June 9, 2023

MEMO TO: Traci N. T. Fujita, Director Office of Council Services

F R O M: Paige Greco, Legislative Analyst

SUBJECT: PACIFIC ISLANDS OCEAN OBSERVING SYSTEM WAVE FLOODING TOOLS FOR WEST MAUI (PAF 23-021(15))

You have requested a brief report on the American Planning Association – Hawai'i Chapter's presentation on "Pacific Islands Ocean Observing System Wave Flooding Tools for West Maui" by Tara Owens on June 7, 2023. Ms. Owens serves as the Coastal Processes and Hazards Specialist for the University of Hawai'i Sea Grant College Program and the Science and Technical Advisor to the County of Maui Planning Department.

The webinar's purpose was to showcase two new West Maui-specific tools that can be used to predict wave run-up and wave flooding. Ms. Owens began with an overview of the unique environmental factors that put West Maui at a disproportionate risk for wave run-up and wave flooding, namely exposure to many swell directions and wave variability.

She provided a virtual tour with pictures of sites across West Maui that have been hardest hit by the effects of wave flooding and summarized the main factors that contribute to wave flooding:

- Mean sea level
- Sea-level rise because of global warming
- Water-level anomalies from events such as El Niño
- Tides
- Waves

Put simply, wave run-up is a factor of water level, wave-driven components, and bathymetry, or sea-floor variations.

Ms. Owens then showcased the two tools related to wave run-up and wave flooding that will soon be integrated into the State Sea-Level Rise Viewer ("SLRXA") tool.

Ms. Traci N. T. Fujita June 9, 2023 Page 2

The first is the West Maui Wave Run-Up Forecast tool that shows the forecast for the coming six days in site specific locations. The tool can be viewed here: http://www.pacioos.hawaii.edu/shoreline-category/runup-westmaui/.

The second is a wave-flooding tool that predicts future, longer-term scenarios of wave flooding on a site-specific basis. This tool can be used to help long-term planning and engineering. The tool can be viewed here: http://www.pacioos.hawaii.edu/shoreline/slr-westmaui/.

Ms. Owens's presentation slides have been attached for your reference.

I hope you find this information useful. Please let me know if I can provide anything further.

paf:pmg:23-021(15)a

Attachment

cc: David Raatz, Deputy Director or Council Services

SCIENCE TO APPLICATION: PACIOOS LAUNCHES WAVE FLOODING TOOLS FOR WEST MAUL TO SUPPORT OMMUNITY PREPAREDNESS AND RESILIENCE













American Planning Association Hawaii Lunch Program Webinar June 7, 2023

Photo credit: Don McLeish

PROJECT TEAM

Melissa Iwamoto,

Principal Investigator



Tara Owens, Co-Investigator, Outreach



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Doug Luther,

Co-Investigator, Modeling



Martin Guiles, Modeler



Camilla Tognacchini, Graduate Student



Maui County



Kaua'i

Oʻahu

Moloka'i

Ni'ihau

Impacts in West Maui June 2017 | Honoapi'ilani Highway, Ukumehame Beach Park

Photo Credit: Asa Ellison

Impacts in West Maui May 2017 | Honoapi'ilani Highway, Olowalu Milemarker 14

Photo Credit: Asa Ellison

Impacts in West Maui May 2017 | Honoapi'ilani Highway, Olowalu Milemarker 14

Photo Credit: Asa Ellison



Impacts in West Maui June 2016 | Honokowai

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Impacts in West Maui September 2017 | Honokowai

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Photo credit: Don McLeish



Impacts in West Maui May 2017 | Kāʻanapali Beach

Photo credit: Louise Rocket



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Impacts in West Maui August 2022 | Kāʻanapali Beach

Photo credit: Kai Nishiki



Impacts in West Maui June 2016 | Kahana Beach (Valley Isle Resort)

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Impacts in West Maui May 2017 | Keonenui Bay

Photo credit: Carol Tuua



Impacts in West Maui 2009 & November 2016 | Keonenui Bay





Impacts in West Maui 2019 | Napili Bay

Photo credits: Pat Lindquist/Napili Bay and Beach Foundation



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MAUI COUNTY-WIDE SEA LEVEL RISE INTEGRATION



Plans, Policies, Projects, and Funds **Regional Resilience** Vulnerability Community Plans Projects Assessments (Planning Department (Planning Department, Long Range Division) (All Departments) Maui County Council) Hazard Mitigation Shoreline Setback Managed Retreat Policy Plan **Revolving Fund** (Maui Emergency (Planning Department (Maui County Council) CZM Program) Management Agency)

WEST MAUI: TAILORED TOOLS

Two Distinct Tools:

. Wave Run-up Forecast

site-specific wave run-up forecast for the coming 6 days

signals potential impacts to inform preparation and response

2. <u>Wave Flooding Tool</u>

site specific future scenarios with sea level rise

informs land use planning

Photo credit: Asa Ellison

What Influences Wave Run-up? Water Level Changes



What Influences Wave Run-up?

