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Overview

Purpose and Scope

This report describes the input preparation process for GSFLOW, version 1.1, specifically, the creation of the PRMS Data File, the GSFLOW maps, the PRMS Parameter File, and the MODFLOW Input Files.

These instructions are not the only way to prepare input for GSFLOW, but are intended to serve as a procedural guide. Clearly, any single step from the outline below, could involve (and may require) much more effort, study, and expertise from a GSFLOW modeler or modeling team. Anyone considering a GSFLOW modeling project is encouraged to work through this outline and complete the example problem to gain insight into what will be required to develop a full application.

The USGS has corporate policies about the hardware and software tools which are made available to its employees and cooperators. These instructions reflect these policies and are not intended to endorse any particular trade, product, or firm. These instructions can (and have been) successfully carried out with many alternative hardware and software configureations.

Software Requirements

The following software packages are required to prepare input for GSFLOW:

- USGS Downsizer (available only on USGS computers)
- ESRI ArcMap and Workstation (version 9.3), including a license for the Spatial Analyst extension
- CRWR ArcHydro extension to ArcMap
- XTools Pro extension to ArcMap
- Microsoft Excel
- USGS PRMS Paramtool
- USGS ModelMuse

Hardware Requirements

The following represents a minimum hardware configuration to prepare input for GSFLOW:

- PC with Windows XP Operating System
- 2.0 GHz PC (or higher) Processor
- 1 GB (or higher) RAM
- 100 GB (or higher) Hard Disk
- SVGA, 1024x768 resolution, 16 bit color (or better) Monitor
- 32 MB RAM (or higher), 24 bit true color Graphics Card

Download Example Problem Data Sets

The data for the following example is available here

(ftp://brrftp.cr.usgs.gov/pub/mows/data/gsflowTrainingMaterial.zip).

These steps should be completed in order, as later steps may require maps or data produced in earlier steps.

Making PRMS Data File

Create a PRMS Data File (for time series climate and stream flow data)

Creating a PRMS Data File with the USGS Downsizer

Start the Downsizer by navigating to the download directory and double click on client.bat.

The Downsizer client window is the parent container from which all Downsizer functionality is accessible. This window contains (1) the desktop area, (2) the tool bar, and (3) the menu bar. These parts are described below.



Use the icons on the toolbar on the right side to go through the steps in order:

Set the time period for the data pull

Click on the Period icon in the toolbar. Set the start period to 1994-10-1. Set the end period to 2009-01-30



Set the PRMS Data File name and format

Click on the Output File icon in the toolbar. Set the File Format to PRMS Format. Set the File Path by browsing to the classProblem\input folder. Name the file sagehen.data



Selecting the stations for the PRMS Data File

Click on the Station Addition icon in the toolbar. Set the North Lat to 39.456; West Lon to -

120.336; East Lon to -120.197; and South Lat to 39.382

🐙 MoWS Downsizer Client 2.2.0.941	
Ele View Help	
+ Station Addition	Period
Add stations by location North Lat 39.456 West Lon East Lon -120.336 -120.197 South Lat 39.382 -120.197 -12	Output File
Add stations from file Climate IDs file path Gage IDs file path Browse Browse	Station Addition
Add stations Add stations Climate IDs	Station Review
Gage IDsAdd stations	Units
Cutput File	
🔍 Station Rev 🗗 💢 Units 🛛 🗗 🗶 Quality Con 🗗 🗆 🗶 Run 🖉 🗖 🗙	Run

Click the Add stations button to bring up the Station Review window.

👯 MoWS D	ownsizer Client 2.2.0.94	1					_ 🗆 🗵
<u>E</u> le ⊻iew	Help						
	-Add stations by location	0			>	5	12 Period
	Nort 39. West Lon	th Lat 456				d.	Cutout File
	Climate stations						output ne
	ID 🛆	Name	Latitude	Longitude	Elevation (m)		
	047641	SAGEHEN CREEK	39.432	-120.241	1,931.518		
							Station Addition
							Q
				Remove selected	Remove all		Station Review
	Gage stations						July
	ID / 1034	Name 3500 SAGEHEN C NR T	RUCKEE	atitude 39.432	Longitude -120.238		
							Units
							\checkmark
							Quality Control
		rant Eile - RIDIX		Remove selected	Remove all		
	S Uni	its BD	🖌 😪 Quality Con		BDX		Run

Also notice that the locations of the stations are shown in the World Wind window.



Zoom in, with the mouse wheel, to better see the selection.



The World Wind window can be used to set the extent of the lat/lon selection box in the Station Addition window. It can also be used to select/deselect individual station in the tables in the Station Review window.

Set the Units for the PRMS Data File

Click on the Units icon in the toolbar. Set the Temperature to F and Precipitation to in (inches).



Look at the Flags for Quality Control Checks

Click on the Quality Control icon in the toolbar. This is where different flags can be set to look for "bad data." This tool will set bad data values to the missing data value

Run the Downsizer

Click on the Run icon in the toolbar. Click on the Run button.



Look at the sagehen.data file that was made by the Downsizer.

🛃 TextPad - C:\markstro\gsflowTraining2009\GSFLOWv1.1\classProb	lem\input	t∖ s agehen	.data			
Eile Edit Search View Tools Macros Configure Window Help						
	ABC ABC		ې م د د	• 110		
	• • 2					- X
Sagenen.data						<u> </u>
		//////				
// Station metadata (listed in the same order as	the da	ata):				
// ID IVpe Latitude Longitude Elevati // 047641 tasmax 39.431667 -120.240555 1931.5	on 5176					
// 047641 tasmin 39.431667 -120.240555 1931.5	176					
// 047641 precip 39.431667 -120.240555 1931.5	5176					
//////////////////////////////////////		//////				
// Unit: temperature = $Å^*F$, precipitation = in,	runoff	= cfs				
tmax 1	///////	/////				
tmin 1						
precip 1						
pan_evap 0						
form_data 0						
runoff 1 rain day 0						

1994 10 1 0 0 0 67 28 -999 1.3						
1994 10 2 0 0 0 70 29 -999 1.3						
1994 10 4 0 0 0 39 32 0.46 1.6						
1994 10 7 0 0 0 60 24 -999 1.5						
1994 10 8 0 0 0 70 23 -999 1.4						
1994 10 9 0 0 0 66 26 -999 1.4						
1994 10 11 0 0 0 60 35 -999 1.4						
1994 10 12 0 0 0 54 32 -999 1.4						
1994 10 13 0 0 0 54 21 -999 1.4						
1994 10 15 0 0 0 39 23 0 18 1.5						
1994 10 16 0 0 0 42 19 -999 1.5						
1994 10 18 0 0 0 58 21 -999 1.5						
1994 10 19 0 0 0 58 20 -999 1.5						الغر
		1				
	27	31	Read	Ovr Block	Sync Re	c C: //

Look at the sagehen.data.summary file that was made by the Downsizer.

👔 TextPad - Cr/markstro/gsflowTraining2009/GSFLOWv1.1\classProblem\input\sagehen.data.summary	
Ble Edit Search Yew Tools Macros Configure Window Help	
□ ☞ 및 등 ⊕ 및 局 以 № 局 그 그 팩 팩 母 ¶ ⊕ ♡ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	
sagehendsta.summary	▼ X
SUMMARY FOR CILMATE DATA	1
ID Name Type Latitude Longitude Elevation [Missing / Total] A B E J Measurement Flags	0 3857 3824 2829
NOTE: # missing (7th column) were counted after QC was performed.	
Data Measurement Flags Accumulated assount since last measurement. B Accumulated assount since last measurement). E Estimated J Value has been manually validated M Missing S Included in a subsequent value. Trace (Expert system adpired value, not validated.) Expert system adproved defined value.	
WOTE: - Flag values of S and A usually occur in pairs (i.e. a daily value vill have Flag assigned as S and the next daily value vill have Flag assigned as A). For so - Other values occasionally appear in Data Measurement Flags for which documentation is not currently available.	e dai.
Data Quality Flags 0 Walid data element (from "unknown" source, pre-1982). 2 Invalid data element (subsecuent value replaces original value).	<u>ب</u>
26 60 Basel Cur. Block Surg Base	Carrie d

Creating a PRMS Data File with a text editor

Create the PRMS Data File according to the description on pages 139 - 142 of GSFLOW -

Coupled Ground-Water and Surface-Water Flow Model Based on the Integration of the Precipitation-

Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005)

(http://pubs.er.usgs.gov/publication/tm6D1).

People have successfully created this file on Linux based systems using the cut, paste, and awk utilities. Also, people have successfully created this file on PC based systems using text editors and/or spreadsheet programs.

Computation of Lapse Rates/Monthly Means using Excel

Start MS Excel. Select Data->From Text and browse to the PRMS Data File (sagehen.data).

Choose "Delimited" in Step 1 of the Text Import Wizard.

Text Import Wizard - Step 1 of 3	? ×
The Text Wizard has determined that your data is Fixed Width.	
If this is correct, choose Next, or choose the data type that best describes your data.	
-Original data type	
Choose the file type that best describes your data:	
Delimited - Characters such as commas or tabs separate each field.	
O Fixed width - Fields are aligned in columns with spaces between each field.	
Start import at row: 1 📑 File origin: 437 : OEM United States	-
Design of the classification of the twice correlation of the second states and the	
Preview of file C:(markstro(gsriow)raining2009(GSECOWVI.1(classProblem(input(sagenen.data.	
1 Sagehen Data File: Independence Lake and Sagehen Creek data staions	_
3// tmax stations are:	
5 // SAGEHEN CREEK	-
Cancel < Back Next >	inish

Check on "Space" in Step 2 of the Text Import Wizard.

Text Import Wizard - Step 2	2 of 3	Ľ
This screen lets you set the delin below.	imiters your data contains. You can see how your text is affected in the preview	
Delimiters	eat consecutive delimiters as one ualifier: "	
Sagehen Data	File: Independence Lake and Sagehen Creek data st	
// INDEPENDENCE // SAGEHEN	LAKE CREEK	-
	Cancel < <u>B</u> ack <u>N</u> ext > <u>F</u> inish	

Click on Finish in Step 3 of the Text Import Wizard.

