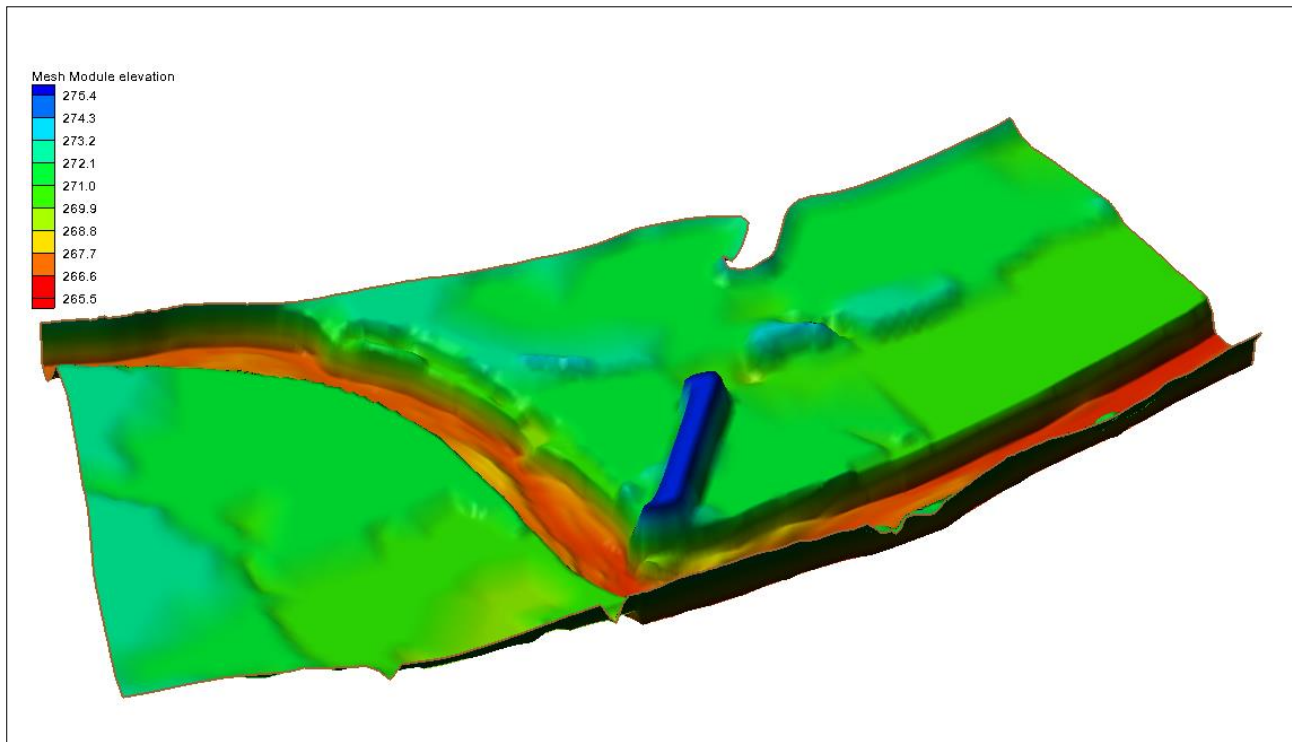*SMS 12.1 Tutorial*
SRH-2D

Objectives

This tutorial shows how to build a Sedimentation and River Hydraulics – Two-Dimensional (SRH-2D) simulation.

Prerequisites

- SMS Overview tutorial

Requirements

- SRH-2D Model
- Map Module
- Mesh Module
- Data files

Time

- 20-30 minutes

1   Introduction

The Sedimentation and River Hydraulics – Two-Dimensional (SRH-2D) model is a two-dimensional (2D) hydraulic, sediment, temperature, and vegetation model for river systems developed at the Unites States Bureau of Reclamation (USBR) and sponsored by the United States Federal Highway Administration (FHWA).

