

Use of 2D Hydrodynamic Models for Stream Restoration Assessment and Design

CTU-Prague: 143SRPP Seminar 1
Winter 2019 Semester

**Ecohydraulics
Approach**

Model Basics

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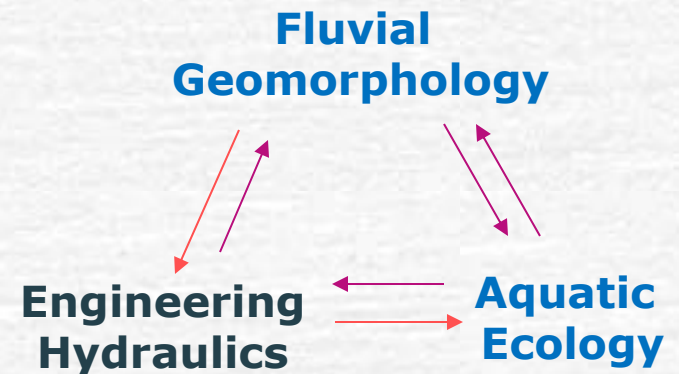
The University of Tennessee at Knoxville

Department of Civil and Environmental Engineering



Ecohydraulic Habitat-based Criteria for Stream Restoration Design

- **Incorporating ecological criteria into the restoration design process by linking multi-dimensional hydraulics with organism use of stream habitat.**
- **Stream restoration practices need to consider bank and bed structure, and multiple stages, in the design process.**
- **A 2D hydrodynamic model is a necessary design tool when lateral habitat is considered.**

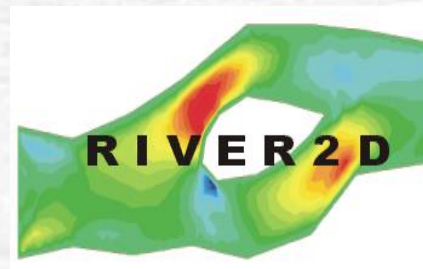


Two-Dimensional Hydrodynamic Models

- Two-dimensional (2D) hydrodynamic models are many: River2D, HEC-RAS-2D, RMA-2V, MIKE21, others.
- 2D hydrodynamic models fundamentally are the same applying the principles of mass and momentum conservation (depth-averaged St. Venant equations), but different in meshing schemes and numerical solution techniques to route mass and momentum.
- River2D uses a finite element unstructured mesh design.
- River2D download site:

<http://www.river2d.ualberta.ca/>

Freeware



Steffler (2002)

River 2D: A Two-Dimensional Hydrodynamic Model

Model Structure: *the operational basics*

➤ **Three Separate Modules:**

1. **R2D_Bed.exe** --- **Used to create a topographic surface**
2. **R2D_Mesh.exe** --- **Used to generate a finite element mesh that lies over the topographic surface to route water mass and momentum from cell to cell**
3. **River2D.exe** --- **Performs the hydraulic modeling per topo and mesh files, and given boundary conditions**
Boundary Conditions – discharge, exit boundary water surface elevation, initial guess at upstream water surface elevation
Computes Steady and Transient Flows (v.95)

Habitat sub-module is in River2D.exe

River 2D: A Two-Dimensional Hydrodynamic Model

Model Set-Up and Computing...

text (.txt) tab delimited file*

Example:
Beaver Creek, Knox Co.,
Halls Crossing



File	Edit	Format	View	Help					
1	786913.259000	196031.472900	309.350054	0.120000					
2	786979.901700	195940.487100	309.715814	0.120000					
3	786988.202300	195925.424400	309.725575	0.120000					
4	787010.528600	195898.318000	309.580212	0.120000					
5	787033.018900	195874.349300	309.543604	0.120000					
6	786968.227500	195933.009000	310.153962	0.120000					
7	787004.524000	195880.716300	310.747666	0.120000					
8	786921.081400	195984.081400	310.282839	0.120000					
9	787036.261900	195851.159000	309.671088	0.120000					
10	787035.138100	195854.197400	309.646801	0.120000					
11	787032.879000	195857.451200	309.664652	0.120000					
12	787027.675400	195862.996400	309.673005	0.120000					
13	787026.388900	195865.298800	309.636946	0.120000					
14	787024.819100	195866.955300	309.705173	0.120000					
15	787023.335100	195869.095200	309.694584	0.120000					
16	787022.347200	195871.019800	309.300985	0.120000					
17	787021.635200	195872.243600	309.521728	0.120000					
18	787020.361400	195873.180400	309.608859	0.120000					
19	787019.402200	195873.624200	309.635800	0.120000					
20	787017.876100	195876.329200	309.606206	0.120000					
21	787016.226500	195878.844800	309.521894	0.120000					
22	787013.914600	195881.182800	309.646542	0.120000					
23	787012.328400	195883.165200	309.661473	0.120000					
24	787010.414600	195885.793500	309.631703	0.120000					
25	787008.281600	195888.512700	309.661018	0.120000					
26	787006.115400	195890.736400	309.613470	0.120000					

