RiskMAP
Increasing Resilience Together

Great Lakes Coastal Flood Hazard Studies Are More than Meets the Eye

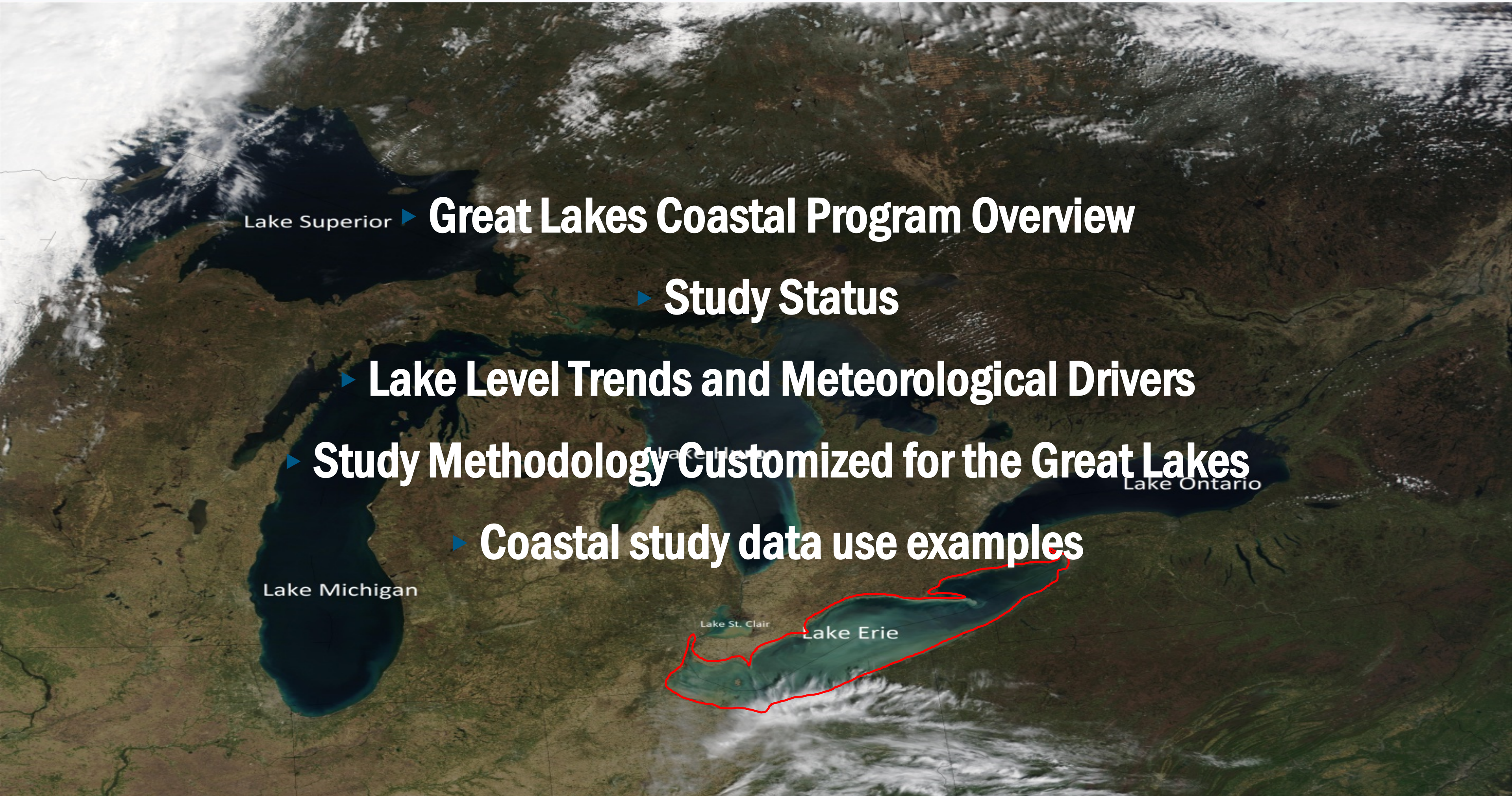
Lead Presenters: Ken Hinterlong (FEMA Region V)
Jeff Gangai (STARR II)

FEMA

STARR II Strategic Alliance for Risk Reduction

Summary

- Great Lakes Coastal Program Overview
- Study Status
- Lake Level Trends and Meteorological Drivers
- Study Methodology Customized for the Great Lakes
- Coastal study data use examples



FEMA

RiskMAP
Increasing Resilience Together

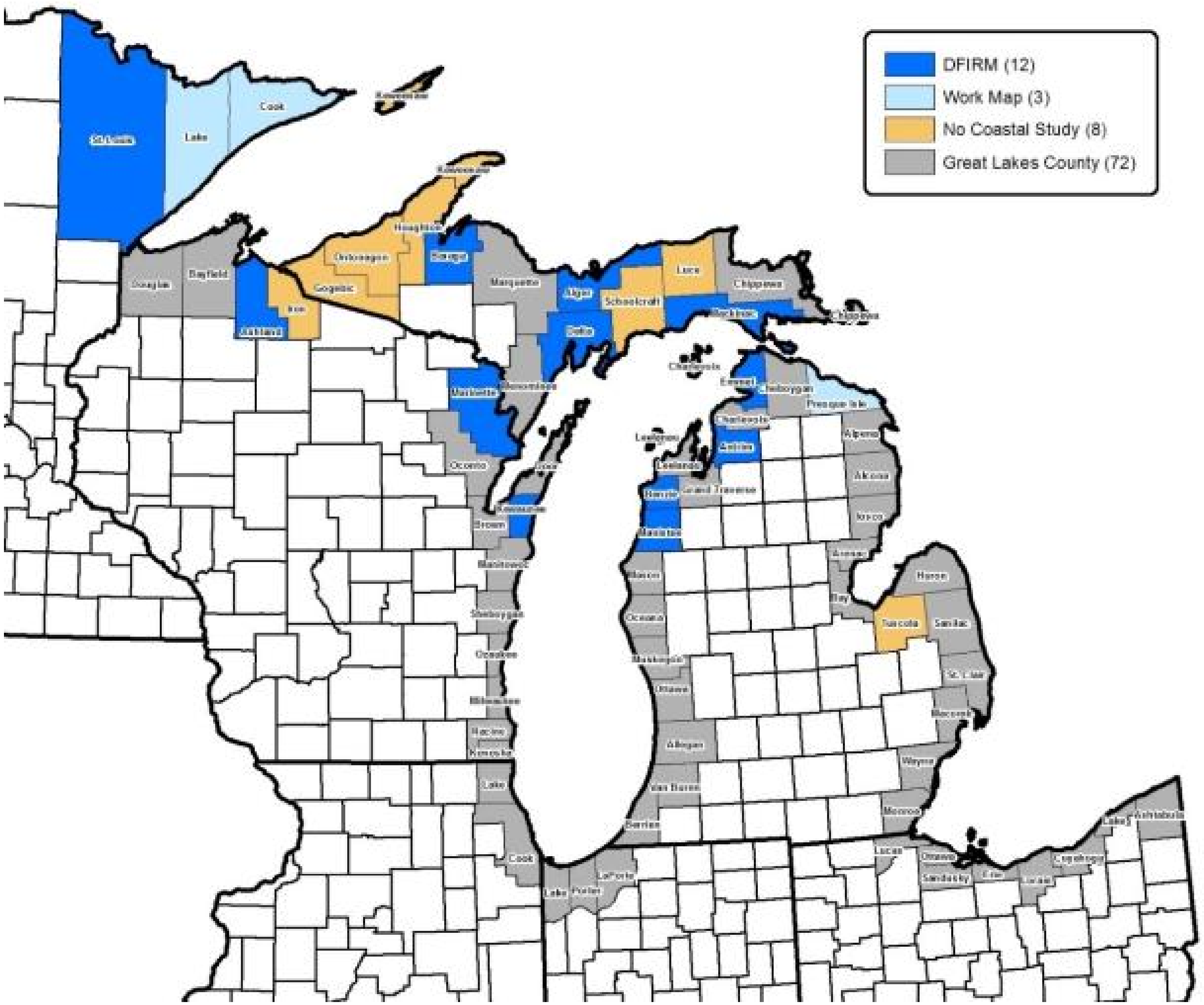
Great Lakes Flood Study

- Latest models, data, and technology
  - Employs continuous time series surface grids and storm sampling built from 50-year record (1960 - 2009) based on NOAA water level stations and compiled datasets for wind, atmospheric pressure and ice cover
  - Comprehensive bathy-LiDAR collections or field-surveyed hydrography
  - *VE velocity mapping designation as appropriate*
- Starting with 2013 goals, delivers updated flood maps for 64 counties in FEMA Region V states
- Flood maps will include new study for inland rivers and lakes in 12 counties
- Early Outreach conducted to survey possible applications for enabling local advancement of resiliency measures.