SRH-2D uses a flexible mesh that may contain arbitrarily shaped cells. In practice, the hybrid mesh of quadrilateral and triangular cells is recommended, though purely quadrilateral or triangular elements may be used. A hybrid mesh may achieve the best compromise between solution accuracy and computing demand. SRH-2D adopts very robust and stable numerical schemes with a seamless wetting-drying algorithm.

SRH-2D is particularly useful for problems where 2D effects are important. Examples include flows with in-stream structures, through bends, with perched rivers, with side channel and agricultural returns, and with braided channel systems.

2   Define Projection and Units

In SMS, a projection should be defined for all projects. Setting a projection taking advantage of all the geo-referencing tools in SMS for pre/post processing, including

loading of online background images. SRH-2D can be run using U.S. Customary or Metric Units.

2.1   Creating a New Project

To start this tutorial:

1. Launch the SMS application.

2. Choose *Display* / **Projection…** to open the *Display Projection* dialog.

3. Set the *Horizontal* component to use a *Global projection*. This will bring up the *Select Projection* dialog (see Figure 1).

4. In the *Select Projection* dialog, set:

    1. *Projection* to "State Plane Coordinate System"

    2. *Zone* to "Oklahoma North (FIPS 3501)"

    3. *Datum* to "NAD83"

    4. *Planar Units* to "Meters"

5. Click **OK** to complete the horizontal projection selection

6. Ensure that *Units* in the *Vertical* section is set to "Meters*." Click the **OK** button to exit the *Display Projection* dialog.

The project has now been set in the state plane projection with NAD 83 datum and the units will be in meters.
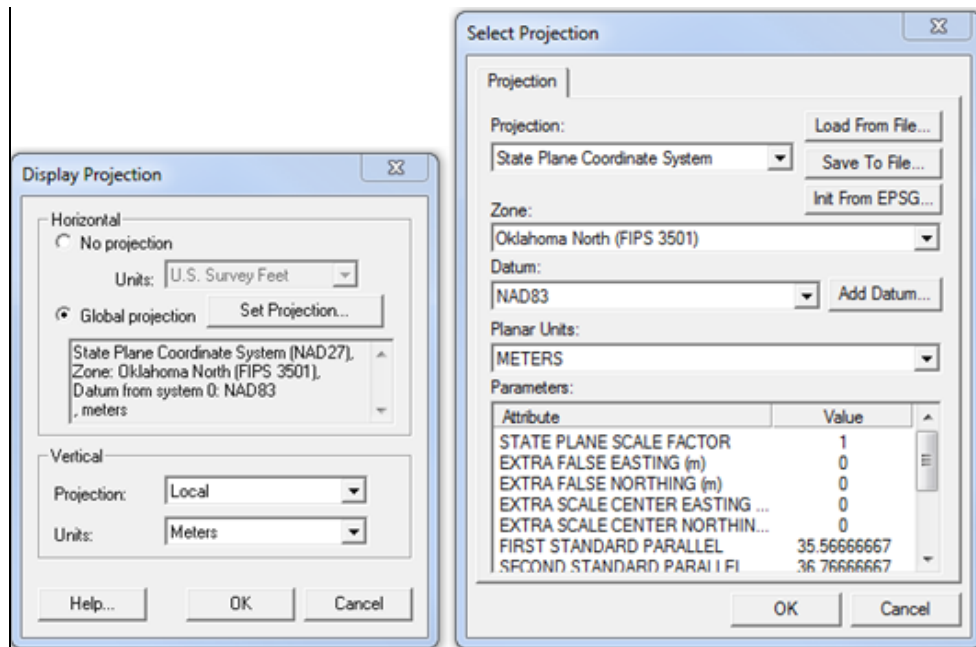

Figure 1. Display Properties and Select Projection dialogs

Note: With SRH-2D, the horizontal and vertical units need to be the same. Importing data with different units is possible but the data must be converted to the desired units before running SRH-2D.

