PACIFIC DISASTER CENTER

Applying Flood Modeling to Risk Assessment Scenarios for Mitigation Planning

May 7, 2009

Andrea Chatman

Disaster Management Applications Analyst

Pacific Disaster Center

1305 North Holopono Street, Suite 2

Kihei, Maui, Hawaii 96753

http://www.pdc.org

PACIFIC DISASTER CENTER

Overview

Scenario Development

Data Requirements

Flood Modeling

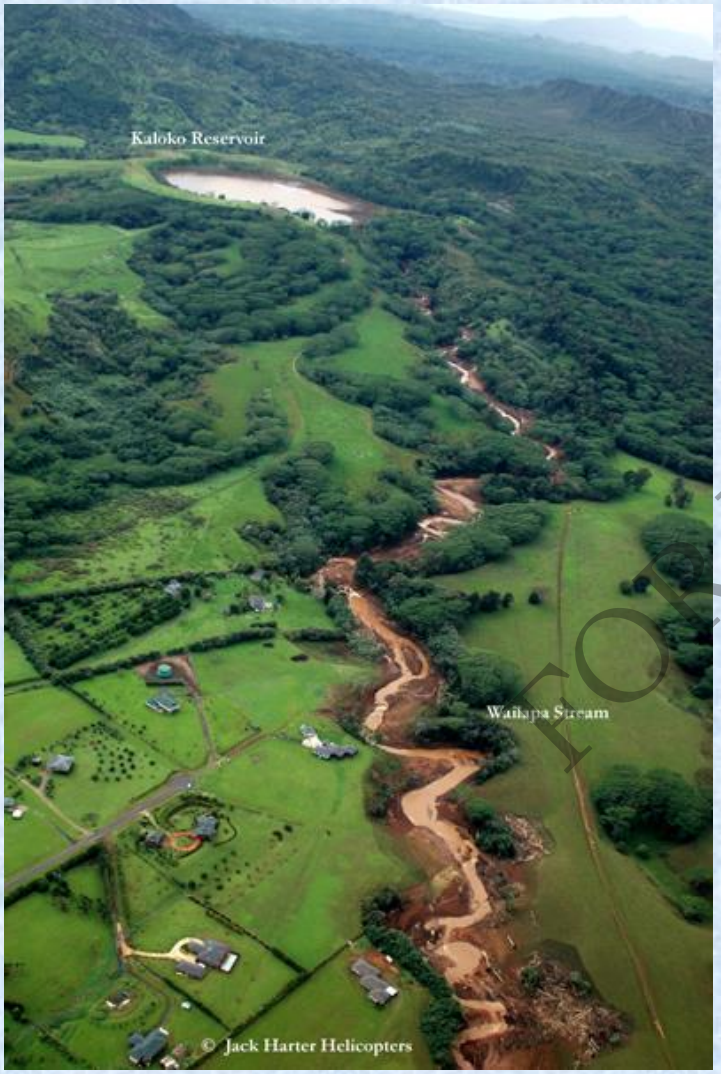
Inundation Mapping

Impact Assessment

Additional Applications

PACIFIC DISASTER CENTER

Hawaii Dam Inundation Project



- Kaloko Dam Failure – March 2006
- Request from the State of Hawaii's Department of Land and Natural Resources Dam Safety Division
- Create dam failure inundation maps for all 135 registered in the State of Hawaii
- Provided:
  - Inundation Maps
  - Basic Damage Assessment
  - Social-Economic Vulnerability Assessment

http://www.hawaiireporter.com/story.aspx?243874ed-8686-496f-abff-40e6deb1581f

PACIFIC DISASTER CENTER

Questions to Consider When Developing a Scenario

- What is the purpose/expected outcome?
- What are you trying to represent conceptually?
- What are the most important components?
- What are the most important components relative to your purpose?
- What are the time, processing, and model constraints?
- What components will you actually represent and how?
- What are the assumptions and how do you expect them to impact results?
- Does this adequately serve your purpose?

PACIFIC DISASTER CENTER

Some Scenario Choices

- Historical event
  - Scenario developed from an actual event
    - Used to validate model
    - Could be used to determine potential impact to current infrastructure and population
- Designed scenario
  - Scenario depicting a potential event
    - Can be based on historical data from an similar event
    - Used when historical data for site is not available
- Expert knowledge
    - Scientists, Engineers, Modeling Experts

PACIFIC DISASTER CENTER

Some Project Scenario Assumptions

1) Sunny day failure with dry downstream conditions
2) Failure occurs when dam is at maximum capacity
3) Failure occurs by piping failure halfway up the dam face
4) Spillways and dam outlet works are inoperable at the time of the breach

PACIFIC DISASTER CENTER

Project Scenario Data Requirements

- Terrain data
- Dam crest height
- Dam length
- Spillway elevation
- Normal volume of reservoir
- Maximum volume of reservoir

PACIFIC DISASTER CENTER

Flood Modeling

- MIKE Flood Model Suite
- Created by DHI Water-Environment-Health, Inc.
- Model a wide range of water related scenarios
  - Dam failure
  - River Flooding
  - Coastal Flooding
  - Urban flooding

PACIFIC DISASTER CENTER

Flood Modeling

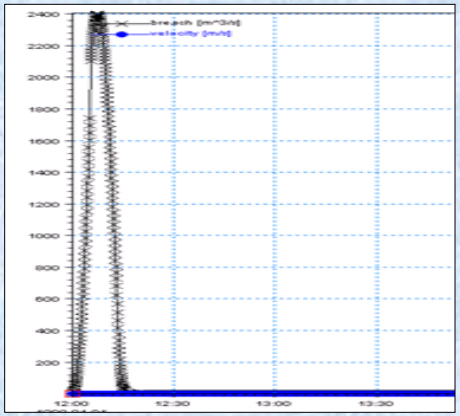
- MIKE 11 – River and Channel Hydraulics Model
  - 1 – dimensional model
  - Used to create dam failure hydrographs
- MIKE 21 – River Hydraulics and Morphology Model
  - 2 – dimensional model
  - Terrain data determines flow path
  - Creates greater stability in modeling floodplain inundation
  - Models multiple flow paths
- MIKE FLOOD
  - Connects MIKE 11 with MIKE 21
  - Used for dam failure in series

