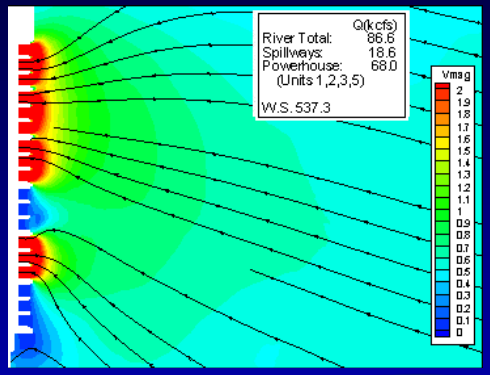
ADaptive Hydrology/Hydraulics Modeling System

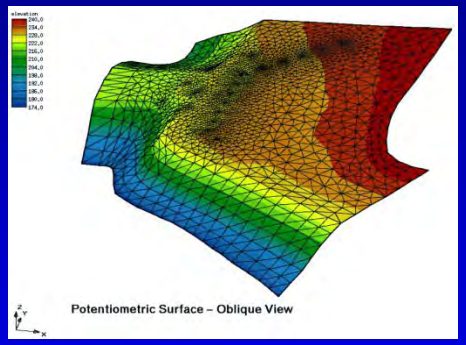
The focus on open channel flow

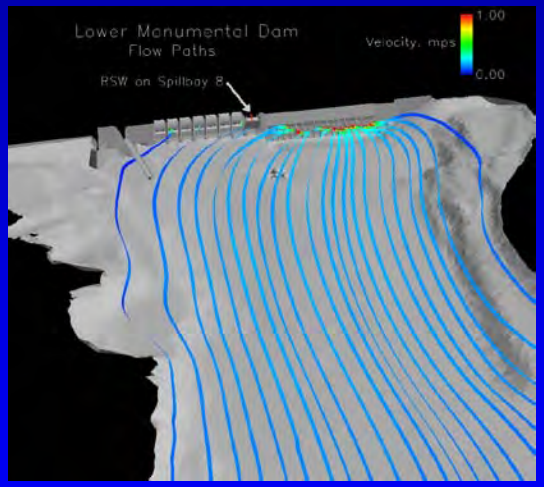
ADH Philosophy

Navier-Stokes Equations

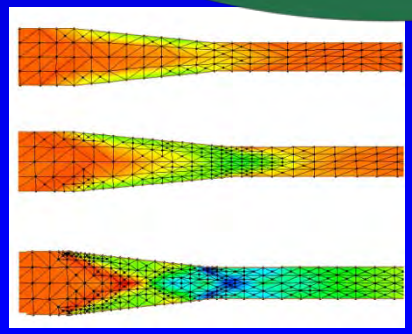


Unsaturated Groundwater Equations

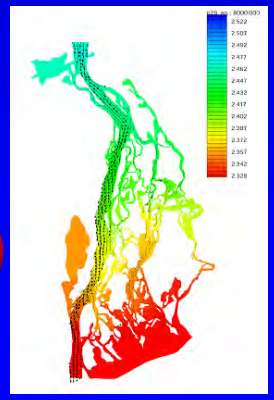




Computational Engine
(FE utilities, preconditioners, solvers, I/O to xMS GUIs)



Shallow Water Equations

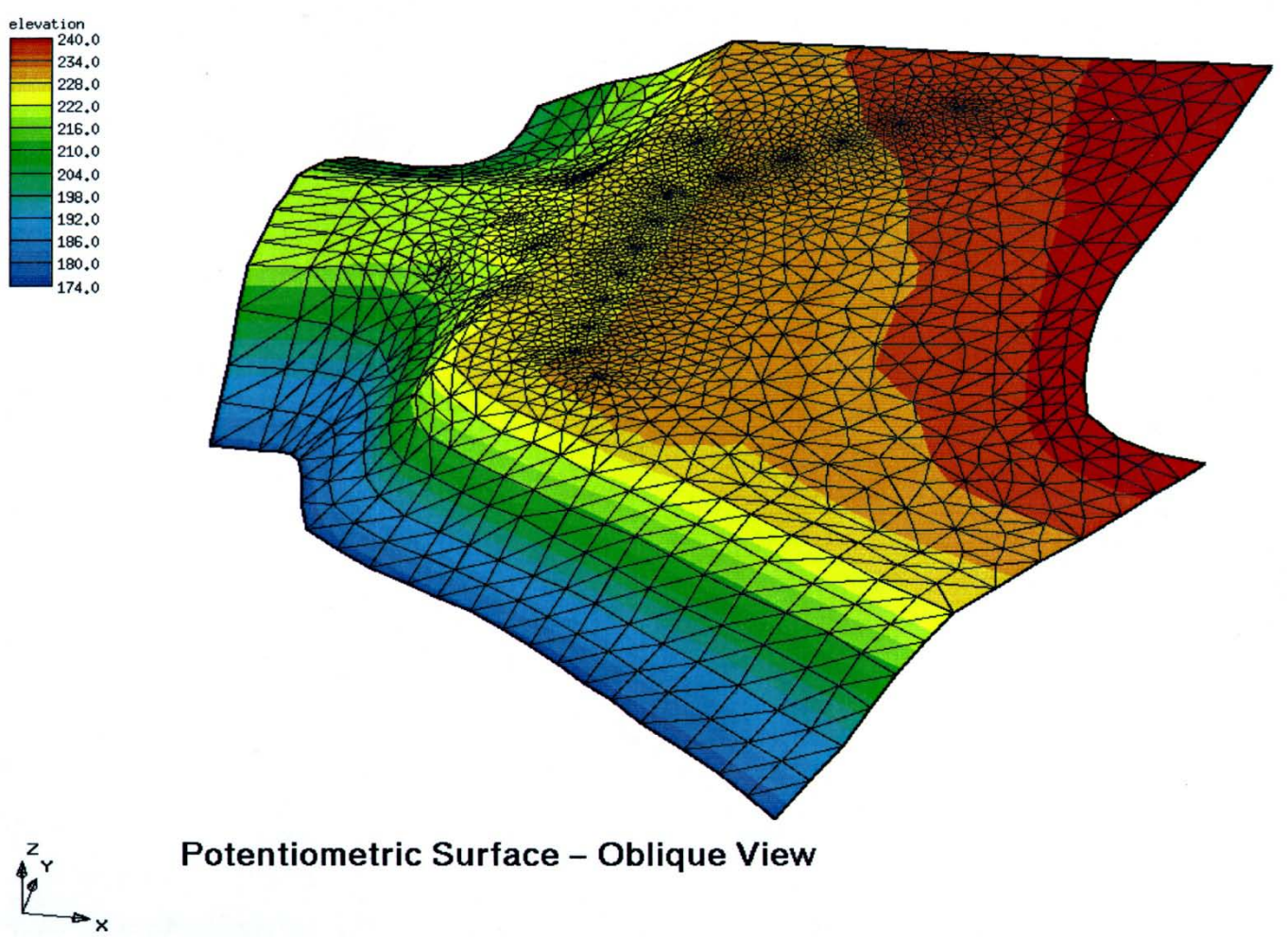


ADH

- Unstructured
- Portable (PC, Unix, Linux)
- Parallel or single processor
- Multi-Physics
- Conservative
- Adaption

Multi-Physics

Predicted Water Table Elevations

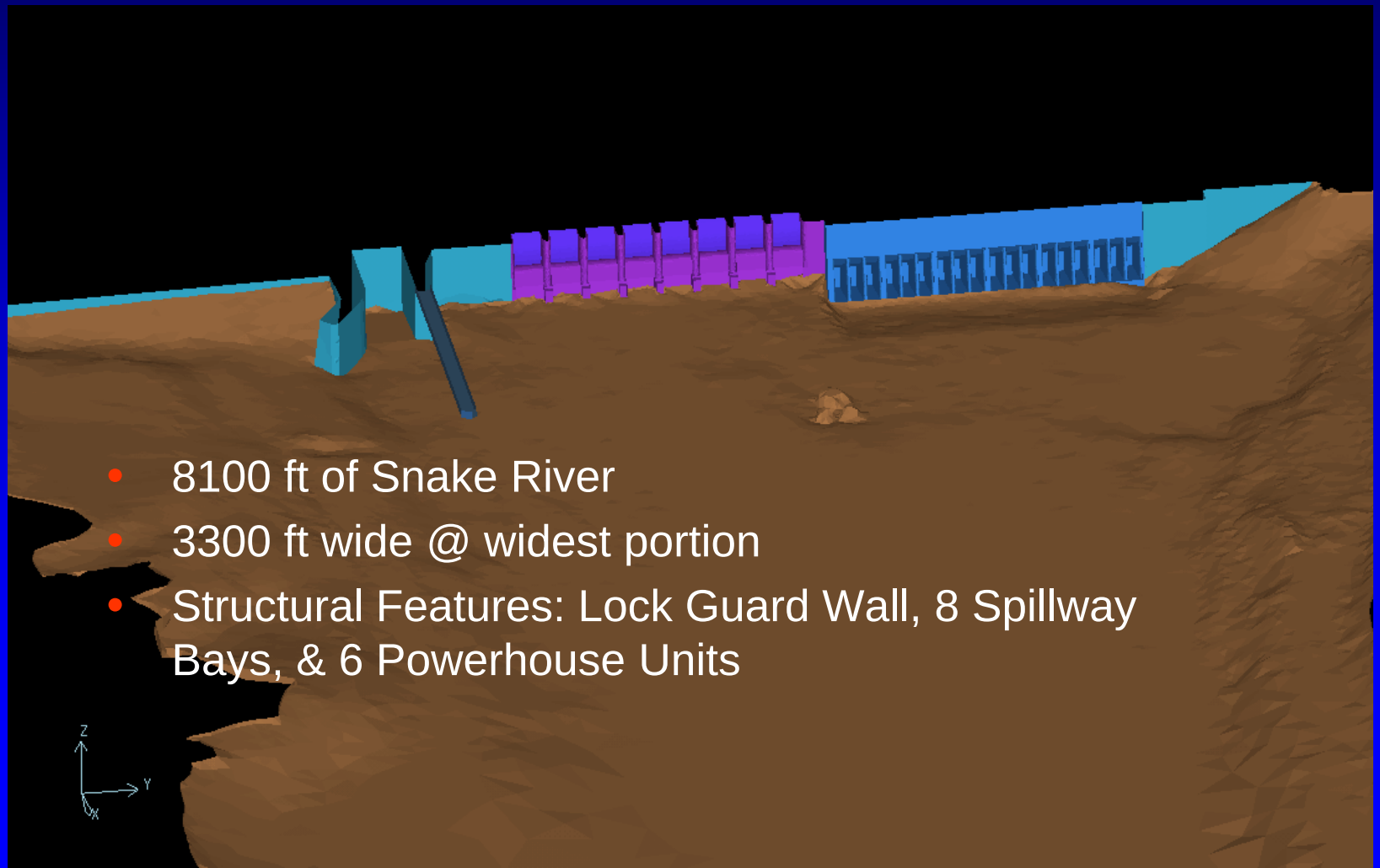


Potentiometric Surface – Oblique View

Computational Hydraulic Model of the Lower Monumental Dam Forebay

Richard Stockstill, Charlie Berger, John Hite,
Alex Carrillo, & Jane Vaughan
Coastal & Hydraulics Laboratory

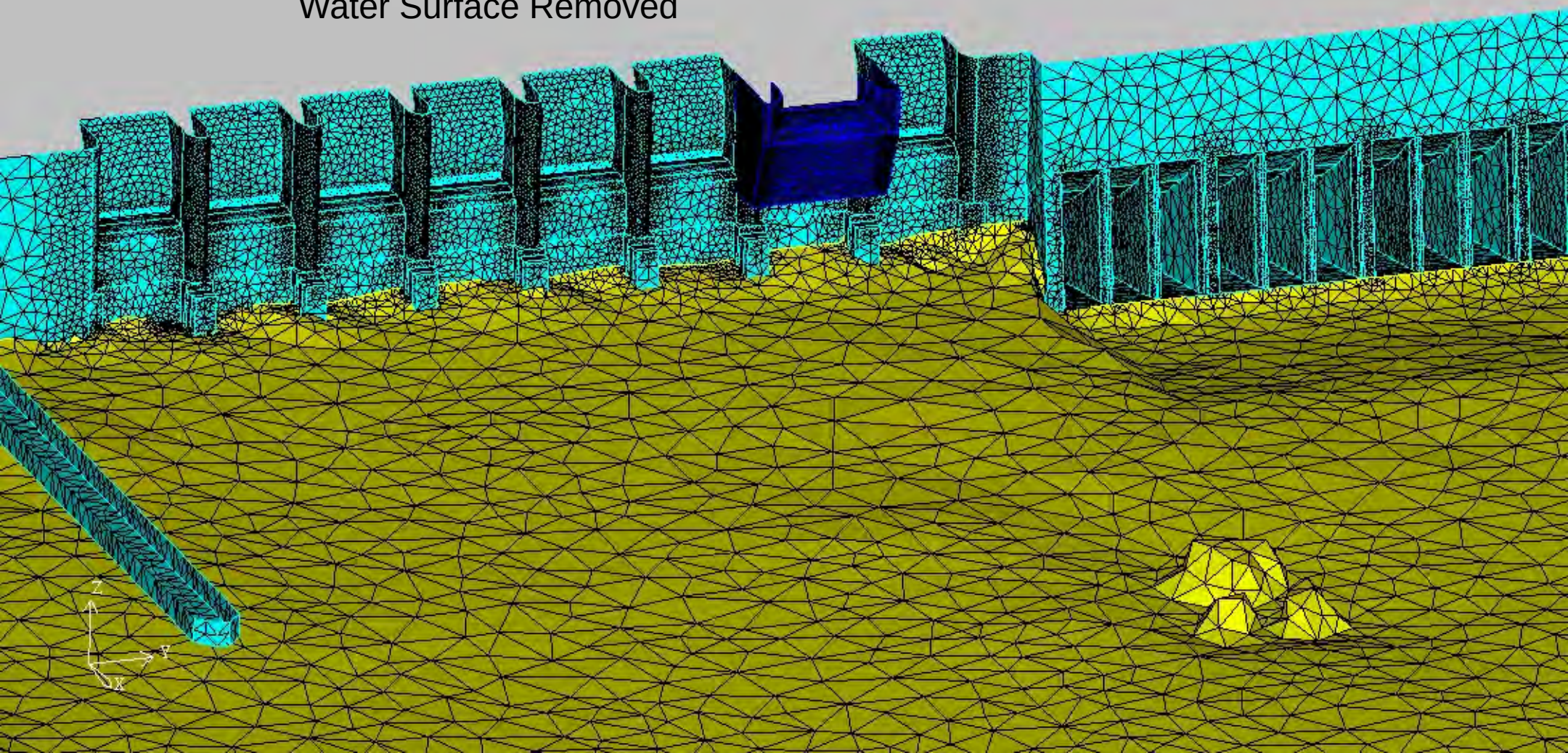
Lower Monumental Model

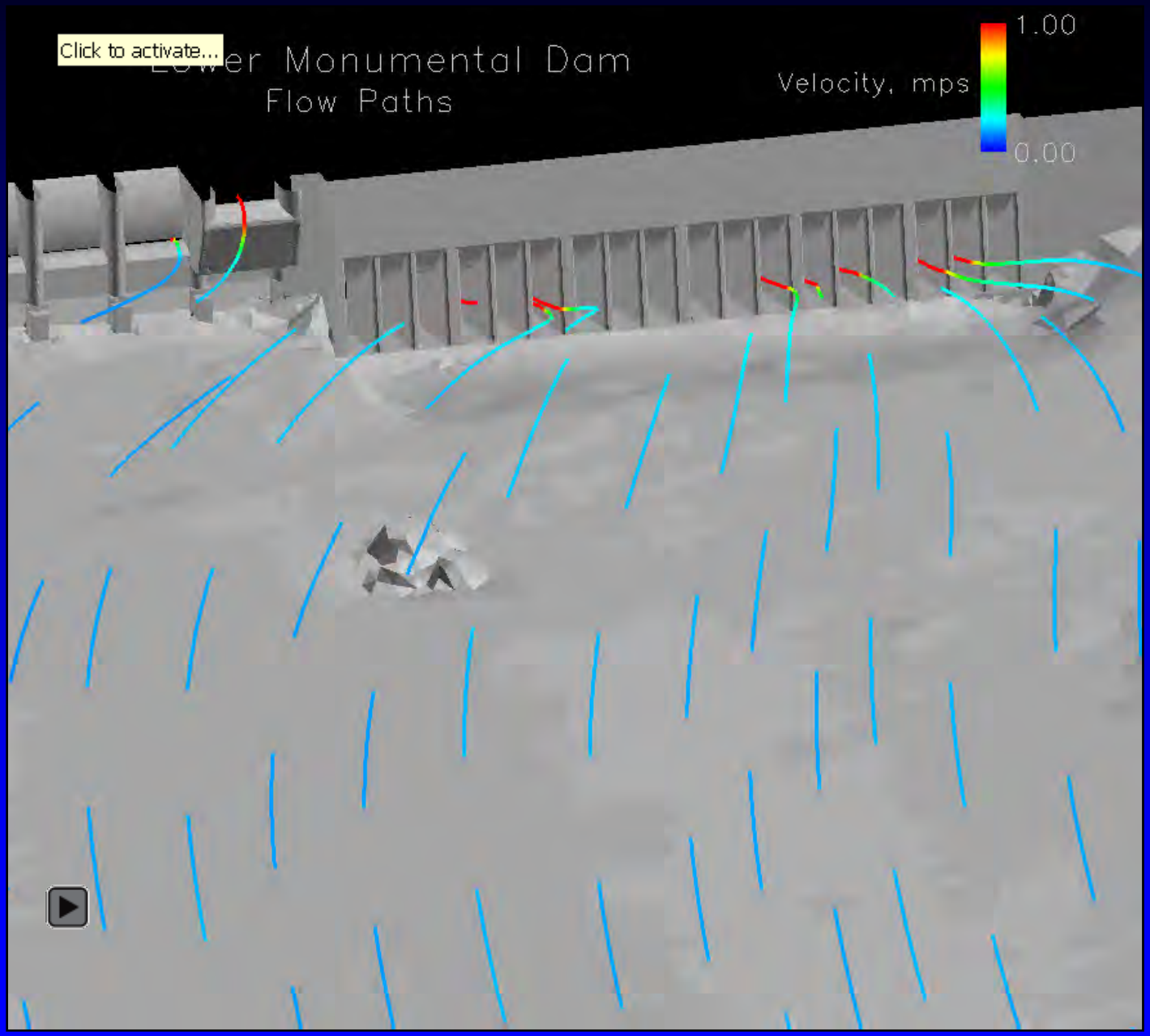


- 8100 ft of Snake River
- 3300 ft wide @ widest portion
- Structural Features: Lock Guard Wall, 8 Spillway Bays, & 6 Powerhouse Units

