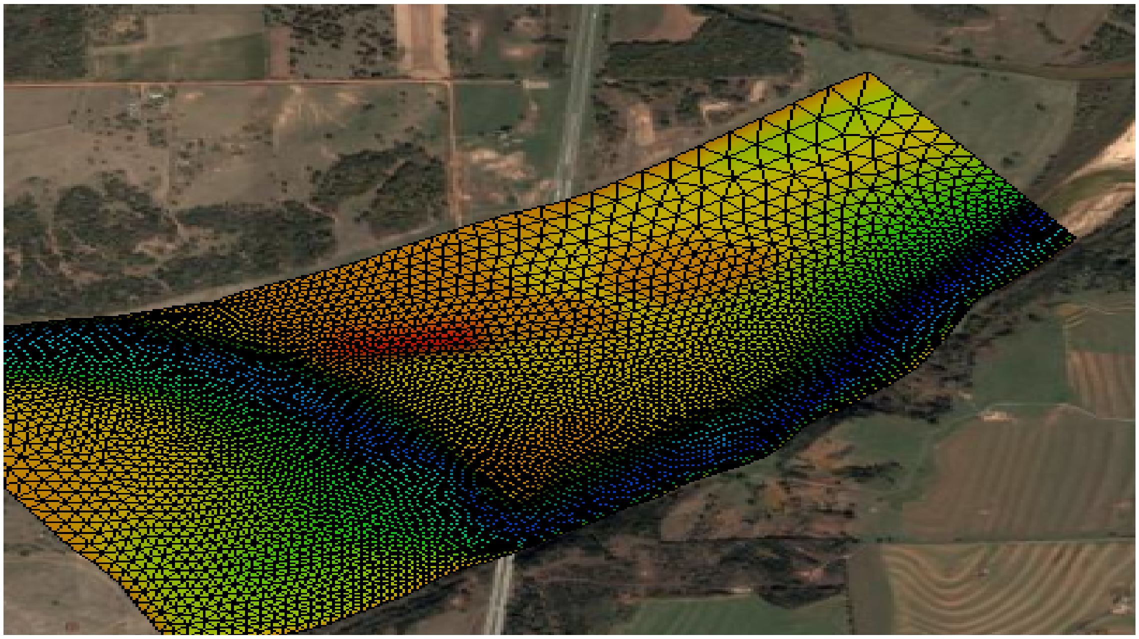
SMS 11.1 Tutorial

AdH- 2D HYDRODYNAMICS



Objectives

This lesson will teach you how to prepare and run a basic AdH model using the *SMS* interface.

Prerequisites

- Overview Tutorial

Requirements

- AdH
- Mesh Module
- Scatter Module
- Map Module
- GIS Module

Time

- 30-60 minutes

1 Introduction

The input files needed to complete this tutorial are found in the Data Files Folder for this tutorial.
AdH is a state-of-the-art Adaptive Hydraulics Modeling system developed by the Coastal and Hydraulics Laboratory, ERDC, USACE (www.chl.erdc.usace.army.mil), and is capable of handling two-dimensional shallow water problems. One of the major benefits of AdH is its use of adaptive numerical meshes that can be employed to improve model accuracy without sacrificing efficiency. It also allows for the rapid convergence of flows to steady state solutions. AdH contains other essential features such as wetting and drying, completely coupled sediment transport (not currently supported in the SMS interface), and wind effects.
The area used in the tutorial is where the Cimarron River crosses I-35 in Oklahoma, about 50 miles North of Oklahoma City.

2 Background Data

The first step in building a model with SMS is to import background data:

1. Geographic (location) and topographic (elevation) data
2. Images of maps and aerial photos
3. Land use data
4. Boundary conditions

2.1 Units

The data used in this tutorial are in SI units, so the current projection will need to be set accordingly:

1. Select *Display | Projection…*
2. In the “Horizontal” section select the “Local projection” option and set the “Units” to “Meters.”
3. In the “Vertical” section set the “Units” to “Meters.”
4. Click *OK* to exit the Current Projection dialog.

2.2 Topographic Data

Topographic data in SMS are managed as triangulated irregular networks (TINs) in the scatter module. The scattered data will be the source of the elevation data for the AdH mesh. To import the TIN:

1. Select *File | Open* and open the file *Cimarron Survey.h5* from the Data Files Folder for this tutorial.

2. Go to *Display* | *Display* options and make sure that points are on in the scatter tab of the dialog. Click OK to exit the Display Options dialog.
3. Hit the frame macro .