PACIFIC DISASTER CENTER

MIKE Flood Models

Input

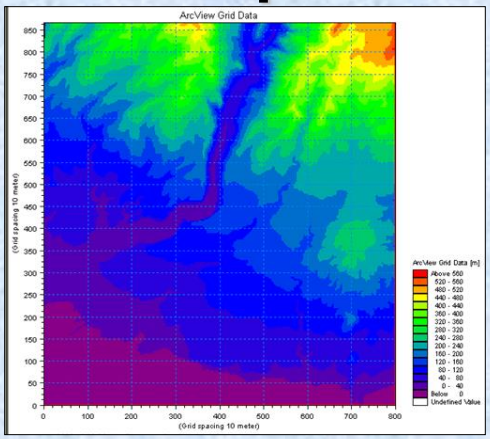
Digital Elevation Map



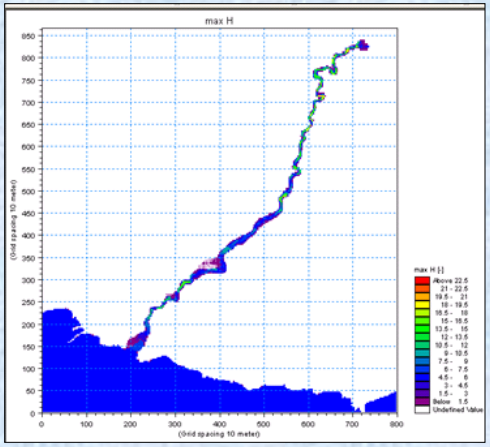
Inflow Hydrograph – MIKE 11 Model

MIKE21 Flow Model

Output



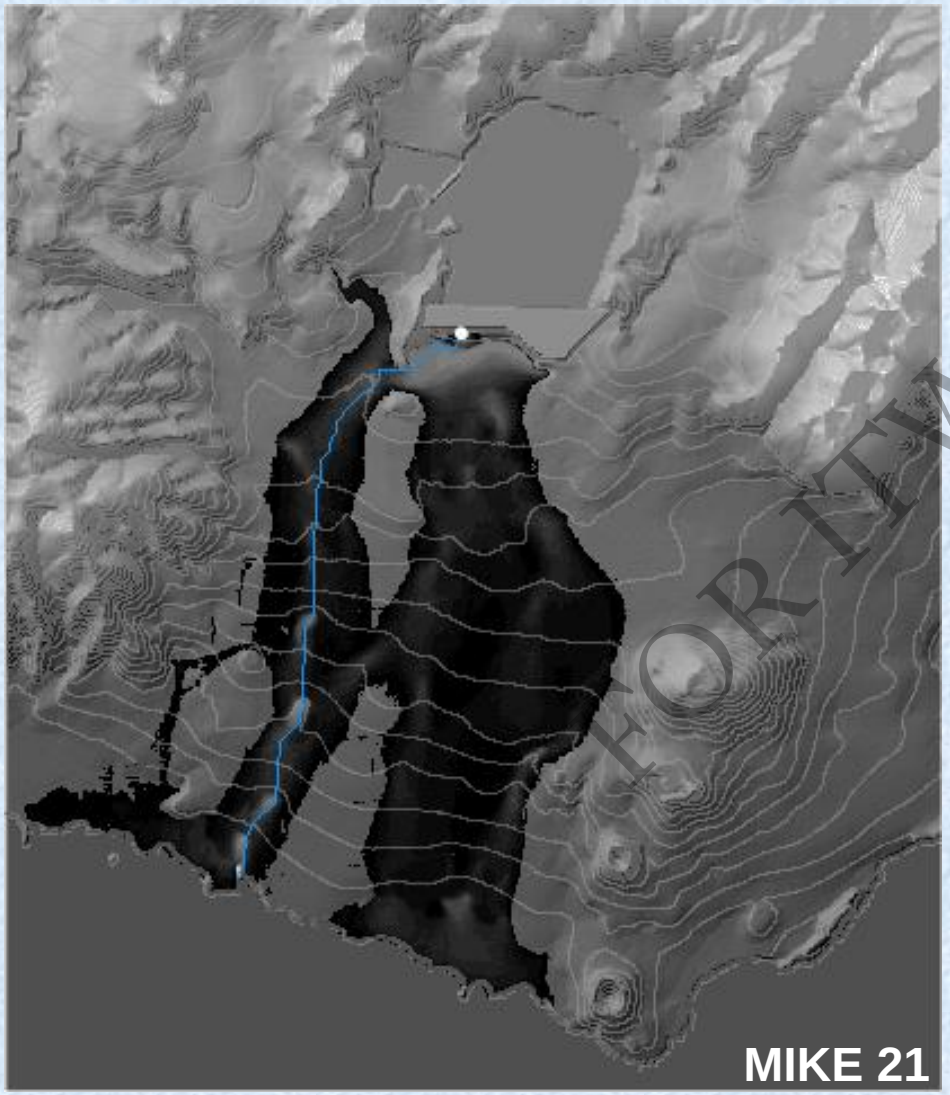
2-Dimensional Modeling

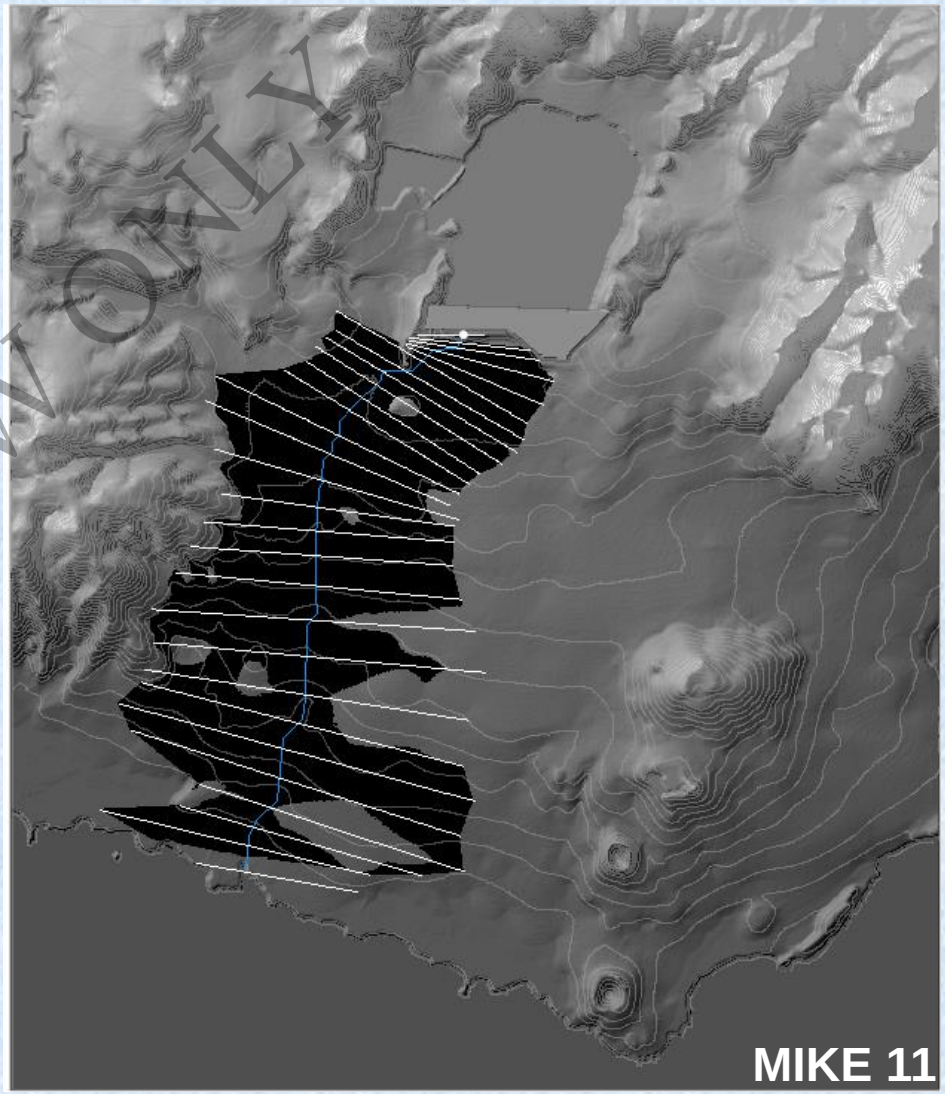


Flood Inundation Mapping

PACIFIC DISASTER CENTER

Inundation Mapping

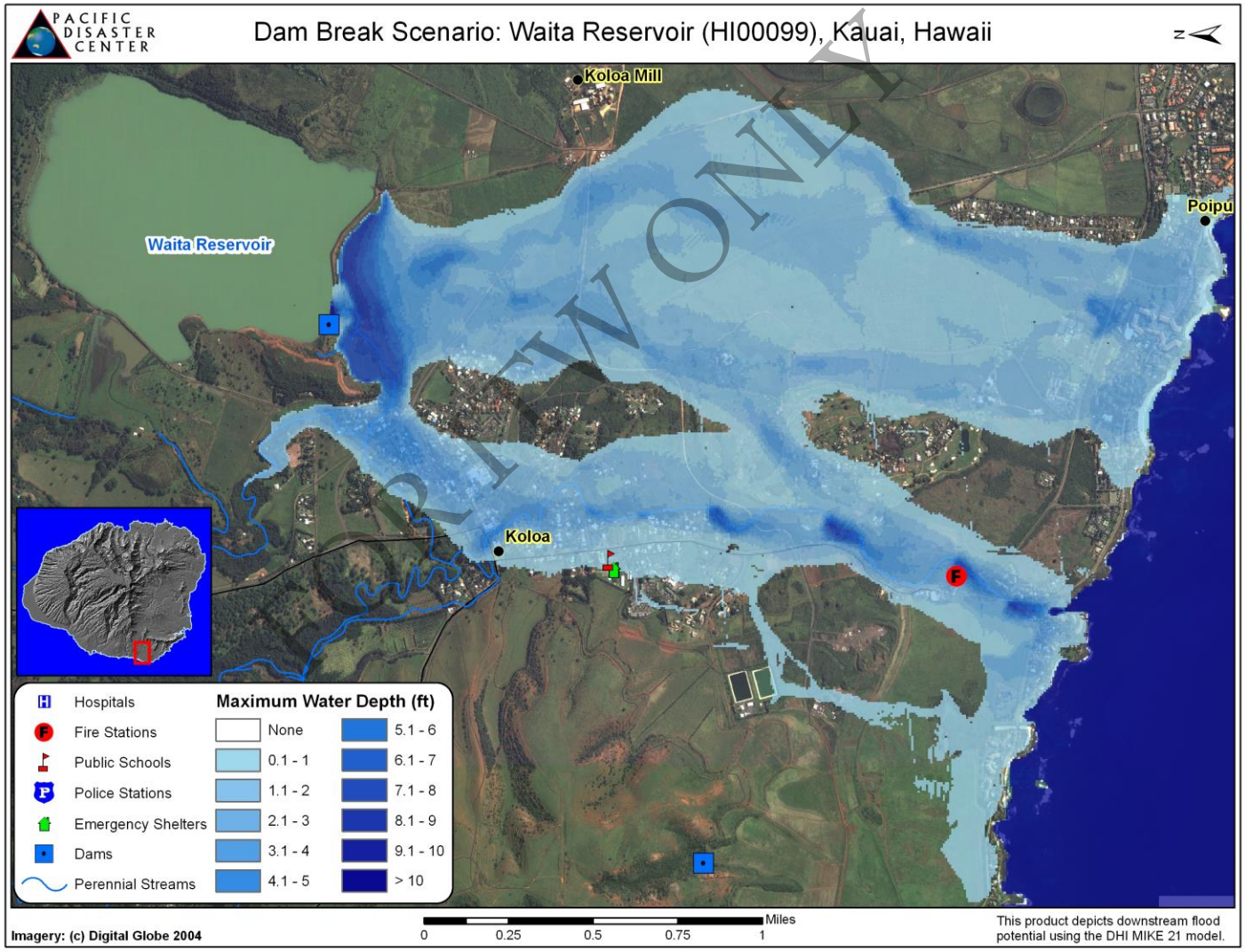




Goosby et al. *Dam Break Inundation Study for the State of Hawaii*. 2008.