2.2   Loading Background Projects

Background information, such as topographic/bathymetric surveys and land use data, provides the basis for any hydraulic simulation. To load the background data for this project:

1. Select *File* / **Open** to bring up the *Open* dialog.

2. Browse to the file "datafiles\Cimarron_survey.h5" and click **Open**. This file contains background elevation data for the project site.

3. Click on the **Frame** 🔍 macro if the data is not visible in the Graphics Window.

4. Repeating steps 1–2,, open the file "datafiles\Cimarron.map". This file contains a defined model domain. If a warning dialog appears stating the coverage is "unsupported without a project", click on **OK**. The Map Data entity in the Project Explorer will now have an entity titled "Domain" under it.

5. Make sure the correct model type is selected by right-clicking on "Domain" and selecting *Type | Generic |* **Mesh Generator**.

6. Repeating steps 1–2, open the file "datafiles\Aerial.tif". This file contains a georeferenced aerial photo of the area being simulated.

7. Select *File |* **Save new project** to bring up a *Save* dialog.

8. Enter the *File name* "CimarronTutorial.sms" and click **Save** to initialize the project.

2.3   Display Options

The display settings control what information is displayed in the Graphics Window. Adjust these settings to visualize and review the topographic data for the area being simulated.

To do this:

1. Make sure "Scatter Data" is toggled on in the Project Explorer.

2. Select *Display* / **Display Options** or press (*Ctrl + D*) to bring up the *Display Options* dialog.

3. Click on *Scatter* on the left pane of the dialog to switch to *Scatter* display options.

4. Toggle off *Points* and toggle on *Boundary* and *Contours* in the *Scatter* display option tab.

5. Switch to the *Contours* tab.

6.   Change the *Contour method* to "Color Fill" and the *Transparency* to 50%.

7. Click **OK** to exit the *Display Options* dialog.

The Graphics Window should appear similar to Figure 2 below. If the Graphic Window is not displaying anything, click the **Frame** 🔍 macro.
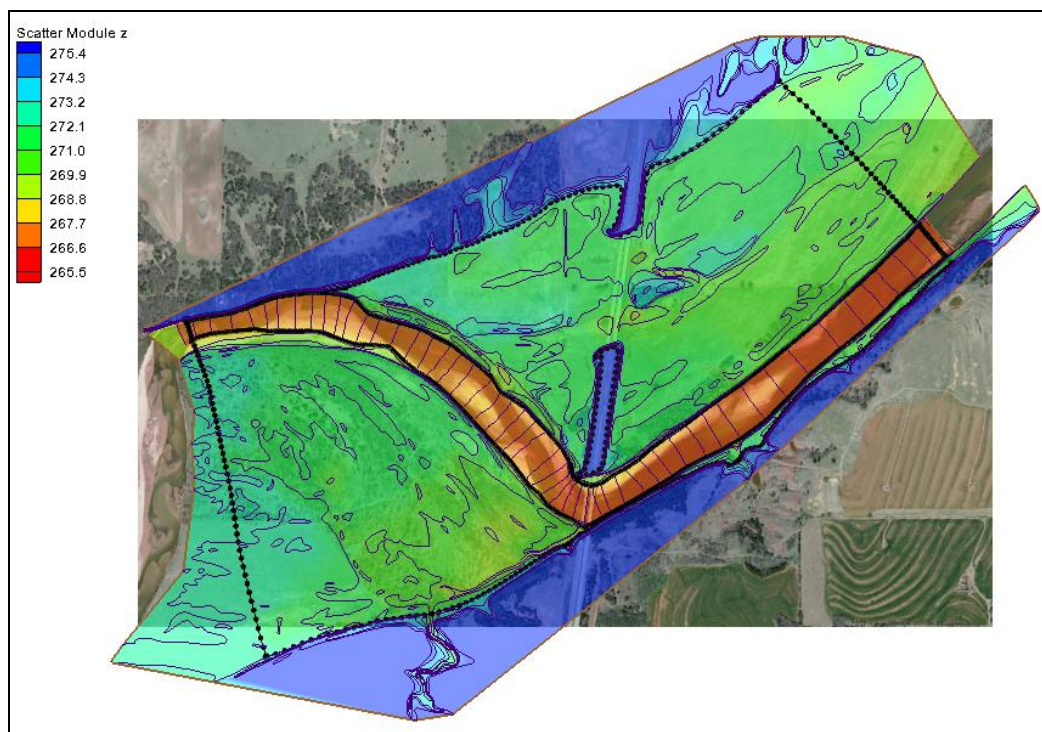

