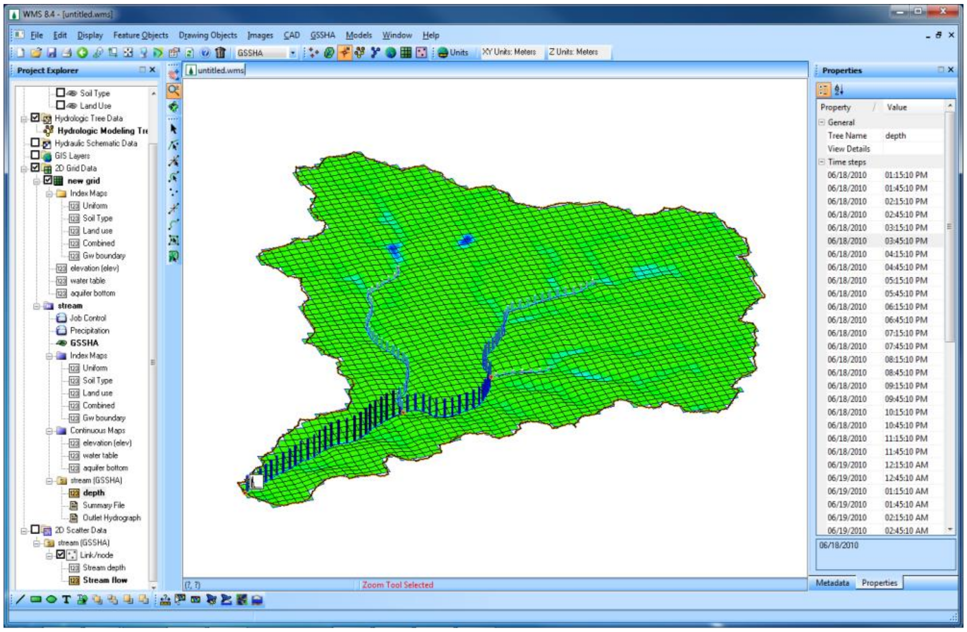
v. 10.0

WMS 10.0 Tutorial

GSSHA – Modeling Basics – Infiltration

Learn how to add infiltration to your GSSHA model



Objectives

This workshop builds on the model developed in the previous workshop and shows you how to add Green & Ampt Infiltration with Soil Moisture Redistribution to your existing model.

Prerequisite Tutorials

- GSSHA – Modeling Basics – GSSHA Initial Overland Flow Model Setup

Required Components

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

Time

- 30-45 minutes

1 Contents

2 Introduction

Infiltration is a key process in a rainfall runoff model and to this point you have not simulated it since you were learning other concepts and you should first make sure the overland flow process runs correctly. During this tutorial, you will set up the inputs needed for the ***Green & Ampt with Soil Moisture Redistribution*** model.

Keep working with the model you have been developing. If you are continuing from the last tutorial then you can skip the first two steps which open your model (or the backup saved in case you have problems) and go to step 3 below.

1. In the 2D Grid Module select ***GSSHA | Open Project File.***
2. Locate the ***Personal***, ***DigitalDam***, ***Raw Data***, ***Tables***, and ***Infiltration*** folders for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
3. Browse and open the file ***Personal\DigitalDam\Clean.prj.*** If this file does not exist, you may open ***DigitalDam\Clean.prj.***
4. Save this project with a different name so that the original project remains unchanged. Select ***GSSHA | Save project File*** and save the project as ***Personal\Infiltration\Infiltration.prj.***

3 Index Map Setup

Describing the spatial variability of almost all parameters is done by setting up an index map and then assigning parameter values to a mapping table. An index map is a grid of ID numbers. Parameter values can be assigned to each index map ID number in the project mapping tables. Index maps are generic and may apply to any number of mapping

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tables. Each table lists the name of the index map associated with the table and all the IDs that the index map (should or could) have, along with parameters for the IDs.