PACIFIC DISASTER CENTER

Inundation Mapping



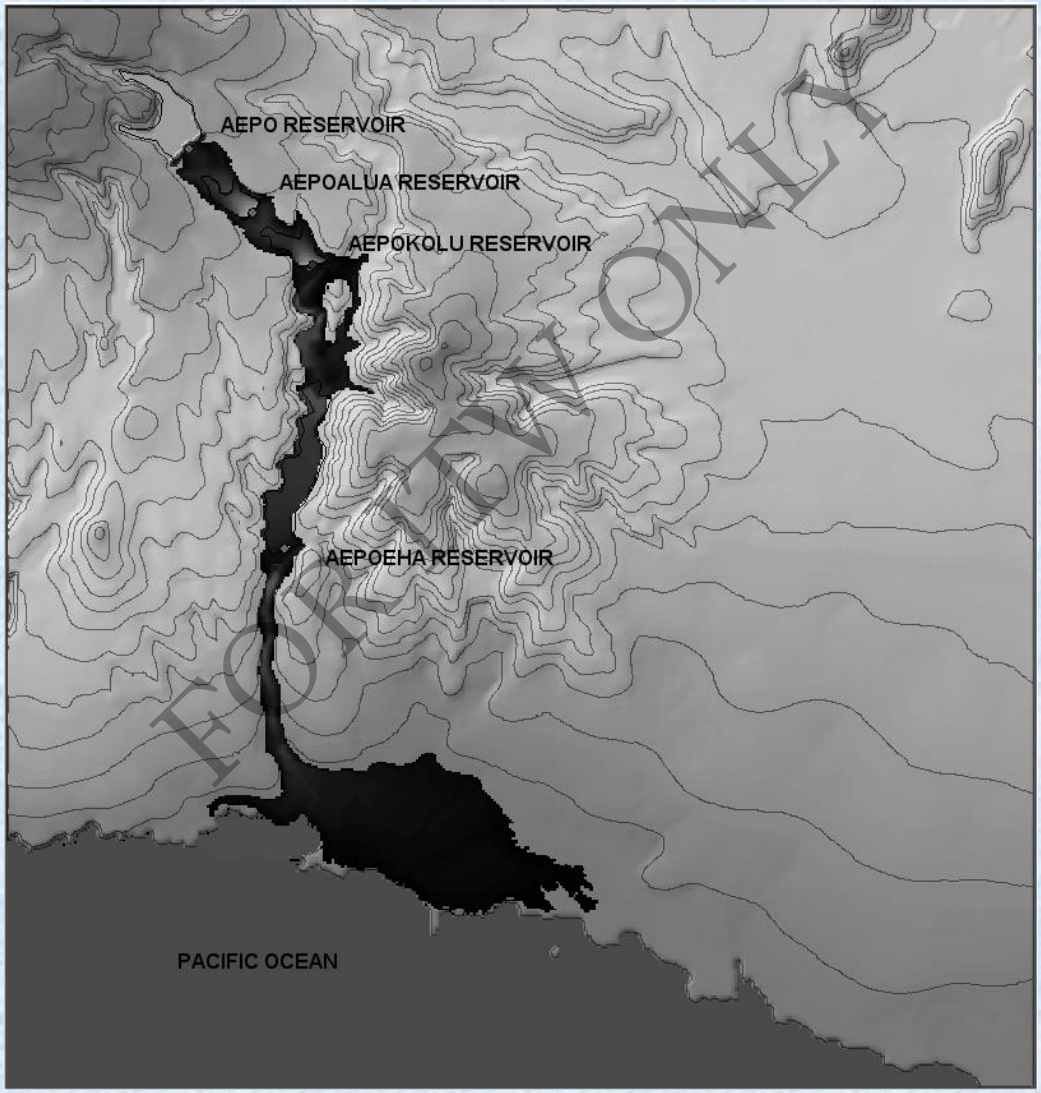
PACIFIC DISASTER CENTER

Inundation Mapping

- Total maximum water depth
- Time of maximum water depth
- Time to first inundation
- Depth at first inundation
- Velocity

PACIFIC DISASTER CENTER

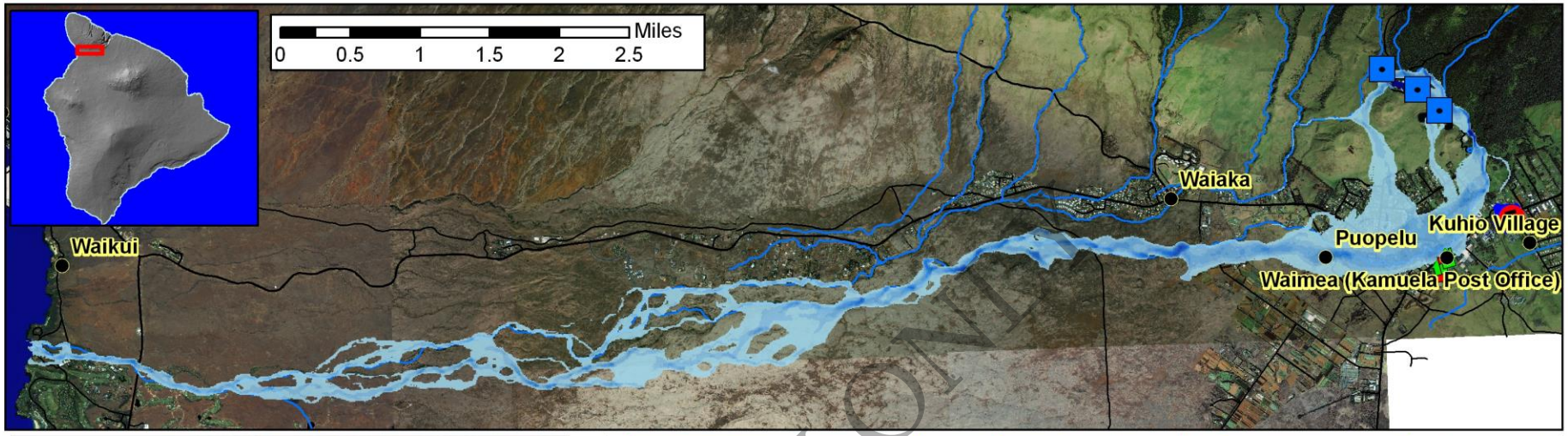
Series Dams

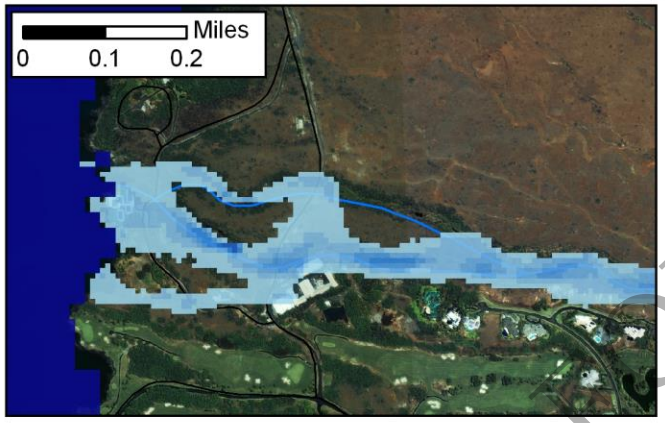


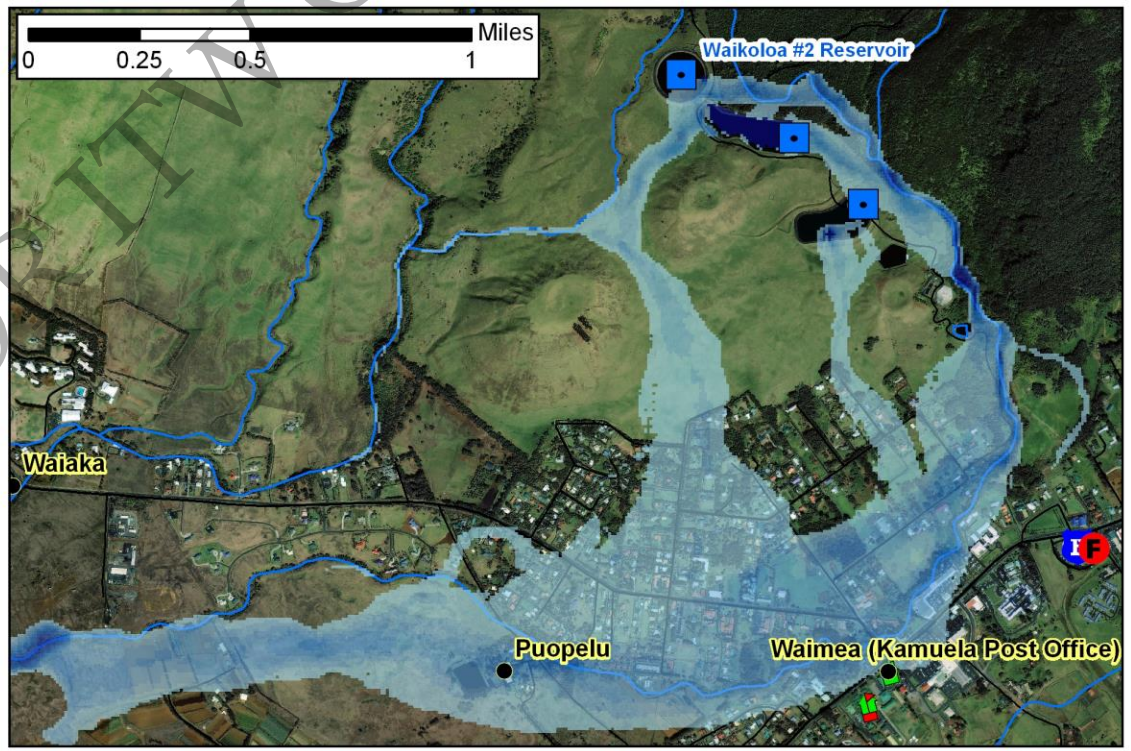
Goosby et al. *Dam Break Inundation Study for the State of Hawaii*. 2008.