The screen will refresh, showing a set of scattered data points.

2.3 Background Image

An aerial photo or map of the study site is useful when building a numeric model. An image for the study site was generated using Google Earth Pro. To open this file:

1. Select *File* | *Open* and open the file *ge_highres.jpg*.
2. Click *yes* if prompted to build image pyramids. This builds images at various resolutions for clearer images at different zoom levels.

2.4 Display Options

Items loaded into SMS can be turned off/on by clicking in the box to the left of the item in the project explorer. As you proceed through this tutorial, you may want to turn the images on/off to reference the location of features or to simplify the display. The display options for the topographic data can also be adjusted:

1. Select the *Display* | *Display Options* menu item.
2. Switch to the “Scatter” tab. Uncheck “Points” to turn off the display of points. Check “Boundary” and “Contours” to turn them on.
3. Switch to the “Contours” tab. Set the “Contour method” to “Color Fill” and set the “Transparency” to 50%.

3 Building a Conceptual Model

An AdH model requires a finite element mesh with linear, triangular elements. Feature objects will be used to create a conceptual model. The conceptual model defines the model domain, material properties, and the mesh type. Specific model control and boundary condition data will be added after the mesh is created.

3.1 Model Extents

To define the model extents, an arc will be extracted from a specific TIN contour that represents a rough estimate of the extents of the flooding:

1. Right click on *Map Data* in the project explorer and select *New Coverage*. Select ADH | ADH for the type and name the coverage “Boundary.” Click OK.

2. Right click on "Survey 2005" scatter set and select *Convert | Scatter Contours -> Map*.
3. In the Create Contour Arcs dialog, enter 271 m for the elevation and 15 m for the spacing. Select "Boundary" for the coverage.
4. Click *OK*. Arcs will be created along the 271 m elevation contour and the vertex spacing on the arcs will be 15 m.

Additional arcs could be extracted at certain elevations representing other key features. For consistency in completing this tutorial, the newly created coverage will be deleted and a map file with feature objects defined will be imported.

1. Right click on *Map Data* in the project explorer and select *Clear Coverages*.
2. Select *File | Open* and open the file *AdH_Model.map*. Note that the imported coverage contains arcs delineating the model boundary as well as the outer river banks as shown in Figure 1.

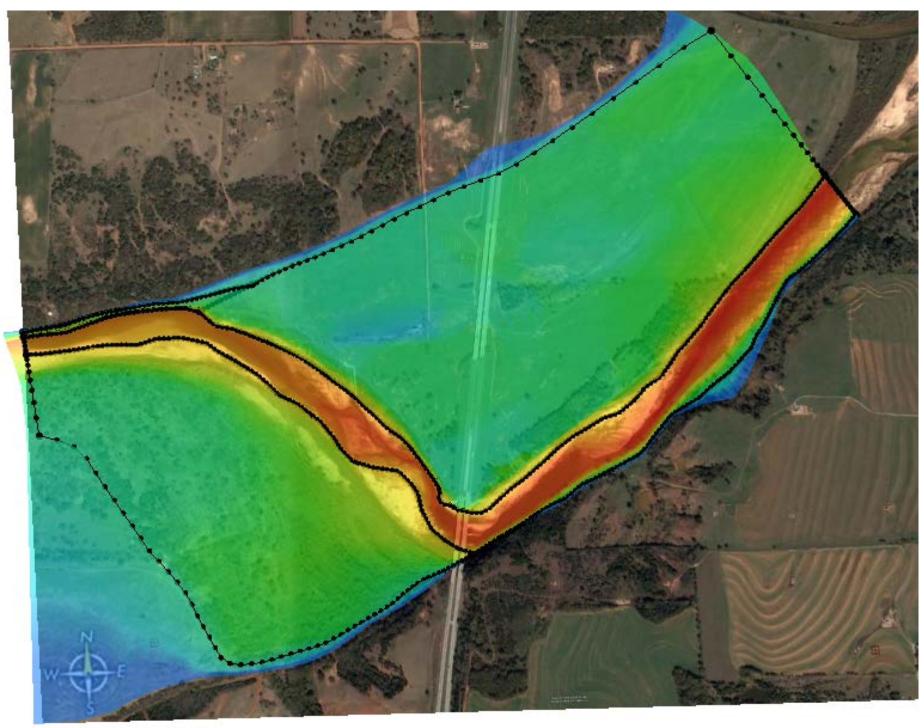


Figure 1 Conceptual Model Extents with Background Image

3.2 Area Properties

Feature polygons in an area property coverage will be used to define the material zones of the model. Polygons can be digitized manually based on a map or aerial photo or they can be imported. For this case, land use data will be imported from an ESRI shapefile.

