2D Hydraulic Modeling, Steering Stream Restoration Design

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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

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.
Hydraulic Modeling

1D Advantages:

- Fewer geometric data are required
- Shorter computational time
- Channel flows computed more efficiently
- Relatively smaller output files
- More traditional/effective data reporting (tables, x-sections, profiles, etc.)
- Easier plan comparative output (i.e. no-rise)
Hydraulic Modeling

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
Hydraulic Modeling

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

- **When is 2D Preferable**
  - Anywhere flow is expected to spread
  - Urbanized Areas
  - Wide Floodplains
  - Downstream of Levee Breaks
  - Downstream of Uprground Reservoir Breaks
  - Stream and Wetland Studies
  - Lake or Estuary Studies
  - Water Quality and Sediment Transport
Hydraulic Modeling

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

- 2D Computational Mesh Optimization Tool (Adaptive Mesh)
Hydraulic Modeling Limitations

1D vs. 2D Modeling

- “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 If Stream Restoration, Headwater Stream
Representative Projects
UNT to Moock Road Pipeline Repair & Stream Restoration - Upstream Pipeline Crossing
Representative Projects
UNT to Moock Road Pipeline Repair & Stream Restoration
- Downstream Pipeline Crossing

Pre Construction

Post Construction
Representative Projects
UNT to Moock Road Pipeline Repair & Stream Restoration
- Downstream Pipeline Crossing
Project Models

Proposed Stream Restoration Plan

Legend:
- Proposed Stream Centers
- Proposed Bankfull Shear Stress (lbf/ft)
- Values:
  - High: 1.1
  - Low: 0

Proposed Conditions
Bankfull Video
Representative Projects

**Horse Branch Pipeline Repair, Bank Stabilization & Stream Restoration**
- City of Edgewood, Kenton County, KY

- 24” NG Pipeline, 1.2 Sq. Mi. Drainage Area, 100 lf Stream Restoration, Soil Nail Wall High Bank Stabilization, FEMA Zone A
Representative Projects

Horse Branch Pipeline Repair, Bank Stabilization & Stream Restoration
- City of Edgewood, Kenton County, KY

• 24" NG Pipeline, 1.2 Sq. Mi. Drainage Area, 100 lf Stream Restoration, Soil Nail Wall High Bank Stabilization, FEMA Zone A
Project Models

Proposed Stream Restoration Plan

Proposed Conditions
Bankfull Video
Pipeline Crossing

Legend:
- Proposed Stream Channel
- Proposed Bankfull Stream Stress (psi)
- Water

CEC
Representative Projects
Georges Creek Mine Reclamation Stream Restoration
- Alleghany County, MD

2-Year Flood Inundation
Modeled Sediment Particle Tracing for 2-Year Flood
Modeled Shear Stress for 2-Year Flood
Representative Projects

Construction Time-Lapse Video
If you build it…

it will come…

Thank You!
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