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System-wide Approach to Flood Risk Management Using HEC-WAT

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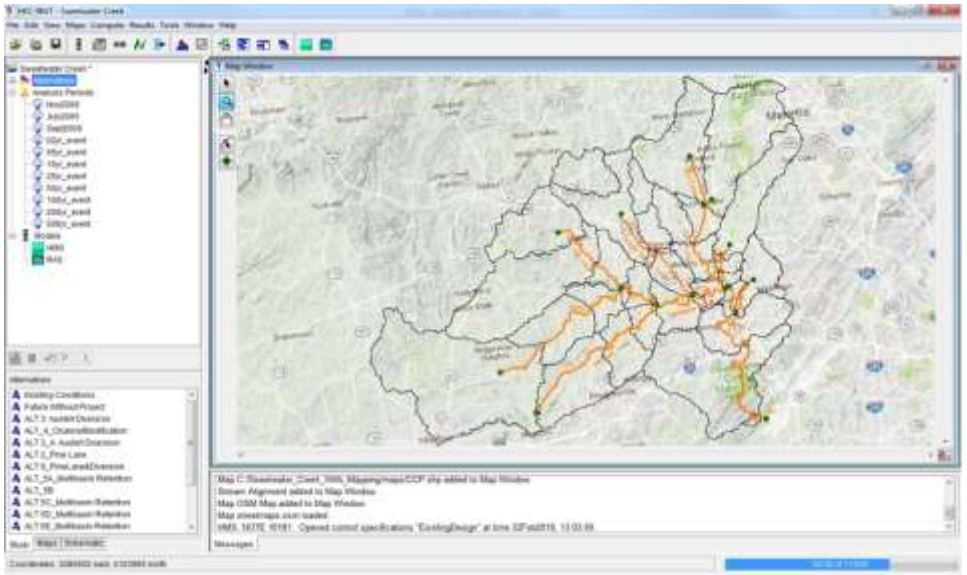
A System Wide Approach to Watershed Management

- What is a system wide approach?
- Why is a system wide approach needed?

Source: USACE

What is HEC-WAT

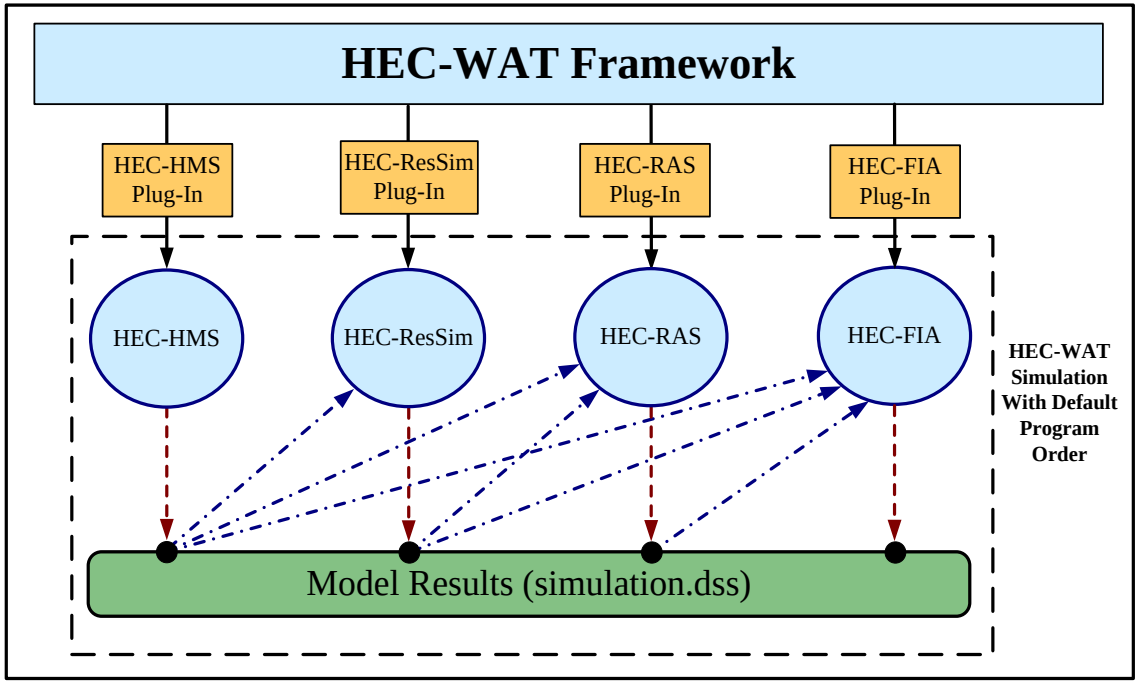
- Model integration tool to support water resources studies
- Allows a comprehensive system-wide approach
- Advanced tools for flood risk assessment
- Can facilitate uncertainty analysis
- Catalog and compare project alternatives
- System performance analysis



HEC-WAT

- Integrates models and provides tools used during the analytical process
  - Hydrology
  - Reservoirs operations
  - Hydraulics
  - Economics
  - Life Safety
- Event or Period of Record simulations

Source: USACE



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Consequence Assessment Using HEC-FIA

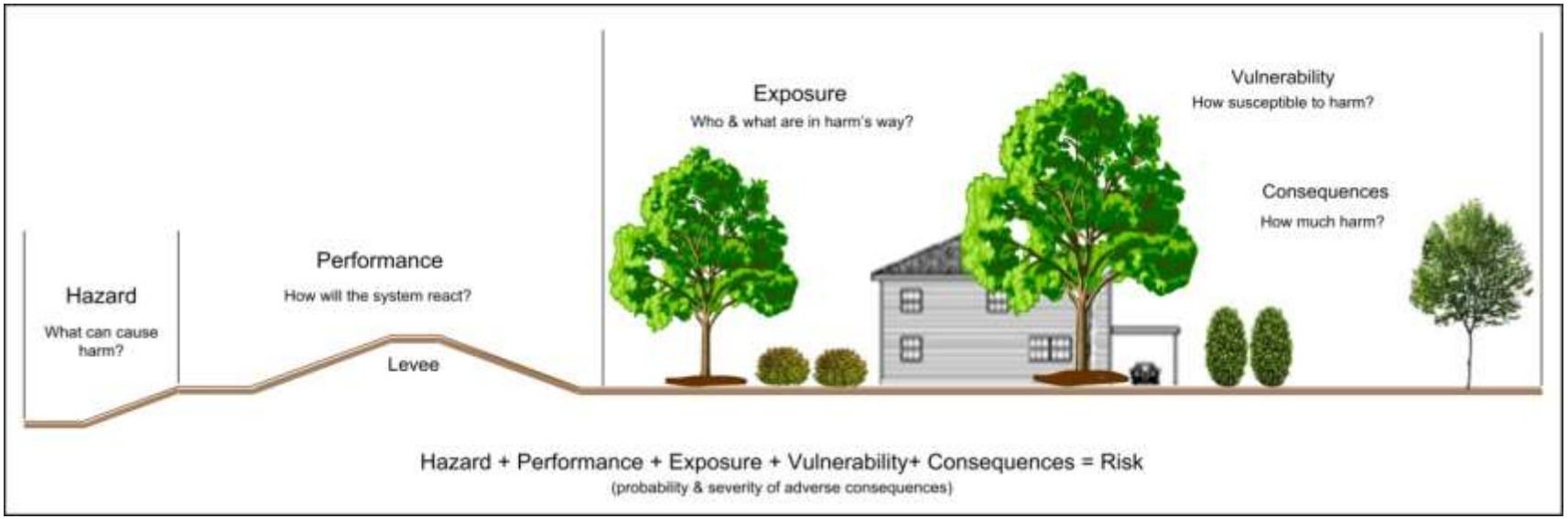
- GIS-based software
- Uses spatial data from a HEC-RAS model (depth grids, hydrograph, cross sections, etc.)
- Structure inventory can be developed using data from HAZUS or user defined inventory
- Program gives a statistical estimate of direct damages and loss of life to individual structures

