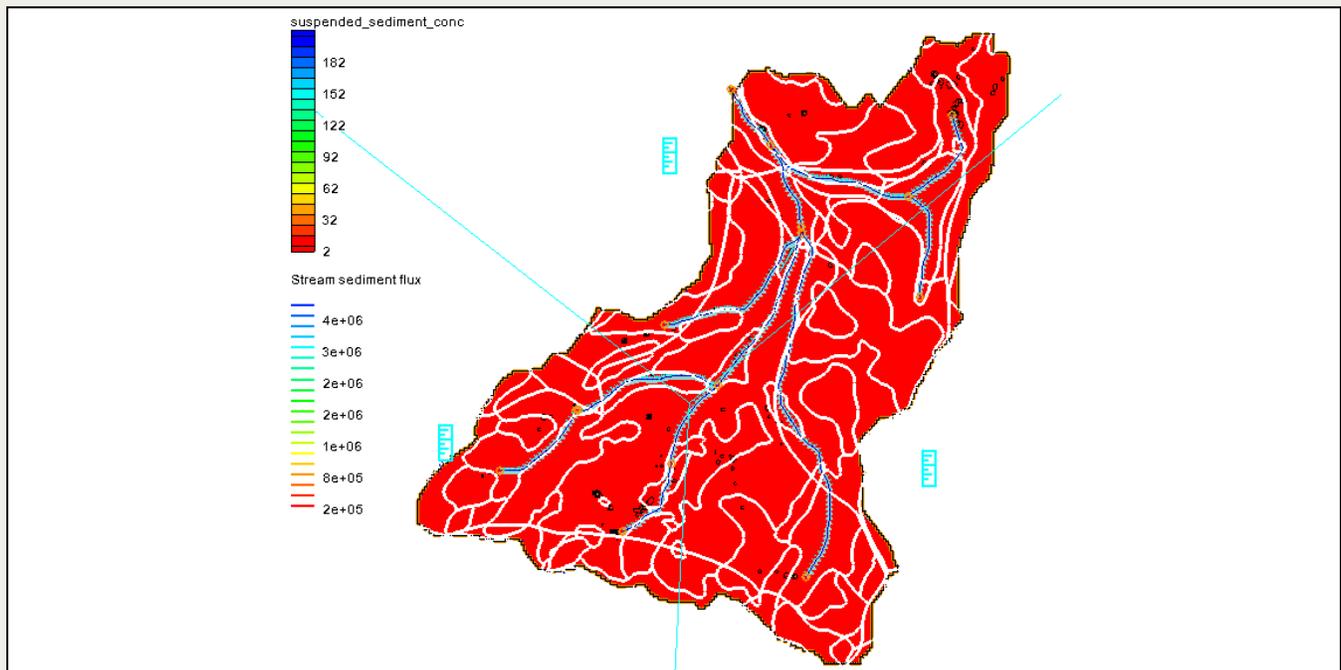*WMS 11.4 Tutorial*

Sediment Transport in GSSHA

Modeling sediment transport in GSSHA

Objectives

Develop input parameters for and run a long-term model that simulates sediment transport impacts based on proposed land use changes.

Prerequisite Tutorials

- Long-Term Simulations in GSSHA

Required Components

- WMS Core
- GSSHA Model

Time

- 20–30 minutes

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1   Introduction

This tutorial demonstrates how to develop inputs for a sediment transport simulation in GSSHA using an existing GSSHA model. It simulates a scenario where some of the forested hill slopes in a ski resort in Park City, Utah, are cleared to develop ski runs. This GSSHA model is set up to run a long term simulation to determine possible increased erosion and deposition.

1.1   Getting Started

To begin the tutorial, do the following:

1. Start WMS, or click **New** ▢ if WMS is already open.

2. Switch to the **2D Grid Module** ▦.

3. Select *GSSHA | **Open Project File...*** to bring up the *Open* dialog.

4. Browse to the *GSSHAApplications5\Sediment* folder for this tutorial.

5. Select "Base.prj" and click **Open** to exit the *Open* dialog.

6. Click *File | **Save As…*** to bring up the *Save As* dialog.

7. Enter "sed.wms" as the *File name* and click **Save** to save the project under the new name and close the *Save As* dialog.

The project should appear similar to Figure 1.

