USACE H&H MODELING TOOLS AND HOW THEY SUPPORT JACKSONVILLE DISTRICT'S MISSION

PRESENTED AT
SAME JACKSONVILLE POST MONTHLY MEETING

16 AUGUST 2023

Ceyda Polatel, Ph.D., P.E.
Lead Hydraulic Engineer
USACE Jacksonville District

U.S. ARMY

US Army Corps of Engineers

"The views, opinions and findings contained in this report are those of the authors(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation."

CONTENT AND PRESENTATION OBJECTIVES

- Provide and Overview of
  - History and mission of USACE and Jacksonville District
  - Basics of Hydrology and Hydraulics (H&H) numerical simulation
  - H&H software developed and used by the Jacksonville District (SAJ)
  - H&H software applications to Jacksonville District projects

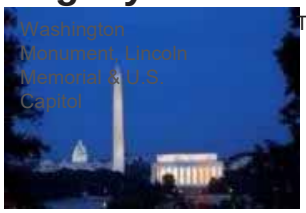
248 YEARS OF SERVICE TO THE NATION

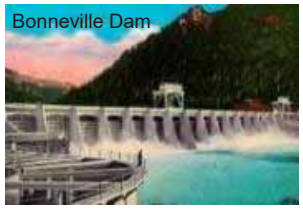
1775 Colonel Richard Gridley named the first Chief of Engineers for the Army

1824 Congress establishes civil works mission for USACE

1800s Crucial role in the growth of the young republic: serving as explorers, surveyors, and map makers

Legacy:





Working Today to Build a Better Tomorrow

JACKSONVILLE DISTRICT: PROUD HISTORY

1884 First permanent USACE office in Jacksonville (Captain W.T. Rossell)

1928 Tampa Harbor dredged

1950 Jacksonville assumes responsibilities of Panama District including Puerto Rico & U.S. Virgin Islands

1960 Herbert Hoover Dike improvements completed

1992 Hurricane Andrew strikes, Jacksonville leads USACE response

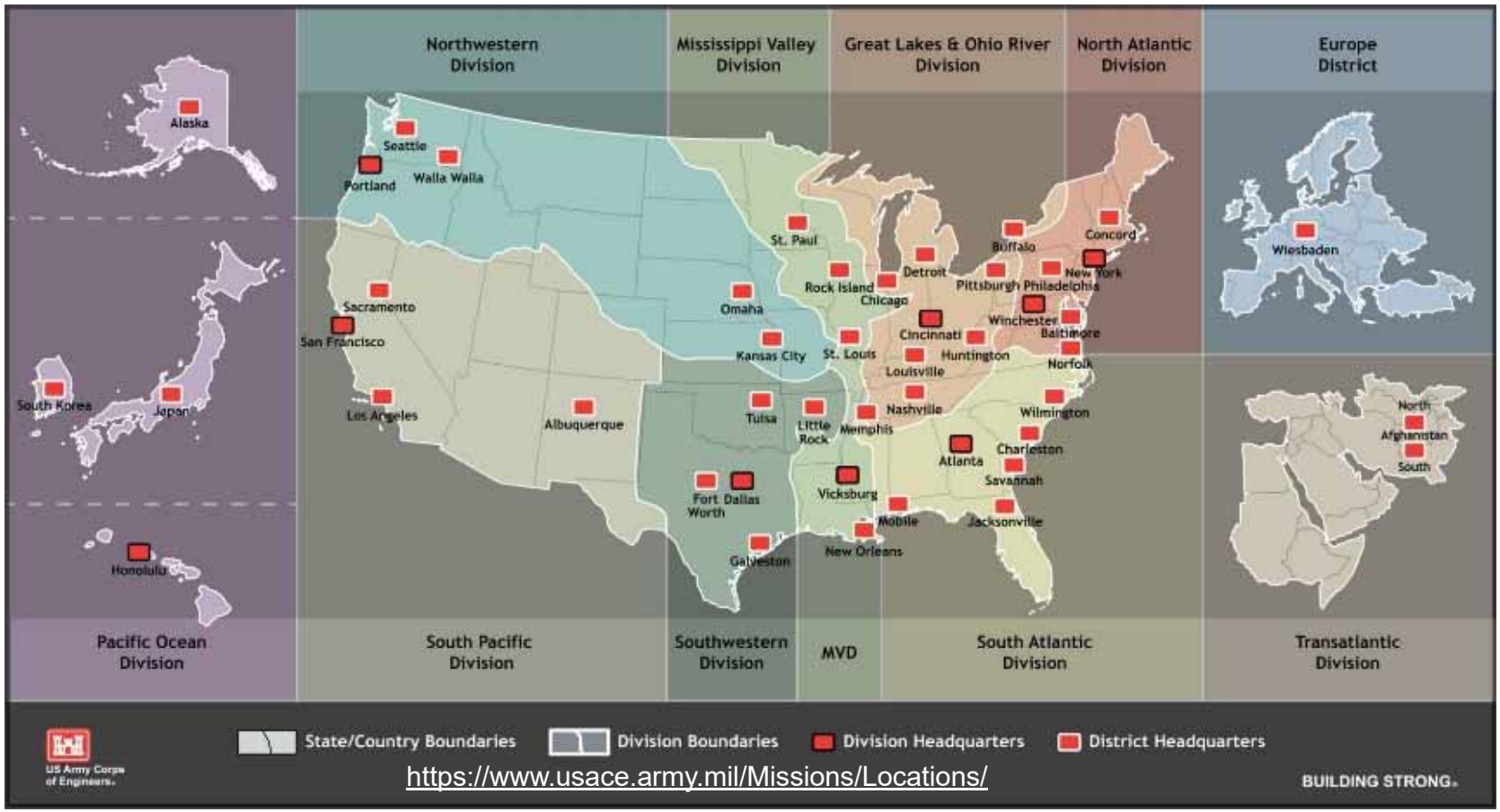
2000 Congress authorizes Comprehensive Everglades Restoration Plan (CERP)

2014 Portugues Dam completed

2016 Antilles School Fort Buchanan (LEED Certified)

Working Today to Build a Better Tomorrow

USACE DIVISION BOUNDARIES AND DISTRICT OFFICES



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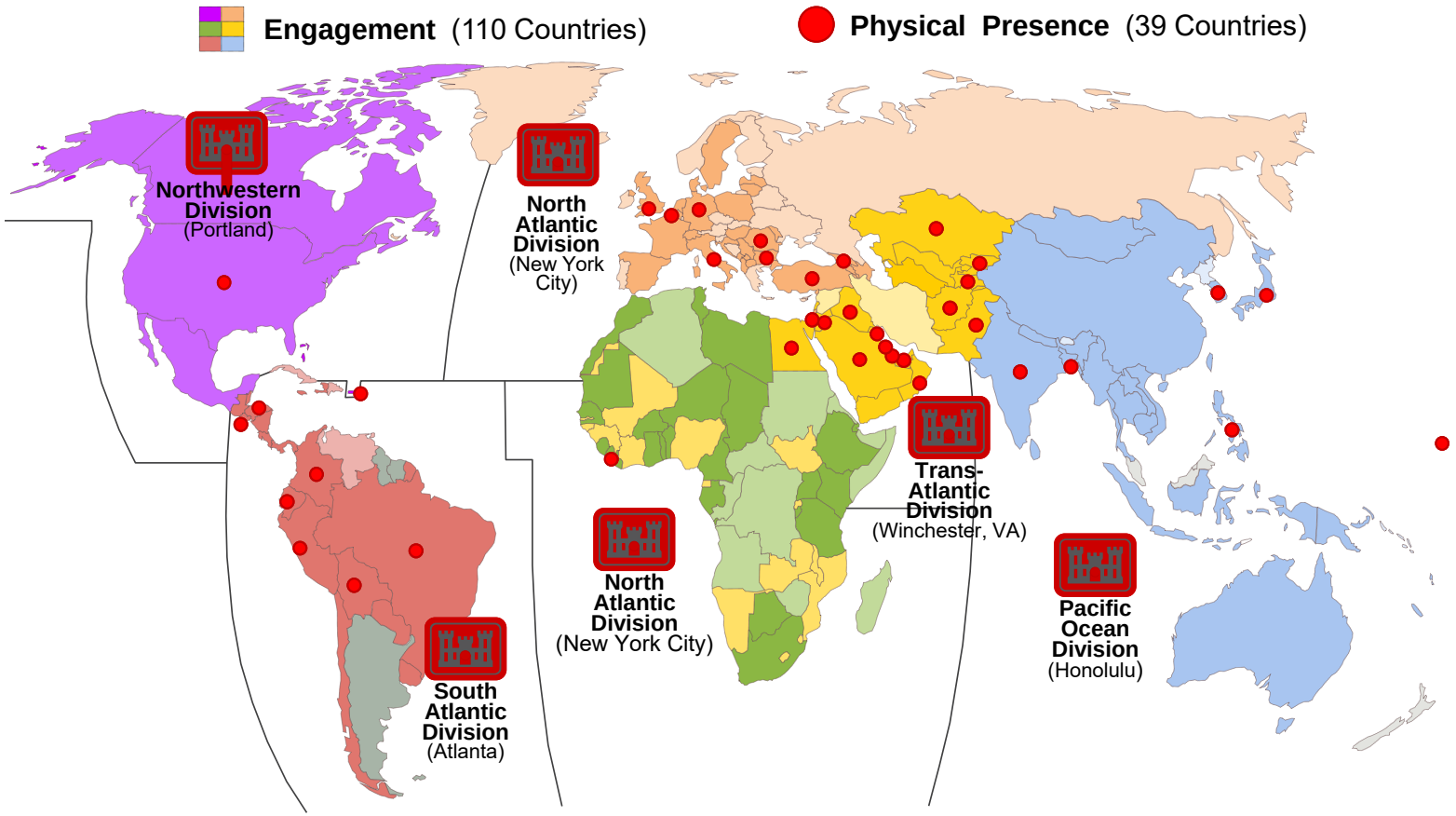
ENGINEERING SOFTWARE DEVELOPMENT

CWMS
HEC-DSS
HEC-DSSVue
HEC-EFM
HEC-EFM Plotter
HEC-FDA
HEC-FIA
HEC-GeoEFM
HEC-GeoRAS
HEC-HMS
HEC-MetVue
HEC-RAS
HEC-ResSim
HEC-RPT
HEC-RTS
HEC-SSP
HEC-WAT

USACE develops and maintains world-class engineering software.
https://www.hec.usace.army.mil/software/