Life Safety Variables

- Warning System Curves
  - Default lowest curve is the emergency broadcast system
- Mobilization curves
  - Default is a maximum of 98% of population mobilized – Can be changed
- Evacuation velocity
  - Structure to the nearest safe zone ~10 mph
- Warning time relative to the flood inundation

Risk and Project Performance

- Risk = Probability x Consequences (x Performance)
- Uncertainty represents the imprecision of parameters and mathematical functions used



Source: USACE

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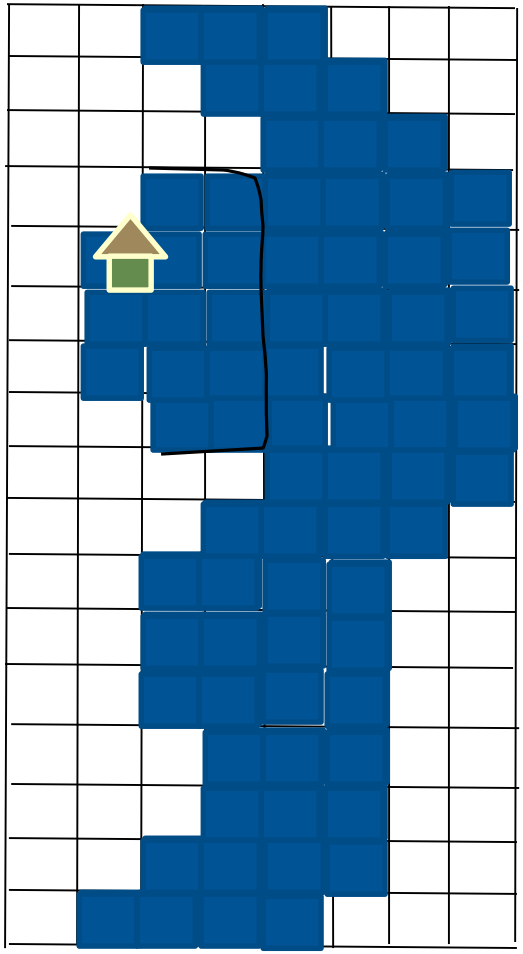
AEP Grid Compute Method

Flood Plain



AEP Database

0	0	2	2	2	0	0	0
0	0	0	2	2	2	0	0
0	0	0	0	2	2	2	0
0	0	0	0	2	2	2	0
0	0	0	0	2	2	2	0
0	0	0	0	2	2	2	0
0	0	0	0	0	2	2	2
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0	0	2	2	0	2	0	0
0	0	2	2	0	2	0	0
0	0	0	2	2	2	0	0
0	0	0	2	2	2	0	0
0	0	2	2	2	0	0	0
0	2	2	2	0	0	0	0

Number of events

Source: USACE

AEP= grid value/number of events

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Economic Performance

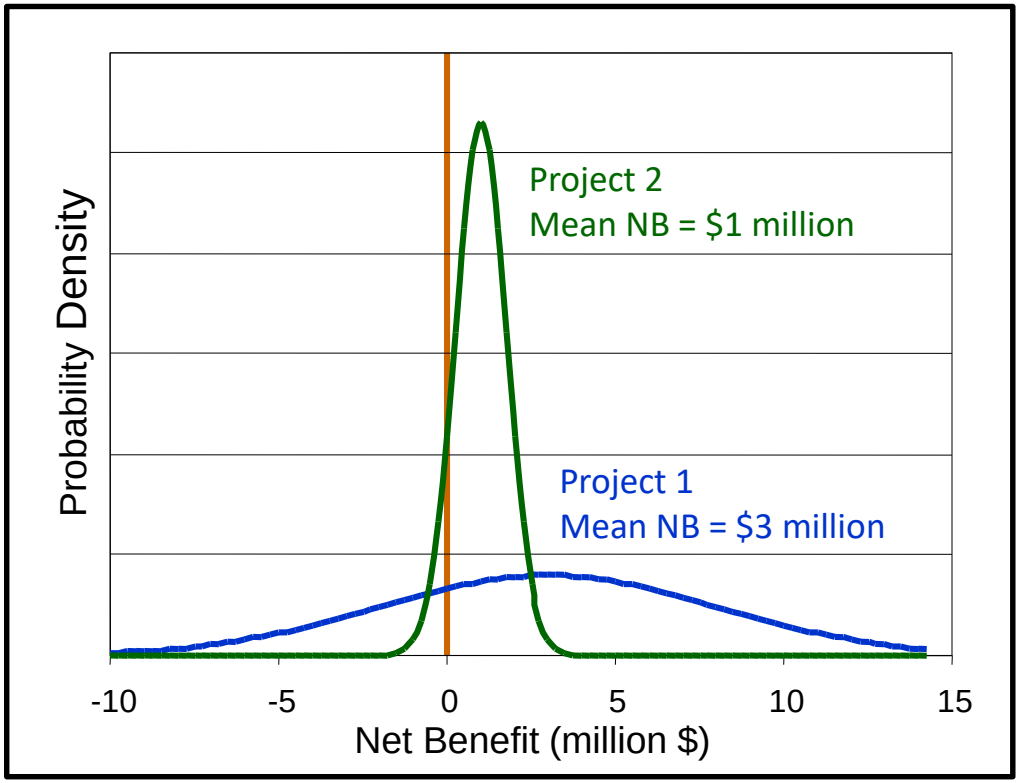
- Distribution of Expected Annual Damage (or Damage Reduced)

