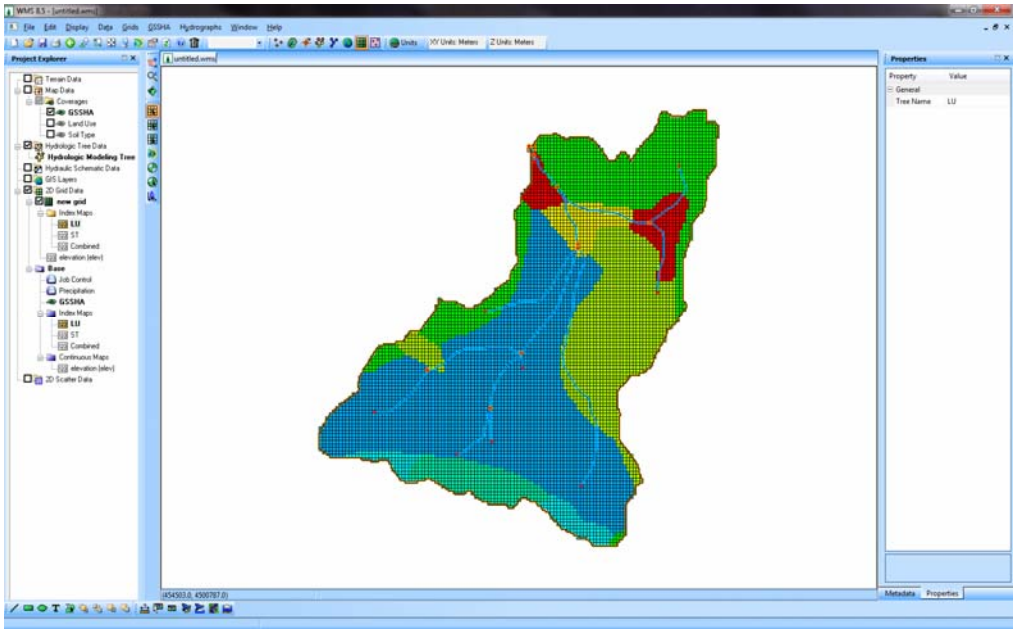
WMS

v. 9.0

WMS 9.0 Tutorial

GSSHA – Applications – Analyzing the Effects of Land Use Change (Part - I)

Model land use changes using GSSHA



Objectives

In this workshop, you learn how to model and compare the effects of land use changes using the GSSHA model.

Prerequisite Tutorials

- GSSHA – Modeling Basics – Developing a GSSHA Model Using the Hydrologic Modeling Wizard in WMS

Required Components

- Data
- Drainage
- Map
- Hydrology
- 2D Grid
- GSSHA

Time

- 30-45 minutes

AQUAVEO™

1 Contents

2 Open an Existing GSSHA Model

In this tutorial you will see how different land use change scenarios can be modeled in GSSHA. These scenarios can be used to compare pre-development and post-development watershed conditions.

In this exercise you will perform the following tasks:

- Change a portion of land from its existing land use to a residential land use.
- Change the location of the residential area to determine the effects of the change.
- Convert the residential area inserted in the first case to an industrial area to simulate an alternative land use plan.

1. Switch to 2D Grid Module and open an existing project by selecting ***GSSHA | Open Project File***.
2. Locate the ***GSSHA Distributed Hydrologic modeling*** folder in your tutorial files. If you have used default installation settings in WMS, the tutorial files will be located in ***\My documents\WMS 9.0\Tutorials\.***
3. Browse and open file ***\GSSHA Distributed Hydrologic modeling \Scenarios\BaseModel\Base.prj.***

Save this project to the personal folder so that the original project remains unchanged.

4. Select ***GSSHA | Save Project File.*** Save the project as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios\Changes\Base.prj.***

3 Changing the Land Use to Residential

The land under consideration for development is in the Park City, UT watershed. To simulate the development, the existing land use will be converted to a residential area. This change impacts both infiltration and the overland roughness characteristics of the watershed.

3.1 Creating a new GSSHA project for the changed land use

There are two steps involved in creating a new GSSHA project for the changed land use:

1) Create a new GSSHA coverage

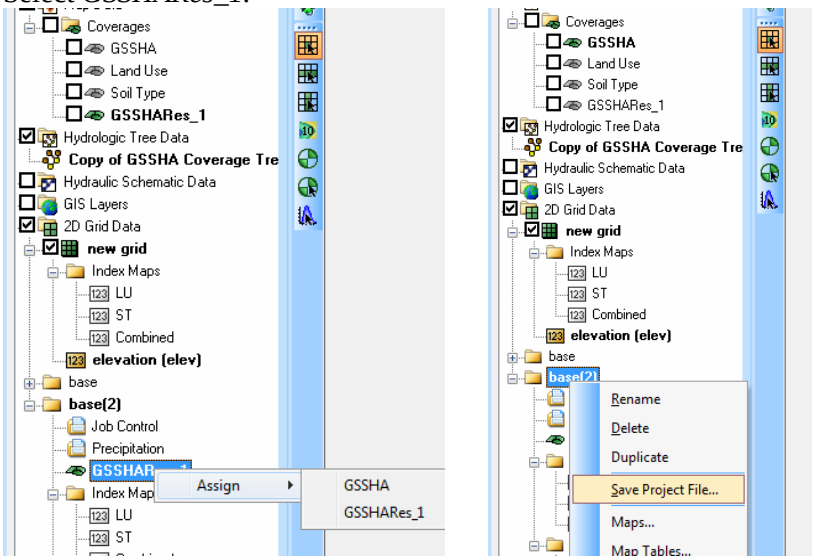
2) Create a new GSSHA project

Creating a new GSSHA Coverage

1. In the project explorer, under *Coverages*, right click the *GSSHA* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHARes_1*.

Creating a new GSSHA Project

1. In the project explorer, under ***2D Grid Data***, right click on GSSHA project named ***Base*** and select *Duplicate.* This will create a new GSSHA project with the name *Base(2).*
2. Under ***2D Grid Data***, expand *Base(2).* Right click on GSSHA and select *Assign.*
3. Select *GSSHARes_1*.



