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

Sam Crampton, P.E., CFM
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
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
AEP Grid Compute Method

AEP = grid value/number of events

Source: USACE
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
Amite River Watershed, LA

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

\[ \text{Probability} \times \text{Consequences} \]

• 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.)
How will it work?

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

Hydrology

Hydraulics

Consequences Assessment

Baseline without project conditions

Project Alternative 1

Project Alternative 2

Project Alternative 3 etc...
Hydrologic and Hydraulic Models
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
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
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
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.
Existing Pine Valley Lake Dam

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

- 14.2 miles of channelization through Austell, GA
- Estimated excavation volume of 2.5 million cubic yards
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’
Spillway Rendering
Aerial View of Site SC1
3D Rendering of Structure SC1
Tentatively Selected Plan (TSP)

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