Column K is the precipitation values for Independence Lake SNOTEL and column L is the precipitation values for Sagehen Creek COOP. Click on the column K label heading and then click on Data-> Filter. Choose Number Filter->Less Than or Equal To for column K. Enter 0.0 into the box next to is less than or equal to.

Custom AutoFilter	<u>?</u> ×
Show rows where:	
is less than or equal to 💽 0.0	•
● And ● Or	
	•
Use ? to represent any single character Use * to represent any series of characters	
OK Can	cel

Right click on column K header and select Clear Contents. This blanks out all cells which are

less than or equal to zero. Repeat this process for column L too.

6 8 8 8	r (***) *			Book1 - Mi	crosoft E	cel								- = X	
Home	Insert PageLayout	Formulas Da	a Review	View A	crobat									0 _ = x	
From Access	From Other Sources * Connections	M A Connect Refresh All - Set Edit Link	$\begin{array}{c c} R \\ \hline R \hline$	R W B 2↓ 2↓ X Clear Image: Clear Consolidate Image: Clear X↓ Sort Filter Advanced Columns Duplicates What-If Analysis *							p Subto	Subtotal			
Ge	t External Data	Connections		Sort & Filter	S			Data Too	DIS			Outin	utline		
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22 #########	***********************			************	****	_					-	Ī			
23	198	30 10	1	0	0	0	-901	85	-901	30			2.3		
24	198	30 10	2	0	0	0	-901	81	-901	32		_	2.3		
25	198	10	3	0	0	0	-901	83	-901	30			2.3		
27	190	20 10	4	0	0	0	-901	80	-901	22			2.3		
28	190	30 10	6	0	0	0	-901	79	-901	31			2.3		
29	198	30 10	7	0	0	0	-901	79	-901	29			2.2		
30	198	30 10	8	0	0	0	-901	78	-901	28	-		2.2		
31	198	30 10	9	0	0	0	-901	74	-901	28	-		2.3		
32	198	30 10	10	0	0	0	-901	71	-901	26			2.3		
33	198	30 10	11	0	0	0	-901	64	-901	35			2.3		
34	198	30 10	12	0	0	0	-901	52	-901	35	0.2	0.59	4		
35	198	30 10	13	0	0	0	-901	48	-901	26	0.1		2.9		
36	198	30 10	14	0	0	0	-901	38	-901	28	0.3	0.2	3.2		
37	198	30 10	15	0	0	0	-901	34	-901	26		0.04	3.1		
38	198	30 10	16	0	0	0	-901	39	-901	25		0.06	3.2		
39	198	30 10	17	0	0	0	-901	49	-901	18	0.4		3		
40	198	30 10	18	0	0	0	-901	58	-901	20	0.3		2.9		
41	198	30 10	19	0	0	0	-901	61	-901	21	_	_	2.8		
42	198	30 10	20	0	0	0	-901	65	-901	22			2.7		
43	198	30 10	21	0	0	0	-901	60	-901	23			2.7		
44	198	30 10	22	0	0	0	-901	59	-901	24			2.7		
45	198	10	23	0	0	0	-901	64	-901	22			2.6		
40	190	20 10	24	0	0	0	-901	52	-901	23	-	0.29	2.0		
47	190	30 10	25	0	0	0	-901	44	-901	20		0.12	3.5		
49	198	30 10	27	0	0	0	-901	43	-901	29	0.4	0.12	3.1		
50	198	30 10	28	0	0	0	-901	51	-901	19			2.8		
51	198	30 10	29	0	0	0	-901	62	-901	17			2.8		
52	198	30 10	30	0	0	0	-901	61	-901	18	-		2.7		
53	198	30 10	31	0	0	0	-901	61	-901	32	-		2.7		
54	198	30 11	1	0	0	0	-901	57	-901	33			2.6		
55	198	30 11	2	0	0	0	-901	60	-901	24			2.6		
56	198	30 11	3	0	0	0	-901	68	-901	25			2.6		
57	198	30 11	4	0	0	0	-901	70	-901	24			2.6	*	
H + > H Shee	et1 / Sheet2 / Sheet3 /	2 /					4)	
Ready				Av	erage: 0.	98512152	Count: 16	587 Su	m: 672.2	9 00	100	6 (-)-		(+) .:	

Mean precipitation amount can be computed from these two columns for days with precipitation. For example, to compute mean monthly precipitation for January, filter column B to show the values for month 1 only. The average value for a station will be the average precipitation (on days with precipitation) for the selected month. These averages can vary greatly depending on which years are included in the analysis, so be sure and choose years that are representative of the simulation time period.

The results of this for both stations, for all months have already been computed and are located in the Excel worksheet sagehenLapseRates.xls.

Making GSFLOW maps

Before Starting

GOAL: Make sure that the GIS software and the basic spatial data sets are ready to go.

Arcmap with Archydro and XTool Pro installed

General notes about ArcMap:

- If tools/windows give an unexpected error, shorten the path names
- If tools/windows give an unexpected error, exit and restart ArcMap.
- In general, anything produced by ArcMap should be moved, copied, deleted, etc. with ArcCatalog. Start the ArcMap application by double clicking on the gis\sagehenGIS.mxd. This will start the
 Sagehen GIS project with the necessary starting data preloaded. Check to make sure that the ArcHydro extension is installed (requires admin rights) and ArcHydro toolbox is added to the ArcToolbox (does not requires admin rights).

http://www.crwr.utexas.edu/giswr/hydro/ArcHOSS/index.cfm

http://support.esri.com/index.cfm?fa=downloads.dataModels.filteredGateway&dmid=15



If the ArcHydro toolbar is not visible Click: View->Toolbars->Arc Hydro Tools 9

If ArcHydro toolbox is not present in the ArcToolbox, add the Archydro Tool box, right click on the ArcToolbox root node and choose Add Toolbox.

Add Toolbo	×			×
Look in:	Toolboxes	• 6	3 6 	*** *** 88
3D Anal Analysis	Eatalog C:\ ArcGIS	Tools	🍓 Tracking / 🍓 USGSEGIS	Analyst Tools 5Tools
Cartogr	ArcToolBox Toolboxes D:\	ols		
Data In Data Ma	i∰ ArcWeb Services i∰ Coordinate Systems i∰ Database Connections	s		
Seostat	 Database Servers GIS Servers Intercoperability Connections 	ols	1	•
Name:	Scalar References		J	Open
Show of typ	Toolboxes Tracking Connections		•	Cancel

Add Toolbox		×
Look in: 🧰 Toolboxes	· <u>e</u>	
🚳 3D Analyst Tools	🚳 Linear Referencing Tools	🚳 Tracking Analyst Tools
analysis Tools	🚳 Mobile Tools	SGSEGISTools
Arc Hydro Tools	🚳 Multidimension Tools	
Cartography Tools	🚳 Network Analyst Tools	
Conversion Tools	🚳 Samples	
Data Interoperability Tools	Schematics Tools	
🚳 Data Management Tools	Server Tools	
Geocoding Tools	🚳 Spatial Analyst Tools	
Geostatistical Analyst Tools	🚳 Spatial Statistics Tools	
Name: Arc Hydro Tool	8	Open
Show of type: Toolboxes		▼ Cancel

Check to make sure that the XTools Pro extension is installed (requires admin rights) and XToolsPro toolbox is added to the ArcToolbox (does not requires admin rights). The USGS has an enterprise license for this extension. If you are a USGS employee, have your system administrator install and configure XToolsPro for you.



Confirm that the XTools Pro extension is turned on. Tool->Extensions->XTools Pro

If the XTools Pro toolbar is not visible Click: View->Toolbars-> XTools Pro

If XTools Pro toolbox is not present in the ArcToolbox, add the XTools Pro Toolbox, right click on the

ArcToolbox root node and choose Add Toolbox.

Add Toolbox				
Look in:	Toolbox Catalog C:\ Program Files DataEast XToolsPro 5.3 Toolbox E:\	•		
Add Toolbox				
Look in: 📄	Toolbox	•	<u>e</u> 300	
Name:				0.505
Show of type:	Toolboxes		•	Cancel

This example problem uses an ESRI "Personal Geodatabase." There are many reasons for this, but ease of set up, distribution, and use are primary ones. Also, it is possible to query the spatial data directly with the Microsoft Access application.

Set the "Environments" for the ArcMap Project

Here's ESRI's webpage describing environment settings:

http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=An_overview_of_geoprocessing_env ironments

If the Environment is set for the ArcMap project, it will retain those settings during any geoprocessing within the project, i.e. Toolbox, toolbars (such as Spatial Analyst), ModelBuilder, etc. If the Environment is set only with the Toolbox, the settings will be retained during any geoprocessing within the toolbox. Also, environments can be set for individual tools as well. For this example, make sure that the environments are set for the entire project.

Within the environments, it is possible to set the current and scratch workspace (workspaces for inputs and outputs), the extent, and output coordinate system. More importantly, the cell size (especially for MODFLOW models) and the snap raster can be set. The snap raster setting is what lines everything up, so subsequent maps don't have slivers. Usually, it is a good idea to set the snap raster to the original DEM:

http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=How_Snap_Raster_works However, the MODFLOW cells the DEM are rarely the same size. So, the cell size can be fixed as a ratio of the original DEM or the cell size can be set to the desired model cell size and interpolation will be used to adjust the cells to that specified size as it is being snapped to the raster. Now, on how to physically set the environments. To set the environments within the ArcMap project, Tools>Options>Geoprocessing>Environments. Once in the Environment Settings dialog box, the Snap Raster can be set under General Settings.