USACE IS REGIONALLY ALIGNED; GLOBALLY RESPONSIVE



As of: 5 Jun 18/POC: Mike Rogalski, CESAD-PM

Working Today to Build a Better Tomorrow

JACKSONVILLE DISTRICT

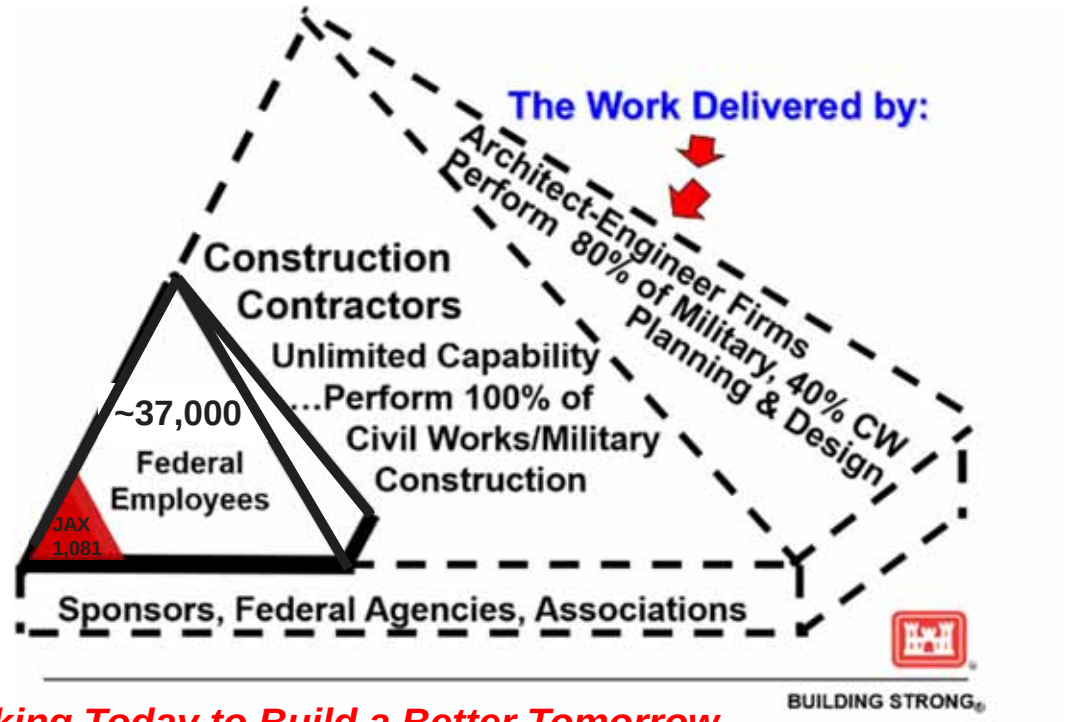
"TEAM OF PROFESSIONALS MAKING TOMORROW BETTER"

OUR TEAM - Growing

6 Military and ~ 1,081 Civilians → **1,250**

- Engineers
- Accountants
- Biologists
- Planners
- Economists
- Archaeologists
- Attorneys
- Project managers
- Architects
- Ecologists
- environmental protection specialists
- Geologists
- Hydrologists
- Park rangers
- Surveyors
- Computer experts
- Realty specialists
- Administrative professionals

Small Team - Huge Impact



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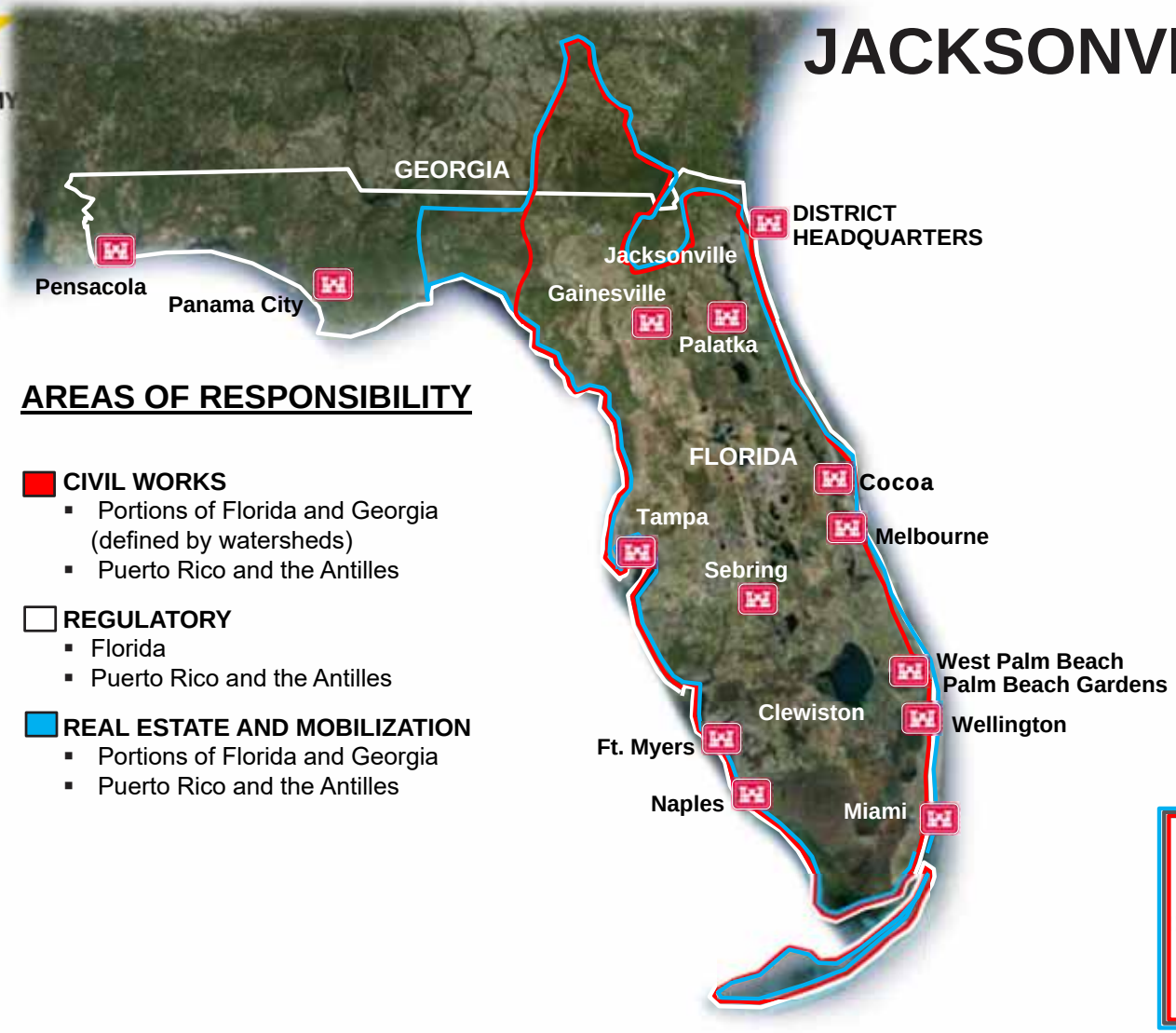
JACKSONVILLE DISTRICT



AREAS OF RESPONSIBILITY

CIVIL WORKS
- Portions of Florida and Georgia (defined by watersheds)
- Puerto Rico and the Antilles

REGULATORY
- Florida
- Puerto Rico and the Antilles

REAL ESTATE AND MOBILIZATION
- Portions of Florida and Georgia
- Puerto Rico and the Antilles

Our Vision

- A team of professionals making tomorrow better.

Our Mission

- Deliver value to the Nation by anticipating needs and collaboratively engineering solutions that support national security, energize our economy and increase resiliency.

Our Area of Responsibility

- Florida
- Georgia
- Puerto Rico
- U.S. Virgin Islands

JACKSONVILLE DISTRICT MISSION AREAS

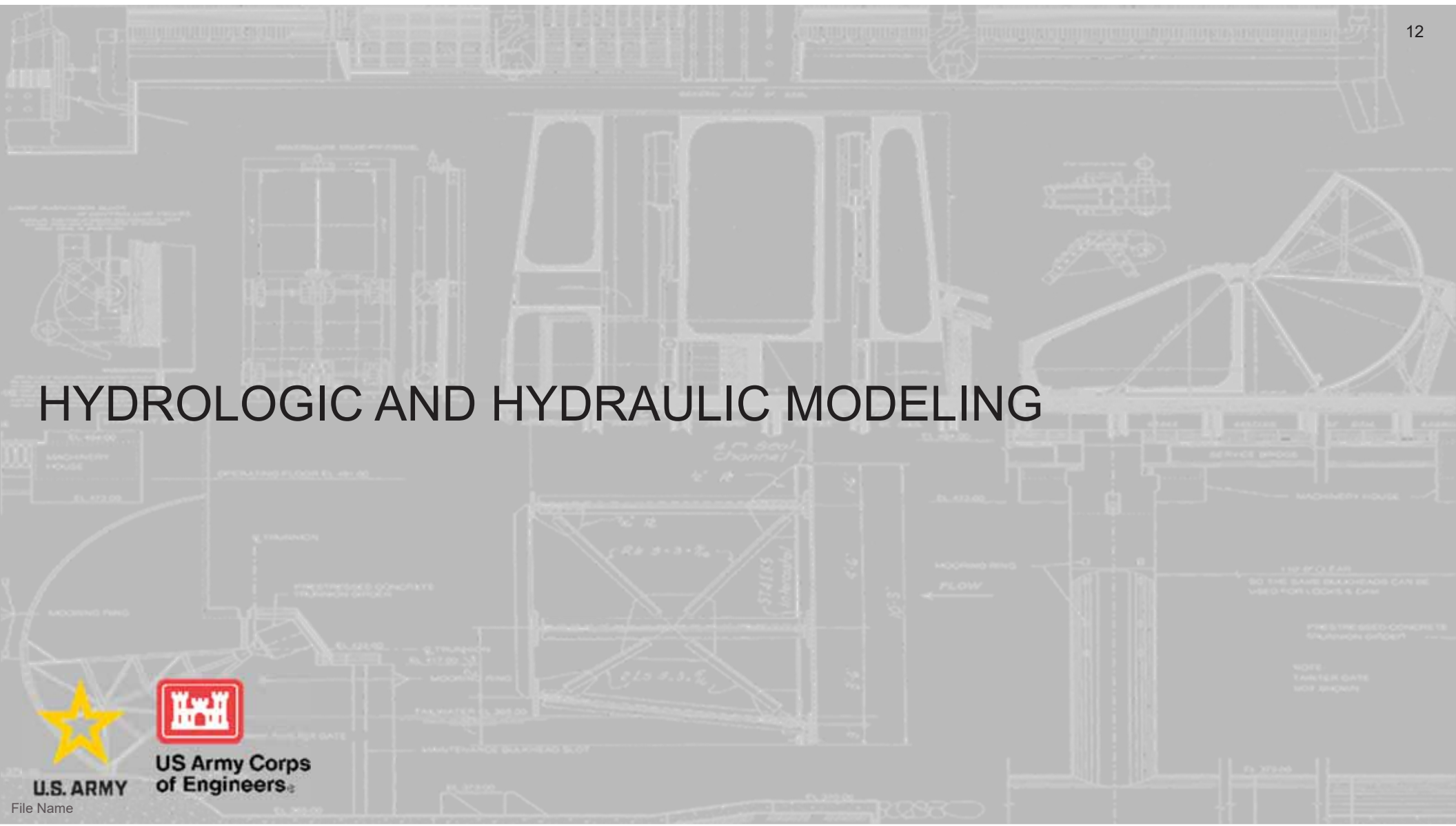
- Navigation
- Flood/Coastal Storm Risk Management
- Ecosystem Restoration
- Operations/Recreation
- Real Estate
- Military/Interagency & International Services
- Regulatory
- Contingency Operations

Working Today to Build a Better Tomorrow

CUSTOMERS, STAKEHOLDERS, AND PARTNER AGENCIES

- South Florida Water Management District (SFWMD), St. Johns River Water Management District (SJRWMD)
- Port Authorities (Tampa, Jacksonville, Canaveral, Everglades, Miami, San Juan)
- Coastal communities (Counties, Cities and Municipalities)
- Florida Department of Environmental Projection (FDEP)
- Florida Inland Navigation District (FIND)
- Fort Buchanan (PR)
- Military Commands: Fort Buchanan (Puerto Rico) and Command Navy Region SE
- Puerto Rico Department of Natural Environmental Resources (DNER)
- Puerto Rico Department of Transportation and Public Works
- Department of Interior (including USFWS, US Forest Service and Everglades and Biscayne National Parks)