4. Right click on project ***Base(2)*** and select ***Save Project File….*** Save it as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios\Changes \Residential_1.prj.*** Saving the file will rename the project to the project base filename.

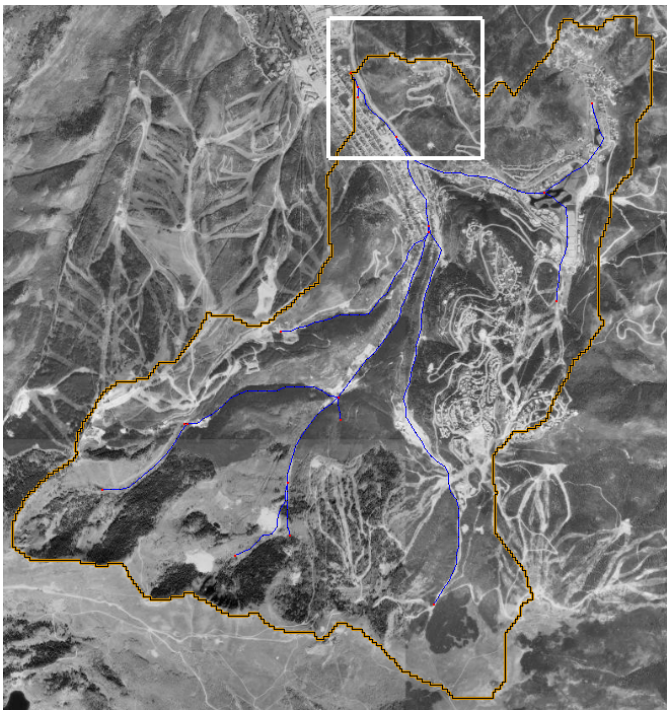
3.2 Changing the Land Use Map

In this section, you will modify the land use data.

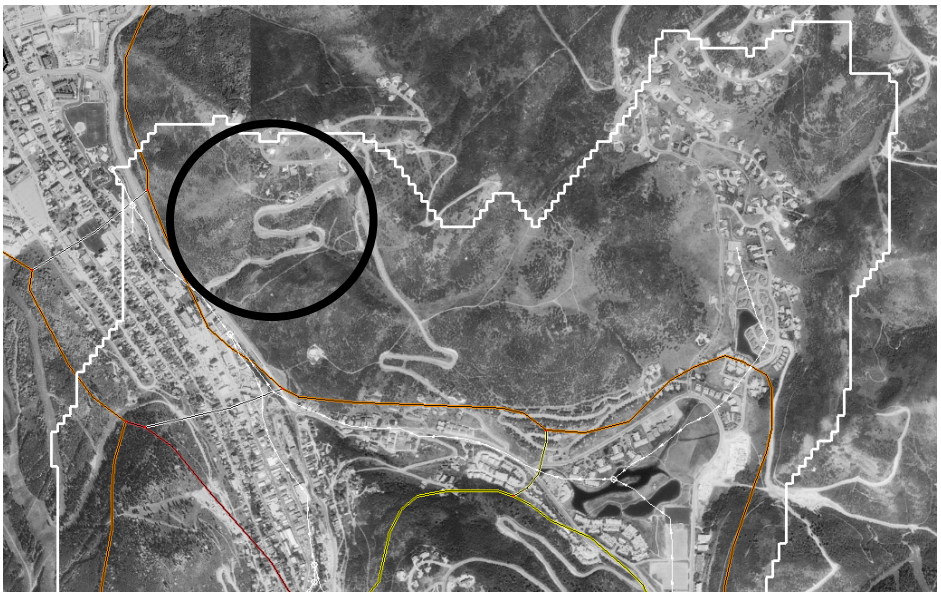
1. Since you are changing the land use map, create a copy of the original land use coverage. Right click on the *Land Use* coverage and *Duplicate* it. Rename it to *LUResidential_1*.
2. A background image will help to identify the proper location of the residential development under consideration. Select ***File | Open***. Browse to ***\GSSHA Distributed Hydrologic modeling\Scenarios\Images\Aerial.jpg*** and open it.
3. Select Yes if prompted to build pyramids.

Use this image to identify the existing land use types.

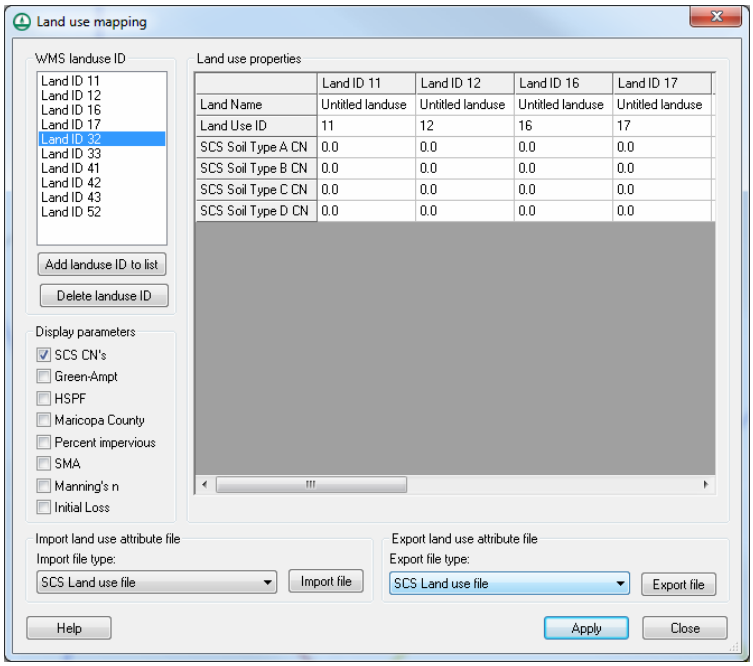
4. Turn off the display of the *GSSHA*, *Soil Type*, and *Land Use* coverages and the *2D Grid Data* folder by checking them off in the data tree. Make sure that the *LUResidential_1* coverage is turned on.
5. Zoom in around the area as shown in the following figure. In the background image, notice that most of the area could be classified as shrub and brush rangeland (Land use ID 32). After development, the area will be converted to a relatively impervious land use type that could be classified as a residential area (Land use ID 11).



