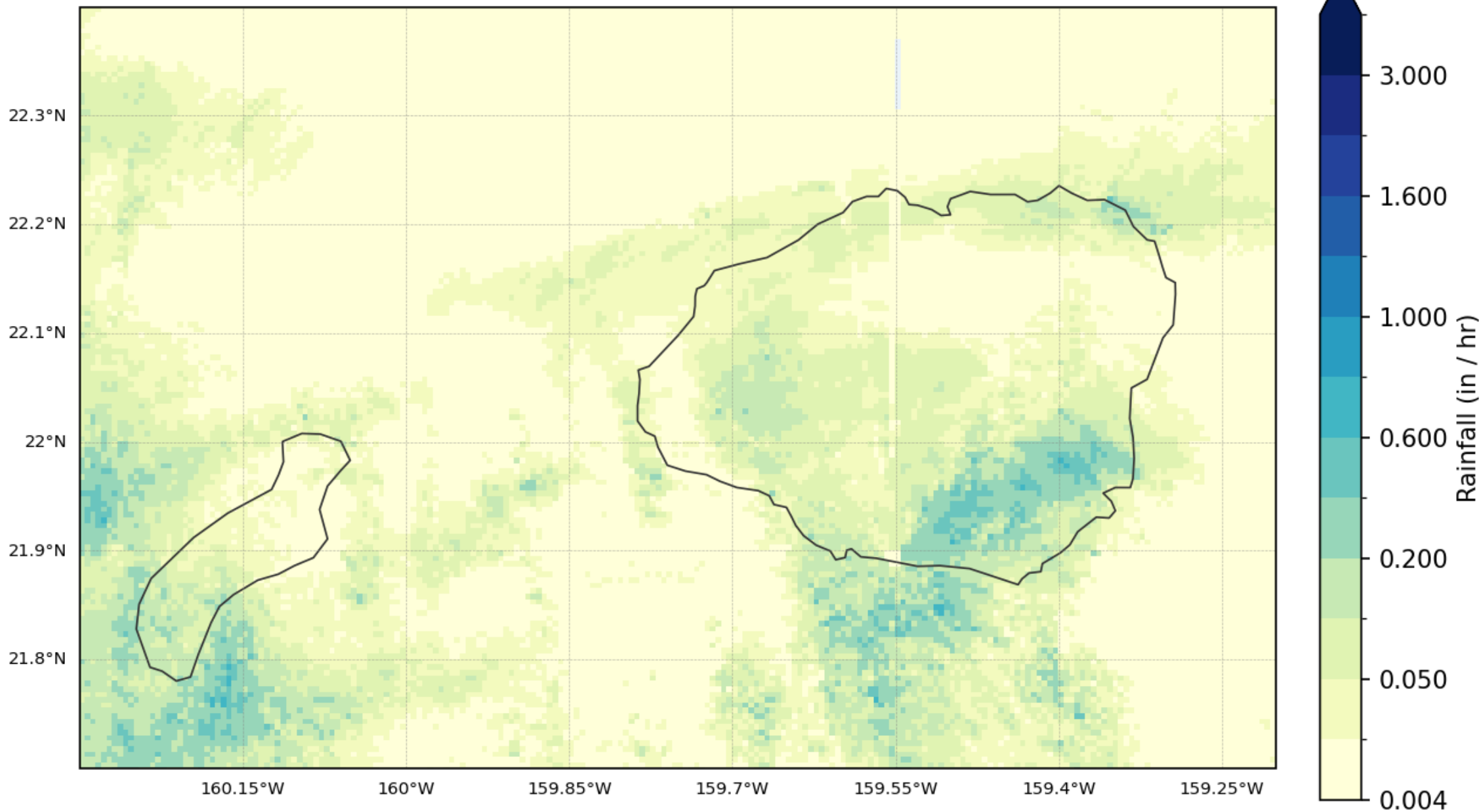
**Date: Thursday, March 12  
16:30 HST**

Zonal Forecast Precipitation:

