



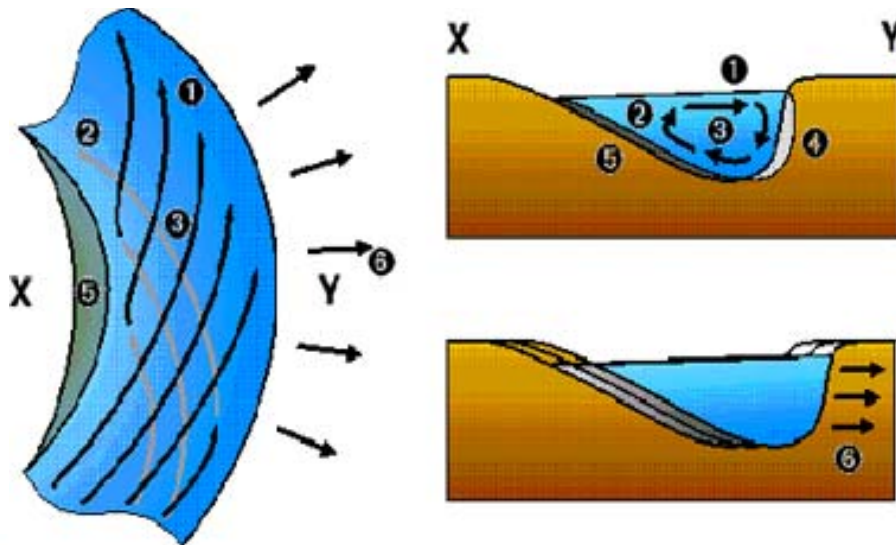
Simulating Stream Flow in GSSHA





Stream Flow

- Concentrated, dynamic flow
- 1D, 2D, and 3D flow patterns, depending on stream size, shape, flow





Stream Flow Generation Mechanism

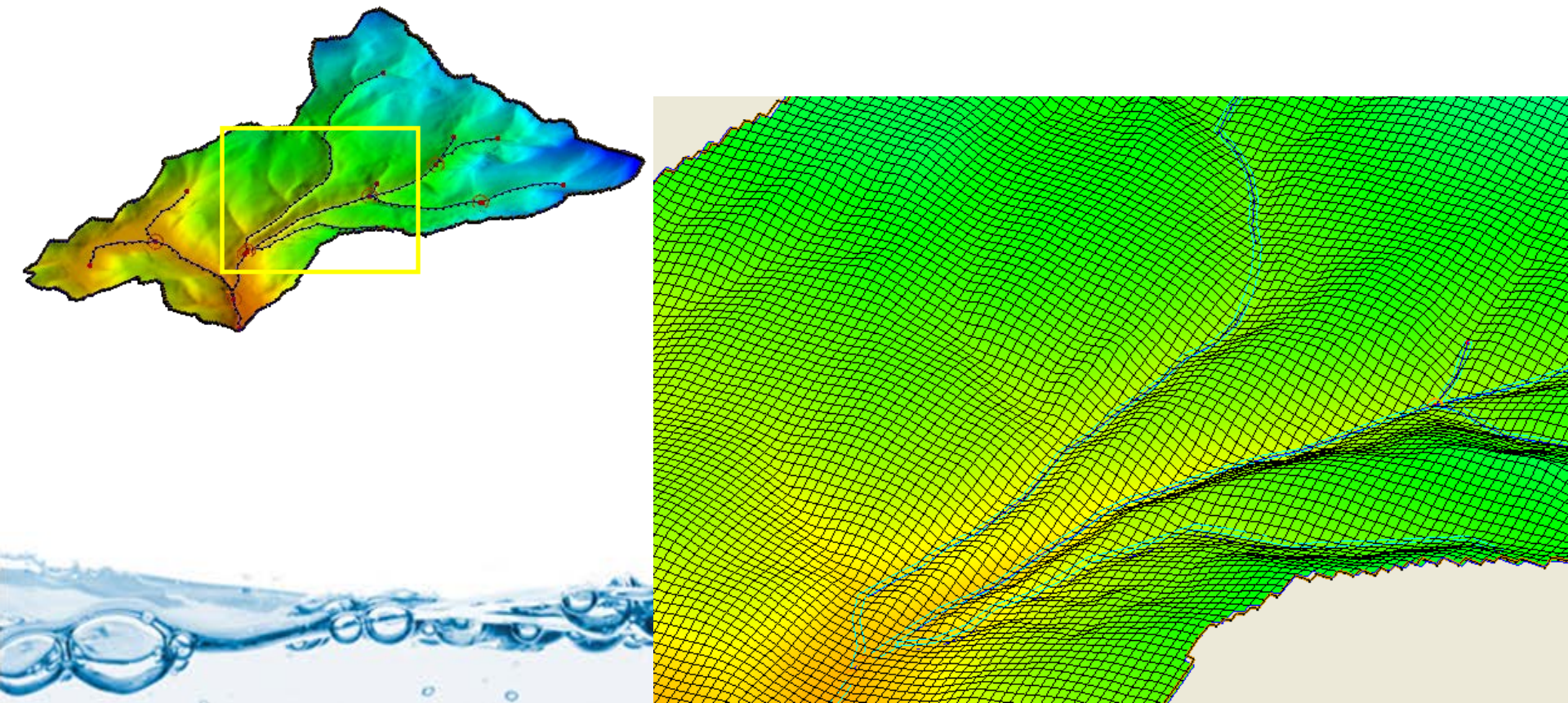
- Overland flow
- Groundwater/interflow
- Storm surge, tidal cycles





