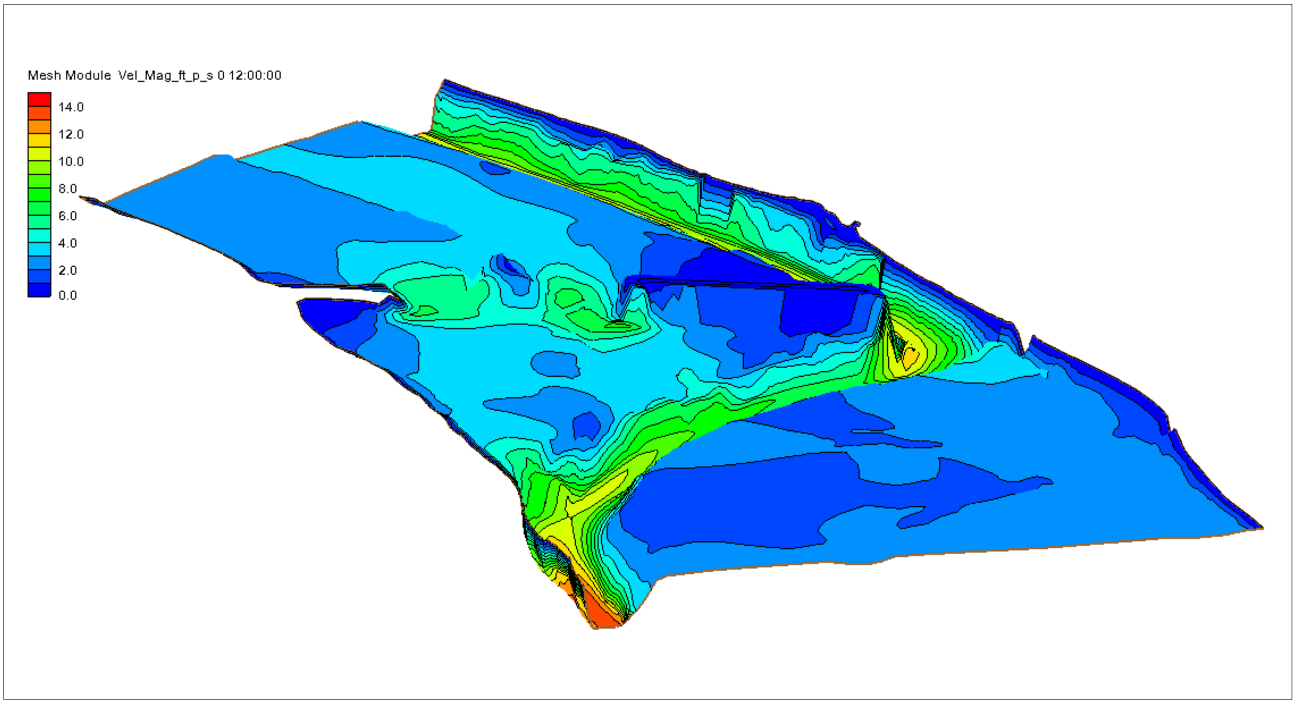
SRH-2D Tutorial

Cohesive Sediment Transport Modeling



Objectives

This tutorial demonstrates how to perform cohesive sediment transport simulations in SRH-2D.

Prerequisites

- SMS Overview tutorial
- SRH-2D
- SRH-2D Sediment Transport

Requirements

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

Time

- 15–30 minutes model setup
- Up to 3 hours model run

1 Introduction

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

For this tutorial, a previously developed SRH-2D sediment transport simulation with steady state flow will be modified to include cohesion materials. The primary interest for FHWA is in relation to bridge scour, and SRH-2D sediment transport simulations can be very informative for estimating contraction scour, which is essentially an erosion and sediment transport problem. SRH-2D also provides detailed hydraulic output that can be used to estimate pier and abutment scour potential.

1.1 Background

The Cimarron River example used in the SMS “SRH-2D Sediment Transport” tutorial will be use in this tutorial. If needed, review the “SRH-2D Sediment Transport” tutorial before proceeding with this tutorial.

This tutorial will cover defining sediment parameters and properties including sediment material types, boundary conditions, transport equation, and other input parameters. This tutorial is for instruction purposes and is not intended as an analysis of actual conditions at this bridge crossing.

2 Getting Started

To start this tutorial:

1. Launch the SMS application.
2. Select *File* | **Open…** to bring up the *Open* dialog.
3. Browse to the file “Cimarron_Sed_Cohesive.sms” located in the *data files* folder for this tutorial.
4. Click **Open** to import the project file and close the *Open* dialog.