23

🏘 Environment Settings		×
General Settings Current Workspace	-	Environment Settings
Scratch Workspace		Environment settings specified in this dialog box
Default Output 2 Value		are values that will be applied to appropriate results from running tools
Output Coordinate System Same as Input		They can be set hierarchically, meaning that they can be set for the
Output has 2 Values		application you are working in, so they apply to all tools: for a model so they
Output has M Values Same As Input	3	apply to all processes within the model; or for a
Maintain fully qualified field names Extent		model. Environments set for a process within a
Default I I I I I I I I I I I I I I I I I I I	5	model will override all other setting, and environments set for all processes in a model will override those set in the application.
Bottom Snap Raster		Changing the default settings that will be used is a prerequisite to performing
Criginal GIS Data Raw dem		geoprocessing tasks. You may only be interested in analyzing a small piece of
OK Cancel Show Help	>>	Tool Help
le Environment Settings		×
 ✓ General Settings ✓ Arc Hydro Settings 	*	Environment ^ Settings
		Environment settings specified in this dialog box
		are values that will be applied to appropriate results from running tools.
Raster Analysis Settings Cell Size Same as layer Raw den 27.4116394527398		They can be set hierarchically, meaning that they can be set for the application you are working in, so they apply to all thele for sorted to be they
Mask	2	apply to all processes within the model; or for a
¥ Raster Storage Settings		particular process within a model. Environments set for a process within a model will overrride all other setting, and environments set for all processes in a model will override those set in the application.
		Changing the default settings that will be used is
	×	a prerequisite to performing geoprocessing tasks. You may only be interested in analyzing a small piece of

Check the Digital Elevation Model (DEM) raster map

A DEM which covers the model domain is required. The DEM for the Sagehen example problem is located in Start Data->dem. DEMs for other basins can be obtained from the USGS "Seamless" server (http://ned.usgs.gov/downloads.asp).

Check the streamgage map

In this exercise, a point corresponding to a streamgage location will be used to help define the model domain. Load this point with is located in Start Data->streamgage.



Data Bin raster maps

The Data Bin folder contains raster maps of information that will be needed to estimate spatially distributed parameters for GSFLOW. This includes: (1) available water holding capacity of the soil (awc1k), (2) clay content of the soil (clayav1k), (3) vegetation density (density1k), (4) land use/land cover (lulc1k), (5) soil depth to bed rock (rockdep1k), and (6) sand content of the soil (sandave1k).



DEM Reconditioning

GOAL: Process the DEM so it is ready for GSFLOW modeling.

Fill the DEM

Sinks may exist in the DEM. These must be filled using Fill (Spatial Analyst) tool. Access all tools using the ArcMap Search window. Use Raw dem as the input. Browse to the raster\ folder and name the new raster map fil. Click OK.



Determine Flow Direction

For each raster cell in fil the flow direction is calculated. These must be done using the Flow

Direction (Spatial Analyst) tool. Name the map fdr.

Flow Direction	
Input surface raster	Output flow direction
Output flow direction raster [C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdbl/ds] Porce all edge cells to flow outward (optional) Output drop raster (optional)	The output raster that shows the flow direction from each cell to its steepest downslope neighbor.
OK Cancel Environments << Hide Help	Tool Help



Determine Flow Accumulation

For each raster cell in fdr, the flow accumulation is calculated. This is done using the Flow Accumulation (Spatial Analyst) tool. Name the map fac.

Flow Accumulation				_ O ×
Input flow direction raster			*	Output accumulation
fdr		×	1	raster
Output accumulation raster	han a'r mellan han dae e Bl	f	-2	The output rector that
C:(markstrojgshow(ranng200%;sage	hen_gis_work(sagenen_start.indb)	rac		shows the accumulated
		-	2	flow to each cell.
Output data type (optional)			_	
FLOAT			-	
			<u>×</u>	y.
	OK	Cancel Environments <<	Hide Help	Tool Help
🗮 sagehen.mol - ArcMap - ArcInfo				
Bie Edit Yew Bookmarks Insert Selection Lools	Window Help			
Spatial gnalyst Layer den	_ ೫ ⊾			
Terrain Preprocessing * Terrain Morphology * Water	shed Processing Attribute Tools Netwo	vk Tools - ApUtilities - S A . II 🖓 😈 🕨 /	ାସ୍ପ	11 11 (7) 0 (4) (4) (4) (4) (4) (4) (4) (4) (4) (4)
			ale Nevi realure	
E Cayers	Type in the keyword to find.			
Value	flow			
High : 56435	Flow Accumulation (archydro)			
Elow:0	Flow Direction (archydro)			
1	Flow Direction (He) Flow Direction with Sinks (archydi Flow Direction with Streams (arch			
4	Flow Length (sa) Focal Flow (sa)		10	
16	Focal Statistics (sa) Frequency (analysis)			
64	GA Layer To Contour (ga) GA Layer To Grid (ga)			
8 2 N	GA Layer To Points (ga) Gaussian Geostatistical Simulation			
14gh : 2720.04	Generate (arc) Generate From/To Node for Liner			
Low : 1792.81	Generate Globe Server Cache (se Generate Map Server Cache (ser			2/TV
🖹 🗹 Start Data	Generate Map Server Cache Tilin Generate Mobile Service Cache (
	Generate Network Spatial Weight Generate Scatial Weight			
	Geocode Addresses (geocoding) Geographically Weighted Regard			-
	Geoprocessing Raster Status (us) Get Cell Value (management)			
	Get Count (management) Get Model Parameter (ga)		and ?	
	Get Raster Properties (manageme Get Visual ID (ungs)			
	Greater Than [sa] Greater Than Equal (sa)			
	tieater Than Frequency (sa)			
	Locate			
Display Source Selection	Favorites Index Search Results			<u>ت</u>
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				2007929 511 2007011 Linkness Links

After all of these map have been created, save the Sagehen ArcMap project by clicking File->Save.

Delineation of Spatial Modeling Features for GSFLOW

Natural Watershed Boundary

Use the Watershed (sa) tool to determine the natural watershed boundary. Use the fdr and streamgage maps as input.




Name the output natbnd. Use the Raster to Polygon (conversion) tool to make a feature map. Name the output natbndf. Make sure the Simplify polygons box is unchecked.

Raster to Polygon	
Raster to Polygon Input raster nathrd nathrd Neid (optional) VALUE Output polygon features C:InarkstrolgsflowTraining2009Isagehen_gis_workIsagehen_start.mdbilbasemapsInathrdf Simplify polygons (optional)	Converts a raster dataset to polygon features.
✓ OK Cancel Environments < <hide help<="" td=""><td>Tool Help</td></hide>	Tool Help

After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

Generation of the Stream Segment map

Find the location of the streams using the flow accumulation (fac) surface. Use the Con (sa) tool to create a new raster map that has a value of 1 in every cell that has a flow accumulation over 1500 cells, and NO DATA in all other cells. Name the output raster str.



Use the Con (sa) tool to get rid of streams outside of Natural Boundary. Use the settings as shown below. This makes the raster map Stream.

Con			_ D ×
Input conditional raster		- Ou	tput raster
natbnd	- 🖌		
Expression (optional)		The	raster to be created.
"VALUE" =0	squ		
Input true raster or constant value			
str	🗾 🖻		
Input false raster or constant value (optional)			
	- E		
Output raster			
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\stream	⊆		
		*	
OK Cancel	Environments << Hide Hel		ol Help



Use the Stream Link (sa) tool to break the stream raster map into stream segments. This makes the raster map StrLnk.

A Stream Link			- 0 >
Input stream raster	*	Output raster	1 A
stream	- 🛋		
Input flow direction raster		The output stream link	
fdr	- 🗃	raster.	
Output raster			
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\strlnk			
	<u>_</u>		
OK Cancel Environments <	< Hide Help	Tool Help	
saachen.mxd - ArcMap - ArcInfo			
Sie Edit View Bookmarks Insert Selection Tools Window Help			
ipatisi Analyst - Layer: dem 🗾 🎉 📐			
Terrain Preprocessing 👻 Terrain Morphology 👻 Watershed Processing 🛎 Attribute Tools 🛎 Network Tools 🛎 ApUtilities 🕷 🏂 🍂 🐛 😲 🐌 🔈	/ Help 🔍 😋	:: :: (?) () (= =) (!!)	N 0
	Create New Feature	Target:	



Use the ArcMap tool Stream to Feature (sa) tool to make features and add connectivity and flow direction. Click off the check box to Simplify polygons. Name the output strseg.

Stream to Feature	
Input stream raster	Simplify polylines (optional)
Input flow direction raster	
fdr Output polyline features	Specifies whether weeding is used.
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\strseg	 Checked — The feature is weeded to reduce the number of vertices. The Douglas-Puecker algorithm for line generalization is used, with a tolerance of sqrt(0.5) * cell size. UnChecked — No weeding is applied.
OK Cancel Environments << Hide Help	Tool Help



Right click on strseg in the ArcMap tree and select Open Attribute Table.

L	OBJECTID *	Shape *	ARCID	GRID_CODE	FROM_NODE	TO_NODE	Shape_Length
ľ	1	1 Polyline 1		4	3	5	420.177254
ſ	2	Polyline	2	5	5	4	488.706484
		Polyline	3	3	4	6	937.839967
ſ	4	Polyline	4	8	6	7	1102.309954
	5	Polyline	5	2	2	7	1417.543796
Γ	6	Polyline	6	10	7	8	385.710995
Г	7	Polyline	7	7	9	5	2448.972819
Γ	8	Polyline	8	12	8	10	903.777114
	9	Polyline	9	1	1	10	1965.776525
Γ	10	Polyline	10	13	10	11	435.83119
Γ	11	Polyline	11	14	11	12	277.441955
Γ	12	Polyline	12	11	13	8	821.945592
Г	13	Polyline	13	9	14	6	1725.723077
Γ	14	Polyline	14	6	15	4	2410.20695
Г	15	Polyline	15	15	16	11	1303.194092

The values in the GRID_CODE column will be used as the stream segment IDs. Click on the Down Arrow (in the lower-right corner of the Attributes window) and select Add Field from the pop-up window. Add the new attribute ID as shown below.

		? ×
ID		
Short Integer		•
ies		
. Values	Yes	
ue		
	04	Consul
	UK	Cancel
	ID Short Integer ies Values ue	ID Short Integer ies Values Yes ue OK

Copy the values from GRID_CODE to ID using the Field Calculator.