Stream Flow in GSSHA

- 1D network of links (reaches) containing nodes (cells)
- Links represent stream reaches of uniform properties.
- Computations are performed on the nodes.





Stream Networks in GSSHA

- 1D channel flow
 - Trapezoidal
 - Natural (Break-point)
- Detention basins / reservoirs
- Hydraulic structures
 - Broad crested weirs
 - Culverts
 - Rating curves
 - Rule curves
 - Scheduled releases





Equations

- Manning's Equation
(Uniform open channel flow)

$$Q_{i-1/2} = \frac{1}{n} A_{i-1} R_{i-1}^{2/3} S_{f_{i-1/2}}^{1/2}$$

- Friction Slope (Diffusive Wave)

$$\frac{\partial h}{\partial x} = S_o - S_f$$

$= \Delta x (\text{node size})$

- Continuity

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = S$$

$= \Delta t (\text{time step})$





Solution

- Finite volume method
- Forward weighted (dependent on flow direction)
- Variable time step dependent on stability criteria
- Predictor-corrector method
 - Fluxes estimated from initial heads
 - Intermediate heads estimated from flow
 - Fluxes calculated with new heads
 - Two fluxes averaged
 - Heads updated with new fluxes
- Picard iterations until flow areas converge





Links

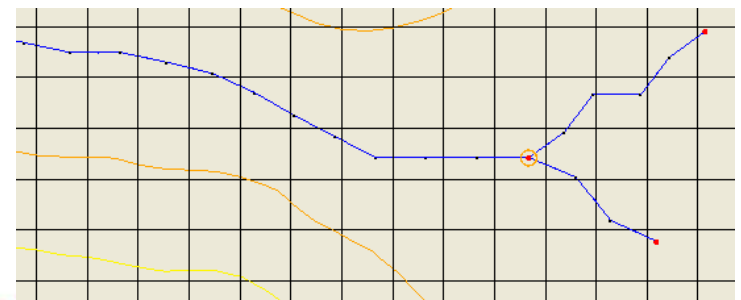
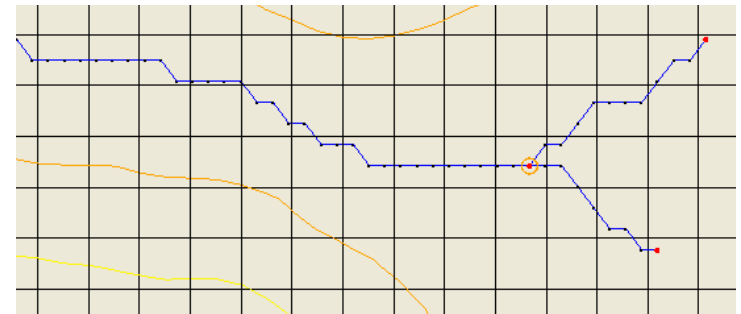
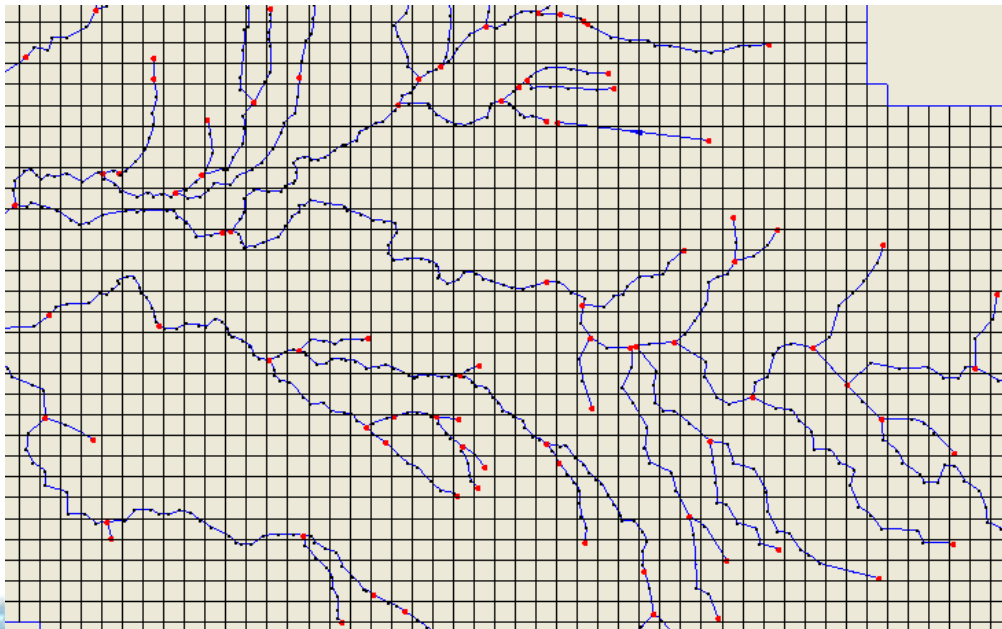
- Links represent a stream reach of uniform area.
- Transitions between cross sectional areas in links should be smooth.
- Include enough links to avoid abrupt changes in cross section or slope.