1. Right click on *Map Data* in the project explorer and select *New Coverage*.
2. In the New Coverage dialog, set the type to *Area Property* under the folder named *Generic*. Type “materials” for the name. Click *OK* to exit the dialog and create the new coverage.
3. Left click on the “materials” coverage to make it the active coverage. This ensures that the when the GIS data are converted to feature objects, the feature objects are added to the “materials” coverage.
4. Select *File |Open* and select the file “materials.shp”. This will load the data into the GIS module.
5. Left click on the *materials.shp* layer in the *GIS Data folder* in the project explorer to make it active.
6. From the *Mapping* menu choose *Shapes* -> *Feature Objects*.
7. Click *yes* to use all shapes. Select *materials* under the *use an existing coverage* section and then click *Next*.
8. In the *GIS to Feature Objects Wizard*, step 1 choose *Material* in the combo-box under *MATNAME*.
9. Click *Next* and then *Finish*.

Notice that the area property coverage contains polygons but the polygons do not cover the entire domain. An additional polygon and material type will be created to cover areas not covered by the shapefile. To create a new material:

1. Select the *Edit | Materials Data* menu item.
2. Click the *New* button.
3. Rename this material to “grasslands.”
4. Click *OK*.

To create the new polygon and assign a material type:

1. Left click on the *materials* coverage in the project explorer to make it active.
2. Select the *Create Feature Arc Tool*.
3. Click to create an arc such that the scatter set is completely encompassed.
4. Select the *Feature Objects | Build Polygons* menu item.
5. Switch to the *Select Feature Polygon* tool.
6. Left click in the newly created polygon to select it. Right click and select the *Attributes…* menu item.
7. In the Land Polygon Attributes dialog, select “grasslands” for the “Material.”
8. Choose *Display | Display Options*.
9. Switch to the Map page and turn on Fill and Legend.

10. Click OK to return to the main SMS screen.
11. Uncheck the scatterset in the project explorer to turn it off momentarily.

The display should look similar to Figure 2 showing where the materials occur within the domain. The colors/patterns may be different depending upon your settings. You can change these by going to *Edit* | *Materials Data*.

Figure 2 Feature Polygons Representing Material Zones

3.3 Meshing Properties

The next step in constructing a conceptual model is to define the mesh generation parameters. Meshing properties will be assigned to feature polygons in the "AdH Model" coverage.

1. Left click on the "AdH Model" coverage to make it active.
2. Switch to the Select Feature Polygon Tool.
3. Select both polygons by dragging a box around them or selecting *Edit* | *Select All* menu command.
4. Select the *Feature Objects* | *Attributes* menu command.

5. Check the “Mesh type” toggle box and select “paving” from the drop-down list. Since AdH requires triangular elements, paving is a good option. Paving creates elements based on the vertex distribution on the boundary arcs of the polygons. Resulting mesh nodes are then relaxed to optimize element quality.
6. Check the “Bathymetry type” toggle box and select “Scatter Set” from the drop-down list.
7. Click the “Scatter Options…” button. In the Interpolation dialog, select the “elevation” dataset and leave all other options at the default values. These options control the elevation values that will be assigned to the mesh nodes, which will be interpolated from the survey data.
8. Click OK to exit the Interpolation dialog and click OK again to exit the Polygon Properties dialog.

4 Model Parameters

4.1 Creating the Mesh

With the meshing parameters set, the conceptual model is ready to convert to a finite element mesh for AdH.

1. Left click on the “AdH Model” coverage to make it active.
2. Select the *Feature Objects | Map -> 2D Mesh* menu item.
3. In the 2D Mesh Options dialog, check the “Use area coverage” toggle box and select the “materials” coverage from the drop-down list.
4. Click OK to exit the 2D Mesh Options dialog.

A finite element mesh with triangular elements is created. The node elevations are interpolated values from the scatter set survey and element material types are based on the materials coverage.
At this point, the background image, scatterset, GIS data, and map data can be turned off to make it easier to work with the mesh. To do this:

1. In the project explorer, uncheck the box next to the “ge_highres” image, the scatterset Survery 2005, the GIS layer materials.shp, and the map coverages.