Field Calculator		? ×
Eields: OBJECTID ARCID GRID_CODE FROM_NODE TO_NODE Shape_Length ID	Type: © Number © String © Date	Abs() Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sar()
ID = [GRID_CODE]	Advanced	* / & + - = Load Save Help
Calculate selected records only	×	OK Cancel

OBJECTID *	Shape *	ARCID	GRID_CODE	FROM_NODE	TO_NODE	Shape_Length	ID
1	Polyline	1	4	3	5	420.177254	4
2	Polyline	2	5	5	4	488.706484	5
3	Polyline	3	3	4	6	937.839967	3
4	Polyline	4	8	6	7	1102.309954	8
5	Polyline	5	2	2	7	1417.543796	2
6	Polyline	6	10	7	8	385.710995	10
7	Polyline	7	7	9	5	2448.972819	7
8	Polyline	8	12	8	10	903.777114	12
9	Polyline	9	1	1	10	1965.776525	1
10	Polyline	10	13	10	11	435.83119	13
11	Polyline	11	14	11	12	277.441955	14
12	Polyline	12	11	13	8	821.945592	11
13	Polyline	13	9	14	6	1725.723077	9
14	Polyline	14	6	15	4	2410.20695	6
15	Polyline	15	15	16	11	1303.194092	15

After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

Strseg is the stream segment feature set.

Generation of the MODFLOW Grid Cell map

Use the Create Fishnet (management) tool to create the MODFLOW Grid. The fishnet origin, number of rows, and number of columns have been computed so that the MODFLOW Grid will totally cover the natbndf natural watershed boundary. Use the following settings for the example problem:

- Set the Output Feature Class to mfgrid
- Set the Fishnet Origin Coordinate to X = -2052121.286 and Y = 2082652.955
- Set the Y-Axis Coordinate to X = -2052121.286 and Y = 2082662.955
- Set the Cell Size Width = 200
- Set the Cell Size Height = 200
- Set the Number of Rows = 34
- Set the Number of Columns = 37
- Uncheck the Create Labels box

Click OK.

Create Fishnet				
Output Feature Class C:/markstrolgsflowTraining2009(sagehen_gis_work(sagehen_	_start.mdb\basemap	s\mfgrid	×	Create Labels (optional)
Template Extent (optional)				Specify whether or not a
Left	p	Right		point feature class will be created containing label points at the center of each fishnet cell. Labels are
Bott	om			generated by default.
Exhapt Origin Country to			Clear	LABELS
X Coordinate	Y Coordinate			
-2052121.286			2082652.955	NO_LABELS
Y-Axis Coordinate	V Coordinate			
-2052121.286	Coordinace		2082662.955	
Cell Size Width				
			200	
Cell Size Height				
1			200	
Number of Rows			24	
I Number of Columns			54	
			37	
Opposite corner of Fishnet (optional)				
X Coordinate	Y Coordinate			
Create Labels (optional)	,		*	
	ОК	Cancel Environments	<< Hide Help	Tool Help



Use the Feature to Polygon (management) tool to create the MODFLOW Grid Cells. Set Input Features to mfgrid. Set Output Feature Class to mfcells. Click OK.

∕≻ Feature To Polygon	
Input Features	Feature To Polygon 🐣
Image: A state of the state	Creates an output polygon feature class from input line and/or polygon features. If lines are used as inputs each distinct "closed" area will be a feature in the output polygon feature class.
Output Feature Class C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\basemaps\mfcells XY Tolerance (optional)	INPUT
Meters	*
Label Features (optional)	OUTPUT
OK Cancel Environments << Hide Help	Tool Help

Add the attribute ROW to the table in the Attributes of mfcells window. The row index can be

calculated according to:

$$RowIndex = NumberOfRows - Int\left(\frac{Index - 1}{NumberOfColumns}\right)$$

This is what it looks like in the Field Calculator.

Field Calculator		? ×
Ejelds: O8JECTID Shape_Length Shape_Area ROW	Type:	Functions: Abs () Atn () Cos () Exp () Fix () Int () Log () Sin () Sar ()
ROW = 34 - Ink (([OBJECTID] -1)/37)	Advanced	* / & + - = Load Save
Calculate selected records only	T	OK Cancel

Add the attribute COL to the table in the Attributes of mfcells window. The row index can be calculated according to:

 $ColIndex = Index - (NumberOfRows - RowIndex) \times NumberOfColumns$

This is what it looks like in the Field Calculator.

Field Calculator		? ×
Ejelds: OBJECTID Shape_Length Shape_Area ROW COL	Type: Dumber C String C Date	Functions: Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sgr()
COL = [OBJECTID] -(34 -[ROW]) *37	Advanced	* / & + - = Load Save Help
Calculate selected records only	×	OK Cancel

Add the attribute CELL_ID to the table in the Attributes of mfcells window. The cell index can be calculated according to:

 $\textit{CELL_ID} = (\textit{RowIndex} - 1) \times \textit{NumberOfColumns} + \textit{ColIndex}$

This is what it looks like in the Field Calculator.

Field Calculator		? ×
Ejelds: OBJECTID Shape_Length Shape_Area ROW COL CELL_ID	Type: <u> P</u> <u>Number</u> String <u>Date</u>	Functions: Abs() Abs() Cos() Exp() Fix() Int() Log() Sin() Sar()
CELL_ID = ([ROW] - 1) *37 + [COL]	C Advanced	* / & + - = Load Save Help
Calculate selected records only	×	OK Cancel

Add the attribute CELL_AREA to the table in the Attributes of mfcells window. Copy the values from

the Shape_Area attribute using the Field Calculator:

	ttribut	es of mfcell	s						_ 🗆 ×
Π	OID	Shape '	Shape_Length	Shape_Area	ROW	COL	CELL_ID	CELL_AREA	
	1222	Polygon	800	40000	1	1	1	40000	-
	1223	Polygon	800	40000	1	2	2	40000	
	1224	Polygon	800	40000	1	3	3	40000	
	1225	Polygon	800	40000	1	4	4	40000	
	1226	Polygon	800	40000	1	5	5	40000	
	1227	Polygon	800	40000	1	6	6	40000	
	1228	Polygon	800	40000	1	7	7	40000	
	1229	Polygon	800	40000	1	8	8	40000	
	1230	Polygon	800	40000	1	9	9	40000	
	1231	Polygon	800	40000	1	10	10	40000	
	1232	Polygon	800	40000	1	11	11	40000	
	1233	Polygon	800	40000	1	12	12	40000	
	1234	Polygon	800	40000	1	13	13	40000	
	1235	Polygon	800	40000	1	14	14	40000	
	1236	Polygon	800	40000	1	15	15	40000	
	1237	Polygon	800	40000	1	16	16	40000	
	1238	Polygon	800	40000	1	17	17	40000	
	1239	Polygon	800	40000	1	18	18	40000	
	1240	Polyann	800	40000	1	19	19	40000	•
	Recor	rd: 14 4	0 🕨	Show: All	Selected	Re	cords (0 out	of 1258 Selected) Option	5 *

After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

The feature set mfcells is the vector version of the MODFLOW grid cell map.

Generation of "Clipped" Model Domain and Active Cells Maps

Choose Selection-> Select By Location from the top level ArcMap menu bar. Choose the

options specified below:

Select By Location ? 🗙
Lets you select features from one or more layers based on where they are located in relation to the features in another layer. I want to: select features from
the following layer(s):
 mfgrid strseg mfcells natbndf ⇒ Start Data treamgage
I Only show selectable layers in this list that:
have their centroid in
the <u>f</u> eatures in this layer:
🔗 natbndf
Use selected features (0 features selected)
Apply a buffer to the features in natbndf
of: 0.000000 Unknown Units
Help OK Apply Close



Right click on the mfcells map in the tree. Choose Data->Export Data to make a new feature class of the active cells. Name this activeCells.

Export Da	ta	? X
Export:	Selected features	•
Use the s	ame coordinate system as:	
🖲 this la	yer's source data	
C the da	ata frame	
C the fe (only)	ature dataset you export the data into applies if you export to a feature dataset in a geodatabase)	
Output sh	apefile or feature class:	
flowTrain	ning2009\sagehen_gis_work\sagehen_start.mdb\activeCells	2
	OK Cance	÷I



Next, dissolve all of the active cells into one big feature to get the map of the "Clipped" Model Domain. Use the Dissolve(management) tool to do this. Name the output feature class modelDomain.

n Dissolve		
Input Features activeCells	× ×	Statistics Field(s)
Output Feature Class		
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start	.mdb\modelDomain	Choose the statistics and
Dissolve_Field(s) (optional)		fields with which to
		attribute fields may be
Shape_Length		summarized using the
☐ Shape_Area		statistics First or Last. Numeric attribute fields may be summarized using any statistic. Nulls are excluded from all statistical calculations.
		 FIRST—Finds the
Select All Unselect All	Add Field	first record in the
Statistics Field(s) (optional)		Input Table and uses
	-	its specified field
		value.
Field	Statistic Type	 LAST—Finds the last record in the Input Table and uses its specified field value.
		Numeric attribute fields
		may be summarized
	•	using any statistic:
	OK Cancel Environments << Hide Help	Tool Help



After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

The feature class modelDomain is the vector version of the model domain map. This map defines that areal extent of the Sagehen example problem. The feature class activeCells is the vector version of the cells which are active in the MODFLOW model.

Generation of PRMS HRU map

Make sure that the Spatial Analyst extension is turned on: Tools->Extensions. Check Spatial Analyst. Use the Catchment Grid Delineation (archydro) tool. Specify the flow direction (fdr) and the stream link (strlnk) grids as input. Name the output grid Cat. Click OK.