↓

X

Y

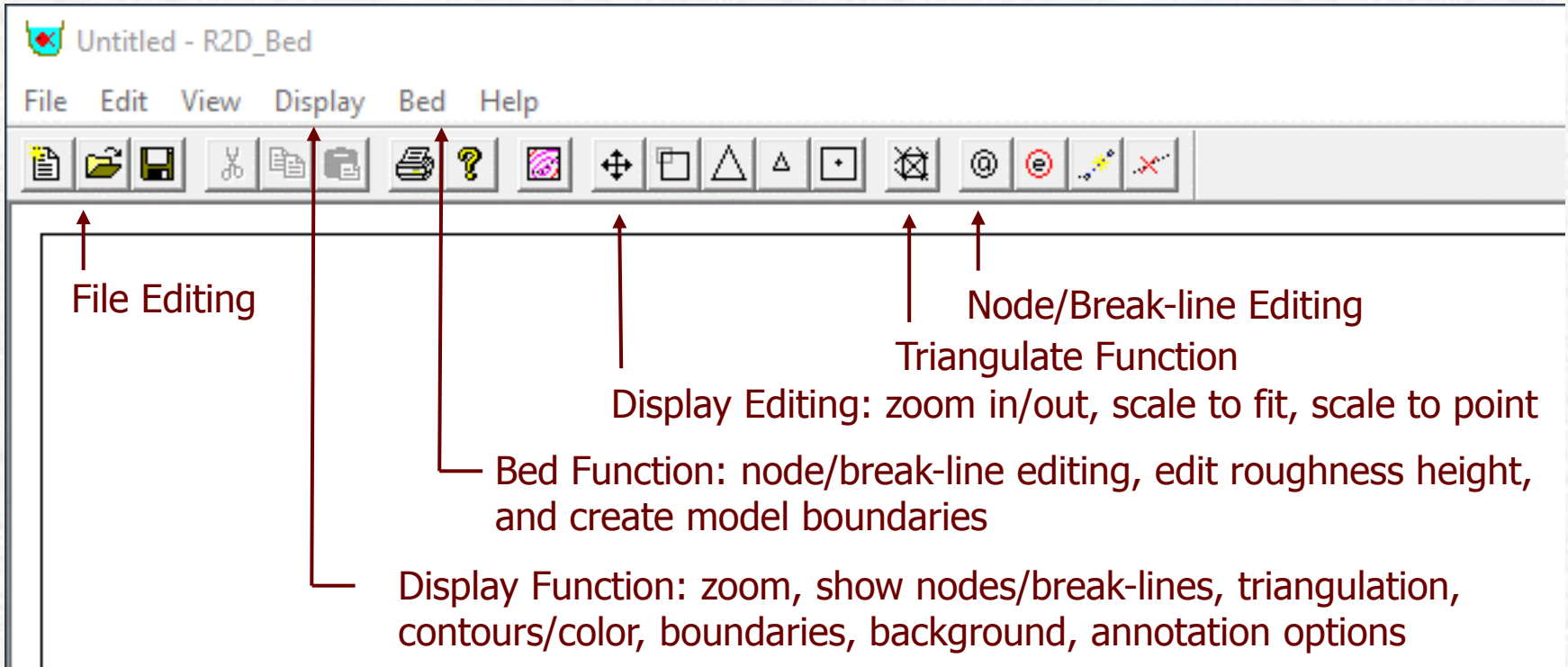
Z

k_s

X,Y = plan coordinates, Z = elevation, k_s = roughness height

River 2D: A Two-Dimensional Hydrodynamic Model

R2D_Bed.exe --- Used to create a topographic surface



The screenshot shows the R2D_Bed.exe software interface. The title bar reads "Untitled - R2D_Bed". The menu bar includes "File", "Edit", "View", "Display", "Bed", and "Help". The toolbar contains various icons for file operations (New, Open, Save, Print, Help), display editing (Zoom, Scale, Fit, Point), and bed function operations (Node/Break-line editing, Triangulate, Boundaries, Background, Annotation). Red arrows point from text labels to specific icons in the toolbar.

File Editing

Node/Break-line Editing

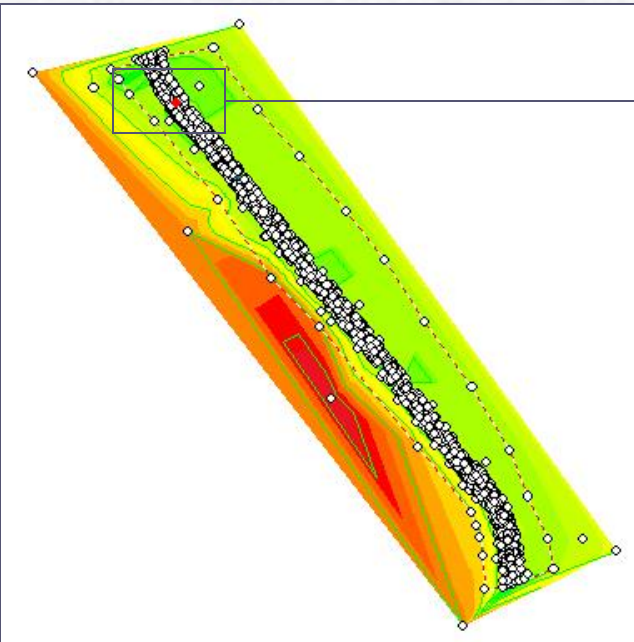
Triangulate Function

Display Editing: zoom in/out, scale to fit, scale to point

Bed Function: node/break-line editing, edit roughness height, and create model boundaries

Display Function: zoom, show nodes/break-lines, triangulation, contours/color, boundaries, background, annotation options