6. Select the ***Map Module***  .



7. In the *Project Explorer*, click on the *LUResidential_1 Coverage* to make it an active coverage.
8. Click on "*Select Feature Polygon Tool*"  . Then double click on the polygon in the area enclosed in the circle (in the above figure). This will open up the "*Land use Mapping*" dialog.

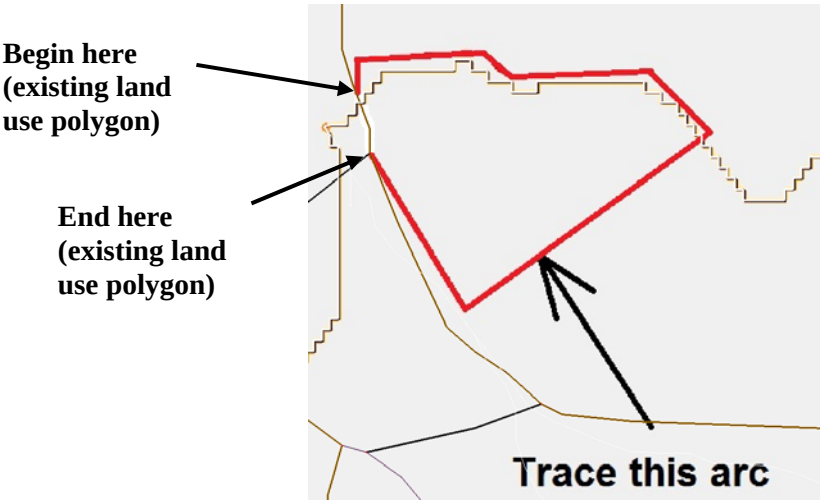


9. On the left side of the dialog, you can see the current land use ID selected. The Land Use ID selected should be 32. According to the USGS land use classification, Land use ID 32 represents Shrub and Brush Rangeland. You will now change a portion of this land use to *Residential* (Land use ID 11).
10. *Close* the *Land use mapping* dialog.
11. *Turn off* the display of background image *Aerial* by unchecking it in the data tree.

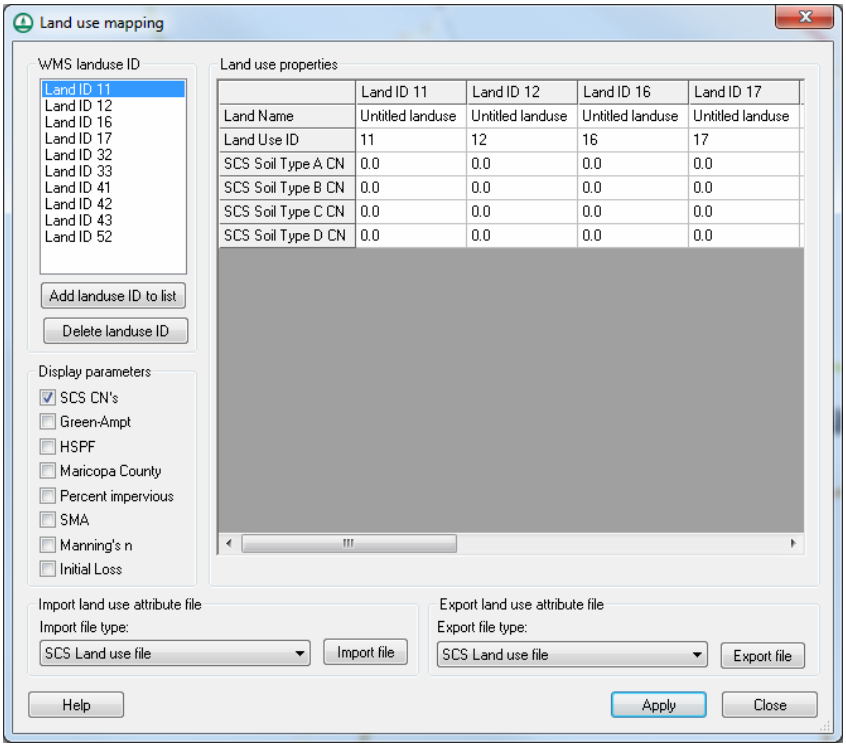
12. A background image has been created using the image of the watershed that shows the location of new development. Select ***File*** **|** ***Open***, the browse and open the file ***\GSSHA Distributed Hydrologic modeling\ Scenarios\Images\Residential1.jpg.***

Note that you will need to zoom into the land use area again after the image is loaded. Once you zoom in, notice a red polygon that shows the location of the new residential development.

13. Make sure the *LUResidential_1 Coverage* is active by selecting it. In the Map Module, select the "*Create Feature Arc Tool*"  and trace a line as shown in the background image. Trace an arc along the line using left mouse clicks and make sure that the arc you trace begins and ends at the existing land use polygons (see following figure).



14. Select ***Feature Objects*** **|** ***Build Polygon*** and click *OK* to use all arcs.
15. In the Map Module, Click on the *Select Feature Polygon* tool  . Double click the area enclosed by the arcs you traced. This will select the new polygon bring up the *Land use Mapping* dialog.



16. The land use ID for this polygon is not yet set. Select *Land ID 11* for this polygon from the list of land use IDs. Changing to this ID tells WMS that this area has been changed to *residential* land use.
17. Click *Apply*. This changes the land use code for the new polygon to 11.

3.3 Creating the Modified Index Maps

With the change you have made to the land use coverage, the index maps that use the land use coverage need to be updated as well. To do this you need to create new land use and combined index maps.