FEMA

RiskMAP
Increasing Resilience Together

Program Goals and Status



FEMA

RiskMAP
Increasing Resilience Together

Current Study Status

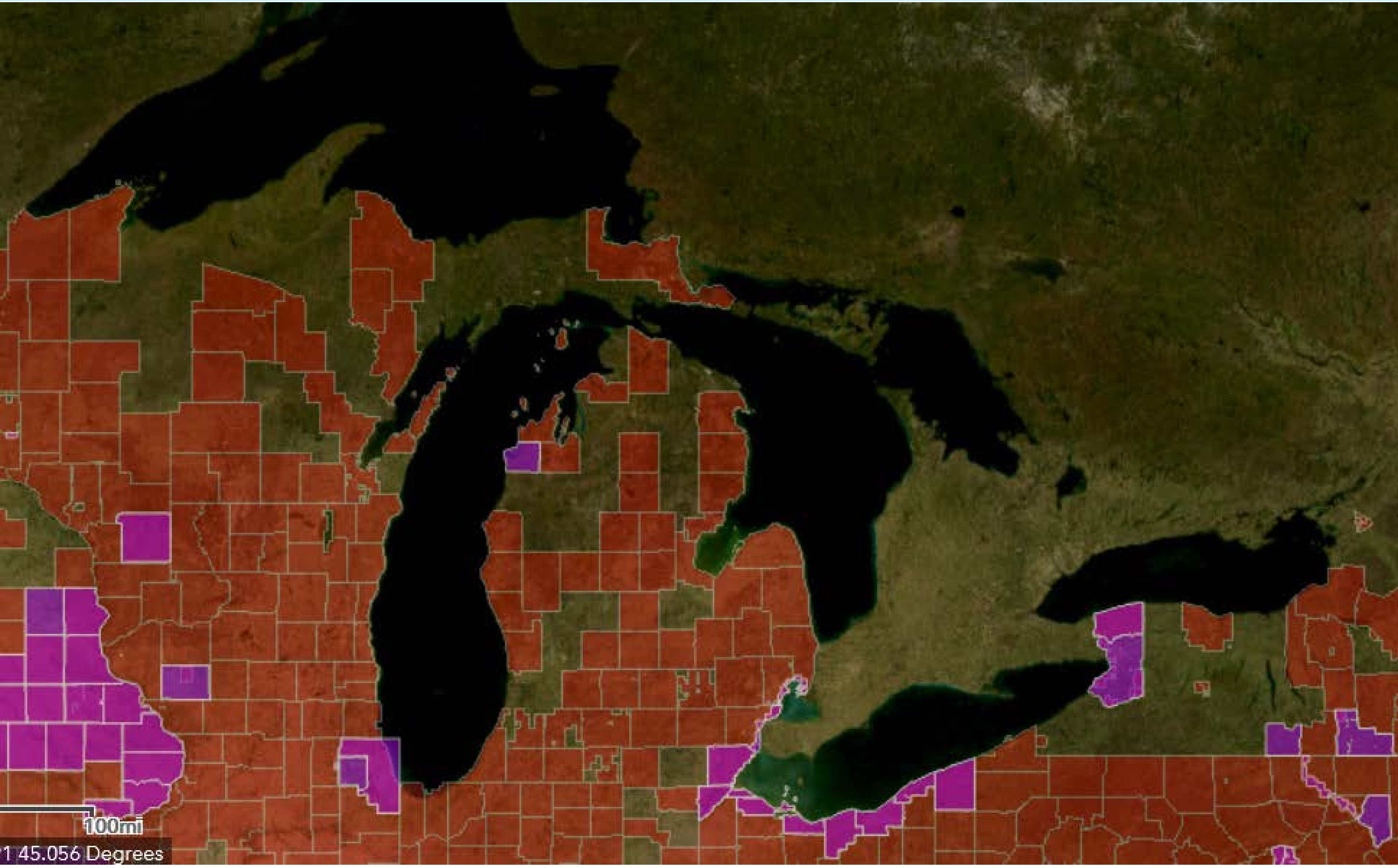
- Lake-Wide Storm Surge and Waves Study
- County Based Overland Analyses
- Workmap Production
- Comment Period
- FIRM Production
- Preliminary FIRM
- Community Coordination Meeting
- Comment and Appeal Periods
- Letter of Final Determination
- Effective FIRM

You are here

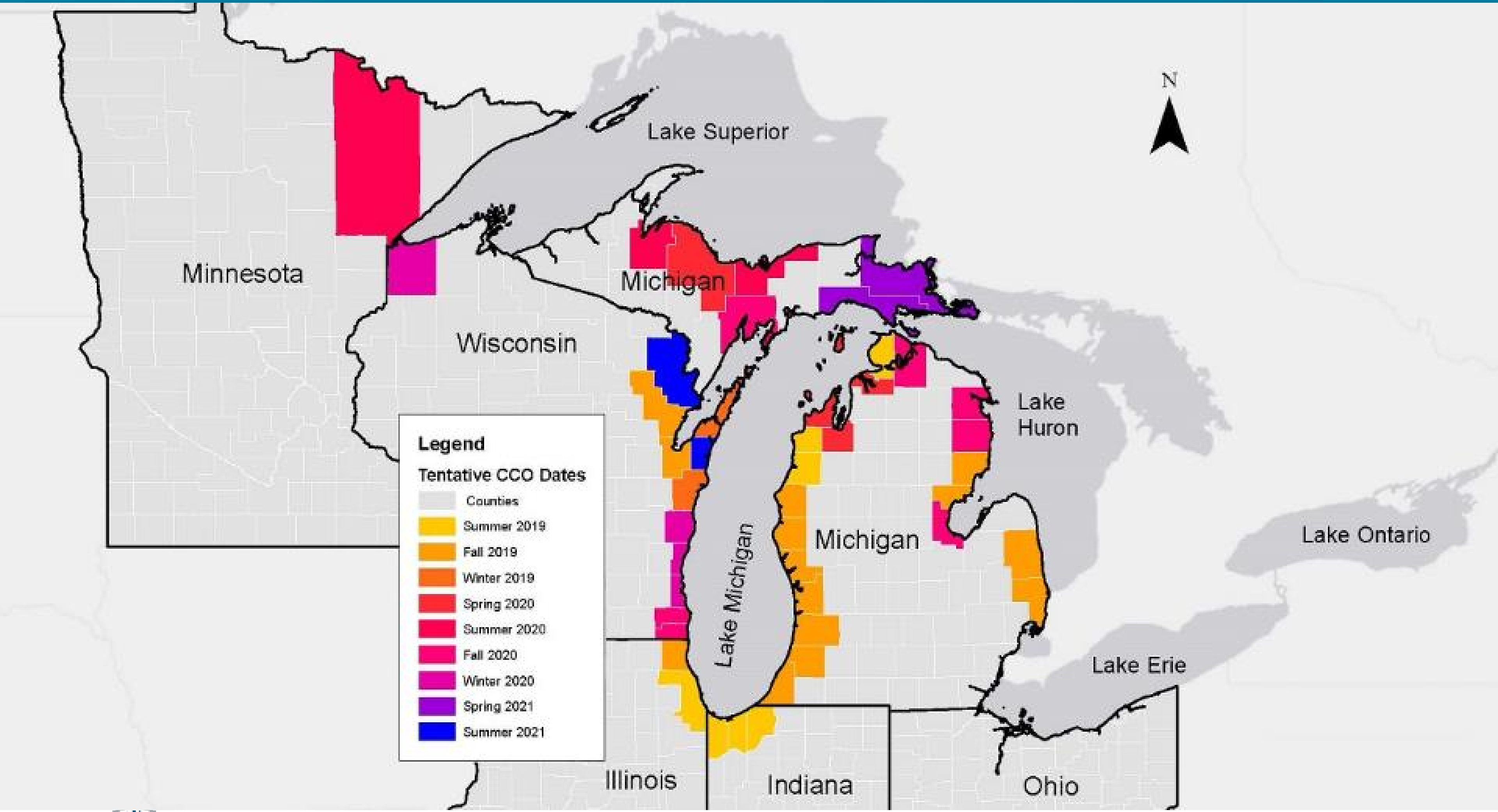
FEMA

RiskMAP
Increasing Resilience Together

Preliminary FIRM Status



Preliminary FIRM Release for Upper Lakes Planned 24-month schedule



FEMA

RiskMAP
Increasing Resilience Together

Lake Erie 2D Modeling

- Simulated approximately 150 historic storm events selected for high water and waves
- 20 storms for water levels and 20 for high wave events, for each station
- Considered long- and short-term lake lever variation
- Considered effects of shore fast ice
- Results are used in Overland Analyses to determine 1%-annual-chance hazards

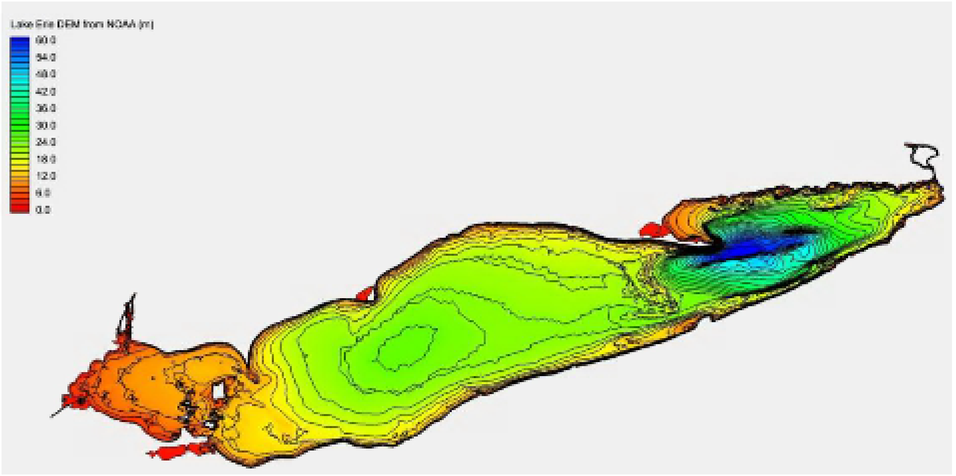
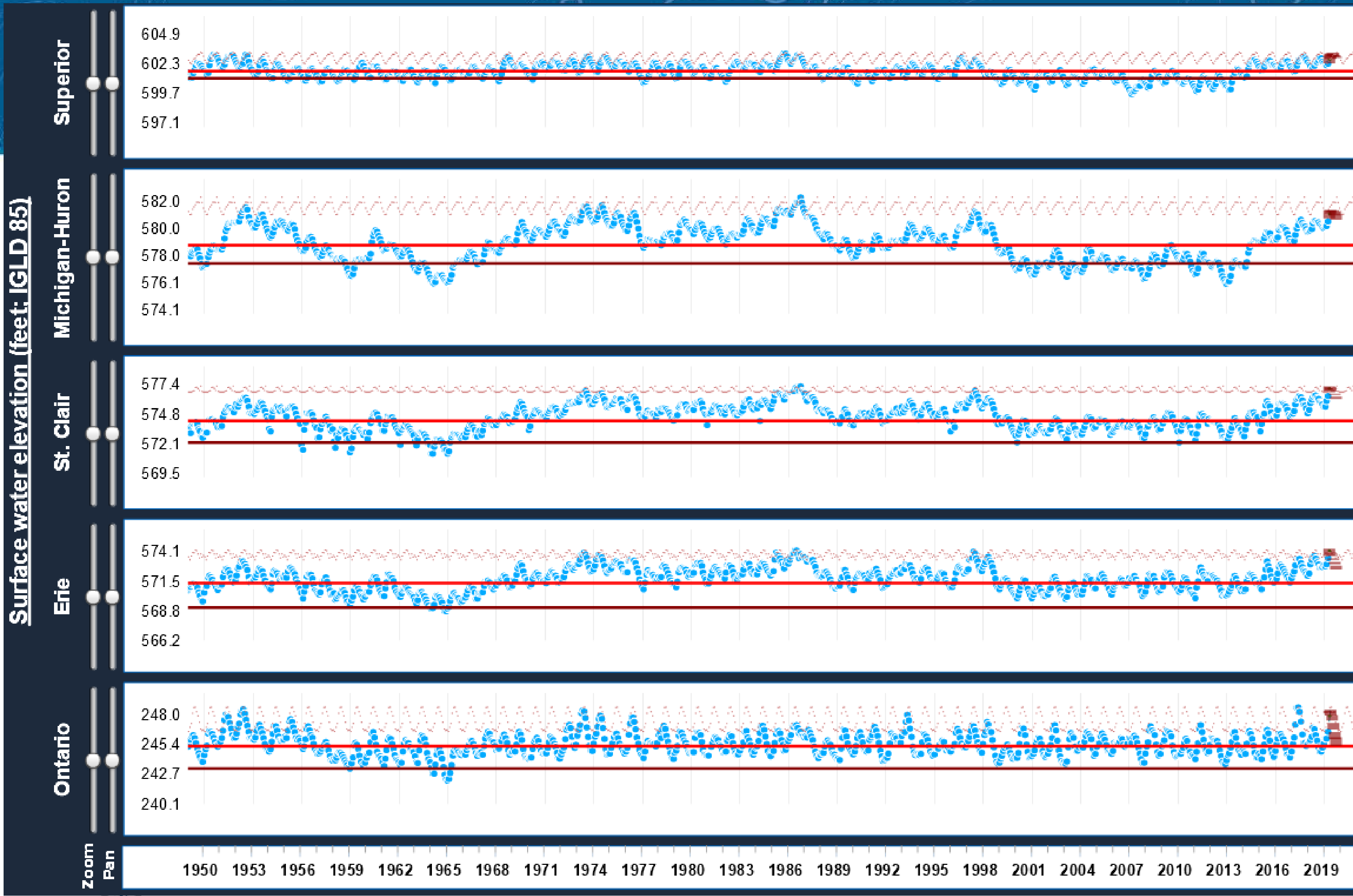