- Kauai North: gust to 65 mph, heavy rain

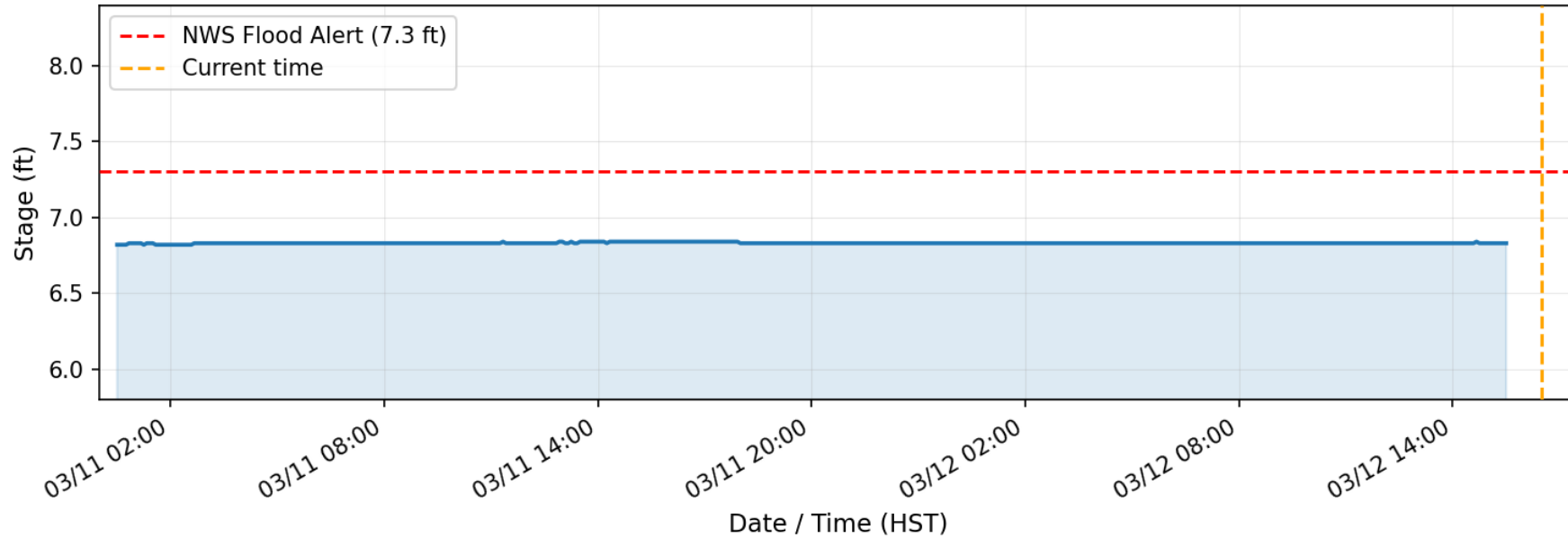
FFW on Oahu; FFA on Maui and Big Island

**MRMS Radar-Only QPE (1-hr rainfall)**  
**March 12 16:30 HST**

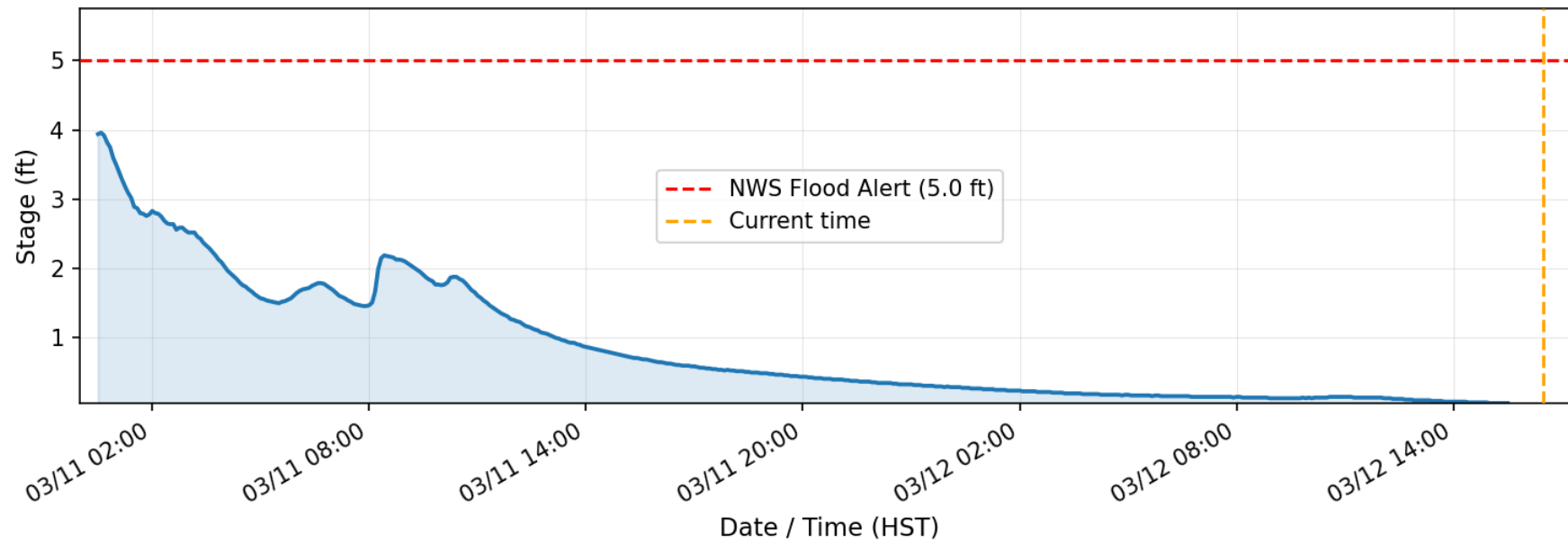


USGS  
Observed  
Stage Data

**USGS 16104200 (Hanalei R at Hwy 56 Bridge nr Hanale)  
(03/12 16:30 HST)**

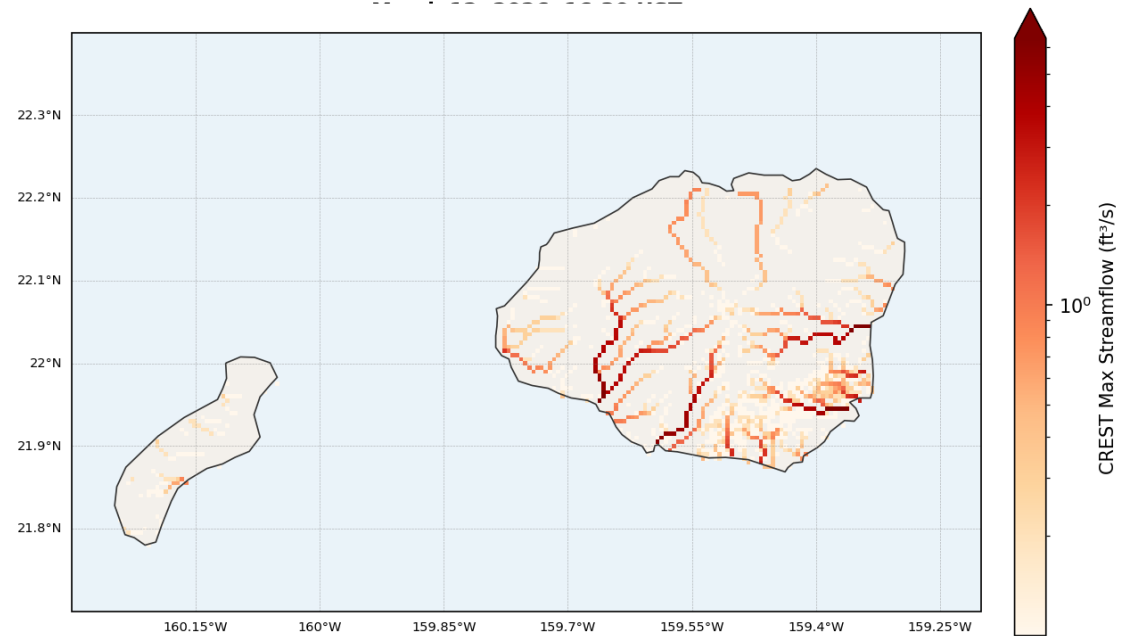


**USGS 16103000 (Hanalei R nr Hanalei)  
(03/12 16:30 HST)**

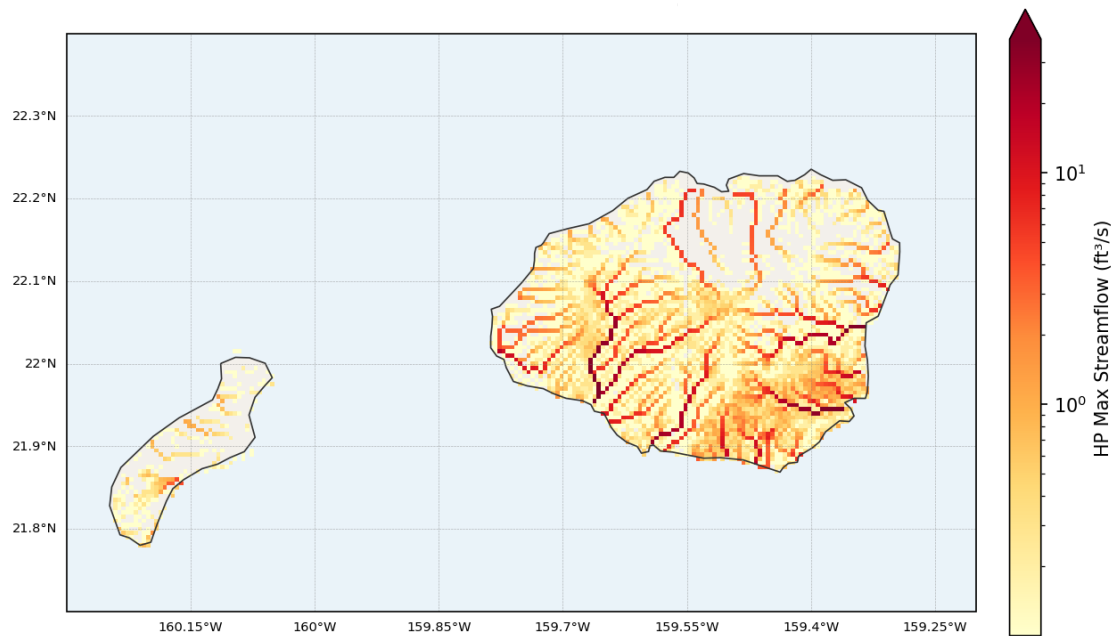


Latest Available  
FLASH products

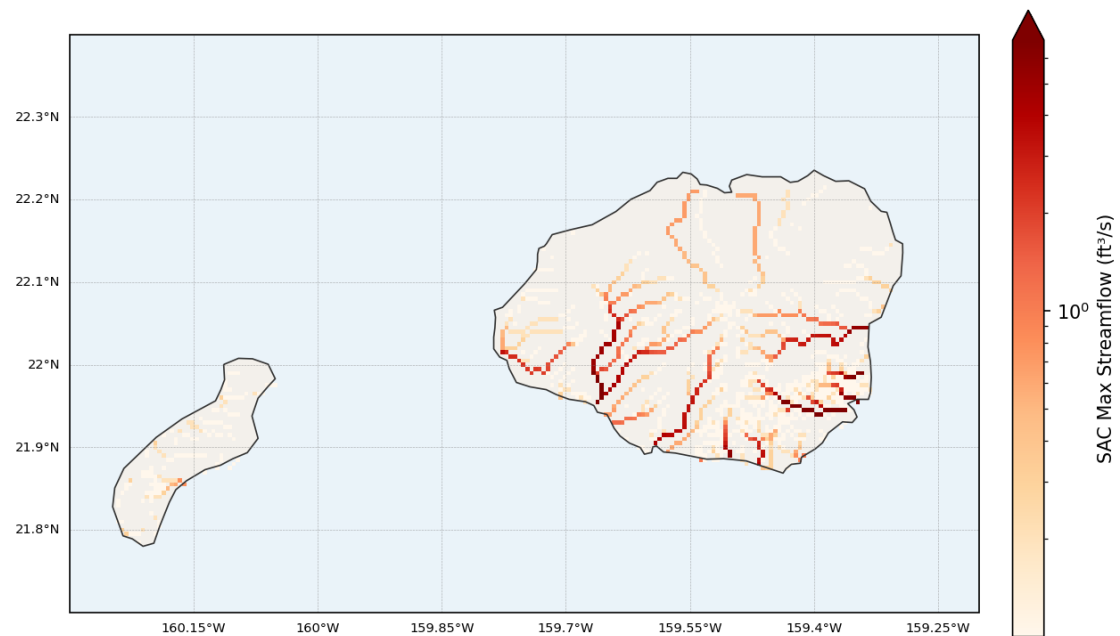
**CREST Max Streamflow (ft<sup>3</sup>/s)**



