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Forensic Hydraulic Detection:

Detecting peak discharge after the flood

New and Evolving Concepts in Indirect Discharge Measurements
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Challenge:

Determine peak discharge after an event.

Peak discharge – maximum flow at a stream location for a time period.

Clues

- High-water marks

- Precipitation records

- Topography, flow structures, land use, vegetation and geology

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Detection Tools

- Surveying equipment
- Topographic maps
- Open-channel flow physics
- Computer programs

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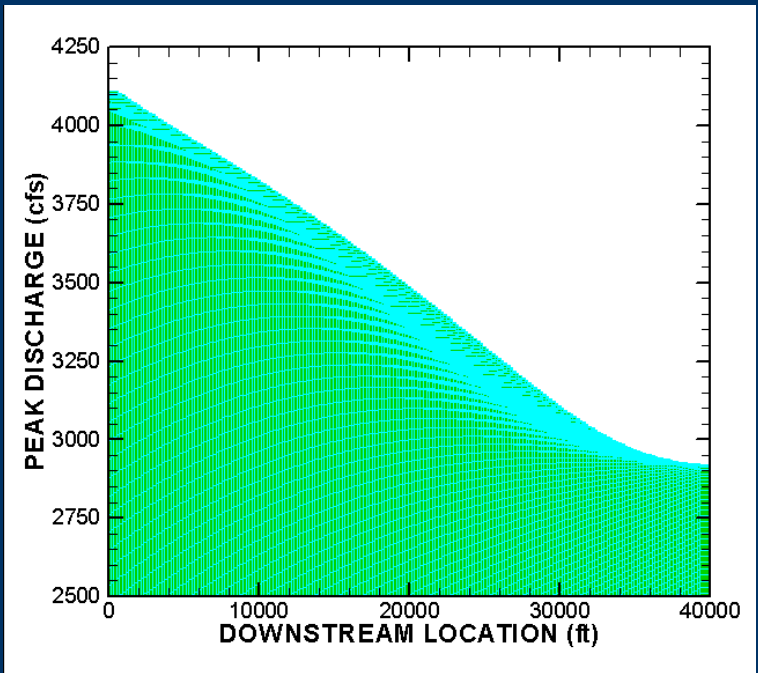
Flood MO*

**modus operandi*

Peak varies with stream location



- Inflows
- Bed friction
- Channel shape changes
- Slope changes
- Peak duration

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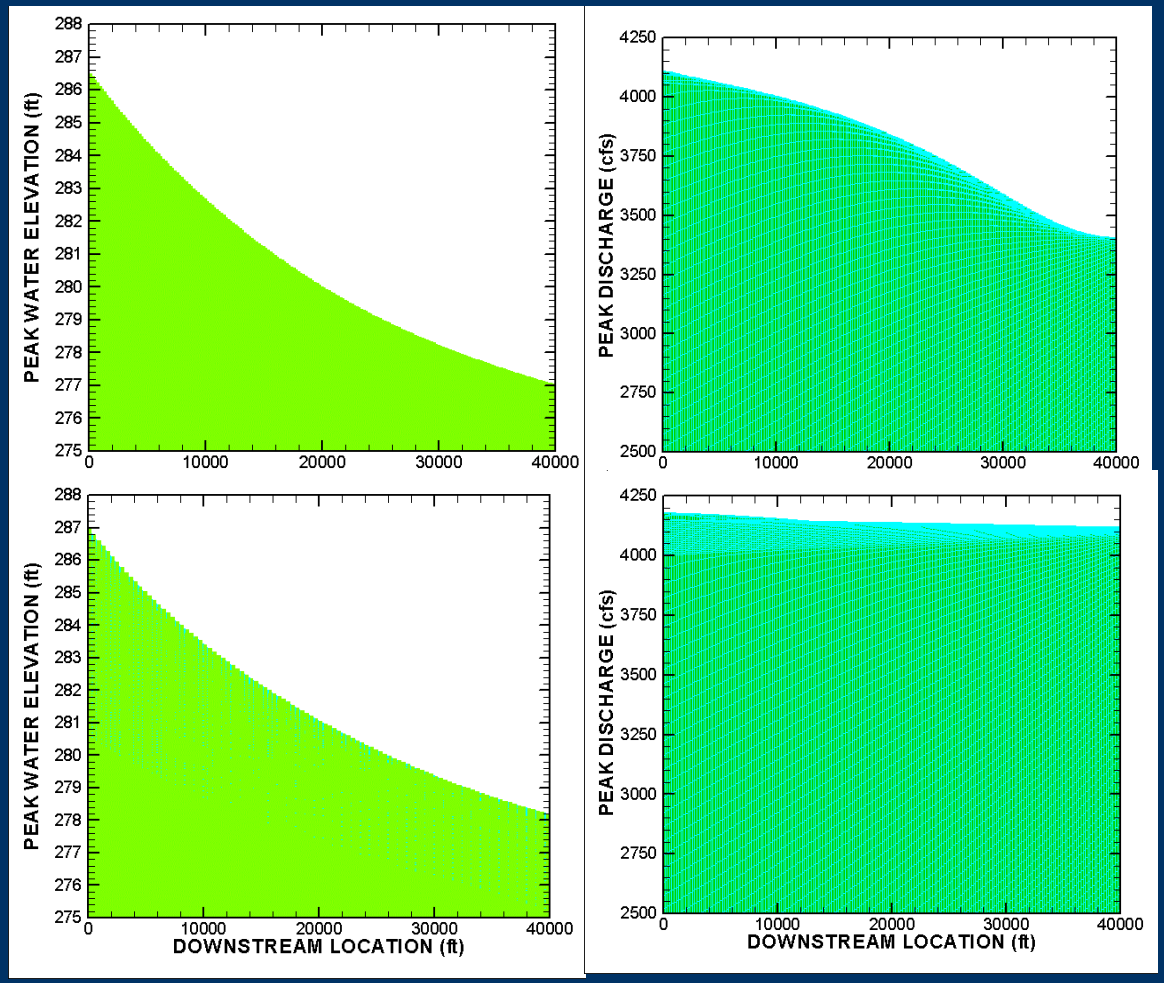
Flood MO*: *Peak duration*