This file opens the existing steady state sediment transport model as shown in Figure 1. To perform cohesive sediment transport modeling under steady-state conditions, this tutorial will demonstrate making a copy of the steady-state sediment transport simulation, then adjust the sediment materials in the vicinity of the secondary bridge to represent cohesive materials.

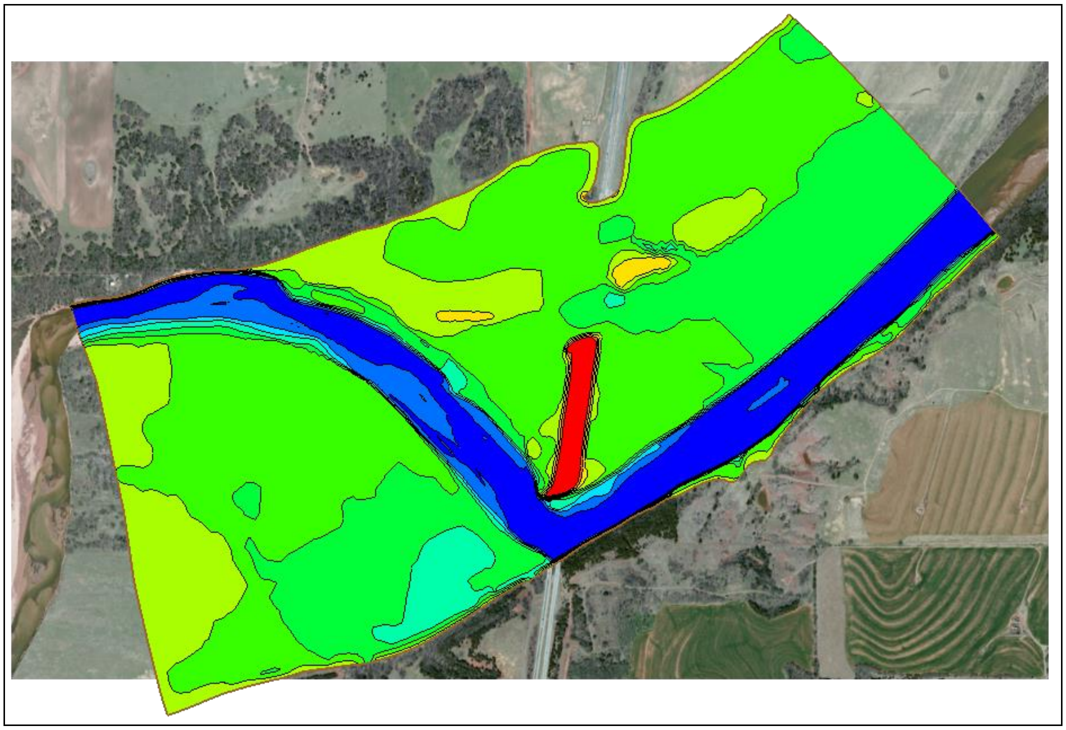


Figure 1 The hydraulic model of the Cimarron River

3 Boundary Conditions

The boundary conditions used for the "SRH-2D Sediment Transport" can be used for this tutorial with some adjustments. Therefore, it will be easier to copy the existing boundary condition coverage and make changes to the duplicate coverage.

1. Right-click on the " BC_Sed" coverage and select **Duplicate**. This will create a new coverage named " BC_Sed (2)" that can be used to define the boundary conditions.
2. Right-click on the " BC_Sed (2)" coverage and select **Rename**. Then enter the name "BC_Cohesive" for this coverage.

Now adjust the boundary condition coverage properties.

3. Right-click on " BC_Cohesive" under " Map Data" and select **BC_Types** to open the *BC Type Parameters* dialog.
4. At the bottom of the dialog, change *Cohesive Sediment Modeling* to "On".

The smallest size faction is considered as cohesive, which in this case is the 0.0025 mm to 0.0625 mm bin.

Note that the values for cohesive sediments entered below are highly variable depending on material properties. Values should be determined through laboratory testing. See also the HEC-18 (FHWA 2012)[1] section on Contraction Scour for Cohesive Sediments for background information on the range of erosion properties. Also, pay particular attention to the units and the form of the equation as described at www.xmswiki.com in the section on cohesive sediment modeling.