PACIFIC DISASTER CENTER

Dam Break Scenario: Waikoloa #2 Reservoir (HI00122), Big Island, Hawaii







Hospitals
Fire Stations
Public Schools
Police Stations
Emergency Shelters
Dams
Perennial Streams

Maximum Water Depth (ft)

None	5.1 - 6
0.1 - 1	6.1 - 7
1.1 - 2	7.1 - 8
2.1 - 3	8.1 - 9
3.1 - 4	9.1 - 10
4.1 - 5	> 10

This product depicts downstream flood potential using the DHI MIKE 21 model.

PACIFIC DISASTER CENTER

Impact Assessment

- Impact to population
  - Number of people potentially impacted downstream
- Impact to transportation
  - Water depth and speed at bridges and road crossings
- Impact to buildings
  - Including replacement cost value
- Impact to critical facilities
  - Schools, hospitals, fire and police stations, government buildings, airports/seaports, shelters

PACIFIC DISASTER CENTER

Assessment Reports

PACIFIC DISASTER CENTER

Individual Assessment Report

1 Identification

Name of Dam:	Waita Reservoir
National Id:	HI00099
Island:	Kauai
Nearest City/Town:	Koloa
Name of affected stream:	Waihohonu Stream Offstream
Current DLNR risk classification:	High
Owner:	Grove Farm Company

2 Background

Location (latitude/longitude):	21.92N 159.46W
Miles to nearest city:	1
Year completed:	1906
Purpose/use:	Irrigation

3 Characteristics

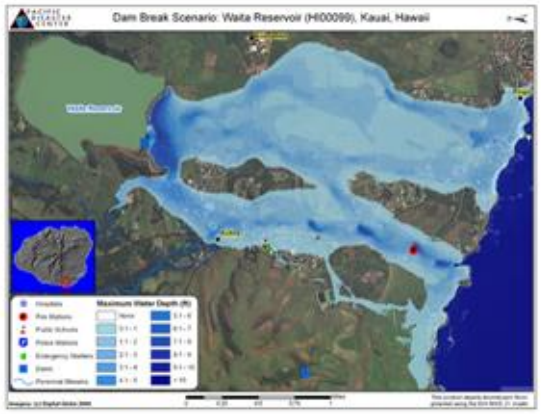
Dam type:	Earthen Dam
Max. storage capacity (acre feet):	9,900
Dam height (feet):	23
Dam length (feet):	3,250

4 Consequence Analysis

4.1 Scenario Parameters

Parameters	Value	Unit of Measure
Reservoir volume prior to breach:	9,900	acre-feet
Duration of breach:	138	minutes
Breach width:	151	feet
Distance from dam to ocean:	2.32	miles
Type of dam:	Earthen Dam	n/a
Type of breach:	Piping breach originating halfway up the dam face	n/a

4.2 MIKE 21 Model Results – Inundation Map*



*While the best available GIS data have been utilized as input to the model and in visualizing model output, due to variations in their currency and accuracy, final product results should be interpreted as "best available estimates" only and not definitive in establishing inundation boundaries.