In this tutorial, you will use a soil type shape file from the NRCS SSURGO soil database to create a soil type index map. You will learn to perform necessary join operations to derive infiltration parameters from SSURGO soil data.

4 Create Soil Type Coverage

1. Right-click on the *Coverages* folder in the project explorer and select *New Coverage*….
2. Change the *Coverage Type* to *Soil Type*.
3. Select *OK*.

5 Import the Soil Data

1. Right-click on *GIS Layers* in the project explorer.
2. Select *Add Shape file Data*. Browse and open ***Raw Data\JudysBranch\SSURGOSoil\Raw\Spatial\soilmu_a_il119.shp.***
3. Right click on ***soilmu_a_il119.shp*** in the project explorer and select *Open Attribute Table*. In the attribute table, notice that there are no soil parameters other than *MUSYM* and *MUKEY* assigned to the soil polygons. Select *OK* to close the *Attributes* dialog.
4. Right click on *soilmu_a_il119.shp* and select *Join NRCS Data*.
5. Toggle the *Fill blank values* and *Compute Hydraulic…* options on.
6. Leave the fields to fill (i.e. B and Silt loam) as is displayed and click *OK*. After the join is completed, you may check the attributes table by right-clicking on ***soilmu_a_il119.shp*** and selecting *Open Attribute Table*; notice that the attributes are now joined to the shape file.

Now we can convert the shape file to a coverage

7. In the **Project Explorer** under coverages, right-click on the *GSSHA* coverage and select *Zoom To Layer* to set the current view so you are zoomed to your GSSHA model.
8. Click on the *Soil Type* coverage in the *Coverages* list to make it the active coverage.
9. Select the *soilmu_a_il119.shp* GIS layer by clicking on it. This will change the active module to the ***GIS module*** .
10. Click the *Select shapes tool*  and drag a rectangle around (and a little outside) the watershed to select the soil polygons that overlay the watershed. Drag a rectangle by clicking and holding down the left mouse button.
11. In the GIS Module, select ***Mapping* | *Shapes* -> *Feature Objects***.
12. Select *Next*. Notice that the fields should be mapped properly. Click *Next* again.

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13. Select *Finish* and wait for WMS to convert the selected shapes to feature objects in the map module.
14. You may now delete the shape file under GIS Layers (***Right click* | *Delete***) since you are done with it.
15. Toggle off the display of the Soil Type coverage so the WMS display will update faster.

6 Creating an Index Map from Soil Data

Now you can generate an index map out of the soil type coverage.

1. Switch to the *2D Grid Module* .
2. Select ***GSSHA* | *Maps…***
3. For the *Input coverage (1)*, use the *Soil Type* coverage. Do not use a second GIS data source.
4. Make sure the Coverage Attribute is set to *Texture*.
5. Change the Index map name to *SoilType*
6. Click on the ***Coverages -> Index Map*** button. It might take a few moments to build the Index map, but when it does you will see the grid display updated and the *SoilType* index map listed under the Index Maps folder in the project explorer.
7. Select *Done*

7 Creating a Mapping Table from the Index Map

Now you can define IDs based on your *SoilType* map in your infiltration mapping table and assign infiltration parameters to each ID.

1. In the 2D Grid Module select ***GSSHA* | *Map Tables***.
2. Select the *Infiltration* tab.
3. Select *Yes* to open the *Job Control* window so you can turn on the simulation of infiltration for your GSSHA model.
4. Under the *Infiltration* heading, select the *Green + Ampt with soil moisture redistribution* option.
5. Select OK.
6. In the *Using Index Map* drop down box, choose *Soil Type*.
7. Click on *Generate IDs* button

The Generate IDs button should have created some IDs, among which IDs 1, 3 and 4 may exist. You can see the soil texture name in the *Description1* field below each ID. You will now define infiltration properties for each of these soil textures.