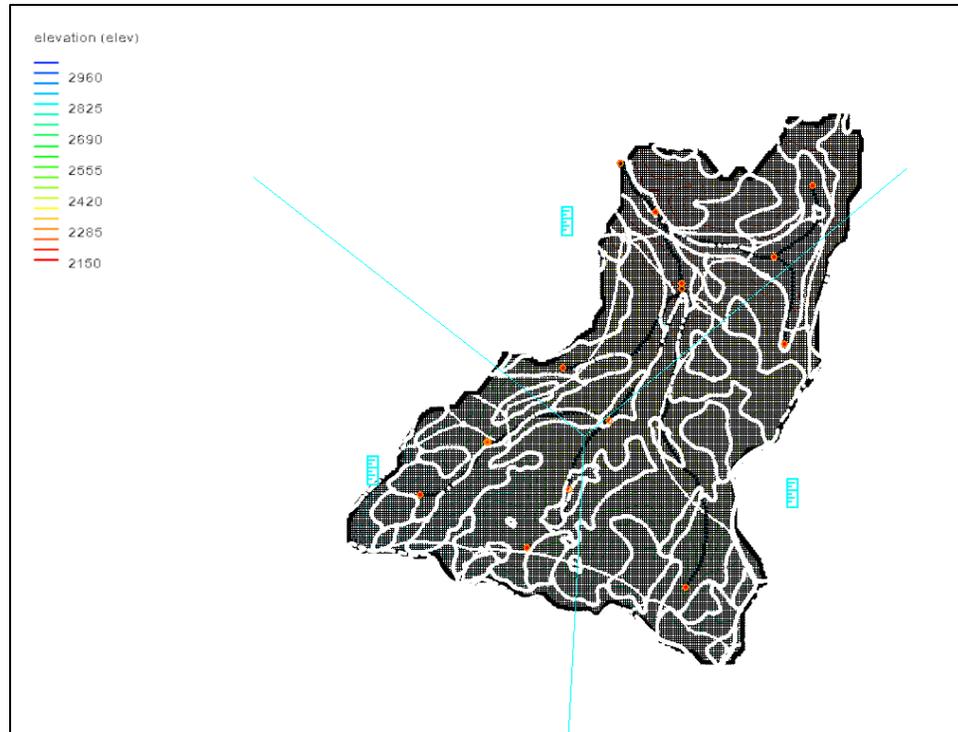*Figure 1   Initial GSSHA project*

2   Adjusting Parameters

There are several parameters that need to be set before running GSSHA.

2.1   Soil Erosion and Adding Sediment

1.   Select *GSSHA | Job Control…* to bring up the *GSSHA Job Control Parameters* dialog (Figure 2).
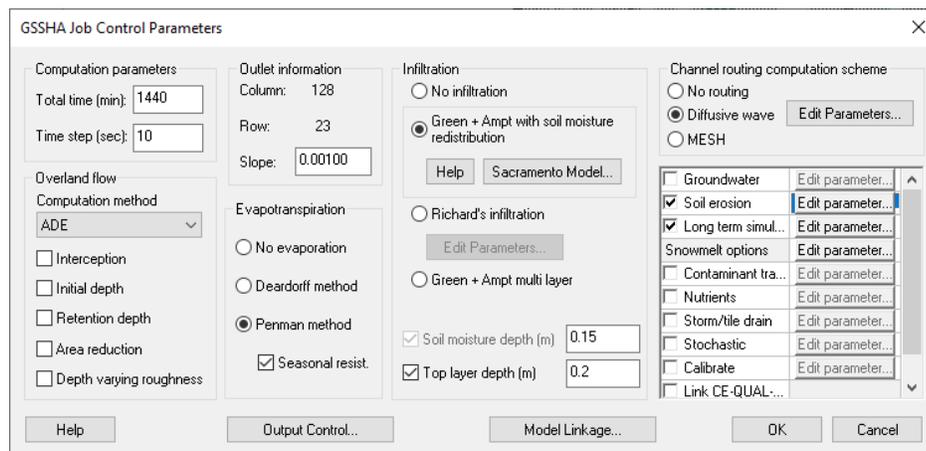