Surface Mesh Near Structure

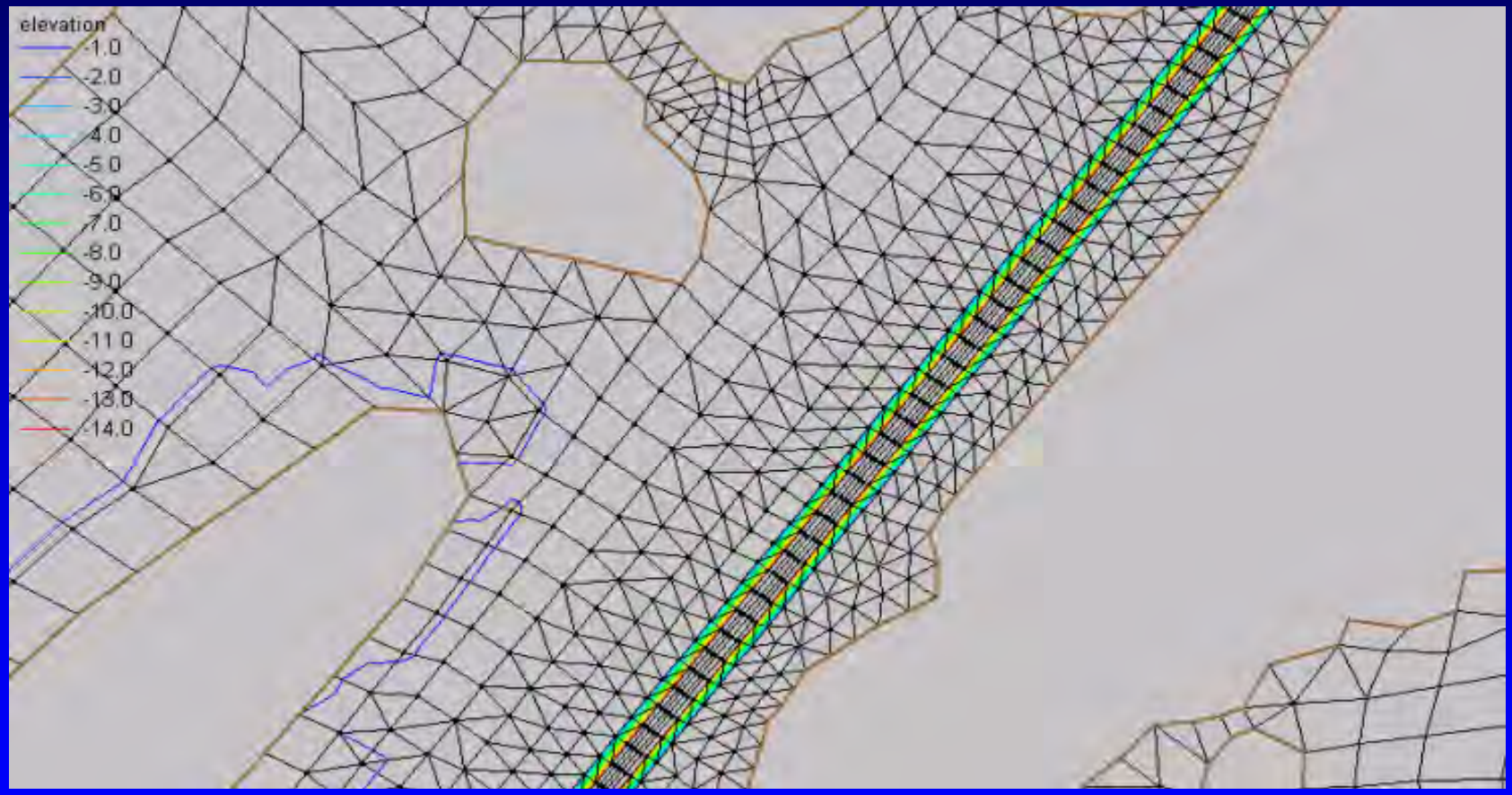
Water Surface Removed



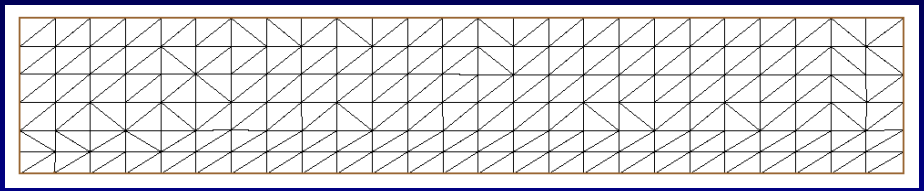

Click to activate...
Lower Monumental Dam
Flow Paths
Velocity, mps
1.00
0.00

Adaption Idea

Modeling Requires a Mesh



How important is grid resolution? Adaption Needs

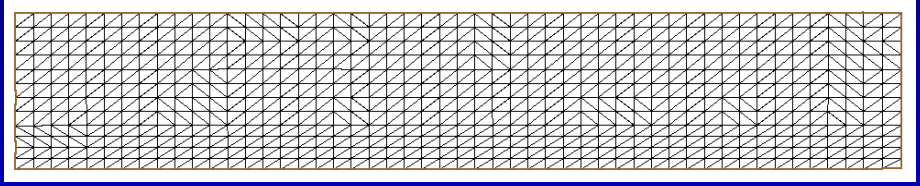


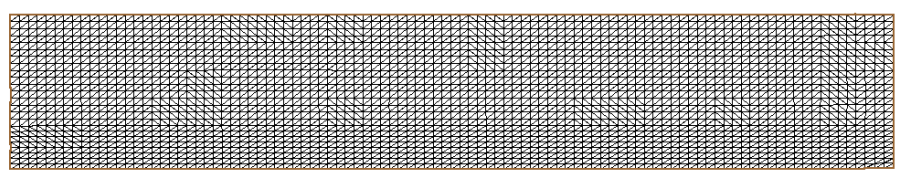
Coarse Mesh

182 nodes/300 elements

Refined Mesh #1

663 nodes/1200 elements



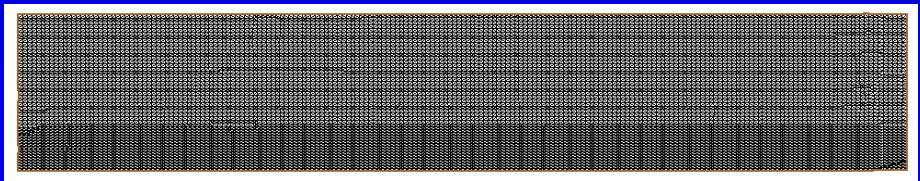


Refined Mesh #2

2525 nodes/4800 elements

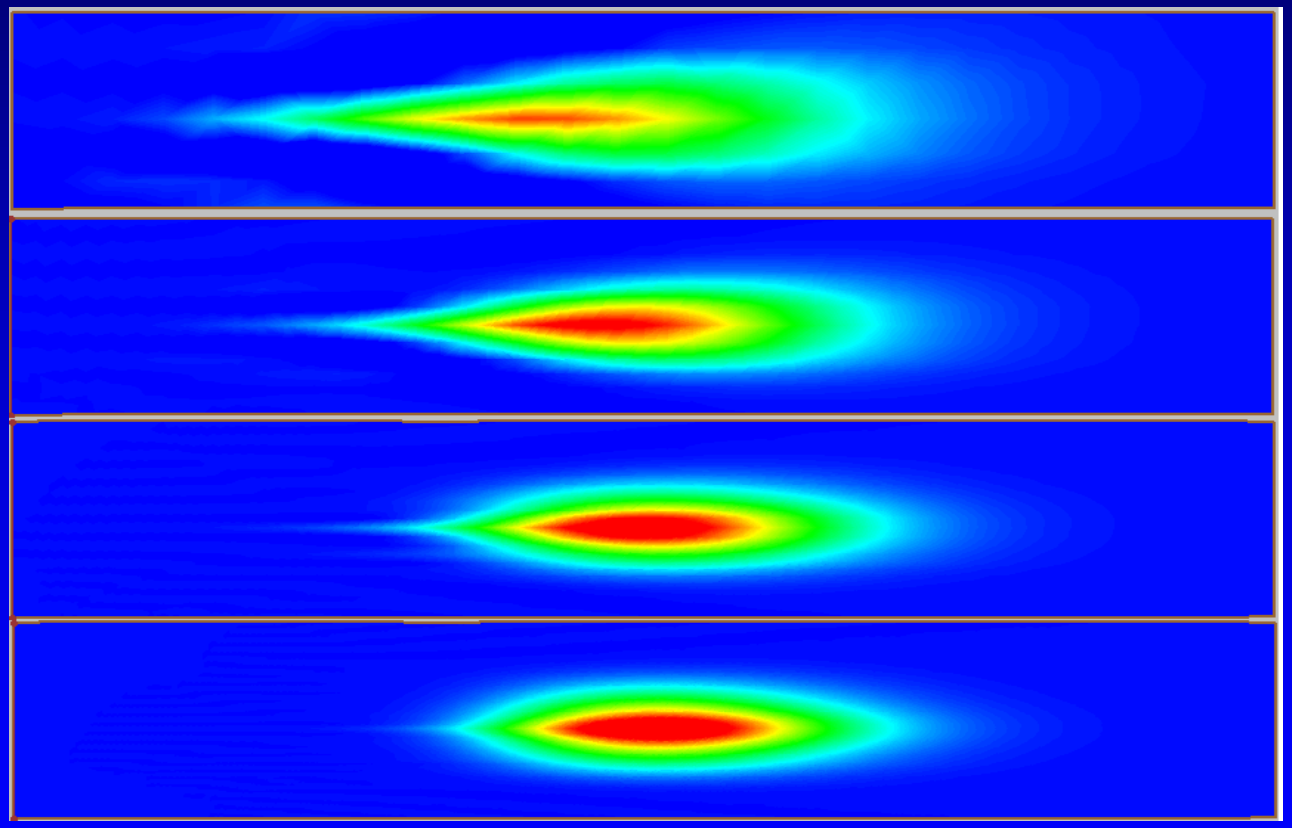
Refined Mesh #3

9849 nodes/19200 elements



Initial Concentration Cloud

Grid Resolution Results…



Coarse

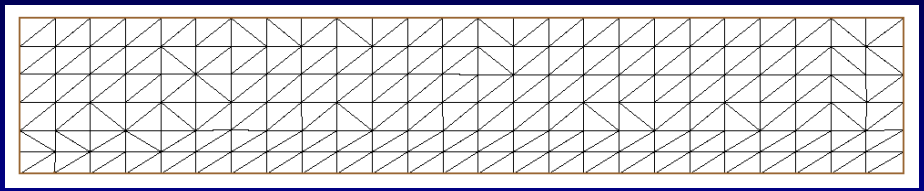
Refined #1

Refined #2

Refined #3

at timestep = 380 seconds

How important is grid resolution? Adaption Needs



Coarse Mesh

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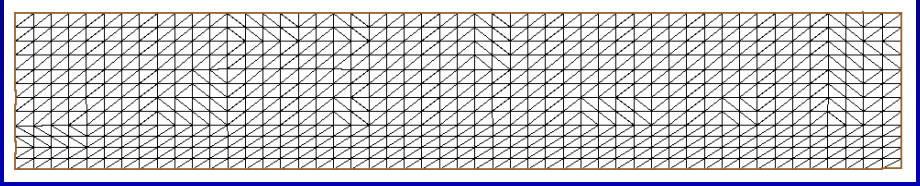

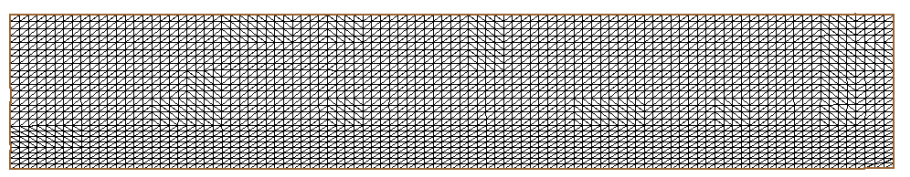

Refined Mesh #2

2525 nodes/4800 elements

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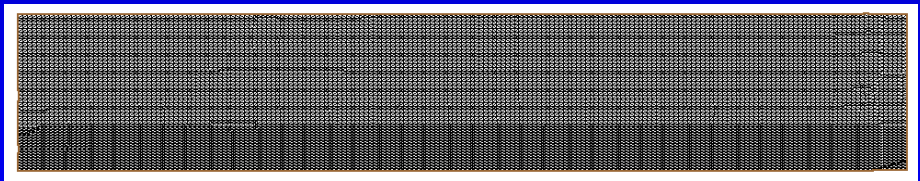
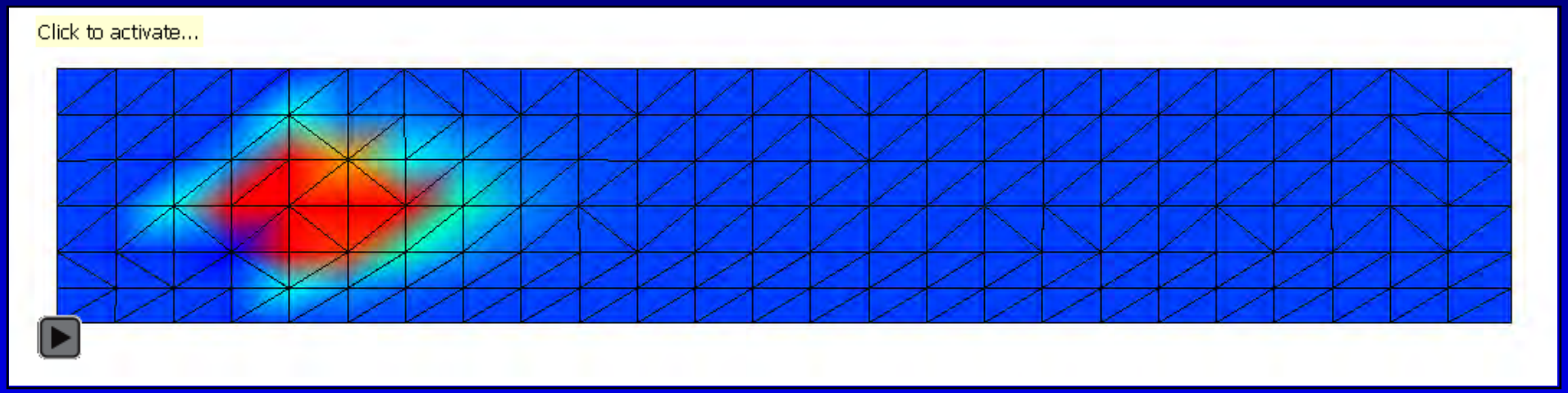
9849 nodes/19200 elements