HYDROLOGIC AND HYDRAULIC MODELING



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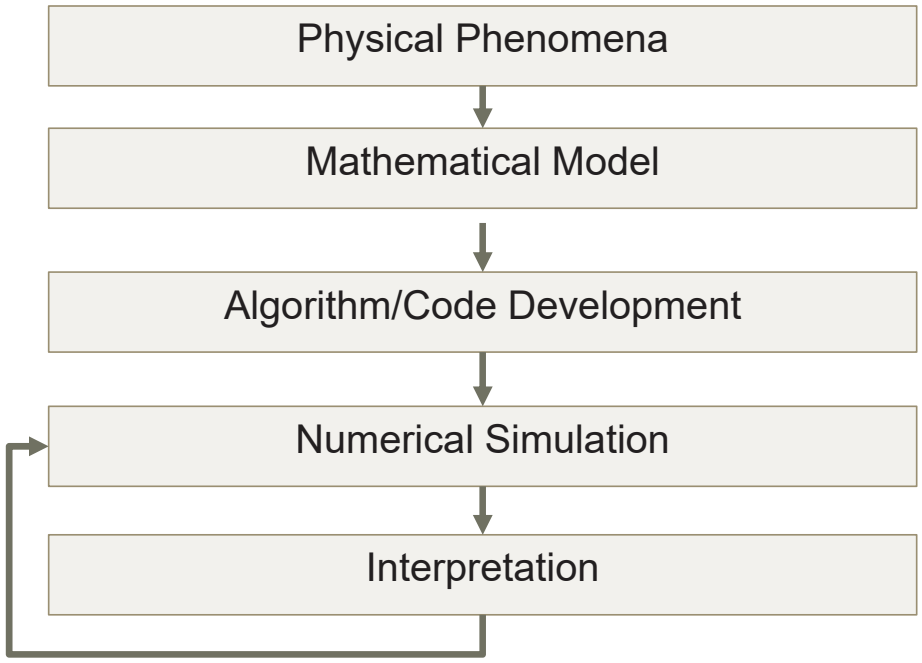
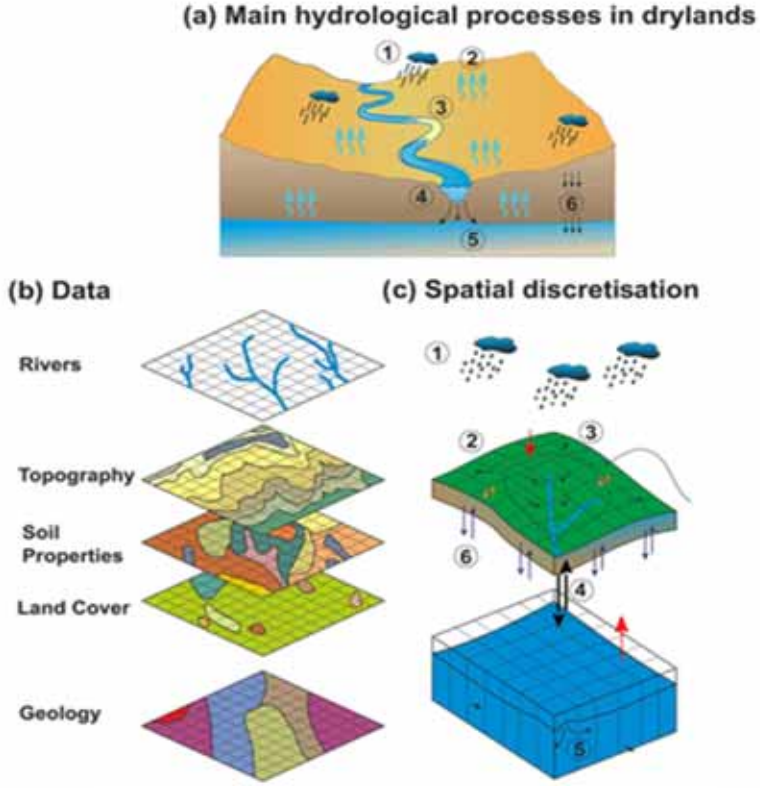
WHY NUMERICAL MODELING

Numerical models are needed to understand complex systems and impacts of potential modifications and optimize engineering design.

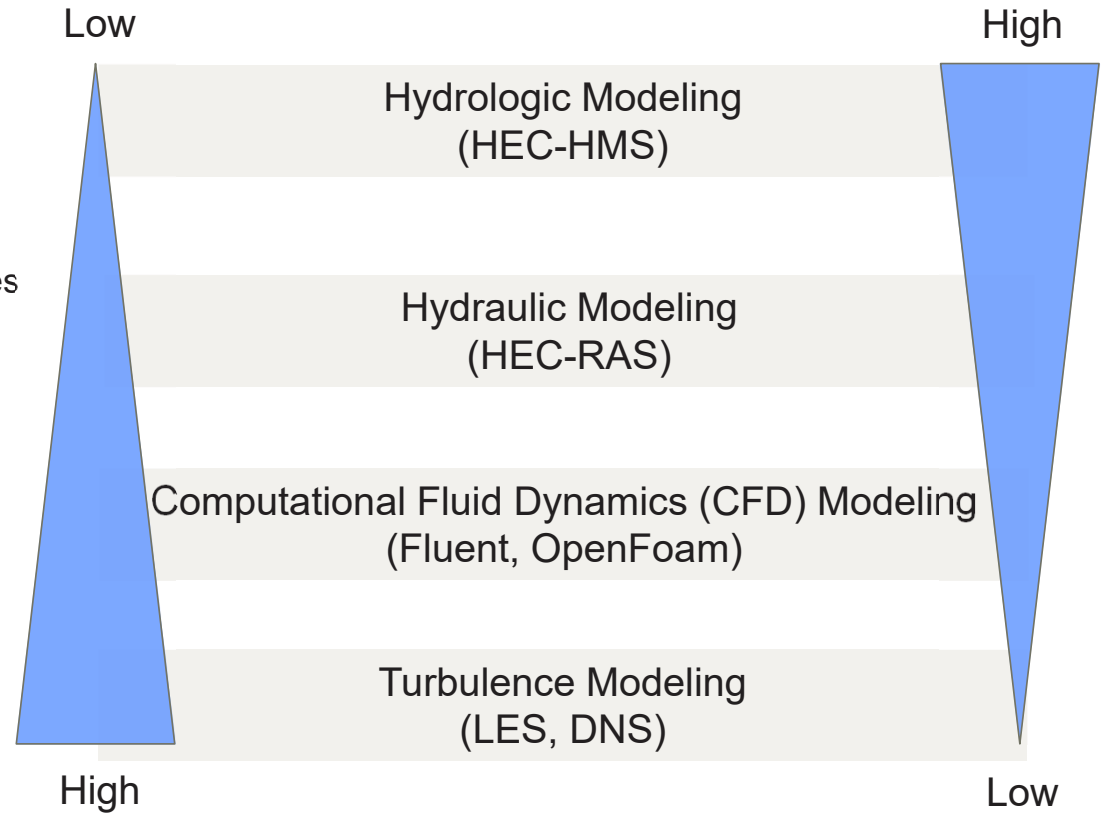




https://gmd.copernicus.org/articles/14/6893/2021/

LEVELS OF H&H NUMERICAL SIMULATION

- Spatial and Temporal Resolution
- Fidelity to Navier-Stokes Equations
- Computational Cost (Run time)
- Distributed parameters

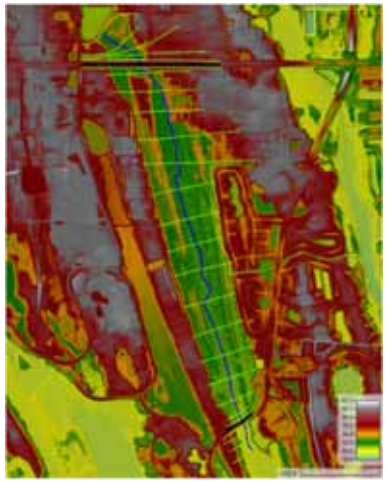


- Spatial and Temporal Coverage
- Approximations in mathematical representations
- Variety of simulated physical processes
- Lumped parameters

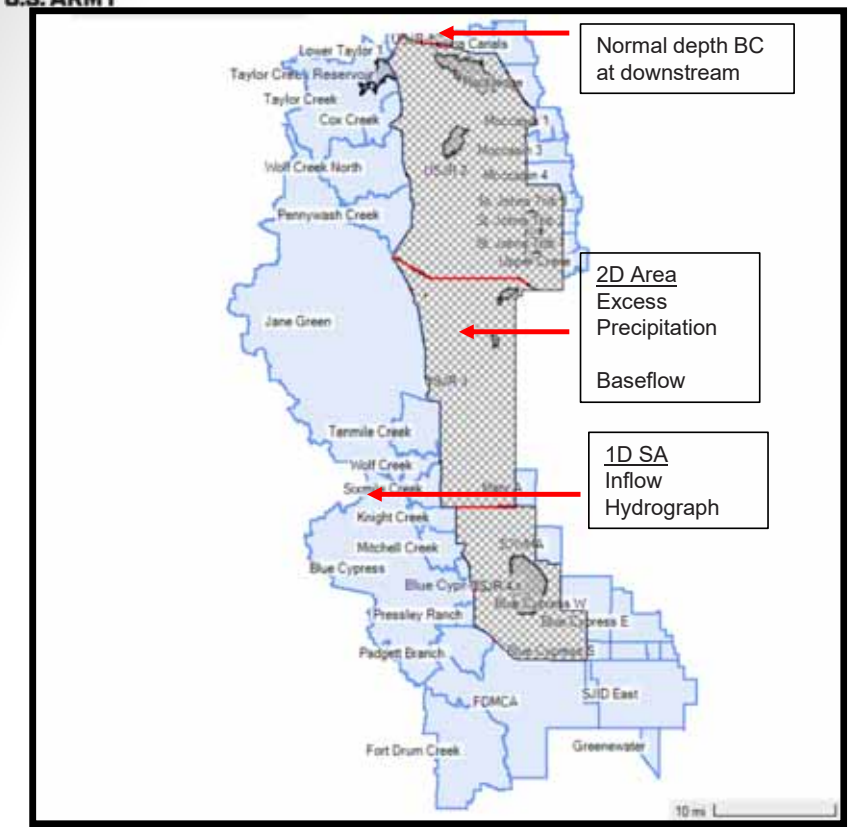
HEC-RAS VS HEC-HMS

- HEC-HMS is a **hydrologic modeling** program that allows to establish rainfall-runoff relationships, based on watershed characteristics.

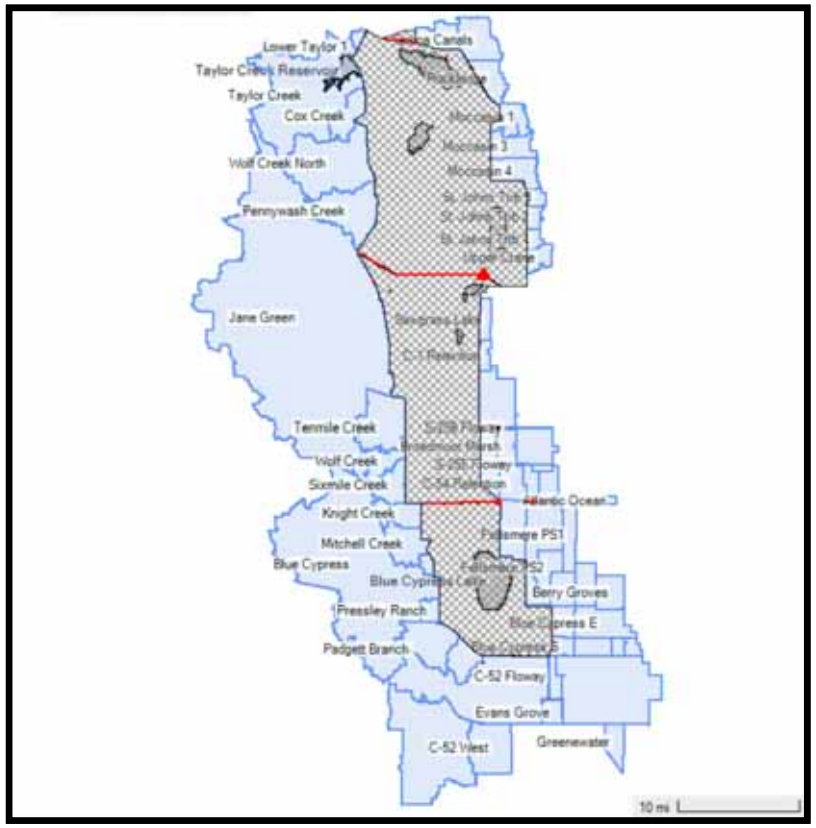
- HEC-RAS is used to make **hydraulic models** that include open channel flow systems including man-made water infrastructure (water control structures, dams, canals).