Figure 2   GSSHA Job Control Parameters dialog

2.   In the list on the lower right side, turn on *Soil erosion.*

3.   To the right of *Soil erosion*, click **Edit parameter…** to bring up the *Overland soil erosion* dialog (Figure 3).
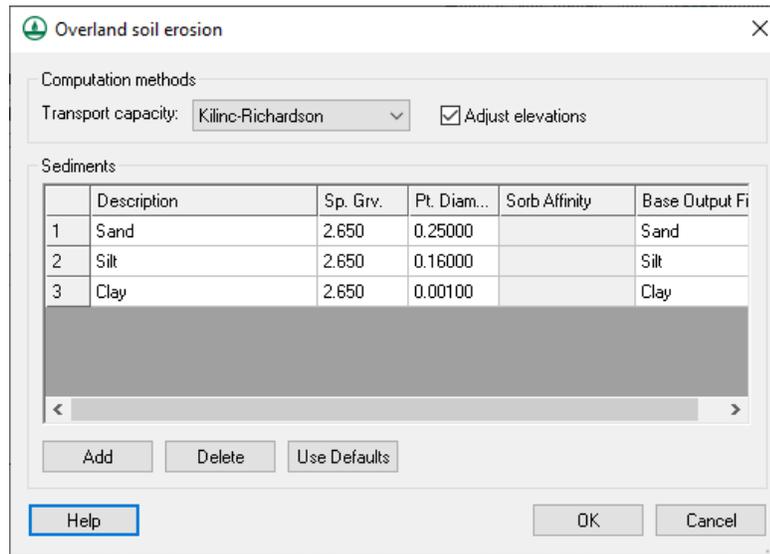

Figure 3   Populated Overland soil erosion dialog

4.   In the *Computation methods* section, select "Kilinc-Richardson" from the *Transport capacity* drop-down.

5.   Turn on *Adjust elevations*.

When this option is turned on, GSSHA creates an adjusted elevation map based on erosion and deposition. This map can then be compared with the original elevation map to determine the areas of erosion and deposition.

6.   In the *Sediments* section, click **Add** three times to add three sediments to the spreadsheet.

The spreadsheet allows any number of sediment particle sizes to be specified. This tutorial only requires three.

7.   Use the following table to enter the parameters for the soil sizes:

ID	Description	Sp. Gr.	Particle Diameter (mm)	Base output file name
1	Sand	2.650	0.25000	Sand
2	Silt	2.650	0.16000	Silt
3	Clay	2.650	0.00100	Clay

8.   Click **OK** to close the *Overland soil erosion* dialog.

9.   In the *Channel routing computation scheme* section, select *Diffusive wave*

10. Click **Edit Parameters...** to bring up the *GSSHA Channel Routing Parameters* dialog.

11. In the *Channel erosion* section, enter "0.4" as the *Sediment porosity.*

12. Enter "20.0" as the *Water temperature*.

13. Enter "0.25" as the *Sand size*.

14. Click **OK** to close the *GSSHA Channel Routing Parameters* dialog (Figure 4).

15. Click **OK** to close the *GSSHA Job Control Parameters* dialog.

Figure 4   GSSHA Channel Routing Parameters dialog

2.2   Assigning an Index Map

Now specify the properties of the soils in the watershed related to soil erosion. Use an existing index map that has new ski tracks to define these parameters. Assign this index map to the current GSSHA model.

1. Right-click on " Index Maps" in the " M Base" solution folder in the Project Explorer and select *Assign* | **SkiTracks**.

Now the Index Map has been prepared for the model run.

2.3   Defining Erosion Parameters

1. Select *GSSHA* | **Map Tables...** to bring up the *GSSHA Map Table Editor* dialog.

Notice the two levels of tabs at the top of the dialog.

2. On the *Soil Erosion* tab, select "SkiTracks" from the *Using index map* drop-down.

3. Click **Generate IDs** to generate four columns of parameters in the spreadsheet below the button.

The last column, with ID "100", represents the new ski tracks. They are assumed to be highly susceptible to erosion.

4. Using the following table, enter the information. Be careful to enter the correct information on each row.

ID	13	14	15	100
Raindrop erodibility factor(1/J)	10.8	20.5	18.5	20.5
Runoff detachment coefficient (s/m)	0.0004	0.0004	0.0004	0.0004
Runoff detachment index (dimensionless exponent)	0.65	0.65	0.65	0.65
Runoff detachment critical shear (Pa)	0.1	0.1	0.1	0.1
Erodibility coefficient (dimensionless)	0.12	0.11	0.13	0.11
Sand	0.65	0.45	0.2	0.34
Silt	0.2	0.35	0.65	0.33
Clay	0.15	0.2	0.15	0.33

The information in the above table is also in a spreadsheet, "ErosionParams.xls", included with the tutorial files. Feel free to copy the information from that spreadsheet if it is more convenient.