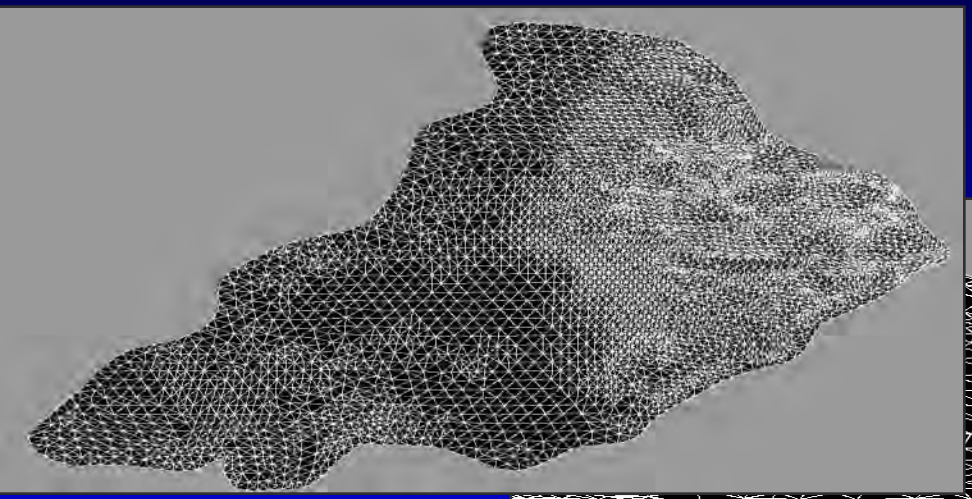


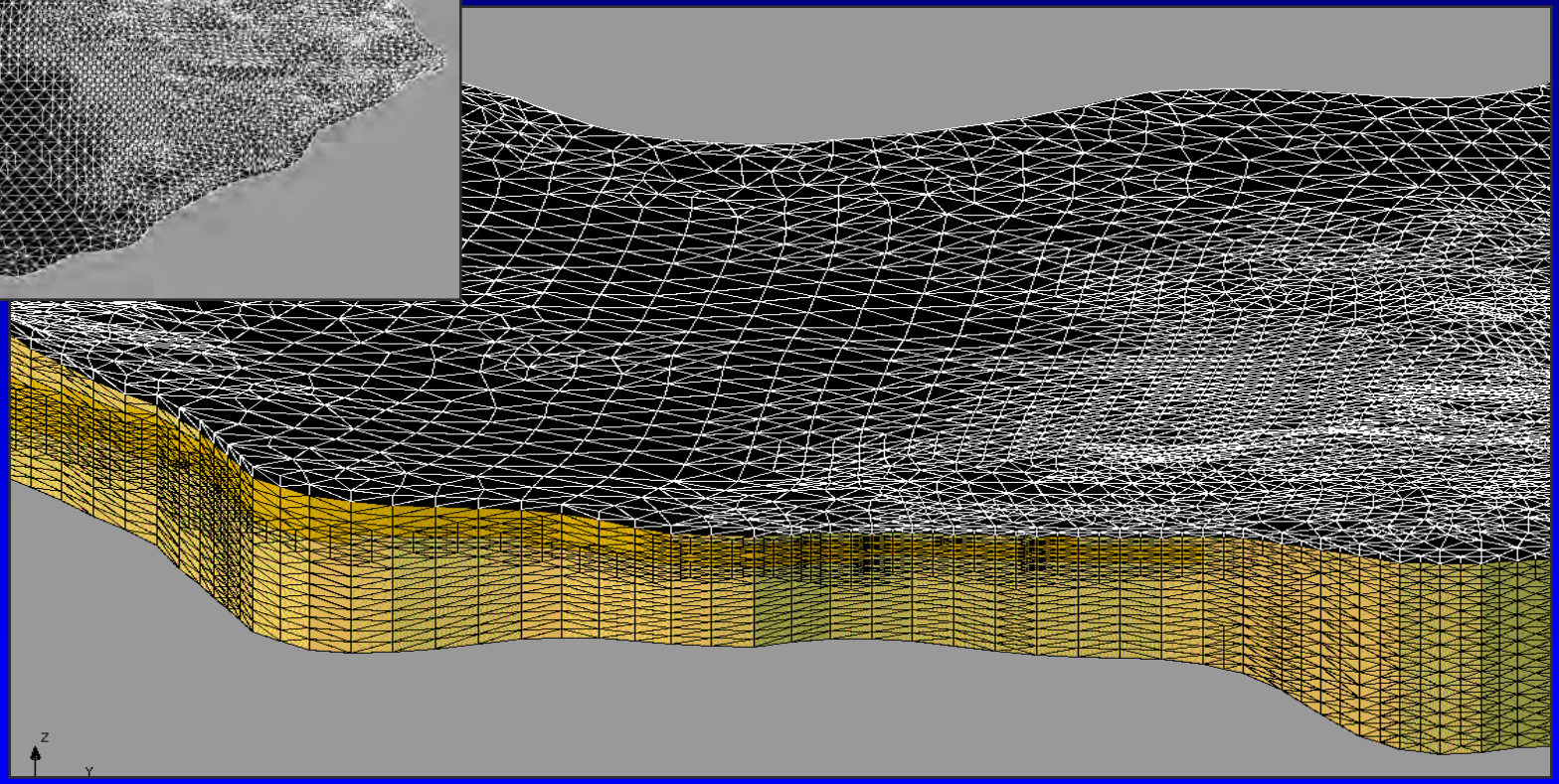
Initial Concentration Cloud

ADH automatic mesh adaption



Mesh Adaption in the Subsurface

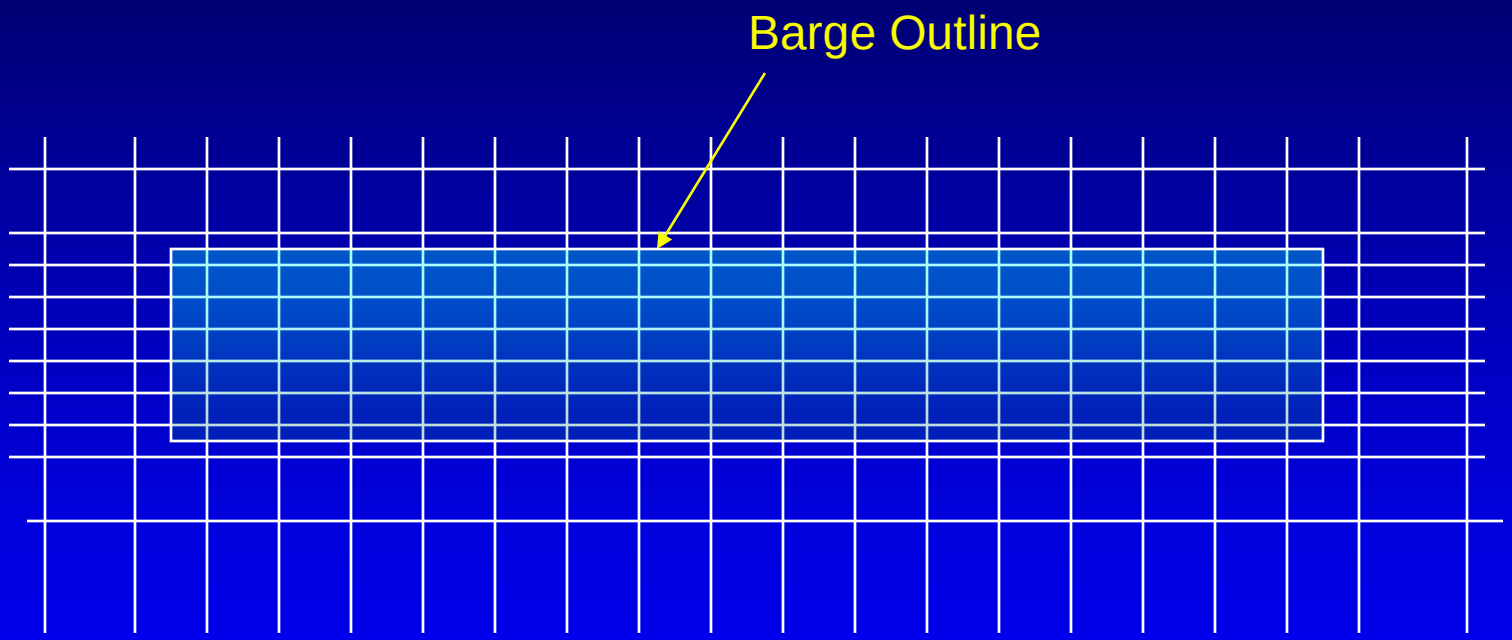




Example of Adaption

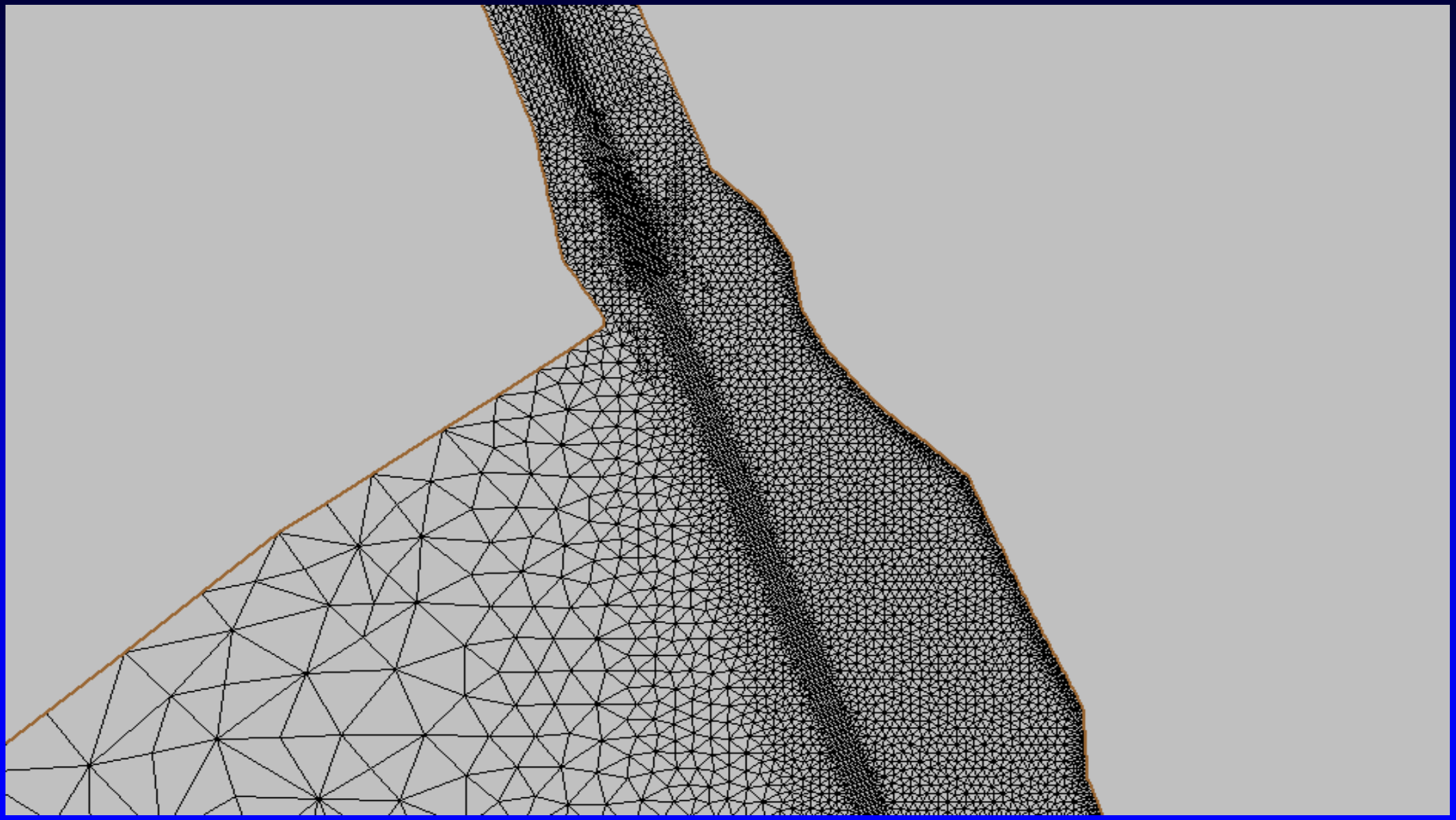
Vessel Effects

Need Special Resolution just for the Vessel Itself

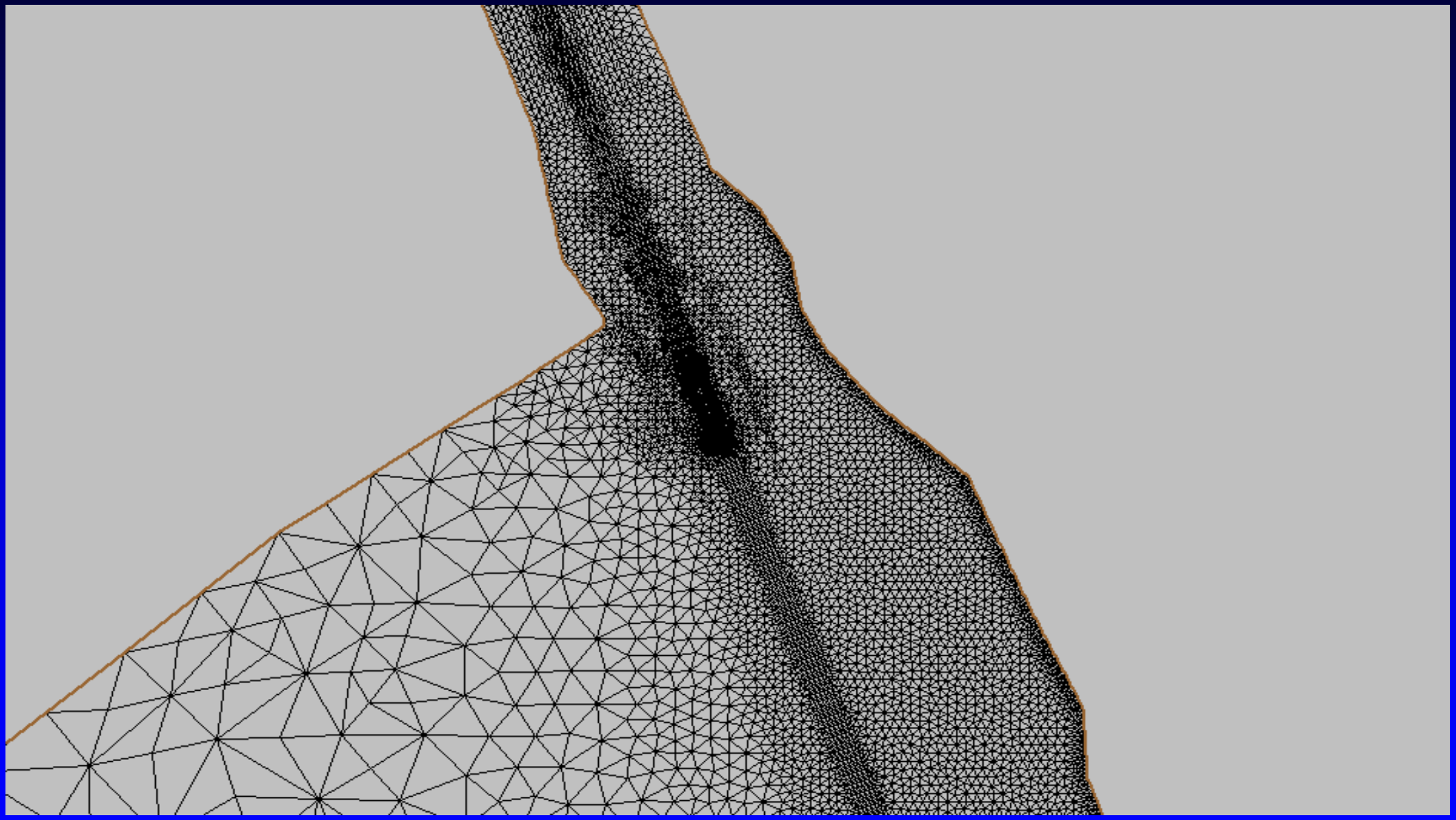


Resolution Needed for Houston Ship Channel with Static Mesh

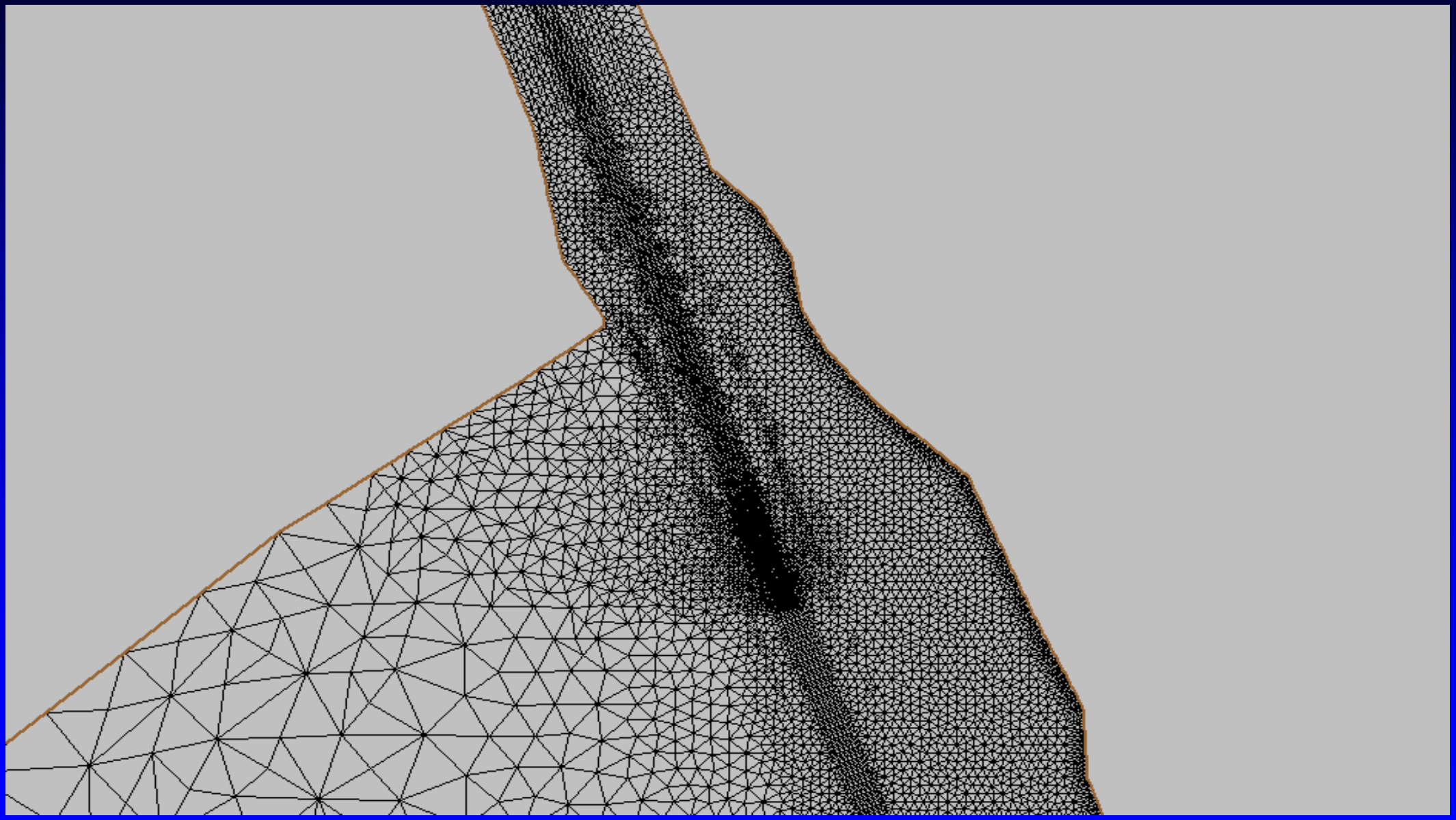
Adaption with ADH - 1



Adaption with ADH - 2



Adaption with ADH - 3



Obvious Adaption Examples

- Sedimentation
- Salinity intrusion
- Vessels

Goal of ADH-SW

Multidimensional hydrodynamic model that engineers use routinely in rivers and estuaries

Comprehensive

- Provide tool for engineering decisions
  - Navigation
  - Flood Control
  - Environmental Restoration

2D Shallow Water Hydrodynamics

- Implicit – time step determined by physics
- Conservative
- Super and subcritical flow
- Wetting/drying
- Baroclinic – density effects
- Bendway correction
- Steady-state option

2D Shallow Water - Sedimentation

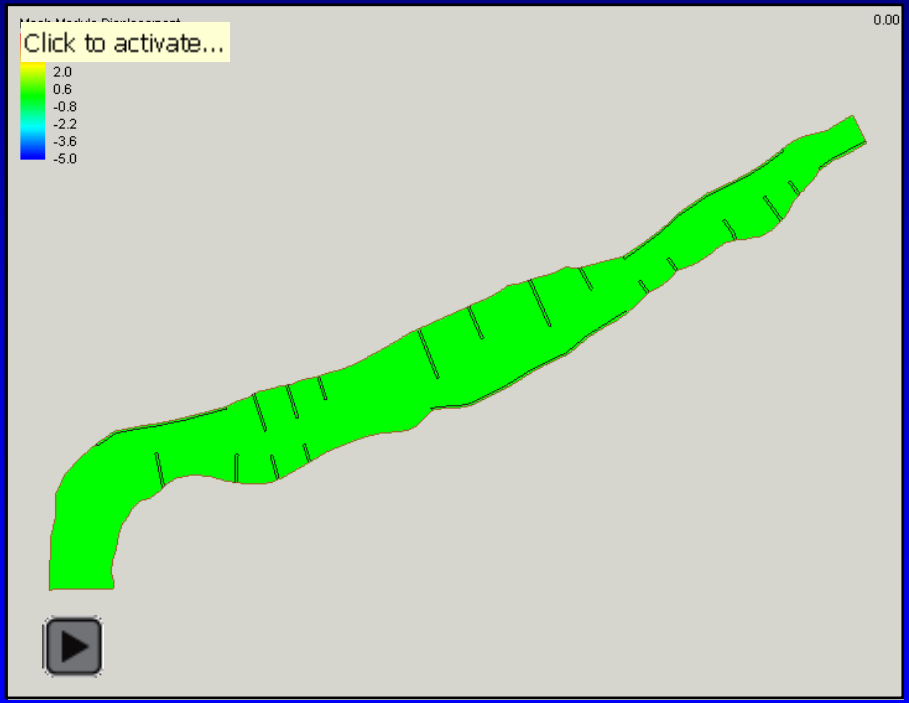
- Mixed beds
- Cohesive
- Noncohesive (bed load and suspended load)
- Bendway Correction
- Nonequilibrium profile
- Armoring

Navigation: Vessel Library (current and stress fields)

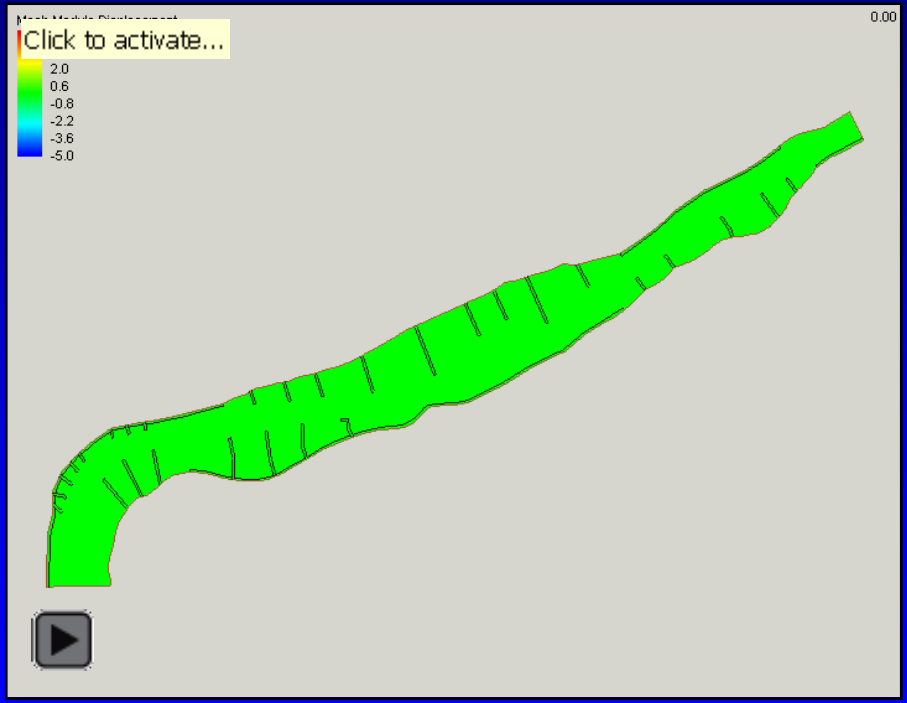
Navigation: Sedimentation

- Dike Fields – Previously
- Bendways Weirs

Dike Field Test
Kate Aubrey Reach
Mississippi River

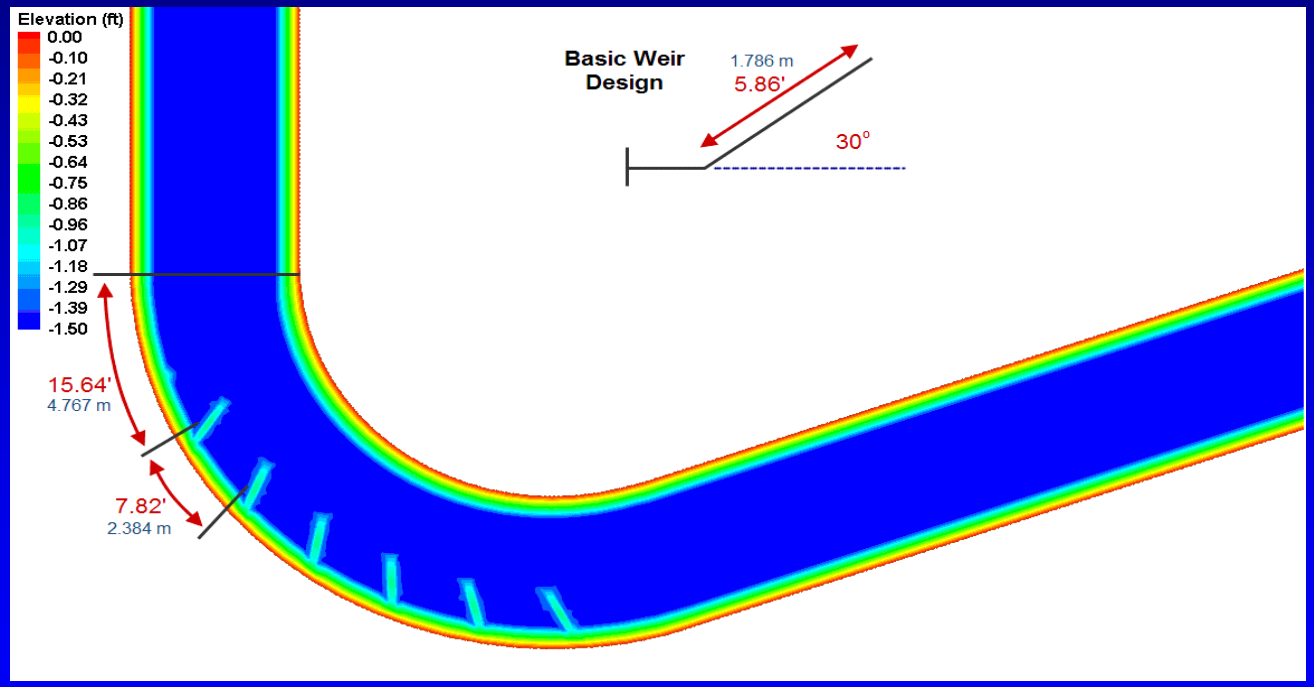


1975 Configuration



1999 Configuration

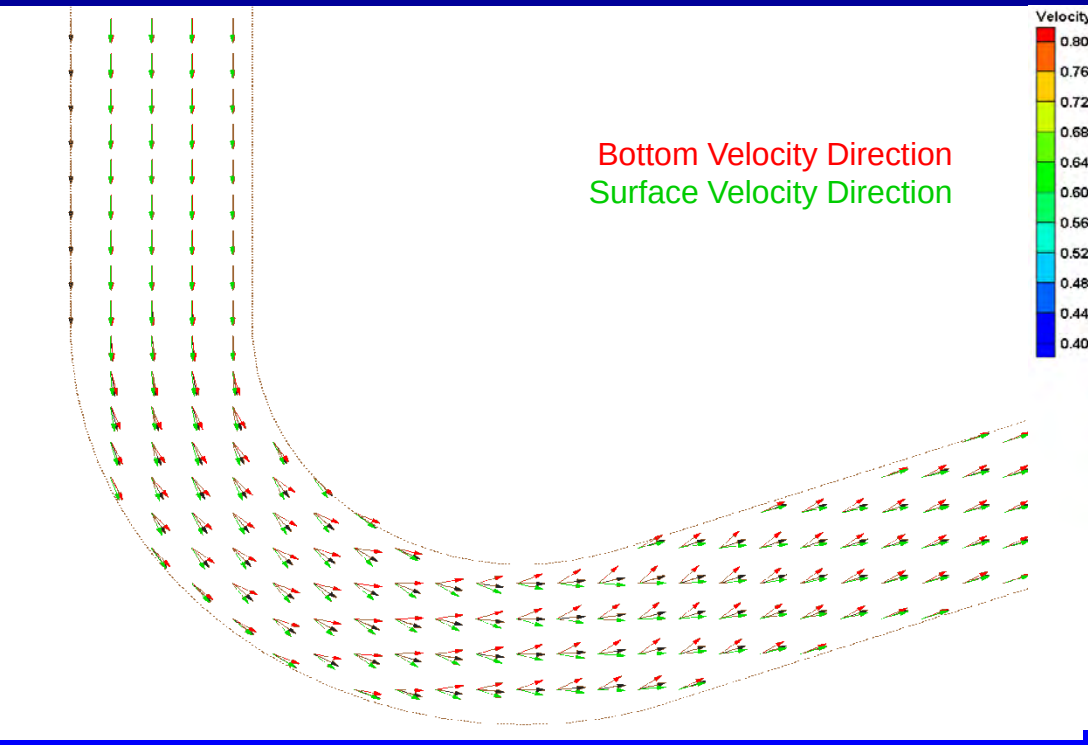
Product Development
Navigation – Bendway Weir Capability