Selecting Node Size

- Small enough to capture required sinuosity.
- Large enough for numerical efficiency.
 - Channel flow tends to be a limiting factor in computational considerations





Data Needs

- Channels
 - Cross-section profile
 - Thalweg profile
 - Roughness
- Detention Basins
 - Min, Max, Initial water surface elevation
- Hydraulic Structures
 - Geometry, hydraulic coefficients





Data Sources

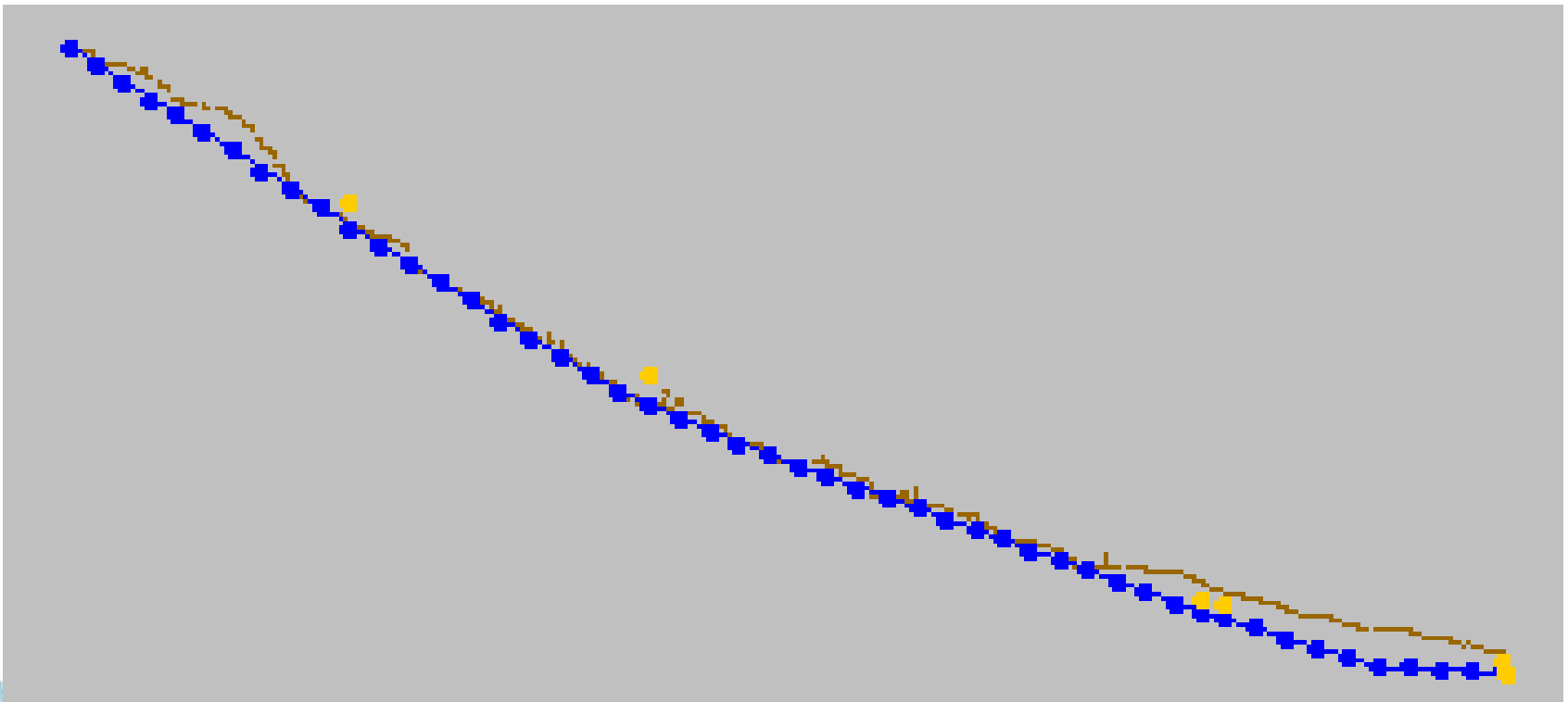
- Stream locations
 - GIS data
 - Derived from DEM data
- Stream shape
 - Surveyed data
 - Estimated
- Stream Roughness
 - Estimated from photos, calibrated