RAS Model Geometry and Boundary Conditions (BC)

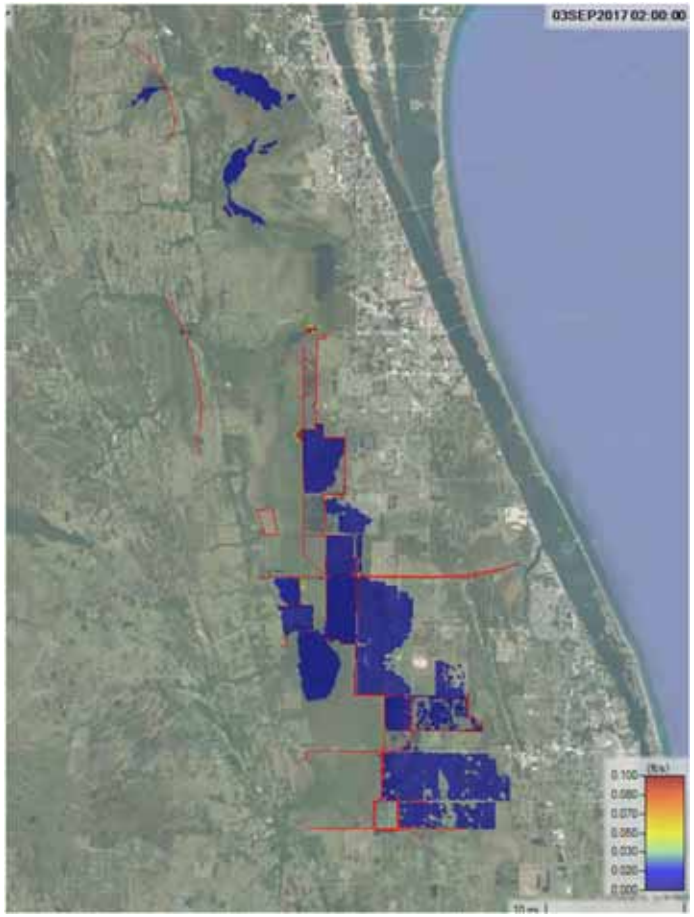


Pre Project (1968) Geometry



Post Project Geometry

Animation of Irma Simulation
REPLACED BY A STILL IMAGE



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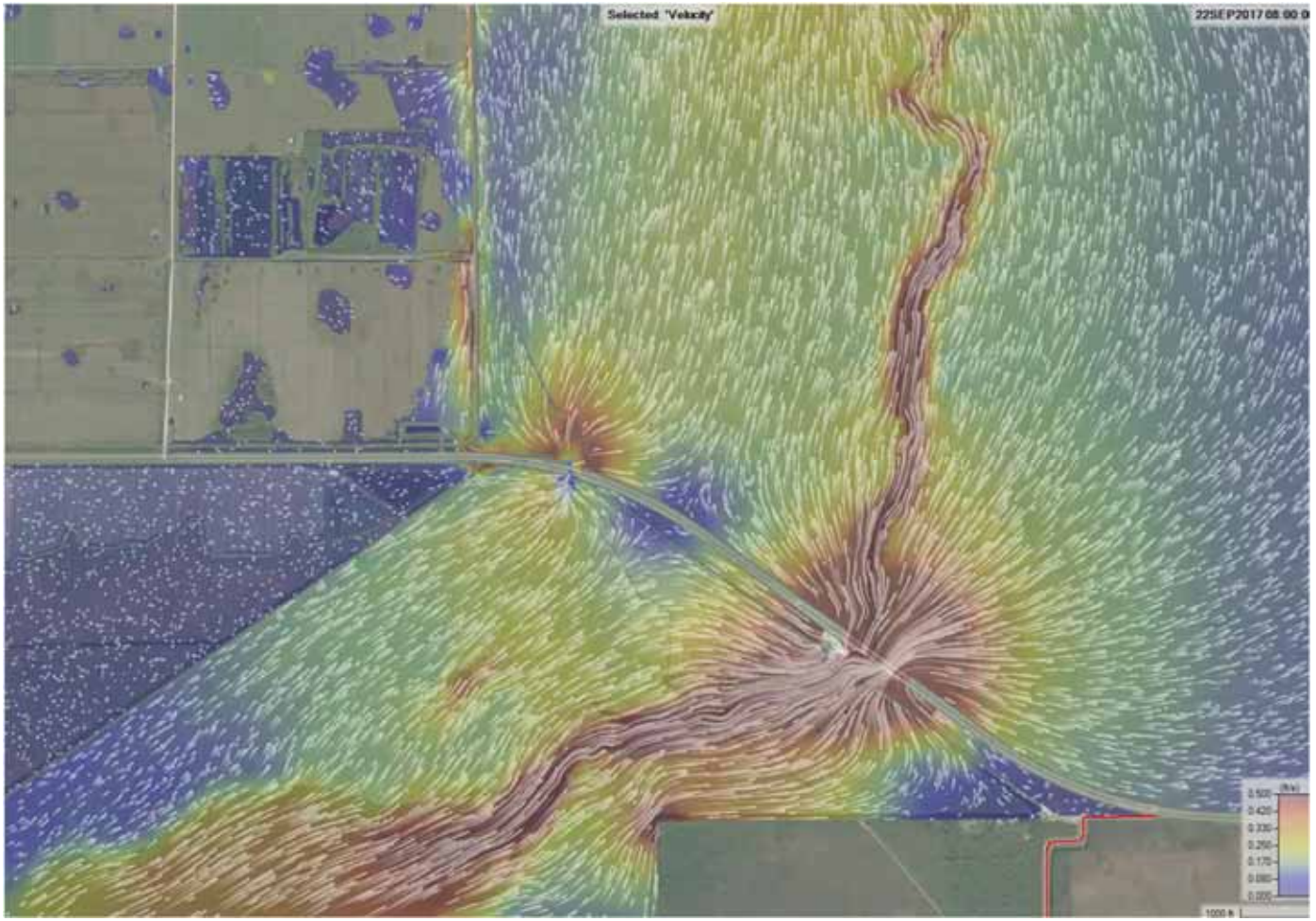
Animation of Flow at SR 192 Irma Simulation
REPLACED BY A STILL IMAGE



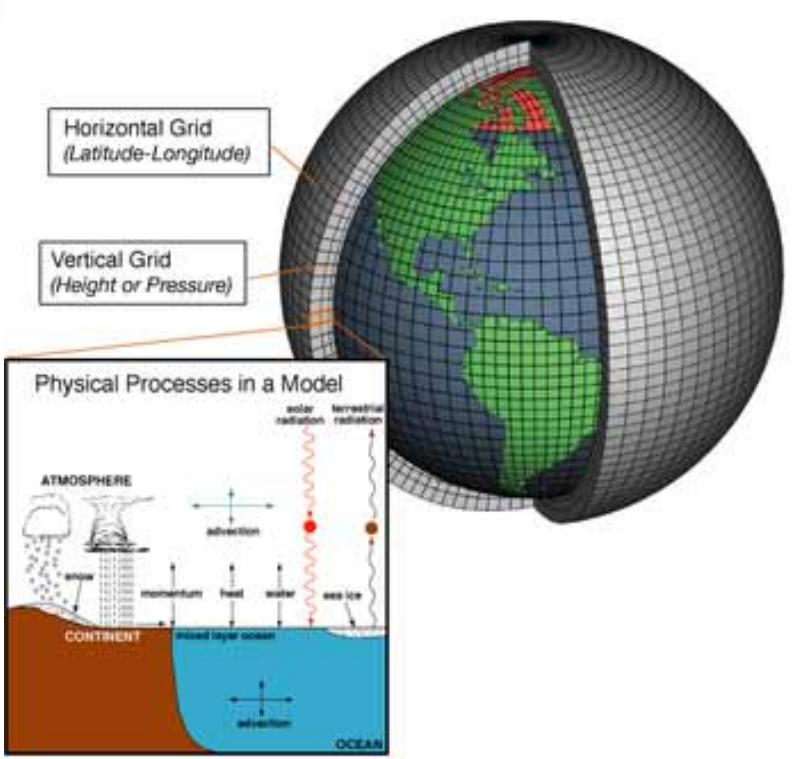
NUMERICAL MODELS USED BY SAJ

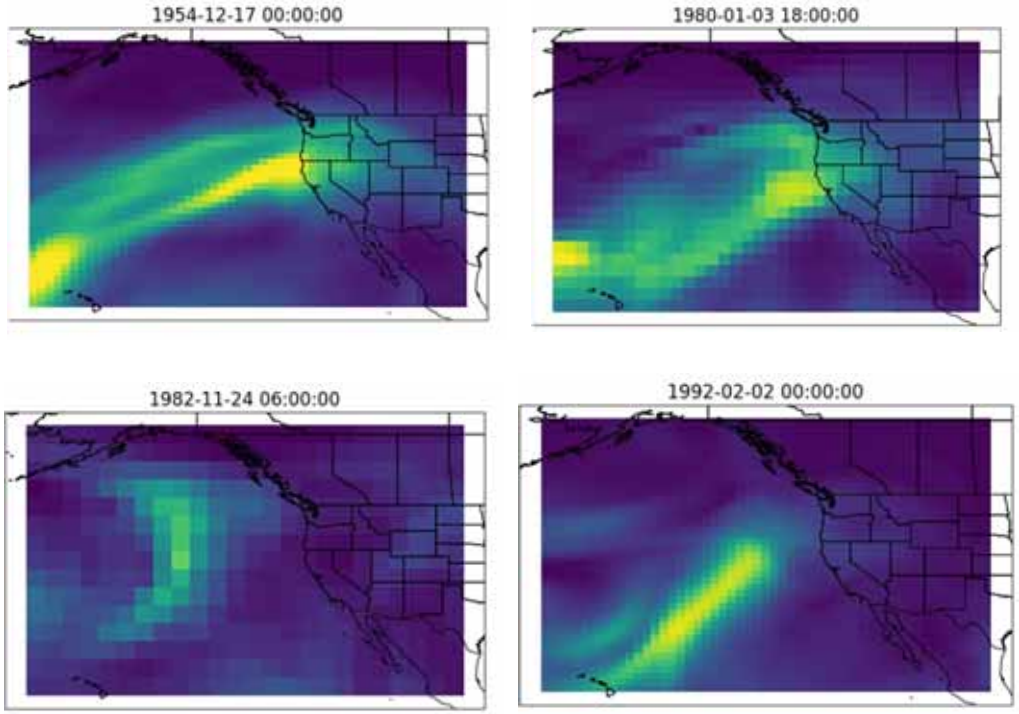
Surface Water
HEC-HMS
HEC-RAS
MIKEFLOOD
ADH
ICPR
SWMM
Groundwater
MODFLOW
WASH3D
Regional
RSM

Integrated
MIKESHE
GSSHA
Hydrodynamic
AdH
RMA-2
EFDC
CFD
OpenFoam
Fluent
Global Climate Models

Coastal
CGWAVE
STWAVE
ADCIRC
CMS-Flow
CMS-Wave
Economic Analysis
GIS (ArcMAP)
STATISTICS
SSP

GLOBAL CLIMATE MODELS





Example: Atmospheric rivers in CMIP6 GCMs for western U.S.