Project 1 – Higher reward, higher risk

~70% positive NB

Project 2 – Lower reward, lower risk

~90% positive NB



Source: USACE

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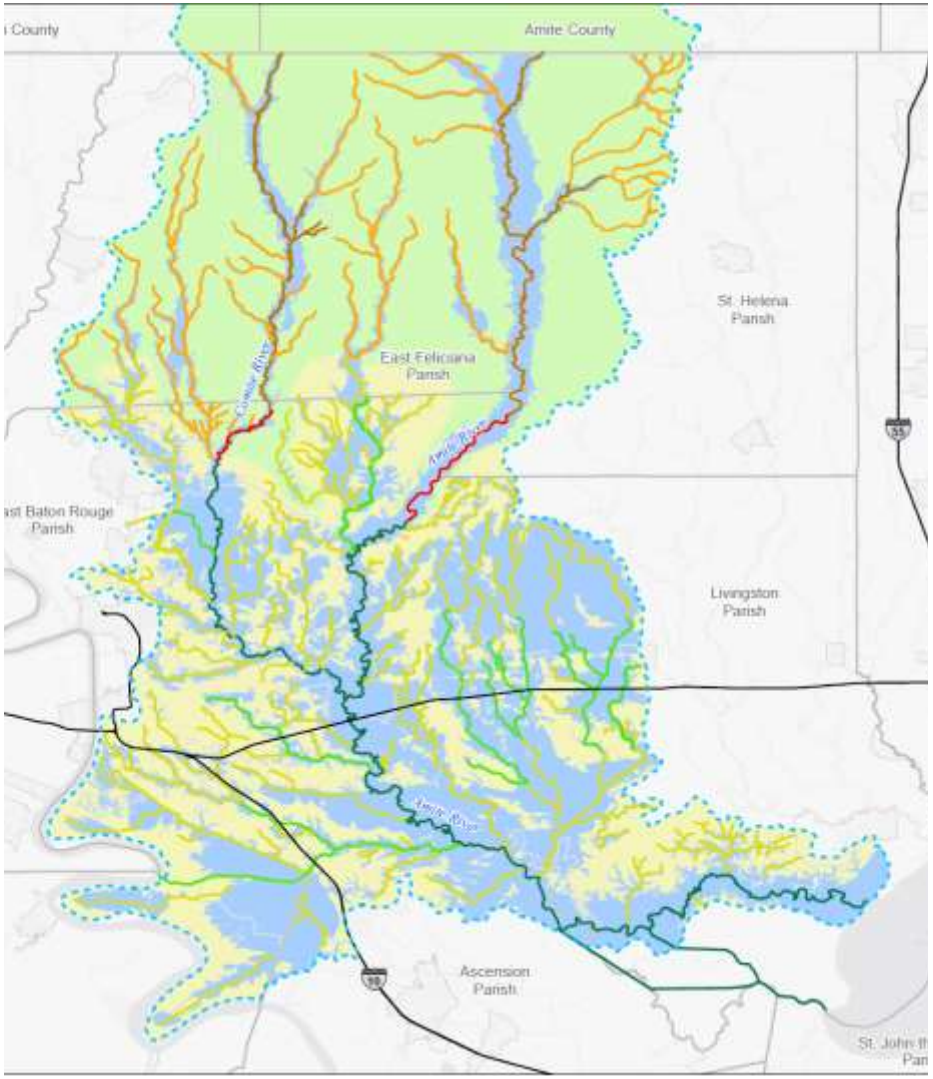
Amite River Watershed, LA

- 1,800 square mile watershed
- 1,200 miles of FEMA mapped floodplains
- Mild slopes
- Significant unconfined flooding sources



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Amite River Project Background

- August 2016 Flood
  - Less than 0.2% Annual Exceedance Probability in Denham Springs (>500 yr)
  - Nearly 5ft higher flood stage than previous flood record
  - Extensive economic losses estimated at $8.7B
  - At least 13 lives lost
  - Increased interest in flood mitigation

Source: Civil Air Patrol

Project Goals

- Provide Stakeholders with the tools to assess flood risks and project impacts on a watershed scale through the development of:
  - Watershed scale floodplain models to assess flood severity; and
  - Integrated economic and life safety models to assess consequences
- Tools to meet requirements of new state law and 44CFR §60.3

Project Applications

- Model will be a common framework for:
  - Assessing the impacts of proposed projects:
    - System wide impacts of new levees, dams, dredging, channelization etc.
  - Assessing the effectiveness of community planning
    - System wide impacts of future land use plans and stormwater management practices
  - Ensuring that flood risk management decisions do not result in adverse impacts

Tiered Approach to Study Detail

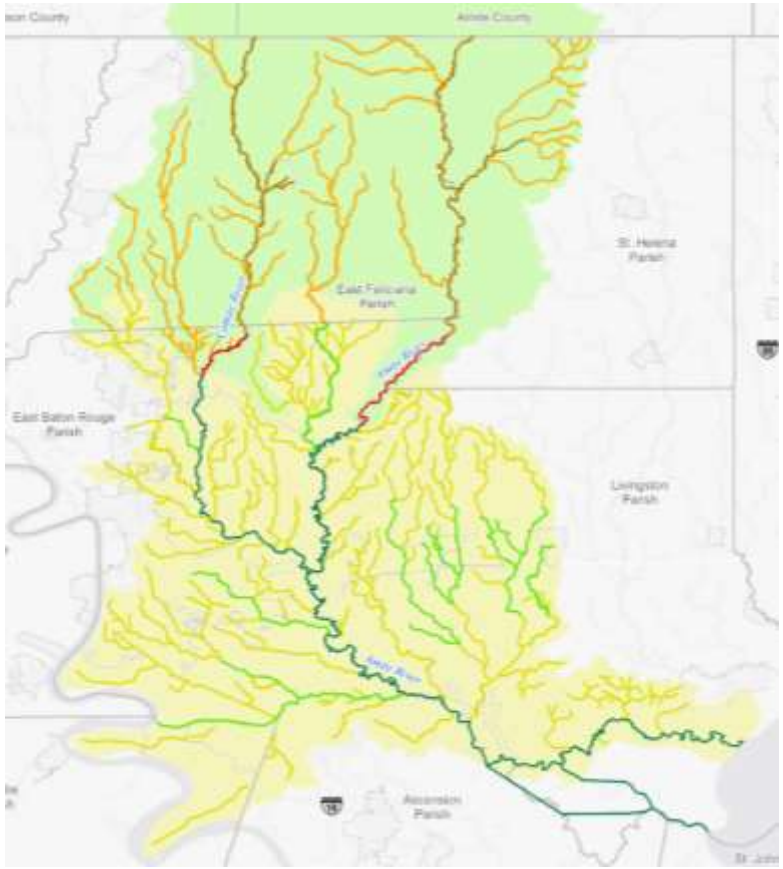
- Risk is a function of:

  Probability × *Consequences*

- Risk is non-uniform throughout basin
- Nearly 1,200 linear miles of mapped flooding sources
- Putting money where the risk is
- Scalable solution
- Developed considering end-users

Model Overview

- Nearly 1,200 miles of floodplain mapped including rivers, creeks, canals and bayous
- Scalable system using no-cost public domain software by the USACE
- New aerial topography LiDAR (1800 sq. mi.)



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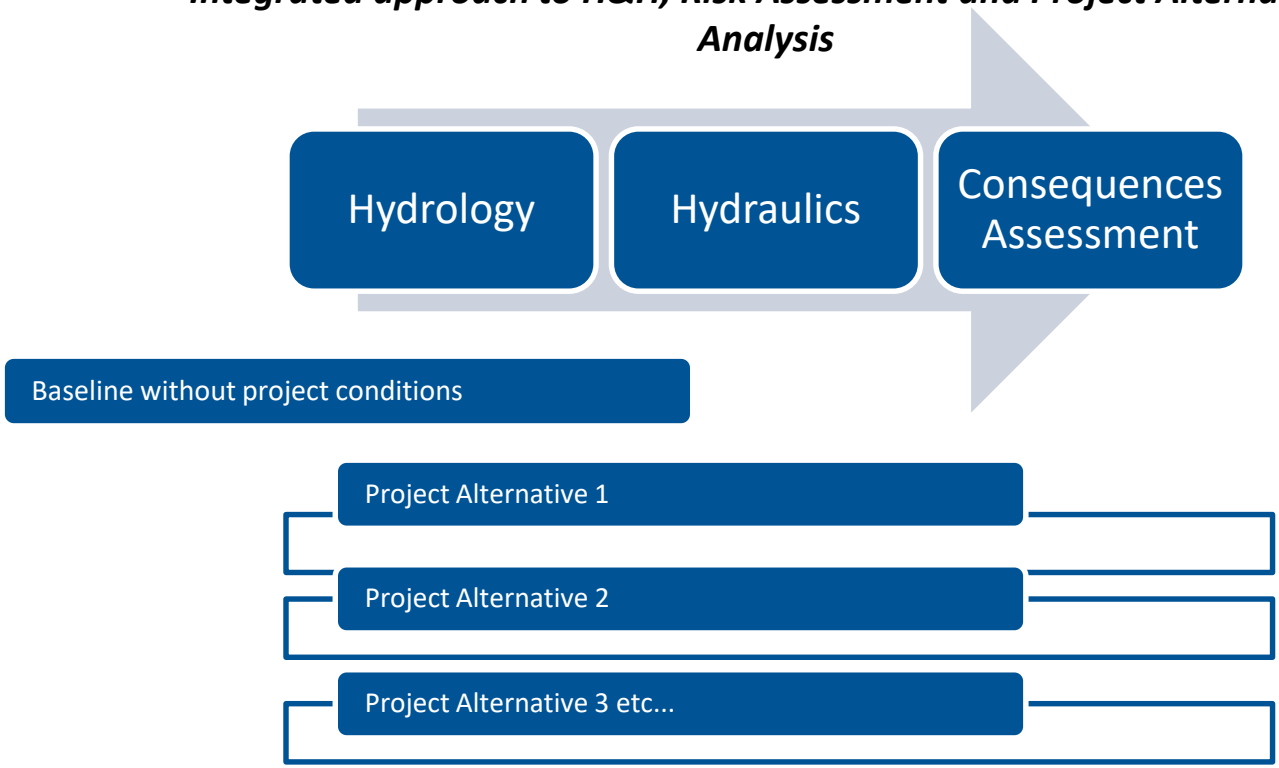
How will it work?