Input Flow Direction Grid Imput Catchment Grid Imput Flow Direction Grid Imput Flow	Catchment Grid Delineation		
C:\narkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\fdf Imput Link Grid Imput Link Grid C:\narkstro\gsflowTrain	Input Flow Direction Grid	<u>^</u>	Output Catchment
Input Link Grid C:tharlstrolgsflowTraining2009[sagehen_gis_work[sagehen_start.mdb]strikk Output Catchment Grid C:tharlstrolgsflowTraining2009[sagehen_gis_work[sagehen_start.mdb]Cat Output catchment grid CitmarkstrolgsflowTraining2009[sagehen_gis_work[sagehen_start.mdb]Cat Other catchment grid Output catchment grid	C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\fdr	- 🛋	Grid
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\strikk. Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Output catchment grid obtained by delineating with the link grid as source. C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sagehen_gis_work\sagehen_start.mdb\Cat Imarkstro\gsflowTraining2009\sagehen_gis_work\sageh	Input Link Grid		
Output Catchmenk Grid obtained by delineating with the link grid as source. C:/markstrolgsflowTraining2009/sagehen_gis_work/sagehen_start.mdb/Cat Image: Catchen and the link grid as source. W Cancel Environments << Hide Help	C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\strlnk	- 🛋	Output catchment grid
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat Image: Image	Output Catchment Grid		obtained by delineating with
▼ OK Cancel Environments < <hde help="" help<="" td="" tool=""><td>C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat</td><td></td><td>the link grid as source.</td></hde>	C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\Cat		the link grid as source.
OK Cancel Environments << Hide Help Tool Help			
OK Cancel Environments << Hide Help			
V OK Cancel Environments << Hide Help Tool Help			
V OK Cancel Environments < <hide help="" help<="" td="" tool=""><td></td><td></td><td></td></hide>			
V OK Cancel Environments << Hide Help Tool Help			
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OK Cancel Environments <<< Hide Help Tool Help			
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OK Cancel Environments << Hide Help Tool Help			
OK Cancel Environments < <hiddle help="" help<="" td="" tool=""><td></td><td>-</td><td></td></hiddle>		-	
	OK Cancel Environments	<< Hide Help	Tool Help

Here is the resulting Cat grid.



These are the natural HRUs. Note that the HRU Grid code matches the corresponding stream segment that was used to define it. This is because the Catchment Grid Delineation (archydro) tool generates HRUs based on only the contributing area to each stream segment.

Move the modelDomain feature class to the top of the ArcMap tree stack and make it "hollow". In some areas, the HRUs need to be clipped, while in others, the HRUs need to be extended to the model domain edge.



Use the Expand (sa) tool to fill in the HRUs that don't quite go to the edge. Set the Number of cells to 20 and fill in the Zone values with all 15 categories (HRU IDs). Name this grid CatExpand.

Expand	
Input raster Cot Output raster Cot Output raster CitmarkstrolgsflowTraining2009(sagehen_gis_work(sagehen_start.mdb)catexpand) Number of cells Cone values 20 Zone values	Output raster
1 2 3 4 5 6 7 8 9 10	
OK Cancel Environments << Hide Help	Tool Help



Here is the resulting catexpand grid.

Now there are no holes between the HRUs and the modelDomain.

Use the Raster to Polygon(conversion) tool to make a feature set from catexpand. Set output polygon feature to hruexpand and uncheck Simplify polygons.

Raster to Polygon	_ 0
Input raster	Field (optional)
catexpand	 iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
Field (optional)	The field used to assign
VALUE	 values from the cells in the
Dutput polygon features	input raster to the polygons
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\hruexpand	in the output dataset.
Simplify polygons (optional)	It can be an integer or a string field.
	-
OK Cancel Environ	nments << Hide Help Tool Help

Use the Clip (anylsis) tool to make the output feature class hrus. Set the Input Features to hruexpand and

the Clip Features to modelDomain.

lip			
nput Features		<u>^</u>	Clip Features
hruexpand		💌 🚄 👘	
Ilip Features			The features used to clip
modelDomain		💌 🚔 👘	the input features.
Jutput Feature Class			
C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\hrus			
Y Tolerance (optional)			
	Meters	•	
		-	
	Land failer f	1	The second se
OK	Cancel Environments	<< Hide Help	Tool Help



Open the Attributes of hrus window and Sort Ascending on the GRIDCODE attribute. This attribute will be used as the HRU ID.

▦	III Attributes of hrus							
	OBJECTID *	Shape *	ID	GRIDCODE	Shape_Length	Shape_Area	—	
	5	Polygon	5	1	11868.825	3392624.060407		
	3	Polygon	3	2	10399.1128	2779960.974317		
	1	Polygon	1	3	5822.419	1433081.574598		
	2	Polygon	2	4	7818.4062	1784685.623361		
	4	Polygon	4	5	8179.8202	931341.293256		
	15	Polygon	15	6	11607.185	4765394.518891		
	13	Polygon	13	7	10477.3778	2437192.289679		
	11	Polygon	11	8	6249.854	951269.850619		
	16	Polygon	16	9	10011.1978	2102893.458782		
	10	Polygon	10	10	8223.4918	988088.327766		
	14	Polygon	14	11	7894.5524	1623771.026204		
	8	Polygon	8	12	4221.3924	467369.539826		
	9	Polygon	9	13	4403.807	520445.751011		
	12	Polygon	12	14	3652.5182	325912.151518		
	6	Polygon	6	15	109.6464	751.395815		
	7	Polygon	7	15	109.6464	751.395815		
	17	Polygon	17	15	9513.384	2894466.768137		
Γ								
		-		-				
	Record: 14	•	•	M Show	All Selected	Records (0 out	•	

There are 17 features, but there are only 15 HRUs. This means that some HRUs are split. Notice that there are 3 features assigned to the GRIDCODE attribute values of 15 and that two of these features have a very small comparative area (751 square meters compared to 2,894,467 square meters). Find these small features by selecting them from the Attributes of hrus table.

🕈 🗱 Window find Hensper 🔛 Charlen Sightwinner. 🗼 An Calabia - Ant Max. 🔮 Sectoralize for Calabia - Ant Max. 🔮 Sectoralize for Calabia - Ant Max. 🔮 Sectoralize for Calabia - Ant Max.	10.05.44
No saparite tana da fartada	
Period from the law and the la	

Select the hrus feature class in the ArcMap tree and then choose the XTools Pro -> Start Editing Selected Layer menu option. Select the features with OBJECTID values of 9, 6, and 7.

	Attributes of h	irus				_ 0
	OBJECTID *	Shape *	ID	GRIDCODE	Shape_Length	Shape_Area
	5	Polygon	5	1	11868.825	3392624.060407
	3	Polygon	3	2	10399.1128	2779960.974317
	1	Polygon	1	3	5822.419	1433081.574598
	2	Polygon	2	4	7818.4062	1784685.623361
	4	Polygon	4	5	8179.8202	931341.293256
	15	Polygon	15	6	11607.185	4765394.518891
	13	Polygon	13	7	10477.3778	2437192.289679
	11	Polygon	11	8	6249.854	951269.850619
	16	Polygon	16	9	10011.1978	2102893.458782
	10	Polygon	10	10	8223.4918	988088.327766
	14	Polygon	14	11	7894.5524	1623771.026204
	8	Polygon	8	12	4221.3924	467369.539826
Þ	9	Polygon	9	13	4403.807	520445.751011
	12	Polygon	12	14	3652.5182	325912.151518
	6	Polygon	6	15	109.6464	751.395815
	7	Polygon	7	15	109.6464	751.395815
	17	Polygon	17	15	9513.384	2894466.768137
	Record: II	• 1	3 🕨	▶ Show	All Selected	Records (3 out

Choose the Editor->Merge menu option. Choose hrus 9 in the Merge window. This will dissolve the two small features into the big adjacent one. Click OK.



Choose the Editor->Stop Editing to save the edits. The hrus map should look like this:



Click on Editor->Stop Editing when finished.

Add the attribute HRU_ID to the hrus feature class in the Attributes of hrus window. Copy the values from the GRIDCODE attribute to the new HRU_ID attribute.

Field Calculator		? ×
Eields: OBJECTID ID GRIDCODE Shape_Length Shape_Area HRU_ID	Type: ⊐I ি Number C String C Date	Functions: Abs () Atn () Cos () Exp () Fix () Int () Log () Sin () Sqr ()
HRU_ID = [GRIDCODE]	Advanced	* / & + - = Load Save
Calculate selected records only	Y	OK Cancel

Т	OBJECTID *	Shape *	ID	GRIDCODE	Shape_Length	Shape_Area	HRU_ID
	5	Polygon	5	1	11868.825	3392624.060407	1
	3	Polygon	3	2	10399.1128	2779960.974317	2
	1	Polygon	1	3	5822.419	1433081.574598	3
	2	Polygon	2	4	7818.4062	1784685.623361	4
	4	Polygon	4	5	8179.8202	931341.293256	5
	15	Polygon	15	6	11607.185	4765394.518891	6
	13	Polygon	13	7	10477.3778	2437192.289679	7
	11	Polygon	11	8	6249.854	951269.850619	8
	16	Polygon	16	9	10011.1978	2102893.458782	9
	10	Polygon	10	10	8223.4918	988088.327766	10
	14	Polygon	14	11	7894.5524	1623771.026204	11
	8	Polygon	8	12	4221.3924	467369.539826	12
	9	Polygon	9	13	4403.807	521948.550864	13
	12	Polygon	12	14	3652.5182	325912.151518	14
	17	Polygon	17	15	9513.384	2894466.768137	15

Calculate X and Y coordinates for each HRU using XTools Pro Toolbar-> Table Operations ->Add X,Y,Z Coordinates. Select hrus Layers, uncheck Add Z coordinate, and modify X and Y field if desired.

ayers	Add X coordinate
strseg	Field name: X
hrus hruexpand	Add <u>Y</u> coordinate
mfgrid activeCells	Field name: Y
natbndf	Add Z coordinate
streamgage	Field name: Z
Use gelected features	Only for <u>3</u> D shapes
Output projection:	What point should be taken from?
	Multipoint Center point
Do not project data Specify	Polyline Center point
Convert angular units to DMS	Polygon Center point

Add the attribute HRU_AREA to the table in the Attributes of hrus window. Copy the values from the

Shape_Area attribute using the Field Calculator:

Attributes of hrus					
T	Shape_Area	HRU_ID	x	Y	HRU_AREA
Î	3392624.060407	1	-2045683.82	2087667.434	3392624.060407
Ì	2779960.974317	2	-2047127.01	2087630.431	2779960.974317
Ì	1433081.574598	3	-2048074.09	2087165.230	1433081.574598
Ì	1784685.623361	4	-2050010.88	2086745.325	1784685.623361
ľ	931341.293256	5	-2048959.22	2086867.218	931341.293256
ĺ	4765394.518891	6	-2049190.82	2085003.978	4765394.518891
Ī	2437192.289679	7	-2050833.55	2085716.178	2437192.289679
ĺ	951269.850619	8	-2047305.45	2085981.417	951269.850619
ĺ	2102893.458782	9	-2047746.68	2084833.353	2102893.458782
	988088.327766	10	-2046381.44	2086428.821	988088.327766
ľ	1623771.026204	11	-2046842.66	2084663.233	1623771.026204
[467369.539826	12	-2046089.97	2085810.147	467369.539826
[521948.550864	13	-2045581.31	2085577.356	521948.550864
I	325912.151518	14	-2045143.05	2085426.012	325912.151518
I	2894466.768137	15	-2046004.86	2083991.408	2894466.768137

After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

The feature class hrus is the HRU map.