short

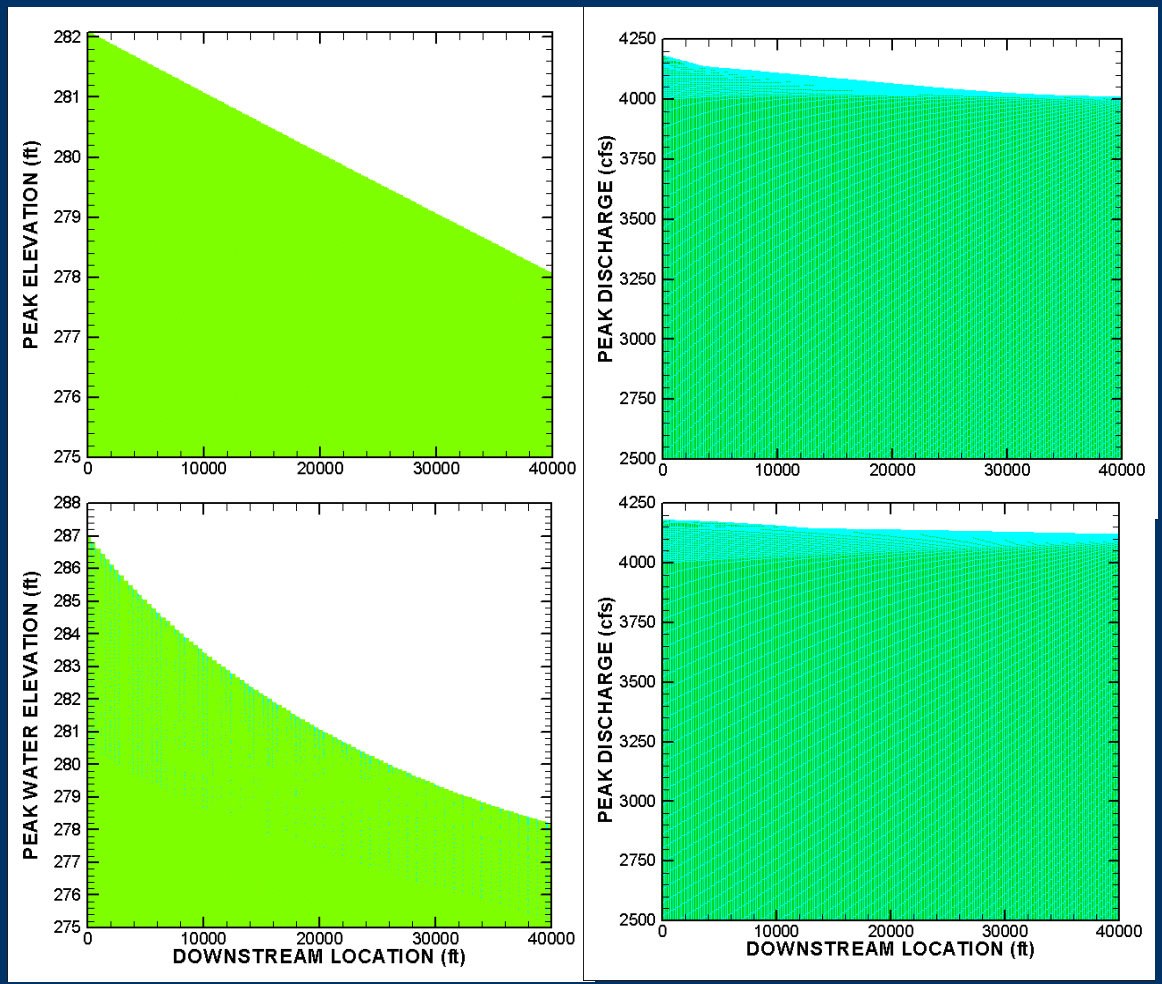
long



Flood MO*: *Channel shape*

constant

expanding



Traditional Detection Methods

Types

- Slope-Area
- Step-backwater
- Contracted openings
- Slope-conveyance

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Traditional Detection Methods

Applications

- One inflow
- Straight reaches of uniform shape and slope

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Traditional Detection Methods

Data requirements

- High-water mark elevations
- One or more cross sections
- Roughness values at cross sections

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Traditional Detection Methods

Differences

- Boundary conditions
- Specialized loss coefficients
- Number of cross sections used

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Traditional Detection Methods

Solution techniques

- Slope-area : water elevations are known & discharge is explicitly solved for
- Step-backwater : downstream water elevation is known and discharge is guessed at until computed water surface matches known water elevations.
- DISCHARGE FOUND ISN'T DEPENDENT ON SOLUTION TECHNIQUE

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Non-Traditional Methods

Types

- Multi-dimensional
- Time varying

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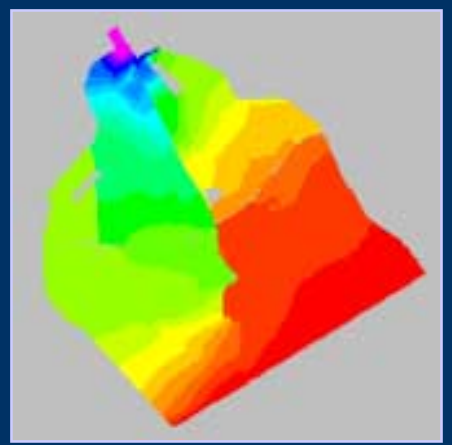
Multi-dimensional Methods:

Applications

- Meandering low-water channel



- Multiple channels
- Water-elevation varies across stream

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Multi-dimensional Methods

Data requirements

- High-water mark elevations
- Topography throughout reach
- Vegetation and soil data throughout reach

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Multi-dimensional Methods