Integrated approach to H&H, Risk Assessment and Project Alternative Analysis



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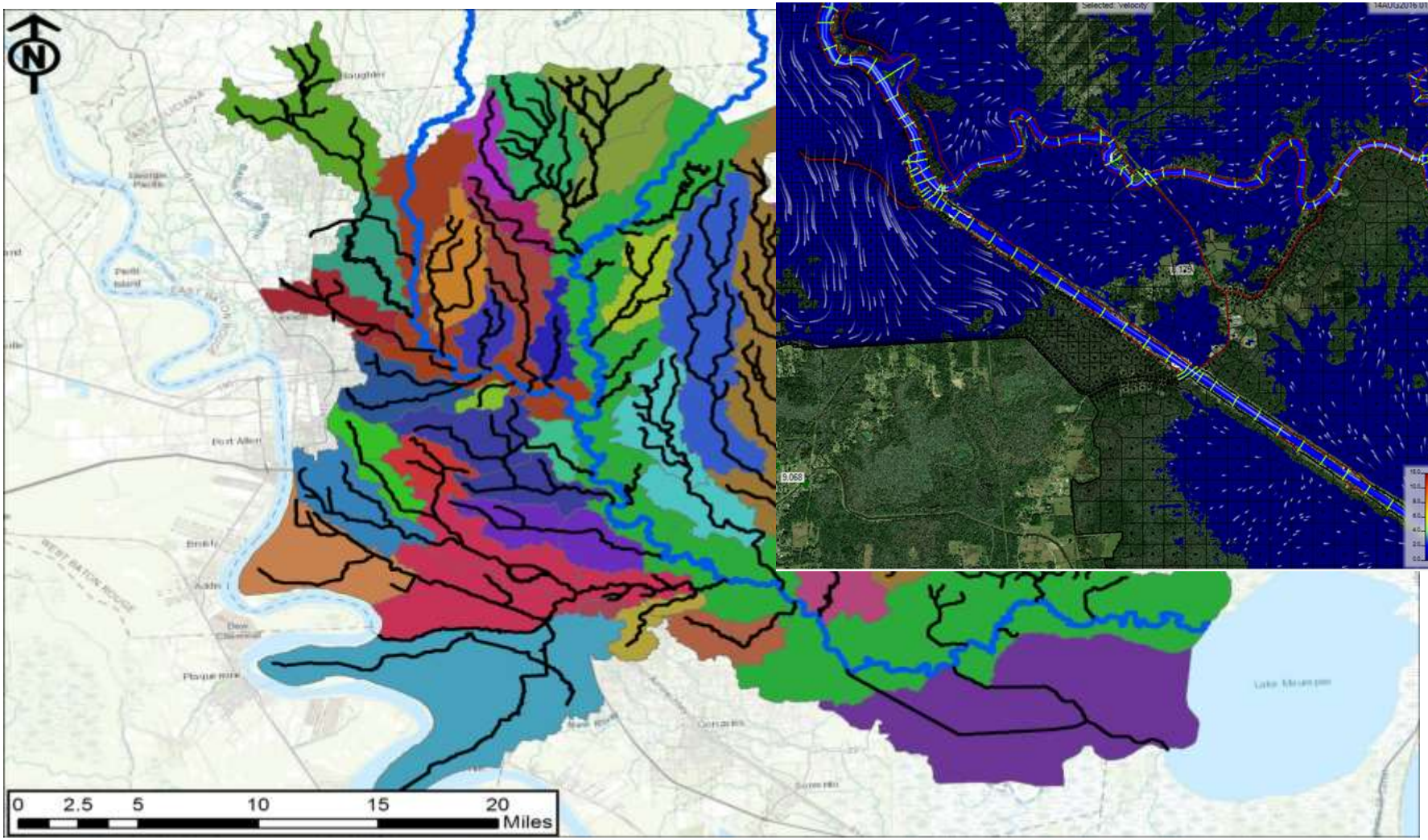
Hydrologic and Hydraulic Models



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What if?

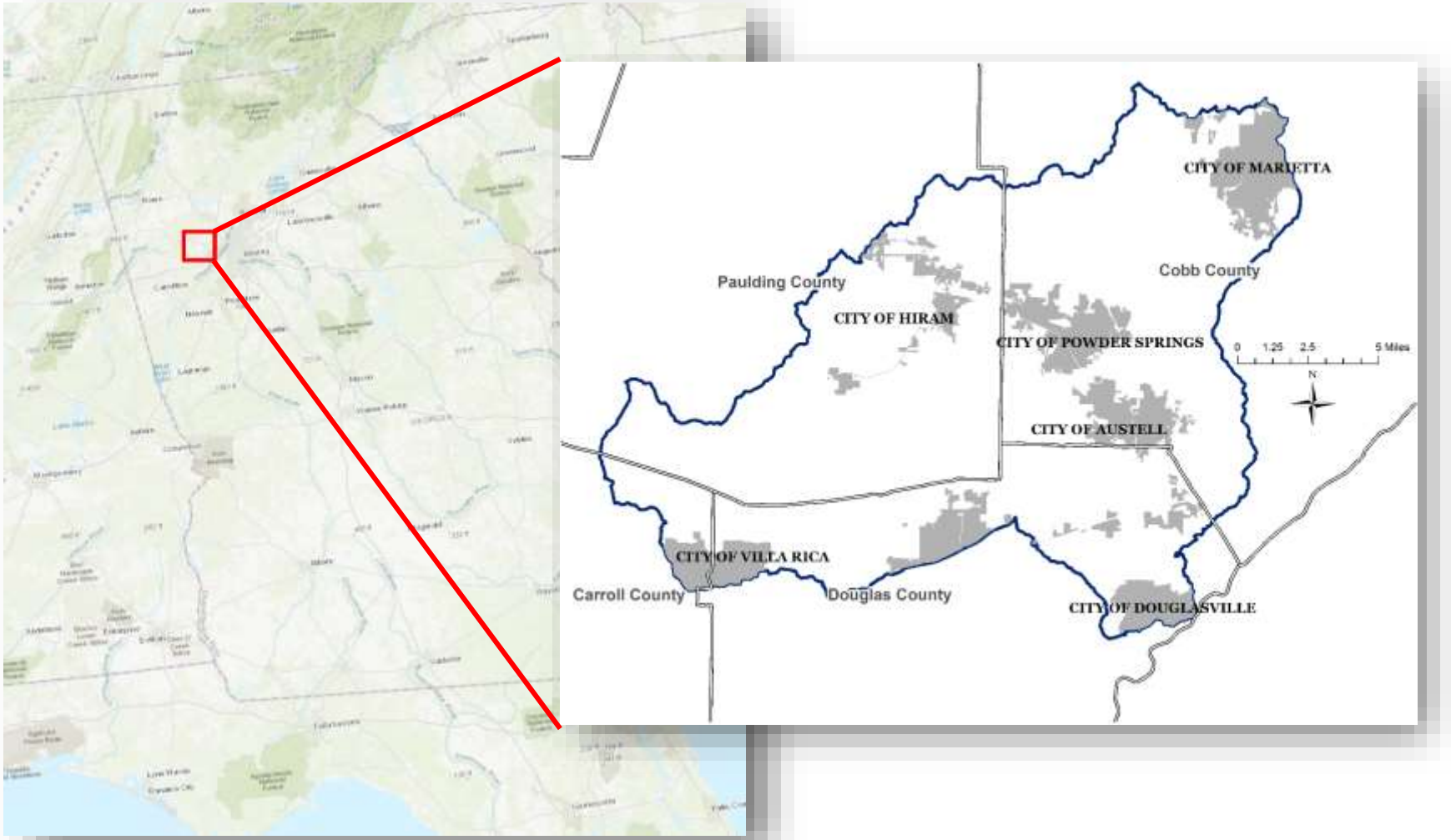
- What are the project impacts of?
  - Building a new reservoir
  - Raising a road embankment or levee
  - Opening up a bridge
  - Diverting flows to another watershed
  - Dredging and/or snagging the river