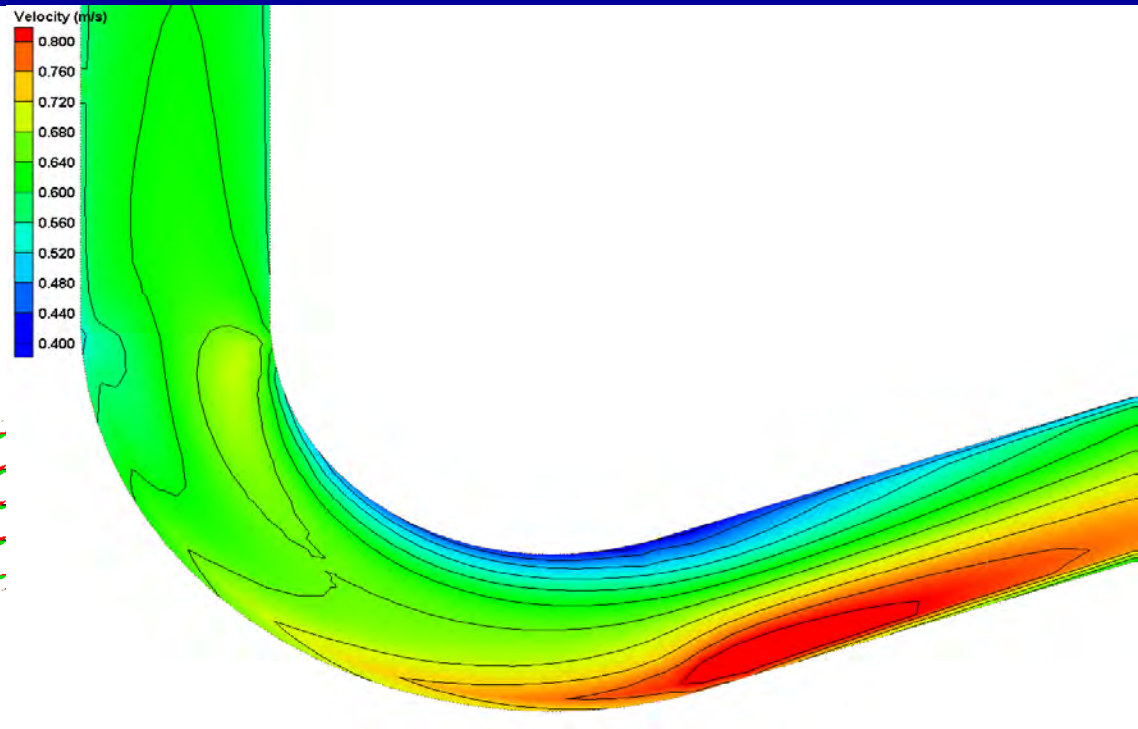
FY 09 Product Development: Navigation: 2D Results

Bendway Weir Evaluation

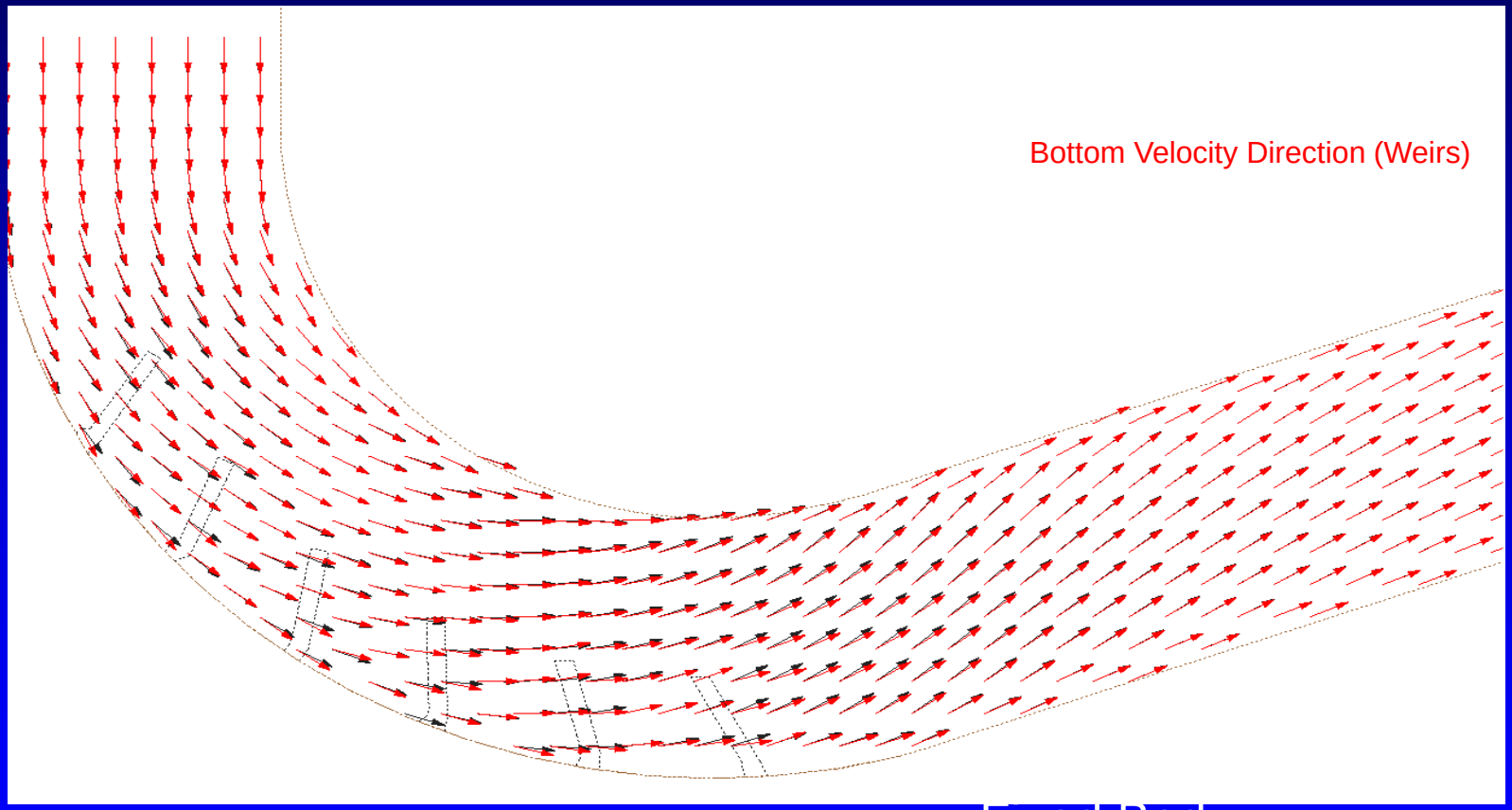
Velocity Direction



Velocity Magnitude

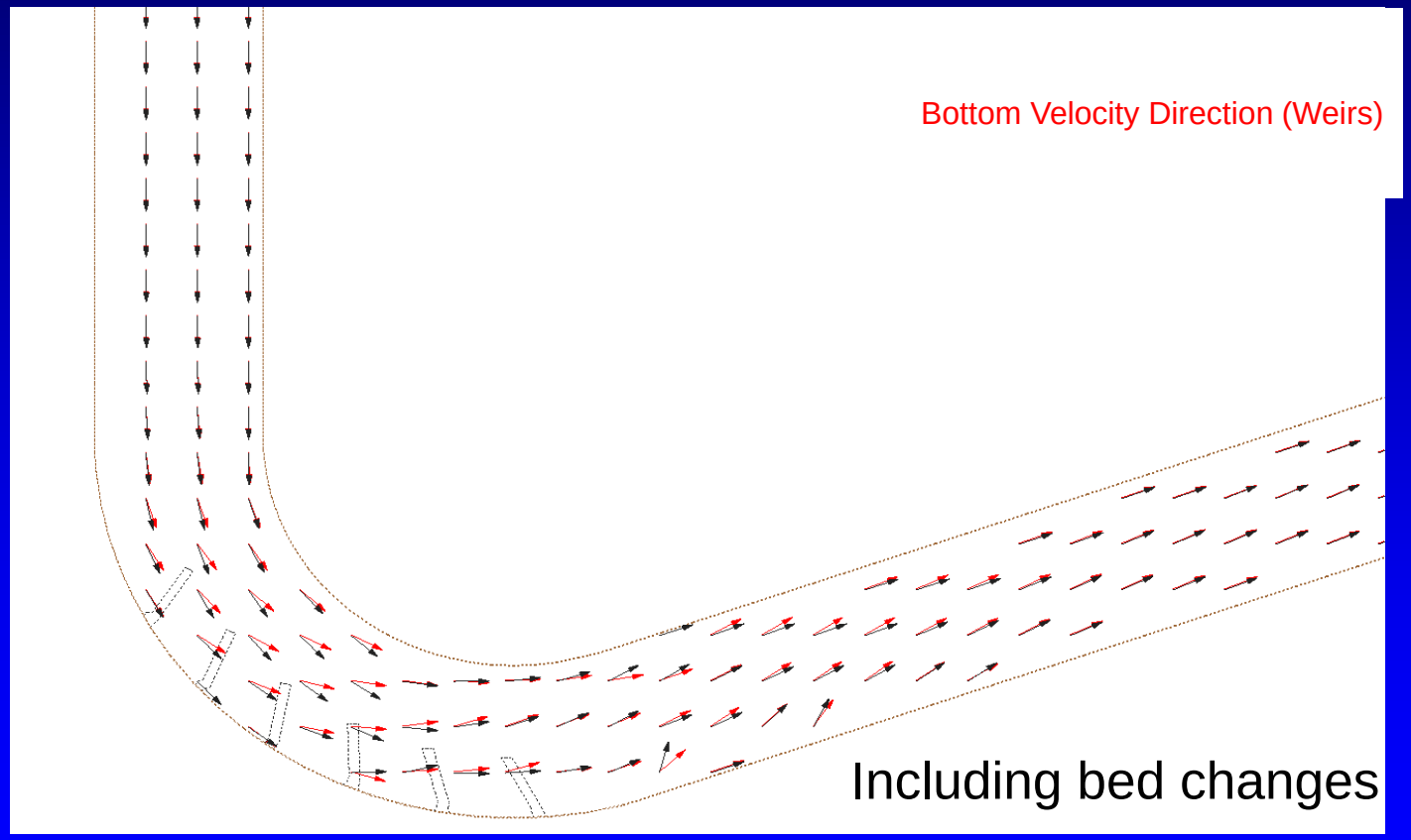


FY 09 Product Development:
2D Results - Bendway Weir



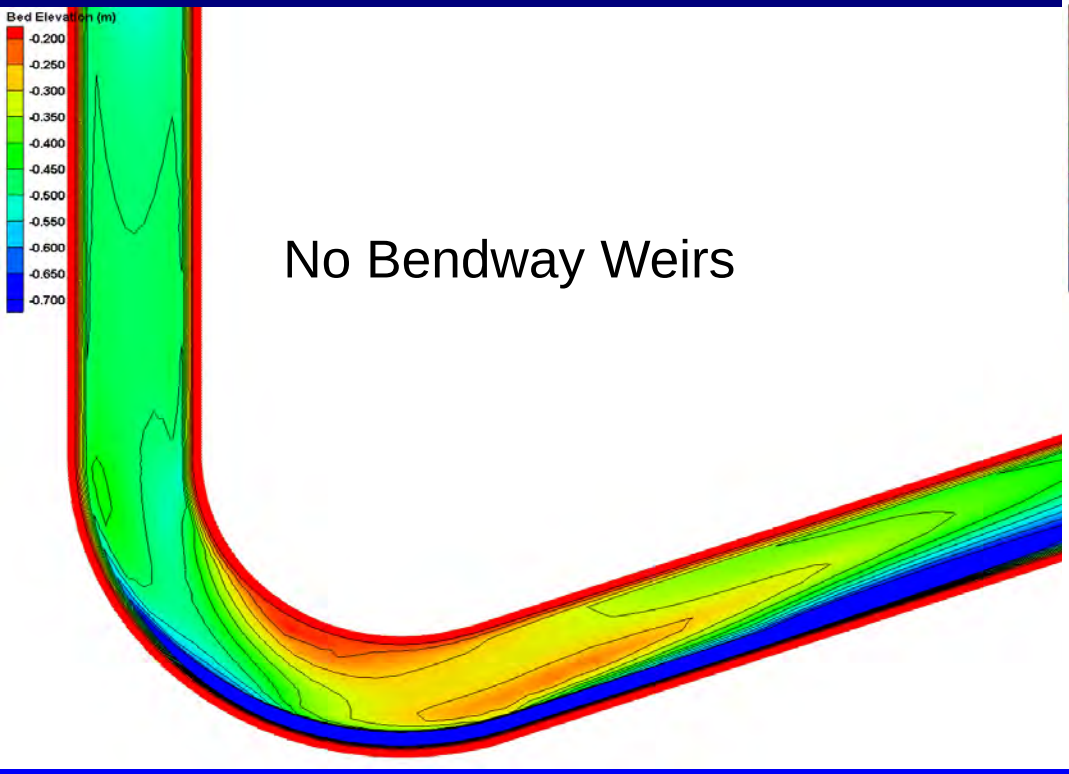
Fixed Bed

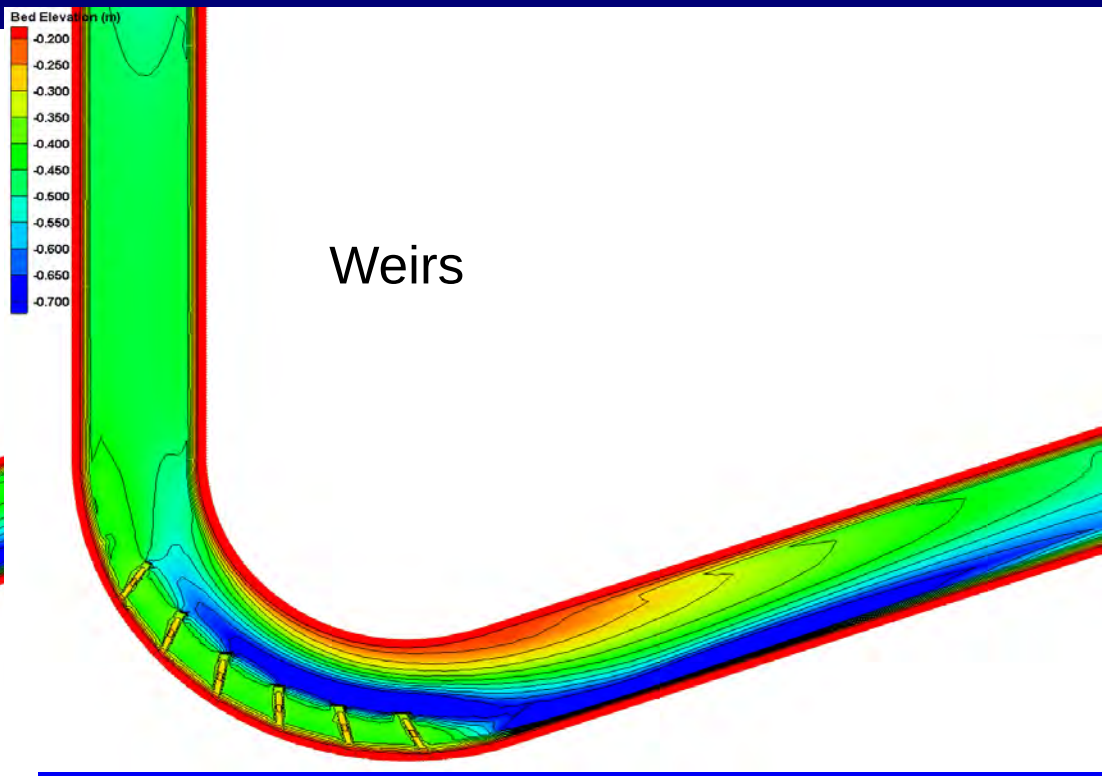
FY 09 Product Development:
2D Results - Bendway Weir