River2D: R2D_Bed Module

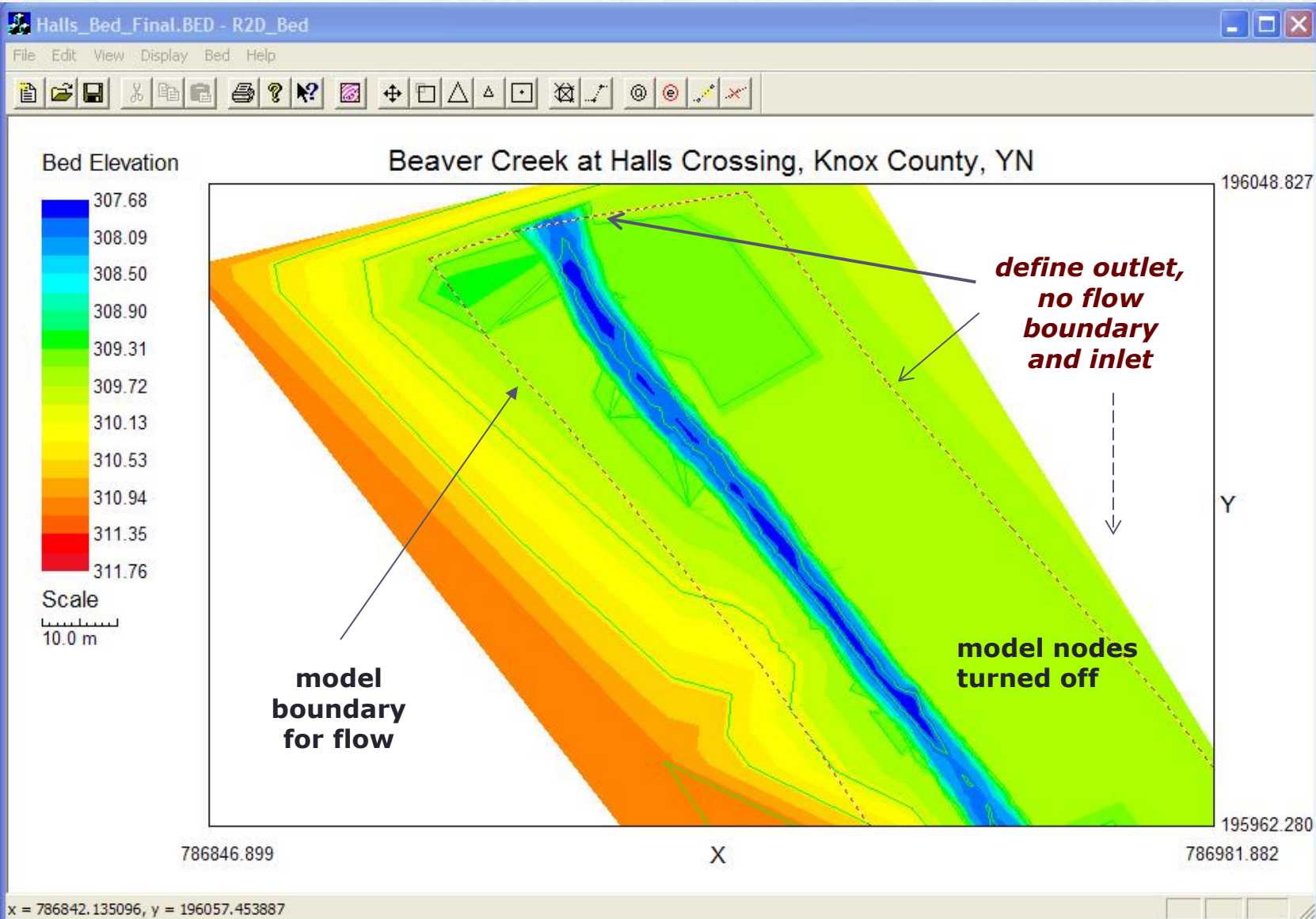


Each node has a unique x, y coordinate, bed elevation, and roughness height (ks)

Field	Value	Label
bed	code	code
786903.3591	x coordinate	x coordinate
196024.6989	y coordinate	y coordinate
307.952776	bed elevation	bed elevation
0.275	roughness height	roughness height

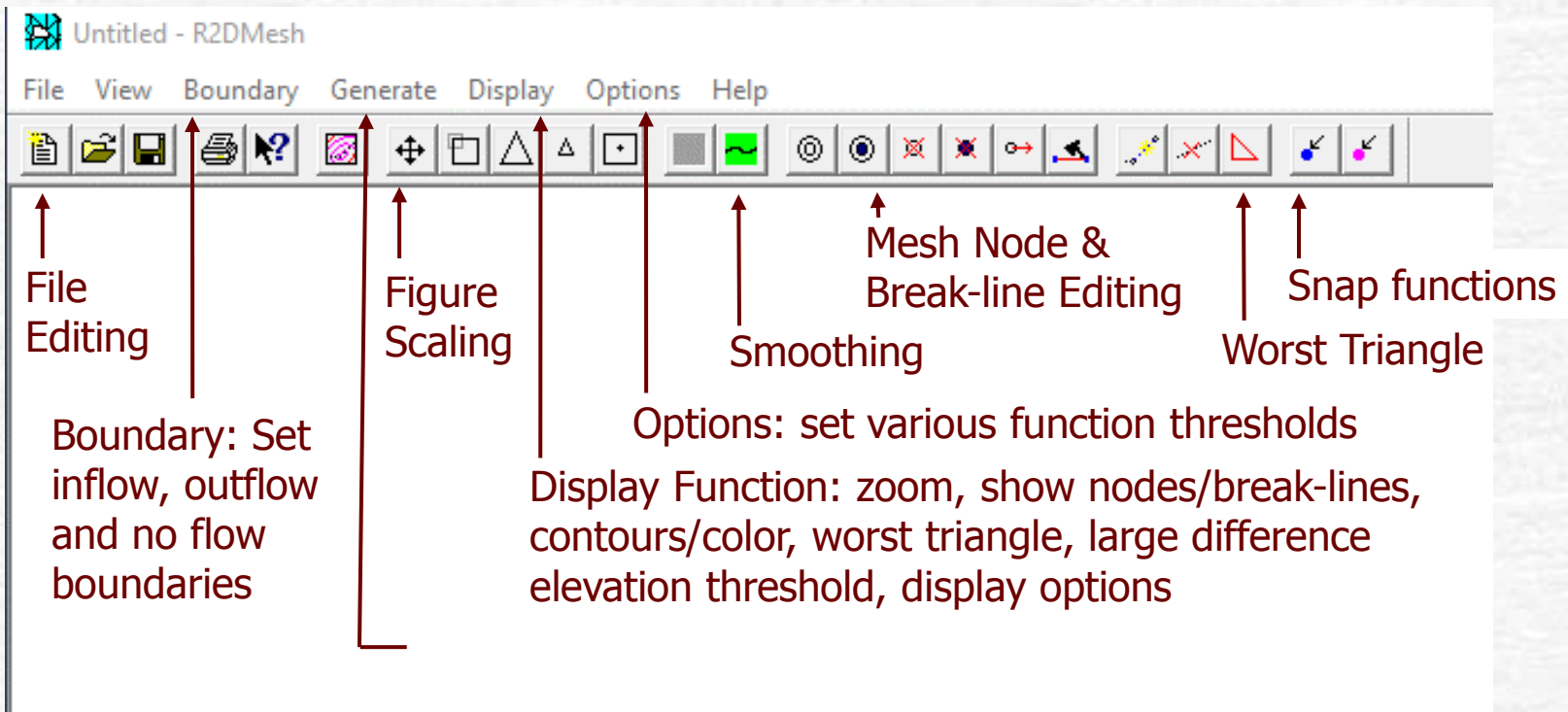
Buttons: Change Node, Delete Node, Next Node, New Node, Done