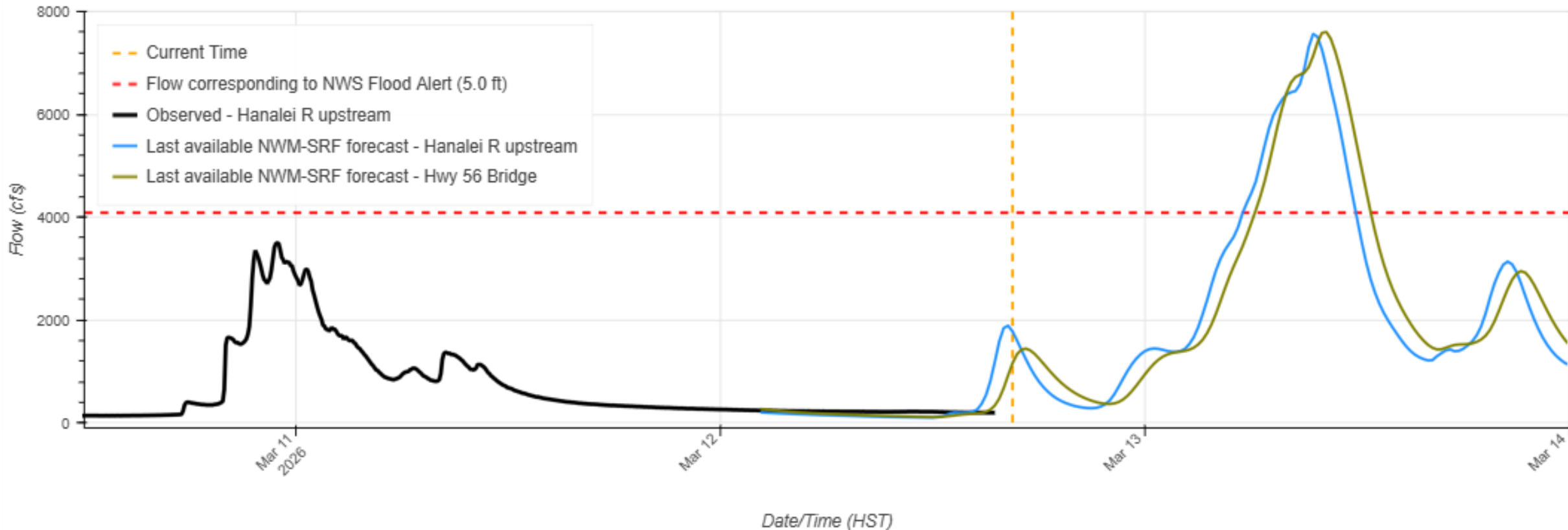
**HP Max Streamflow (ft<sup>3</sup>/s)**



**SAC Max Streamflow (ft<sup>3</sup>/s)**



# Latest Available NWM Short Range Forecasts



# Scenario 2

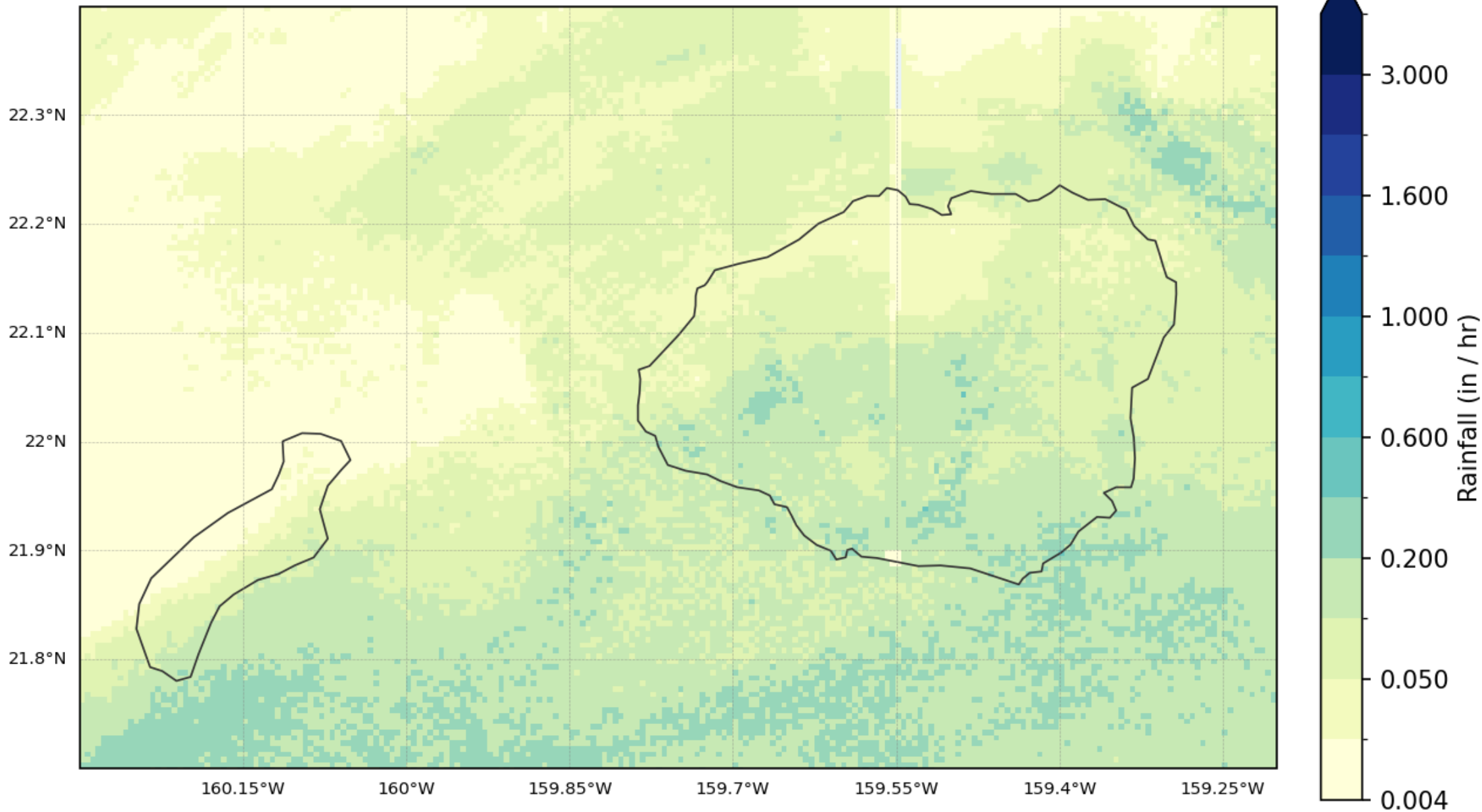
**Date: Friday, March 12  
22:30 HST  
(Decision Point)**

Zonal Forecast Precipitation:

- Kauai North: locally heavy rain possible, gust to 60 mph

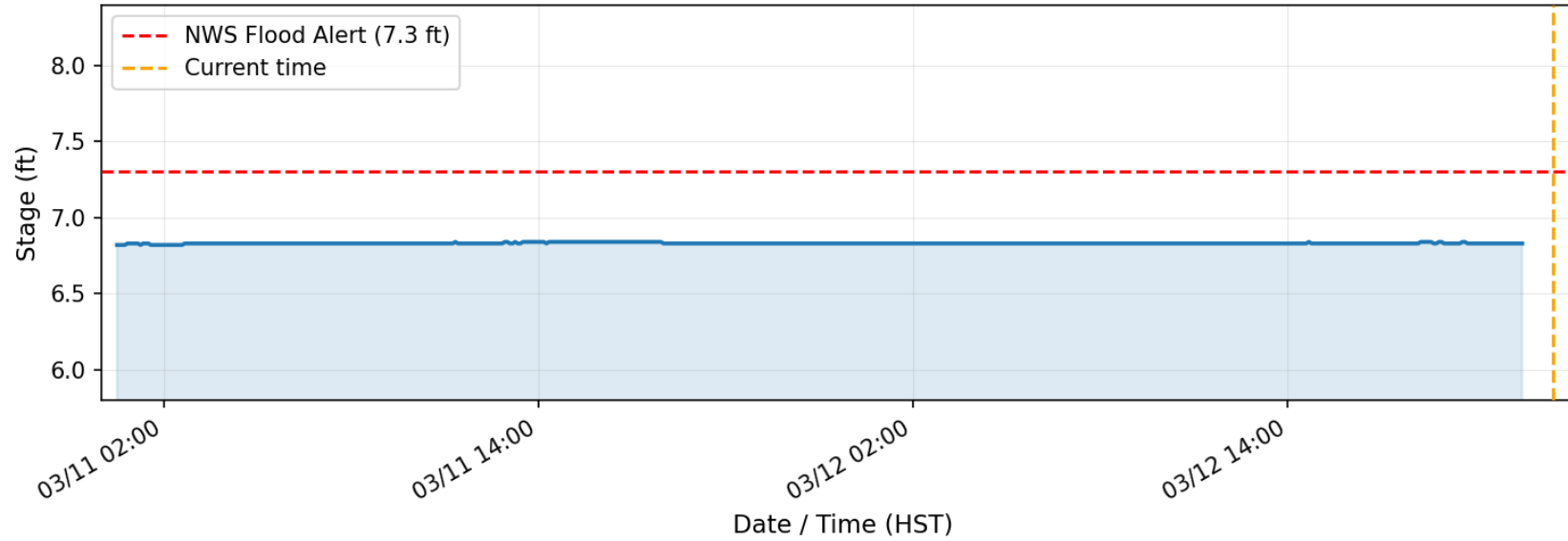
FFW on Oahu; FFA on Maui and Big Island

**MRMS Radar-Only QPE (1-hr rainfall)**  
**March 12, 22:30 HST**

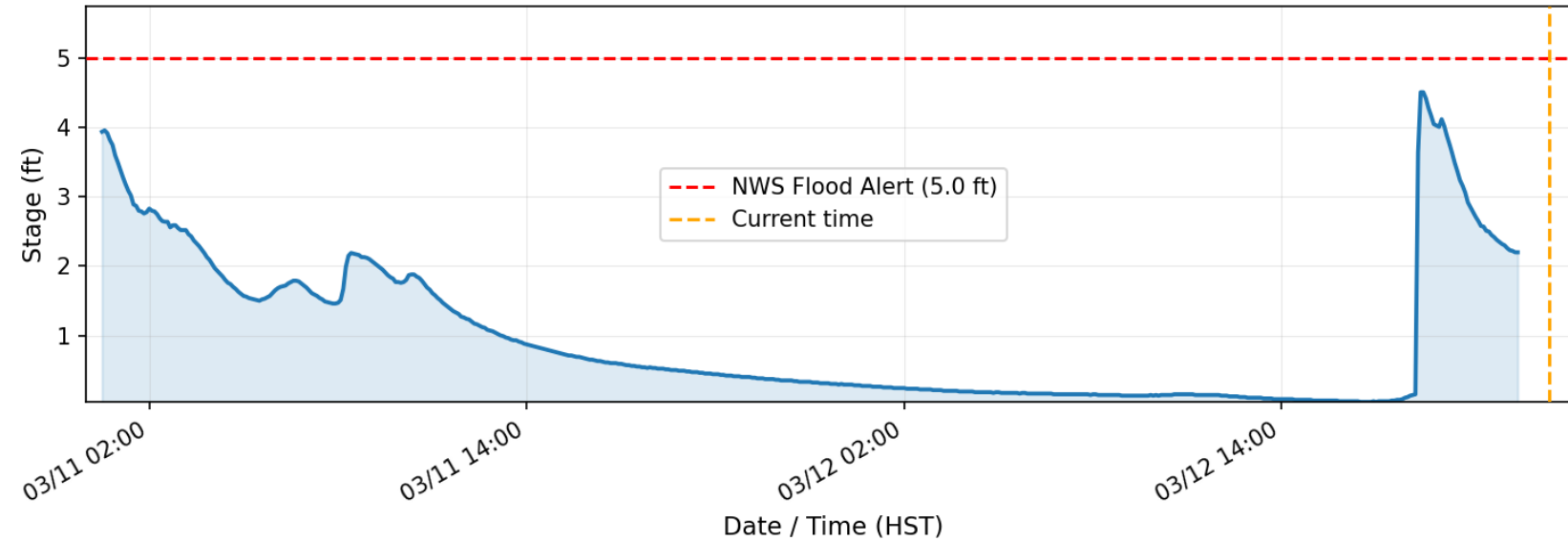


USGS  
Observed  
Stage Data

**USGS 16104200 (Hanalei R at Hwy 56 Bridge nr Hanalei)  
(03/12 22:30 HST)**

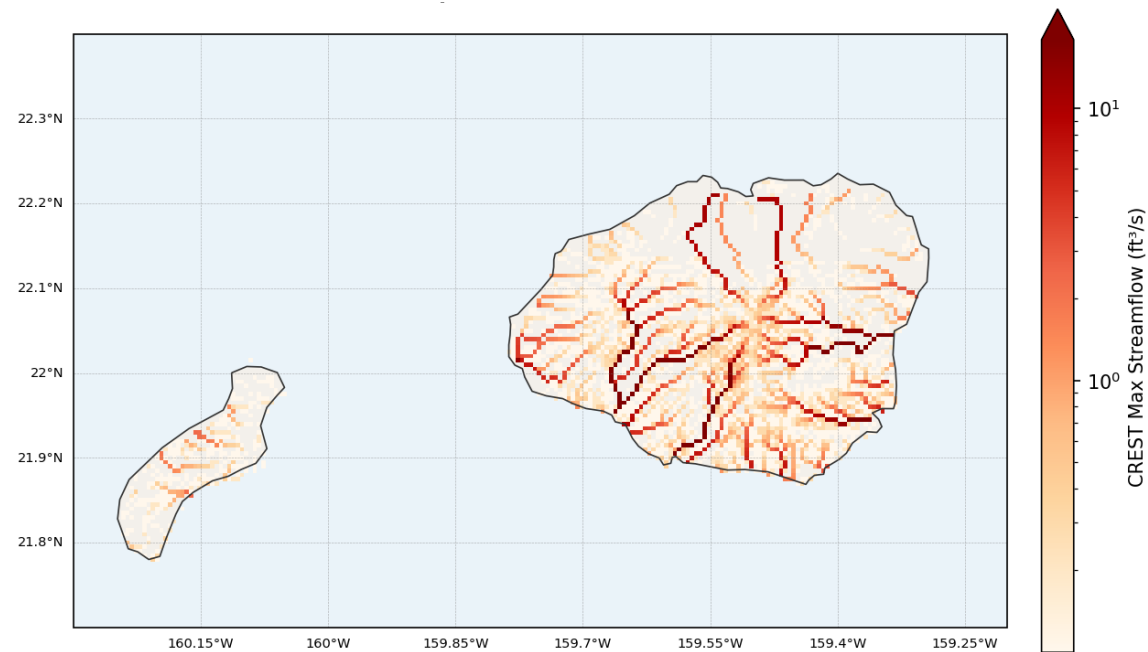


**USGS 16103000 (Hanalei R nr Hanalei)  
(03/12 22:30 HST)**

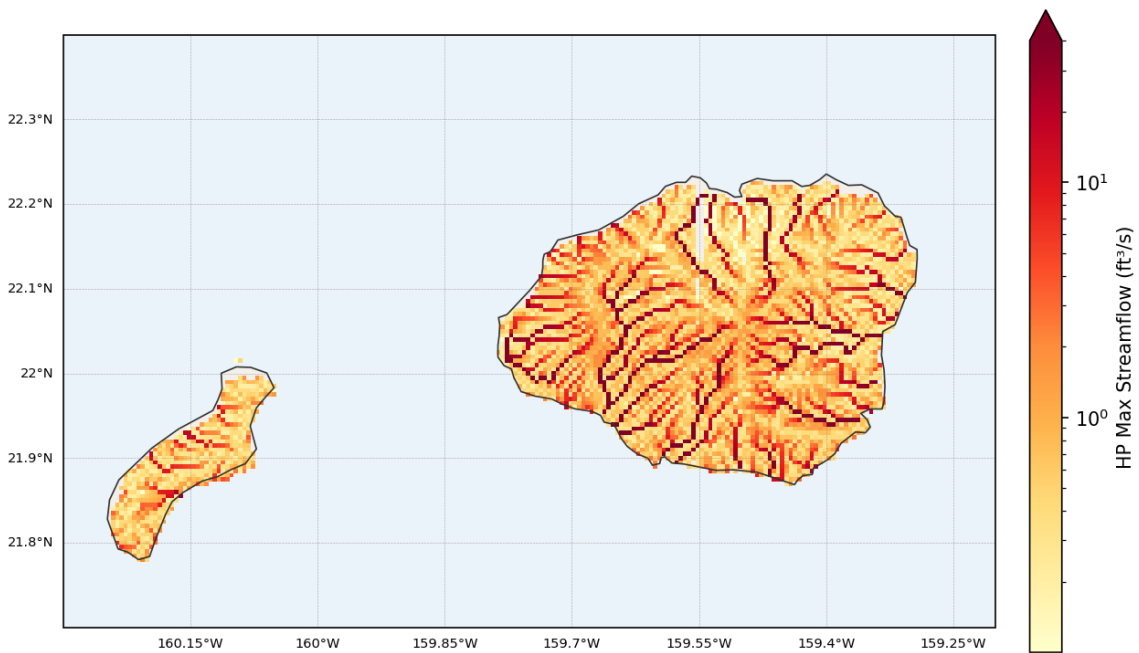


Latest Available  
FLASH products