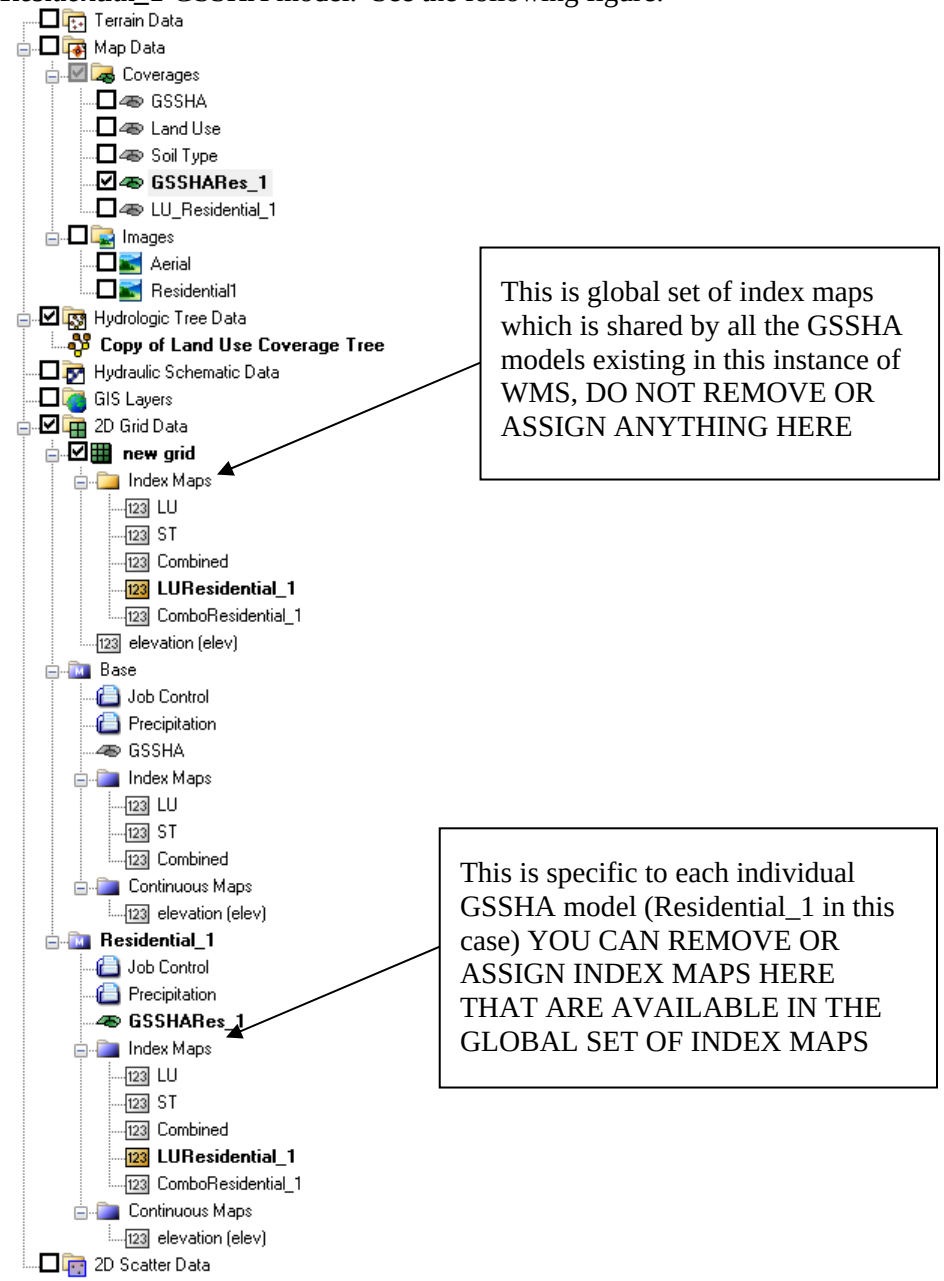
1. In the project explorer under *2D Grid Data*, right click project *Residential_1* GSSHA model and select ***Maps…***
2. In the "Index-Grid" tab, select the Input coverage to be *LUResidential_1* with coverage attribute as ID and the Index map name *LUResidential_1*.
3. Click on the *Coverages->Index Map* button.
4. Next you will create a new index map which is a combination of soil type data and the modified land use data. Select the following:
   Input coverage (1): *LUResidential_1*
   Coverage attribute: Id
   Select **input Coverage (2)** by checking it ON.
   Input coverage (2): Soil Type
   Coverage attribute: Texture
   Index map name: *ComboResidential_1*
5. Click on the *Coverages ->Index Map* button.
6. Click *Done* to close the *GSSHA Maps* dialog.
7. Turn off the background images and *LUResidential_1* coverage.
8. Turn on the display of *2D Grids data.*
9. Frame the display by clicking  .

10. Check the new index maps, you can see the location were new land use was inserted into the index map.

You should have two new index maps added to the data tree.

3.4 Assigning new index maps and updating the parameters

1. Under ***2D Grid*** Data, click on the ***Residential_1*** GSSHA project.
2. Expand the *Index Maps* folder and check if ***ST, LUResidential_1 and ComboResidential_1*** index maps are listed in there. If they are not listed, right click *Index maps* folder and assign these maps.
   Note: There is another *Index map* folder right under *2D grid data*. Make sure the new index maps that you have created are listed under the ***Residential_1*** GSSHA model. See the following figure:



3. Right-click on the *Residential_1* model index map folder and Remove *LU* and *Combined* index maps which were developed for the original land use.
4. This GSSHA project uses the *ST, LUResidential_1* and *ComboResidential_1* as the index maps. Make sure these index maps are assigned to the *Residential_1* project.
5. Once the new index maps are created, we now need to update the mapping tables as well. Under ***2D grid Data***, right click on the GSSHA project ***Residential_1*** and select ***Map Tables***…
6. In the *Roughness* tab, select "*LUResidential_1"* for the "*Using index map*" field and click the *Generate IDs* button.
7. Click *No.*
8. There will be no new IDs added because Land use ID 11 already existed in the original index map. By changing some of the land use to residential, you increased the number of cells with ID 11 and decreased the number of cells with ID 32.
9. Switch to the *Infiltration* tab. Select *ComboResidential_1* for the *Using index map* field.
10. Click on the *Generate IDs* button and click *NO*.
11. Again, there will be no fields added to this table.
12. Click *Done.*
13. In the *Project Explorer*, right click on ***Residential_1*** and select ***Save Project File…***.
14. Save the project as ***\GSSHA Distributed Hydrologic modeling\Personal\ Scenarios\Changes\Residential_1.prj***.
15. Select Yes if prompted to replace your existing file.