Water Level + Wave-driven Components + Bathymetry



What Influences Wave Run-up?

Bathymetry Impacts Magnitude of Run-up



Ocean Depth Sh<mark>allower Deep</mark>er

Changes in bathymetry ↓ Zones of high refraction ↓ Focused wave energy & breaking ↓ Increased wave set-up, swash, infragravity and run-up

Takeaway: Exposure to swell direction affects the shoreline very differently.



Takeaway: There is a lot of variability in how waves affect the shoreline.

Bathymetry



Modeling Example with wave refractrion



Takeaway: Sea level rise will increase wave energy at the shoreline.

<u>Today's Conditions</u>: High tides plus wave swell causes flooding

Long Period Swell Breaks at Reef Edge Short Period Waves Reach

Shore

Takeaway: Sea level rise will increase wave energy at the shoreline.



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Photo credit: Asa Ellison

TOOL 1: 6-DAY WAVE RUN-UP FORECAST

Wave Model: North swell



Wave Model: South swell







Model Validation

Citizen Science Ground-Truthing



Submit: www.pacioos.org/wm

View: www.pacioos.org/wmm

- Determine the thresholds of flooding and overtopping
- Each domain is different: At which point in the forecast is flooding and overtopping observed?

Mahalo to Hawaii and Pacific Islands King Tides Project









TOOL 1: 6-DAY WAVE RUNUP FORECAST - IMPACTS

West Maui : Kahana, Maui



Attention: The forecast is not accurate when a tsunami, tropical storm or cyclone watch/warning is in effect. For these events, please seek information for either tsunamis or tropical storms/hurricanes. In case of a possible inundation event, please consult with local authorities and emergency responders to seek further information and direction.

One or more of the following threshold levels is/are shown in the red shaded area in the plot below: (a) Light Impacts, (b) Hazardous Impacts, (c) Critical Impacts. To better understand their definitions, please check out the **Run-up Examples**.



Impact Thresholds:

- (a) Light Impacts
- (b) Hazardous
 Impacts
 - (c) Critical Impacts

TOOL 1: 6-DAY WAVE RUNUP FORECAST - EXAMPLES

West Maui : Kahana, Maui



Run-up Thresholds

(a) Light Impact – beach and nearshore activities disrupted as occasional waves may sweep the beach slopes or intermittently reach vegetation or infrastructure.

(b) Hazardous Impact – heavy wave action on beaches; battering of shoreline hardening structures; likely run-up onto low-lying, nearshore roads and into unprotected yards and houses; and/or erosion of vegetation, dunes, or volcanic sediment in vulnerable locations.

(c) Critical Impact – strong battering of shoreline hardening structures; waves frequently overtopping protective sand berms or dunes and shoreline hardening structures; flooding of adjacent land and buildings; energetic flooding over low-lying roads; and/or significant erosion of exposed volcanic sediment.

Run-up Examples

- + (a) Light Impact Event July 13, 2019 | Pohaku Park
-) (a) Light Impact Event May 16, 2020 | Kaʻopala Beach
- (a) Light Impact Event July 3, 2020 | Kahana
- + (b) Hazardous Impact Event April, 2016 | Kahana Beach (Royal Kahana and Valley Isle)

(b) Hazardous Impact Event — May 26, 2017 | Sands of Kahana





TOOL 2: WAVE FLOODING TOOL



Simulates Long-Term Wave Flooding Scenarios with Sea Level Rise

- <u>Minimum wave height</u>: minimal swell + high background water level
- <u>Annual High wave height</u>: large swell + high background water level
 <u>Maximum wave height</u>:
- largest swell + highest background water level

STRATEGIES: COASTAL MANAGEMENT TOOLBOX

- Protection: Armoring (i.e. permanent rock revetment or seawall)
- Accommodation (i.e. elevate, reconfigure)
 - Ecosystem-based Adaptation (i.e. dune, beach, and wetland restoration)
- Managed retreat (i.e. setbacks, relocation)
- Do nothing

oreferred strategies















MAHALO NUI LOA!



Waves Currents

www.pacioos.org

Shoreline Impacts

Water Characteristics Weather Projects

How is this new Tool used with the State of Hawaii Sea Level Rise Viewer?

Hawaii Sea Level Rise Viewer



West Maui Wave Flooding Tool



Enhancements: 1. More physically accurate model

- 2. Finer spatial resolution
- 3. Depths of flooding provided

6-DAY WAVE RUNUP FORECAST: MODELING APPROACH

Grid Resolution





Image: Baby Beach, Lahaina

WAVE FLOODING TOOL: MODELING APPROACH



Google Earth



Image: Baby Beach, Lahaina