4.2 Material Properties

Elements in the mesh have been assigned material types, but the parameters and properties associated with each material still need to be specified. To set the material properties:

1. Click on the mesh (ADH Model) to make sure it is active.

2. Select the *ADH | Material Properties…* menu item.
3. For each material in the list, set the “Eddy viscosity” method to “Estimated” and enter 0.5 for the “Weighting factor.”
4. For each material in the list, set the “Friction” method to “Manning’s n” and set the Manning’s n roughness values according to the table below.
5. Click *OK* to exit the ADH Material Properties dialog.

Material	**Mannings n**
Channel	0.03
Roadway	0.02
forest	0.10
Light forest	0.08
grassland	0.06

4.3 Boundary Conditions

Boundary conditions force the model with certain hydrodynamic conditions. For this model, flow vs. time forcing will be specified at the upstream boundary and water surface elevation vs. time downstream.

1. Left click on the “AdH Model” item in the Mesh Data folder of the project explorer to make it active.
2. Switch to the *Create Nodestring* Tool.
3. Create nodestrings at the upstream and downstream boundaries as shown in Figure 3. Be sure to include all nodes along the boundary in the nodestrings (you can use all the nodes along the boundary by holding down the shift button).
4. Switch to the *Select Nodestring* Tool.
5. Select the upstream nodestring. Right click and select the *Renumber Nodes* menu item.
6. Right click and select the *Boundary Condition | Assign…* menu item.
7. In the “Flow” tab of the ADH Boundary Condition Assignment dialog, select “Total discharge” from the drop-down list. Click on the button below “Discharge data.”
8. In the Time Series dialog, click the “New…” button. Enter “Inflow BC” for the curve name and click OK.

9. In the “Curve Data” section, change the “Time” units to hours and the “Discharge” units to m^3/s.
10. Open the file “AdH_bc.xls” in a spreadsheet program, and copy the times to the first column and the inflow values to the second column.
11. Click OK to exit the Time series dialog and click OK again to exit the ADH Boundary Condition Assignment dialog.
12. Select the downstream nodestring. Right click and select the *Boundary Condition | Assign…* menu item.
13. In the “Flow” tab of the ADH Boundary Condition Assignment dialog, select “Water surface elevation” from the drop-down list. Click on the button below “Water surface elevation data.”
14. In the Time Series dialog, click the “New…” button. Enter “Outflow BC” for the curve name and click OK.
15. In the “Curve Data” section, change the “Time” units to hours and the “WSE” units to m. Copy the times and WSE values from the “AdH_bc.xls” spreadsheet.
16. Click OK to exit the Time series dialog and click OK again to exit the ADH Boundary Condition Assignment dialog.

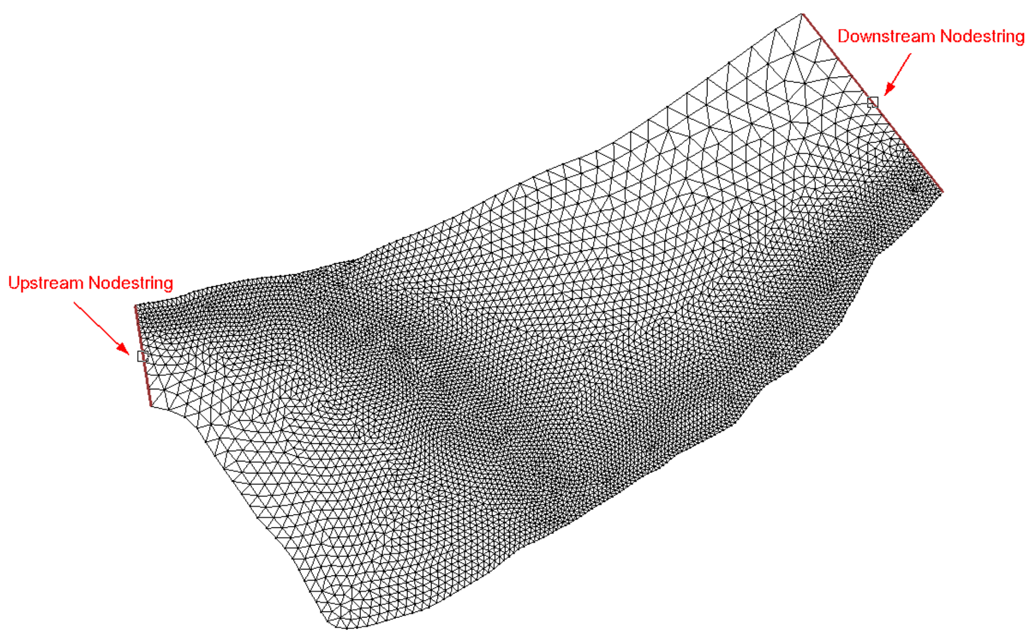


Figure 3 Nodestring Locations

4.4 Time Control

Time control parameters for the model will now be set.