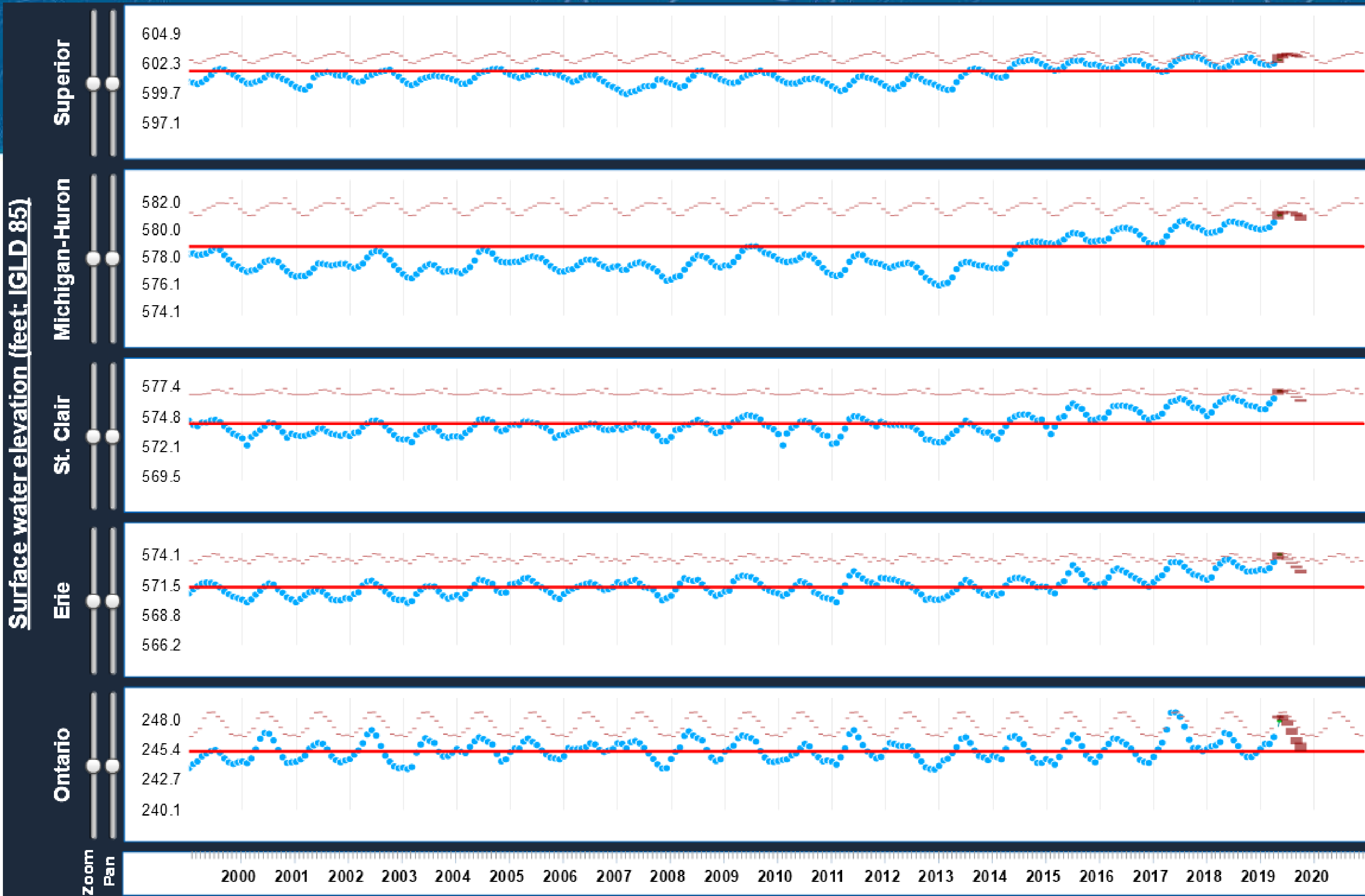
Figure 5-2 328 foot Grid Size Bathymetry DEM from NOAA National Geophysical Data Center

Figure 5-5 Lake Erie ADCIRC/SWAN Mesh



FEMA

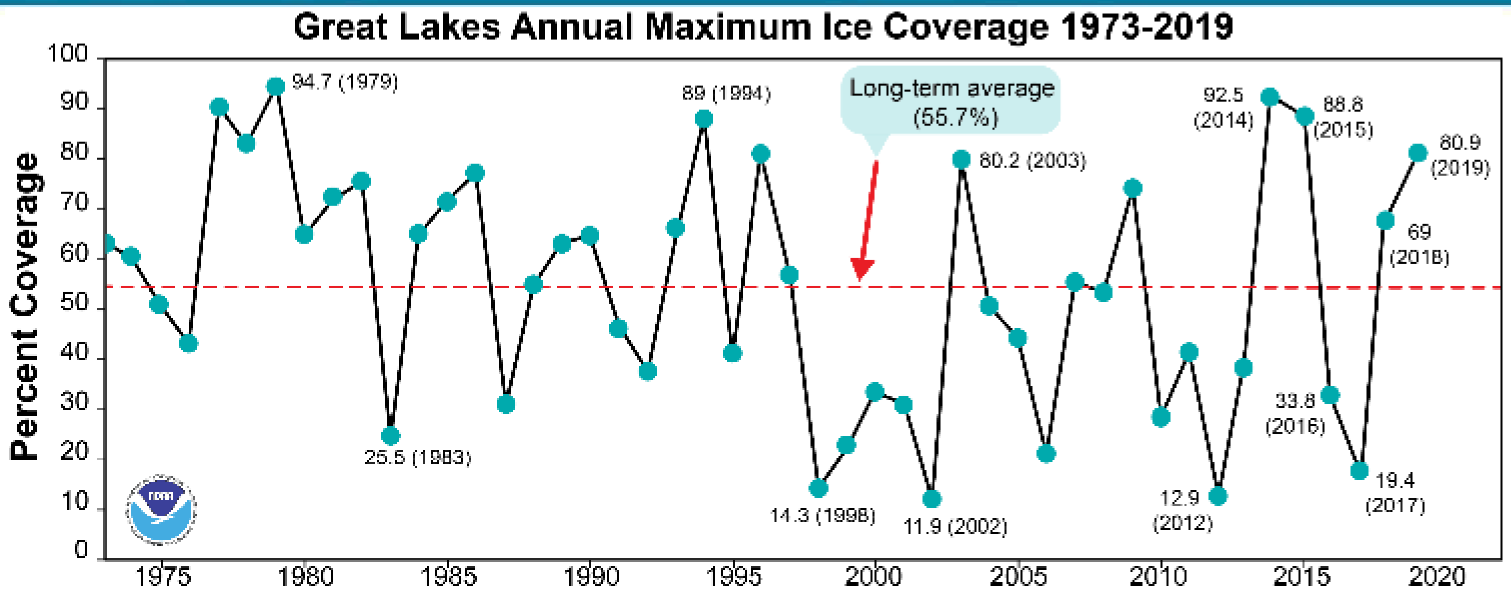
RiskMAP
Increasing Resilience Together

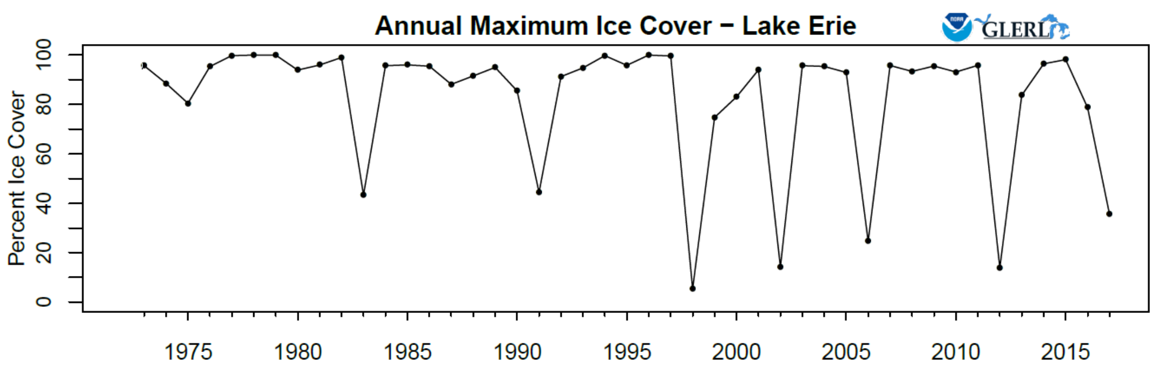


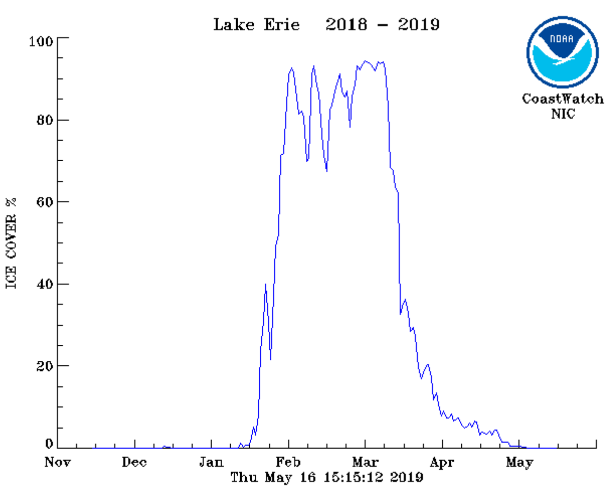
FEMA

RiskMAP
Increasing Resilience Together

Ice Impacts







FEMA

Data Availability

- Water levels and waves for historic storms all along shorelines
  - Time-series data
  - Maximum output from each historic storm
    - Water levels
    - Wave heights and periods
    - Winds
    - velocities