APPLICATION OF NUMERICAL MODELS TO SAJ PROJECTS

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PROJECTS

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CERP/Feasibility
BBSEER
WERP
Lox
LOWRP
CERP update
Dam/Levee Safety
BAMM
Risk Cadre
Levee Screenings
PED
EAA
IRL-S
BCWPA

Resiliency
216 study
WERP
LOWRP
Reviews
Section 408
Regulatory
SPP (many)
Real-time forecasting
CWMS
CSRM
City of St. Augustine
San Juan Metro
Lake Okeechobee Culverts
Big Sarasota Pass

Operational
LOSOM
KRR
CEPP
C43/C44
FRM
USRB
Supplemental
Rio Culebrinas
Arecibo
Guajataca
Navigation
Tampa Harbor
Miami Harbor

FLOOD RESILIENCY STUDY

GRAPHIC EXECUTIVE SUMMARY – PAGE 1

THE CENTRAL AND SOUTHERN FLORIDA PROJECT
BACKGROUND ON THE ORIGINALLY AUTHORIZED PROJECT

BACKGROUND

The Central & Southern Florida (C&SF) Project extends in the area shown and even into the upper St. Johns. The Comprehensive Everglades Restoration Plan (CERP) is encompassed within the C&SF project. C&SF history includes:

- Authorized in 1948, after the 1947 flood
- Flood Control Act of 1954 established that Chief of Engineers had discretionary authority to modify the plan
- One of the world's largest and most complex water management systems
- Jointly operated by USACE and South Florida Water Management District
- Spans 18 counties
- Covers 18,000 square miles
- C&SF serves multi-purposes and provides
  - Flood protection
  - Water supply/control (agriculture, municipal & industrial, Everglades National Park)
  - Navigation
  - Prevention of salinity intrusion
  - Protection of fish and wildlife
- CERP was authorized under WRDA 2000.
  - To restore, preserve and protect ecosystem while maintaining C&SF project purposes

STUDY PURPOSE & EXISTING CONDITIONS

A large extent of Florida is facing extraordinary changes which are challenging the original project purposes of the authorized C&SF project. The main drivers of change can be largely grouped into categories of population growth, increased development of land, temperature increase, and sea level change trends. There are already increasing problems in terms of flood vulnerabilities, water supply, and coastal flooding. In the next 50 to 200 years, the effects of the existing problems will become more extreme. This report shows that the risk of no-action is too large to ignore, and that there is an opportunity to address these problems now with phased approaches through the use of two different holistic studies.

RECOMMENDATIONS

This Section 216 Initial Appraisal Report determines there is Federal interest in further investigation of improvements to the C&SF Project due to significant changed conditions since the time the C&SF project was constructed. A C&SF Project Update Feasibility Study is recommended under the authority of Section 216 of the Flood Control Act of 1970, as amended.

This Section 216 Initial Appraisal Report also determines there is a Federal interest in working with the State of Florida through its Department of Environmental Protection and in cooperation with its five Water Management Districts on five coordinated watershed planning studies. The purpose would be to develop a multi-generational long-term Adaptive Risk Management (ARM) Strategy as a framework for interagency coordination and planning for cost effective adaptation actions to address future sea level changes of more than 2-3 feet above 1992 datum levels.

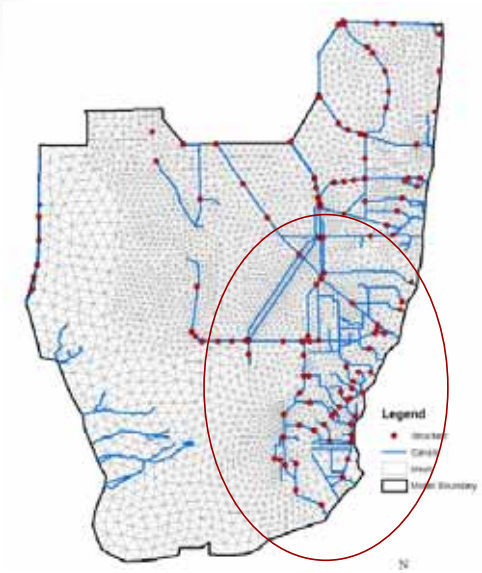
C&SF PROJECT PURPOSES INCLUDING CERP

CENTRAL AND SOUTHERN FLORIDA, SECTION 216 INITIAL APPRAISAL

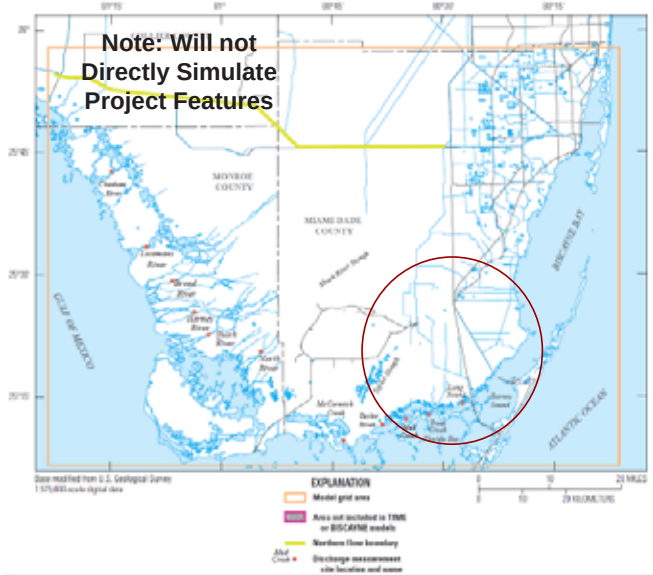
U.S. Army Corps of Engineers, Jacksonville District

BBSEER MODELS, ROLES & RESPONSIBILITIES

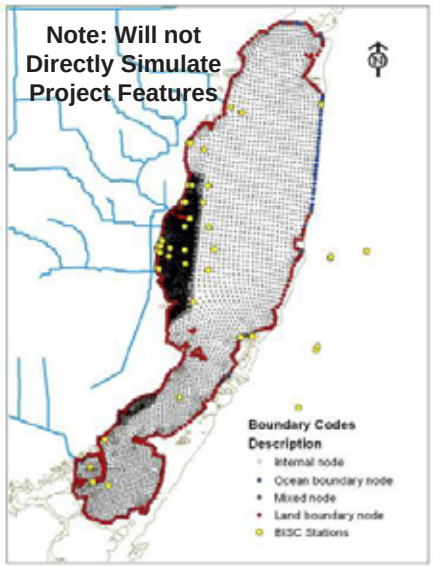
RSMGL
Hydrology
Run by IMC
(Primary Formulation Tool)



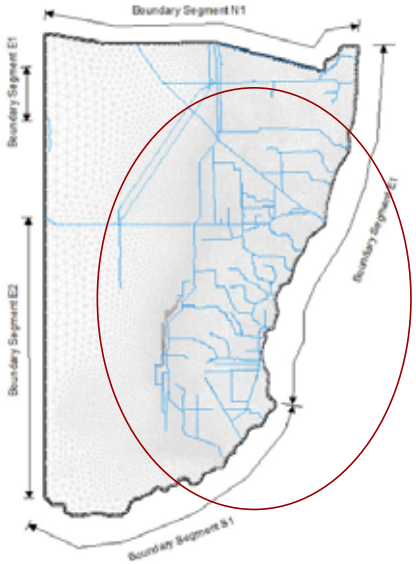
BISECT
Marsh Salinity
Run by FIU



BBSM
Nearshore Salinity
Run by IMC



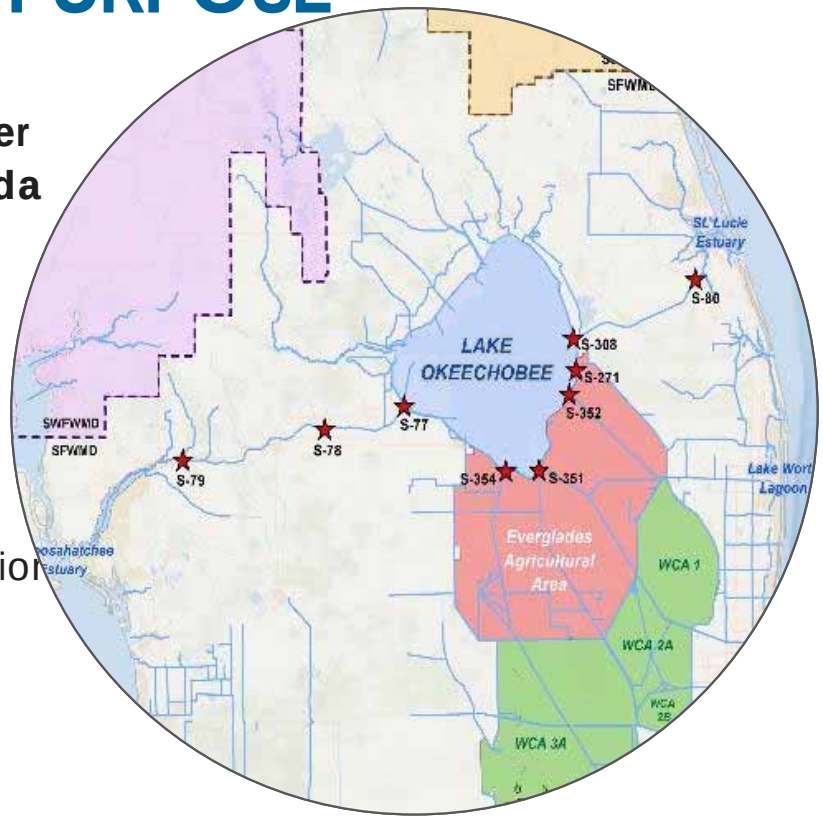
MDRSM
Flood Hydrology
Run by IMC



LAKE OKEECHOBEE SYSTEM OPERATING MANUAL (LOSOM) PURPOSE

Develop a new operational strategy for Lake Okeechobee including a regulation schedule and operating criteria for water control structures while considering Central and Southern Florida (C&SF) infrastructure that is completed or will soon be operational.