3.5 Save the projects as a GSSHA group

You will save all the GSSHA projects as a single GSSHA group so they can be opened or run together. If you close any GSSHA project, you can open the group file and resume the tutorial. As you add new GSSHA models to our project, you can save all of them as a GSSHA group. Saving all the models could be done after you have created all the model scenarios, but it is advisable to save your projects frequently so that you can open, modify and close all the projects at any time.

1. In *2D Grid Module*, select ***GSSHA | Save Group.***
2. Toggle on both the GSSHA projects listed in the *Save GSSHA Groups* dialog. Browse and save the group as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios\Changes\Scenarios.ggp.***

4 Changing the location of the Residential area

In the previous section, we changed the land use from Shrub and Brush Rangeland to Residential. GSSHA being a fully distributed model, the location of such change makes a significant difference. Now we will insert the residential area at a different location and re-run the model to see the variation in watershed response.


In the previous scenario, the change in land use occurred close to the watershed outlet (See above figure, left). Now, we will change the land use to residential at the far upstream location (See above figure, right). The area of new residential lands are approximately same in both cases. We are varying the location of such change keeping the area of the change the same.

4.1 Creating a new GSSHA project for the changed land use

Creating a new GSSHA Coverage

1. In the project explorer, under *Coverages*, right click the *GSSHA* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHARes_2.*

Creating a new GSSHA Project

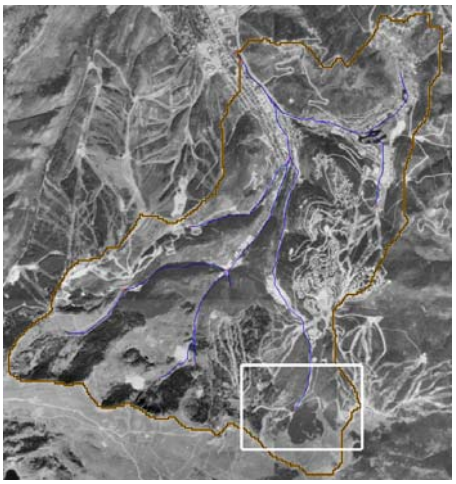
1. In the project explorer, under ***2D Grid Data***, right click on GSSHA project named ***Base*** and select *Duplicate.* This will create a new GSSHA project with the name *Base(2).*
2. Under ***2D Grid Data***, expand *Base(2).* Right click on GSSHA and select *Assign.*
3. Select *GSSHARes_2*
4. Right click on project ***Base(2)*** and select ***Save Project File….*** Save it as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios \Residential_2.prj.*** This will also rename the project.

4.2 Changing the Land Use Map

Let us now modify the land use.

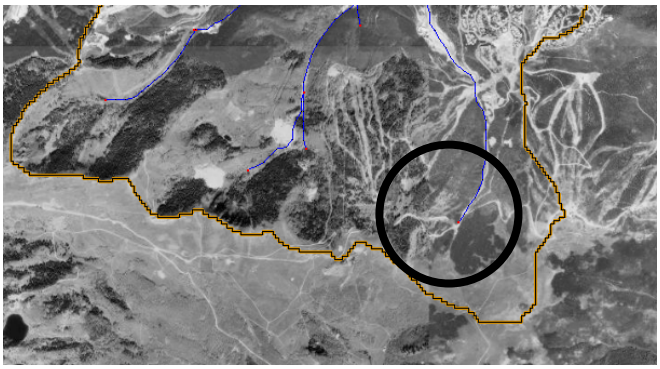
1. Create a copy of the original land use coverage. Right click on *Land Use* coverage and *Duplicate* it. Rename it to *LUResidential_2.*
2. Turn off the display of all the coverages except*"GSSHARes_2"*and *"LUResidential_2".* Turn off *"2D Grid Data"* by checking them off in the data tree.

3. Zoom in around the area as shown in following figure.

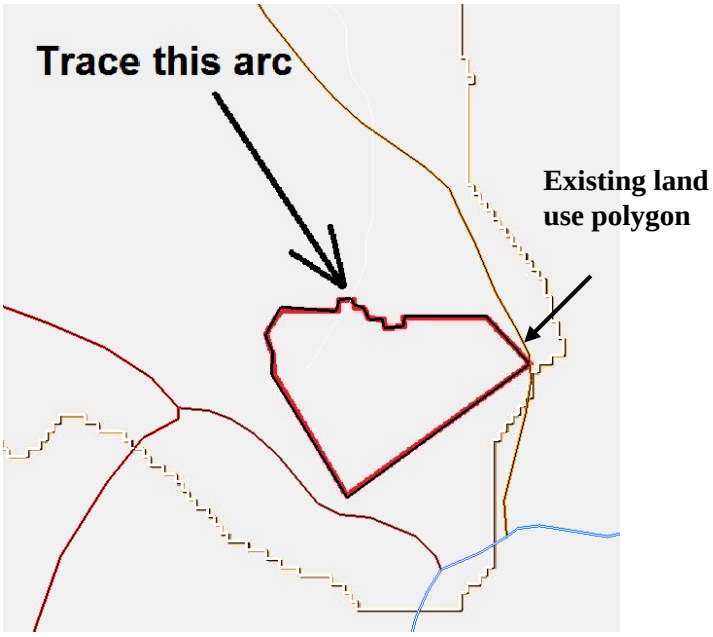


4. Select the ***Map Module*** .

The highlighted area is evergreen forest (LUCode 42). After the development, let us assume that the area will be converted to relatively impervious almost similar to a residential area (LUCode 11).