FY 09 Product Development: 2D Results - Bendway Weir

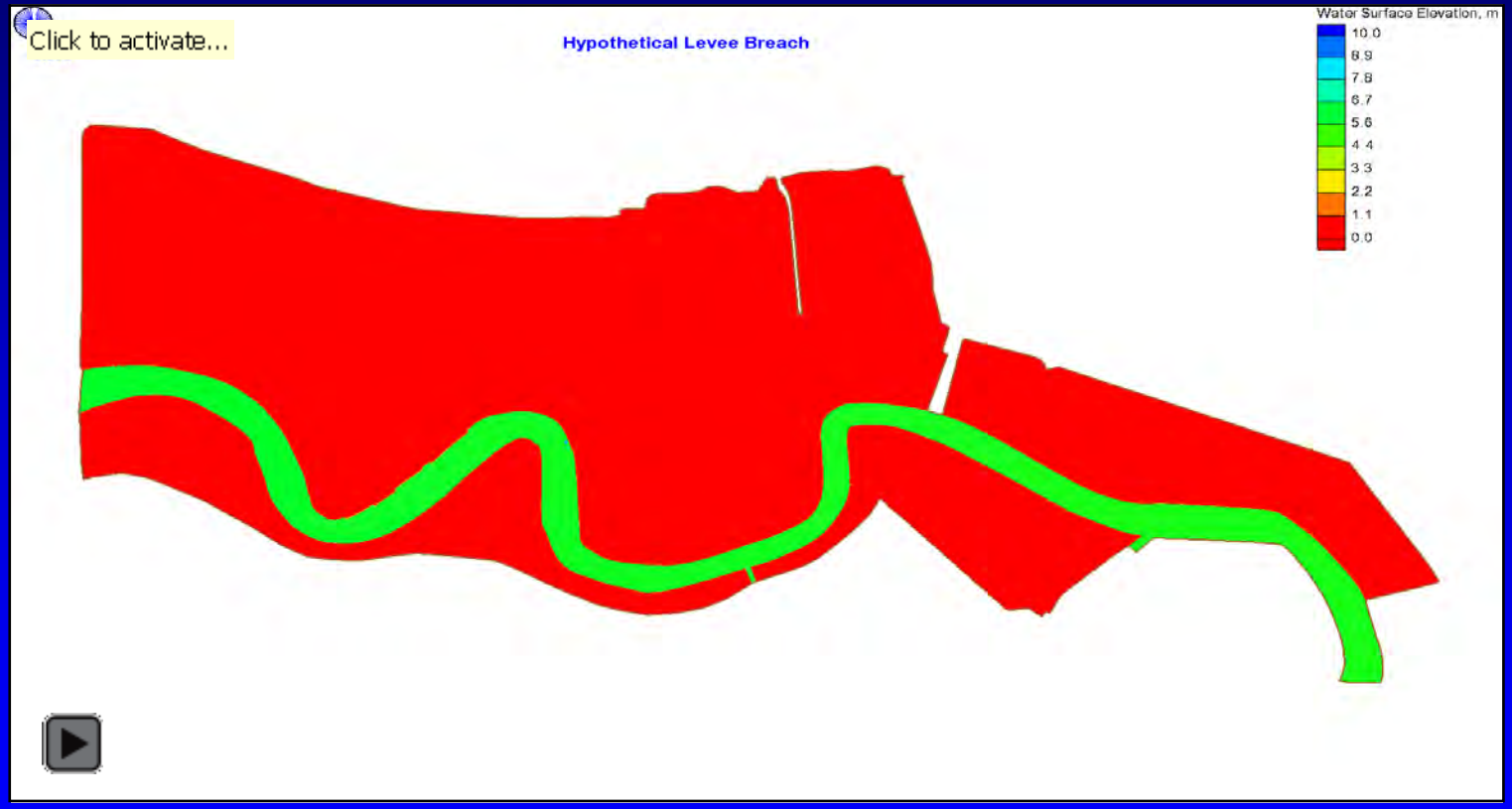
Model Bed Elevation-End of Simulation



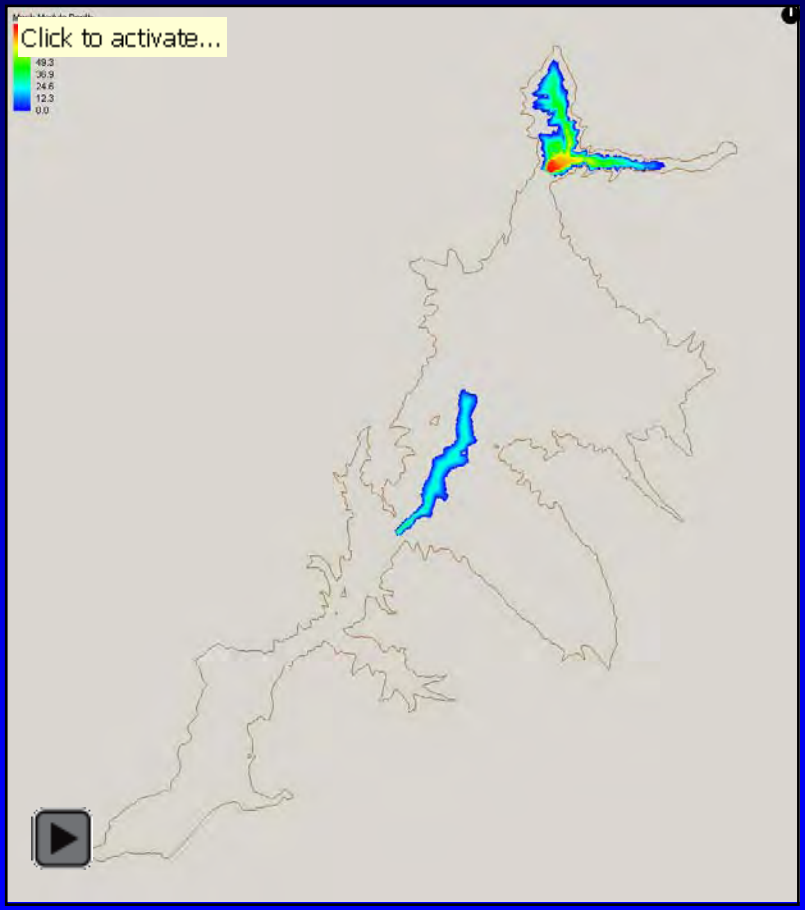


Flood Control:
Adaptive Time Stepping

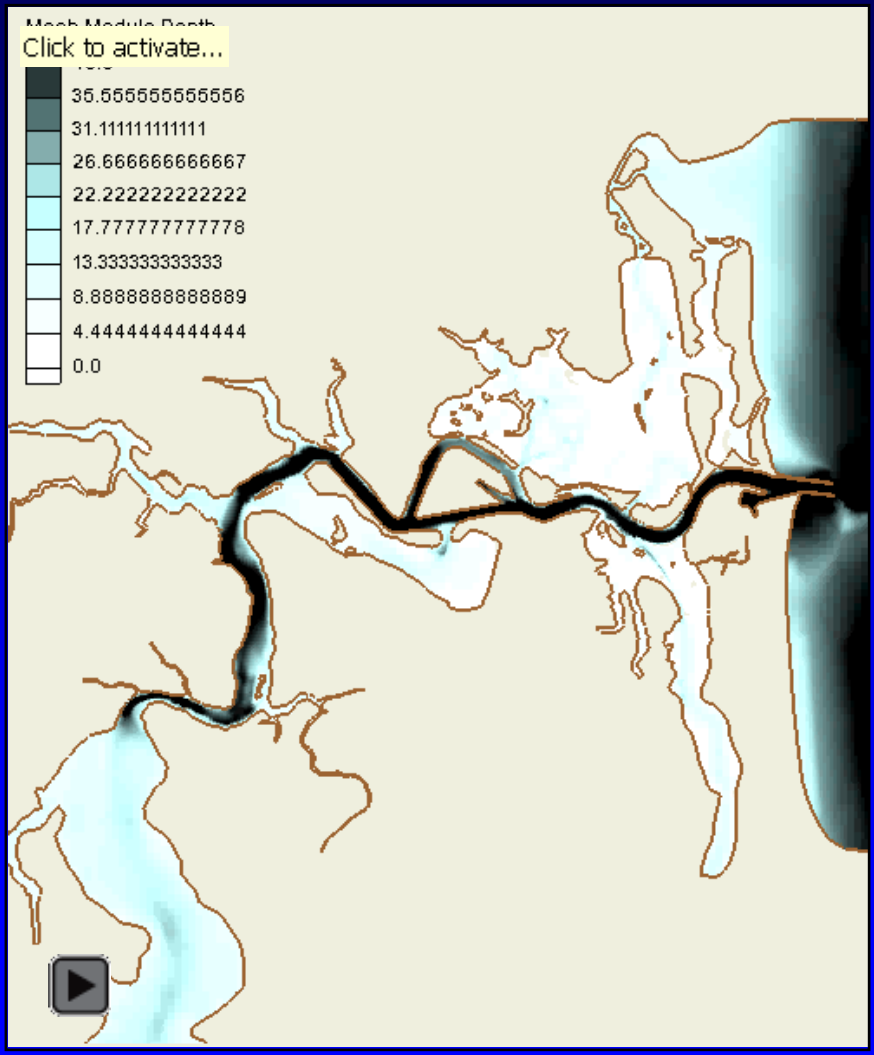
ADH-Flood Control
Levee Breach Demonstration



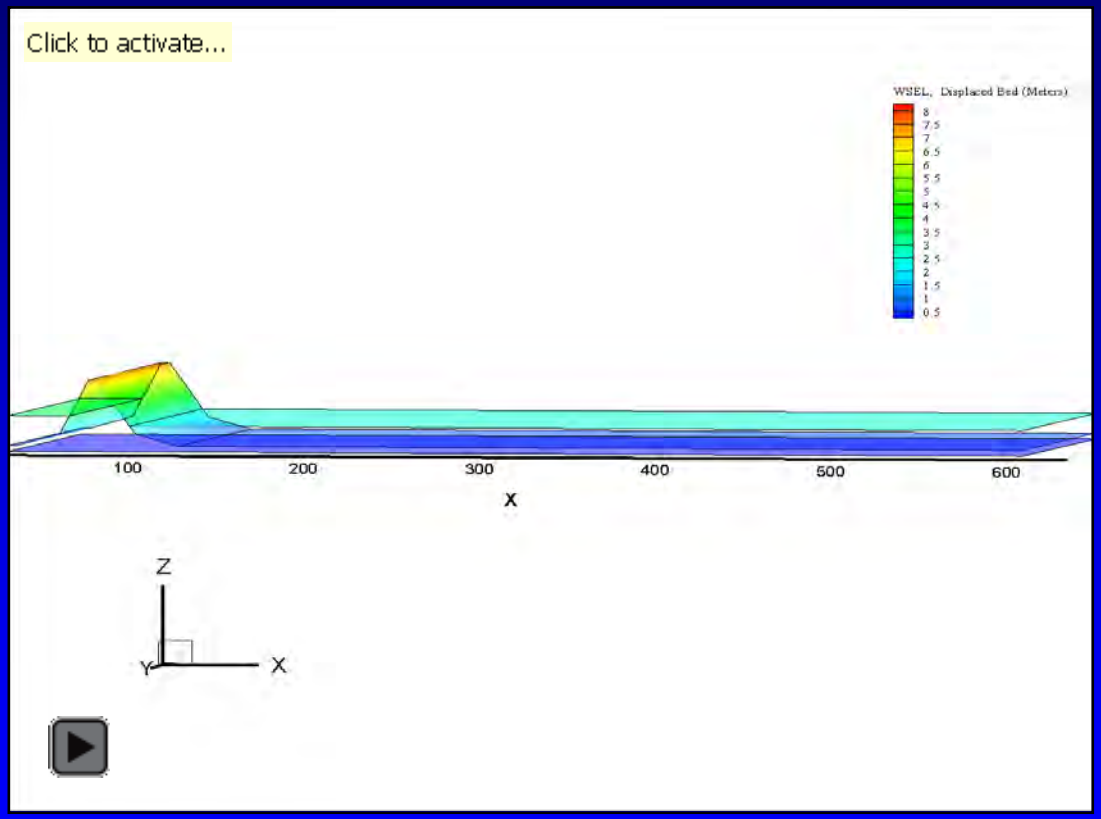
Flood Control
Provo Dam Failure



Tidal Wetting/drying



Flood Control
ADH Dune Overwash – PTC example

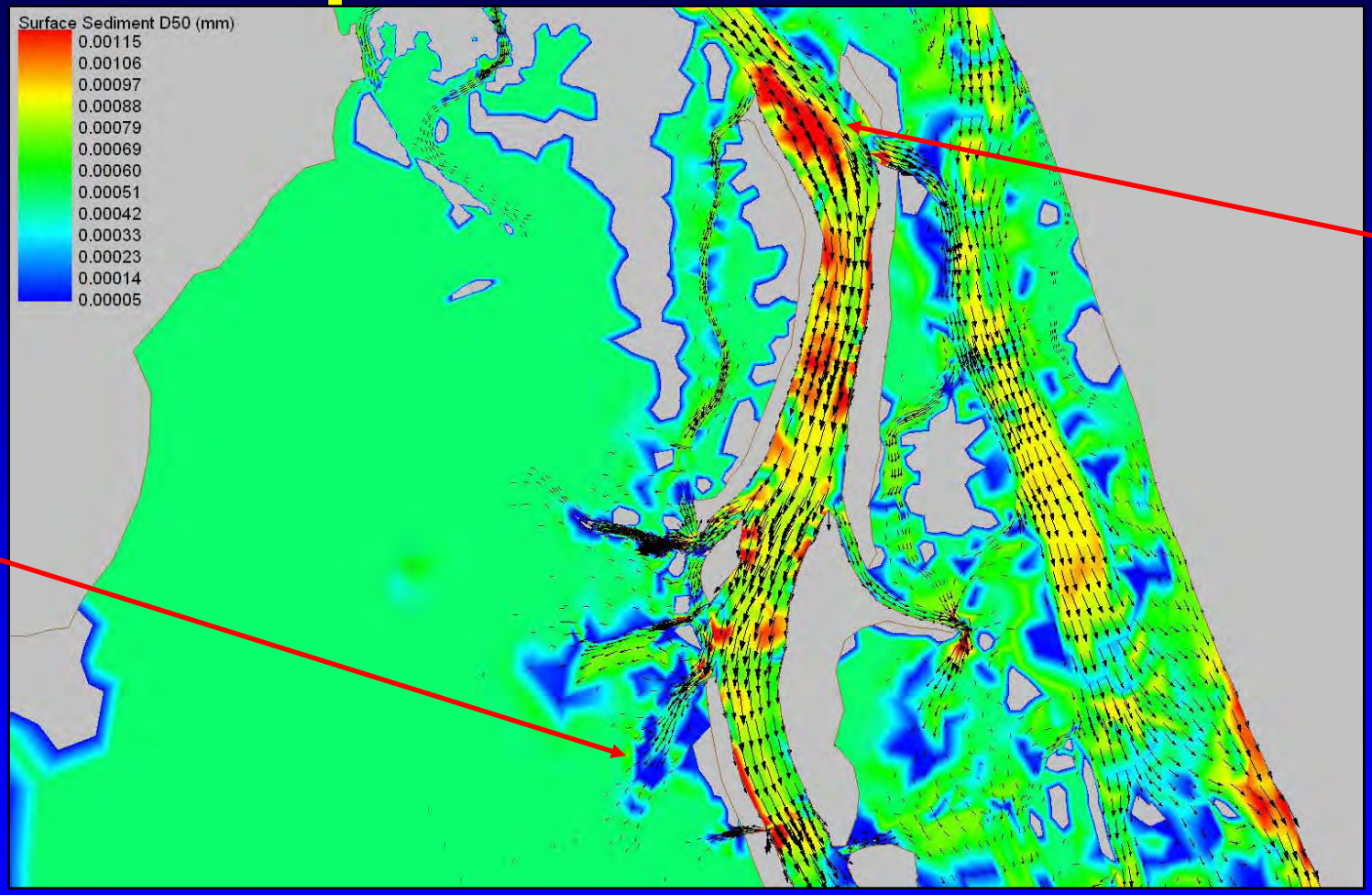


Environmental Restoration

- Links to ecosystem and water quality

  Later presentations by David Smith and Soupy Dalyander
- Link to NSM – Gaurav Savant

Sample Results: Pool 5

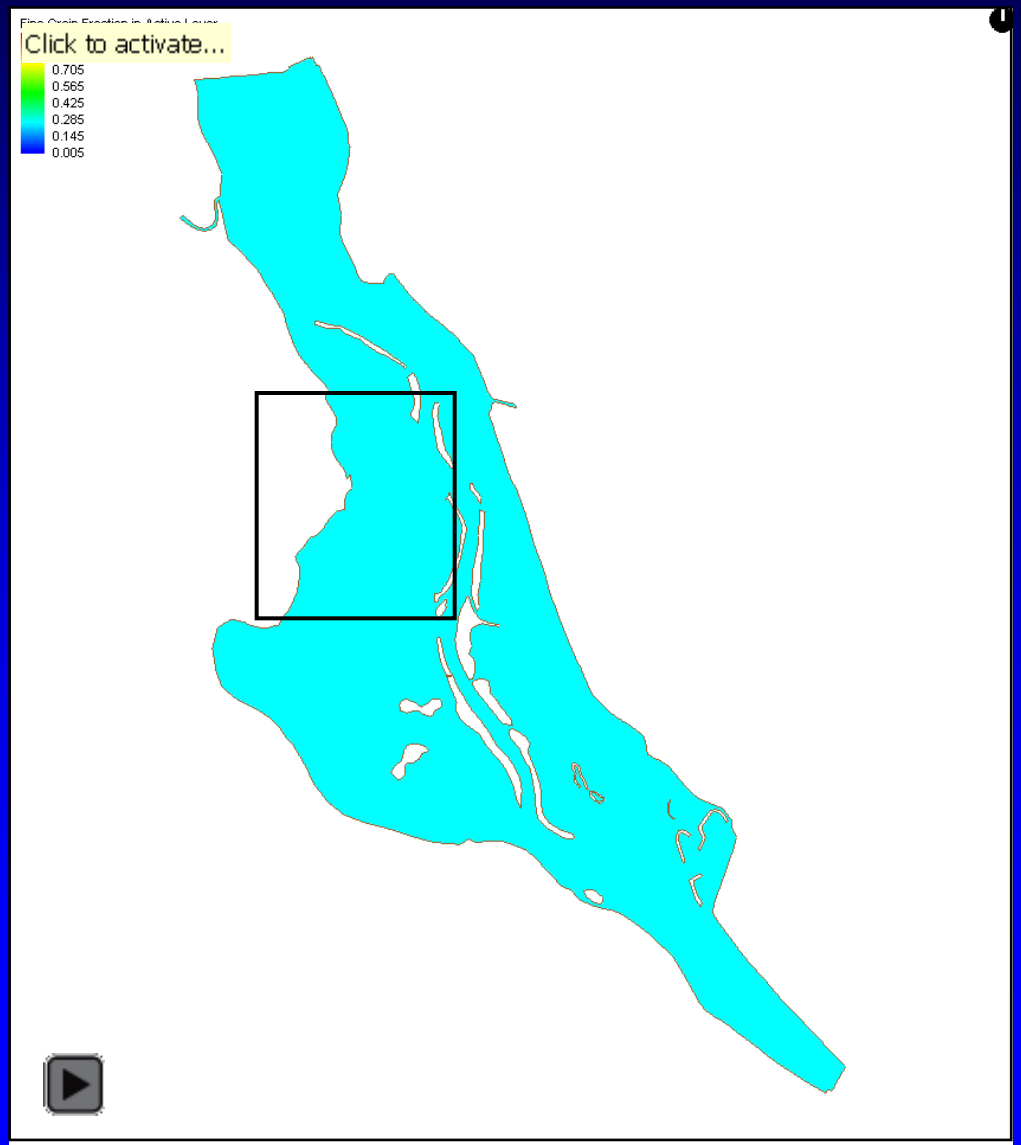


Bed armoring

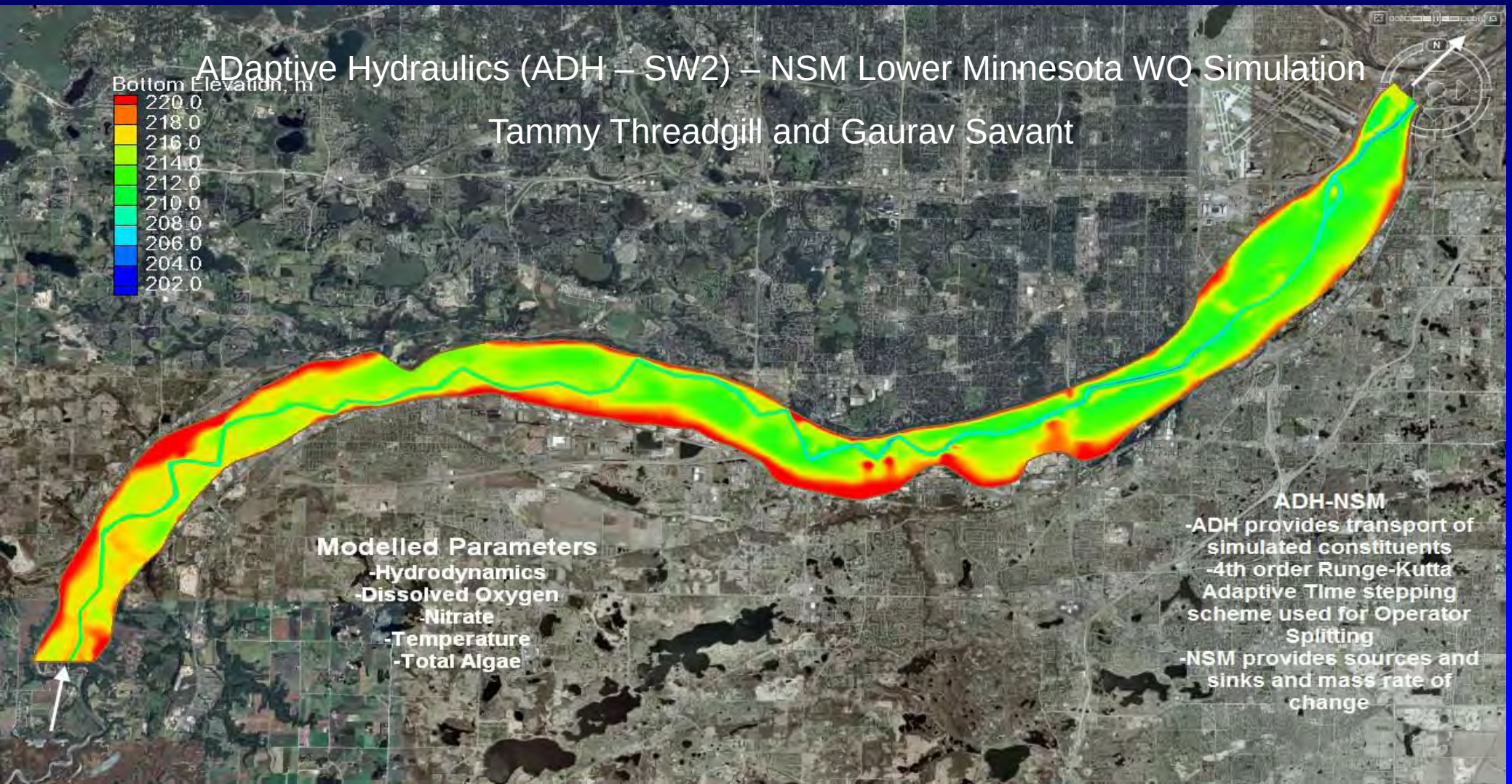
Fine sediment deposition

Mississippi River Pool 5

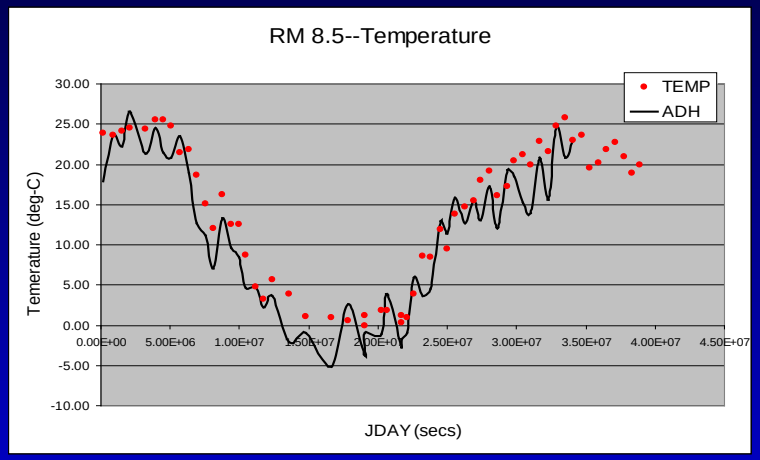
Fine grain fraction in bed surface, larger values (red) = finer sediment