River2D: R2D_Bed Module



River 2D: A Two-Dimensional Hydrodynamic Model

R2D_Mesh.exe --- Used to generate a finite element mesh that lies over the topographic surface (bed file) to route water mass and momentum from cell to cell



The screenshot shows the R2D_Mesh.exe software interface. The title bar reads "Untitled - R2DMesh". The menu bar includes "File", "View", "Boundary", "Generate", "Display", "Options", and "Help". The toolbar contains various icons for file operations, mesh generation, and display functions. Red arrows point from text labels to specific icons in the toolbar.

File Editing

Boundary: Set inflow, outflow and no flow boundaries

Figure Scaling

Options: set various function thresholds

Display Function: zoom, show nodes/break-lines, contours/color, worst triangle, large difference elevation threshold, display options

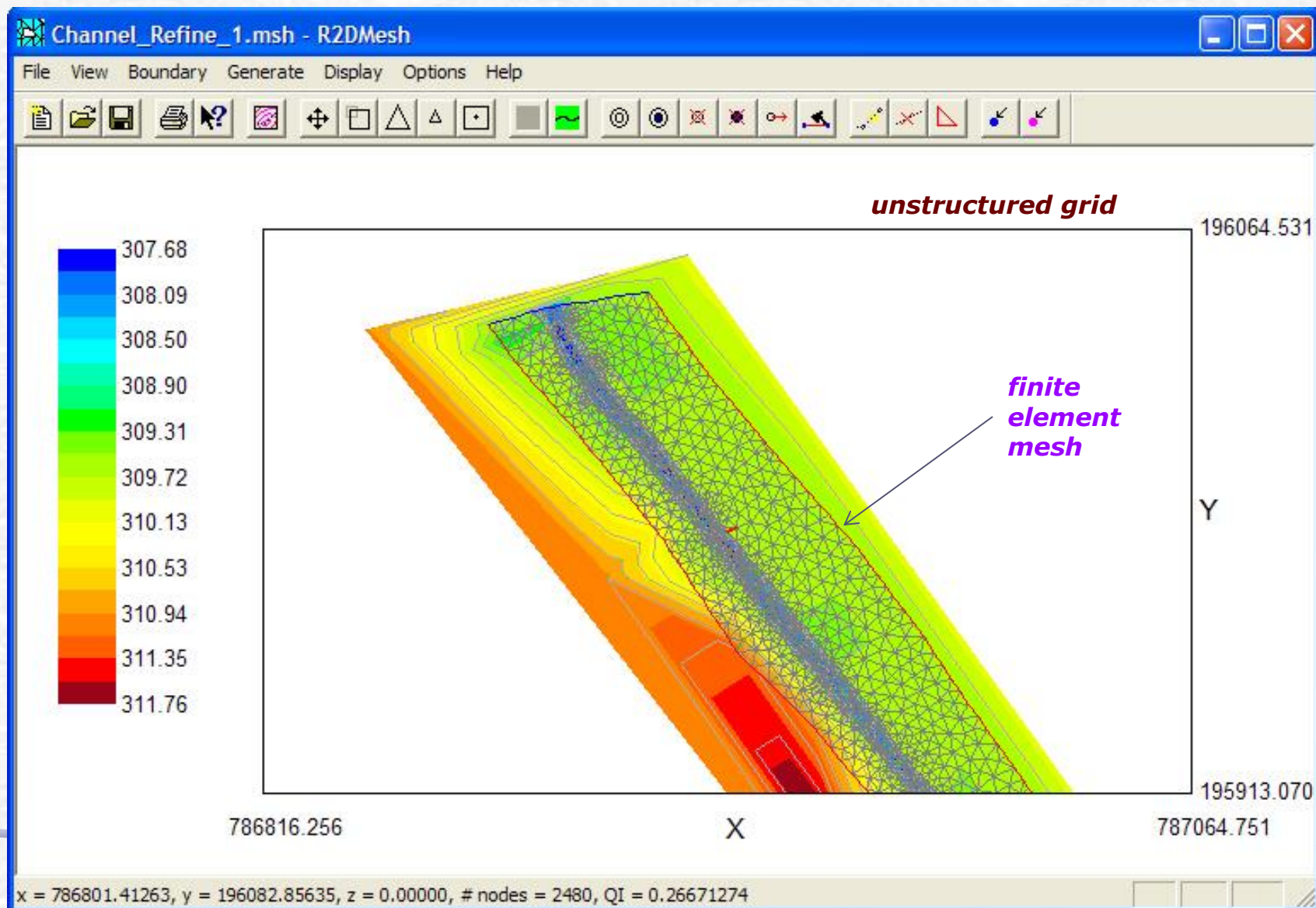
Smoothing

Mesh Node & Break-line Editing

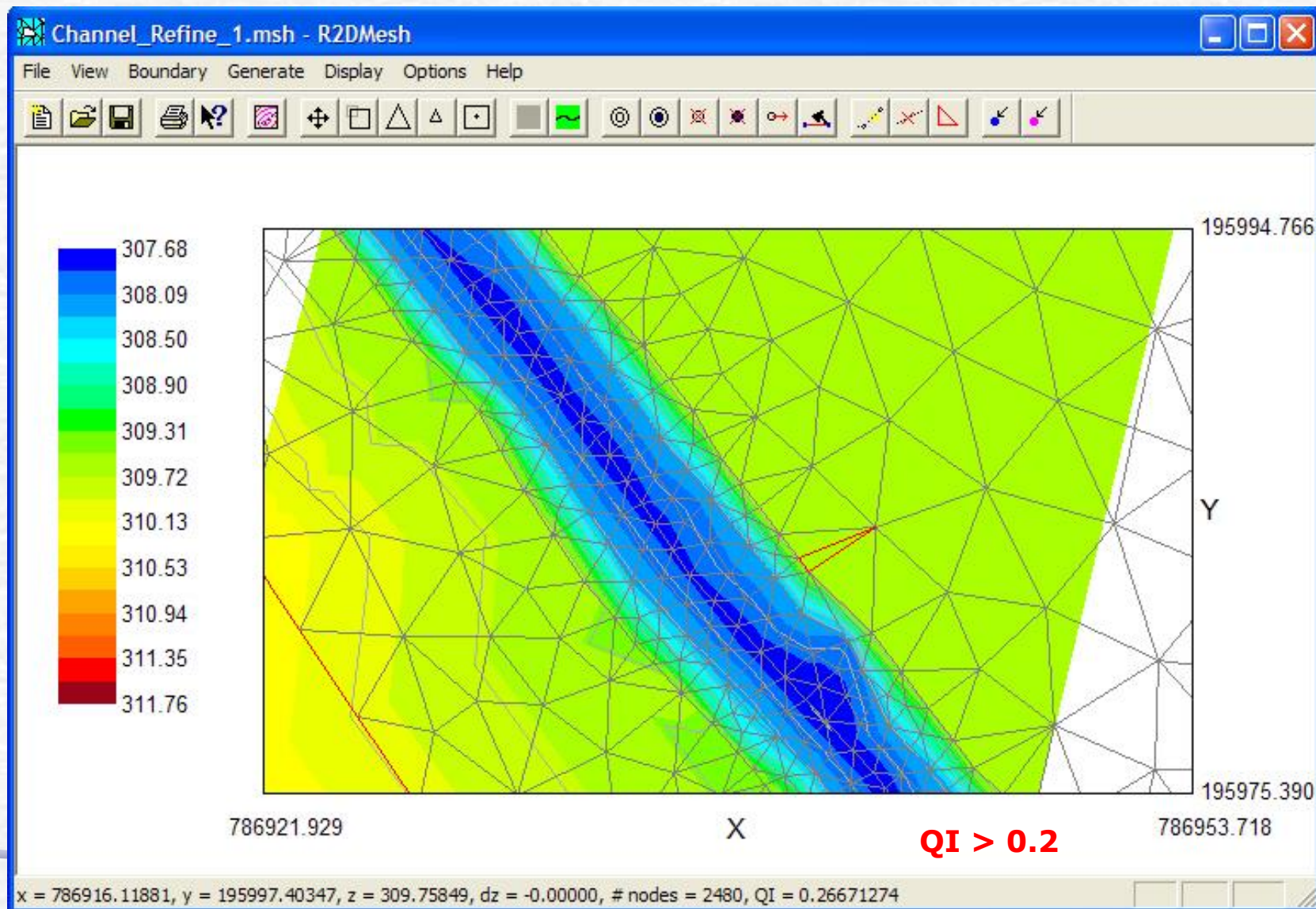
Worst Triangle

Snap functions

River2D: R2D_Mesh Module

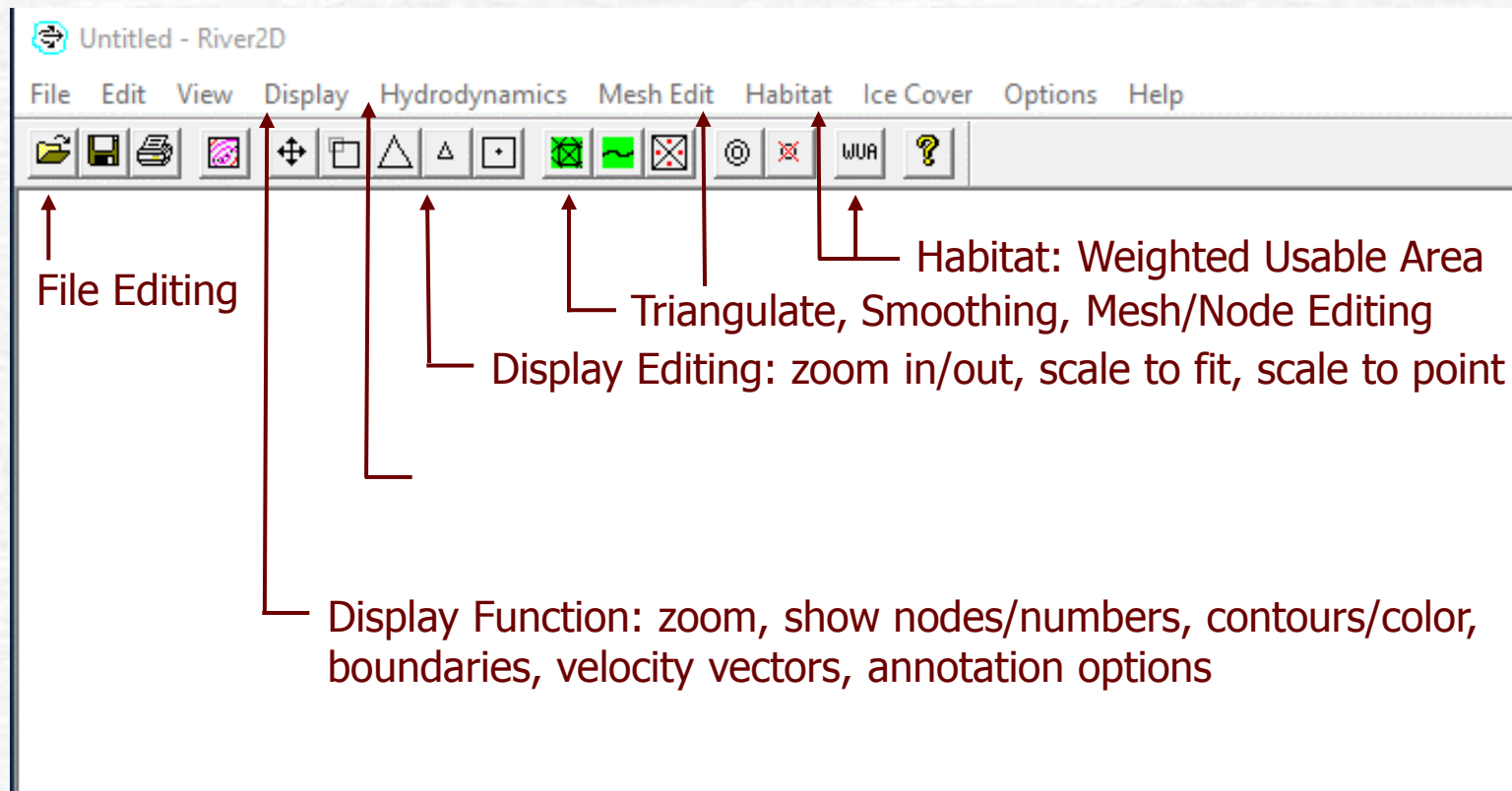


River2D: R2D_Mesh Module



River 2D: A Two-Dimensional Hydrodynamic Model

River2D.exe --- Performs the hydraulic modeling per topo and mesh files, and given boundary conditions



The image shows a screenshot of the River2D software interface. The window title is "Untitled - River2D". The menu bar includes File, Edit, View, Display, Hydrodynamics, Mesh Edit, Habitat, Ice Cover, Options, and Help. The toolbar contains various icons for file operations, display editing, mesh editing, and habitat calculation. Red arrows point from text labels to specific icons in the toolbar.