Vertical Thalweg Profile

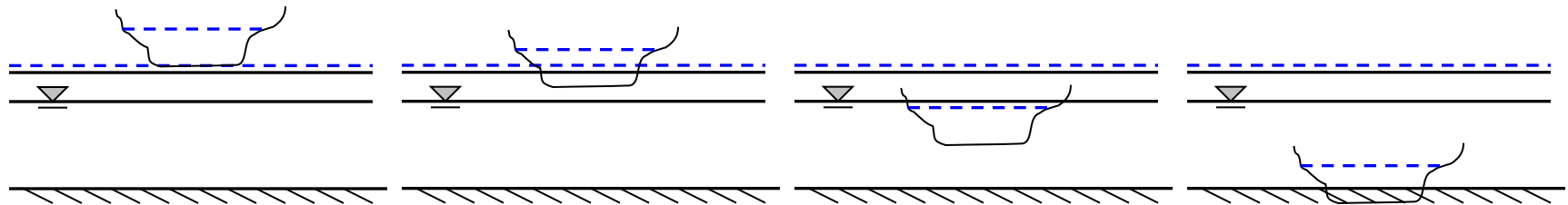
- Can be estimated relative to the land surface
- Must be relatively smooth, may contain small adverse slopes





Integrating the Channel Model: Vertical Location

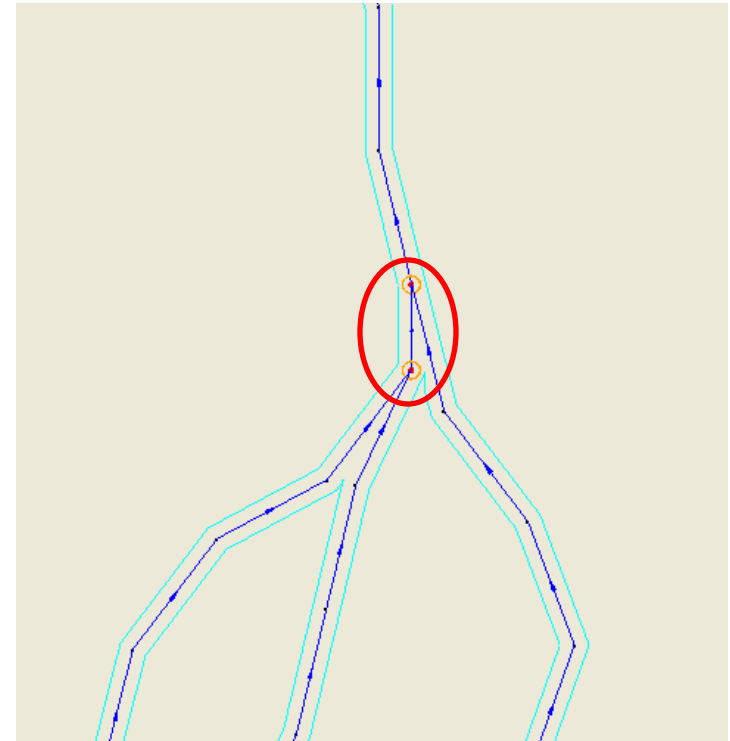
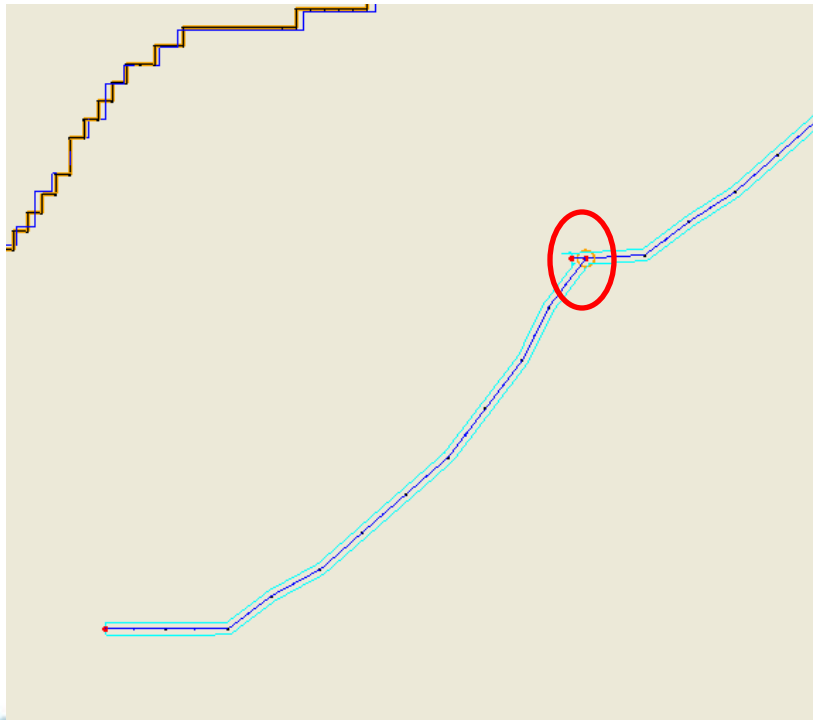
- Full interaction with:
 - Overland flow
 - Groundwater