In most cases, these basic parameters should not require changing. For the Kilinc-Richardson transport capacity, the key parameters are the sediment size and the erodibility coefficient.

5. Click **Done** to close the *GSSHA Map Table Editor* dialog.

2.4   Specifying the Output Parameters

Now specify the output parameters.

1. Select *GSSHA|* **Job Control…** to bring up the *GSSHA Job Control Parameters* dialog.

2. At the bottom of the dialog, click **Output Control…** to bring up the *GSSHA Output Control* dialog (Figure 5).

3. On the left side, in the *Gridded data sets* section, turn on *Suspended sediment concentration* and *Sediment flux*.

4. On the right side, in the *Link / Node data sets* section, turn on *Sediment flux*.

5. In the *Gridded data set output format* section, select *ASCII*.

6. Click **OK** to close the *GSSHA Output Control* dialog.

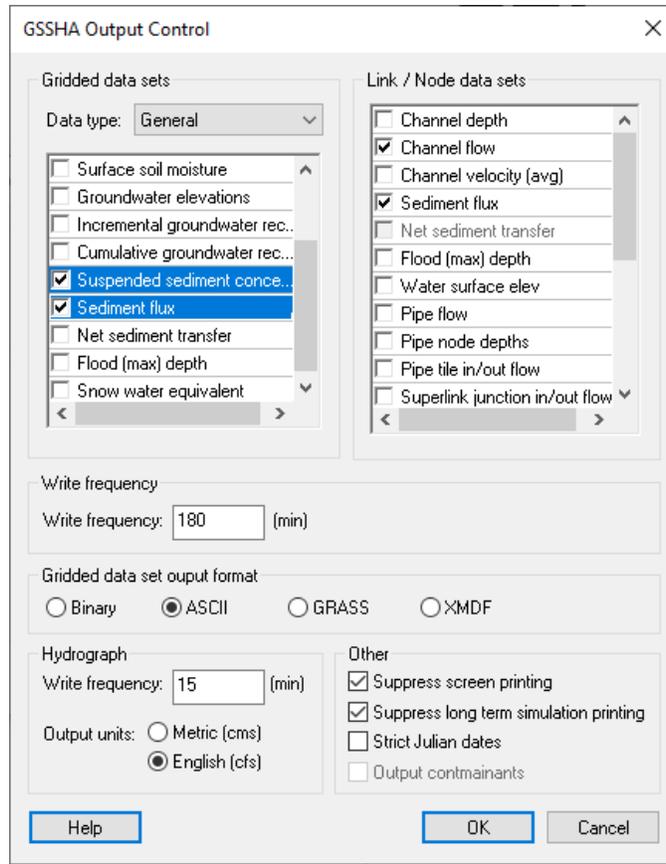7. Click **OK** to close the *GSSHA Job Control Parameters* dialog.

Figure 5   GSSHA Output Control dialog

2.5   Saving and Running the Model

Before running the model, the project should be saved.

1. Select *GSSHA* | **Save Project File...** to bring up the *Save GSSHA Project File* dialog.

2. Enter "sedtrans.prj" as the *File name*.

3. Click **Save** to save the project under the new name and exit the *Save GSSHA Project File* dialog.

4. Select *GSSHA* | **Run GSSHA…** to bring up the *GSSHA Run Options* dialog.

Notice that "sedtrans.prj" is listed in the *Location* section.

5. Click **OK** to close the *GSSHA Run Options dialog* and bring up the *Model Wrapper* dialog.

Depending on the speed of the computer, GSSHA may take several minutes to complete its run.

6. When GSSHA finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

3   Visualizing the Results

There are several methods for visualizing the results. This section will discuss some of them.

3.1   Outlet Sediment Graph

To view the sediment graph, do the following:

1. Right-click on " 📄 Outlet Sediment Graph" under " 🗂 sedtrans (GSSHA)" and select **View Graph…** to bring up the *Sedograph* dialog.

2. Click **Close** [×] in the top right corner of the dialog, when finished viewing the graph.

The *Sedograph* dialog should appear similar to Figure 6.