- Historic storms on a variety of lake levels
  - Scenarios and maximum cases of high water level and waves

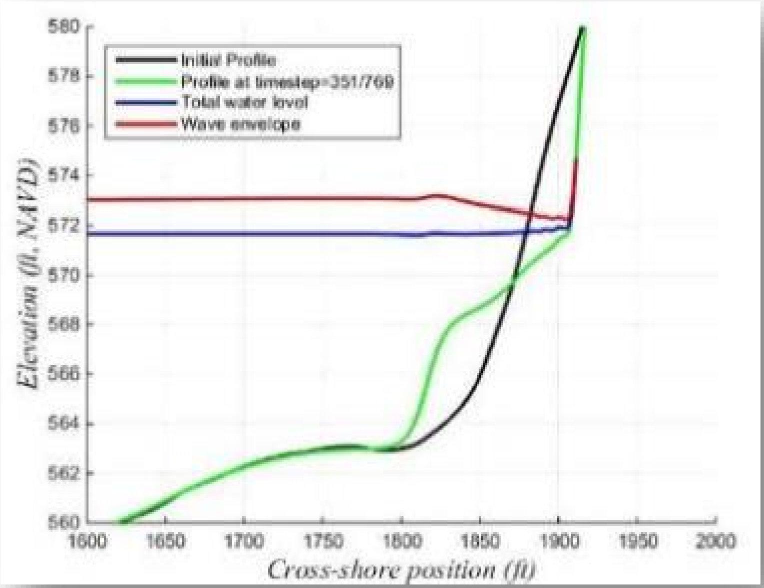
- Storm erosion and wave runup with each historic event

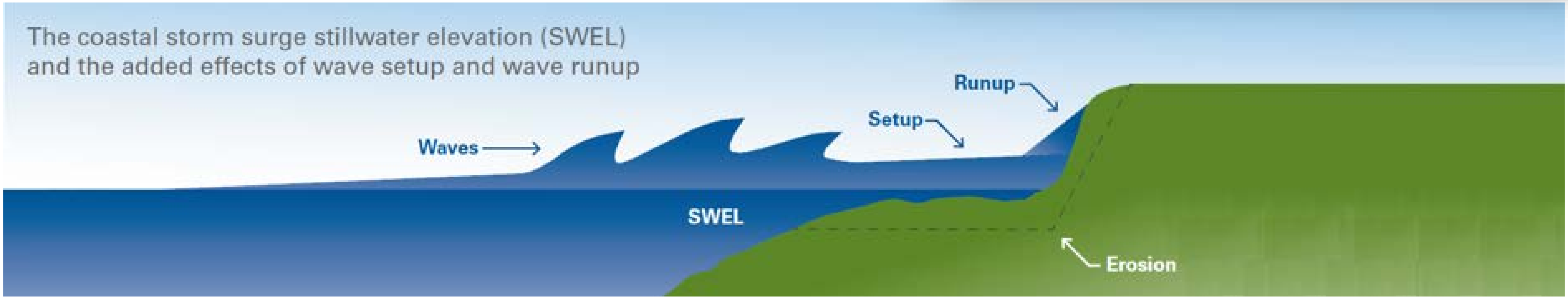
FEMA

RiskMAP
Increasing Resilience Together

CSHORE Processes

- 1D cross-shore transect model
  - Models near-shore processes simultaneously
    - Sediment transport / erosion
    - Wave setup
    - Wave transformation and breaking
    - Wave runup & overtopping
  - Accurate nearshore bathymetry is important

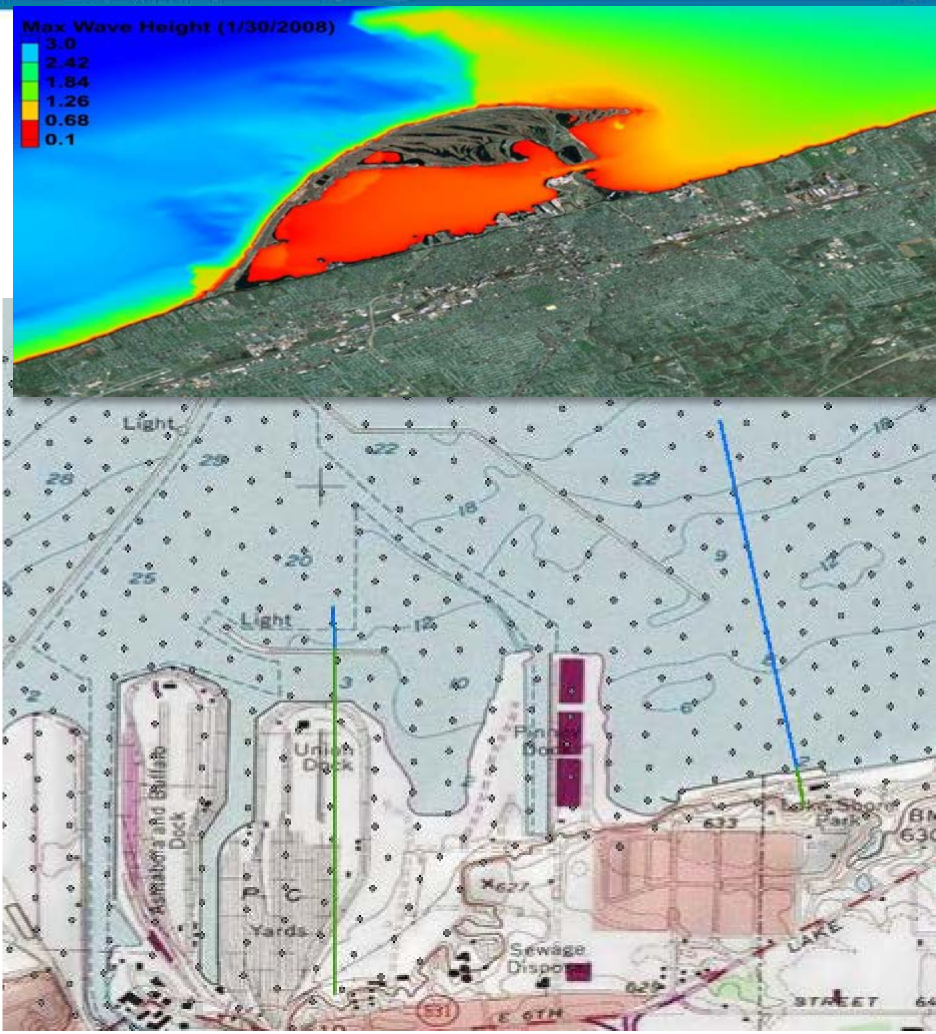




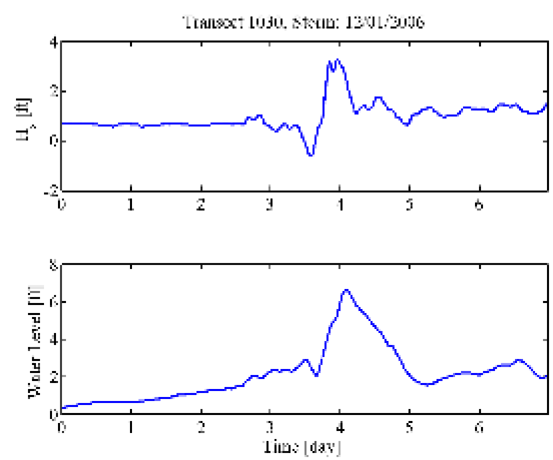
FEMA

RiskMAP
Increasing Resilience Together

2D to 1D Model Handoff



- 2D model has too large a scale for accurate results in surf zone and onshore
- 1D models were used to analyze erosion, runup and overtopping, and overland wave propagation
- 1D models used 2D time series model results as input

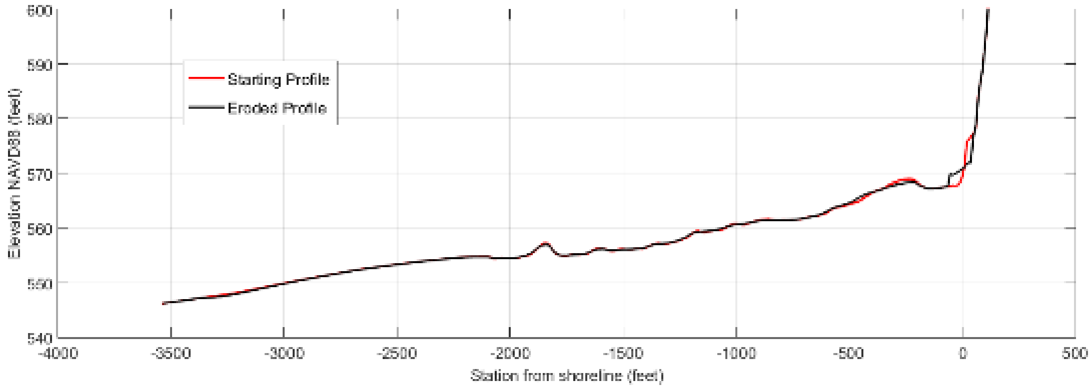


FEMA

RiskMAP
Increasing Resilience Together

Erosion

Ashtabula County, Transect 26



USACE CSHORE model:

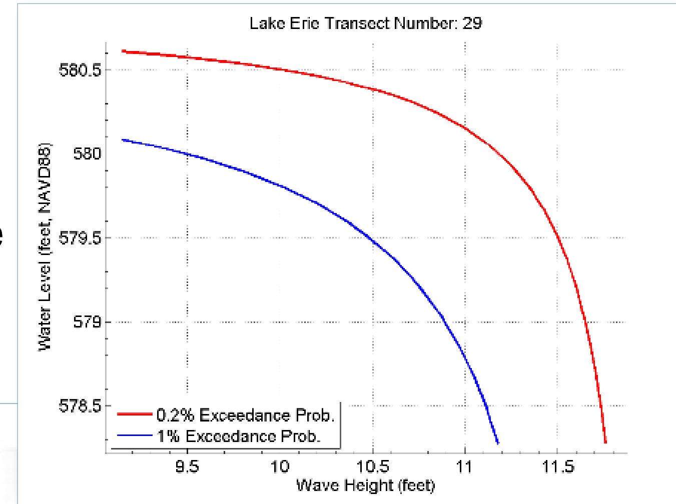
- Applies real physics
- Near-shore wave processes
- Cross-shore sediment transport

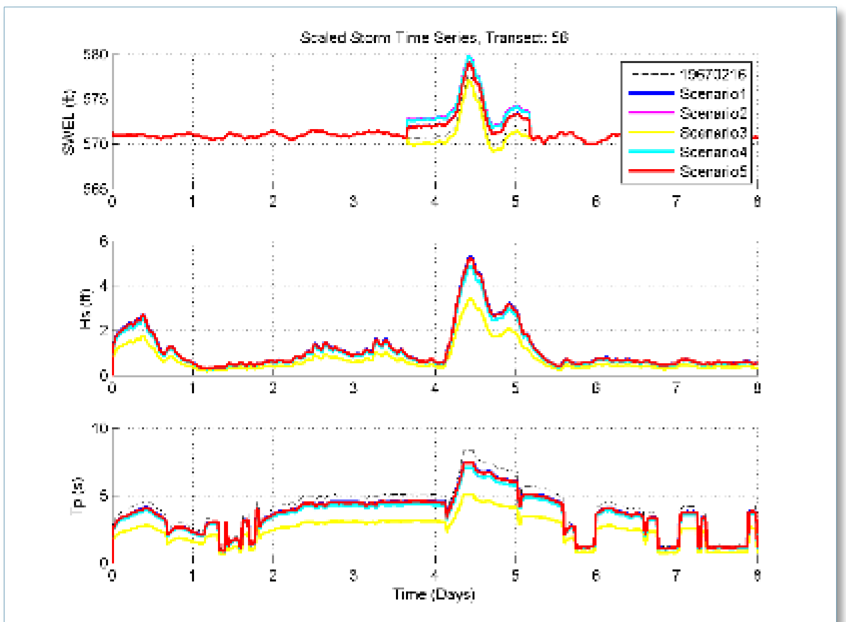
FEMA

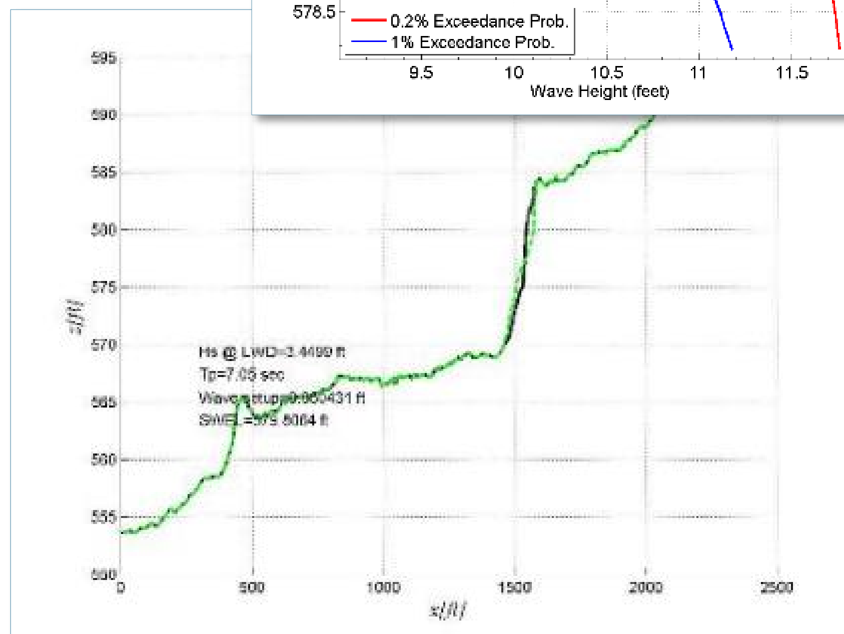
RiskMAP
Increasing Resilience Together

Event-based Modeling

- Event-based (1% annual chance) modeling
  - Five scenarios/events modeled using WHAFIS
  - JPM (Joint-Probability Method) for water level/wave analysis
    - Combined probability of water levels and waves at the shoreline
  - Inputs come from CSHORE:
    - Wave conditions at shoreline (unsteady state hydrographs)

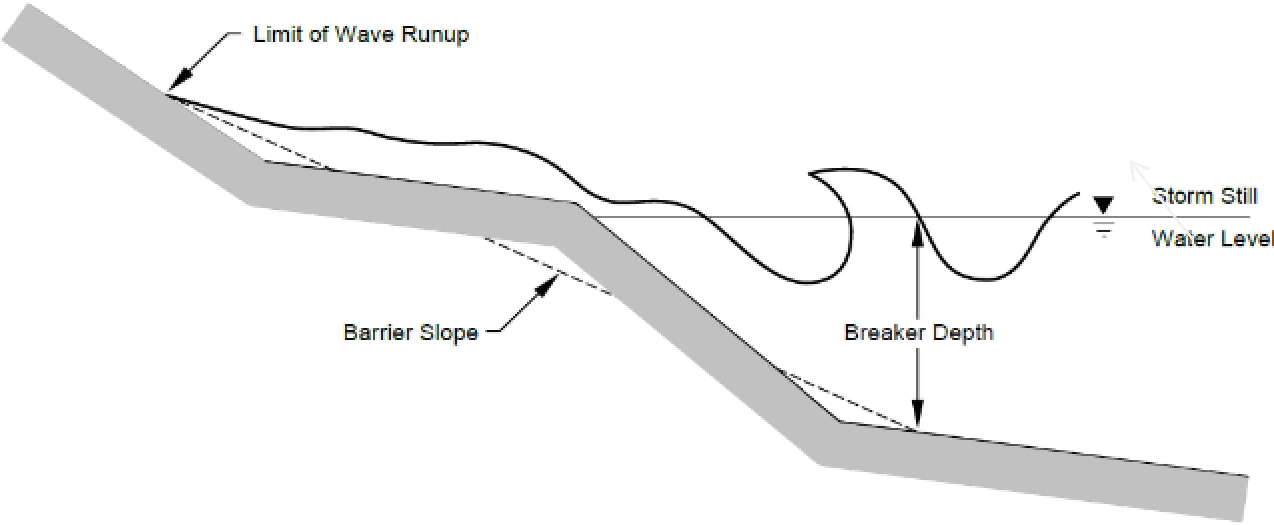






Response-Based Wave Runup

- Wave runup is the uprush of water from wave action on a beach or shore barrier such as a steep dune, bluff or coastal structure.
- It was calculated for every time step of the CSHORE simulation for each of the 155 storms at each transect.
- A statistical analysis was performed on the maximum runup results at each transect to obtain the 1-percent-annual-chance runup elevation.