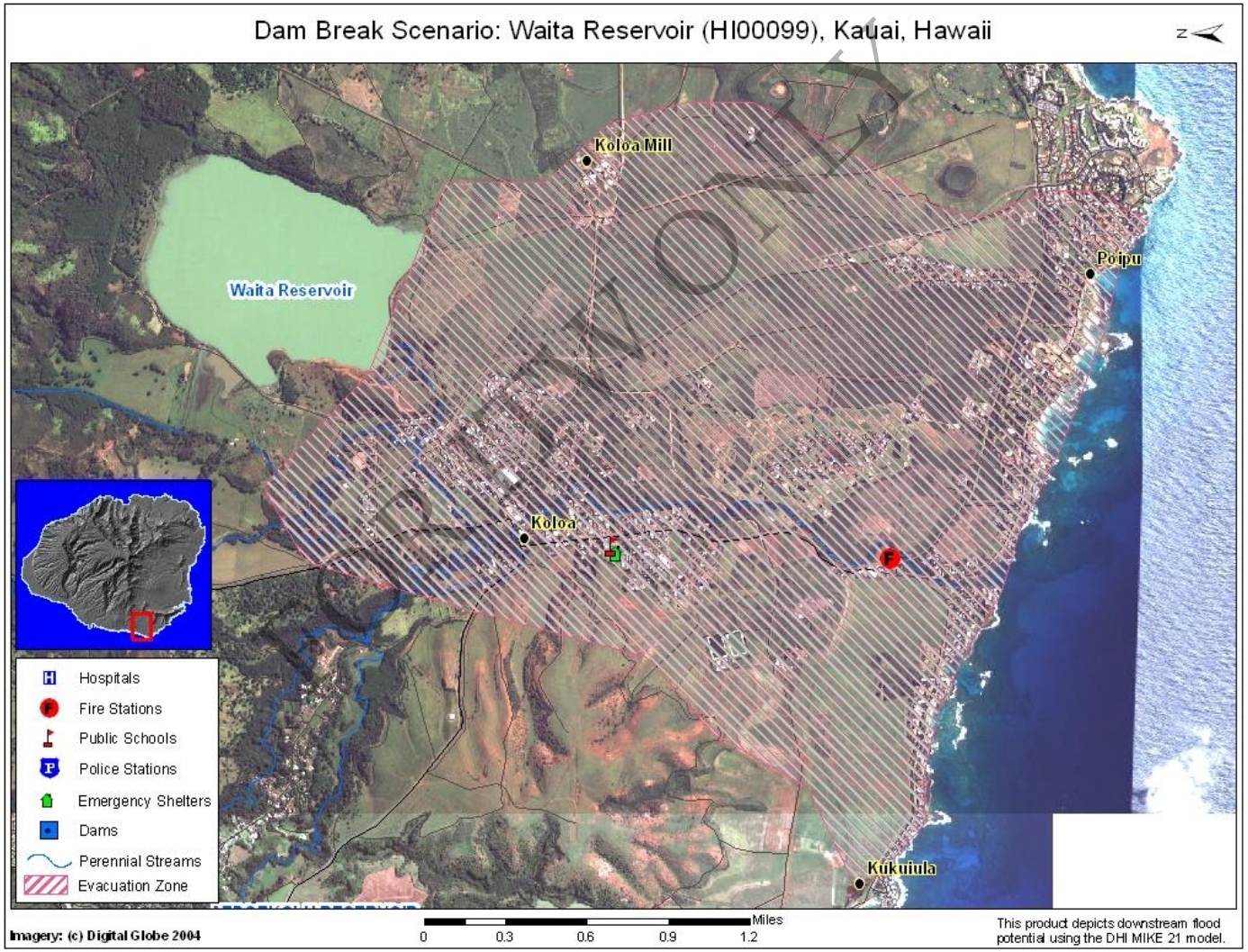
PACIFIC DISASTER CENTER

Additional Products

- Can apply the inundation layers to a number of different analyses
  - Evacuation Mapping
  - Social Vulnerability Assessment
  - Visualization – Animation
  - On-line GIS viewers