8. Using the following table, enter the values for each soils type

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Parameters	**Clay loam (Id 1)**	**Silt loam (Id 3)**	**Silty clay loam (Id 4)**
Hydraulic Conductivity (cm\hr)	0.2	0.68	0.2
Capillary Head (cm)	20.88	16.68	27.3
Porosity (m^3\m^3)	0.464	0.501	0.471
Pore distribution index (cm\cm)	0.242	0.234	0.177
Residual Saturation (m^3\m^3)	0.075	0.015	0.04
Field Capacity (m^3\m^3)	0.318	0.33	0.366
Wilting Point (m^3\m^3)	0.148	0.141	0.212

9. Switch to the *Initial Moisture tab.*
10. In the *Using index map* drop down box, select the *Soil Type* index map.
11. Click on the *Generate IDs* button.
12. Enter the following values of *Initial Moisture*.

Clay loam (Id 1)	**Silt loam (Id 3)**	**Silty clay loam (Id 4)**
0.15	0.1	0.2

The initial moisture value must always be less than porosity.

13. Click *Done*.
14. Save your project as ***Personal\Infiltration\Infiltration.prj.***
15. Run the model using the *Run GSSHA…* command in the *GSSHA* menu. When running GSSHA, you should turn off the option to *Suppress screen printing* so you can see the GSSHA output while running.

8 Running the model and Visualization

You can see the volume infiltrated or volume of discharge and other summary values by opening the summary file.

1. In the project explorer, under the *Infiltration* solution, double-click on the summary file to open the file. If your *Clean* solution is still open from running a previous tutorial, double-click on this solution's summary file also.
2. Find the following values in each summary file and compare the values with each other:
   - Volume of infiltrated water

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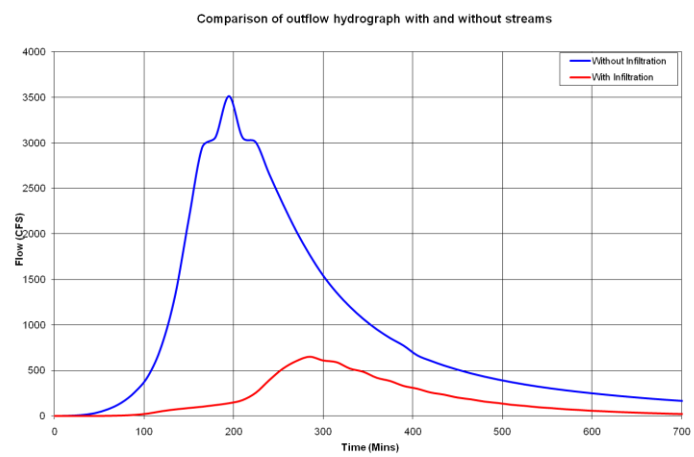
- Volume of discharge
- Volume ground water recharge
- Volume remaining on surface
- Mass conservation error

3. Double-click on the *Outlet Hydrograph* to view it.
4. To export the hydrograph ordinates to an Excel spreadsheet, right click on the hydrograph plot and choose *View Values*.
5. Select all the *Flow* data values, right click and select *Copy*.

In the previous GSSHA tutorial, you ran GSSHA without infiltration. You will now compare the results from running without infiltration to the results from running with infiltration in this tutorial.

6. Open the spreadsheet ***tables\InitialGSSHAComparison.xls*** and paste the hydrograph ordinates under the column *With Infiltration-Flow (CFS)*. Paste only the data values (no text) and paste your data in the white areas only.
7. Visualize the difference in outflow hydrograph in the two models. Your plot may be similar to this:



You should have noticed that the peak flow and the runoff volume have significantly decreased. Some of the rainfall should have infiltrated into the soil with the infiltration option turned on.

8. In WMS, close the Hydrograph plot window after you are done comparing the infiltration plot with the plot from the model without infiltration.

9 Defining variable surface roughness

So far in your model you have set up uniform watershed roughness, uniform precipitation, and variable infiltration parameters. You will now setup spatially varied roughness coefficients. Setting up non-uniform precipitation will be covered in a later workshop.