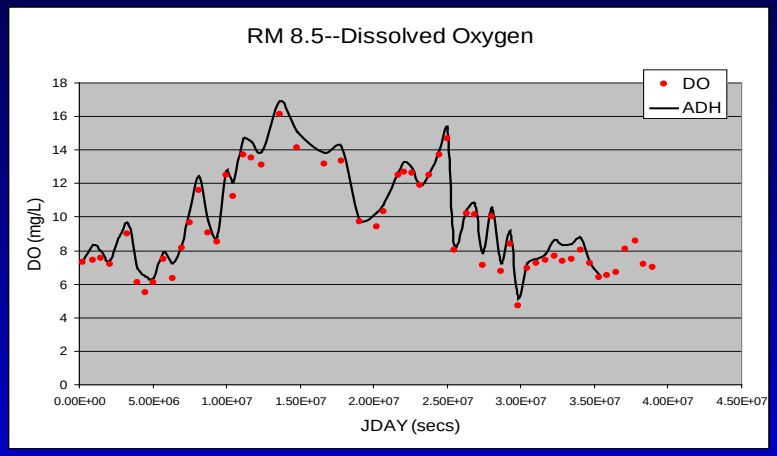


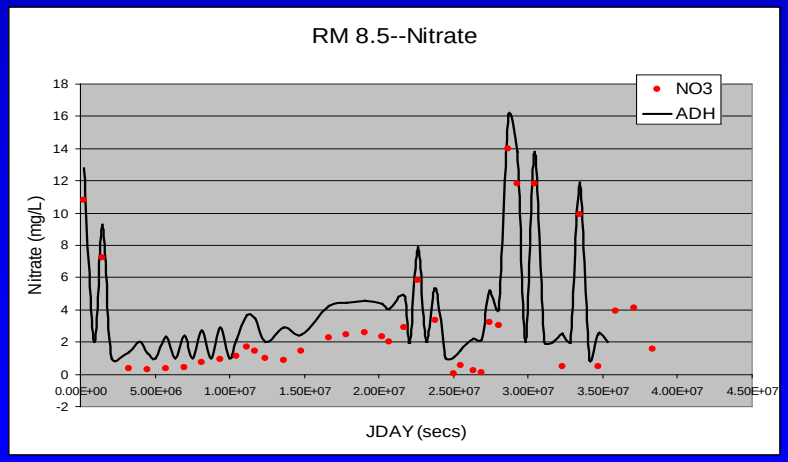
ADH-NSM Demonstration of Capability Minnesota River

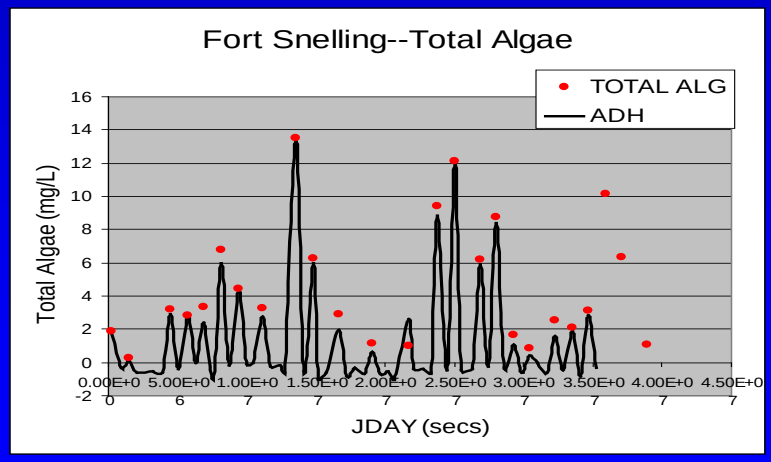


ADaptive Hydraulics (ADH – SW2) – NSM Lower Minnesota WQ Simulation









Comprehensive: Other features

- Baroclinic (McAnally presentation)
- Ice effects (Aaron Buesing presentation)
- Sediment (Cohesive and noncohesive, Gary Brown presentation)
- Hydraulic Structures (Gaurav Savant)

ADH – Flow Control Structures Library

- ADH now has the capability to incorporate flow control structures.
- The following structures are included:

  Culverts: Free flow and pressurized

  Weirs: Submerged and unsubmerged

  Flap Gates
- The formulations are not intended to model the near field characteristics of the flow, rather they are formulated to pass the correct flow.

Goal: Easy to use
How this is being accomplished

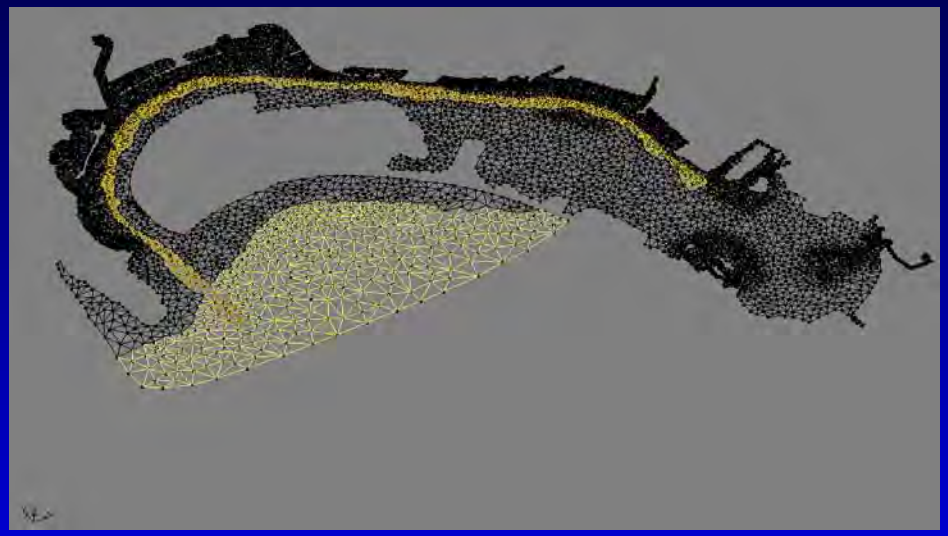
- Unstructured
- Robust Model
- Adaption
- Direct links to NSM, CASM, SedLib
- Implementation in SMS
- Linkage with HEC-RAS and implementation of DSS file system
- 3D bc and mesh from 2D model

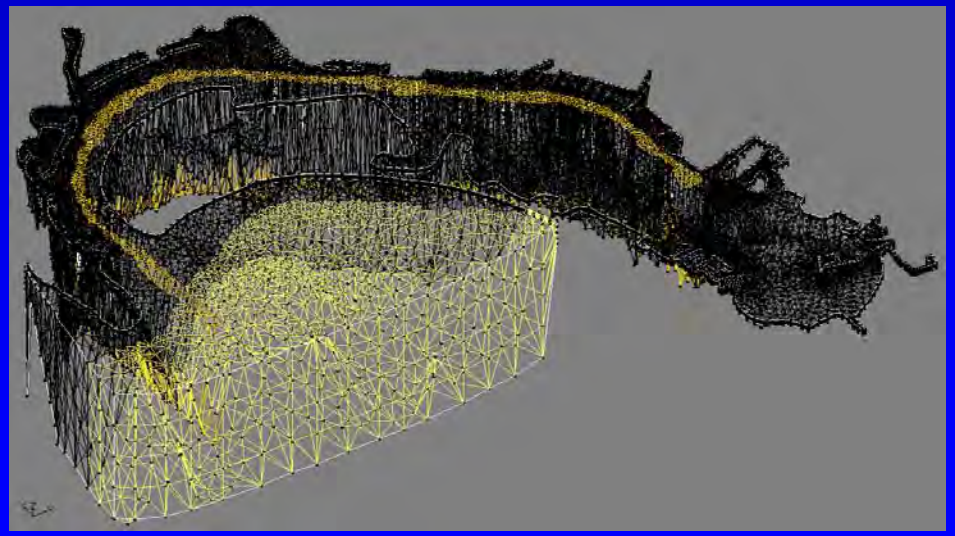
ADH - DSS

- DSS is an information storage and retrieval system developed by HEC during the 1980s
- ADH is presently being modified to include options for DSS format file handling
- DSS is the primary storage format for the USACE districts for data utilized in 1D modeling
- DSS information can be viewed on the PC, HPC, UNIX and SOLARIS systems using DSSView.

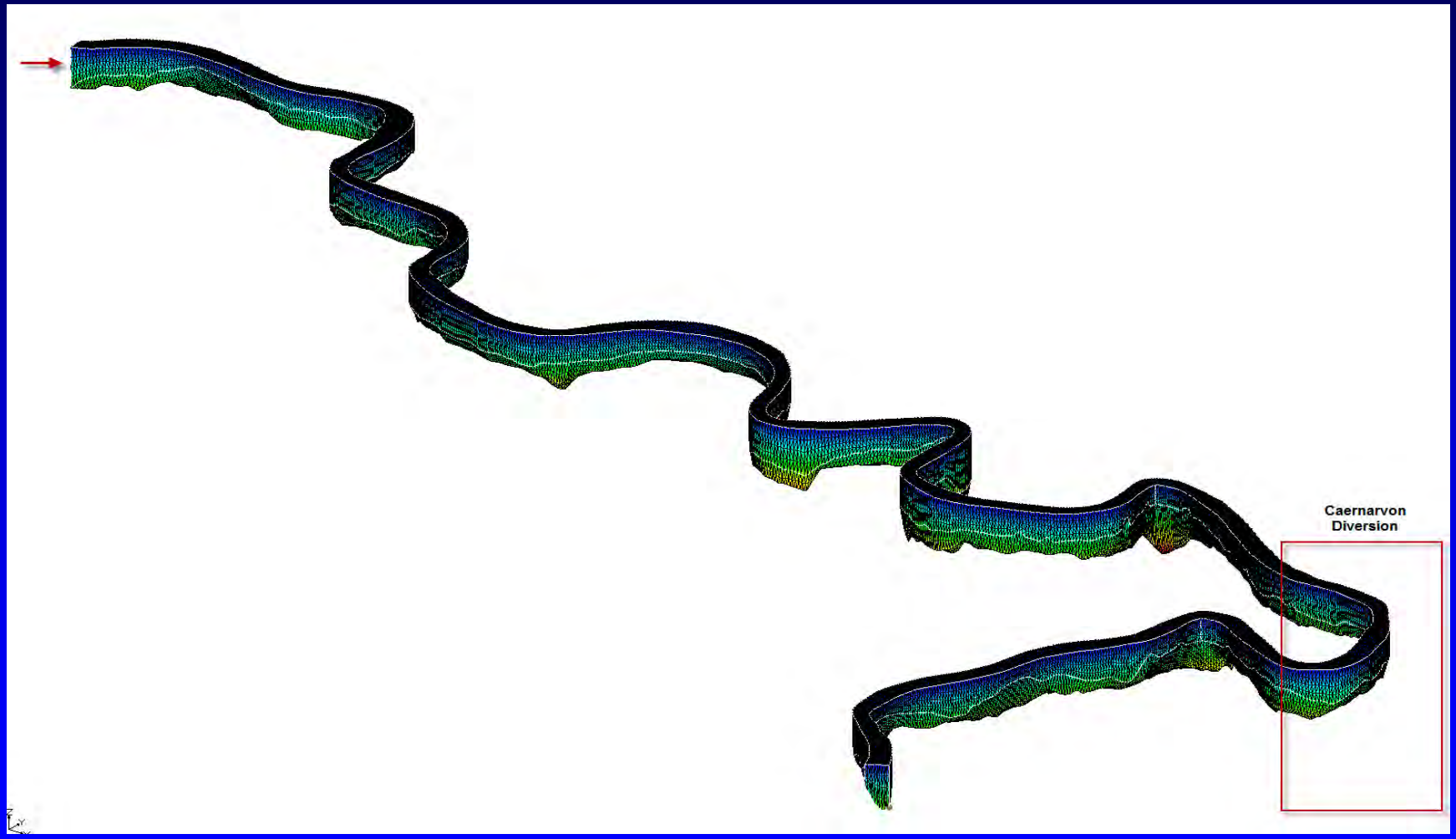
FY 09 Product Development: 3D set-up using existing 2D files

- *Often, it is convenient to first set-up and test a model in 2D mode, and then to extend the model to 3D mode for further, more detailed investigations*
- *A method has been developed whereby a 2D mesh can be easily extended to 3D, by running a simple utility code*
- *3D input features (such as boundary conditions) are also being modified to mimic, as closely as possible, 2D conventions*
- *These developments should make the transition from 2D to 3D modeling as seamless as possible.*





Mississippi River 3D Model



SMS and Documentation

Adaptive Hydraulics

- Available Documentation
- SMS Capabilities

Our Philosophy

- We want to provide the district user (and associated contractors) a means to perform numerical modeling with ADH such that information is readily available and there is a reasonable ease of use.
- We want to know what works for you. Without your input we are wasting our time.
- We want to make information available so that you feel confident and can perform simulations with little additional help from us.

Available Documentation

- ADH website
- CHL website
- Users Manual
- Quick Reference
- Publications
- Analytical Solutions

The ADH website is maintained at CHL by Ms. Cassandra Ross. The information is updated continuously and more information is added periodically. Always check this site first for guidance and information.

https://adh.usace.army.mil/

ADaptive Hydraulics Modeling HomePage

Manuals

- Groundwater-Surface Water Interaction (Howington etal.)
- Navier-Stokes Manual (Berger and Schmidt, 2004)
- Navier-Stokes Manual (Berger and Schmidt, 2000)
- Shallow Water Manual (Berger and Tate, 2005)
- Quick Reference (Carrillo and Hallberg, 2005)

External Packages

ADH can (but need not) use the following packages:

- PETSc
- UMFPACK
- SuperLU
- ParMetis
- SPOOLES
- hypre

Getting ADH

ADH is a product of the US Army Corp of Engineers ERDC and can be obtained through the Coastal and Hydraulics Laboratory. To obtain ADH please contact:
Cassandra.G.Ross@erdc.usace.army.mil

What Is ADH?

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ADH Downloads

The ADH software is intended solely for 2D shallow water applications. Support for the ADH software is provided by the US Army Corps of Engineers, Engineer Research and Development Center, Coastal and Hydraulics Laboratory and is limited to Corps of Engineers organizations. Technical support cannot be provided to users outside the Corps of Engineers. ADH can be downloaded by clicking on the link above.

Also, please note the terms and conditions of the software.

ADH solves:

- Ground Water Flows
- Two-Dimensional Shallow Water Flows
- Three-Dimensional Navier Stokes Flows

2D Shallow Water Manual and Quick Reference matching the current release version of ADH

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Manual & Quick Reference

ADaptive Hydraulics/Hydrology (ADH) Modeling System
Quick Reference

(Note: The quick reference has been updated to be used with ADH revision #5939 dated January 2009)

Constituent Properties | Iteration Parameters | Material Properties | Operation Parameters | Output Controls | Boundary Conditions | Friction Controls | String Structures | Time Controls | Time Series | Vessel Movement Library

ITERATION PARAMETERS

2D-SW
GW
NS
Heat

2D Shallow Water Cards

IP_FLI
IP_FNI
IP_ITL
IP_MIT
IP_NIT
IP_NTL
IP_RTL
IP_SST

Groundwater Cards

IP_FLI
IP_FNI
IP_ITL
IP_MIT
IP_NIT
IP_NTL

Navier-Stokes Cards

Non-linear Tolerance

Field	Type	Value	Description
1	char	IP	Card type.
2	char	NTL	Parameter.
3	real	≥ 0	Tolerance for Non-Linear Equations

Convergence tolerance for the non-linear iterations.

Increment Tolerance

Field	Type	Value	Description
1	char	IP	Card type.
2	char	ITL	Parameter.
3	real	≥ 0	Tolerance for maximum change in the velocity, depth and concentration solutions.

Optional card that allows convergence to be determined by the change in the velocity, depth and concentration solutions. By zero.

Linear Iterations (option 1)

Field	Type	Value	Description
1	char	IP	Card type.
2	char	MIT	Parameter.
3	int	≥ 1	Maximum number of linear iterations by the interative solver.

If the internal linear tolerance (0.0001 * NTL) is not met, the solution stops.

Linear Iterations (option 2)

Field	Type	Value	Description
1	char	IP	Card type.

2D Shallow Water Manual and Quick Reference matching the current release version of ADH

Link to the ADH download page on the CHL website. This is where all updated releases will be stored.

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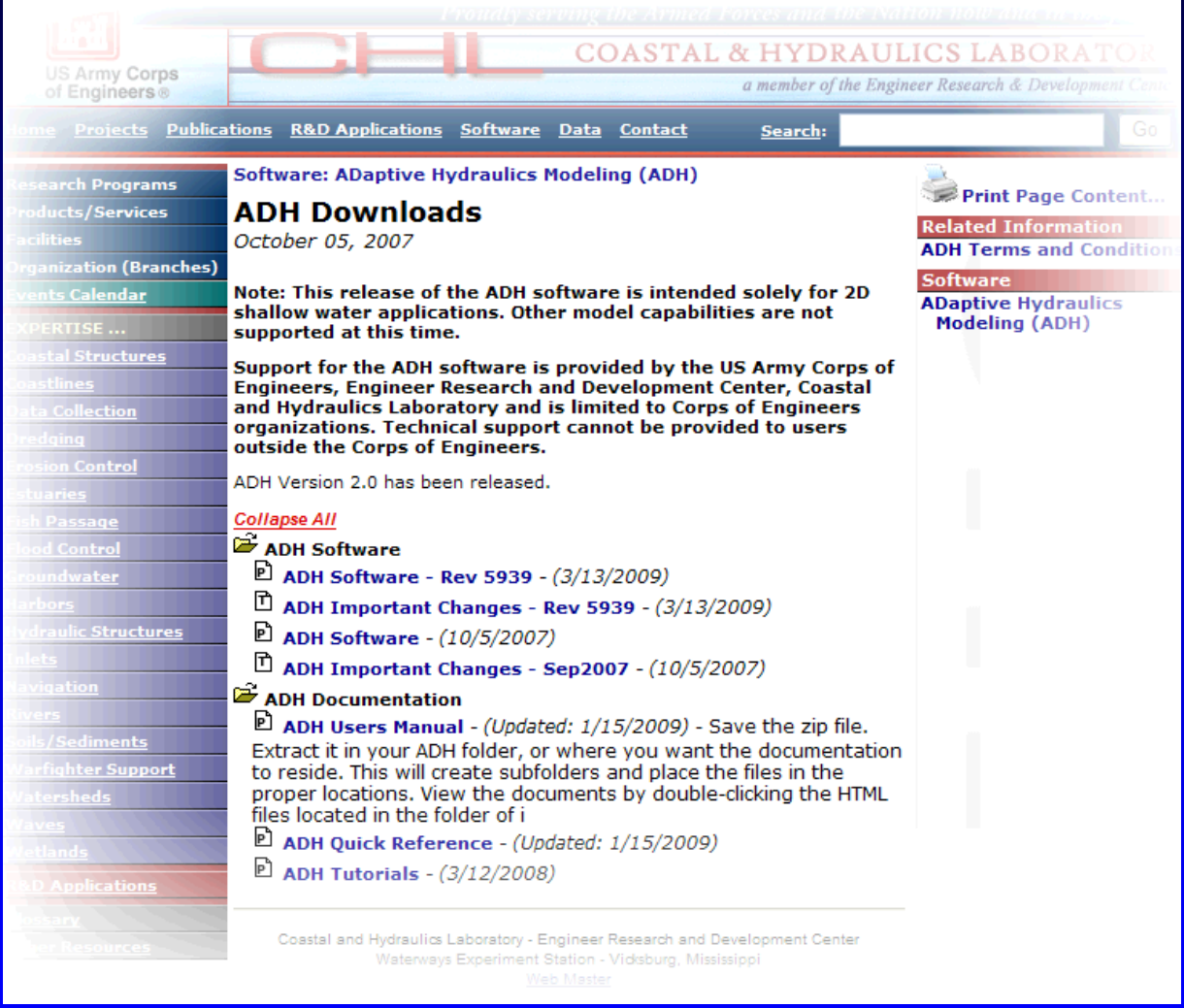
ADH Download

The ADH executables (pre_adh & adh) can be downloaded from the CHL website http://chl.erdc.usace.army.mil/adh.