5. Set *Fall Velocity* to "Kaolinite Properties".
6. Set *Erosion Rate* to "Input Parameters".
7. Set *Critical Shear Stress for Surface Erosion* to "0.10" (lb/ft^2).
8. Set *Critical Shear Stress for Mass Erosion* to "0.7" (lb/ft^2).
9. Set *Surface Erosion Constant* to "10" (lb/ft^2/hr).
10. Set *Mass Erosion Constant* to "20" (lb/ft^2/hr).
11. Set *Units for Erosion Shear Stress* to "English".
12. Set *Critical Shear Stress for Full Deposition* to "0.005" (lb/ft^2).
13. Set *Critical Shear Stress for Partial Deposition* to "0.021" (lb/ft^2).
14. Set *Equilibrium Concentration* to "3.0" (g/l or kg/m3, note 1 g/l is approximately 1000 ppm-wt).
15. Set *Units for Depositional Shear Stress* to "English".
16. Click **OK** to exit the *BC Type Parameters* dialog.
17. Save (**Ctrl + S**) the project.

4 Sediment Materials Properties

Now adjust the bed material to show cohesive sediment in the vicinity of the secondary bridge opening:

1. Right-click on the " Sed_Material" coverage and select **Duplicate**. This will create a new coverage named " Sed_Material (2)".
2. Right-click on the " Sed_Material (2)" coverage and select **Rename**. Then enter the name "Sed_Material_Cohesive" for this coverage.
3. Select " Sed_Material_Cohesive" to make it active.

[1] Richardson, E.V. and Davis, S.R., 1995. *Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18.* Publication FHWA-IP-90-017.

4. Using the **Select Feature Polygon** tool, double-click on the area under the relief bridge (as shown in Figure 2) to bring up the *Assign Material Properties* dialog.

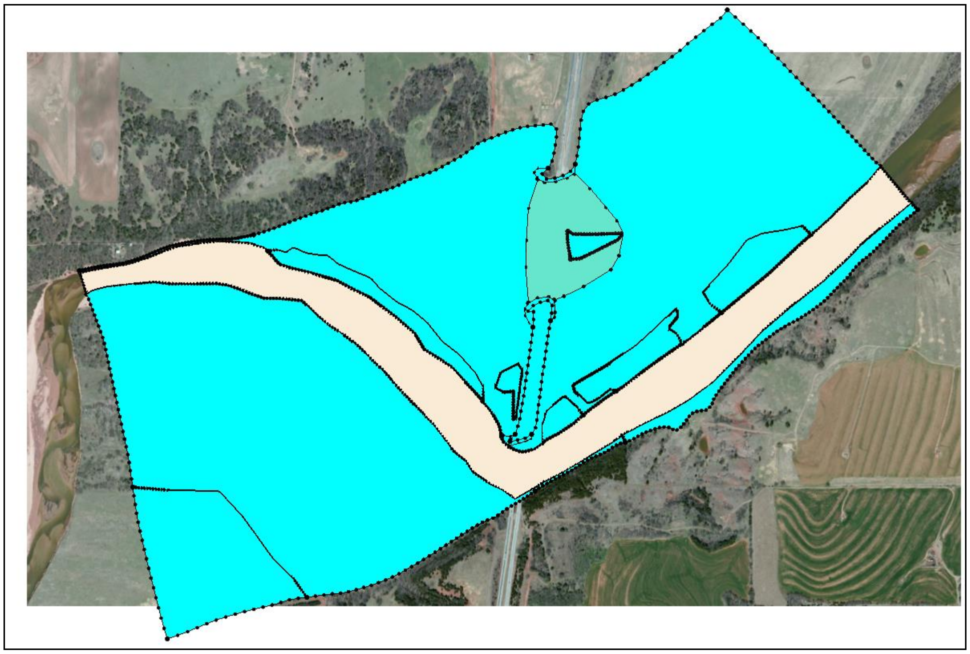


Figure 2 Cohesive sediment material located near the secondary bridge opening (shown in green)

5. Click the button to create a "new material".
6. Double-click on "new material" and rename it to "Cohesive"
7. Select the **Insert Above** button to add properties to the "Cohesive" material.
8. Set the *Thickness* to "1" ft, *Units* to "English", and *Density* to "58" lb/ft^3.
9. Scroll to the right and click on the **Define** button under *Gradation Curve* to bring up the *XY Series Editor* dialog.
10. Enter the sediment gradation parameters as shown in Table 1 below.