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You will be using a land use GIS file to create an index map that will be used with the roughness mapping table. Using land use data to create an index map for roughness makes your model more closely represent real-world conditions since your model can use both a land use map to describe watershed roughness and a soil type map to describe watershed infiltration. Before the model is complete, you will consider how land use affects infiltration and adjust the infiltration parameters based on a combined land use/soil index map.

Continue working on the model in the previous section. If you have already closed the model then open your saved model or the backup model and save your model as a new project.

1. In the 2D Grid module, select ***GSSHA | Open Project File***. If it is not already open, browse to and open the file ***Personal\Infiltration\Infiltration.prj***. If you do not have this project file saved you may open ***Infiltration\Infiltration.prj***
2. Save this project with a new name using GSSHA | Save Project File so that the original project remains unchanged. Save the new project as ***Personal\Roughness\Roughness.prj.***

10 Using Land Use Data

1. Right-click on Coverages folder in the project explorer and select *New Coverage*.
2. Change the Coverage Type to *Land Use*. Click *OK*. You should have three coverages: GSSHA, Soil Type and Land Use.
3. Right click on the *GIS Layers* folder in the project explorer and select *Add shapefile data...*
4. Browse to the folder ***Raw Data\JudysBranch\Landuse*** and open the files ***Belleville.shp and StLouis.shp.***
5. Right-click on the *GSSHA* coverage and select *Zoom To Layer* to set the current view so you are zoomed to your GSSHA model.
6. Click on the *Land Use* coverage in the *Coverages* list to make it the active coverage.
7. Select the *GIS Data* folder by clicking on it. This will change the active module to the ***GIS module***.
8. Click the *Select shapes tool* and drag a rectangle around (and a little outside) the watershed to select the soil polygons that overlay the watershed.
9. In the GIS Module, select ***Mapping | Shapes -> Feature Objects***.
10. Select *Next*. Make sure *LUCODE* is mapped to *Land Use*. Click *Next* to accept the attribute mappings.
11. Select *Finish* and wait for WMS to convert the selected shapes to feature objects in the map module.
12. You may now delete both shape files under *GIS Layers* (***Right click | Delete***) since you are done with them.
13. Toggle off the display of the Land Use coverage so the WMS display will update faster. If your Soil Type coverage is displayed, you should also toggle off the display of this coverage.

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14. Select the *GSSHA* coverage to make this the active coverage.

11 Creating an Index Map from Land Use Data

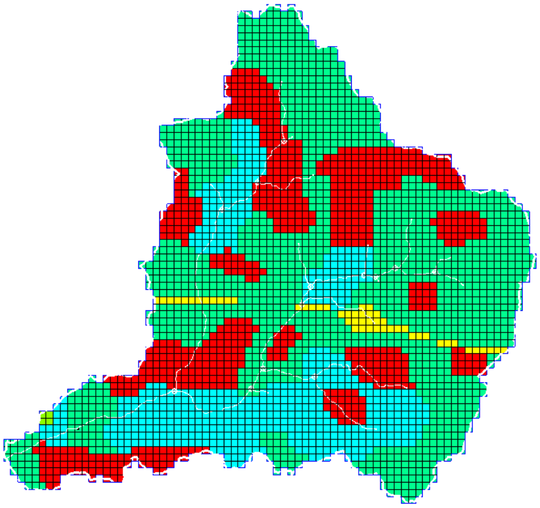
Now you can make an index map out of the land use coverage:

1. Switch to the 2D Grid Module .
2. Select ***GSSHA | Maps…***
3. In the *Index – Grid* tab, for the *Input coverage (1)* use the *Land Use* coverage. Do not use a second GIS data source.
4. Set coverage attribute to *Id***.**
5. Change the Index map name to *LandUse*.
6. Click on the ***Coverages -> Index Map*** button.
7. Select *Done*.