The PC software and documentation compatible with each release version are available and labeled accordingly. We request that the revision numbers are maintained as you use these executables so that we can help if you experience problems. There is no install for ADH. Each download includes an “Important Changes” document to note changes from the previous release.



2D Shallow Water Manual and Quick Reference matching the current release version of ADH

Link to the ADH download page on the CHL website. This is where all updated releases will be stored.

Link to the 2D Shallow Water instructions and examples.

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ADH Website

- Presentation files indicating how to set up the ADH input files and run ADH on a PC. Examples of text input files, card structures, and using SMS are available.
- Also available is a document explaining the link between the ADH input cards and the SMS interface.

ADH 2D Shallow Water Modeling

Getting Started with ADH

The following is a list of links to documentation that may help you to get started using ADH to solve 2D Shallow Water flows:

- Running ADH
- Creating a Boundary Condition File
- Hotstarting ADH
- Converting Files from RMA2 or HIVEL2D to ADH Format
- ADH Main Points

SMS 10 now has the ability to generate ADH boundary condition files from within it. The user is also able to run ADH from within SMS. At this time, however, SMS only supports 2D shallow water hydrodynamics - no transport boundary conditions can be created from within SMS.

- Creating a Simple Boundary Condition File using SMS10 using the angle_bt example
  - angle_bt.bc
  - angle_bt.hot
  - angle_bt.3dm
  - angle_bt.bt

ADH Menus in SMS 10.0

The document ADH_menu_with_cards is a guide to help with the menu options that you will use when working with ADH from within SMS10.0. It will serve as a guide to aid the user when inputting the various control cards that will create your boundary conditions information file.

Modeling Vessel Effects

The following is a list of links that reference the topic: Modeling Vessel-Generated Waves, Currents, and Shear Stresses. The Kampsville Site example under "2D SW Examples" goes along with this subject.

- Introduction
- Running ADH
- Vessel Effects

Modeling Vessel Effects

The following is a list of links that reference the topic: M
under "2D SW Examples" goes along with this subject

- Introduction
- Running ADH
- Vessel Effects
- Vessel Effects Simulations

2D SW Examples

- Example - Vessel Movement
  - vessel.bc
  - vessel.hot
  - vessel.3dm
  - vessel.bt
- Example - Flow Around a Dike - Adaption
  - dike.bc
  - dike.hot
  - dike.3dm
- Kampsville Site Example
  - A22.bc
  - A22.hot
  - A22.3dm
  - A22.bt

- Instruction available for inclusion of vessel effects
- Several 2D Shallow Water example file sets and instruction
- Basic instruction for implementing sand transport
- Sand transport example file sets
- Tutorials: step by step instruction for setting up an example in either a text format or SMS format

Sediment Transport in ADH

The following is a list of links to documentation that can help you ge
grains) sediment transport:

- Sediment Transport Model Overview
- Running ADH for Sediment
- Creating a Sediment Boundary Condition File
- Hotstarting ADH for Sediment

2D SW Sediment Transport Examples

- Example - Riprap Facility, 4 grains
  - riprap2d-sed.bc
  - riprap2d-sed.hot
  - riprap2d-sed.3dm
- Example - Mississippi River, Pool 5
  - pool5-ss-sed.bc
  - pool5-ss-sed.hot
  - pool5-ss-sed.3dm

Tutorials

The following tutorials use the riprap2d-steady state example. The

- Riprap-Hydro-SMS
- Riprap-Hydro-Text
- Riprap-Adaption
- Riprap-Vorticity
- Riprap-Sediment
- riprap2d-steady.3dm

ADH H

New to the Website

- Publications
  - Found on the ADH homepage
  - Lists websites, articles, conference proceedings, ERDC publications, and presentations by year
  - Quick links are available to the article source when possible
  - User publications/presentations can be included if applicable

Websites

ADH Homepage:
http://adh.usace.army.mil

ADH Software:
http://chl.erdc.usace.army.mil/software

Overview of ADH

Publications

Articles

2008

Brown, Gary L. 2008 "Approximate Profile for Nonequilibrium Suspend Sediment" J. Hydr. Engrg. 134, 1010 (2008), DOI:10.1061/(ASCE)07 9429(2008)134:7(1010). (Quick Find)

2006

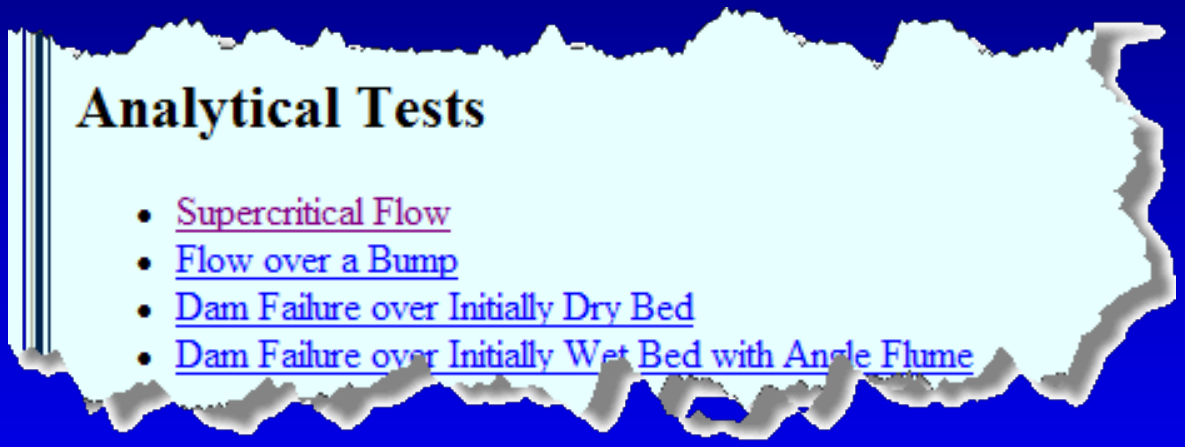
Tate, J. N., Berger, R. C., Stockstill, R. L. 2006. "Refinement Indicator fo Mesh Adaption in Shallow-Water Modeling," ASCE J. Hyd. Eng., Vol. 132, No. 8, 854-857, Aug 2006. (Quick Find)

2005

Stockstill, R.L., Berger, R.C., and Hite, J.E. Jr. 2005. "Application of Computational Hydraulics for the Evaluation of Navigation Structures," PIANC AIPCN 119 April 2005, pp 31-35.

New to the Website

- Analytical Tests
  - Example problems showing how ADH compares to analytical solutions and journal published results
  - Includes ADH input files and results along with reference information
  - Hope to add several more examples this year

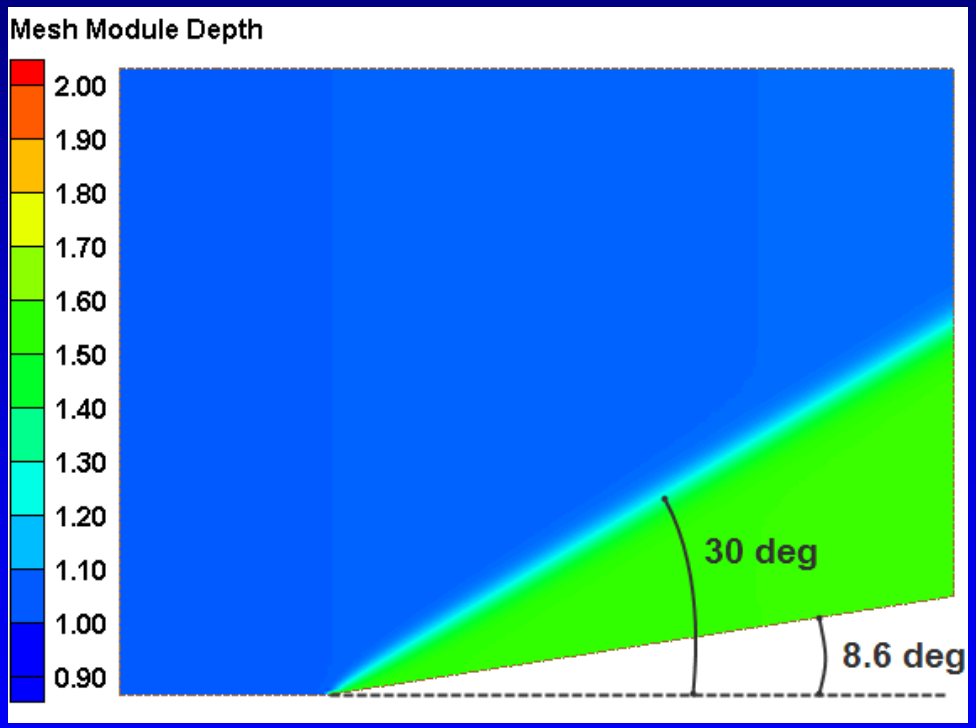


Analytical Tests

- Supercritical Flow
- Flow over a Bump
- Dam Failure over Initially Dry Bed
- Dam Failure over Initially Wet Bed with Angle Flume

Hydraulic Jump

- **Source:** Choi et. al; "*A Spectral Finite Volume Model for Shallow Water Equations*". Journal of the American Meteorological Society , July 2004, 1777-1791.
- *Frd* = 2.74 US
- Constriction Angle = 8.958°
- **Analytical Solution:**
  - *DS h* = 1.5 m
  - DS | u | = 7.9556 m/s
  - *DS Frd* = 2.075
  - the angle between the original flow direction and the jump is 30.0°



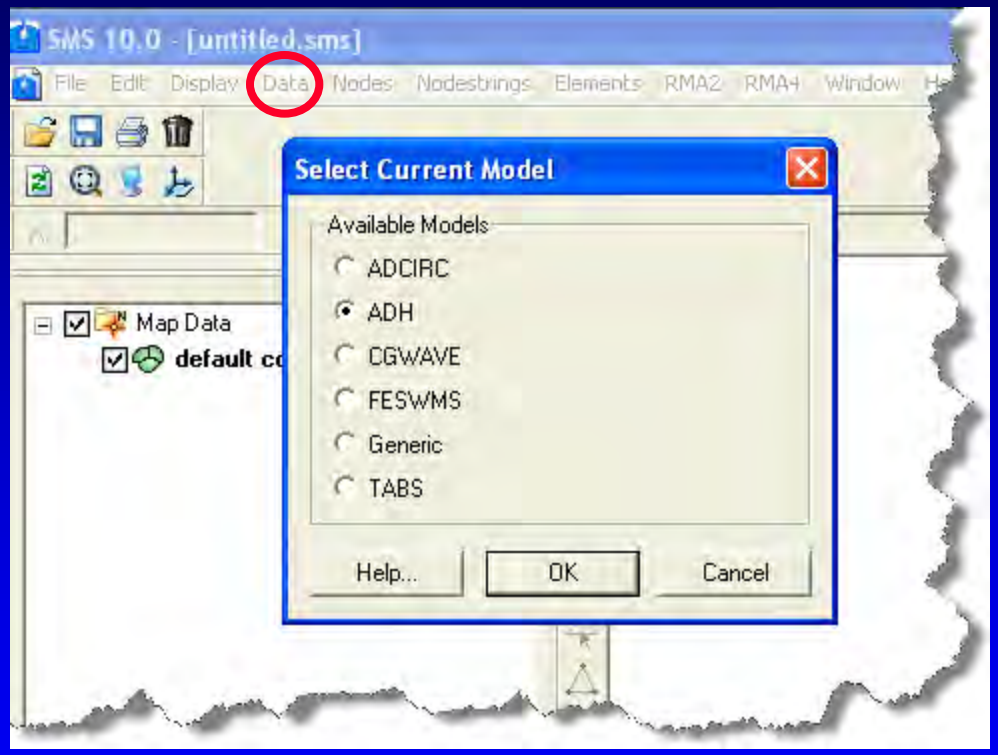
Documentation Plans

- Bug Reporting System
  - Web based system to allow users to log in and report problems, see issues/concerns from other users, and see what issues have been addressed
  - Bugzilla MANTIS (Free software)
- ADH Wiki's
  - One for development checklists
  - One for a user forum for tips, tricks, and questions

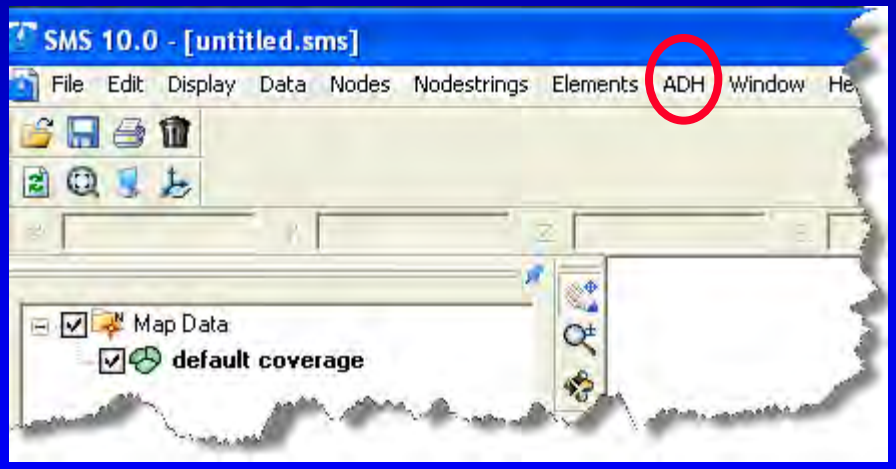
SMS Capabilities

- Hydrodynamics Complete
- GUI set up for selection of parameters
- Ability to Run inside SMS
- Visualization of Results
- Transport Options Coming Soon

SMS 10



- First ensure that you are in the ADH module



SMS/ADH Reference

- angle_bt.bt

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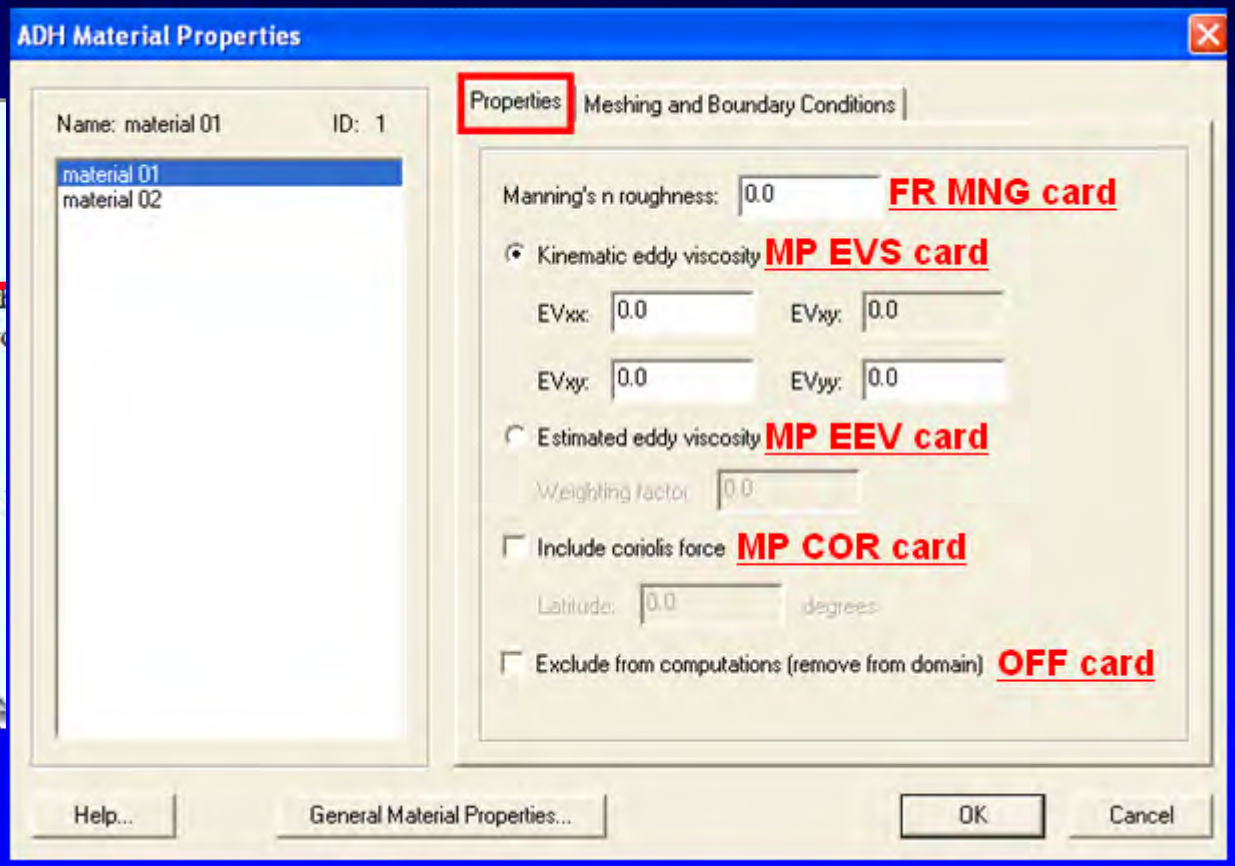
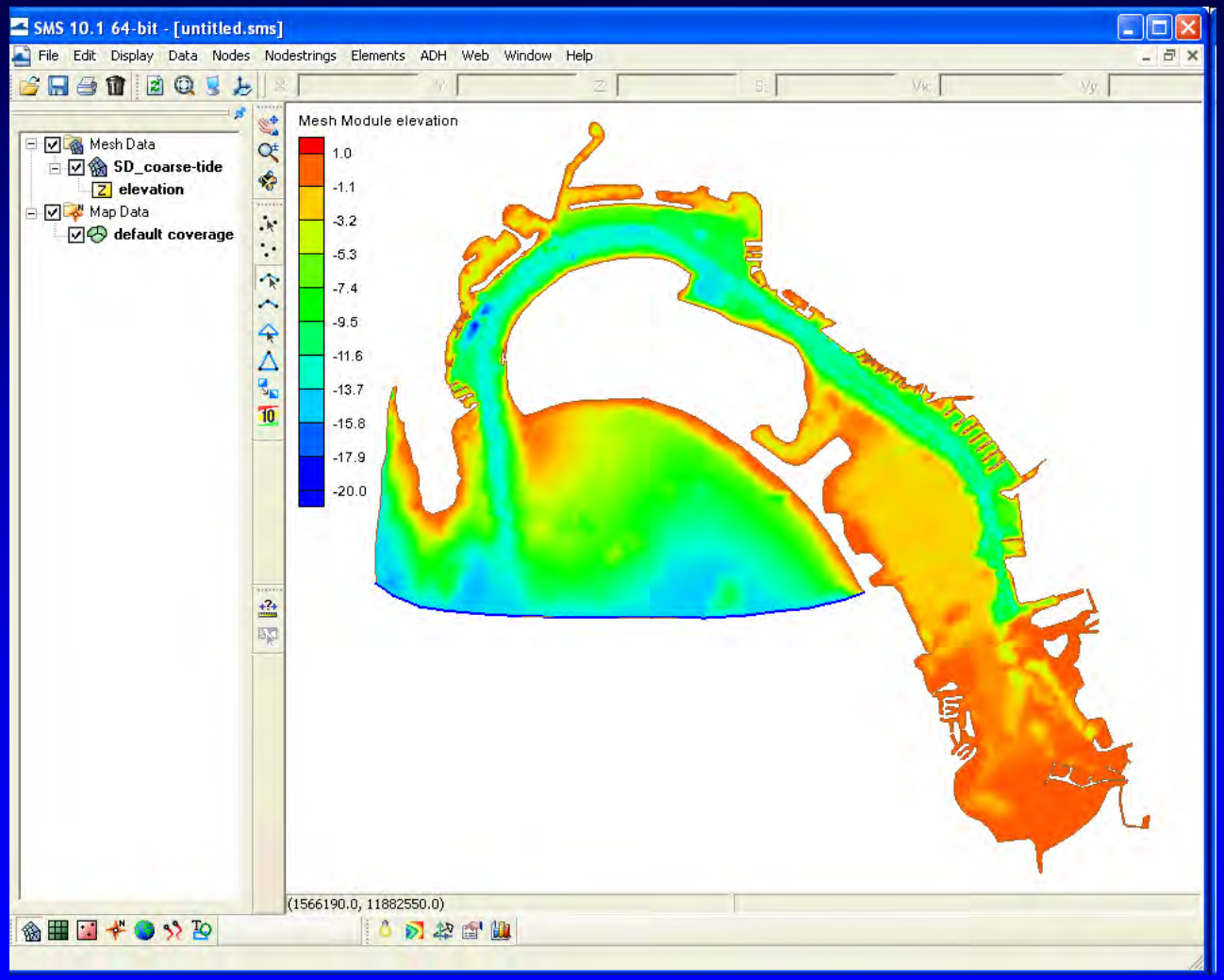
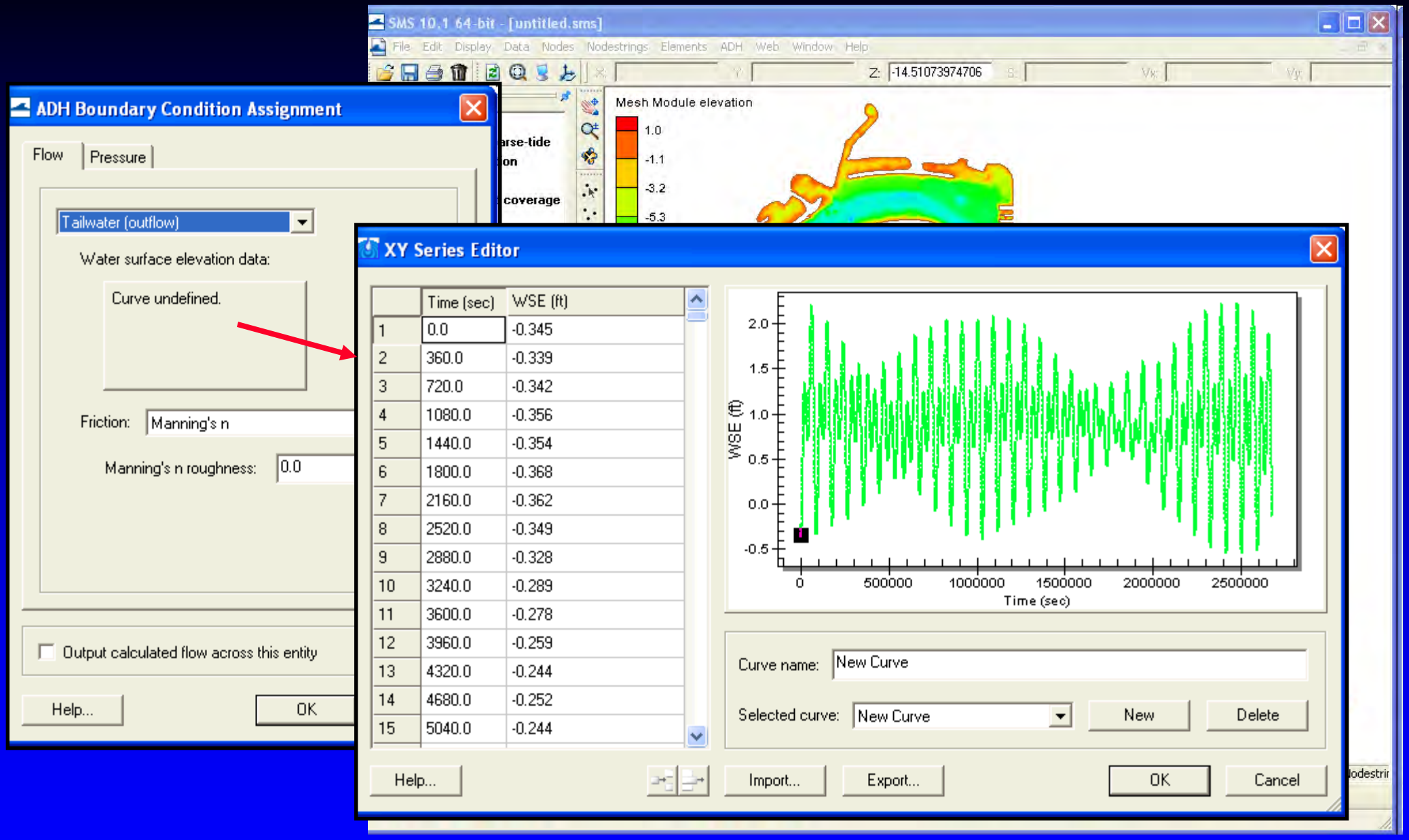