- Are additional measures needed to offset adverse impacts?

HEC-WAT Summary for Amite Study

- Models can be run from single interface, or...
  - Can be extracted and run standalone
- Effective way to manage models
- Advanced tools available for flood risk analysis will be invaluable for future assessments
- Providing all stakeholders with the tools to assess flood risk and make informed floodplain management decisions
  - Improved efficiency making a systemwide modeling approach cost effective and feasible

Sweetwater Creek FRM Study



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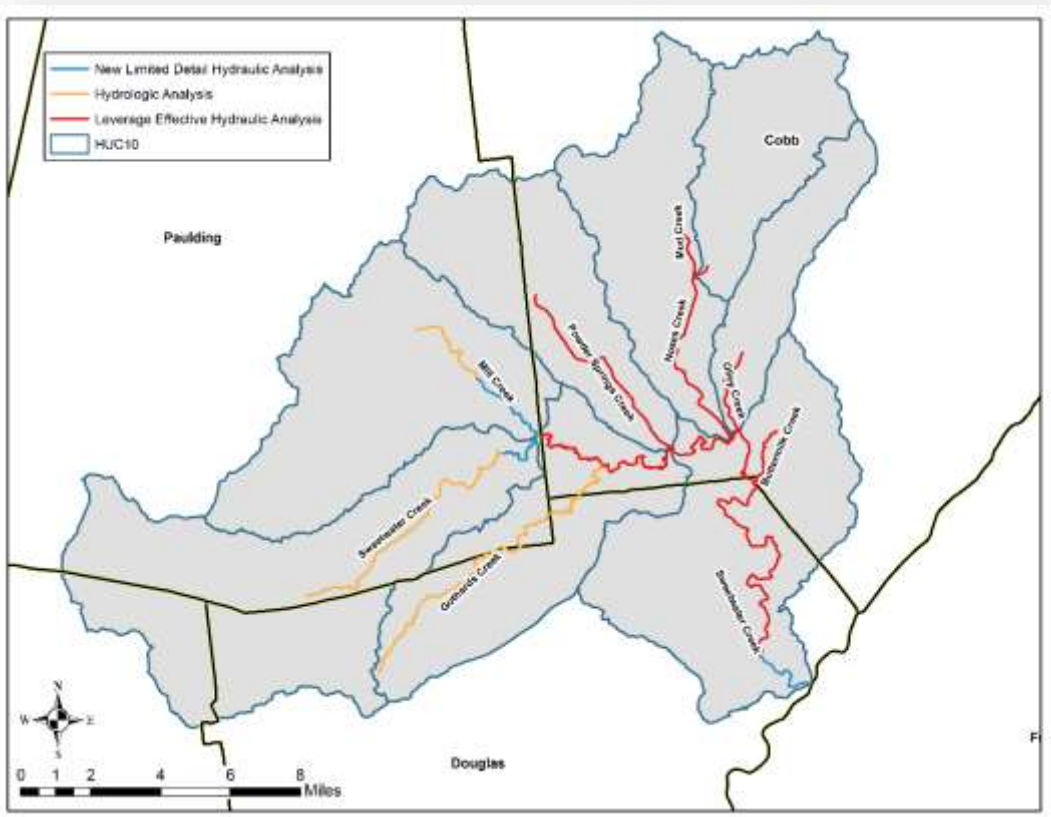
Sweetwater Creek Flood Risk Management Study



- One of the first corps implementations of HEC-WAT
- Quantify flood risks in the Sweetwater Creek Watershed and to evaluate potential alternatives to reduce that risk
- Planning level HEC-HMS and locally leveraged HEC-RAS
- Collaboration between Dewberry, USACE, & local stakeholders

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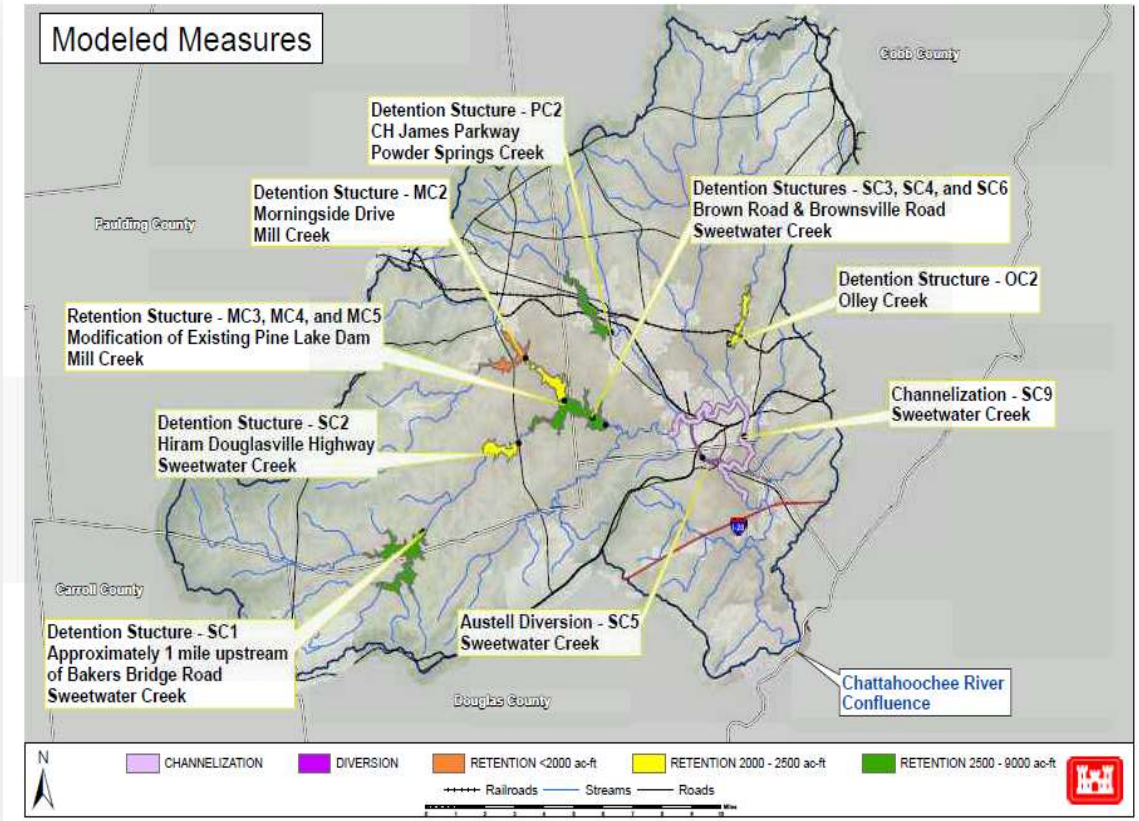
Flood Risk Alternatives