5. Click on the *LUResidential_2 Coverage* to make it an active coverage. .
6. You may use "*Select Feature Polygon Tool*" to check what existing land use is, in that area.
7. There is a background image that shows the location of new land use polygon. Select ***File|Open***, browse and open file ***\GSSHA Distributed Hydrologic modeling\Scenarios\Images\Residential2.jpg.*** Once this image opens, you can see a red arc pointed out by an arrow head. You might need to zoom in again after the image loads.
8. Make sure that *LUResidential_2 Coverage* is active and turned on. In the Map Module, Select the "*Create Feature Arc Tool*" and trace a line as shown in the background image. Trace an arc along the line using left mouse click and make sure that the arc you trace will start and end at an existing land use polygon arc/s (see following figure).



9. Select ***Feature Object | Build Polygon*** and click *OK* to use all arcs.
10. In the Map Module, Click on the "*Select Feature Polygon Tool*" tool. Then double click the area enclosed by the arcs you traced. This will select the new polygon for the area and bring "*Land use Mapping*" dialog up.
11. Assign ID 11 for this area to represent that it has been changed to *residential* land use.
12. You may turn off the display of background image and *LUResidential_2* Coverage and frame your window .

4.3 Creating the Modified Index Maps

With the change in land use coverage, the index maps that use Land use coverage need to be updated as well. To do this we will create new land use and combined index maps.

1. In the project explorer under *2D Grid Data*, right click GSSHA project ***Residential_2*** and select ***Maps…***
2. In the "Index-Grid" tab, select the Input coverage to be *LUResidential_2* with coverage attribute as ID and the Index map name *LUResidential_2*.
3. Click on the *Coverages->Index Map* button.
4. Next we will create a new index map which is a combination of soil type data and the modified land use data. Select the following:

Input coverage (1): *LUResidential_2*

Coverage attribute: Id

Select **Input Coverage (2)** by checking it ON

Input coverage (2): Soil Type

Coverage attribute: Texture

Index map name: *ComboResidential_2*

5. Click on *Coverages ->Index Map* button.
6. Click *Done* after it completes.
7. Turn off *LUResidential_2* coverage if you did not do it earlier.
8. Turn on the display of *2D Grids data.*

You should have two new index maps added to the data tree.

4.4 Assigning new index maps and updating the parameters

1. Under ***2D Grid*** Data, click on the GSSHA project named ***Residential_2.***
2. Remove (*Right Click*|*Remove*) all the index maps *LU* and *Combined* as they were developed for the original land use.
3. The new GSSHA project uses *ST, LUResidential_2* and *ComboResidential_2* as the index maps. Make sure that these maps are assigned to this GSSHA model.
4. We need to update the mapping tables as well. Under ***2D grid Data***, right click on GSSHA project ***Residential_2*** and select ***Map Tables***…
5. In the *Roughness* tab, select "*LUResidential_2"* for the "*Using index map*" field and click the *Generate IDs* button.
6. Click *No.*
7. There will be no new field added because ID 11 already existed in our original index map. Just the number of cells with ID 11 has increase and the number of cells with ID 42 has decreased.
8. Switch to the "*Infiltration*" tab. Select "*ComboResidential_2*" for the "Using index map" field.
9. Click on the *Generate IDs* button and click *NO*.
10. Again, there will be no new fields added at the end of the table for the new land use.
11. Click *Done*
12. On the data tree, right click on ***Residential_2*** and select ***Save Project File…*** Save the project (as ***\GSSHA Distributed Hydrologic modeling\ Personal\Scenarios\Changes\ Residential_2.prj*)**
13. Select Yes if prompted to replace existing file.

4.5 Save the projects as a GSSHA group

1. In *2D Grid Module,* select ***GSSHA|Save Group.***
2. Toggle on all the three GSSHA projects listed in *Save GSSHA Groups* dialog, browse and save the group as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios\ Changes\Scenarios.ggp.***

5 Changing the Land Use from Residential to Industrial

To simulate a progressive development scenario, let us assume that the portion of land which we changed to a residential in the first part of this workshop (i.e. *Residential_1*) now changes to an industrial area. So, we will update the GSSHA model to reflect this change and see the differences in the watershed response.

5.1 Creating a new GSSHA project for the changed land use

There are two steps involved in creating new GSSHA project.

Creating a new GSSHA Coverage

1. In the project explorer, under *Coverages*, right click *GSSHARes_1* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHAIndus.*

Creating a new GSSHA Project

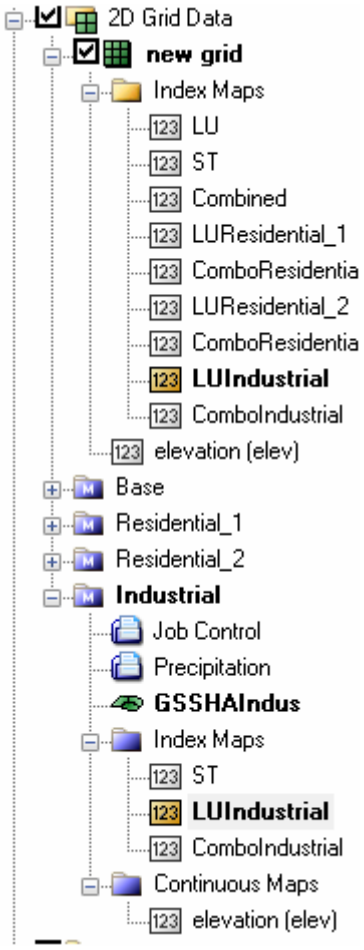
1. In the project explorer, under ***2D Grid Data***, right click on GSSHA project named ***Residential_1*** and select *Duplicate.* This will create a new GSSHA project with name *Residential_1(2).*
2. Under ***2D Grid Data***, ***e***xpand *Residential_1(2).* Right click on *GSSHARes_1* and assign *GSSHAIndus*
3. Right click on project ***Residential_1(2)*** and select ***Save Project File….*** Save it as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios \Changes\Industrial.prj.*** This will also rename the project.