File Editing

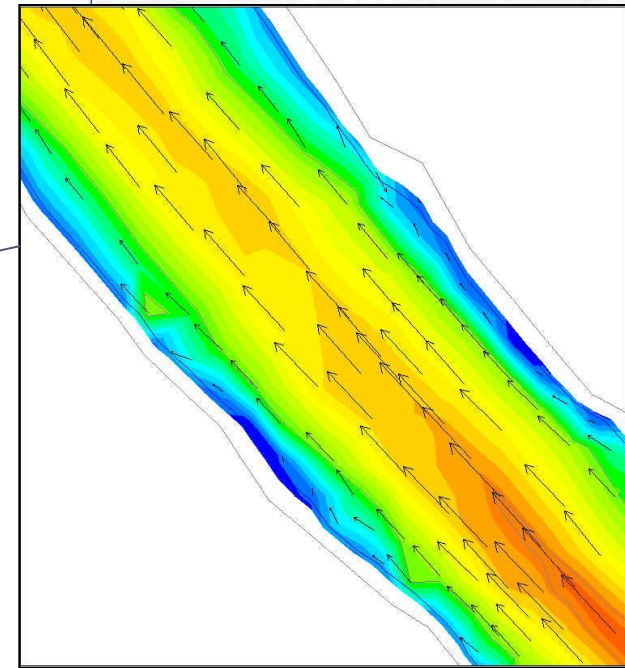
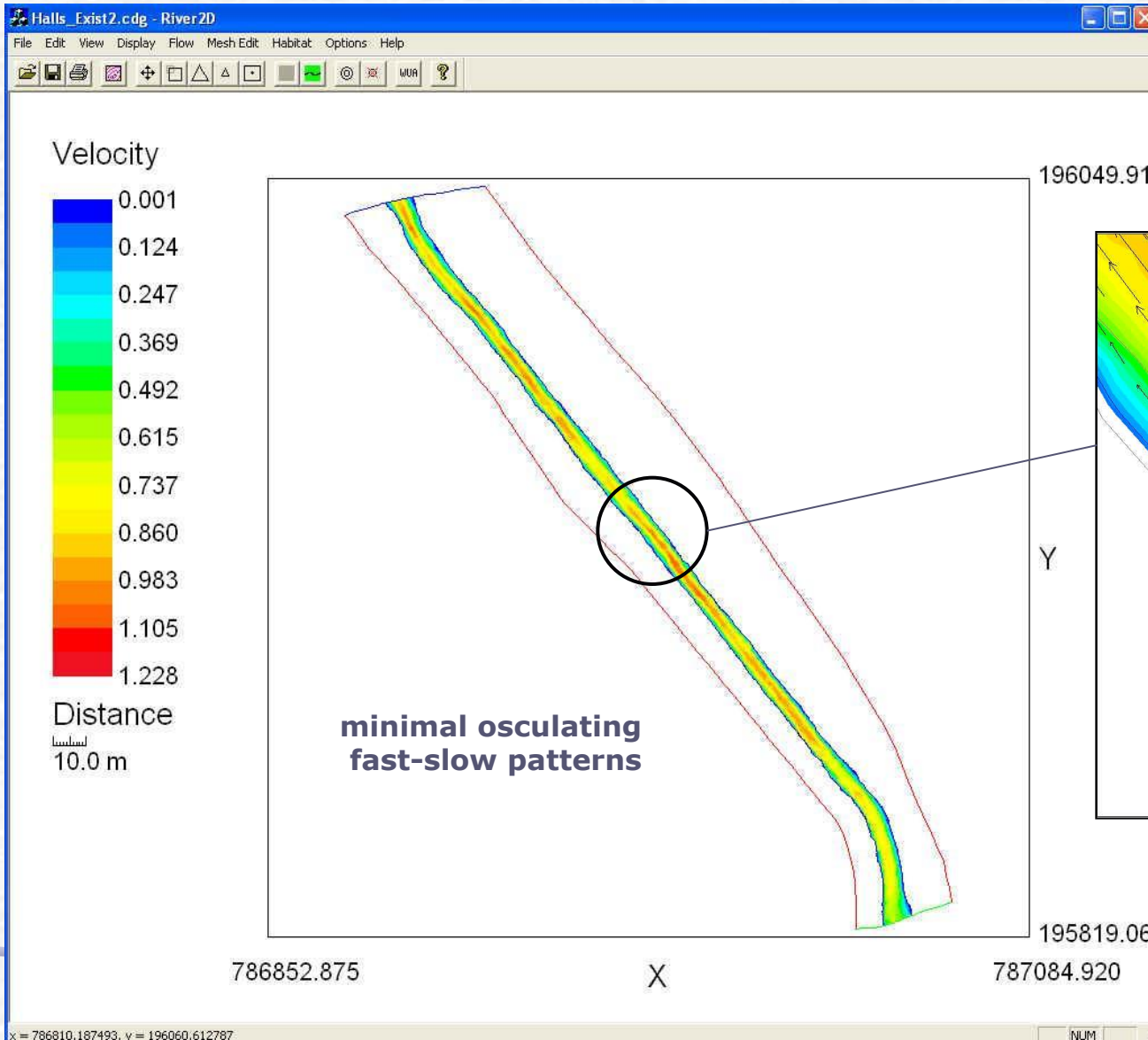
Display Function: zoom, show nodes/numbers, contours/color, boundaries, velocity vectors, annotation options