Generation of GSFLOW Gravity Reservoir (GVR) map

Use the Union (analysis) tool to cut the feature class activeCells with the feature class hrus. Click off the Gaps Allowed check box. Name this feature class gvrs. Click OK.

	<u> </u>	2	(optional)
Features C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\activeCells C:\markstro\gsflowTraining2009\sagehen_gis_work\sagehen_start.mdb\trus	Ranks	+ × + +	Gaps are areas in the output feature class that are completely enclosed other polygons. This is r invalid, but it may be desirable to identify thes for analysis. To find the
	E	2 •	gaps in the output, set the option to NO_GAPS, and feature will be created in these areas. To select these features, query the output feature class base on all the input feature's FID values being equal to 1.
Gaps Allowed (optional)			 Checked—No feature will be created for areas the output that an completely enclose by polygons. This the default.
			 Unchecked—A feature will be



Use the Delete Field (management) tool. Set input table to grvs and select fields to delete. Delete the attributes FID_hrus, ID; GRIDCODE; and FID_activeCells. Click OK.

velete Field		
nput Table gvrs	ے ای ا	Delete Field
rop Field		Deletes one or more fields
FID_activeCells ROW COL CELL_JD CELL_AREA FID_frus D CELS_AREA		from a table of a feature class, feature layer, and/or raster catalog.
	-	
•	2	
	<u>×</u>	

Add attribute GRV_ID to the gvrs feature class. Use the Field Calculator to copy the values from the OBJECTID attribute to the new GRV_ID attribute.

Calculate X and Y coordinates for each gvrs using XTools Pro Toolbar-> Table Operations ->Add X,Y,Z Coordinates. Select gvrs Layer, uncheck Add Z coordinate, and modify X and Y field if desired. Note make sure to overwrite existing values, as they are remnants and don't represent the correct values.

Layers	Add 🛛 coordinate				
gyr Angel Domain	Field name: X				
strseg hrus hruexpand mfgrid	✓ Add <u>Y</u> coordinate Field name: Y				
activeCells mfcells	Field name: Z				
Use selected features	Conly for 3D shapes				
Output projection:	What point should be taken from?				
	Multipoint Center point				
Do not protect data Specify	Polyline Center point				
Convert angular units to DMS	Polygon Center point				

OID	Shape *	HRU_ID	x	Y	Shape_Length	Shape_Area	GVR_ID	
1	Polygon	15	-2046821.286	2082952.955	800	39999.999999	1	
2	Polygon	15	-2046621.286	2082952.955	800	40000	2	
3	Polygon	15	-2046821.286	2083152.955	800	39999.999999	3	
4	Polygon	15	-2046621.286	2083152.955	800	39999.999999	4	
5	Polygon	15	-2046421.286	2083152.955	800	39999.999999	5	
6	Polygon	15	-2046221.286	2083152.955	800	40000	6	
7	Polygon	15	-2046021.286	2083152.955	800	39999.999999	7	
8	Polygon	15	-2045821.286	2083152.955	800	39999.999999	8	
9	Polygon	15	-2045621.286	2083152.955	800	39999.999999	9	
10	Polygon	15	-2045421.286	2083152.955	800	39999.999999	10	
11	Polygon	9	-2047421.286	2083352.955	800	40000.000001	11	
12	Polygon	9	-2047221.286	2083352.955	800	40000.000001	12	
13	Polygon	11	-2047029.262451	2083398.635743	677.0366	16215.921222	13	
14	Polygon	9	-2047101.415259	2083334.576806	489.6024	6940.745193	14	
15	Polygon	15	-2046980.587271	2083316.549085	672.6982	16843.333585	15	
16	Polygon	11	-2046916.6505	2083443.53015	56.2414	174.755569	16	
17	Polygon	15	-2046820.867535	2083352.557551	800	39825.244432	17	
18	Polygon	15	-2046621.286	2083352.955	800	40000.000001	18	
19	Polyann	15	2046421 286	2083352 955	800	40000 000001	19	

After the feature class gvrs has been created, save the Sagehen ArcMap project by clicking File->Save.

The feature class gvrs is the gravity reservoir map.

Adding modeling attributes to the GSFLOW maps

HRU map

PRMS HRU Parameters (these sections come from unpublished document by Gregg Lamorey). Several of the PRMS parameters are determined using a DEM and other GIS coverages including coverages of vegetation and soil data. The GIS coverages used in parameterization are available for the US on a 1 km grid. The required coverages are: vegetation type (lulc), vegetation density (density), available water-holding capacity (awc), soil depth (rockdep), sand content (sandave) and clay contents (clayav). These coverages should be projected into the same projection, same extent and same cell resolution as the local DEM used to delineate the basin. The "Environments" setting should be set to the extent and cell size used in the DEM for all coverages generated.

Note: the clipping steps have already been done for the Sagehen example problem and are located in Sagehen Data Bin in the ArcMap tree. All ArcMap analysis tools can be accessed using the ArcMap Search window.



This shows LULC clipped to the extent of the DEM.



Remap tables used to reclassify coverages are also used in the parameterization. The necessary tables are in the folder gis\startData\SagehenDataBin\remap. The cov-den-winter2.rmp, prms-intcp_srain.rmp, and prms-intcp_wrain.rmp remap tables are in percent or hundredths of an inch and need to be divided by 100 to obtain the correct values while the temp_adj.rmp remap table is in tenths of degrees and needs to be divided by 10 to obtain the correct values (this was done because of problems reclassing an integer to a real number in ArcMap).

cov_type

The coverage type (0 for bare, 1 for grass, 2 for shrub, 3 for deciduous trees, and 4 for coniferous tress) is determined from the vegetation type coverage. This can be calculated in ArcMap by first using "Spatial Analyst Tools > Reclass > Reclass by ASCII file" with the vegetation species coverage "lulc" as the input raster, "cov-type_new.rmp" as the "Input ASCII remap file", and "cov_type" as the "Output raster."
The values for each HRU can be determined using the Zonal Statistics (Spatial Analyst) tool in ArcMap with the HRU shapefile specified as the "Input raster or feature zone data", the HRU id field as the "Zone field", and "cov_type" specified as the "Input value raster". The output from the zonal statistics is a .dbf file that can be opened in a spreadsheet.

*****Do not modify the .dbf file in excel it will corrupt the data *****

Make a new field "cov_type" in the HRUs shapefile. Join the table made above and bring up the attribute table. Copy the values from the joined "MAJORITY" field into the cov_type field. Unjoin the table from the HRUs shapefile.

covden_sum

The vegetation coverage density in the summer is the mean value of the vegetation density. This can be calculated Zonal Statistics (Spatial Analyst) tool with the HRU shapefile specified as the "Input raster or feature zone data", the HRU id field as the "Zone field", and "SagehenDataBin\density1k" specified as the "Value raster."

Use the Zonal Statistics as Table tool:

onal Statistics as Table			
put raster or feature zone data		-	Output table
vus shapefile			and the second second
one field			Output table that will
HRU_ID		-	contain the summary of the
put value raster		leal m	values in each zone.
C:(markstro)gsRowTraning2009(SagehenDataBin(density1)		i 🔄	
utput table			
C:\markstrolgsflowTraining2009\gis\tables\covden_sum_tat	xke		
7 Ignore NoData in calculations (optional)			
		2	

Be sure to set Environments->Raster Analysis Settings -> Cell Size to Same as layer dem. This sets the cell size in the analysis to 27.4... This is important because this tool converts the HRU shapefile to a raster to do the analysis. If the Input value raster is too coarse (in this case it is 1 km2) the HRUs will not be able to be represented and the zonal statistics will be messed up. If the generated zonal statistics table does not have a valid row for each HRU, this is what happened.

Choose the MEAN value from the joined table and using the Field Calculator, divide by 100 (to make decimal fraction out of percent) and copy it into a new field called covden_sum (type double), as for parameter cov_type.

	14	
⁵ General Settings ⁵ Arc Hydro Settings	-	Environment Settings
Cartography Settings		12 (1997) 12 (1997)
Coverage Settings		Environment settings specified in this dialog box
Geodatabase Settings		are values that will be
Geostatistical Analysis Settings		applied to appropriate results from running tools.
Raster Analysis Settings Cel Sce		They can be set hierarchically, meaning that
Same as layer dem	<i>i</i>	application you are working
27.4116394527398		in, so they apply to all tools for a model, so they
Mask		apply to all processes
° Raster Storage Settings		particular process within a model. Environments set for a process within a model will override all other setting, and environments set for all processes in a model will override those set in the application. Changing the default settings that will be used is a prerequisite to performing geoprocessing tasks. You may only be interested in

201	do you want to join to this layer?
n a	ttributes from a table
1.	Choose the field in this layer that the join will be based on:
2.	Choose the table to join to this layer, or load the table from disk:
	🖾 covden_sum_table 🗾 🗭
	Show the attribute tables of layers in this list
3.	Choose the field in the table to base the join on:
	Rowid
-3	oin Options
	All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
	C Keep only matching records
	If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.