- Herbert Hoover Dike rehabilitation
- C-43 West Storage Reservoir south of the Caloosahatchee River
- Indian River Lagoon – South C-44 Reservoir
- Additional projects that also factor into Everglades Restoration (such as the Kissimmee River Restoration Project)



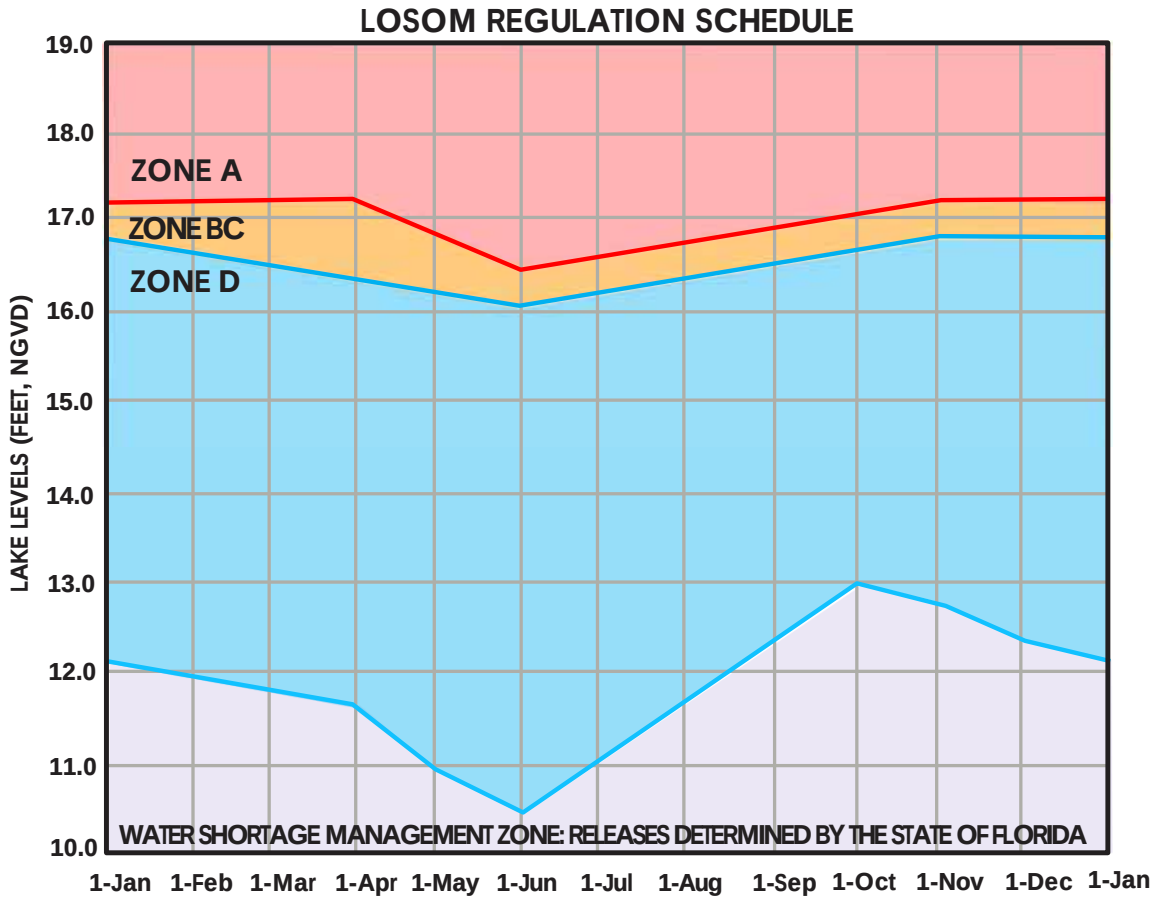
WATER CONTROL PLAN AND LOSOM REGULATION SCHEDULE

OVERALL PLAN FOR WATER MANAGEMENT

Intent: Balance of LOSOM aims to achieve synergy with project purposes and maximize system-wide benefits with available water with flexible water management operations.

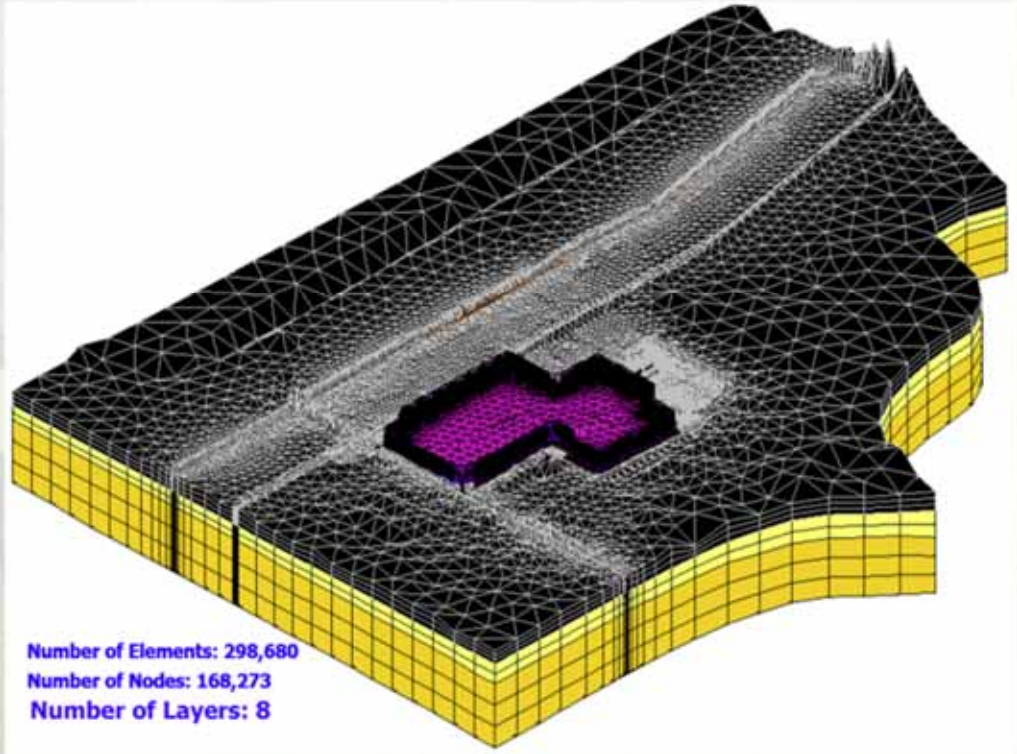
Utilize all available information to make informed decisions.

- Current climate conditions
- Climate and weather forecasts
- Hydrologic and tropical outlooks
- Water-supply conditions
- Estuary conditions
- Lake Okeechobee stage and ecological conditions
- Navigation and recreation conditions
- Seminole Tribe of Florida (STOF) water supply conditions
- Algal Bloom conditions
- Stormwater Treatment Area (STA) conditions
- Water Conservation Area (WCA) conditions
- Everglades National Park (ENP) conditions
- Minimum Flows and Levels (MFLs)



GROUNDWATER

C-11 WASH3D Impoundment Model



IRL-S, C-23/24
South Reservoir
Purpose: to reduce freshwater discharges to St. Lucie Estuary

RSMBN (Regional Simulation Model BasiNs)

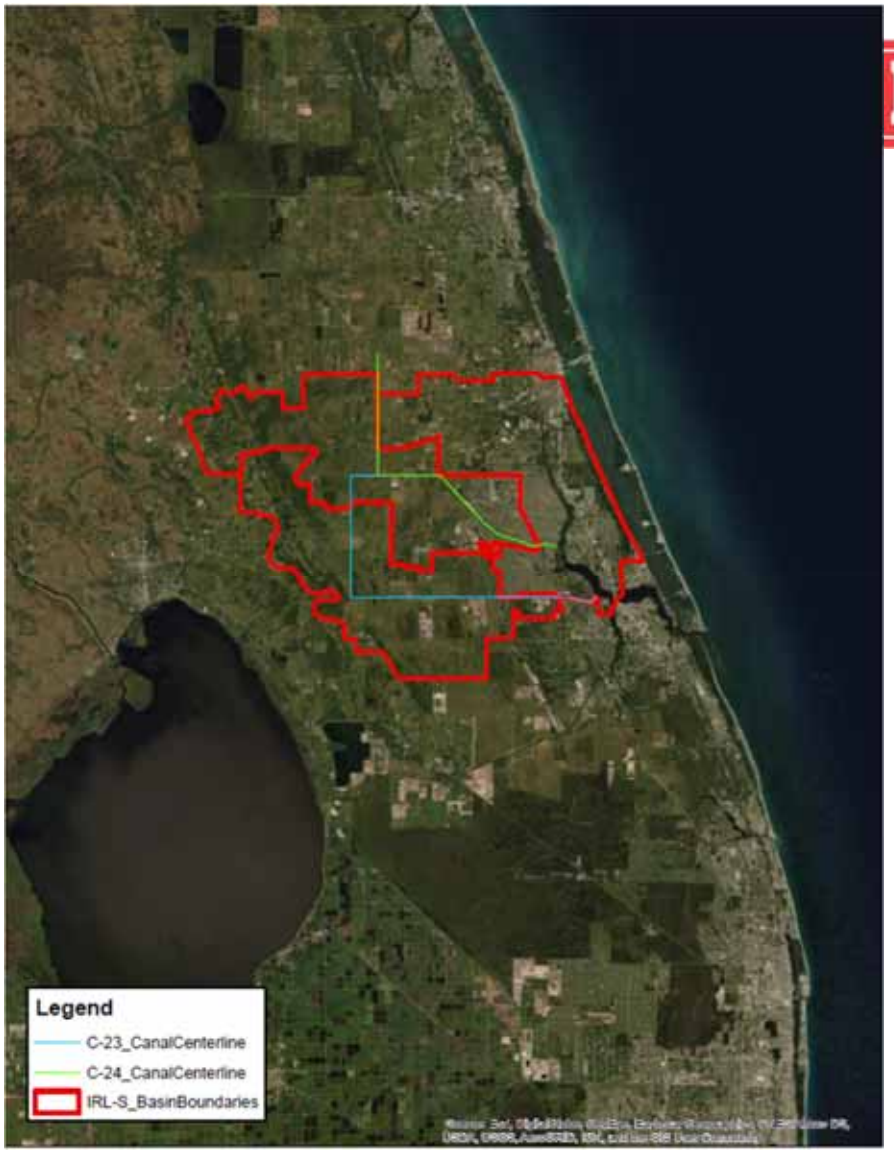
- Analyze the performance of proposed C-23/24 reservoir configurations, and compare to the PIR design to determine how well each scenario performs to achieve benefits

HEC-HMS (Hydrologic Engineering Center Hydrology Modeling System)

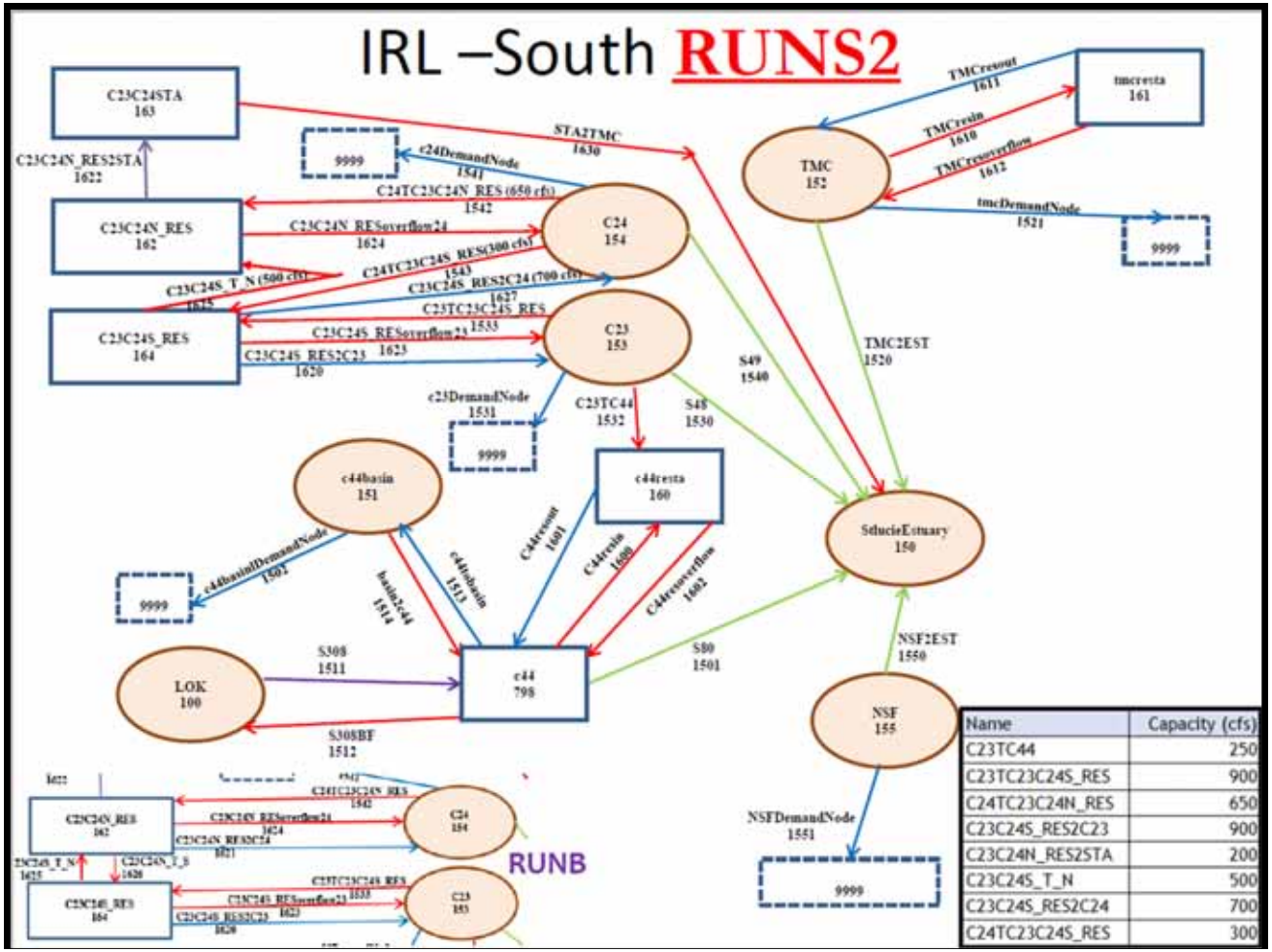
- Estimate runoff volumes and flow hydrographs