Setup

- Select computer model
- Create topography mesh (femi, sms, tecplot)
- Select roughness parameters
- Input measured outflow water-surface elevation

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Multi-dimensional Methods

roughness selection

- Hydrologic judgment
- Calibrate and validate

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Multi-dimensional Methods

Execution

1. Estimate discharge
2. Run model simulation
3. Match high-water marks?
4. Repeat 1 to 3 until match

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Multi-dimensional Models

- Feswms – 2D finite element
- UnTrim – 3D finite volume
- Mike21 – 2D finite difference
- EFDC – 3D finite difference
- Swift/Simsys2d – 2D finite difference

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Time Varying Methods

Applications

- Dam failures *(manmade or natural dams)*
- Very intense precipitation events *(hurricanes, thunderstorms)*

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Time Varying Methods

Data requirements

- High-water mark elevations
- Topography throughout reach
- Vegetation and soil data throughout reach
- Inflow hydrograph estimates or data

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Time Varying Methods

Setup

- Select computer model
- Create topography mesh
- Select roughness parameters
- Set inflow and outflow hydrographs

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Time Varying Methods

Setup: *hydrographs*

- Measured water elevations
- Estimated inflow and constant outflow water-slope

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Time Varying Methods

Setup: *Inflow estimates*

- Dam breaks – total flow equals reservoir volume, timing is function of dam breach