Table 1: Sediment Gradation Parameters

Particle size, di (mm)	% finer
0.0025	0.0
0.0625	80.0
0.125	87.0
0.25	94.0
0.5	98.0
1.0	99.0
2.0	100.0

When done, the *XY Series Editor* dialog should resemble Figure 3.

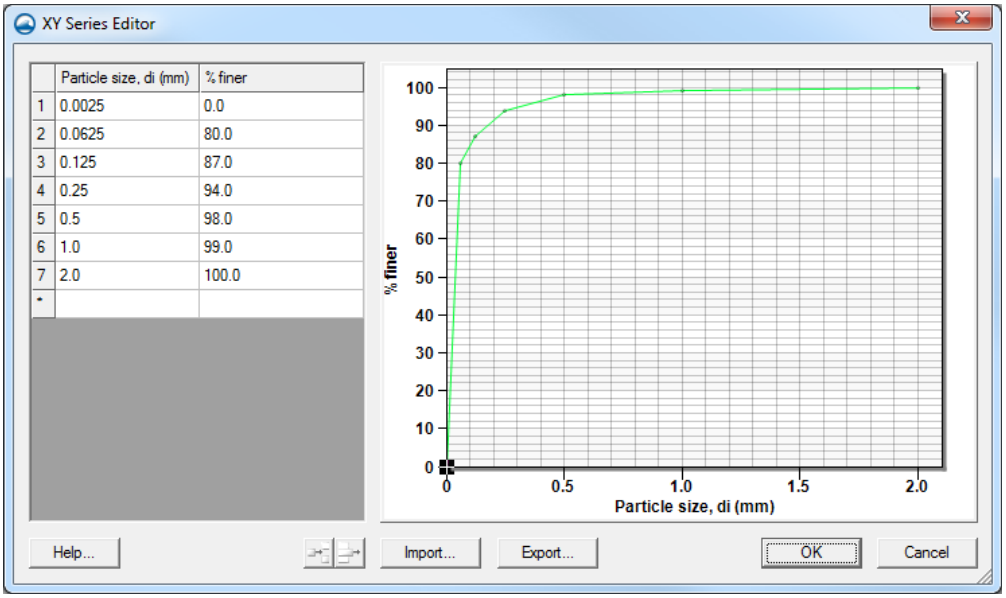


Figure 3 Sediment gradation curve for cohesive material

11. Click **OK** to close the *XY Series Editor* dialog and return to the *Assign Material Properties* dialog.

Now add a second layer to the “Cohesive” material. SRH-2D guidance indicates that a minimum of two layers is recommended even if the bed material is vertically uniform.

12. Click the **Insert Below** button to add another row underneath the existing row.
13. Set the *Thickness* to “20” ft, *Units* to “English”, and *Density* to “58” lb/ft^3.
14. Click on the **Define** button under *Gradation Curve* to bring up the *XY Series Editor* dialog.
15. Enter the sediment gradation parameters as shown in Table 1 above.
16. Click **OK** to close the *XY Series Editor* dialog.
17. Click **OK** to close the *Assign Material Properties* dialog.

5 Defining the SRH-2D Simulation

Many of the properties and components that were used in the “Sed_Steady_State” simulation can be used for the cohesive sediment transport simulation. To save time, the steady state simulation can be copied and modified.

To copy a simulation:

1. Right-click on the “ Sed_Steady_State” simulation and select the **Duplicate** command. This creates a copy of the simulation with its model parameters and components.
2. Right-click in the “ Sed_Steady_State (2)” simulation and select the **Rename** command. Enter “Sed_Cohesive” as the new name.

5.1 Linking Components

Most of the components needed for the simulation are already linked since they were copied from the original simulation. However, the boundary condition coverage and material coverage components need to be changed.

Change the component by:

1. Right-click on the " BC_Sed" item under the " Sed_Cohesive" simulation and select **Unlink**.
2. Right-click on the " Sed_Materials" item under the " Sed_Cohesive" simulation and select **Unlink**.
3. Right-click on the " BC_Cohesive" coverage and select the *Link To* | **SRH-2D Simulations → Sed_Cohesive** command.
4. Right-click on the " Sed_Materials_Cohesive" coverage and select the *Link To* | **SRH-2D Simulations → Sed_Cohesive** command.

All the necessary components are now linked to the simulation.

5.2 Assigning SRH-2D Parameters

The steady state model parameters were also copied. Most of these parameters will work for the model run, but a few of the parameters must be changed.

