2D Hydraulic Modeling, Steering Stream Restoration Design

PREPARED FOR:  
EcoStream 2018 Stream Ecology & Restoration Conference

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August 16, 2018
Overview

Two-Dimensional Modeling Approach

1D vs. 2D Modeling

Representative Projects Overview

Representative Projects Models
Two-Dimensional Modeling Approach

Hydraulic Modeling for Stream Design Utilizing GeoHEC-RAS 2D

- 2D hydrodynamic flow routing within unsteady flow analysis
- 1D, 2D or combined 1D/2D unsteady-flow routing
- 2D flow areas in HEC-RAS can be used in a number of ways
  - Detailed 2D channel modeling
  - Detailed 2D channel and floodplain modeling
  - Combined 1D channels with 2D floodplain areas
  - Combined 1D channels with 2D flow behind levees
  - Directly connect a 2D flow area to 1D storage area with a hydraulic structure
  - Simplified to very detailed Dam Breach analyses
Two-Dimensional Modeling Approach

Hydraulic Modeling Utilizing GeoHEC-RAS 2D

Definitions

▪ 1D Modeling
  Solves the fully dynamic St. Venant equations of conservation of mass and momentum along a singular dimension.

▪ 2D Modeling
  Solves the fully dynamic St. Venant equations of conservation of mass and momentum along two dimensions.
1D vs. 2D Modeling

Hydraulic Modeling Utilizing GeoHEC-RAS 2D

- 1D Advantages
  - Fewer geometric data are required
  - Shorter computational time
  - Channel flows computed more efficiently
  - Relatively smaller output files

- 2D Advantages
  - Flowpaths do not need to be predefined
  - Provides realistic depiction of flow throughout a system
  - Perform 1D and 2D modeling within the same unsteady flow model allows users to model larger river systems, 1D where appropriate (main river) and 2D modeling in areas that require a higher level of hydrodynamics
  - Flowpaths can change with flow depth
  - Cross-momentum of flow splits is accounted for (significant for roadway crossing systems)
  - Losses due to 2D effects (i.e. bends, flow separations, etc.) automatically included within computations
  - Floodplain storage is implicitly defined
  - Inputs and outputs can be defined spatially in GIS-type environments (better data continuity)
  - Does not require extraction of cross sections from survey data
  - Detailed Flood Mapping and Flood Animations – based on underlying terrain, each cell can be partially wet/dry reflected in the mapping and animations
  - Can provide results directly for mapping flood extents and inundation depths, velocities, and safety hazards
1D vs. 2D Modeling

Hydraulic Modeling Utilizing GeoHEC-RAS 2D

▪ When is 1D Okay
  o Locations where flow isn’t required to spread (uni-directional flow)
  o Well-defined channel/overbank systems (defined valleys)
  o Simply-connected floodplains where flow in main channel is well connected to flow in the overbank and both are primarily uni-directional
  o When elevation data of only limited quality/quantity are available

▪ When is 2D Preferable
  o Anywhere flow is expected to spread
  o Urbanized Areas
  o Wide Floodplains
  o Downstream of Levee Breaks
  o Downstream of Upground Reservoir Breaks
  o Stream and Wetland Studies
  o Lake or Estuary Studies
  o Water Quality and Sediment Transport
1D vs. 2D Modeling

Hydraulic Modeling Utilizing GeoHEC-RAS 2D

▪ 1D or 2D?
  o What is the length-to-width ratio of the project area? (> or < 3:1?)
  o Does the project have features that force flow to rapidly contract or expand?
  o Does the project have any features that redirect flow significantly (i.e. buildings)?
  o What kind of output animations are needed to convey the results to the stakeholders?
1D vs. 2D Modeling
1D vs. 2D Modeling

Sustainable Restoration Approach Hydraulic Modeling

- Floodplain Management & Permitting
- HEC-RAS 1D – Flood Impact Analysis
- HEC-RAS 2D – Stream Restoration Design
  - In-Stream Structure Modeling (3D Objects)
  - Near Bank Shear Stress Management
  - Floodplain Connectivity
  - Stream and Wetland Complex Modeling
  - Velocity Particle Tracing
  - Depth Grid Mapping
1D vs. 2D Modeling

Sustainable Restoration Approach Hydraulic Modeling

2D Computational Mesh Optimization Tool (Adaptive Mesh)
1D vs. 2D Modeling
1D vs. 2D Modeling

Hydraulic Modeling Utilizing GeoHEC-RAS 2D

“All models are wrong, but some are useful.”
-George E. P. Box

“For every complex problem there is an answer that is clear, simple, and wrong.”
-H.L. Mencken
Representative Projects

UNT to Moock Road Pipeline Repair & Stream Restoration
- City of Southgate, Campbell County, KY

20" NG Pipeline, 0.1 Sq. Mi. Drainage Area, 2,500 lf Stream Restoration, Headwater Stream
Representative Projects

UNT to Moock Road Pipeline Repair & Stream Restoration
- Upstream Pipeline Crossing
Project Models

Existing Conditions Bankfull Video

Proposed Conditions Bankfull Video

Pipeline Crossing

Pipeline Crossing
Representative Projects

UNT to Moock Road Pipeline Repair & Stream Restoration
- Downstream Pipeline Crossing
Representative Projects

**UNT to Moock Road Pipeline Repair & Stream Restoration**
- Downstream Pipeline Crossing
Representative Projects

UNT to Moock Road Pipeline Repair & Stream Restoration
- Downstream Pipeline Crossing
Project Models

Proposed Stream Restoration Plan

Legend:
- Proposed Stream Corridor
- Proposed Bankfull Shear Stress (W/ft²)

Value:
- High: 1.1
- Low: 0

Proposed Conditions Bankfull Video

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Project Approach

Proposed Stream Restoration Plan

Legend
- Proposed Stream Conditions
- Proposed Bankfull Shear Stress (ft/s/ft)

Value
- High
- Low

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Representative Projects

Construction Time-Lapse Video
Summary

If you build it... it will come...

Thank You
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