- Intense precipitation events – use precipitation records and rainfall/runoff modeling

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Time Varying Methods

Execution

1. Estimate inflow hydrograph
2. Run model simulation
3. Match high-water marks?
4. Repeat 1 to 3 until match(es)

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Time Varying Methods:

- 1D – Branch, FourPt, Feq, Unet(Hec-Ras),DaFlow, Mike11
- 2D – Untrim, Swift/simsys2d, EFDC, Mike21

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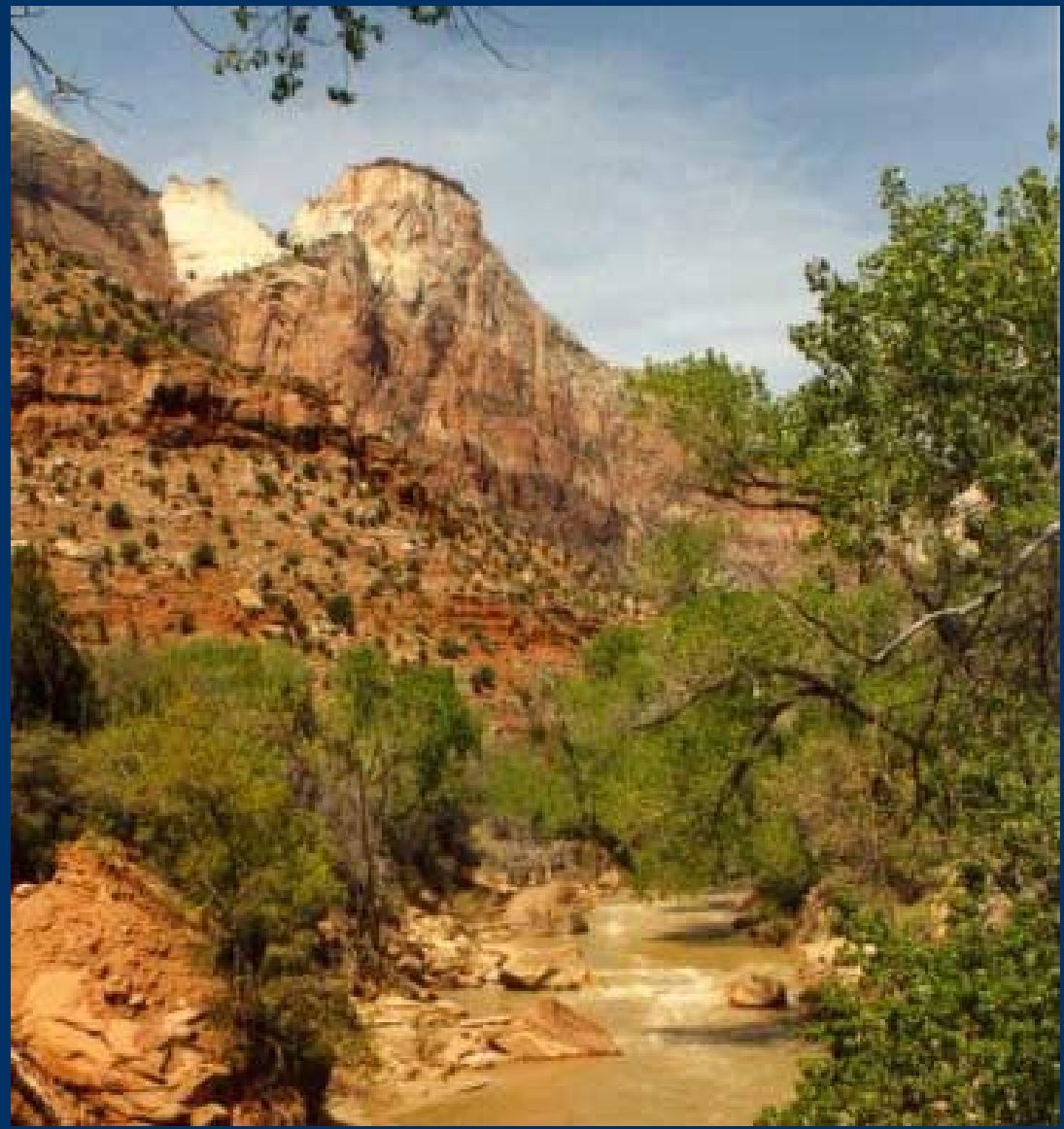
Future Detection Methods

- Discharge error estimations
- Monte Carlo simulations

Questions and Discussions



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