Figure 2   Elevation Data and Background Image

3   Create Mesh

SRH-2D uses an unstructured 2D mesh composed of quadrilateral and/or triangular elements. Generally speaking, meshes made of triangular elements require less manipulation, but are also less efficient computationally. In this tutorial, triangular elements will be used.

The "Domain" coverage, read in from "Cimarron.map" includes four polygons representing different portions of the domain. These include the channel area, the left and right flood plains and a region representing an embankment for the highway.

Elements in each area should be small enough to represent the topographic and bathymetric variations of the surface over which the water will flow. They should also be small enough to represent the variations in the water surface and velocity profile— typically at least 5–10 elements used to represent a cross section of a natural channel,

for example. This requirement for resolution should be weighed against the increased computational time as the number of elements increases.

3.1   Mesh Attribute Polygons

For simplicity, the tutorial uses the paving approach to fill all the polygons of the domain coverage with elements/cells for SRH-2D computation. Take note of the spacing of vertices on the arcs in the "Domain" coverage since this spacing is used to determine the size of the elements when using simple paving.

To specify the polygon attributes:

1. Turn off the display of Scatter Data in the Project Explorer.

2. Click on "Domain" coverage to make it active. Then click on the **Select Feature Polygon** ⬛ tool.

3. Right-click in the Graphics Window and select the **Select All** command to select all polygons.

4. Right-click again and select the **Attributes** command. The *2D Mesh Multiple Polygon Properties* dialog appears.

5. Check on the *Mesh type* attribute and make sure that "Paving" is the active method.

6. Check on the *Bathymetry type* attribute. Make sure that the "Scatter Set" method is selected.

7. Click the **Scatter Options…** button to bring up the *Interpolation* dialog.

8. Make sure the "Cimarron" scatter set is active, and "z" dataset is selected, then click **OK** to close the *Interpolation* dialog.

9. Click **OK** to exit the *2D Mesh Multiple Polygon Properties* dialog.

3.2   Map to 2D Mesh

All the parameters required for the Mesh creation have now been defined.

1. Right-click "Domain" coverage and select *Convert* | **Map → 2D Mesh**. The *2D Mesh Options* dialog will appear.

2. Make sure *Options* has been set to "Mesh & assign attributes*"* and *Create _____ element* type is set to "Linear.*"*

3. Leave all other options and click **OK** to close the *2D Mesh Options* dialog. SMS will generate a new unstructured mesh and the *Mesh Name* dialog will appear.

4. Enter the name "Cimarron01" as the name of the new mesh and click **OK** to close the *Mesh Name* dialog and to finish generating the mesh.

3.3   Mesh Display Options

It can be useful to adjust the mesh display settings to see the elevations contoured.

1. Select *Display* / **Display Options**.

2. Select *2D Mesh* in the list on the left.

3. Turn off the *Nodes* option.

4. Turn on the *Contours* option if it is turned off.

5. Under the *Contours* tab, change the *Contour Method* to "Color Fill."

    *   If desired, reverse the ramp to reverse the coloring scheme by clicking on
        the **Color Ramp…** button, clicking the **Reverse** button at the bottom of the
        Color Options dialog, then clicking **OK**.

6. Change *Transparency* to "50%" and click **OK** to exit the *Display Options*
    dialog.

3.4   Mesh Display Options

SMS can also visualize the topography represented by the mesh in 3D view.