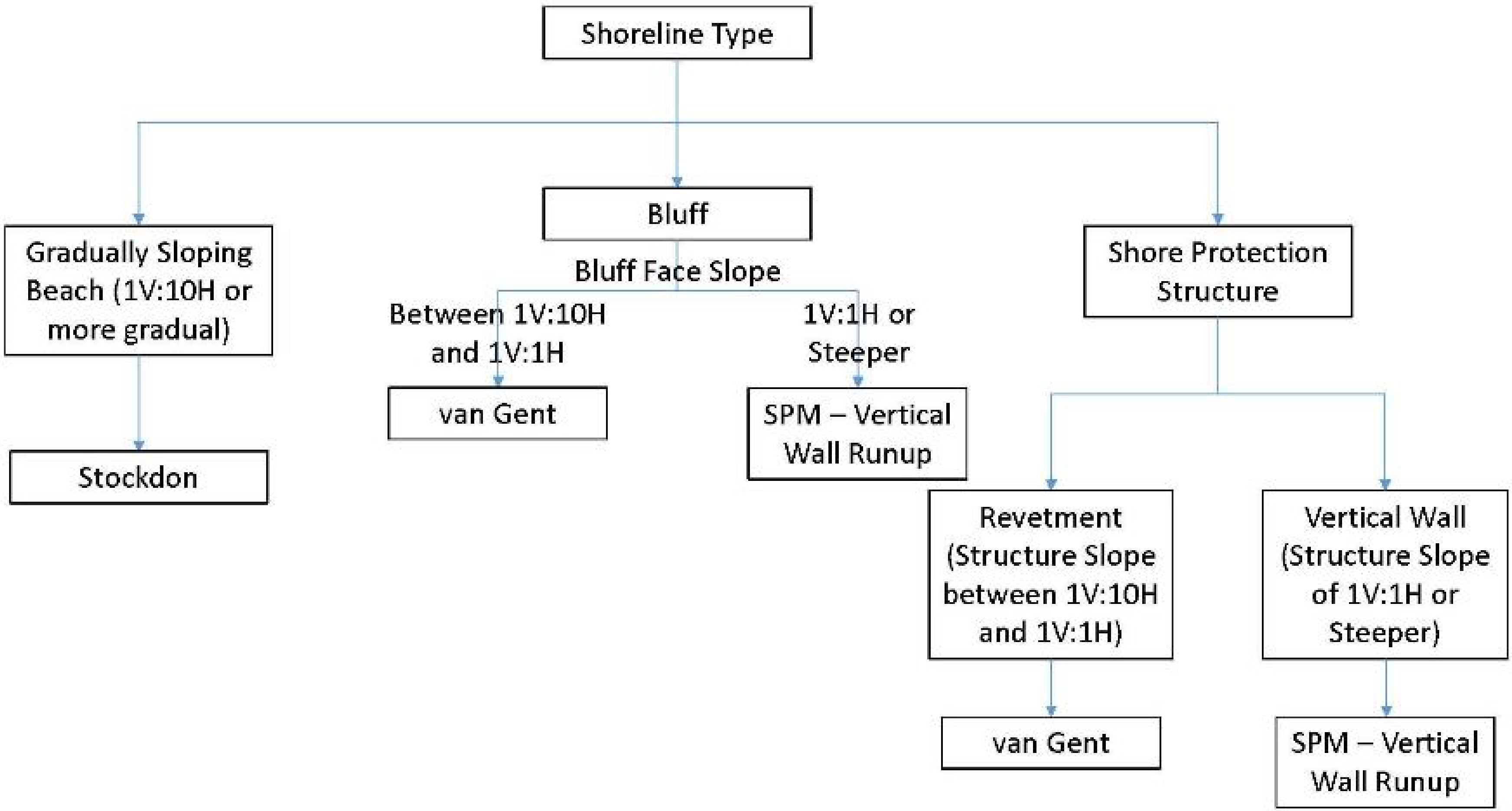


FEMA

RiskMAP
Increasing Resilience Together

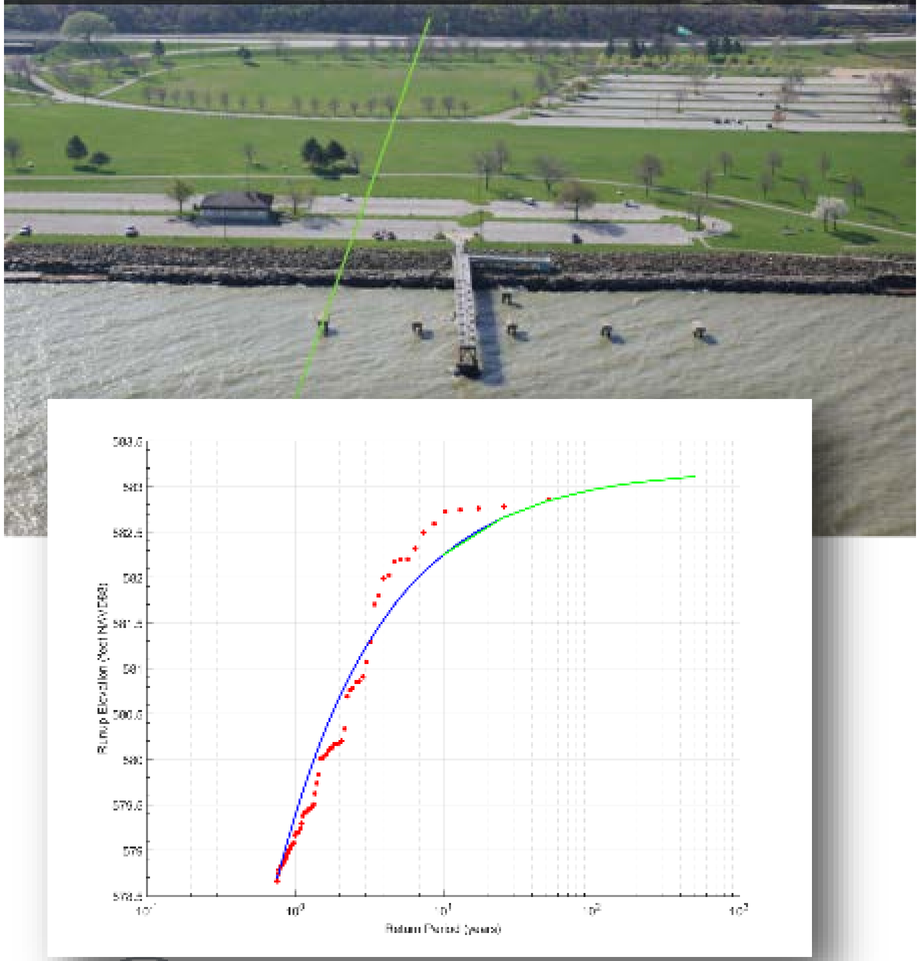
Response-Based Wave Runup

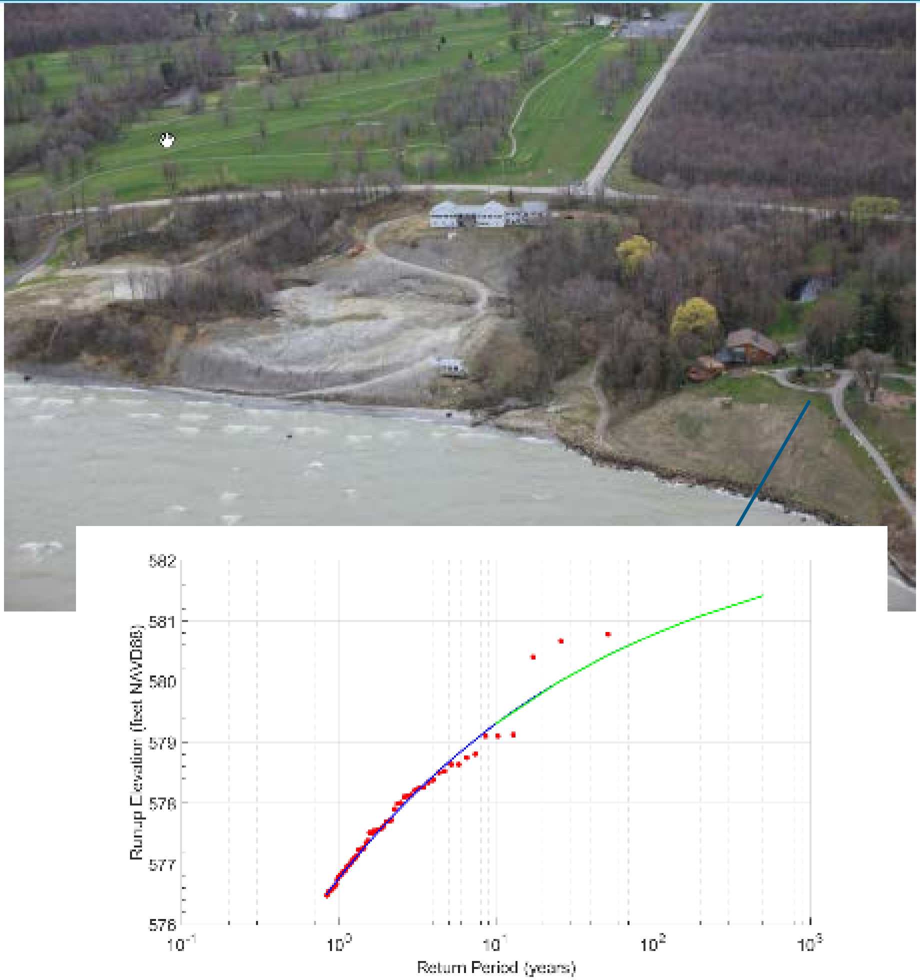
Runup Method Decision Flow Chart



Response-Based Wave Runup

Cuyahoga Transect 22





Vertical Wall Runup

- For very steep slopes and vertical structures the Shore Protection Manual (SPM) was applied to calculate the runup elevation
- The runup elevation was evaluated using the 5 WHAFIS Scenarios
  - Impractical to use SPM method in response based analyses
  - Choose highest runup as 1% hazard (same as WHAFIS technique)

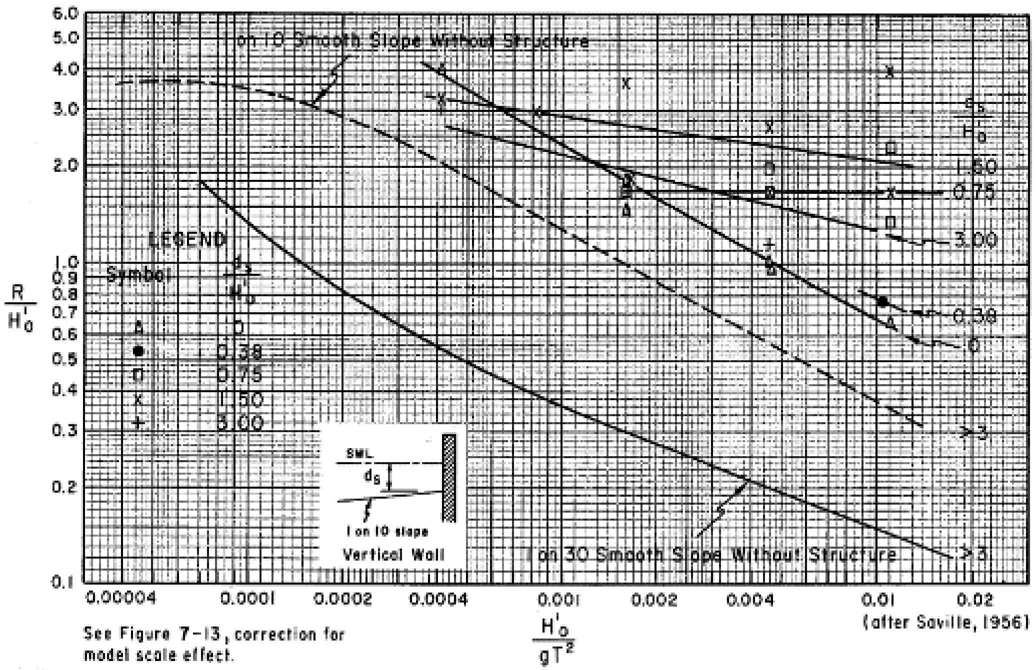
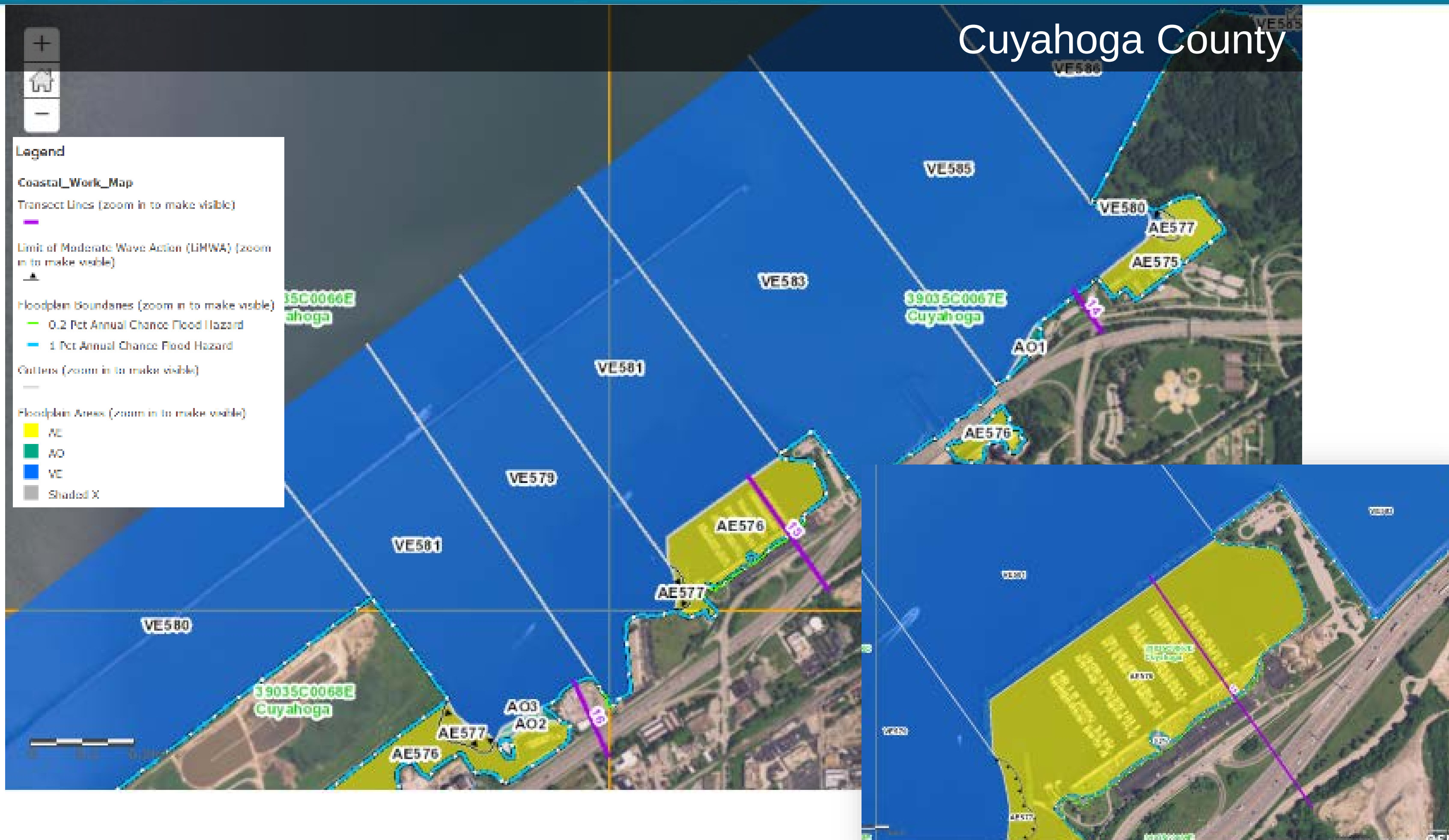