Under the 2D Grid Data folder in the project explorer you will notice that there are now three index maps listed: *Uniform*, *SoilType* and *LandUse*.

12 Creating a Mapping Table from Index Map

When you select the land use index map, the display should show grid cells colored in several colors representing the different land use IDs of the polygons that were mapped to the grid cells. Next, you will assign the Land Use index map to the roughness table and set up roughness values for each of the IDs in the Land Use index map.



1. Select ***GSSHA | Map Tables…***
2. Select the *Roughness* tab if it is not already selected.
3. Under '*Using index map'* choose the "Land Use" index map.
4. Click on "*Generate IDs*". Click *Yes* when asked to delete the selected process' existing IDs.
5. Fill out the Roughness values according to the table below. To enter a roughness value for an ID, highlight the surface roughness box below the ID then edit the roughness value. (You may also edit the descriptions if you wish, however you should leave the original polygon ID description as

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is.) If one of the roughness values does not show up in your mapping table, just define roughness parameters for the values that show up in the mapping table.

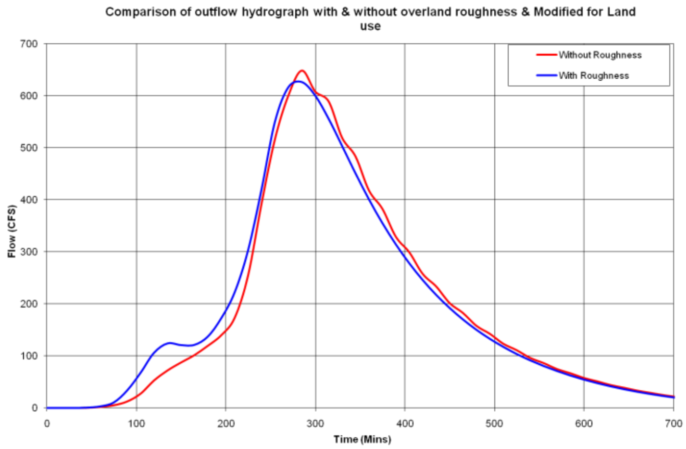
ID	*Description*	*Roughness*
11	Land ID #11, Residential	0.011
12	Land ID #12, Commercial Services	0.012
14	Land ID #14, Highway	0.011
16	Land ID #16, Mixed Urban or Built-Up Land	0.011
21	Land ID #21, Cropland and Pasture	0.035
23	Land ID #23, Confined Feeding Operations	0.035
41	Land ID #41, Deciduous Forest Land	0.100

6. Once you are done entering the roughness values, select *Done*.
7. Save your project as ***Personal\Roughness\roughness.prj.***
8. Run GSSHA.

13 Visualization

After GSSHA successfully runs, open the outflow hydrograph.

1. Double-click on the outlet hydrograph to bring up the hydrograph plot.
2. Right click on the hydrograph plot and choose *View Values*…
3. Select the values under the *Flow* column, Right Click and select *Copy*.
4. Open the spreadsheet ***tables\InitialGSSHAComparison.xls*** and paste the hydrograph ordinates under the column *With Roughness*. Paste your data on the white areas only.
5. Visualize the difference in the outflow hydrograph (under the *W_WO_Roughness* tab) in the two models.
6. Close the *View Values* window and the *Hydrograph* plot window in WMS after you are done.



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14 Creating a Combined Index Map

You will now adjust the model to take into account the effects of land use on the infiltration parameters. The values you have been using from Rawls and Brakensiek are for "bare earth" and do not account for the effects of land use. For instance, cropland with sandy soil and the concrete parking lot built on sandy soil will obviously have different "effective" infiltration rates. In this section, you will see how you can determine the effects of land use on infiltration in a GSSHA model.

You will continue with the model you have been working on. The first thing you will start with is to create a combined index map which will use both the soil and the land use coverages.