- WAT provided framework for combining and evaluating various alternatives in a comprehensive system-wide approach linking multiple hydrologic and hydraulic models
  - Retention basins
  - Diversions
  - Dredging
  - Channelization
- Validated results with standalone HMS/RAS



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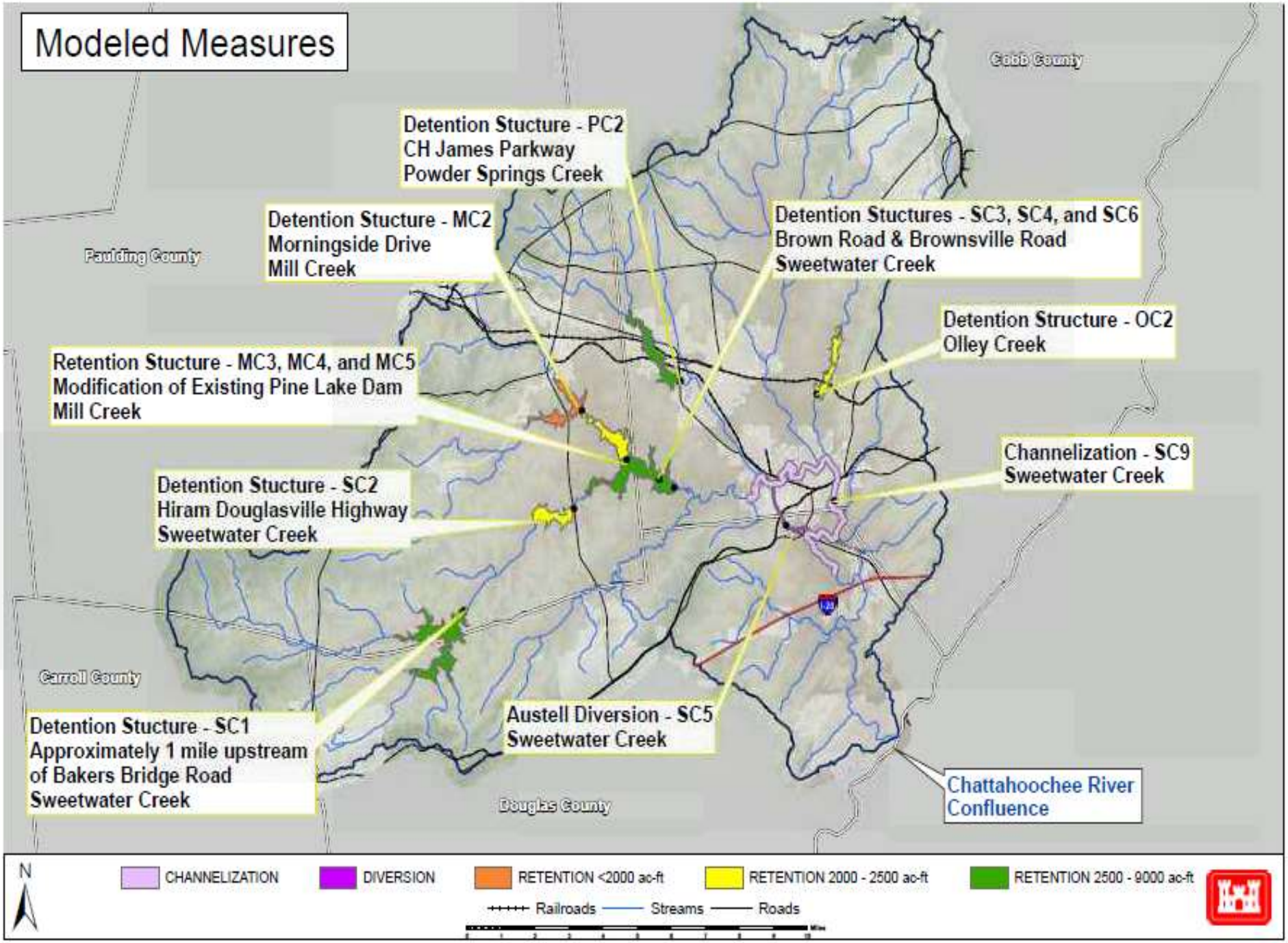
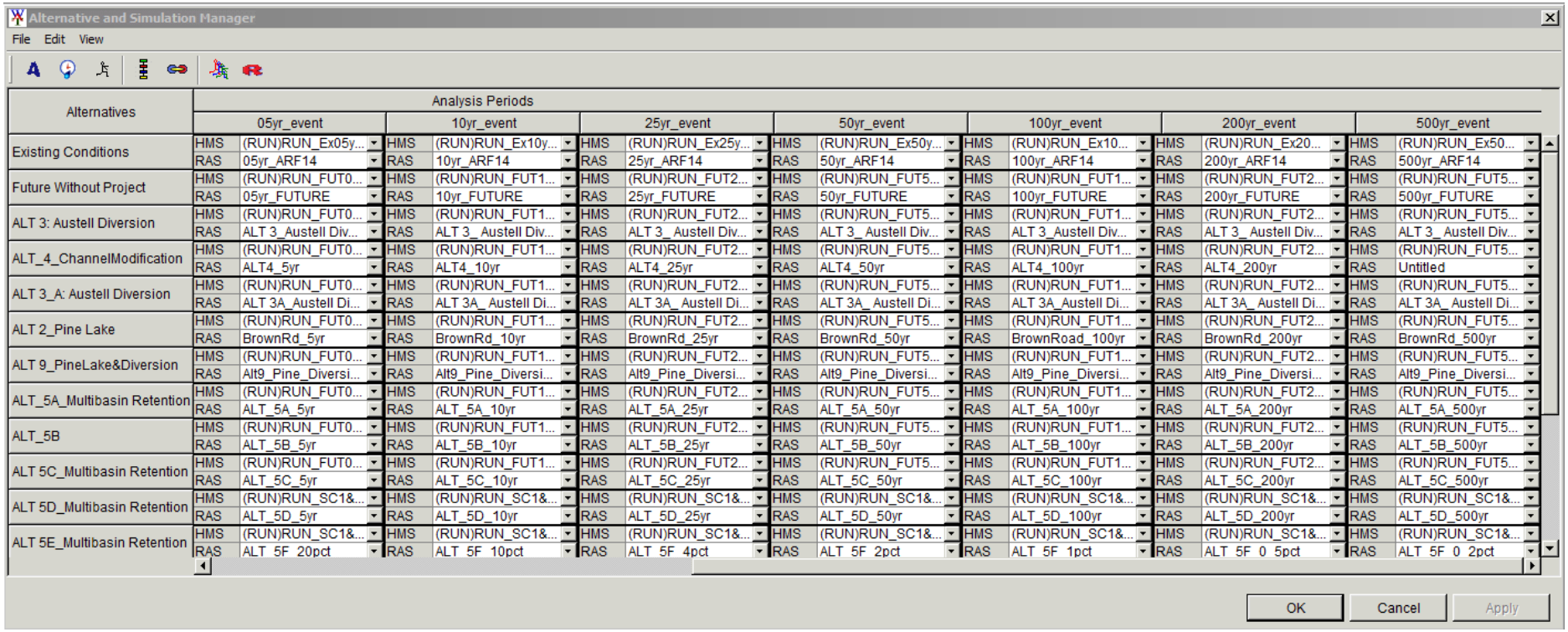