1. Select the **Rotate** 🧭 tool from the Static Toolbar.

2. Left-click in the Graphics Window and drag to rotate the grid in 3D. The mouse
    wheel can be used to zoom in and out in this view. The background image will
    disappear while the map is being rotated.

3. Return to plan view by selecting the **Plan View** 🦶 icon in the Display
    Toolbar. The background image will reappear once this icon is clicked.

4   Assigning Boundary Conditions

Boundary conditions force certain hydronamic conditions onto the model. For this
model, an inflow boundary condition will be specified at the upstream boundary and
water surface elevation at the downstream end of the model.

4.1   Creating the Boundary Condition Coverage

In SRH-2D, the boundary conditions come from an *SRH-2D Boundary Condition*
coverage. This coverage will become part of the SRH-D simulation.

To create the boundary conditions coverage for this simulation:

1. Turn off the display of Mesh Data from the Project Explorer.

2. Right-click on the "Domain" coverage and select **Duplicate**. This will create a
    new coverage named "Domain (2)" that can be used to define boundary
    conditions.

3. Right-click on the "Domain (2)" coverage, select **Rename**, and enter the name "BC" for this coverage.

4. Right-click on the "BC" coverage and select *Type | Models | SRH-2D | Boundary Conditions* as the new type.

5. Click on the "BC" coverage to make it active. Then click on **Select Feature Arc** tool to make it active.

6. Drag a box around the three arcs on the left side of the Graphics Window that cross the upstream side of the floodplain. This will select all three arcs at once.

7. Hold down the *Shift* key and drag a box around the three arcs on the right side of the Graphics Window that cross the downstream side of the floodplain. This will add these arcs to the selection so that all six arcs are selected.
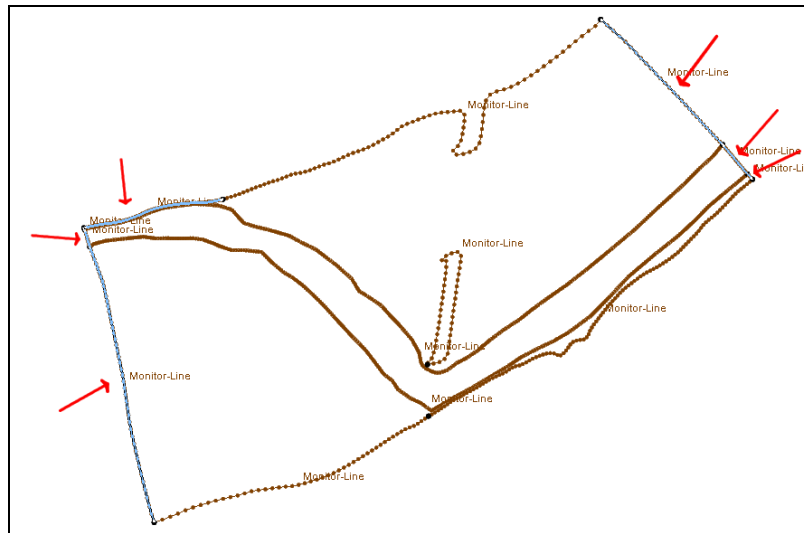

Figure 3   Select these six arcs

8. Right-click in the Graphics Window and select **Invert selection** to select all the arcs except the six previously selected arcs.

9. Click the *Delete* key to delete the selected arcs, selecting **Yes** in the dialog which comes up (leaving only six arcs in the coverage).

10. Click on **Select Feature Point** tool.

11. Right-click and select the **Select all** command.

12. Right-click and select the **Convert to Vertices** command to merge the arcs into two arcs, one on the upstream side and one on the downstream side.

4.2   Assigning the Inflow Boundary Condition

1. Click on **Select Feature Arc** tool and double-click on the arc on the left (upstream) side. This will open *SRH-2D Linear BC* dialog.