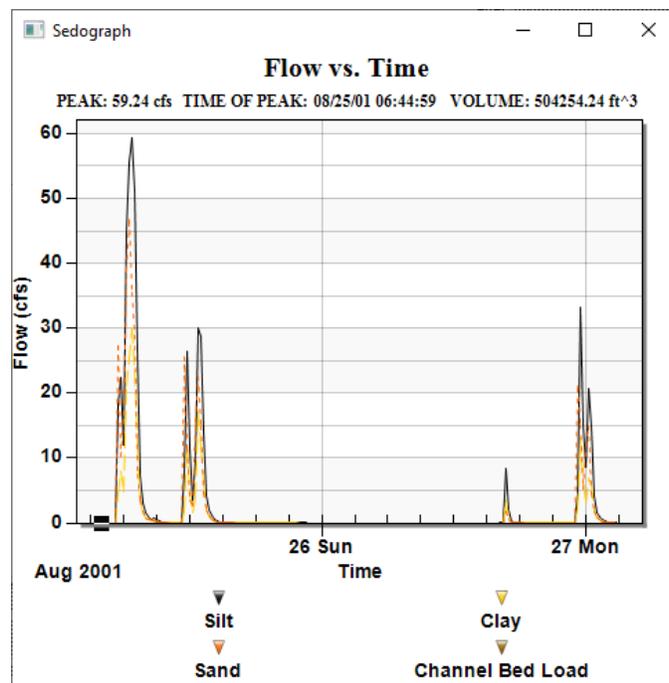*Figure 6   Sedograph dialog*

3.2   TSS Plot

GSSHA generates the TSS plot as well. To see the TSS plot at the watershed outlet, do the following:

1. Right-click " 📄 Outlet Sediment TSS Graph" and select **View Graph…** to bring up the *Sediment TSS Graph* dialog.

2. Click **Close** [×], when finished viewing the graph.

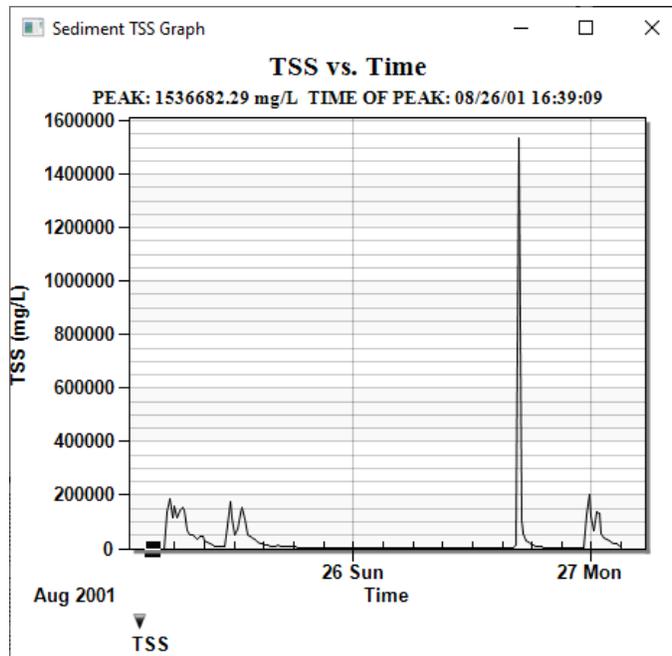The *Sediment TSS Graph* dialog should appear similar to Figure 7.

Figure 7   Sediment TSS Graph dialog

3.3   Sediment Flux in the Channel

To visualize the sediment motion in the channel network, do the following:

1. Click **Display Options** 🖥 to bring up the *Display Options* dialog.

2. Select "2D Scatter Data" from the list on the left.

3. On the *Scatter Point* tab, turn on *Contours*.

4. Enter "15" as the *Radius*

5. Enter "0.1" for *Z-magnification*.

6. Click **Options…** to bring up the *Stream sediment flux Contour Options* dialog.

7. In the *Contour method* section, select "Color fill" from the first drop-down.

8. Click **OK** to close the *Stream sediment flux Contour Options* dialog.

9. At the bottom left of the *Display Options* dialog, turn off *Auto z-mag*.

10. Enter "1.0" as the *Z magnification*.

11. Click **OK** to close the *Display Options* dialog.

12. Select **Rotate** 🔆 and rotate the watershed as shown in Figure 8.

13. Select "📋 Stream sediment flux" and scroll through time steps to see the variations over time.

Most of the sediment fluxes are associated with the runoff events, so fluxes increase whenever there is a storm or whenever there is a considerable peak in the outflow hydrograph. Figure 8 shows the flux levels for time step "08/24/2001 02:45:00 PM". Alter the display settings as needed to properly visualize each time step.
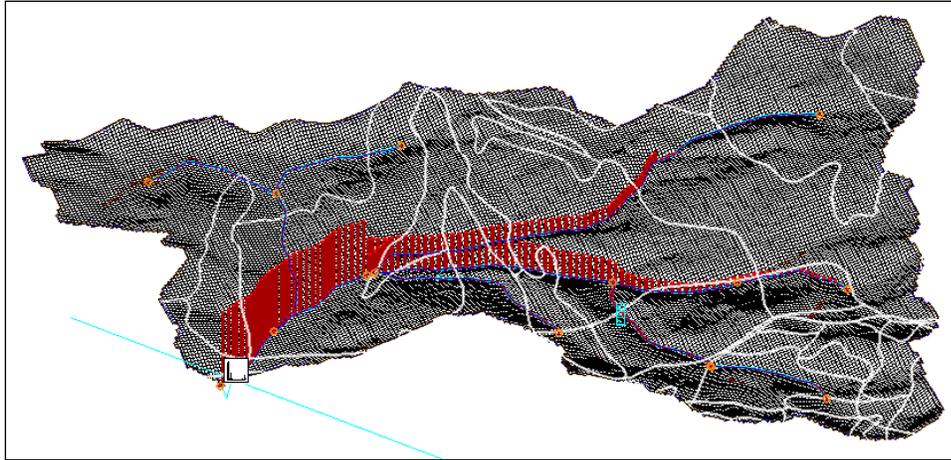
Figure 8   Showing time step "08/24/2001 02:45:00 PM"

3.4   Erosion and Deposition Map

GSSHA produces an adjusted elevation map based on erosion and deposition. This map is not loaded into WMS with the GSSHA results, but it can be manually imported.

1. In the Project Explorer, right-click on "▦ new grid" and select **Import Scalar Dataset…** to bring up the *File Formats* dialog.

2. Select *GRASS ASCII grid file* and click **OK** to close the *File Formats* dialog and bring up the *Open* dialog.

3. Select "All files (*.*)" from the *Files of type* drop-down.

4. Select "sedtrans_adj.ele" and click **Open** to exit the *Open* dialog.

This adds the "▤ sedtrans_adj" dataset to the Project Explorer.

5. Select *Data* | **Data Calculator…** to bring up the *Data Calculator* dialog.

Notice the calculation buttons at the lower right side of the dialog.

6. Below the *Data sets* section, click in the *Expressions* field and type or click "(" to add it to the *Expression* field.

7. In the *Data sets* section, double-click "d9. sedtrans_adj" to add it to the *Expression* field.

8. Click **minus** "-",

9. Double-click on "d1. elevation (elev)" to add it to the *Expression* field.

10. Click ")"

11. Click **multiply** "*".

12. Enter "10000"at the end of the equation in the *Expressions* field.

The equation should appear as "(d9-d1)*10000".

13. Enter "ErosionDeposition" as the *Result*.

14. Click **Compute**.

Do not close the *Data Calculator* dialog.

A new " ⊞ ErosionDeposition" dataset should appear in the Project Explorer.

3.5   Uniform Index Map

The next step is to create a uniform index map for comparison with the erosion deposition map. To do this, do the following:

1. Enter "1" in the *Expression* field.

2. Turn on *Index map*.

3. Enter "Uniform" as the *Result*.

4. Click **Compute**.

A new " ⊞ Uniform" dataset should appear in the Project Explorer.

5. Click **Done** to close the *Data Calculator* dialog.

3.6   Zonal Classification

The zonal classification now needs to be set up by doing the following:

1. Select *Data* | **Dataset Zonal Classification…** to bring up the *Dataset Zonal Classification* dialog.

2. In the *Dataset 1* section, choose "ErosionDeposition" from the *Select dataset* drop-down.

3. In the *Dataset 2* section, turn on *Compare to additional dataset*.

4. Choose "Uniform" from the *Select dataset* drop-down.

5. In the *Dataset 1* section, enter "3" as the *Number of divisions*.

6. In the *Dataset 2* section, enter "2" as the *Number of divisions*.

7. In the *Ranges* spreadsheet in the *Dataset 1* section, enter the following in the *Minimum* column:

Minimum
-2329.1016
-0.0001
0.0001

8. Click **Display…** to bring up the *Dataset Zonal Classification Display* dialog (Figure 9).

9. Scroll right to make the Color column visible.

10. On row *1*, click the down arrow ⯆ and select "Red" from the list of colors.

Hover over the color boxes, if needed, to see the color names.