Modeled Measures
Cobb County
Paulding County
Carroll County
Douglas County
Detention Stucture - PC2
CH James Parkway
Powder Springs Creek
Detention Stucture - MC2
Morningside Drive
Mill Creek
Detention Stuctures - SC3, SC4, and SC6
Brown Road & Brownsville Road
Sweetwater Creek
Detention Structure - OC2
Olley Creek
Retention Stucture - MC3, MC4, and MC5
Modification of Existing Pine Lake Dam
Mill Creek
Channelization - SC9
Sweetwater Creek
Detention Stucture - SC2
Hiram Douglasville Highway
Sweetwater Creek
Austell Diversion - SC5
Sweetwater Creek
Detention Stucture - SC1
Approximately 1 mile upstream
of Bakers Bridge Road
Sweetwater Creek
Chattahoochee River
Confluence
N
CHANNELIZATION
DIVERSION
RETENTION <2000 ac-ft
RETENTION 2000 - 2500 ac-ft
RETENTION 2500 - 9000 ac-ft
Railroads
Streams
Roads

Alternative Constraints

- Limited undeveloped land with large storage potential
- No adverse downstream impacts
- No adverse impacts or structural measures to impact historical Sweetwater Creek Mill
- Environmental & Cultural Resource Protection

Alternative Manager

- Evaluated 16 different combinations of structural and non-structural measures including new or rehabilitated detention structures, channel modifications, creek diversions and structure relocations.



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Existing Pine Valley Lake Dam

- Partially breached private dam
- Cobb/Paulding County Border
- 1,100 ac-ft available storage

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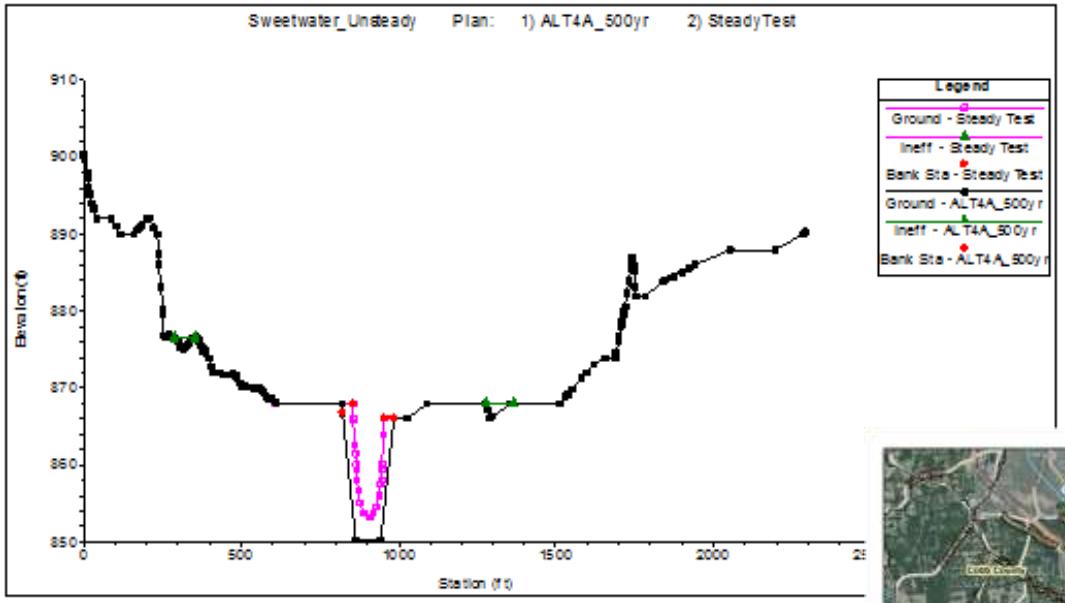
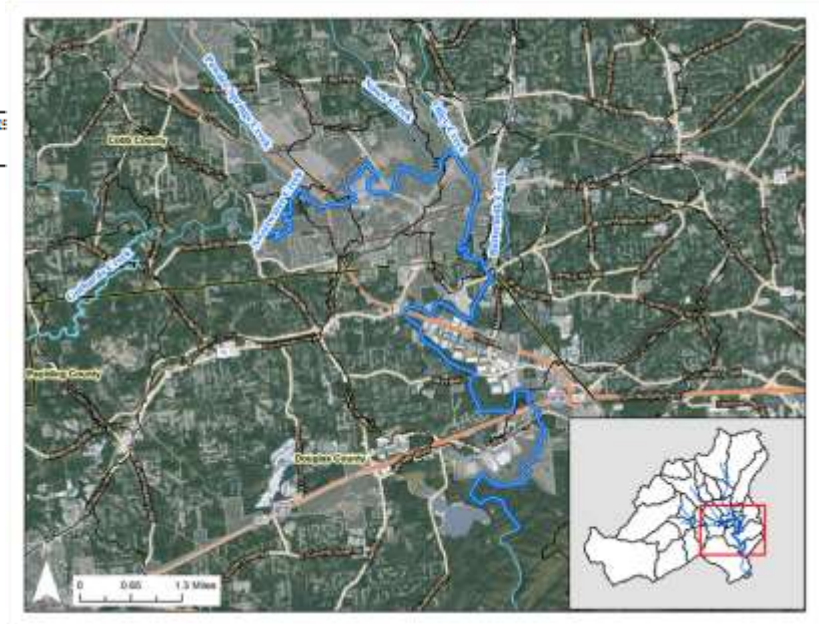
Sweetwater Creek Channelization





- 14.2 miles of channelization through Austell, GA
- Estimated excavation volume of 2.5 million cubic yards

