2D Hydraulic Models For Complex Floodplain Analysis: Case Study – FM 1442

Presentation Team

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1911
Founded in
Dayton, Ohio

40+
Offices Worldwide

1200+
Global
Employees

Areas of Specialization

ARCHITECTURE
ENGINEERING
GEOSPATIAL
Outline

- What is 2D Modeling
- 2D vs 1D Model
- Case Study
- Why 2D Modeling
- Hydrology Development
- 2D Model Development
- 2D Model Validation
- Model Results
- Summary
What is 2D Modeling

- Hydraulic property changes in both X and Y direction
- Discretization of floodplain into grid cells/meshes
- Utilize high resolution terrain data even with coarse cell size
- Solve either 2D Shallow Water Equation or 2D Diffusion Wave Equation
- Implicit finite volume algorithm
  - Larger time step
  - More stability
2D vs 1D Model

“The MODEL is as good as the INPUT (DATA)”

2D Model
- Wider floodplain
- Shallow overland flow
- Low flow condition
- Split flow
- Narrow crossing with significant contraction / expansion

1D Model
- Unidirectional stream with defined banks (canal, mountain stream)
- Unavailability of good terrain data – Easy to fix terrain anomalies in 1D model

2D Modeling Case Study:
FM 1442 Project
Project Background

- TxDOT Project – Beaumont District
- Project located in Orange County, Texas
- FM 1442 between FM 105 South and FM 408
- 4.91 miles of proposed roadway improvements

Project Background - H&H

- Located within Cows Bayou and Neches River watershed
- Flat coastal terrain
- Tidal impact
Project Background - H&H

- Mostly within FEMA zone AE

- 14 drainage crossings
  - 11 non-bridge class
  - 1 bridge class (CV5)
  - 2 equalizers

Why 2D Hydraulic Modeling?
Hydraulic Modeling – Why 2D

- Flow interaction between drainage crossings
- Complexity in the upstream floodplain
- Multiple crossings draining to the same outfall
- Variability in flow direction
- Good terrain data source (3.28’X3.28’)
- Recent development in HEC-RAS 2D

Hydrology Development
Hydrologic Analysis

- Validate the Peak Rate Factor (PRF)
- Three gauges along Cows Bayou
- Analysis was performed using HEC-SSP 2.2
- Bulletin 17B procedure to perform Log Pearson III Distribution
- HMS Model with delineated area for the gauges
- Gauges were calibrated with PRF 350
- All subsequent hydrology based on same PRF

2D Model Development
2D Model Development

- Floodplain: 41.5 sq.miles
- 2D cell size: 100' X 100'
- No of cell: 113k (approx.)
- Landuse: NLCD Landcover (USGS)
- Inflow hydrographs: At the upstream of each crossing
- MSL data: NOAA Local Tides and Currents

2D Model Development

- Roadway defined using 2D-2D connection weir
- Connection length to match with DA
- Weir coeff = 1.50 (for 1 ~3 ft above natural ground)
- Driveway (DW) culverts were added
- Cell face adjustment where DW culvert info is not available
- Terrain modification to incorporate survey flowline EL
2D Model Validation

- Rainfall Event: May 14th, 2020
  - Backyard flooding
  - Parking lot flooding
Model Validation

- NOAA’s Next Generation Weather Radar (NEXRAD)
- NOAA ATLAS 14 Estimates
Model Results

Model Results - Design Storm Event

Rising Storm  Peak Storm  Storm Recession
Model Results- Design Storm Event

Rising Storm  Peak Storm  Storm Recession

Model Results- HY8 vs RAS 2D

CV2 : (1)- 8’X5’ RCB

<table>
<thead>
<tr>
<th>Storm Event</th>
<th>Peak Discharge (cfs)</th>
<th>Culvert Discharge (cfs)</th>
<th>Roadway Discharge (cfs)</th>
<th>Culvert Discharge (cfs)</th>
<th>Roadway Discharge (cfs)</th>
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<tr>
<td>25 Year</td>
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<td>100 Year</td>
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<table>
<thead>
<tr>
<th>Storm Event</th>
<th>Roadway Elevation</th>
<th>HW Elevation</th>
<th>Overtopping depth (ft)</th>
<th>HW Elevation</th>
<th>Overtopping depth (ft)</th>
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Summary

- 2D model is an effective tool to model complex floodplain
- Physics based approach, less assumptions
- Less model instability than traditional 1D unsteady or 1D-2D couple models
- Hydraulic modeling option for alternative analysis on an accelerated schedule
- Simulation time could be adjusted (based on computational time step, cell size, solution equations, etc)