To see the HRUs colored by the parameter values (do this for every parameter), bring up the properties

for the HRUs shapefile and set the Symbology to something similar to what is shown:



Repeat the above steps (reclass, zonal statictics, table join, copy out the parameter values into fields in the HRU shape file) for the rest of the PRMS parameters (steps 4.13 through 4.1.18)

covden_win

The vegetation coverage density in the winter is the mean value of the product of the vegetation density and the leaf keep factor. The leaf keep factor is determined by reclassing the coverage type (cov_type) using a table that relates coverage type to leaf keep factor (cov-den-winter2.rmp).

Use the Raster Calculator (Spatial Analyst) tool to multiply the vegetation

(SagehenDatabin\density1k) and leaf keep factor coverages (divide by 100.0 to keep it as a percentage).

dem	-	*	7	8	9	=	\diamond	And
density1k fac fdr		1	4	5	6	>	>=	Or
ฟ HRUs		•	1	2	3	<	<=	Xor
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(density1k) * [leat Keep	17 100.0						

Then use the Zonal Statistics as Table (Spatial Analyst) tool to determine the mean value for each HRU.

out raster or feature zone data		-	Output table
rus shapefile			output table
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veroenent Settings eneral Settings rc Hydro Settings artography Settings eodatabase Settings eostatistical Analysis Settings aster Analysis Settings d See 27.4116394527390 ask	OK Cancel Enveronments		Cell Size The output cell size, or resolution. The default output resolution, when a feature class is used as input, is the width or the height (whichever is shortest) of the extent of the feature class divided by 250 Maximum of inputs - The largest cell size of all input datasets. This is the default Minimum of inputs - The smallest cell size of all input datasets As Specified Below- Specify the exact cell size value.

soil_moist_max

The soil moisture maximum is the product of the Available Water Content (awc) and the rooting depth.

The rooting depth is calculated as the minimum of the root depth and the soil depth. The root depth is determined by reclassing from vegetation species (SagehenDataBin\lulc1k) to root depth using the Reclass by ASCII file (Spatial Analyst) tool with the remap table, prms_rt_depth.rmp.



The minimum of root depth and bed rock depth (SagehenDataBin\rockdep1k) coverages can be generated using the Cell Statistics (Spatial Analyst) tool and specifying the two coverages as the input rasters and setting the "Overlay statistic" to "Minimum".

it rasters or constant values	and the second	Call Statistics
		Cell Statistics
tdgbh_table C-ImarkstrolgsflowTraining20099;SagetvenDataBin%rockdep3k	+×+	Calculates a per-cell statistic from multiple rasters.
put raster jnaristrolgsflowTraining2009i.gisjtablesisidpth_table	-	
rlay statistic (optional) N2MLM	-	
OK Canad Environments		1) .

The product of the awc and minimum depth rasters can be determined with the Raster Calculator

(Spatial Analyst) tool.

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	3	2	1	•		oildp_table itr
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	-	,		<u> </u>	1	

A zonal mean of this raster for each HRU can be calculated using the Zonal Statistics as Table (Spatial Analyst) tool.

Input rister or feature zone data Inus shapefle Inst value raite Catulation Information Informatio Information Informatio Informatio Information Information In	- 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2	Couty Conta value	put table sut table that will an the summary of the s in each zone (Help
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			 As Specified Below Specify the exact cell size value.
			 Same as Layer - Specify an input raster layer on which to base the cell

in a	ttributes from a table
	Cables from a cable
1,	Choose the field in this layer that the join will be based on:
	HRU_ID 💌
2.	Choose the table to join to this layer, or load the table from disk:
	🔲 sm_max_table 💌 🎽
	Show the attribute tables of layers in this list
з.	Choose the field in the table to base the join on:
	Rowid
r)	oin Options
	All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
	C Keep only matching records
	If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.

Copy the zonal MEAN value to sm_max (PRMS parameter soil_moist_max) in HRUs shapefile.

soil_rchr_max

The soil recharge zone maximum value is the minimum of the rooting depth and 18 inches multiplied by AWC. First, the minimum of the rooting depth (determined under soil_moist_max) and 18 inches is calculated using the Cell Statistics (Spatial Analyst) tool.

el statistics		
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	1	 MAXIMUM — Calculates the maximum (largest value) of the inputs.
		 MEDIAN — Calculates the median of the inputs.
	z.	 MINIMUM — Calculates the minimum (smallest value) of the innuts

Next, the resulting coverage is multiplied by awc using "Spatial Analyst > Raster Calculator".

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A zonal mean of this raster for each HRU can be calculated using Zonal Statistics as Table (Spatial

Analyst) tool

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Copy the zonal MEAN value to rchr_max (PRMS parameter soil_rchr_max) in HRUs shapefile.

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soil_type

The soil type (1 for sand, 2 for loam, and 3 for clay) is determined by first calculating the zonal means of the sandave and clayav coverages for each HRU using the Zonal Statistics as Table (Spatial Analyst) tool.

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9 Polyg	on 13	-14	219446-47814	54	-3045199.72958	2005448 16554	4	100	100	4.176	2.088	43.459354	18.9144
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If sandav is greater than 50% then the type is 1, if clayav is greater than 40% then the type is 3, otherwise the type is 2. This calculation can be implemented by hand by sorting the means and setting the corresponding cells.

snow_intcp

The snow interception storage capacity is determined by reclassing from vegetation species (lulc) to snow interception storage capacity using the Reclass by ASCII File (Spatial Analyst) tool with the remap table prms-intcp_snow.rmp.

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A zonal mean of this raster for each HRU can be calculated using the Zonal Statistics as Table (Spatial

Analyst) tool.

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Zonal Statistics as Table Input rester or feature sone data Inus shapefie Zone field IRU_ID IRUU value raster Inow_intcp Cutput table C_(naristrolgsflowTraining2005(gis)tables(snow_intop_table V (grore NoD)ata in calculations (optional)	2	Output table Output table that will contain the summary of the values in each zone.
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Zonal Statistics as Table Input rester or feature zone data Input shapefie Zone field Input value matter Input value matter Input value matter Chynaristro(gpflowTraining2009(gs)(tables)snow_intop_table () Ignore NoDiata in calculations (optional) I Ignore NoDiata in calculations (optional)	1	Output table Output table that will contain the summary of the values in each zone
Zonal Statistics as Table Input rester or feature zone data Input rester or feature zone data Input stapefile Zone field Input value reater mov_ritcp Cutput table C (nveristro(geflowTreining2009(gefltables(snow_intop_table) I genore NoDeta in calculations (optional) I genore NoDeta in calculations (optional)		Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Tiput ratter or feature zone data Insus shapefile Zone field IRU_JD Irput value ranter mow_pitcp Cutput table C (markstrolg:#owTraneng2005igs/stables/snow_pitcp_table V (gnore NaDiate in calculations (optional)	-	Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Input rester or feature zone data Input rester or feature zone data Input value raiter Input value raiter Input value raiter C uput table C (markstrolgsRowTraining2009(gs)tables)snow_intep_table V (gnore NoData in calculations (optional)	-	Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Input rester or feature zone data Input rester or feature zone data Input value ranter Input value ranter Input value ranter C (markstrolgsPowFranang2009(gs)tables/snow_intop_table I (gnore NoData in calculations (optional) I (gnore NoData in calculations (optional)	1	Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Input rater or feature zone data Input rater or feature zone data Input value ranter Input value ranter Input value r	1	Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Trout rester or feature zone data Inus shapefie Zone field Inus shapefie To the matter Inow, letcp Output table C (nvariatro (gaflow Training2009(ga)(tables(snow_intop_table) V (genore NoD) ata in calculations (optional) V (genore NoD) ata in calculations (optional)	1	Output table Output table that will contain the summary of the values in each zone.
Zonal Statistics as Table Trus shapefie Zone field TPUX vision matter unow_vitcp Output table C_Invaristro (gpflow Training2009)(gis)(tables(snow_intop_table C_Invaristro (gpflow Training2009)(gis)(tables(snow_intop_table) ✓ Ignore NoD ata in calculations (gptional)	1	Output table Output table that will contain the summary of the values in each zone

Divide these values by 100.0 when copying the zonal mean field into the snow_intcp field.

wrain_intcp

The winter rain interception storage capacity is determined by reclassing from vegetation species (lulc) to winter rain interception storage capacity using the Reclass by ASCII File (Spatial Analyst) tool with the remap table prms-intcp_wrain.rmp. A zonal mean of this raster for each HRU can be calculated using the Zonal Statistics as Table (Spatial Analyst) tool. Divide these values by 100.0 when copying the zonal mean field into the wrain_intcp field.

srain_intcp

The summer rain interception storage capacity is determined by reclassing from vegetation species (lulc) to summer rain interception storage capacity using the Reclass by ASCII File (Spatial Analyst) tool with the remap table prms-intcp_srain.rmp. A zonal mean of this raster for each HRU can be calculated using the Zonal Statistics as Table (Spatial Analyst) tool. Divide these values by 100.0 when copying the zonal mean field into the srain_intcp field.

hru_lat

The latitude of the centroids of the HRU's can be determined by first converting the polygon coverage of the HRU's to centroids using the Feature to Point (Data Managment) tool. The centroid coverage can be projected to latitude and longitude using the Project (Data Management) tool and specifying the output coordinate system (by clicking on the button next to "Output Coordinate System" and selecting the "Select" button on the resulting "Spatial Reference Properties" dialog box) to be "Geographic > North America > North American Datum 1983.prj". The new coordinates can be added to the coverage attribute table using the Add XY Coordinates (Data Management) tool.