2. Under *Type*, select "Inlet-Q (subcritical inflow)" option.

3. Leave *Discharge (Q)* at "Constant", change the *Constant Q* flow unit to "cms" and enter a value of "1000" m^3/s for *Constant Q* as shown in Figure 4, below.

4. Click **OK** to exit the *SRH-2D Linear BC* dialog.
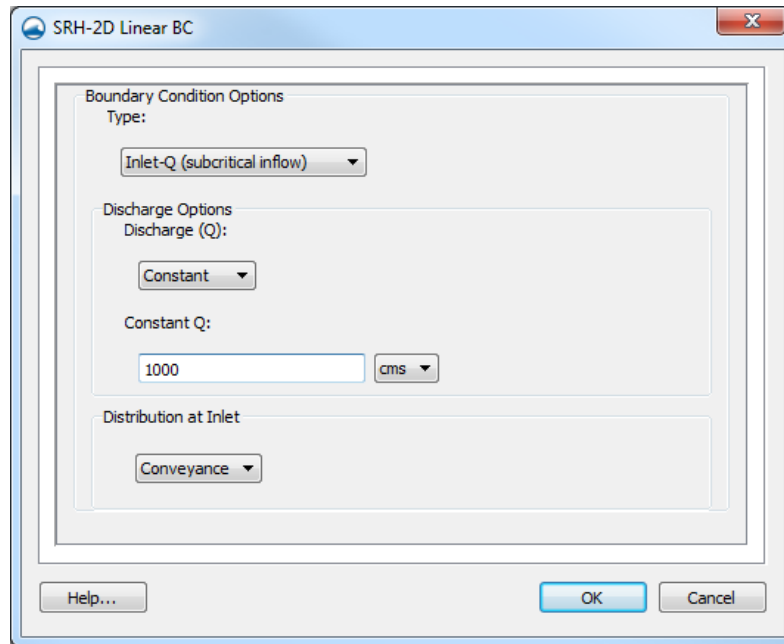

Figure 4   SRH-2D Linear BC dialog

4.3   Assigning the Outflow Boundary Condition

1. Double-click on the arc on the right (downstream) side of the coverage to reopen the *SRH-2D Linear BC* dialog.

2. Change *Type* to *"Exit-H (subcritical outflow)."*

3. Leave the *Water Elevation (WSE)* as "Constant", change the *Constant WSE* unit to "Meters" and enter a *Constant WSE* of "271.5" meters.

4. When done, click **OK** to exit the *SRH-2D Linear BC* dialog.

5. Save (**Ctrl** + **S**) the project.

5   Assigning Material Properties

In nature, the vegetation and subgrid topology of each element, or cell, of the mesh resists flow of water through that area. For SRH-2D, this resistance is specified as a material type with an associated Manning's *n* roughness coefficient.

The material zones are assigned using polygons in the *SRH-2D Materials* coverage.

5.1   Creating the Materials Coverage

To create the materials coverage for this simulation:

1. Right-click on the "Domain" coverage and select **Duplicate**. This will create a new coverage named "Domain (2)" that can be used to define boundary conditions.

2. Right-click on the "Domain (2)" coverage and select **Rename**. Then enter the name "Materials" for this coverage.

3. Right-click on the "Materials" coverage and select *Type | Models | SRH-2D |* **Materials** as the new type.

The polygons that exist in this coverage that were used for mesh generation already define the principal zones. Those are: channel, flood plain and highway. Therefore, no additional feature generation is required.

5.2   Creating the Materials List

The SRH-2D simulation can use as many different material types as assigned in the Material Properties dialog. In this simulation, three material types—each with its own roughness characteristics—will be defined.

To do this:

1. Right-click on the "Materials" coverage and select **Material Properties** to bring up the *Material Properties* dialog.

2. Click the ![icon] button three times to create three new material types.

3. Double-click each new material name in turn and specify the name as indicated in the table below. Enter the roughness value for each material in the *Constant N* field to the right of each selected entry.