5.2 Creating the Modified Index Maps

In this case we already know the location where the land use is changing from *Residential* to *Industrial*, so we do not need to update the landuse coverage.

We will rather update the index map directly.

1. In the project explorer under *2D Grid Data*, right click GSSHA project ***Industrial*** and select ***Maps…***
2. Click on *Data Calculator* button
3. In Data calculator, double click on *LUResidential_1* dataset which will put a symbol (something like 'd5') in the *Expression box.*
4. Enter *LUIndustrial* in *Result* field.
5. Toggle *Index Map* option on.
6. Click *Compute*, which will create a copy of *LUResidential_1* index map.
7. Still in the *Data calculator* dialog, double click on *ComboResidential_1* dataset which will put a symbol (something like 'd6') in the *Expression box.*
8. Enter *ComboIndustrial* in *Result* field.
9. Toggle *Index Map* option on.
10. Click *Compute*, which will create a copy of *ComboResidential_1* index map.
11. Click *Done* and *Done* again. This should have added two new index maps in the project explorer.
12. Right click and remove the index maps *LUResidential_1* and



ComboResidential_1 from this GSSHA project.

13. Your data tree should look something like the figure to the right.
14. Right click on project ***Industrial*** and select ***Save Project File….*** Save it as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios \Changes\Industrial.prj.***

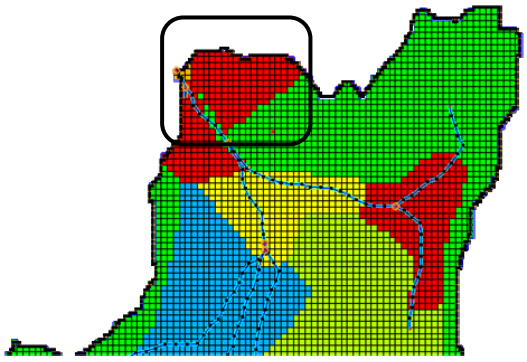
5.3 Modifying the Index Maps

We are making an assumption that the land that was converted to residential is converted to Industrial. Since we are converting all the residential areas to industrial, you can modify the residential index map (which you duplicated in the previous step using the data calculator) instead of creating a new one.

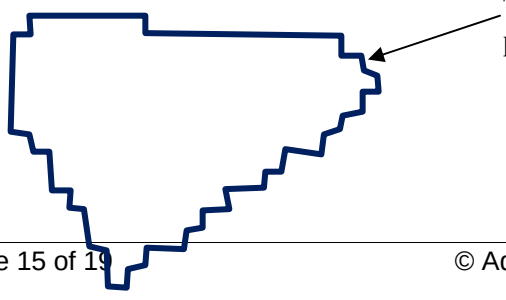
In the mapping table, if you change the parameters for LU11 (which is the residential area), you will also change parameters for other grid cells which have same land use. To avoid this, assign new ids to the cells at the location where the landuse changed from *Residential_1* to *Industrial*.

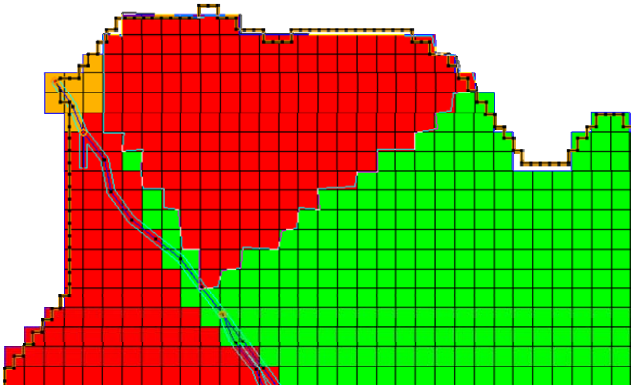
Modifying Land use Index map

1. Turn off the display of all the coverages except *GSSHAIndus* and frame the window  .
2. Zoom into the area where Residential landuse is converted to Industrial, see following figure.

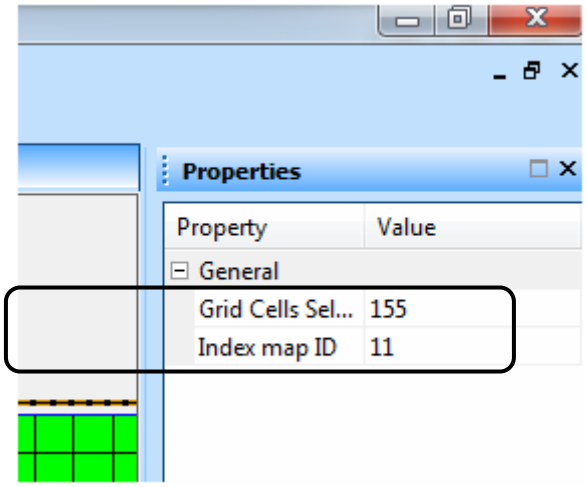


3. Under ***2D Grid Data***, click the GSSHA project named ***Industrial*** to make it active.
4. Then under ***Industrial***, expand *Index Maps* folder and select the index map *LUIndustrial.*
5. Make sure *Select Grid Cell*  tool is selected.
6. Select ***Edit | Select With Polygon*** and click ***OK*** to enter a polygon interactively.
7. Then start tracing a polygon around the changed landuse, see the following figure.