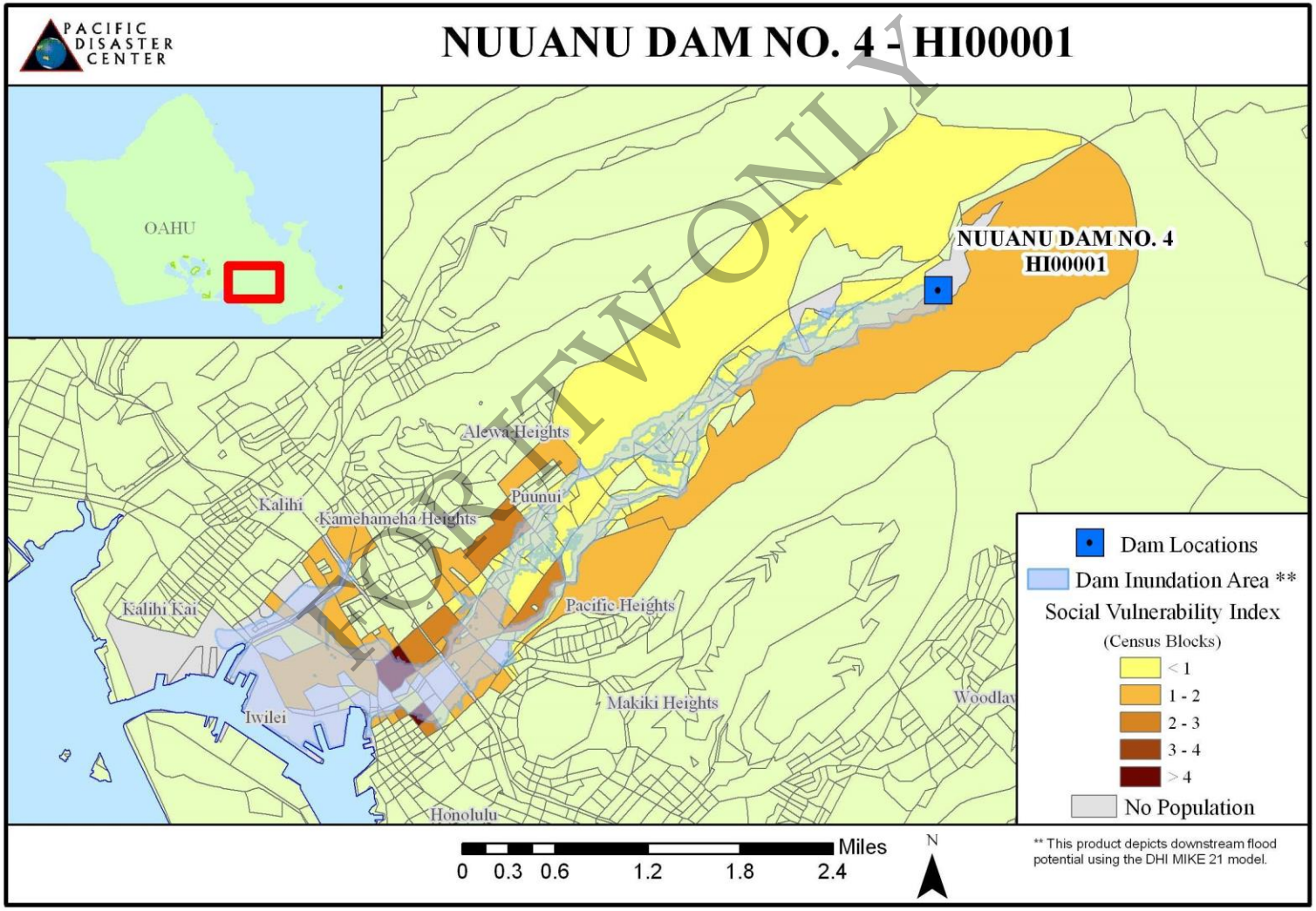
PACIFIC DISASTER CENTER

Evacuation Mapping



PACIFIC DISASTER CENTER

Social Vulnerability Assessment

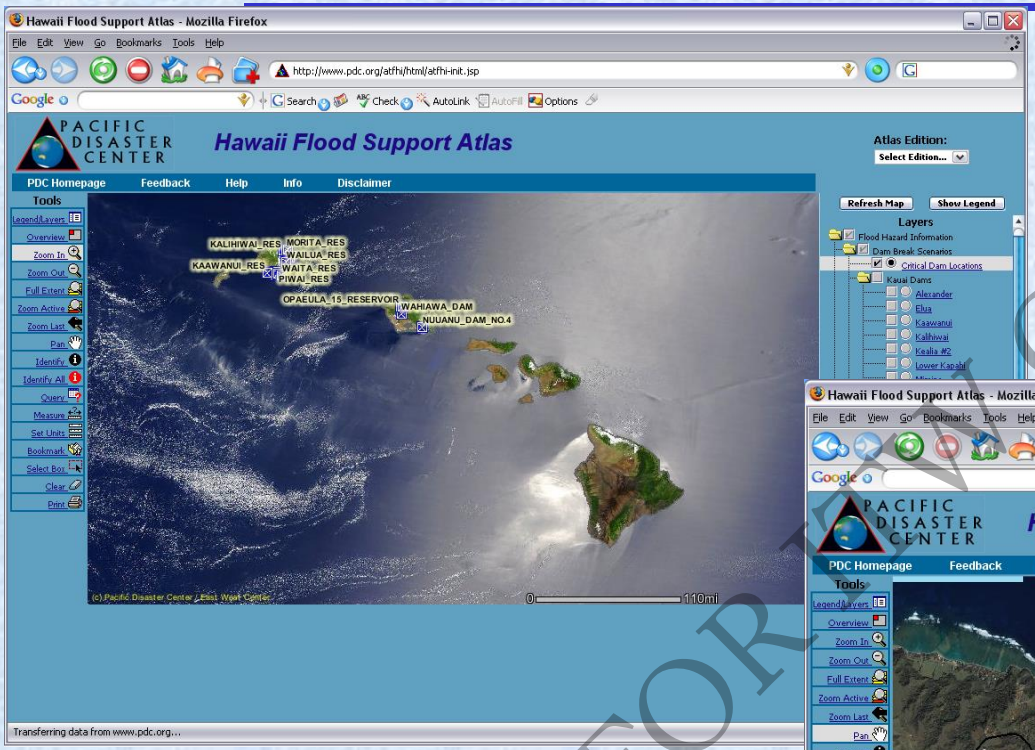


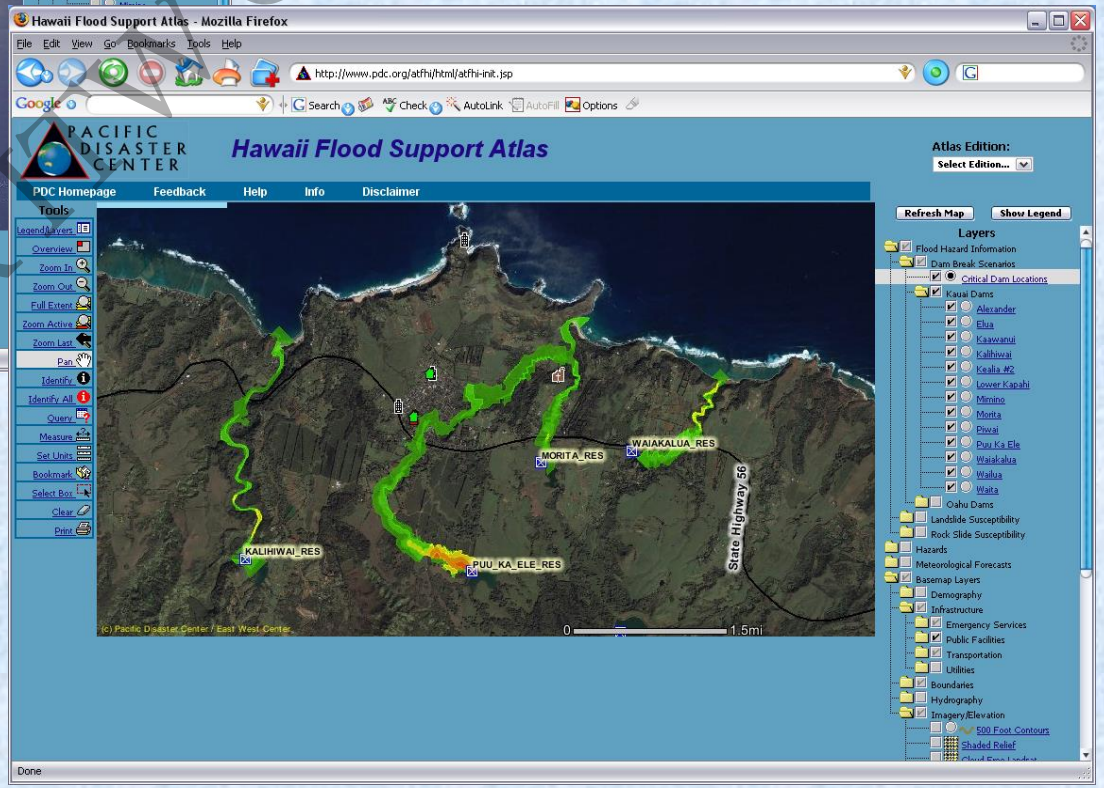
PACIFIC DISASTER CENTER

Visualization

PACIFIC DISASTER CENTER

Flood Viewer





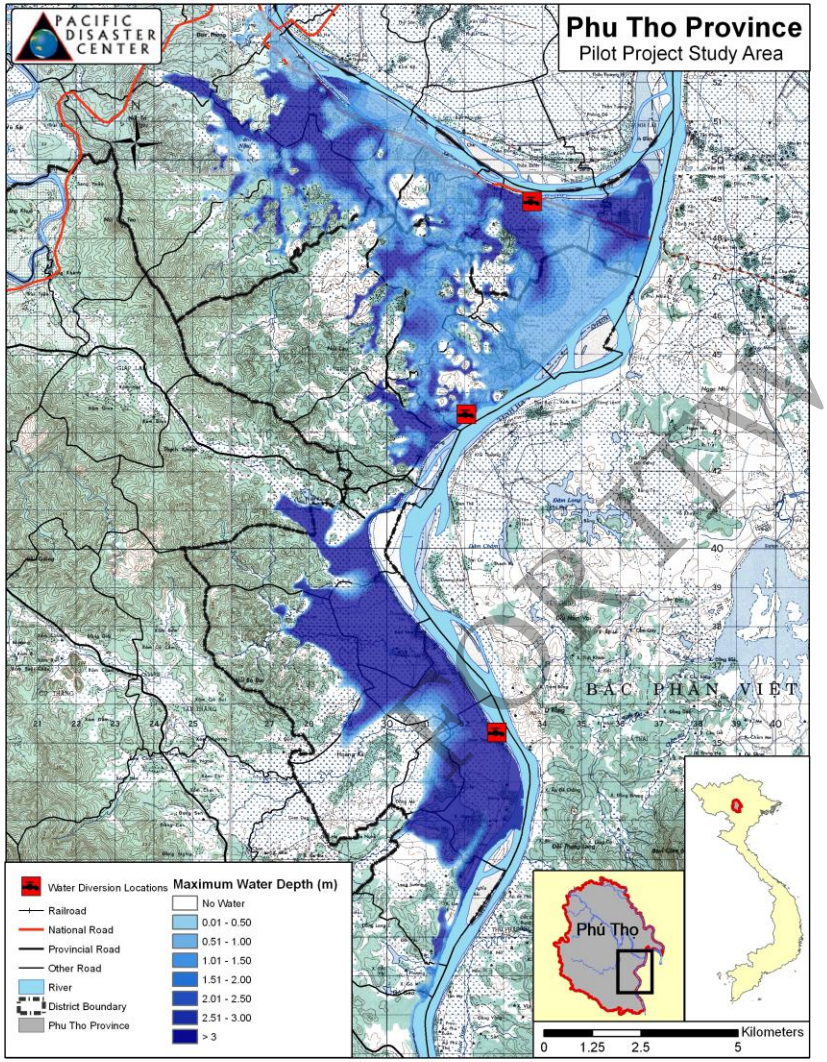