To do this:

1. Right-click on the " Sed_Cohesive" simulation and select **Model Control…** to bring up the *SRH-2D Model Control* dialog.
2. Select the *General* tab and define the data:
    a. Set *Simulation Description* to "Cohesive Sediment Transport".
    b. Set *Case Name* to "Sed_Cohesive".
    c. Set *Initial Condition* to "Restart File".
    d. Click the **Select** button to bring up a *Choose file* browser.
    e. Navigate to the data files folder for this tutorial and select the "Q50YR_RST.dat" file, then click **Open** to set the file as the restart file.
3. Leave all the parameters under the *Flow* tab as currently set.
4. Leave all the parameters under the *Output* tab as currently set.
5. Click **OK** to close the *SHR-2D Model Control* dialog.
6. Save (**Ctrl + S**) the project.

5.3 Running SRH-2D

Since running sediment transport models is a long process, this section can be skipped to save time. The solution files have been provided for the next section.

> ***Note:*** Sediment transport simulations require significant computation power. Any computer system with hardware less than the recommended system for running SMS will not be able to complete an SRH-2D sediment transport simulation.

To run the model:

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.

This model takes approximately 1–2 hours to run.

Once the run is complete, SRH-2D will display a completion message.

2. Click **Yes** to close the console window.

Note the *Load Solution* option at the bottom of the *SRH-2D* model wrapper asking if the solution should be read in. If the run that has just been completed is meant to replace an already loaded solution, the *Load Solution* option should be checked.

3. Click **Exit** to close the model wrapper.

5.4 Viewing SRH-2D Output

Use the visualization tools in SMS to evaluate the results.

If the model run was skipped to save time, import the solution file by doing the following:

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Browse to *Solution\Cimarron_Sed_Cohesive_Final\SRH-2D\Sed_Cohesive* in the *data files* folder for this tutorial and select the "Cimarron_Sed_Cohesive_XMDF.h5" file.
3. Click **Open** to close the *Open* dialog and import the solutions file.

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

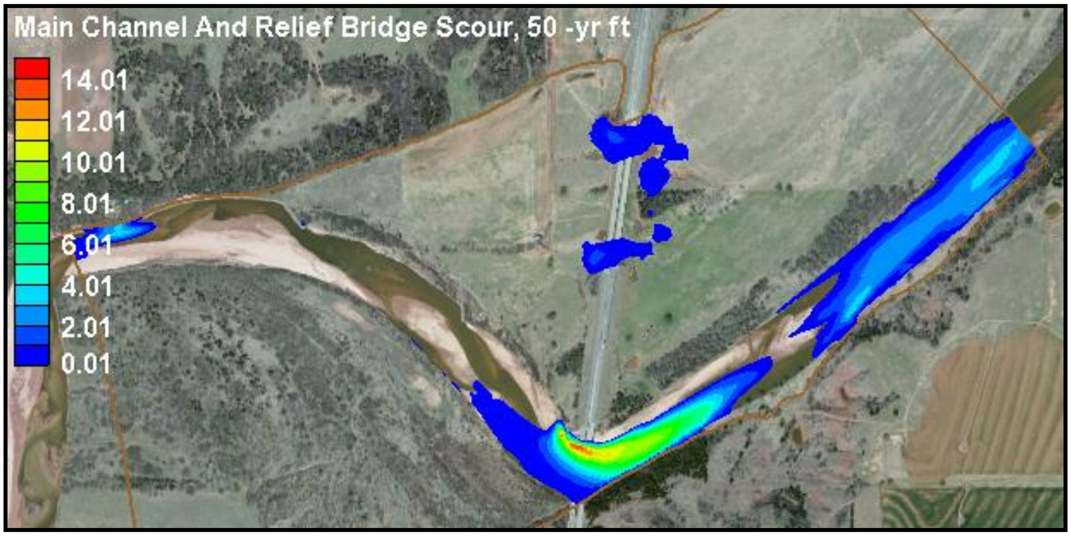


Figure 4 Erosion at the end of the cohesive sediment transport simulation

6 Conclusion

This concludes the "SRH-2D Cohesive Sediment Transport Modeling"[2] tutorial. This tutorial demonstrated:

- Setting the SRH-2D boundary condition coverage for use in cohesive sediment transport.
- Setting the SRH-2D sediment materials coverage for cohesive sediment transport.
- Defining the SRH-2D simulation for cohesive sediment transport.

Continue to experiment with the sediment transport options for SRH-2D in SMS or exit the program.

[2] This tutorial was developed by Aquaveo, LLC under contract with the Federal Highway Administration.