Materials Name	Manning's *n*
Flood Plain	0.06
Road	0.025
River	0.02

4. Click **OK** when done to close the *Material Properties* dialog.

The material list has now been defined. Note that the color and pattern for each material type can be changed by clicking the large button to the right of each material name in the *Material Properties* dialog.

5.3   Assigning Material Types to Material Polygons

Each material polygon must have a material type assigned to define what resistance to flow will exist for elements in that area.

To do this:

1. Click on **Select Feature Polygon** 🔲 tool.

2. Double-click on one of the four polygons to bring up the *Assign Material Properties* dialog.

3. Select the appropriate material type for that zone, as shown in Figure 5 below.

4. Click **OK** to close the *Assign Material Properties* dialog.

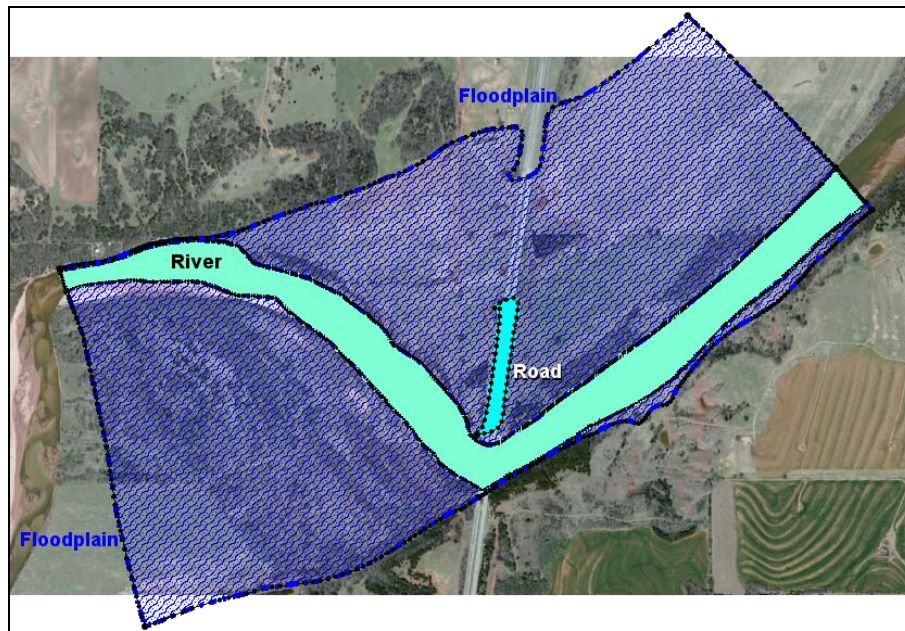5. Repeat steps 1–4 for each of the other three polygons.

Figure 5.Material types of the four polygons

Note: The material zones can be displayed by opening the *Display Options* dialog and turning on the *Polygon Fill* option under the *Map* tab. This display can conflict with the elevations contours, so turning one or the other display option off is helpful for better visualization.

6   Defining the SRH-2D Simulation

The SRH-2D simulation is created as a separate entity in the SMS project. Individual components for the simulation are associated or linked to the simulation, and simulation parameters are assigned to the simulation.

To create the simulation:

1. Right-click in the white space at the bottom of the Project Explorer and select *New Simulation* / **SRH-2D**. This creates a new simulation, "Sim", in the tree.

2. Right-click in the new simulation and select the **Rename** command. Enter "Steady State" as the new name.

6.1   Linking Components

Add the components to the simulation by either right-clicking on the component and selecting the *Link to ->* command, or by dragging and dropping the component on the new simulation.

To link the components for this simulation, do the following:

1. Right-click on the "Cimarron01" mesh and select the *Link To | **SRH-2D Simulations → Steady State** command.

2. Repeat for the "BC" coverage and the "Materials" coverage.

6.2   Assigning SRH-2D Parameters

It is also necessary to set up the SRH-2D control data and define the model parameters.