Display Editing: zoom in/out, scale to fit, scale to point

Triangulate, Smoothing, Mesh/Node Editing

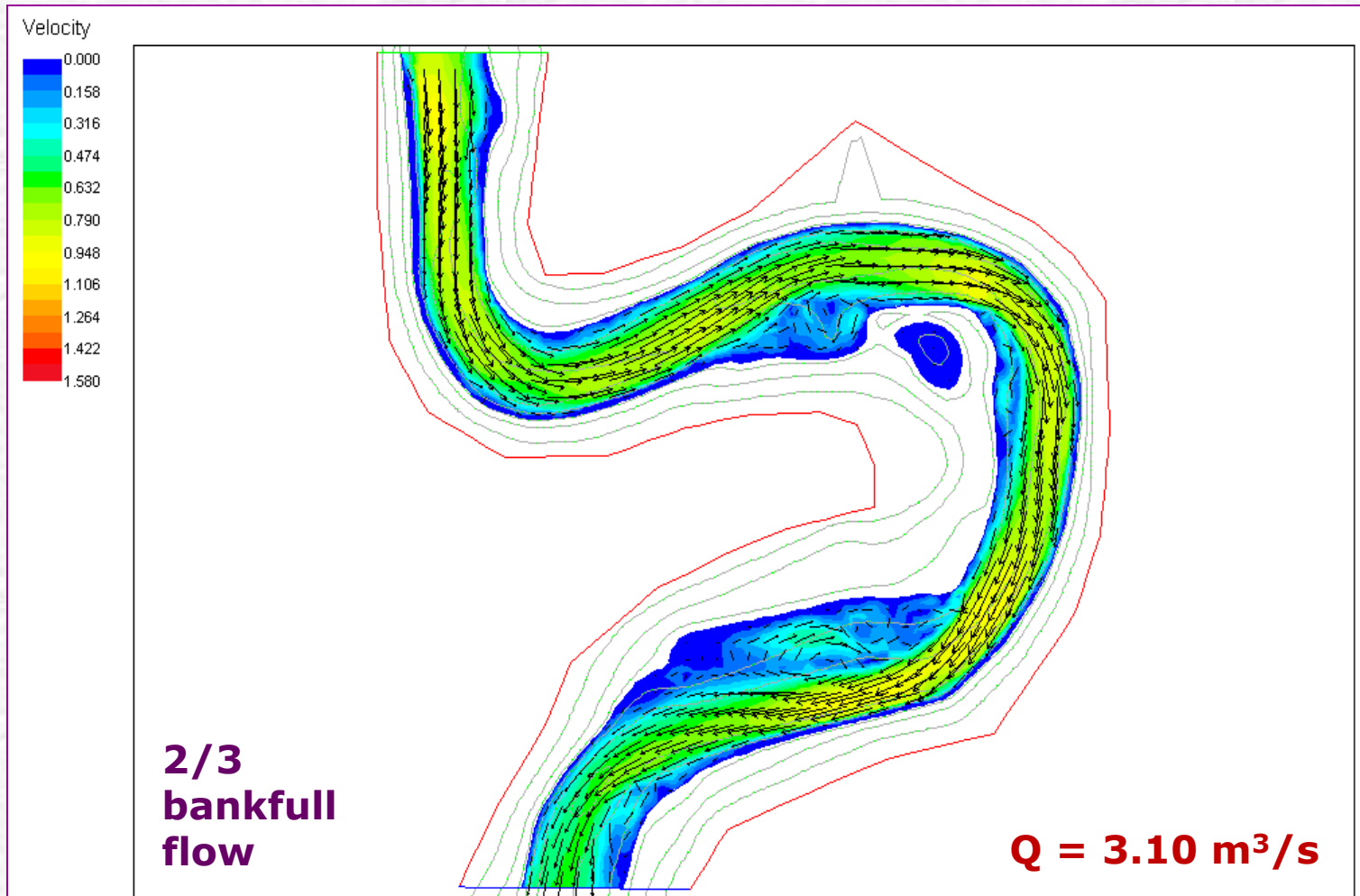
Habitat: Weighted Usable Area

River2D.exe Hydraulic Module



vector output

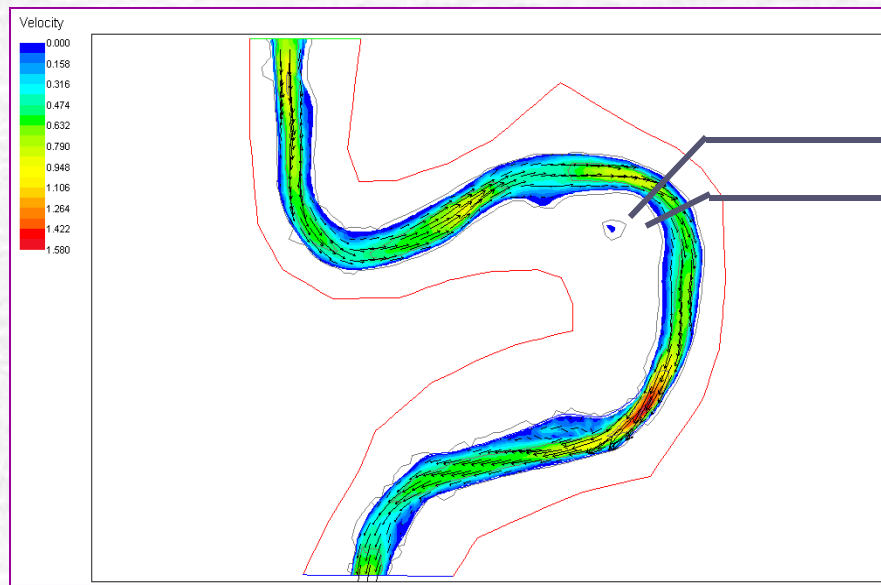
River2D Model Example Output



Embarras River, Champaign County, Illinois

Verification of River2D Model Output

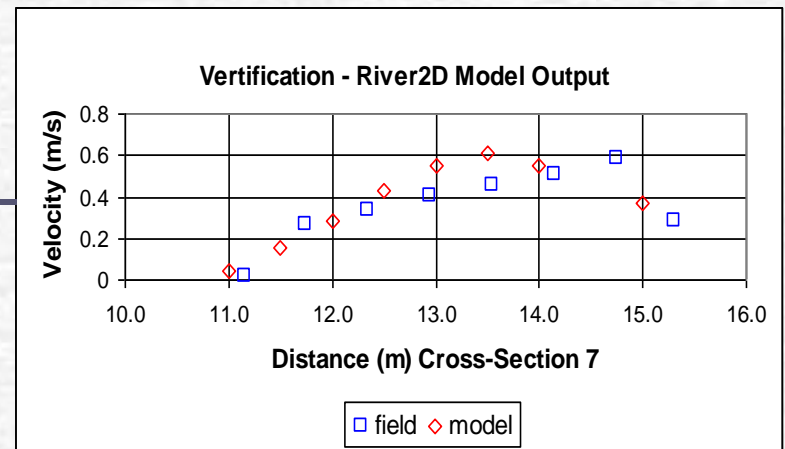