PACIFIC DISASTER CENTER

Additional Flood Scenarios

- Levee Failure
- Riverine Flooding
- Coastal Flooding from Storm Surge

PACIFIC DISASTER CENTER

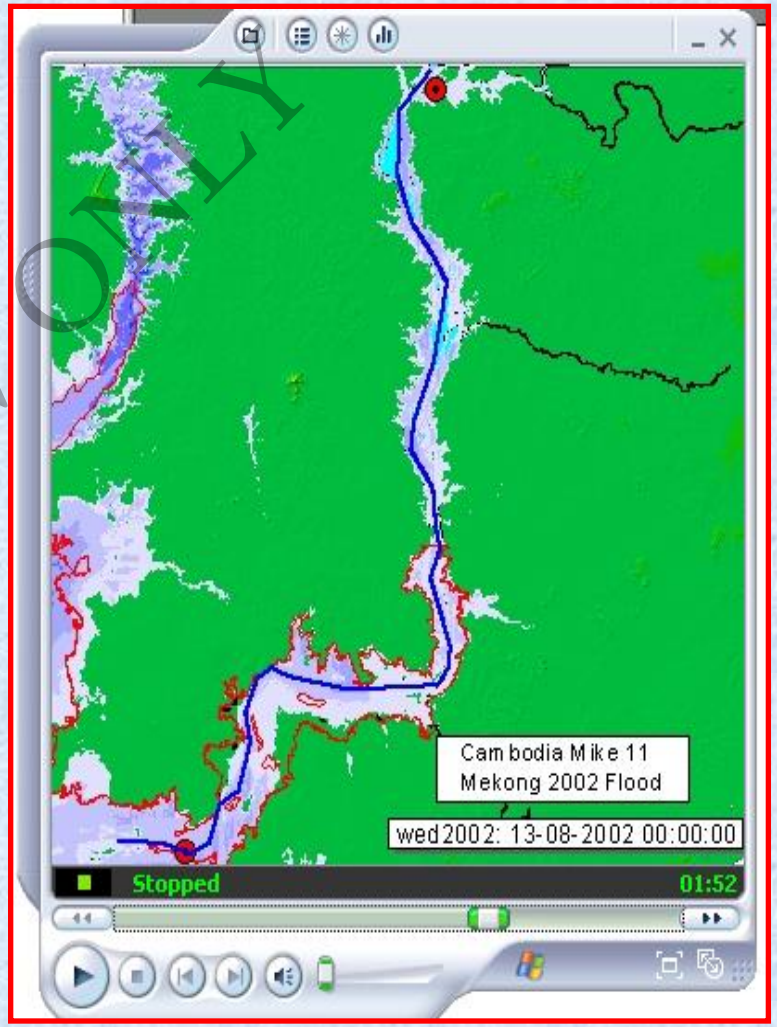
Vietnam Levee Project



- **Phu Tho Province**
- **Breach of three levees**
- **Flood control planning**
- **24 hour scenario**