Integrating the Channel Model: Horizontal Location

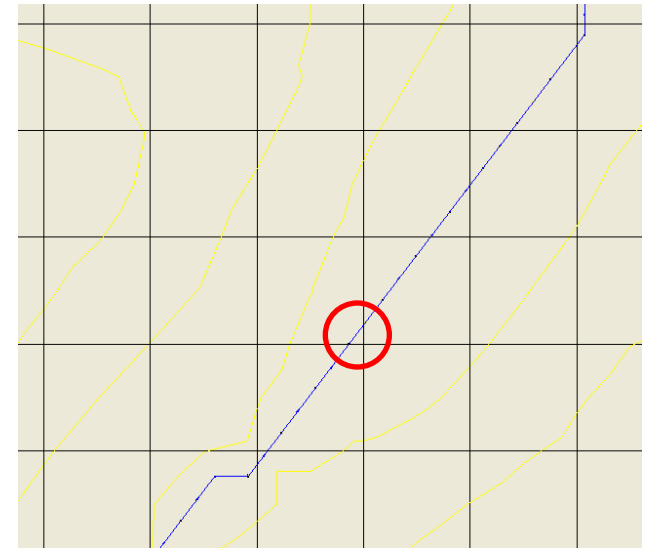
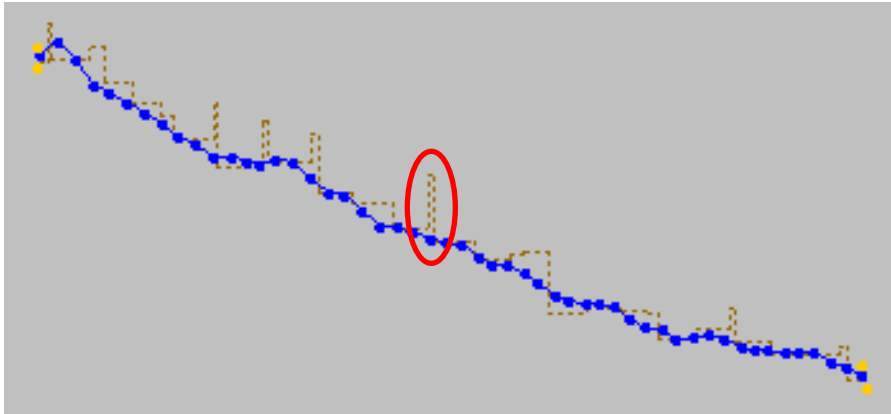
- Remove very short streams (1 node streams)





Integrating the Channel Model: Horizontal Location

- Adjust nodes laterally to lie in lowest nearby cells
- Caused by cell size differences between DEM and GSSHA grids.





Start Simple, Build on Success

- Start with the main channel.
- Add lower order streams as necessary.
- Stop adding lower order streams when the addition of more streams no longer affects the observations of interest.





Eau Galle River, Wisconsin