11. Repeat step 10 for row *2*.

12. Repeat step 10 for rows *3* and *4*, selecting "White" as the color.

13. Repeat step 10 for rows *5* and *6*, selecting "Grey – 50" as the color.

14. Click **OK** to close the *Dataset Zonal Classification Display* dialog.

15. Click **OK** to close the *Dataset Zonal Classification* dialog.
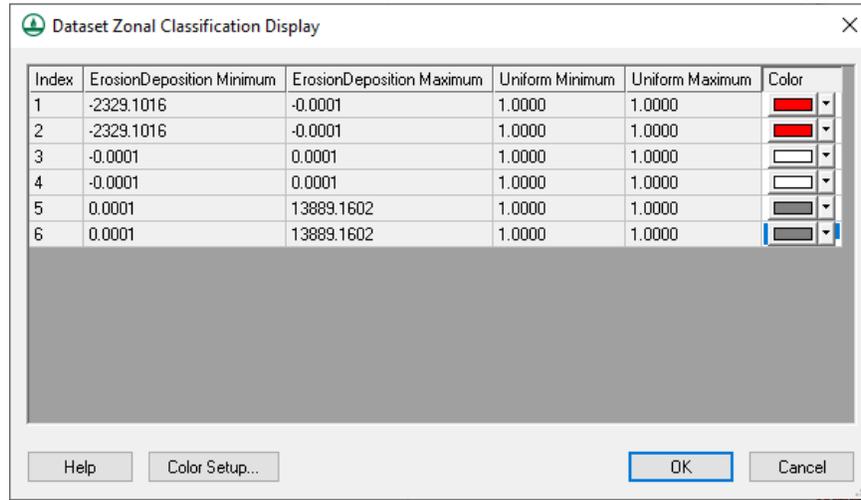
16. Switch to 🔲 **Plan View**.

Index	ErosionDeposition Minimum	ErosionDeposition Maximum	Uniform Minimum	Uniform Maximum	Color
1	-2329.1016	-0.0001	1.0000	1.0000	🟥
2	-2329.1016	-0.0001	1.0000	1.0000	🟥
3	-0.0001	0.0001	1.0000	1.0000	⬜
4	-0.0001	0.0001	1.0000	1.0000	⬜
5	0.0001	13889.1602	1.0000	1.0000	◼
6	0.0001	13889.1602	1.0000	1.0000	◼

Figure 9   Dataset Zonal Classification Display dialog

17. Click **Display Options** 🖥 to bring up the *Display Options* dialog.

18. Select "2D Grid Data" from the list on the left.

19. Turn off *Cells*.

20. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 10. The red cells are those where erosion has occurred, the white cells are those where there was no change, and the gray cells are where the deposition occurred.
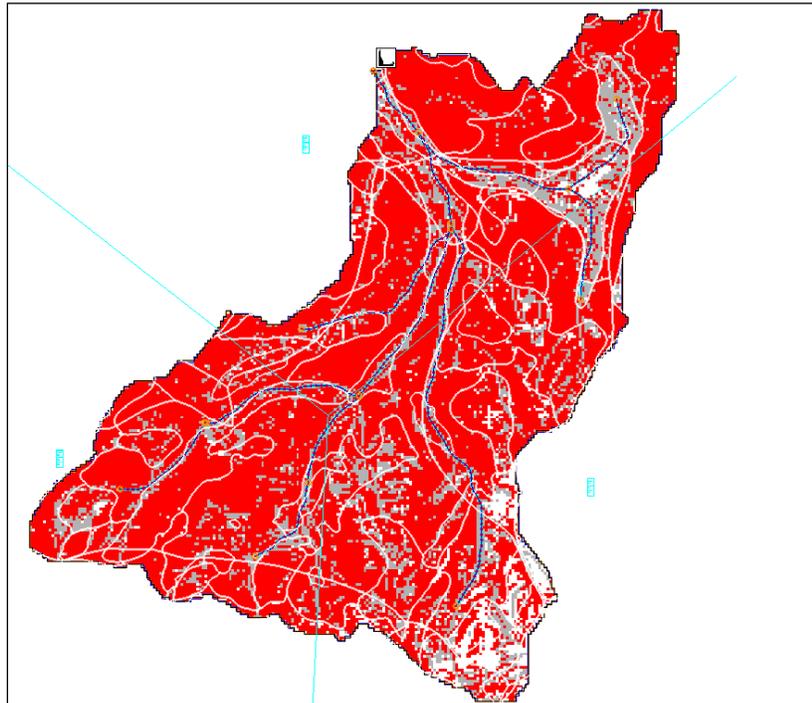
Figure 10   Red, white and gray cells illustrating erosion zonal classifications

3.7   Summary File

To view the summary file, do the following:

1. Double-click on "Summary File" in the Project Explorer to bring up the *View Data File* dialog.

If *Never ask this again* was previously turned on, this dialog will not appear. In this case, skip to step 3.