SMS 10

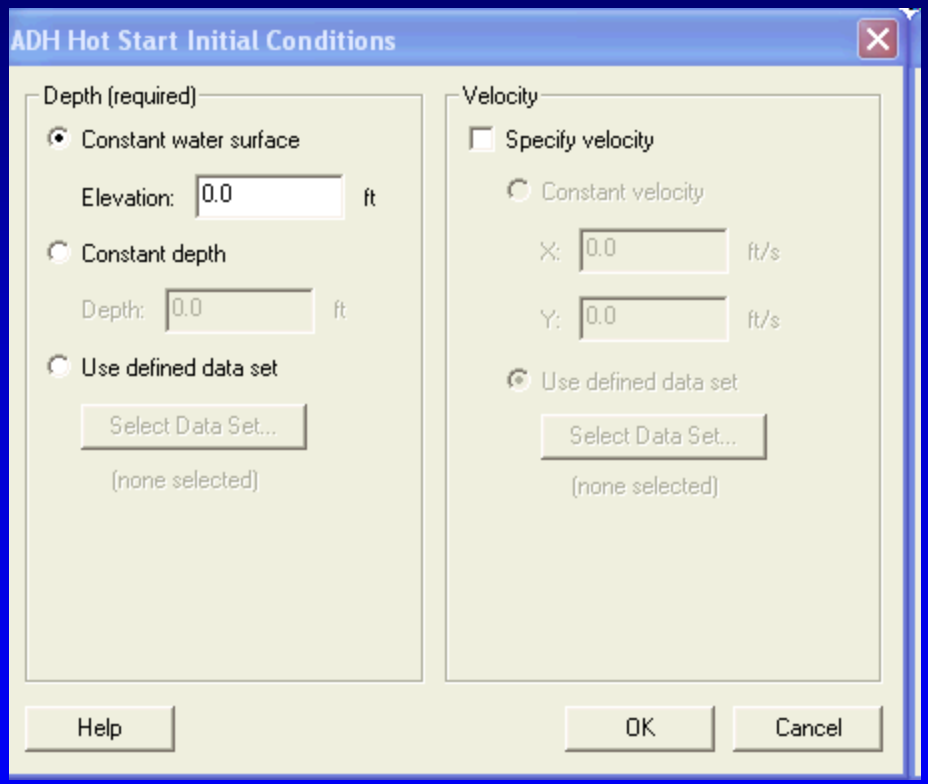
- Same general SMS options
  - Conceptual Model (Map building)
  - Mesh is generated with linear elements
  - Data Tree
  - Saves project *.3dm, *.hot, and *.bc




SMS 10.1 64-bit - [untitled.sms]
File Edit Display Data Nodes Nodestrings Elements ADH Web Window Help
Z: -14.51073974706
Mesh Module elevation
1.0
-1.1
-3.2
-5.3
ADH Boundary Condition Assignment
Flow
Pressure
Tailwater (outflow)
Water surface elevation data:
Curve undefined.
Friction:
Manning's n
Manning's n roughness:
0.0
Output calculated flow across this entity
Help...
OK
XY Series Editor
Time (sec)
WSE (ft)
1 0.0 -0.345
2 360.0 -0.339
3 720.0 -0.342
4 1080.0 -0.356
5 1440.0 -0.354
6 1800.0 -0.368
7 2160.0 -0.362
8 2520.0 -0.349
9 2880.0 -0.328
10 3240.0 -0.289
11 3600.0 -0.278
12 3960.0 -0.259
13 4320.0 -0.244
14 4680.0 -0.252
15 5040.0 -0.244
WSE (ft)
2.0
1.5
1.0
0.5
0.0
-0.5
0
500000
1000000
1500000
2000000
2500000
Time (sec)
Curve name:
New Curve
Selected curve:
New Curve
New
Delete
Help...
Import...
Export...
OK
Cancel

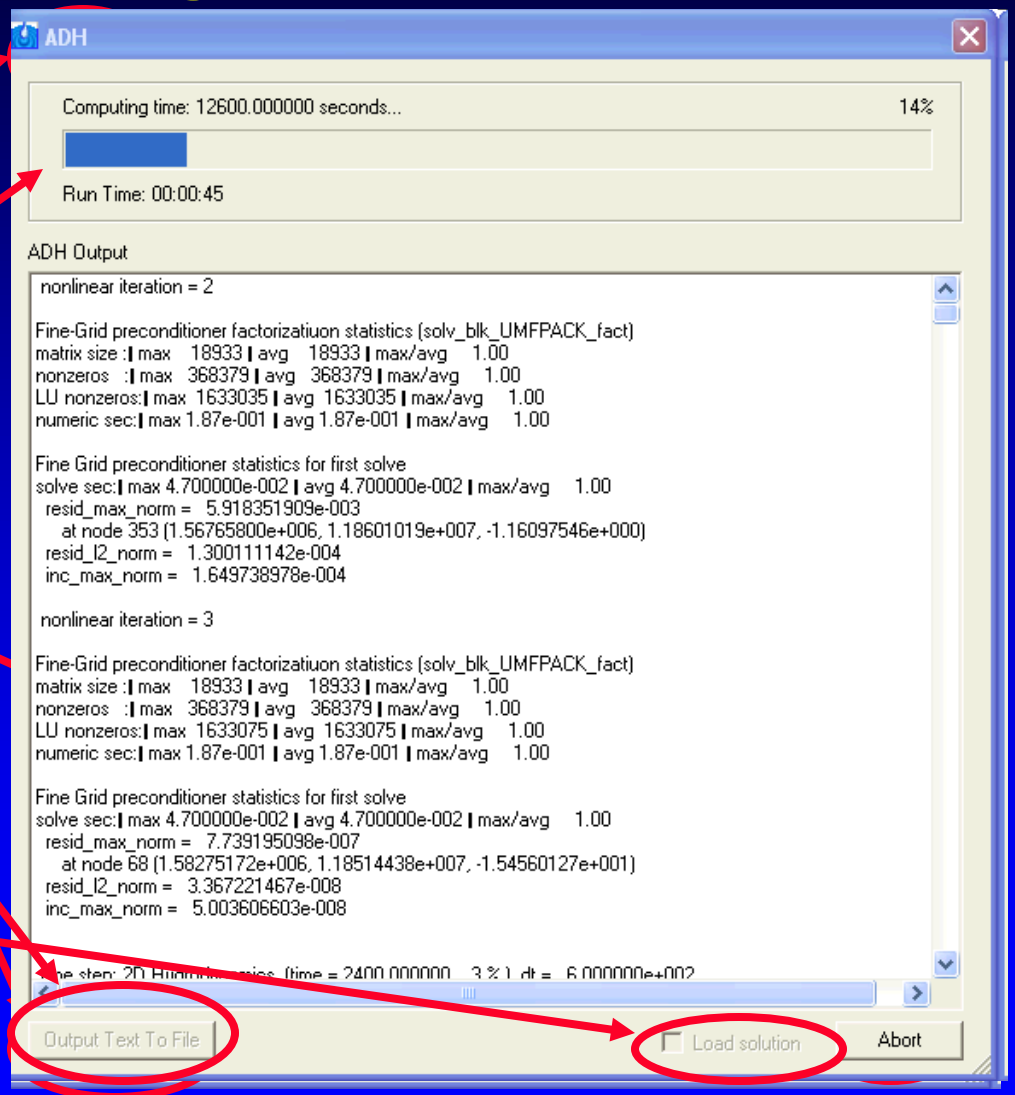
Hotstarting

- Generation of hotstart files is easier and several options are available for both initial depths and velocities.



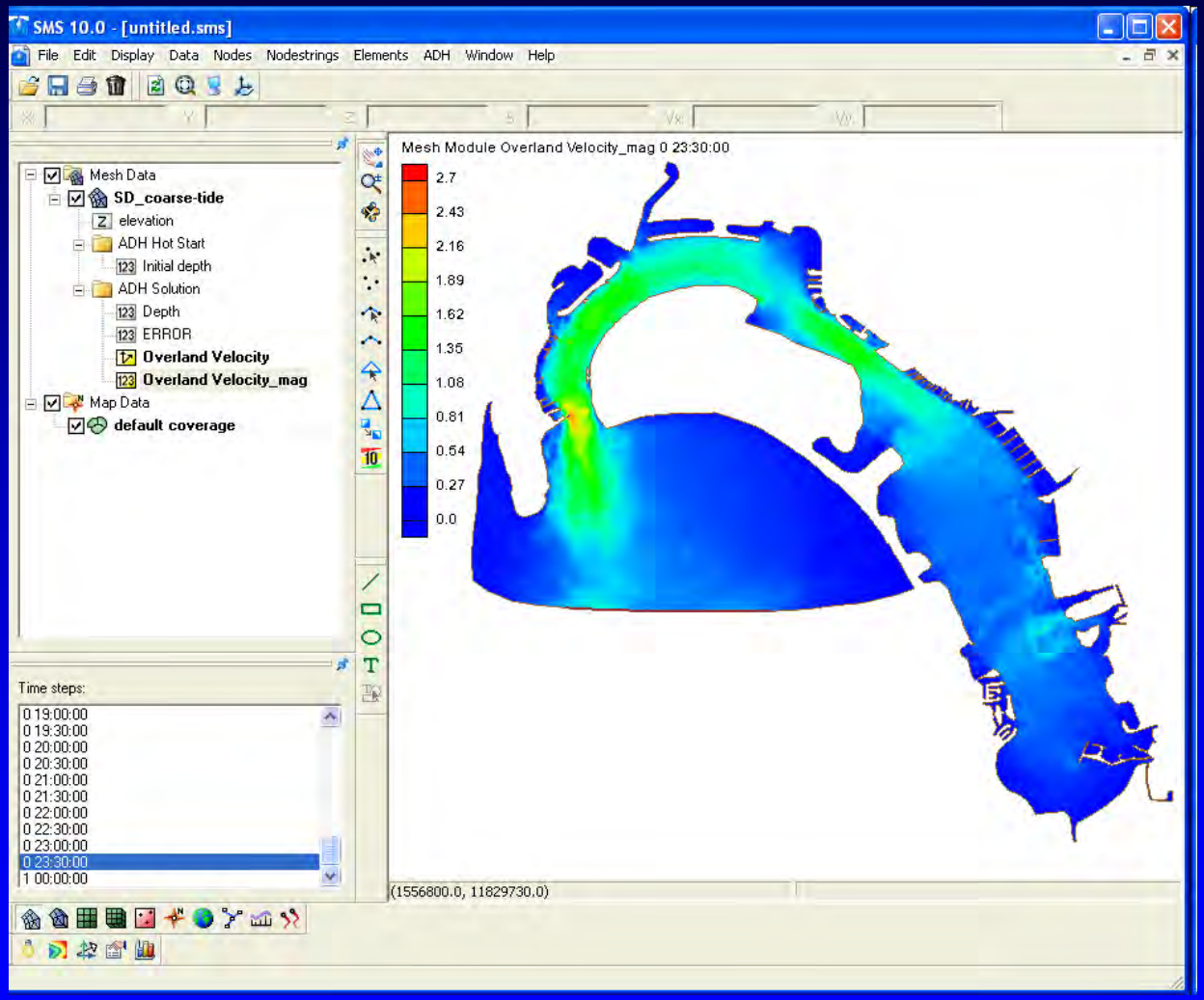
Running

- Run ADH
  - Pre_adh runs first
  - Screen output is shown and can be saved to a file
  - Run ADH
  - Progress Bar
  - Screen output is shown and can be saved to a file when ADH completes
  - Checkbox for automatic loading of the solution when ADH completes



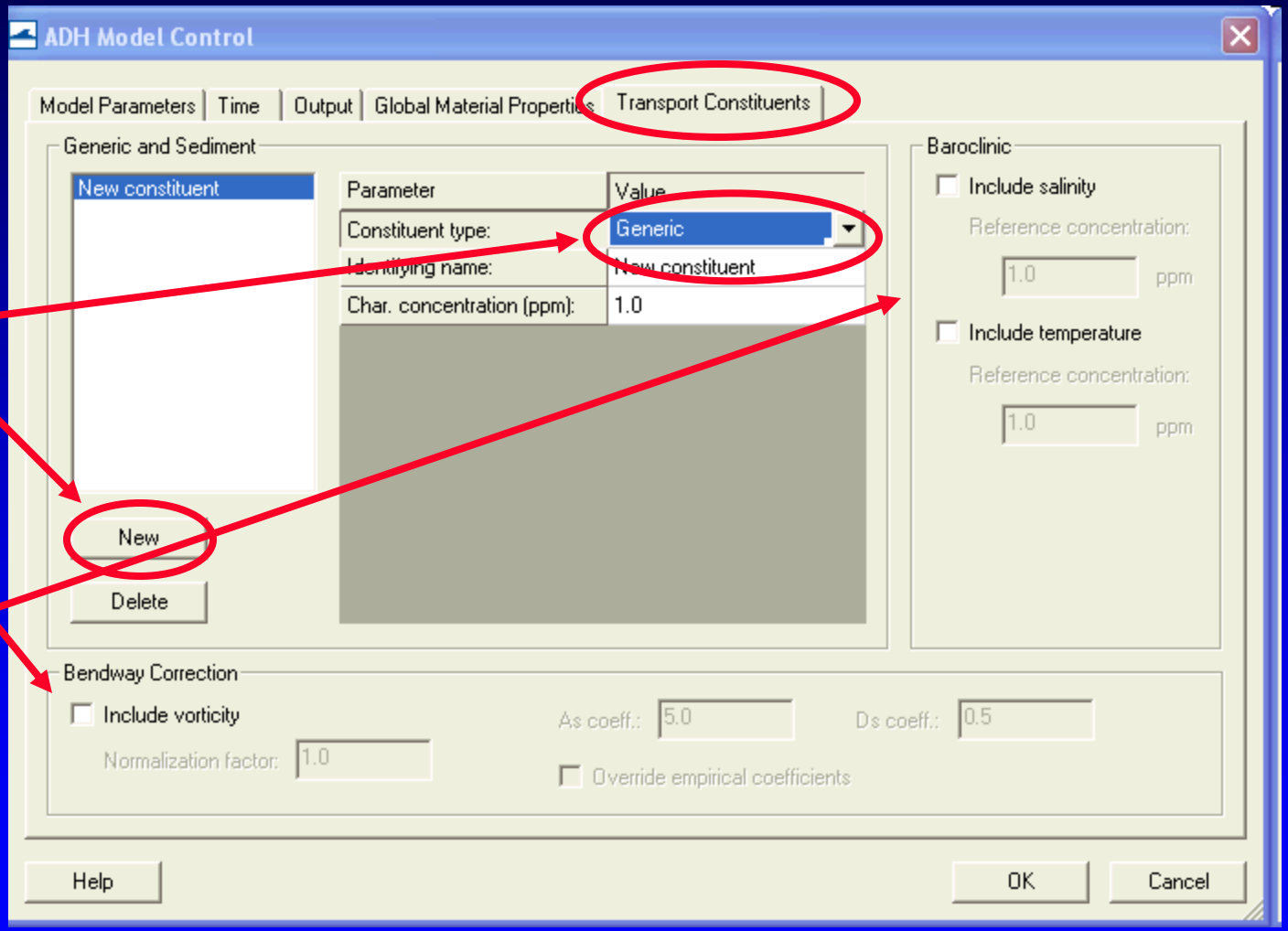
Visualization

- ADH files labeled in the data tree
- Solution timesteps listed
- Nothing unique for ADH at this point



Transport

- Found under Model Control
- Select “New” and specify the type (generic, sand, clay/silt)
- Options for:
  - Vorticity (Bedway Correction effects)
  - Salinity
  - Temperature



Coming Soon

- Viewing multiple meshes and results in SMS
- Refinement tolerance – SMS utility to choose for the user
- Hydraulic Structures
- Guidance notes for several parameters
- General Bug Fixes

Coming Soon for Transport

- Ability to set initial concentrations
- Ability to set bed layer information
- Ability to read in sediment output files of multiple columns
  - Grain size fractions from a single data set
  - Bed Layer distribution from a single data set

ADH

- User’s time is important
- Burden on the code (Unstructured, adaption, adaptive time step, transition to 3D)
- Documentation available and complete
- Links to SedLib, HEC-RAS, NSM, ICM