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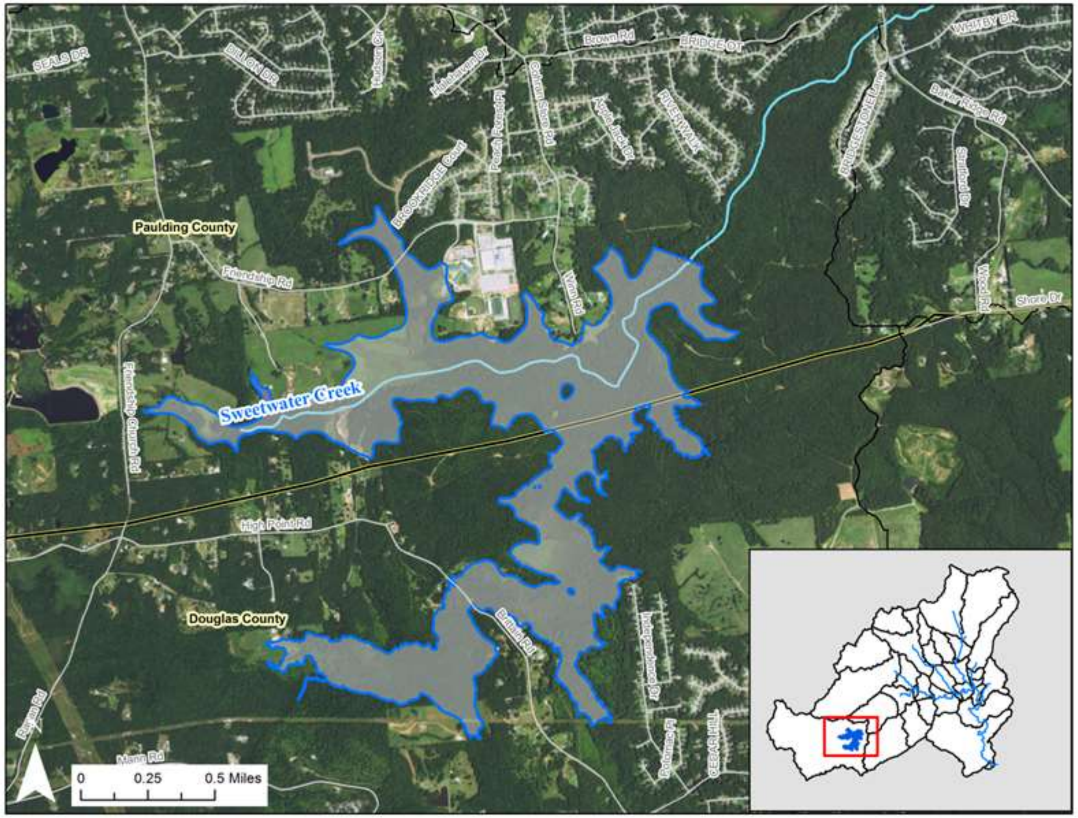
Sweetwater Creek Diversion

- 1.5 mile diversion
- Open channel, cut and cover tunneling, and bored tunnel sections
- Would require at least five 12’ RCP under 165’ of vertical elevation change
- Resulted in increased flows and water surface elevations downstream of Austell

- On request of city investigated 18 mile diversion to the Chattahoochee River

SC1 Detention Structure



- Initially located at Baker's Bridge Road providing 1,800 ac-ft of potential storage
- Revised location just 1 mile upstream provided a total potential storage of 7,600 ac-ft
- Working on its own, this measure reduced the 100YR WSEL in Austell by 3.3'

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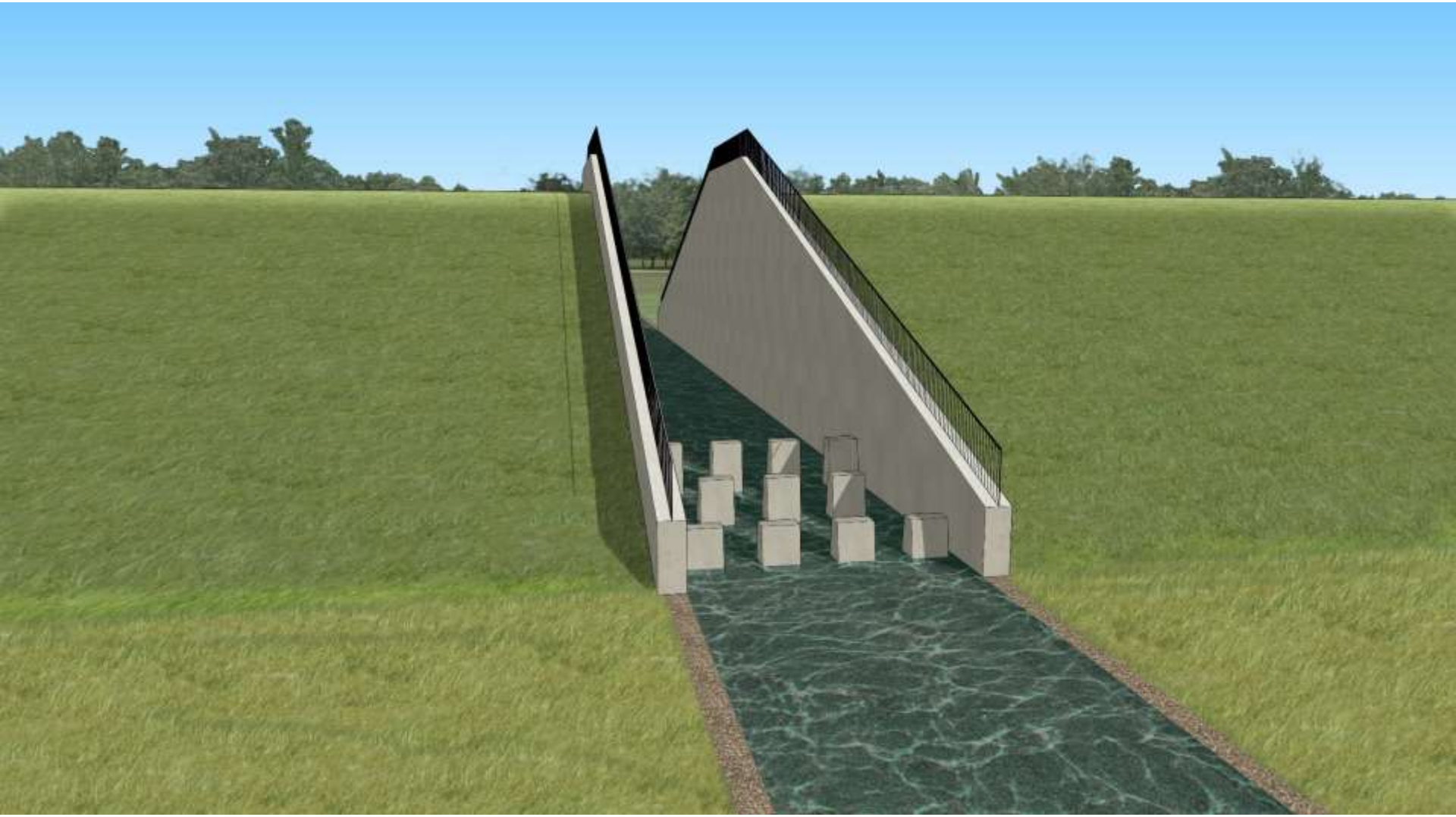
Spillway Rendering



Aerial View of Site SC1

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3D Rendering of Structure SC1

Tentatively Selected Plan (TSP)

- Non-Structural Approach - Relocation/Buyout alternative for 20 structures

10YR Floodplain 25YR Floodplain 100YR Floodplair

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HEC-WAT Summary for Sweetwater Creek FRM Study

- Integration of models was tediously initially, however once linked, benefits were recognized
  - Initially hit many bugs, however HEC has addressed many of these now
- HEC-WAT provided benefits when developing, running and assessing alternatives
- Systemwide, dynamic modeling approach was critical to recognize adverse impacts

Summary

- Impacts of individual projects can have a much wider system impact (positive and/or negative)
- System wide modeling can be a bit like:

  1 + 1 = 4, if you are lucky!

  or

  1 + 1 = -4 if you are not so lucky!

- Critical to making risk informed decisions
- HEC-WAT continues to evolve with improved stability and tools to support system wide watershed analysis