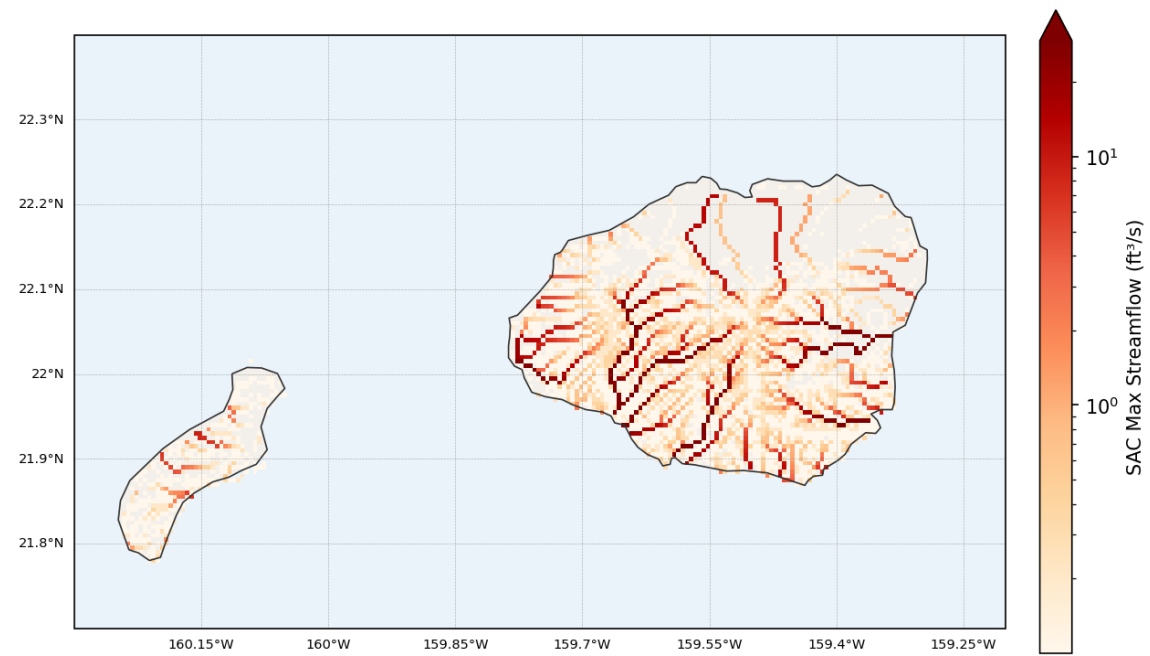
**CREST Max Streamflow (ft<sup>3</sup>/s)**



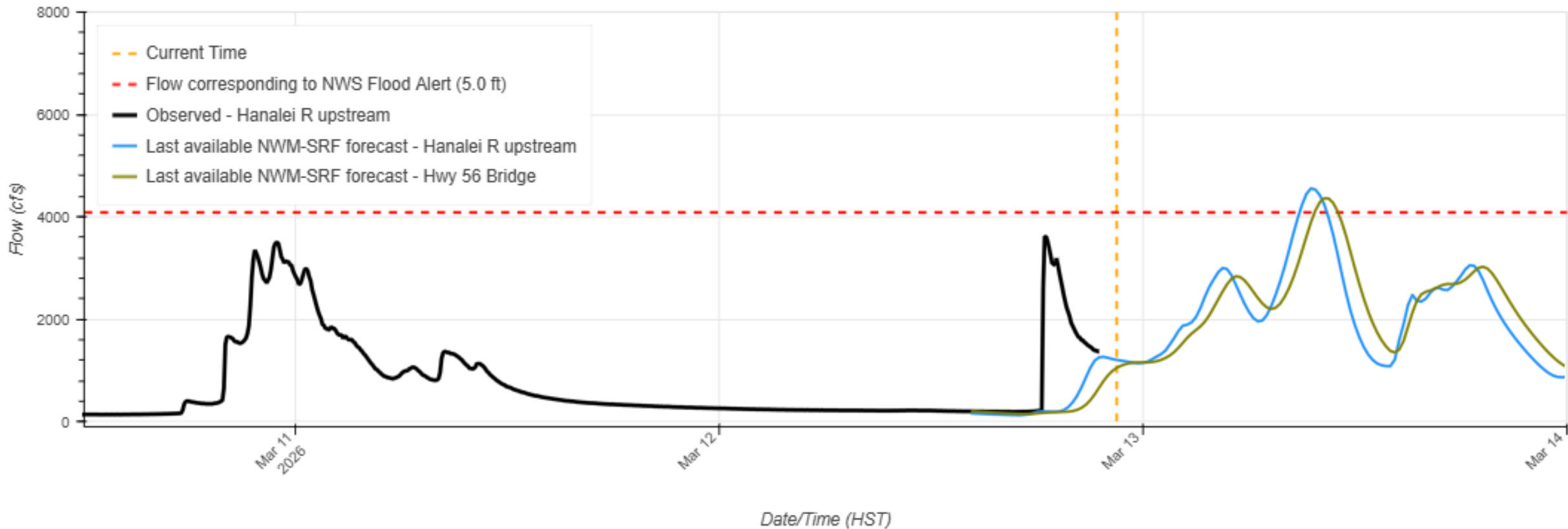
**HP Max Streamflow (ft<sup>3</sup>/s)**



**SAC Max Streamflow (ft<sup>3</sup>/s)**



# Latest Available NWM Short Range Forecasts



# Scenario 2 – Decision 1



**Date: Friday, March 12  
22:30 HST**

## **WFOs**

Issue flood product

## **EMs**

Close the bridge  
Prepare for evacuation  
Evacuate areas at risk

# Scenario 2

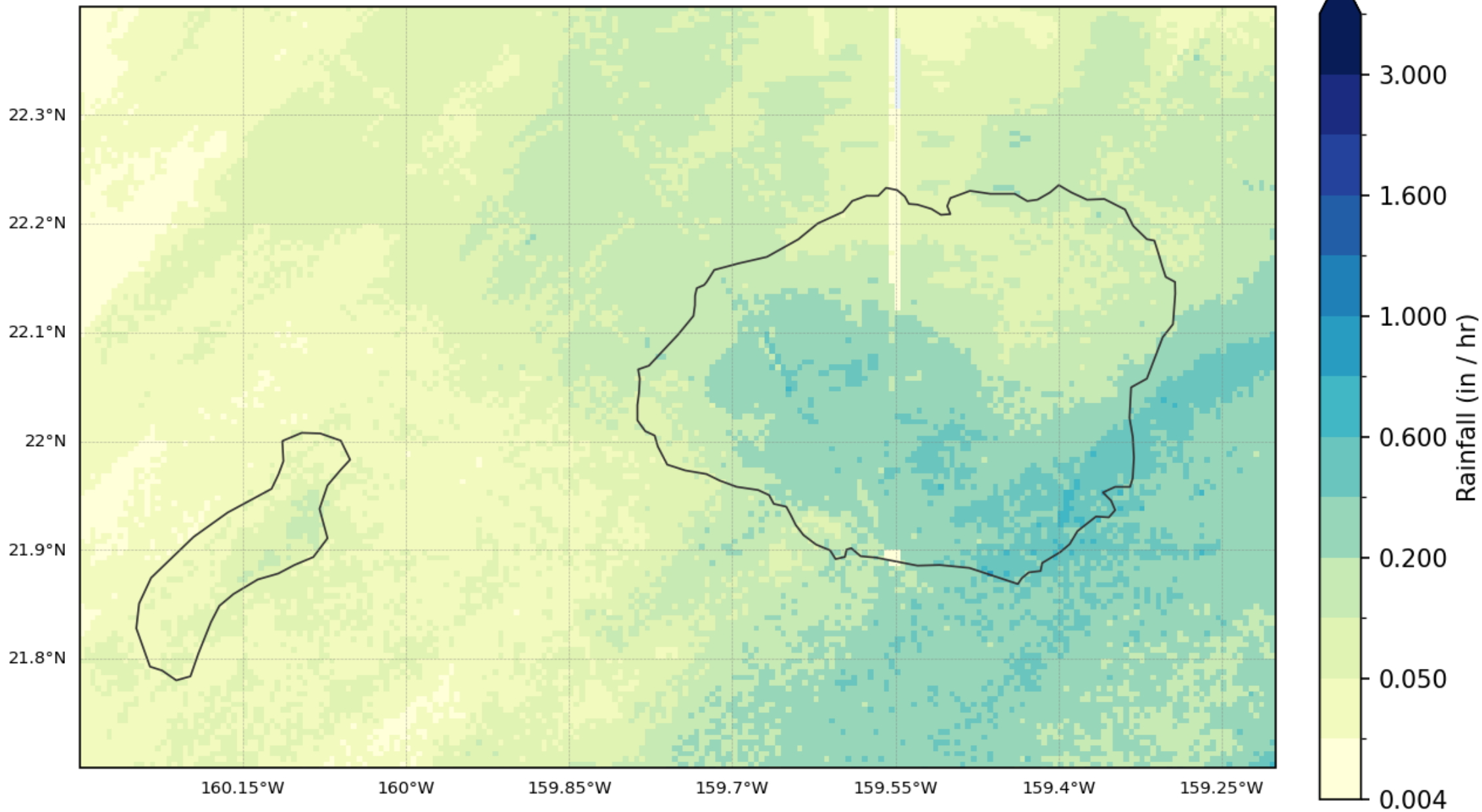
**Date: Friday, March 13  
04:30 HST  
(Decision Point)**