HEC-RAS (River Analysis System)

- Estimate flows, velocities, and stages in channels for pump drawdown analysis, and over land for dam breach scenarios

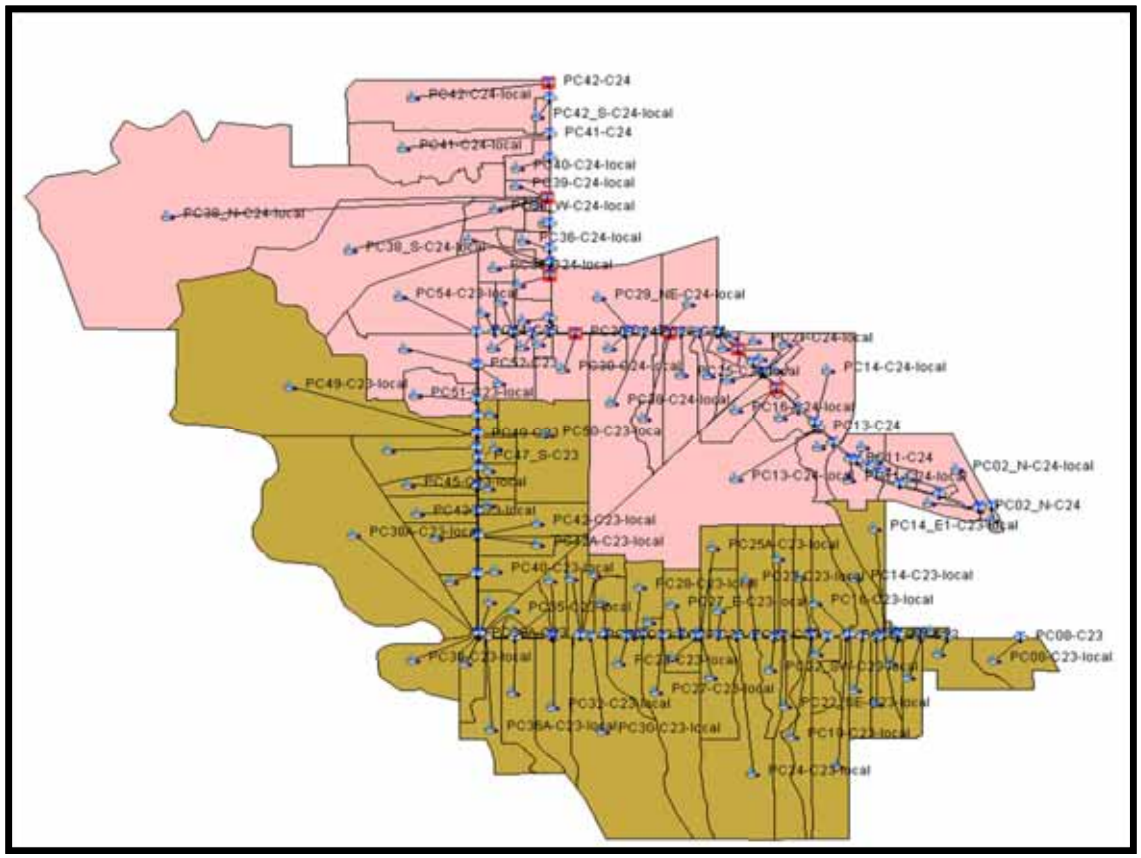


RSMBN
Water Budget



HEC-HMS

Inflow Points Map



City of St. Augustine Back Bay Coastal Storm Risk Management (CSRM) Feasibility Study

- Use HEC-RAS to model rainfall, riverine, and coastal flooding as independent conditions on relative flooding impacts to St. Augustine neighborhoods.

Modeling Framework

Rainfall-Riverine

RR1: MHHW

- NOAA MHHW = 2.0 ft-NAVD88 at Station 8720587 St. Augustine Beach, FL
- NOAA Atlas 14-1% AEP 24-Hr Duration Hyetograph

RR2: 100% AEF CI

- CHS 100% or "1-Year" BE AEF SWL = 5.3 ft-NAVD88 at St. Augustine Inlet (Save Point 19209)
- NOAA Atlas 14-1% AEP 24-Hr Duration Hyetograph

Coastal Inputs

CI:1% AEF

- CHS 1% or "100-Year" AEF SWL Hydrographs
  - St. Augustine Inlet (Save Point: 19179)
  - Tolomato River (Save Point: 19029)
  - Matanzas River (Save Point: 19365)

ACRONYMS

AEP: Annual Exceedance Probability
AEF: Annual Exceedance Frequency
MHHW: Mean Higher High Water
CI: Coastal Inputs
RR: Rainfall-Riverine
SWL: Still Water Level
BE: Best Estimate
CHS: Coastal Hazards Systems
NOAA: National Oceanic and Atmospheric Administration

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Lake Okeechobee
S-271 Culvert

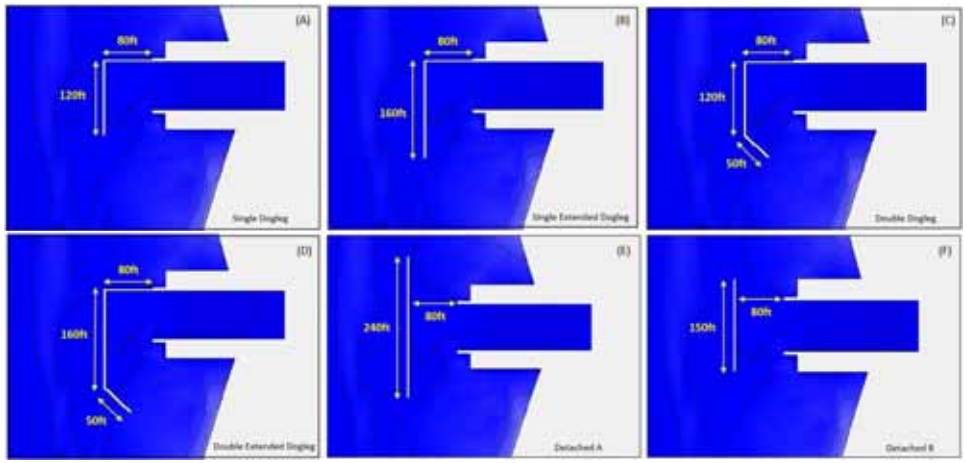
Evaluation of the effectiveness of wave attenuation structures at reducing wave heights (wave energy) at the eastern flap gates

Numerical Models:

STWAVE (STeady-state spectral WAVE)
- wave transformation model for estimating wave conditions due to wind speed and direction

CGWAVE (Coastal Gravity WAVE)
- wave response model for assessing wave reflection and wave amplification within the culvert

Proposed Wave Attenuation Structures



S-271
Location

S-271

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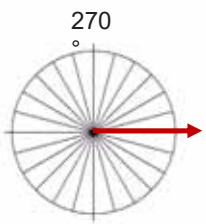
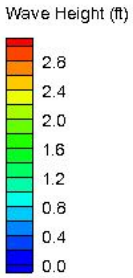
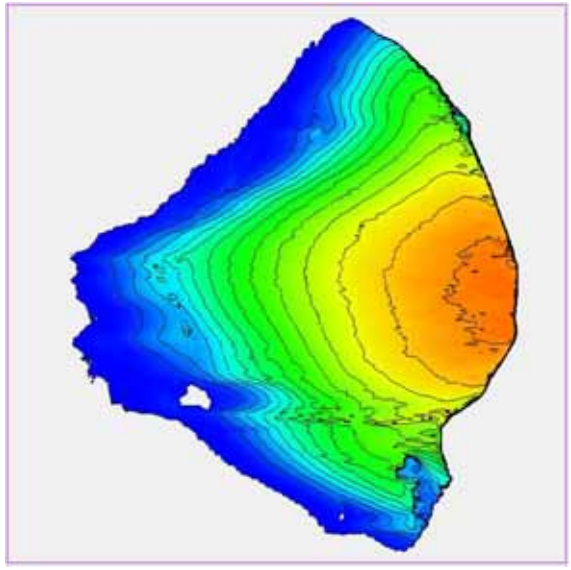
STWAVE – Wave Transformation

Example:
25mph Wind Speed
270° Wind Direction

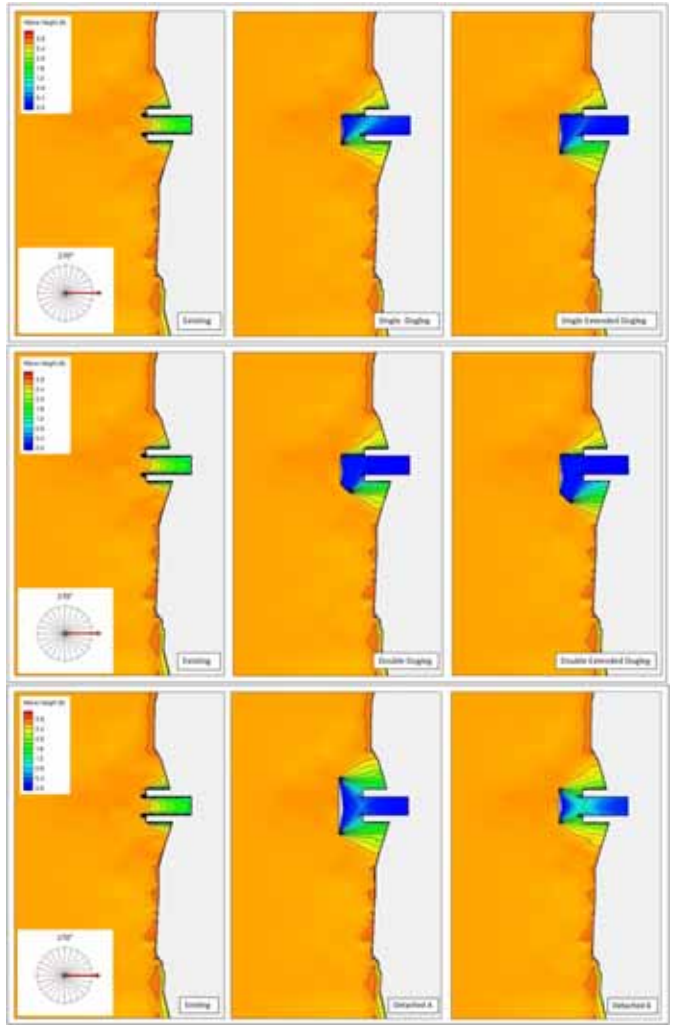




Wave Heights - Coarse Resolution Grid



Wave Heights - Fine Resolution Grids



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San Juan Metro (SJM) CSRM Study

Modeling results (developed by ERDC & SAJ) were used to develop tropical storm hydrographs for the study (Reaches 1 and 3).