2. Select the desired external text editor from the *Open With* drop-down and click **OK** to close the *View Data Files* dialog and open the summary file.

3. Review the summary file, including for the following items:

    •   The volume of sediment (sand, silt, and clay) that eroded from the surface.

    •   The volume of eroded sediment that reached the stream.

    •   Notice that the initial volume of sand in the channel is zero. This is because the channel was not allowed to erode in this tutorial. In reality, channel beds also erode.

4. When finished, exit the text editor and return to WMS.

The following section shows how to include channel erosion.

4   Updating Channel Erodibility Parameters

In the previous GSSHA run, the channels were not allowed to erode. In this section, turn on the channel erosion option and rerun the model by doing the following:

1. Switch to the ✦ᴺ **Map** module.

2. Using the **Select Feature Line Branch** 🔍 tool, double-click on the stream arc just upstream of the watershed outlet to bring up the *Properties* dialog (Figure 11).

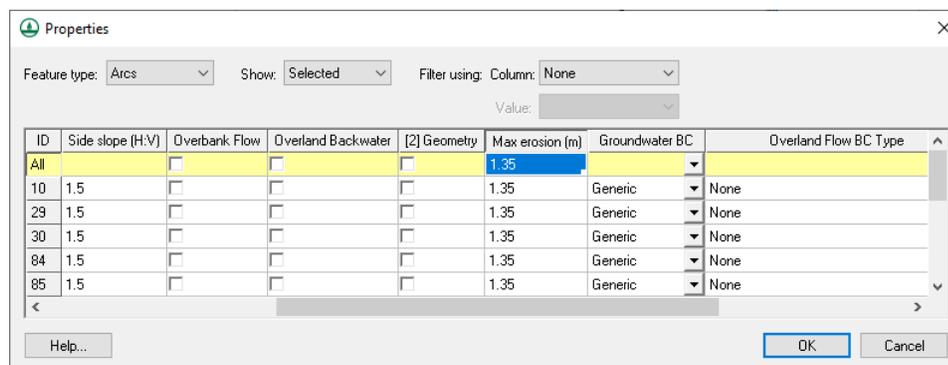| ID	Side slope (H:V)	Overbank Flow	Overland Backwater	[2] Geometry	Max erosion (m)	Groundwater BC		Overland Flow BC Type	
All		☐	☐	☐	1.35		▼		
10	1.5	☐	☐	☐	1.35	Generic	▼	None	
29	1.5	☐	☐	☐	1.35	Generic	▼	None	
30	1.5	☐	☐	☐	1.35	Generic	▼	None	
84	1.5	☐	☐	☐	1.35	Generic	▼	None	
85	1.5	☐	☐	☐	1.35	Generic	▼	None	

Figure 11   The Max erosion (m) column in the Properties dialog

3. In the spreadsheet, scroll to the right so the *Max erosion (m)* column is visible.

4. In the *All* row, enter "1.35" in the *Max erosion (m)* column.

5. Click **OK** to close the *Properties* dialog.

6. Switch to the ▦ **2D Grid** module.

7. Select *GSSHA |* **Save Project File…** to bring up the *Save GSSHA Project File* dialog.

8. Enter "sedStrErosion.prj" as the *File name* and click **Save** to save the project under the new name and close the *Save GSSHA Project File* dialog.

9. Select *GSSHA |* **Run GSSHA…** to bring up the *GSSHA Run Options* dialog.

10. Click **OK** to close the *GSSHA Run Options* dialog and open the *Model Wrapper* dialog.

11. When GSSHA finishes running, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

12. Repeat the visualization steps in Section 3 to see the differences in stream sediment flux.

5   Conclusion

This concludes the "Sediment Transport in GSSHA" tutorial. Feel free to continue to experiment, or exit the program.