1. Select ***GSSHA* | *Maps…***
2. In the *GSSHA Maps* dialog, select the following:

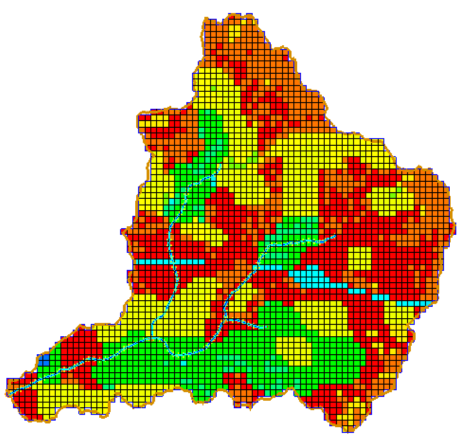
   Input Coverage (1): Soil Type

   Coverage attribute: Texture

   Check on *Input coverage (2)* and select: Land Use

   Coverage attribute: Id

   Index map name: Combined
3. Click on the ***Coverages -> Index Map*** button. WMS will compute a new index map which specifies a unique ID for each combination of land use and soil type.
4. Click *Done* once the calculation is complete to close the *GSSHA Maps* dialog.
5. Now you can see an index map which should look something like this:



6. Next you will define the infiltration parameters for this combined index map in the infiltration mapping table. Select ***GSSHA* | *Map Tables…***
7. In the *GSSHA Map Table Editor*, switch to the Infiltration tab. For the *Using Index map* field select *Combined* and click on the *Generate IDs* button. Click *Yes* to delete the existing IDs.
8. Several fields are added in the table. These fields show all possible combinations of land use and soil type present in the watershed.

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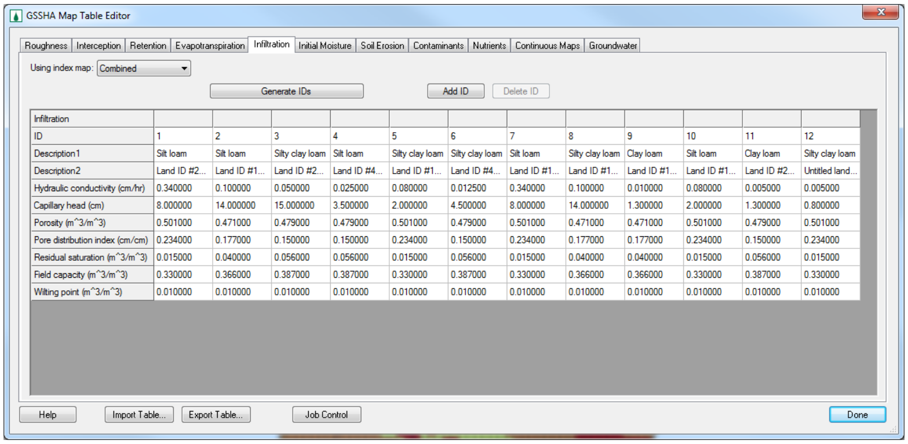
The infiltration parameters listed in the Rawls and Brakensiek table represent the bare earth soil infiltration parameters. However, you have generated a combined index map that combines the effects of land use and soil cover. The mapping table for this index map should account for the change in infiltration parameters caused by land use changes in a watershed.

You can import the standard *GSSHA.cmt* file and change the infiltration parameters for each land use type in the mapping table but for this exercise an updated .cmt file has already been created at ***(Infiltration\UpdatedInfiltrationParams.cmt***)

9. In the infiltration tab, click on the *Import Table…* button in the lower part of the editor.

10. Browse and open ***Infiltration\UpdatedInfiltrationParams.cmt***.

Now you can see the values filled in for all the fields.



Use the following table to compare whether the values are mapped correctly in the *Infiltration* tab.