Zonal Forecast Precipitation:

- Kauai North: locally heavy rain possible, gust to 60 mph

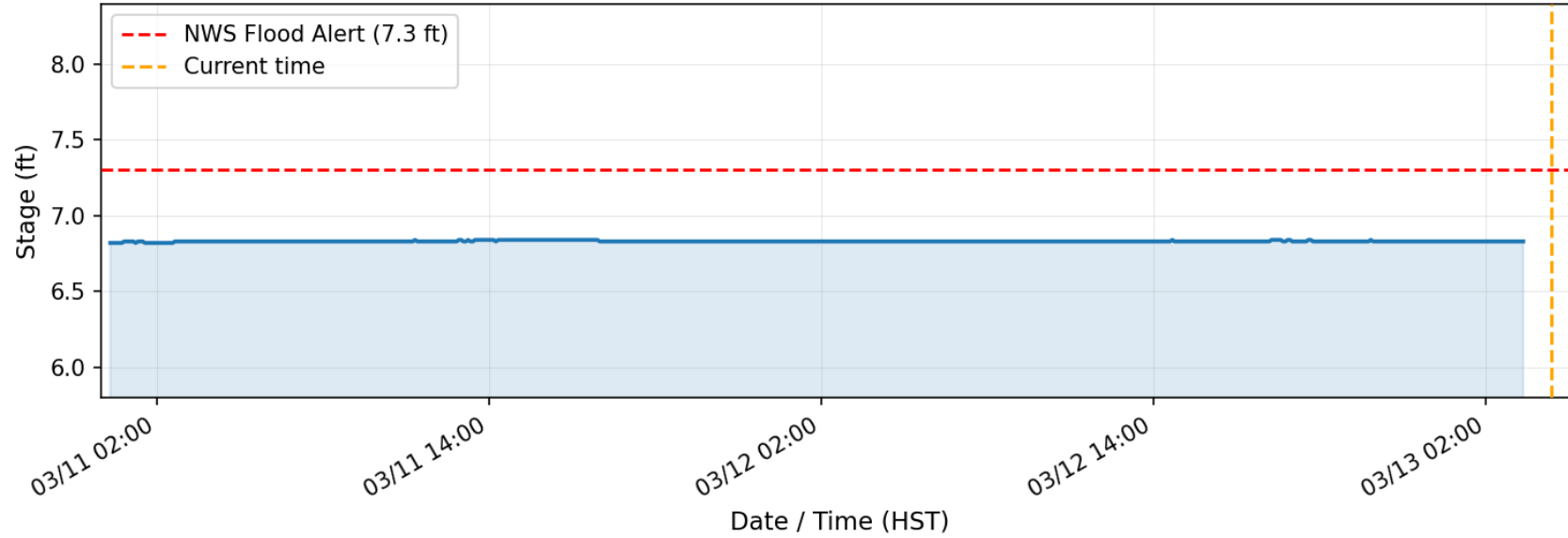
FFW on Oahu; FFA on Maui and Big Island

**MRMS Radar-Only QPE (1-hr rainfall)**  
**March 13 04:30 HST**

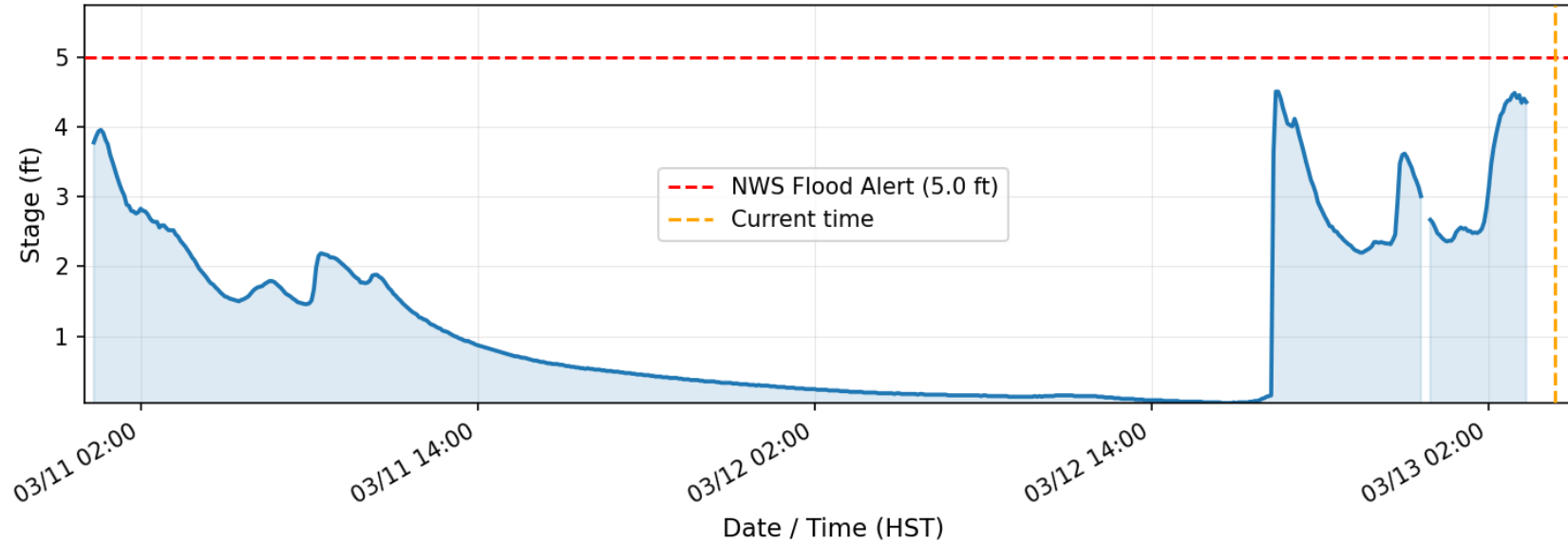


USGS  
Observed  
Stage Data

**USGS 16104200 (Hanalei R at Hwy 56 Bridge nr Hanale)  
(03/13 04:20 HST)**

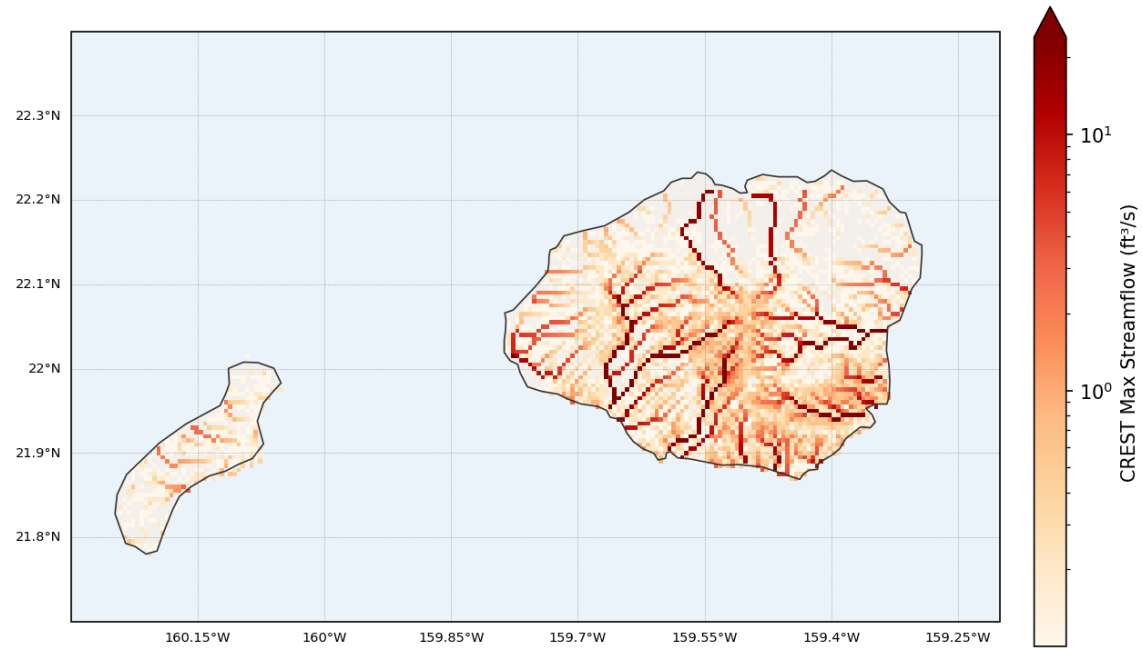


**USGS 16103000 (Hanalei R nr Hanalei)  
(03/13 04:20 HST)**

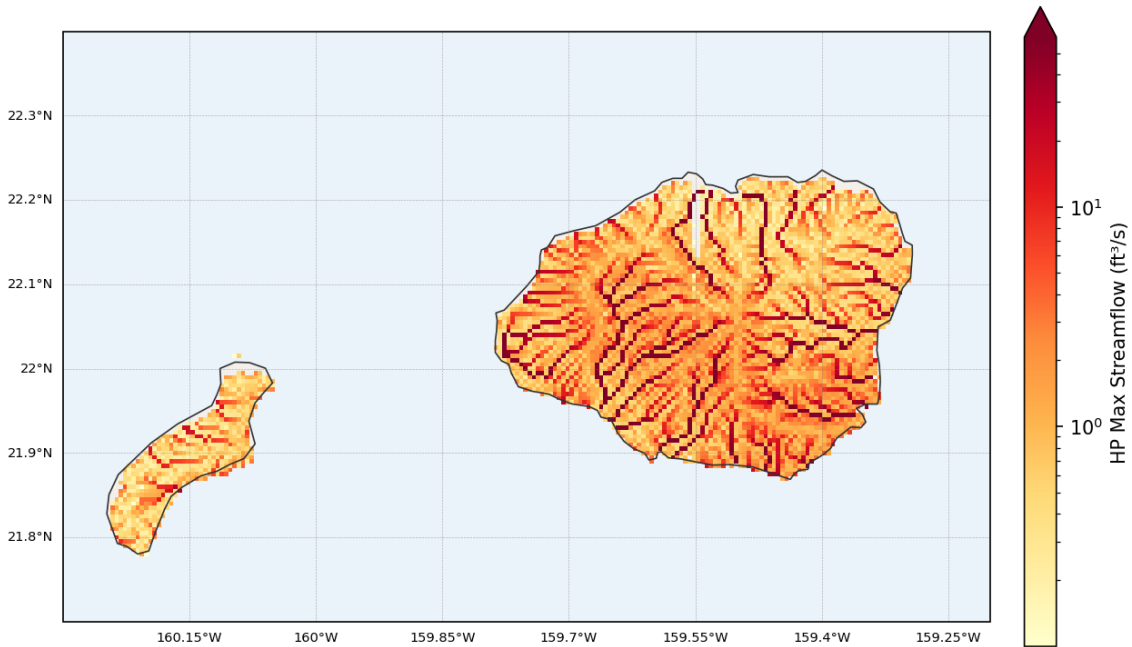


Latest Available  
FLASH products

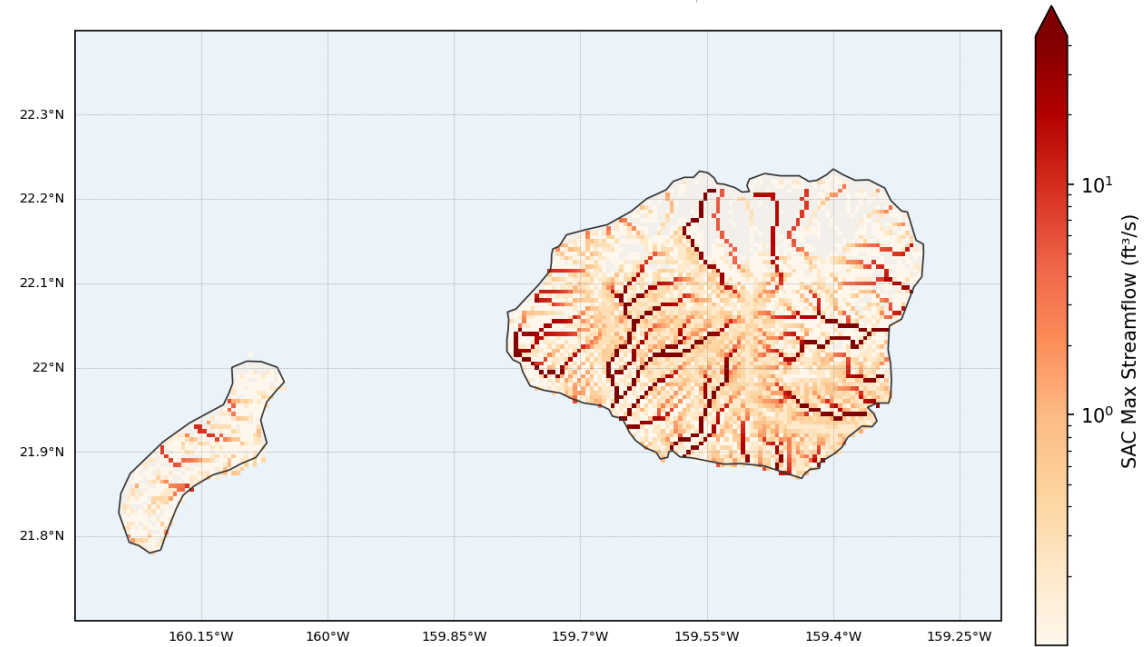
**CREST Max Streamflow (ft<sup>3</sup>/s)**



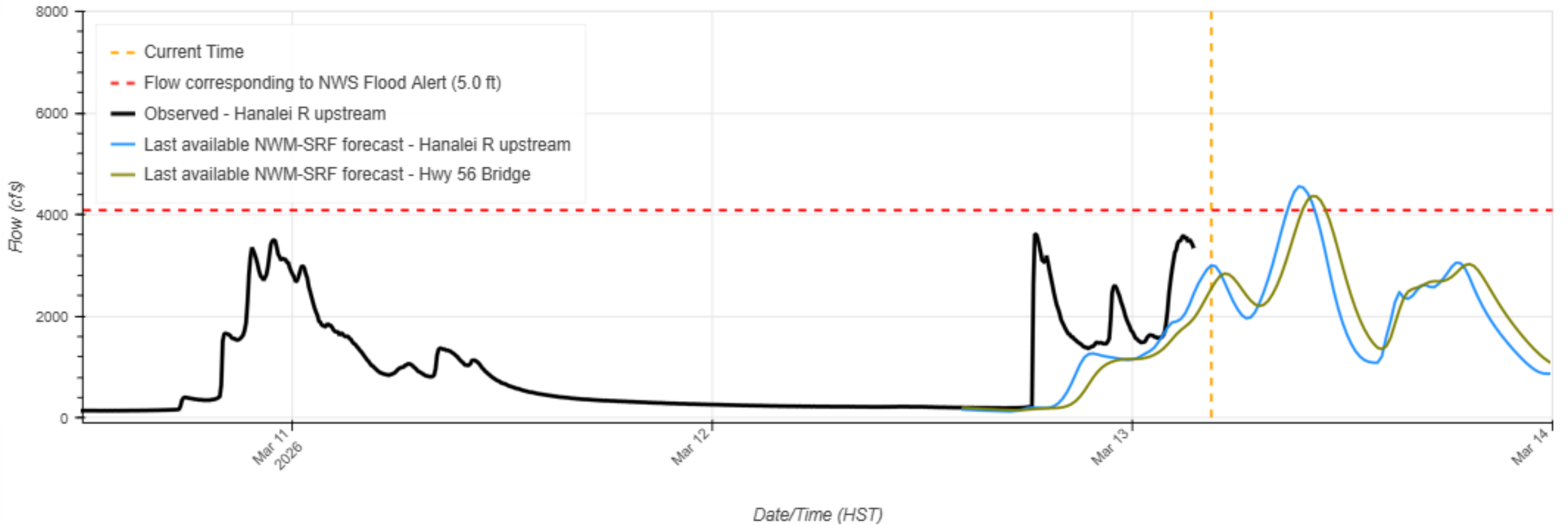
**HP Max Streamflow (ft<sup>3</sup>/s)**



**SAC Max Streamflow (ft<sup>3</sup>/s)**



# Latest Available NWM Short Range Forecasts



# Scenario 2 – Decision 2

**Date: Friday, March 13  
04:30 HST**

## **WFOs**

Issue flood product

## **EMs**

Close the bridge  
Prepare for evacuation  
Evacuate areas at risk

# Scenario 2 – Decision Outcome

- [Real decision timeline](#)
- Share flood outcome
- Discuss the thinking process
  - What factor(s) most influenced your decision?
  - What other information do you WISH you had?
  - How confident did you feel about the information?

[Jump to Debrief](#) 

# Debrief

## **The information:**

- Were the forecasts “wrong”?
- Did the forecasts translate into the right action?