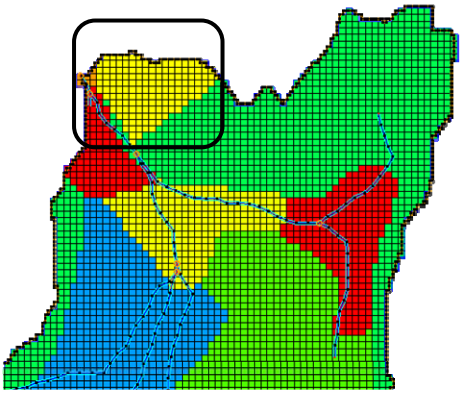




8. Once you are done tracing the polygon, double click at the endpoint. This will select all the grid cells enclosed in the polygon you traced. The selected cells are marked with a red dot at the centroid of each cell but if the grid cell is red, you might not be able to notice the selection marker. Just to make sure, look at the *Properties* window on the right side which will show the number of *Grid Cells Selected.*



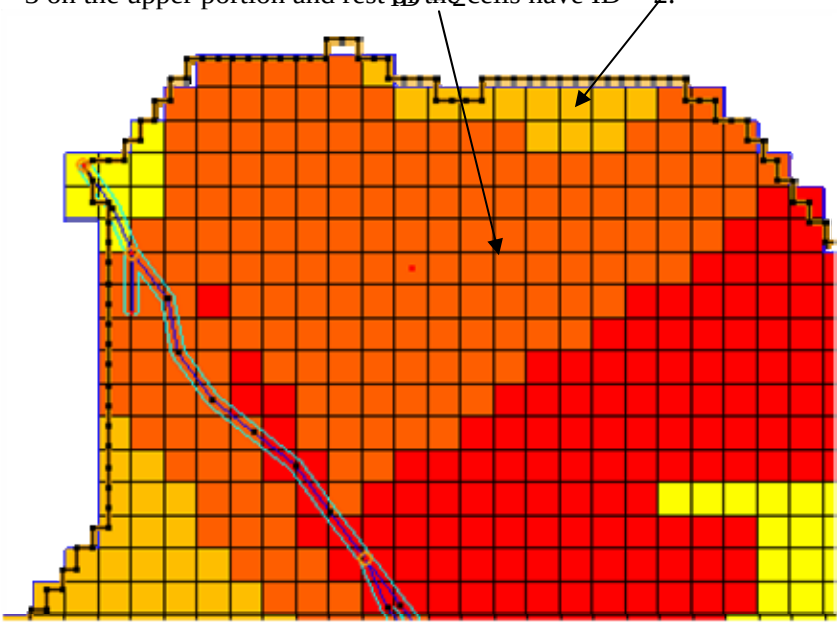
9. Without clicking anywhere on the WMS main window, change Index Map ID in the properties window from 11 to 15.
10. This will change the color of the grid cell.



Modifying Combined Index map

We will repeat the same steps and modify the grid cell id for in *ComboIndustrial* index map as well.

1. Then under ***Industrial***, expand *Index Maps* folder and select the index map *ComboIndustrial.*
2. Make sure *Select Grid Cell* tool is selected.
3. Select ***Edit | Select With Polygon*** and click ***OK*** to enter a polygon interactively.
4. There are two different types of Ids in that area, there are few cells with ID = 3 on the upper portion and rest of the cells have ID = 2.



5. Select the cells with ID = 2 and change their ID to 101.
6. Similarly select cells with ID = 3 and change their ID to 102.
7. WMS will automatically assign different colors to these cells.

We are done updating the grid IDs in the new industrial landuse. Now we will modify the parameters to these grid cells in the mapping table.

5.4 Changing the Roughness and Infiltration Parameters

1. Under ***2D Grid*** Data, right click the GSSHA project named ***Industrial.***
2. Right click on the GSSHA project named ***Industrial*** on the data tree and select ***Map Tables***…
3. In the *Roughness* tab, select "*LUIndustrial"* for the "*Using index map*" field and click the *Generate IDs* button.
4. Click *No.*
5. There will be a new field with Id =15 added because we changed the grid ID in *LUIndustrial* index map to be 15.
6. Make sure that the following values are defined

ID	11	12	**15**	16	17	32	33	41	42
Surface Roughness	0.011	0.012	**0.01**	0.011	0.011	0.05	0.04	0.1	0.15

7. Switch to the "*Infiltration*" tab. Select "*ComboIndustrial*" for the "Using index map" field.
8. Click on the *Generate IDs* button and click *NO*.
9. Scroll all the way to the right, and you will see two new IDs 101 and 102 added. Enter the following values for these IDs.

Parameter	**ID = 101**	**ID = 102**
Hydraulic Conductivity	0.01	0.03
Capillary Head	35.44	32.28
Porosity	0.464	0.464
Pore Distrib Index	0.242	0.242
Resideual Saturation	0.075	0.075
Field Cap	0.318	0.318
Wilting Point	0.1	0.1

10. All other values will remain the same.
11. Click *Done*
12. On the data tree, right click on ***Industrial*** and select ***Save Project File…*** Save the project (as ***\GSSHA Distributed Hydrologic modeling\Personal\ Scenarios\Changes\Industrial.prj*)**

5.5 Save the projects as a GSSHA group

1. In *2D Grid Module*, select ***GSSHA | Save Group.***
2. Toggle on all the GSSHA projects listed in *Save GSSHA Groups* dialog, browse and save the group as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios\Changes\Scenarios.ggp.***
3. In *2D Grid module*, select ***GSSHA|Save group.*** Toggle on all the four GSSHA projects (base, Residential_1, Residential_2 and Industrial) and save as ***\GSSHA Distributed Hydrologic modeling\Personal\Scenarios \Changes\Scenarios.ggp.***

6 Running a GSSHA Group

Now we will run the scenarios so that we can compare the effects of land use change, location of the change and conversion of the same land to an industrial area.

1. Select ***GSSHA | Run GSSHA group…***.
2. Make sure that all four projects are selected and the path is correct.
3. Click *OK*
4. If you created the models properly, WMS will run all the scenarios and plot the outflow hydrographs on the same plot. If you did not see results for any

of the models, that means that model did not run. Examine the model and try running it individually.

5. Export all the four hydrographs to the spreadsheet named ***\GSSHA Distributed Hydrologic modeling\tables\ScenarioModeling.xls***

In the next workshop, we will use some abatement measures so that the effects of these land use changes can be mitigated.