Combination	Hydraulic Conductivity	Capillary head	Porosity	Pore distrib index	Residual saturation	Field capacity	Wilting Point
Silt loam Pasture (#21)	**0.5**	16.68	0.501	0.234	0.015	0.33	0.1
Silt loam Residential (#11)	**0.1**	16.68	0.501	0.234	0.015	0.33	0.1
Silty clay loam Pasture (#21)	**0.15**	27.3	0.471	0.177	0.04	0.366	0.1
Silt loam Forest (#41)	**0.6**	16.68	0.501	0.234	0.015	0.33	0.1
Silty clay loam Residential (#11)	**0.05**	27.3	0.471	0.177	0.04	0.366	0.1
Silty clay loam Forest (#41)	**0.15**	27.3	0.471	0.177	0.04	0.366	0.1
Silt loam Industrial (#14)	**0.1**	16.68	0.501	0.234	0.015	0.33	0.1
Silty clay loam Industrial (#14)	**0.05**	27.3	0.471	0.177	0.04	0.366	0.1

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Clay loam Transportation (#16)	**0.05**	20.88	0.464	0.242	0.075	0.318	0.1
Silt loam Transportation (#16)	**0.1**	16.68	0.501	0.234	0.015	0.33	0.1
Clay loam Pasture (#21)	**0.1**	20.88	0.464	0.242	0.075	0.318	0.1
Silty clay loam Untitled land use	**0.1**	27.3	0.471	0.177	0.04	0.366	0.1

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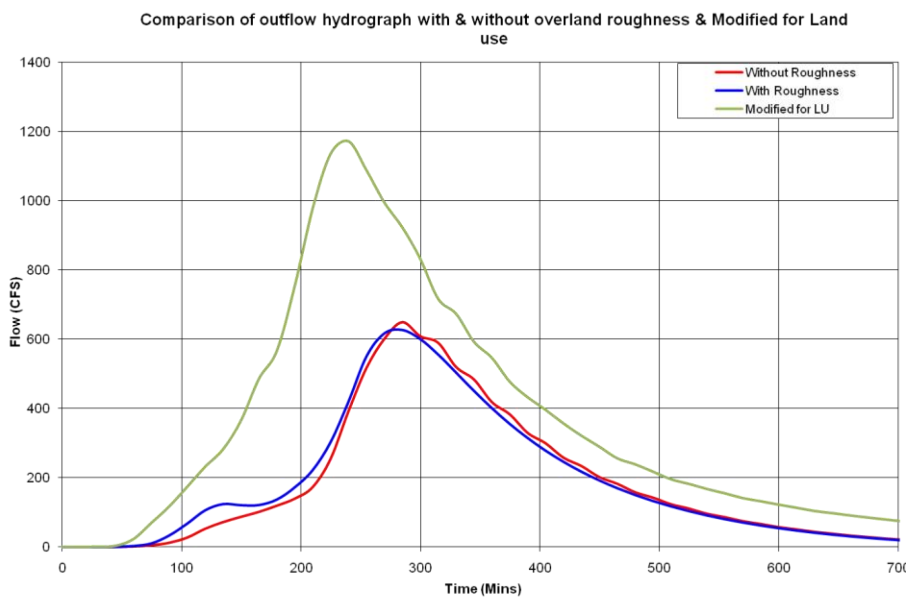
Note: Only the **Bold** faced numbers are changed from the Rawls and Brakensiek values. The rest of the parameters are the same as the values from standard *GSSHA.cmt* (Rawls and Brakensiek) table.

1. Once you have filled in the values, click *Done.*
2. Save the GSSHA project as ***Personal\Infiltration\UpdatedInfil.prj***
3. Run GSSHA.
4. Open the outflow hydrograph.
5. Right click on the hydrograph plot and choose *View Values*. Select the hydrograph ordinates, right click, and select *copy*.
6. Open the spreadsheet ***tables\InitialGSSHAComparison.xls*** and paste the hydrograph ordinates under the column *Modified for roughness*. Paste your data on the white areas only.
7. Compare the results you get here with the results from your previous simulation where you did not modify the parameters based on land use.
8. Close the *View Values* window and the *Hydrograph* plot window in WMS after you are done.



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