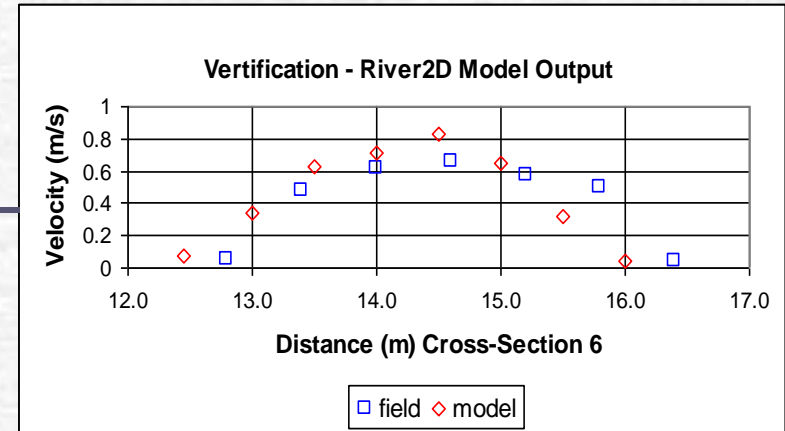
Embarras River Meandering Reach



$$Q = 0.95 \text{ m}^3/\text{s}$$

1/3
bankfull
flow

depth-averaged, downstream velocities



River2D Model – Exercise 1

- Learn basic model functions for bed mesh, and hydraulic modeling modules.
- Use Embarras River topo and ks data provided in file: **EmbarHS.bed**

Topographic file has been smoothed with CAD

Photos:
Embarras River
Champaign County, IL