- **Assessment of Critical Facilities**
- **20 meter terrain data**

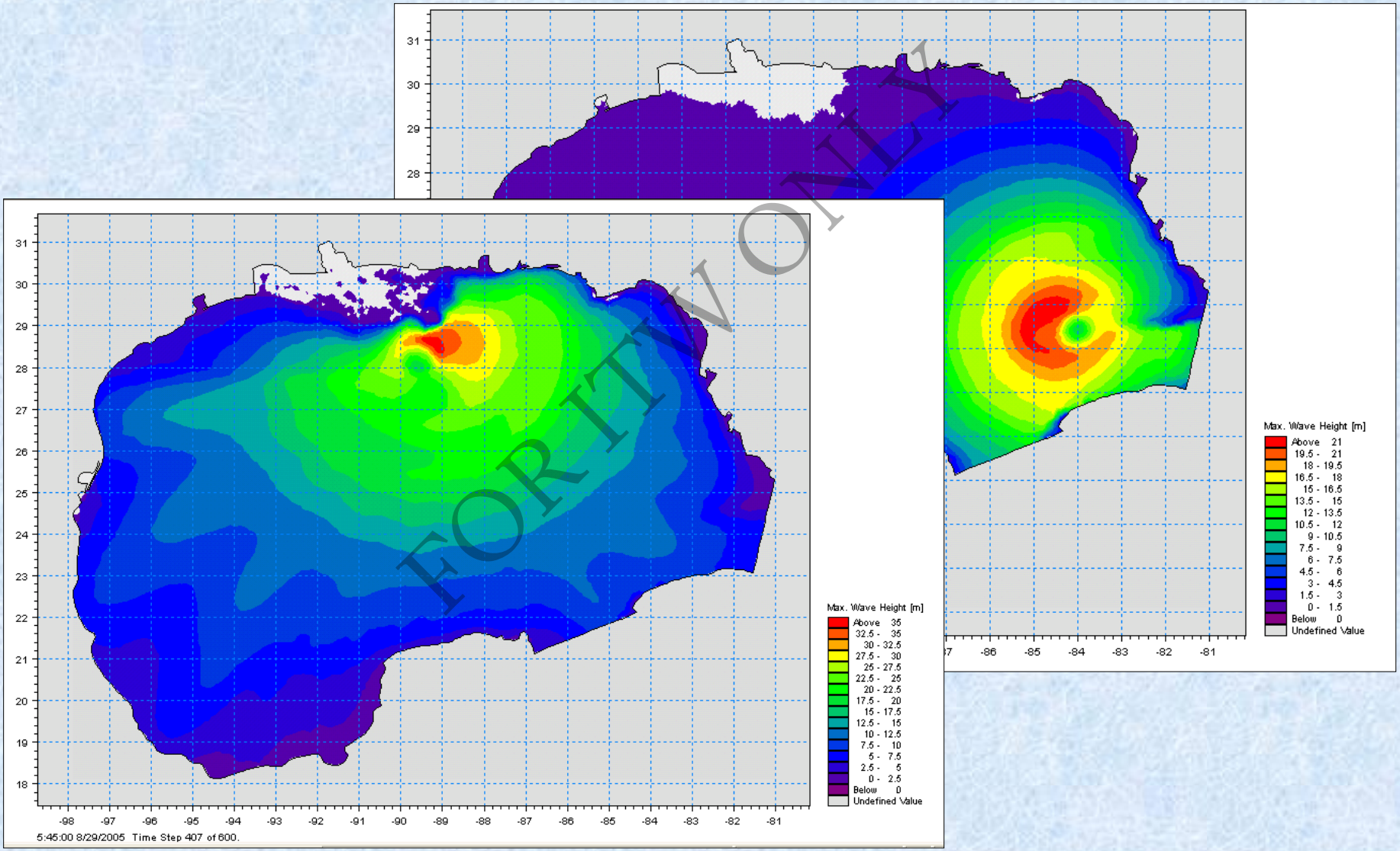
PACIFIC DISASTER CENTER

Mekong River Project (2003)



PACIFIC DISASTER CENTER

Storm Surge Modeling



Questions?

Andrea Chatman
Disaster Management
Applications Analyst
Pacific Disaster Center
Kihei, Maui, USA
1-(808)891-7947
achatman@pdc.org