To do this:

1. Right-click on the *Steady State* simulation and select **Model Control…** to bring up the *Model Control* dialog.

2. Select *General* tab and define the data:

   - Set the *Simulation Description* to "Cimarron"

   - *Case Name* to "Steady"

   - *Start Time (hours)* is set to 0

   - *Time Step (seconds)* is set to 5

   - *End Time (hours)* is set to 4

   - *Initial Condition* is set to "Dry"

3. Leave all the parameters under *Flow tab* as is.

4. Select *Output* tab.

   - Make sure the *Result Output Format* is set to "XMDF"

   - *Result Output Unit* is set to "SI"

   - *Result Output Method* is set to "Specified Frequency"

   - *Result Output Frequency (hours)* is set to 0.1 (i.e. 6 minutes).

5. Click **OK** to close the *Model Control* dialog.

6.3   Model Check

Before assigning SRH-2D parameters, the **Model Check** should be run.

To do this:

1. Right-click on the *Steady State* simulation and select **Model Check…**

2. If everything is correct, a dialog comes up indicating "No model checks violated."

3. If there are any errors, follow the instructions in the *Model Checker (Potential Issues Found)* dialog to correct them.

4. Once all of the errors are corrected, proceed to the next section.

7   Running SRH-2D

The simulation is now ready to run. This involves three steps.

- *Exporting the SRH-2D files:* SMS writes out a *SRH-2D* folder in the same directory where the SMS project is saved. The SRH-2D folder has several files which have mesh geometry information, boundary conditions, material definitions as well as model control information defined in the model.

- *Running the pre-processor:* SRH-Pre is a pre-processor that reads in the files exported from SMS and crates an input file for SRH-2D.

- *Running SRH-*2D: After running SRH-Pre, an input file (*.dat) is written out which is used to RUN SRH-2D hydrodynamic engine.

To invoke this command:

1. Right-click on the simulation and select **Save, Export and Launch SRH-2D**. This command will save the SMS project, export all necessary files for PreSRH-2D, run the preprocessor and then run SRH-2D.

2. SMS will renumber the boundary conditions as needed when exporting the files for SRH-2D. When this happens, SMS will display a message that this will occur. Click **OK** to continue from this message.

While executing the run command, SMS assumes that SRH-2D executables are stored into the SMS installation folder, if it cannot find those executables, a prompt will ask to manually locate those. This is a one-time process and SMS will remember the location of the executables after this.

As the model run progresses, SRH-2D displays a status window with one or two plots indicating progress through the simulation.

3. Once the run is complete (it should take 6-8 minutes depending on the CPU being used), SRH will display a completion message. Click **Yes** to close the console window.

4. Note the *Load Solution* option at the bottom of the model wrapper asking if the solution should be read in. This option can be checked if the solution has not already been read in to expedite this process, as is the case in this situation. If the run that has just been completed is meant to replace an already loaded solution, the *Load Solution* option should be unchecked. Click **Exit** to close the model wrapper.

8   Viewing SRH-2D Output

Once SRH-2D run completes, it will generate a XMDF file which will have a name "Steady_XMDF.h5". SMS loads this file in by default if the toggle in the model wrapper is not unchecked.

This file includes at least the following datasets:

1. "B_Stress_N_p_m2": bottom stress at the ground in Newtons per square meter
2. "Froude": dimensionless Froude number (< 1 indicates sub-critical flow)
3. "Vel_Mag_m_p_s": velocity magnitude in meters per second
4. "Water_Depth_m": depth of water in meters
5. "Water_Elev_m": water surface elevation in meters above the datum
6. "Velocity": *x* and *y* components of velocity in meters per second

Note: SRH-2D also supports options for additional dataset computation in a variety of situations. Refer to other SRH-2D tutorials to learn about these.

Use the visualization tools in SMS as described in the "Data Visualization" tutorial, or other tutorials, to evaluate the solution created by the SRH-2D model.

9   Conclusion

This concludes the basic tutorial for the SRH-2D model. Experiment with other tutorials to learn additional features of SRH-2D and SMS.