## **Your process:**

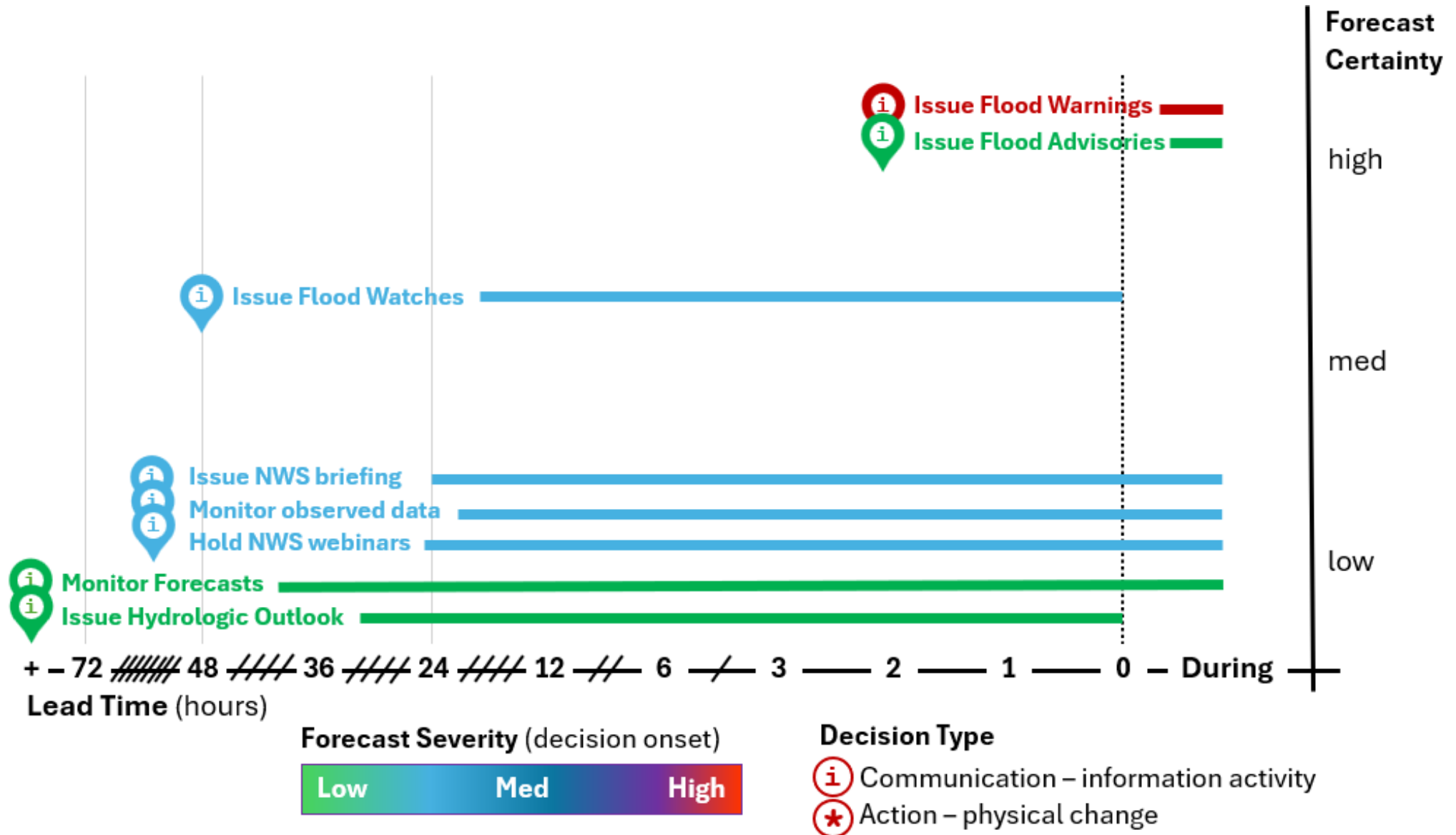
- What factor(s) most influenced your decision?
- What other information do you WISH you had?
- How confident did you feel about the information?

# What we left out

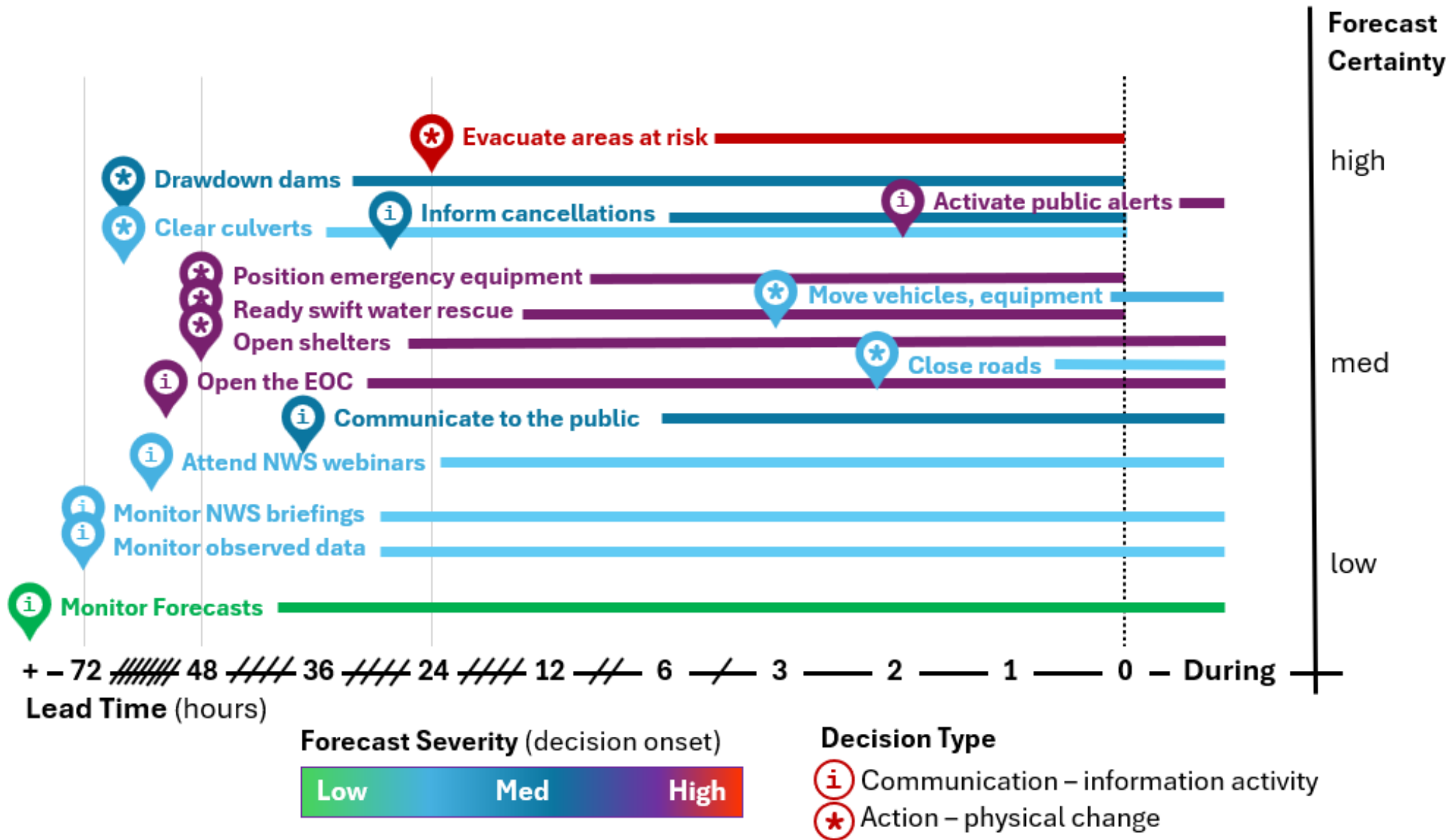
## **You do *not* receive** (but would have in real-life):

- More decisions, and more decision complexity
- Pressure from business owners to **not** close the bridge
- Reminders of both near misses and false alarms in past events
- Misinformation spreading throughout the community
- Conflicting forecasts from a different sources
- Inconsistent (jumpy) forecasts from prior cycles
- Even greater (1h+) forecast latency
- ...

# WFO Decisions



# EM Decisions



# Takeaways



# Takeaways

- Making decisions in a flash flood situation is extremely difficult
- Forecast “skill” *does not alone* make a forecast useful
- Adding probability *does not alone* make a forecast useful
- Latency can significantly reduce the utility of a flash flood forecast → decision timelines often precede forecast updates

What is *possible* to improve *operationally*?

What are the components of the *flash flood information stream* that are **limiting effectiveness** and **how can they be improved**?