Figure 7-14. Wave runup on impermeable, vertical wall versus H'_o/gT^2 .

Runup Mapping

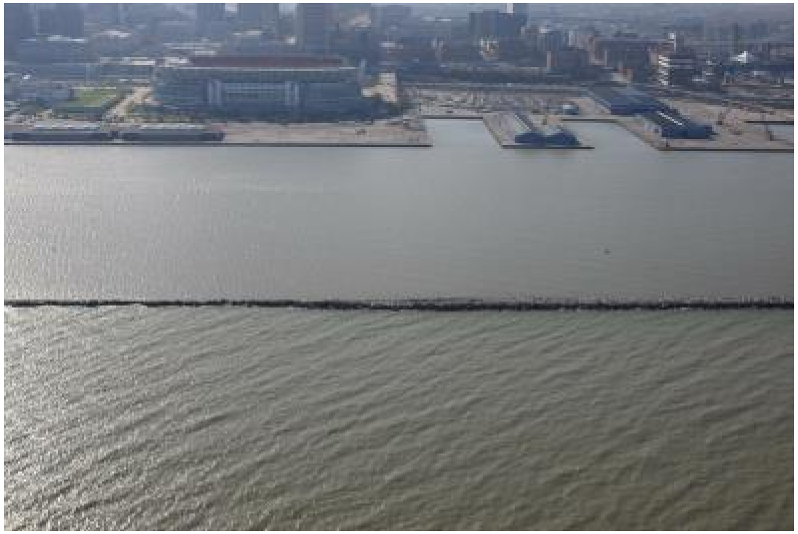


FEMA

RiskMAP
Increasing Resilience Together

Shoreline Structures

- **Major Structures**
  - High relative to lake
  - Designed for storm protection
  - Continuous along shoreline



- **Minor Structures**
  - Low relative to lake
  - Not designed for storm protection
  - Small scale

FEMA

RiskMAP
Increasing Resilience Together

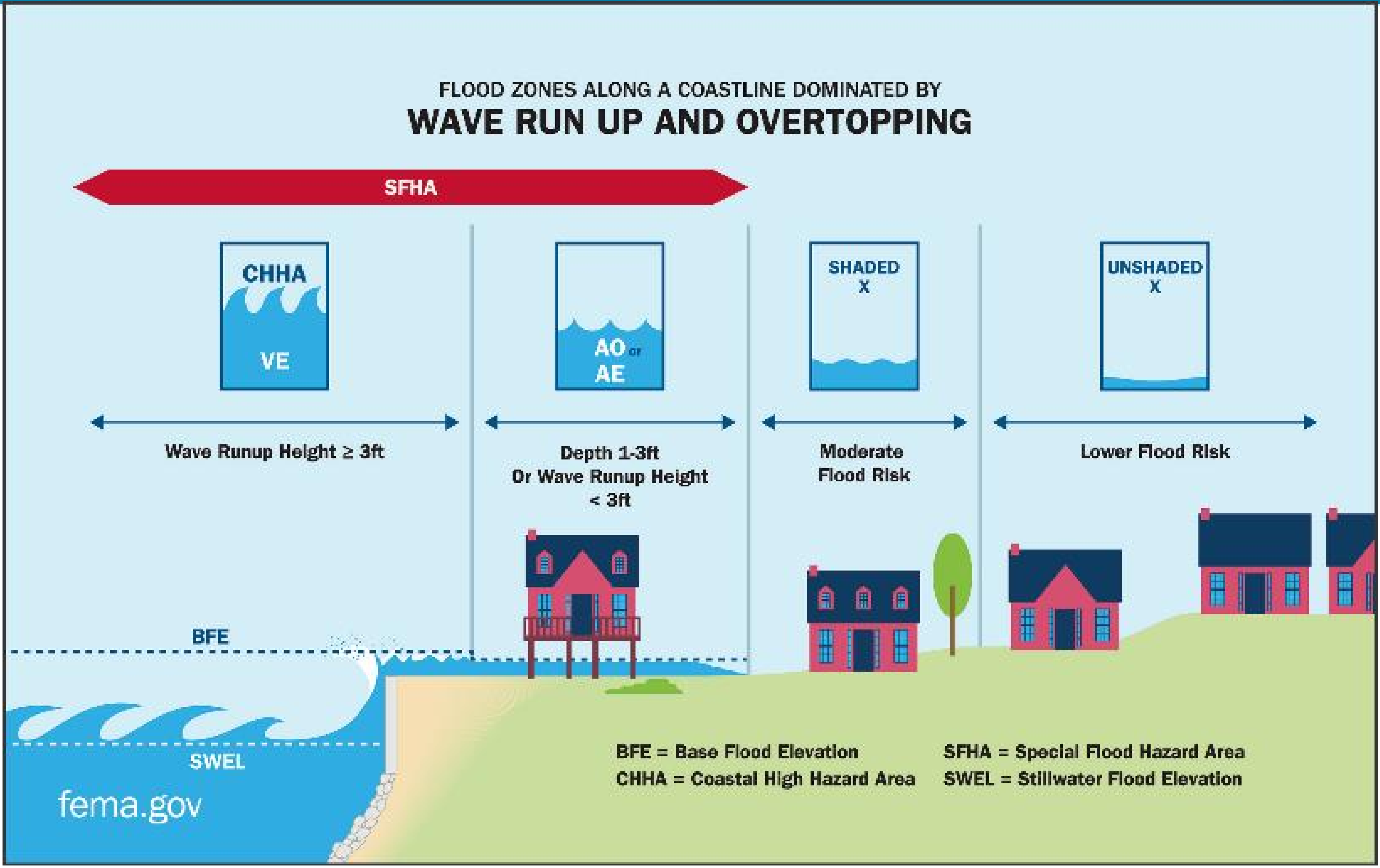
Wave Overtopping

- Overtopping rate considerations for establishing Flood Insurance Rate Zones
- Magnitude of overtopping rates was calculated by applying formulas of the EurOTop Manual
- Overtopping rate determines AO Zone (sheet flow) depth

Wave overtopping on the coast of Lake Ontario during a 1973 Storm, Edgemere Drive, Monroe County, NY.