Numerical Models:

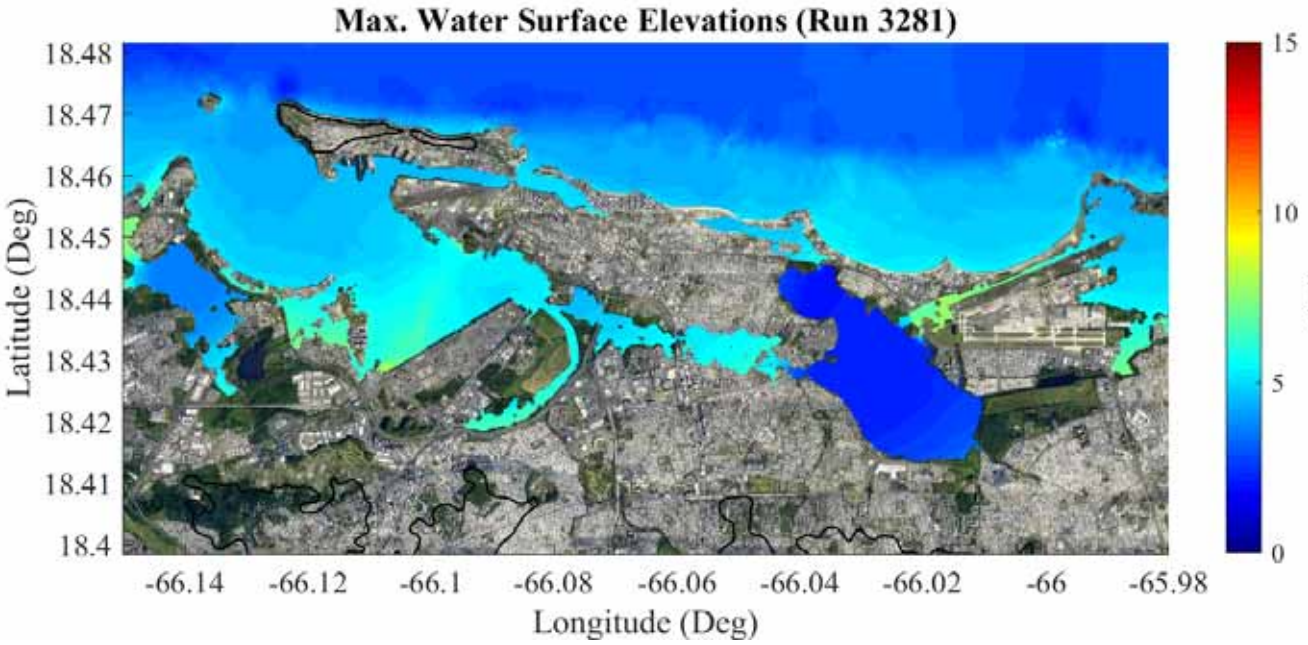
- ADCIRC (Advanced Circulation Model)
  - conducts short- and long-term simulations of tide and storm surge elevations and velocities in deep-ocean, continental shelves, coastal seas, and small-scale estuarine systems
- STWAVE (Steady State Spectral Wave)
  - allows coastal project engineers to numerically model wave generation and transformation over complex bathymetry, interaction of waves with currents and structures, and propagation of waves in entrances and harbors

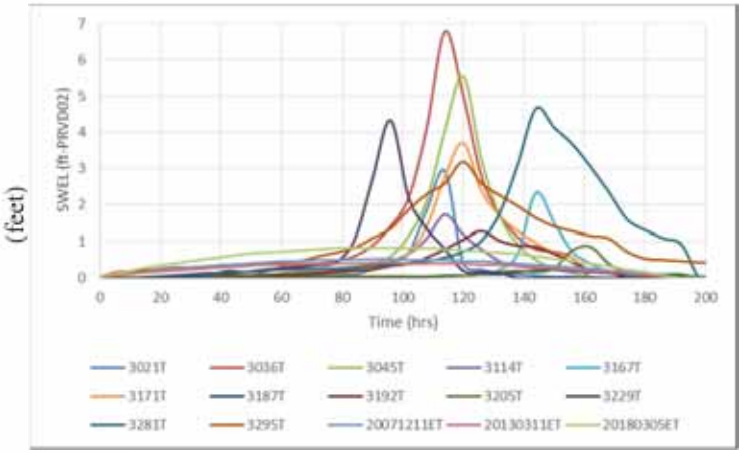
SJM Location

Reach 1 & 2 Savepoints

ADCIRC/STWAVE – WSE Results

Example:
Storm 3281 & Resulting





U.S. ARMY

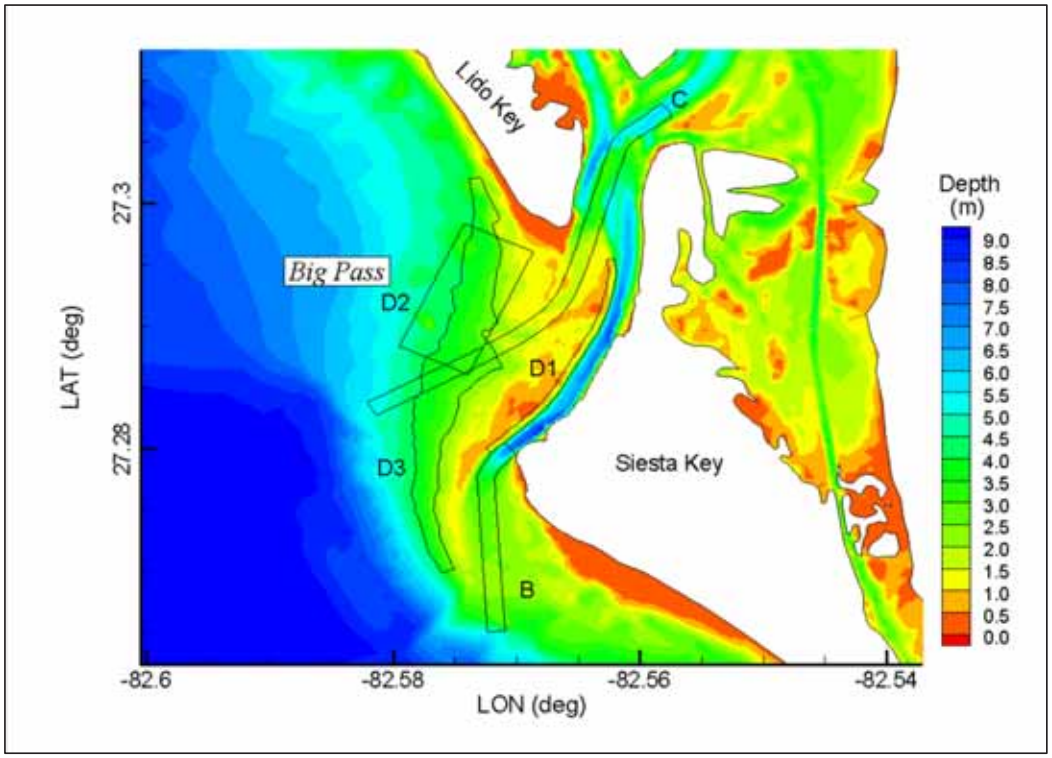
Study of Big Sarasota Pass Sediment Mining Alternatives Lido Key SPP

Project Location

Modeling outputs were used to evaluate whether future excavation of the ebb shoal at Big Sarasota Pass would significantly alter the ebb shoal morphology or local/regional sediment transport patterns in such a way that there would be adverse effects on adjacent beaches.

Numerical Models:

- CMS-Flow (Coastal Modeling System-Flow)
  - a finite-volume, depth-averaged model that can calculate water surface elevation, flow velocity, sediment transport, and morphology change.
- CMS-Wave (Coastal Modeling System-Wave)
  - calculates spectral wave propagation including refraction, diffraction, reflection, shoaling, and breaking, and also provides wave information for the sediment transport formulas.



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CMS Results

Example: No Action

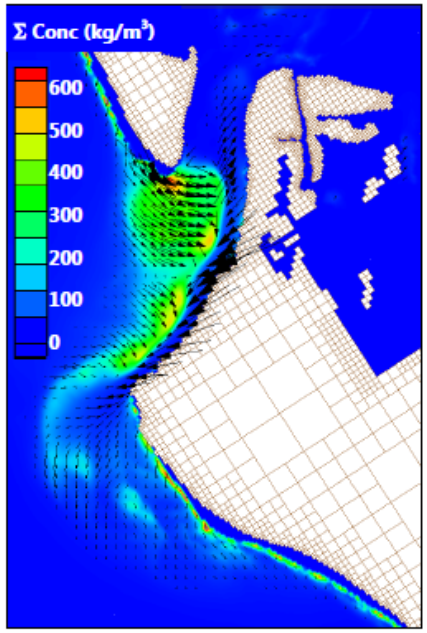

Figure 109: Integrated sediment transport concentration and transport vectors for the no action condition: May 2004 - November 2004 waves

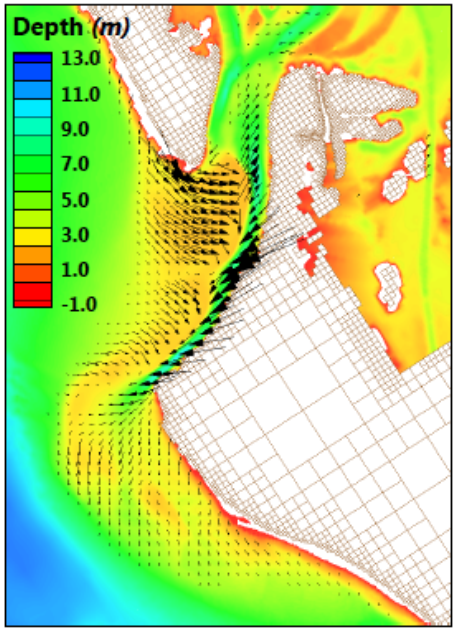

Figure 110: Integrated sediment transport vectors final bathymetry "No Action" Alternative November 2004

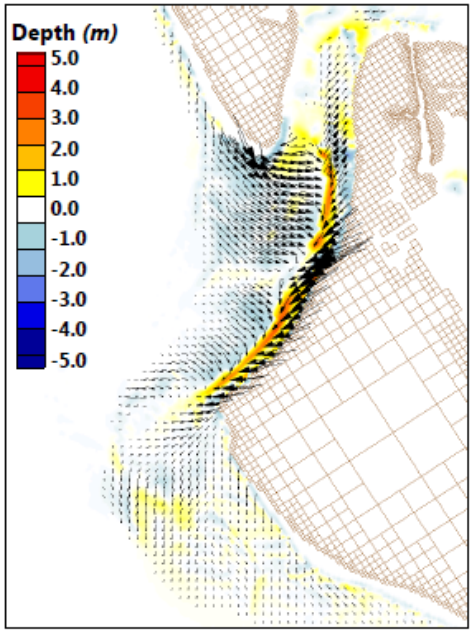

Figure 111: Integrated sediment transport vectors final morphologic change "No Action" Alternative November 2004