1. Select the *ADH | Model Control* menu item. Click on the "Time" tab.
2. Set the "Simulation" type to "Dynamic." Enter 36.0 hours for the "Duration."
3. Click on the "Time step size:" button.
4. Select "hour" from the drop-down list for the "Time" units and "second" for "Time step size." Enter two rows of data (0.0, 600.0) and (36.0, 600.0). For this model, a constant timestep is specified and AdH will adjust the timestep throughout the run as needed.
5. Click OK to exit the Time Series dialog.

4.5 Output Control

The AdH model has a lot of flexibility for controlling frequency of model outputs. For this model, solution data will be output every 15 minutes for the entire simulation duration.

1. Click on the "Output" tab of the ADH Model Control dialog.
2. In the "Output Times" section, select the "Add by specifying a range" option. Change start and end to use hours by changing the combo-box to the right of "Start at." Enter 0.0 hours for the "Start at" time, 36.0 hours for the "End at" time, and 15.0 minutes for the "Increment." From the "View output times in" drop-down list, select "hours."
3. Click the "Add" button to populate the output times list.
4. Click OK to return to the main SMS screen.

4.6 Initial Conditions

AdH requires initial conditions be specified for a model run. The initial conditions could be interpolated solution data from a previous model run or conditions with simple hydraulics, which are numerically stable. For this model, initial depths that match the starting boundary condition will be specified.

1. Select the *ADH | Hot Start Initial Conditions…* menu item.
2. In the ADH Hot Start Initial Conditions dialog, select "Constant water surface" and enter 270.24 m for the "Elevation."
3. Click *OK* to exit the ADH Hot Start Initial Conditions dialog. Notice that an initial condition dataset now appears in the project explorer.

5 AdH Model Execution

Before running AdH, an SMS project file will be saved. Project files contain all data associated with a project.

1. Select *File | Save New Project*.
2. Save the file as “AdH_Project.sms”.
3. Click the *Save* button to save the files.

With the project files saved, the AdH model can be launched. The model contains two separate programs that run in sequence: Pre-AdH and AdH. Pre-AdH examines the model geometry and input file to look for errors. Upon successful completion of Pre-AdH, AdH can be run. AdH is the numerical engine that generates solution data. Before running AdH, the model check should first run to check if there are any errors in the model.

1. Select the *ADH | Model Check*. If there are no problems with the model, then proceed to run the model. If there are problems found, then go through the steps to fix the problems as outlined in the Model Checker dialog.
2. Select the *ADH | Run ADH* menu item. Pre-AdH will launch in the model wrapper and should finish in a few seconds.
3. Upon successful completion of Pre-AdH, the “Abort” button in the model wrapper will change to “Run ADH.” Click the button to start AdH. The AdH model run will take some time. Depending on the speed of your computer, the model will finish in 1-2 hours.

6 Viewing the Solution

The primary output of AdH are files containing velocity vectors and depth values for each node in the mesh. These files can be automatically imported into SMS for viewing.

1. Upon successful completion of AdH, the “Abort” button in the model wrapper will change to “Exit.” Check the “Load solution” toggle and click the “Exit” button. A folder will appear in the project explorer containing the AdH solution datasets.
2. In the project explorer, uncheck the toggle boxes to turn off all Map Data and Scatter Data. Check the toggle box next to Mesh Data and left click on “ADH Model” to make it active.Turn on
3. Select the *Display | Display Options* menu item. In the 2D Mesh tab, turn on contours and vectors.
4. Switch to the Contours tab and select Color Fill as the contour method.
5. Click *OK* to close the Display Options dialog.

Solution data for each output time can be visualized in the graphics window. For more information on visualization options, consult the “Data Visualization” tutorial.

7 Conclusion

For practice, you may want to experiment with changing various model parameters and observing the effects on the model output. Adjust roughness values and/or experiment with different levels of element refinement. Be sure to save new project files to avoid overwriting the original tutorial files.