— Photo Courtesy of Dr. Martin

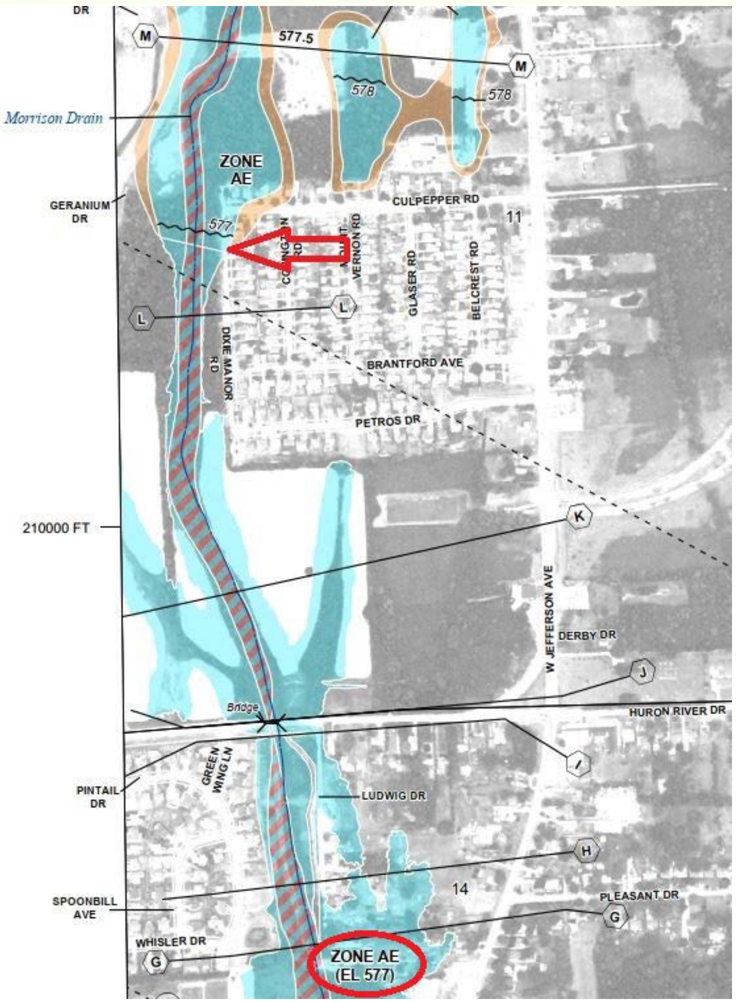
FIRM Mapping

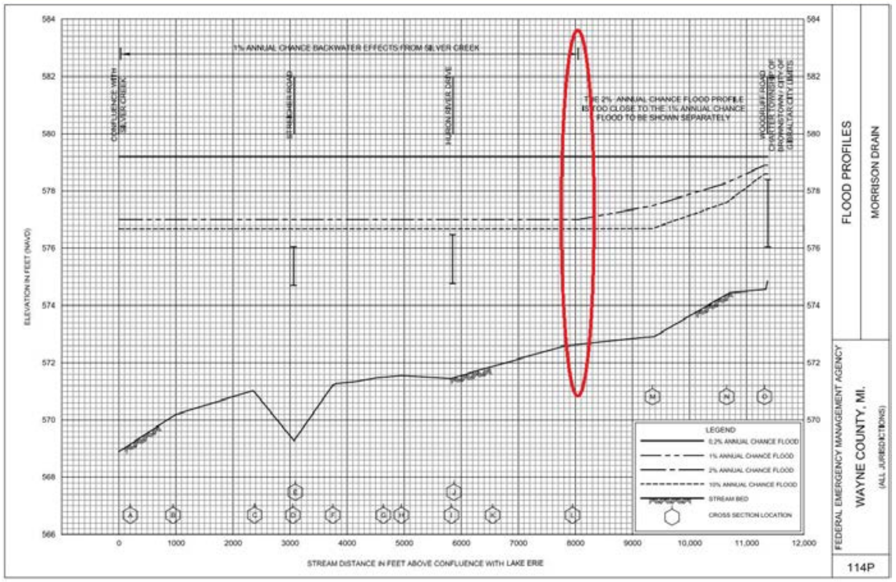


FEMA

RiskMAP
Increasing Resilience Together

Integrating Riverine and Coastal Data





FLOODING SOURCE		FLOODWAY				1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WIDTH REDUCED FROM PRIOR STUDY (FEET)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
MORRISON DRAIN									
A	200	136	566	0.4		*	574.1[2]	574.2	0.1
B	950	136	433	0.5		*	574.1[2]	574.2	0.1
C	2,380	265	502	0.4		*	574.2[2]	574.3	0.1
D	3,050	14	42	4.8		*	574.2[2]	574.3	0.1
E	3,091	9	43	4.7		*	574.2[2]	574.3	0.1
F	3,750	198	253	0.8		*	574.6[2]	574.6	0.0
G	4,635	142	245	0.8		*	574.8[2]	574.8	0.0
H	4,950	150	258	0.8		*	574.9[2]	574.9	0.0
I	5,828	11	35	5.6		*	574.9[2]	575.0	0.1
J	5,871	11	51	3.9		*	576.2[2]	576.3	0.1
K	6,550	91	231	0.9		*	576.6[2]	576.6	0.0
L	7,950	112	215	0.9		*	576.9[2]	577.0	0.1
M	9,350	112	193	1.0		577.5	577.5	577.6	0.1

* Controlled by coastal flooding – see Flood Insurance Rate Map for regulatory base flood elevation

FEMA

RiskMAP
Increasing Resilience Together

Integrating Riverine and Coastal Data

System morphology

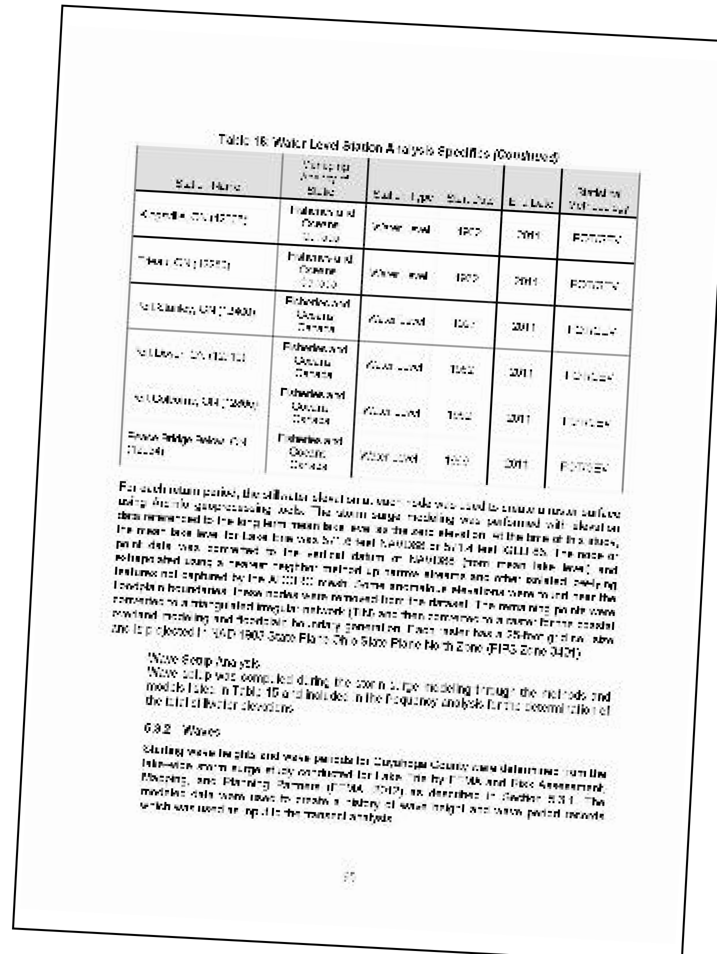
- Tribs outflowing to lakes will have one of following characteristics:
  1. Small streams that discharge from steep-slope ravines
  2. Shallow, slow-moving tributaries that outflow from low-bluff regions
  3. Larger rivers that transition into a dredged or widened condition or inland lake system
- Exceptions found on Lake Superior and north Lake Michigan where streams outflow through non-cohesive and mostly sandy substrate.

Issues for Flood Map Production

- Nature and currency of current NFIP model for contributing trib: Are lake TSWL elevations higher or lower than stream BFE at lowest modeled point for free-flow conveyance? For large unsheltered rivers, is joint probability analysis appropriate?
- FEMA's *Guidance for Flood Risk Analysis and Mapping, Combined Coastal and Riverine Floodplain* (May 2015) serves as generalized procedure.
- FEMA and STARR II production teams drafted additional guidance in March 2019

Customization of the Flood Insurance Study (FIS) text

- The Great Lakes cover lands inside U.S. involving more that 80 counties across eight states.
- Methods and terminology references for the FEMA FIS were required for unique coastal language and customized methods:
  - Tidal gage tables are replaced by tables showing employed NOAA water level stations
  - Building on draft documents compiled during analysis phase, comprehensive review was made for Wave Hazard Analysis summary descriptions
  - Numerous graphics are updated
- An “edits roadmap” was compiled for future production efforts inside FEMA



FEMA

RiskMAP
Increasing Resilience Together

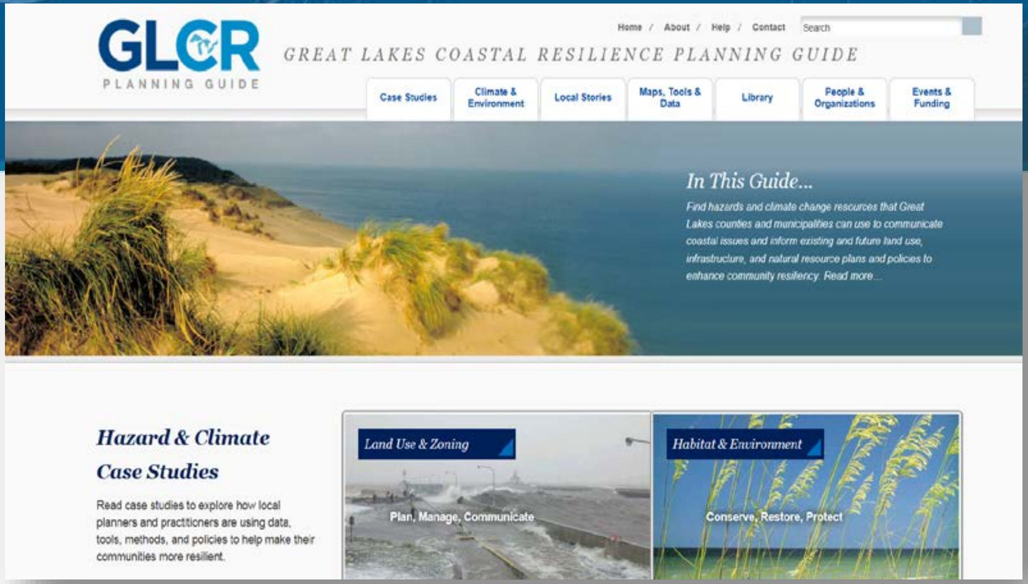
Online Resources

Great Lakes Coastal Flood Study:
http://www.greatlakescoast.org/

Many new Fact Sheets

Great Lakes Coastal Resilience Planning:
http://www.greatlakesresilience.org/

High resolution oblique aerial images
http://greatlakes.erdc.dren.mil/



Great Lakes Coastal Flood Study

Review

- Great Lakes coastal flood risk has changed and will continue to change
- Study will advance our scientific understanding of the interrelated Great Lakes System
- Comprehensive analysis of coastal Great Lakes flood hazards uses latest models, technology, and data
- Study provides FEMA, States, and coastal communities with valuable coastal data and planning tools to adapt and thrive in a changing environment

Questions

KEN HINTERLONG
Senior Engineer, Risk Analysis
FEMA Region 5
312-408-5529
ken.hinterlong@fema.dhs.gov

JEFF GANGAI
Dewberry
703-849-0251
jgangai@dewberry.com

FEMA

RiskMAP
Increasing Resilience Together