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	sand_pct	clay_pct	soil_type	snow_intcp	wrain_intc	srain_intc	ORIG_FID	POINT_X	POINT_Y
l	43.459354	18.914499	2	10	5	5	0	-120.277548	39.439629
ĺ	46.156151	17.349684	2	10	5	5	1	-120.298134	39.431656
	43.459354	18,914499	2	10	5	5	2	-120.268197	39.445852
Ì	43.805038	18.713917	2	10	5	5	3	-120.286909	39.435186
i	43.459354	18.914499	2	10	5	5	4	-120.252456	39.449834
i	43.459354	18.914499	2	10	5	5	5	-120.25104	39.43237
Ì	43.459354	18.914499	2	10	5	5	6	-120.244708	39.43124
i	43.459354	18.914499	2	10	5	5	7	-120.256152	39.437111
İ	43.459354	18.914499	2	10	5	5	8	-120.265349	39.431151
ĺ	43.459354	18.914499	2	10	5	5	9	-120.239823	39.431346
İ	52.675301	13.566948	1	10	5	5	10	-120.30488	39.420685
i	47.616589	16.502266	2	10	5	5	11	-120.283837	39.4185
	43.459354	18.914499	2	10	5	5	12	-120.256184	39.4208
	43.459354	18.914499	2	10	5	5	13	-120.266938	39.420245
i	43,459354	18.914499	2	10	5	5	14	-120 244575	39.416741

hru_elev

The hru elevation is determined as the zonal median elevation instead of mean elevation because the median is less sensitive to outliers such as a few very high elevation points. To calculate the median elevation, the DEM used to delineate the basin (Fil) must first be converted to an integer coverage using the Int (Spatial Analyst) tool. The zonal median for each HRU can be calculated from this coverage using the Zonal Statistics as Table (Spatial Analyst) tool.

e do you wa	ant to join to this layer?	
n attributes	from a table	
1. ⊆hoose t	he field in this layer that the	e join will be based on:
HRU_ID		3
2. Choose t	he <u>t</u> able to join to this layer	, or load the table from disk:
elev	_table	- 0
I▼ Show	the attribute tables of laye	rs in this list
3. Choose t	he field in the table to base	the join on:
Rowid		<u>i</u>
Join Option	ns	
€ Keep	all records	
All re Unma apper	cords in the target table are itched records will contain n nded into the target table fr	shown in the resulting table. ull values for all fields being om the join table.
С Кеер	only matching records	
If a re table	ecord in the target table doe , that record is removed from	esn't have a match in the join m the resulting target table.

ripuk rasker ur reakure zone uasa	+	Input raster or
rrus shapefile	1 🔊	feature zone data
tone field		
HRU_ID	*	Dataset that defines the
nput value raster	the second	zones
AL.	 	
Jutput table		It can be a raster or teature dataset
C:[markstrolgsflowTraining2009[gis][tables][elev_table	2	

* General Settings	<u></u>	Cell Size
 Seneral Settings Arc Hydro Settings Cartography Settings Coverage Settings Geodatabase Settings Geostatistical Analysis Settings Raster Analysis Settings Cel See State as kyer file 27.41163945274 Math 		Cell Size The output cell size, or resolution. The default output resolution, when a feature class is used as input, is the width or the height (whichever is shortest) of the extent of the feature class divided by 250. • Maximum of Inputs - The largest cell size
¥ Raster Storage Settings	<u>ی</u> ت	of all input datasets. This is the default. Minimum of Inputs - The smallest cell size of all input datasets. As Specified Below - Specify the exact cell size value. Same as Layer - Specify an input raster layer on which to have the cell



hru_slope

The hru slope can be calculated from Fil using the Slope (Spatial Analyst) tool and select the output measurement as "percent_rise". The zonal mean for each HRU can be calculated from this coverage using the Zonal Statistics as Table (Spatial Analyst) tool. Divide these values by 100.0 when copying the zonal mean field into the hru_slope field.



hru_aspect

The hru aspect can be calculated from Fil using the Aspect (Spatial Analyst) tool. To calculate the median aspect, the Aspect map just created must first be converted to an integer coverage using the Int (Spatial Analyst) tool. The zonal median for each HRU can be calculated from this coverage using the Zonal Statistics as Table (Spatial Analyst) tool.



tmax_adj

tmax_adj is an adjustment made to the hru maximum temperature based on the aspect of the hru. This parameter is estimated with the equation:

 $tmax_adj = -1.8 cos(hru_aspect * 0.0175)$

Use the Field Calculator to fill in the tmax_adj field. The multiplier 0.0175 converts degrees to radians. In addition to the tmax_adj method calculated above a more simple method can be employed.

Degree	Direction	tmax_adj
337.5-22.5	North	-1.7
22.5-67.5	Northeast	-1.0
67.5-112.5	East	0.0
112.5-157.5	Southeast	1.0

157.5-202.5	South	1.7
202.5-247.5	Southwest	1.0
2478.5-292.5	West	0.0
292.5-337.5	Northwest	-1.0

This is the method employed in the original GSFLOW Sagehen example problem.

Ejelds:	Type:	Functions:
FID ID GRIDCODE AREA HRU_ID X Y cov_type covden_sum covden_sum sm_max sm_max	▲ © Number C String C Date	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sar()
max_adj = -1.8* Cos ([hru_aspect]*0.0175)	Advanced	+ - = <u>L</u> oad <u>Save</u> <u>H</u> elp
Calculate selected records only	×	OK



tmin_adj

tmin_adj is an adjustment made to the hru minimum temperature based on the aspect of the hru. The values are the same as calculated for tmax_adj.

hru_area

The area of the hru's is already a field in the hru polygon shapefile. The area listed in this field is the number of cells in each hru. This must be converted to acres by first converting to map units (square meters if in UTM) then converting to acres (1 acre = 4047 m2).



jh_coef_hru

This air temperature coefficient used in Jensen-Haise potential evapotranspiration computations can be calculated for each HRU using the following equation: $jh_coef_hru = 27.5-0.25*(high_sat - low_sat)-(hru_elev/1000)$ where high sat is the saturation vapor pressure, in millibars, for the mean maximum air temperature for the warmest month of the year and low_sat is the saturation vapor pressure, in millibars, for the mean minimum air temperature for the warmest month of the year. The saturation vapor pressure can be calculated using sat function = $6.1078exp^{(17.269(x)/(x + 237.3))}$ where x is the temperature. Assume the minimum temperature is 10 C and maximum temperature is 25 C so that low_sat is 10.02 and high_sat is 31.67. This parameter can be calculated with a spreadsheet since it is only a function of hru_elev. So, if hru_elevation is in meters, the equation is: $jh_coef_hru = 22.0 - (hru_elev * 0.00328)$

jelds:	Type:	Functions:
sand_pct clay_pct soil_type snow_intcp wrain_intc srain_intc hru_elev hru_slope hru_aspect tmax_adj tmin_adj	▲ ^{II} © Number C String C Date	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() * / &
nro_area n_coef_hr = 22.0 - ([hru_elev] * 0.00328)	Advanced	+ - = Load Save Help
Calculate selected records only	×	OK Cancel



rad_trncf

The transmission coefficient for short-wave radiation through the winter vegetation canopy can

be calculated as

rad_trncf = 0.9917 * exp(-2.7557 * covden_win).

This parameter can be calculated with the Field Calculator since it is only a function of covden_win.

Fields:	Type:	Functions:
FID ID GRIDCODE AREA HRU_ID X Y cov_type covden_sum covden_sum covden_win soil_moist soil_moist	▲ © Number © String © Date	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sqr()
ad_trncf = 0.9917 * Exp (-2.7557 * [covden_win])	Advanced	+ _ =
Calculate selected records only	*	ОК

MODFLOW Grid Cell map (shapefile mfcells)

Add fields X (double) and Y (double) use Calculate Geometry to fill them in. Add fields ALT

(integer), PRECIP (double), ACTIVE (integer), IRUNBND (integer).

IFEMBND	ACTIVE	PRECIP	ALT	Y	x	SEGNUM	COL	ROW	MF3_POL_ID
0	0	0	0	2089352.955	-2052171.286	1	1	1	1
0	0	0	0	2089352.955	-2051971.286	2	2	1	2
0	0	0	0	2089352.955	-2051771.286	3	3	. 1	3
0	0	0	0	2089352.955	-2051571.286		- 6	1	4
0	0	0	0	2089352.965	-2051371.286	5	5	1	5
0	0	0	0	2089352.965	-2051171.286	6	6	1	6
0	0	0	0	2089352.955	-2050971.286	7	7	1	7
0	0	0	0	2089352.955	-2050771.286	8	8	. 1	8
0	0	0	0	2089352.955	-2050571.286	9	9	1	9
0	0	0	0	2089352.955	-2050371.206	10	10	1	10
0	0	0	0	2089352.955	-2050171.286	. 11	11	1	11
0	0	0	0	2089352.955	-2049971 286	12	12	1	12
0	0	0	0	2089352.955	-2049771.206	13	13		13
0	0	0	0	2089352.955	-2049571.286	14	14	1	14
0	0	0	0	2089352.955	-2049371.286	15	15	1	15
0	0	0	0	2089352.955	-2049171 266	16	16	1	16
0	0	0	0	2089352.955	-2048971.286	17	17	1	. 17
0	0	0	0	2089352.955	-2048771.286	18	18	1	18
0	0	0	0	2089352.955	-2048571.286	19	19	1	19
0	0	0	0	2089352.955	-2048371.286	20	20	1	20
0	0	0	0	2089352.955	-2048171.286	21	21	1	.21
0	0	0	0	2089352.955	-2047971.206	22	22	. 1	22
0	0	0	0	2089352.955	-2047771.286	23	23	1	23
0	0	0	0	2089352.955	-2047571.205	24	.24	1	24
0	0	0	0	2089352.955	-2047371.286	25	25	1	25
0	0	0	0	2089352.955	-2047171.206	26	26	1	26
0	0	0	0	2089352.965	-2046971.286	27	27	1	27
0	0	n	0	2089352.955	-2046771 2R6	28	78	1	78

Fill in the cell altitude attribute (ALT)

The fiield ALT is the cell top altitude and is determined as the zonal median altitude. To calculate the median altitude, use the integer version of the DEM (Int_Fil) that was created to determine the parameter hru_elev. The zonal median for each cell can be calculated from this coverage using "Spatial Analyst > Zonal Statistics".

Input raster or reature zone data		Output table
mfcells		
Cone field		Output table that will
SEQNUM		 contain the summary of the
input value raster		values in each zone.
Int_Fil	-	· 😂
Dutput table		
C:\markstro\gsflowTraining2009\gis_final\tables\cell_alt_table		

Click on the Environments button to set the Raster Analysis Settings Cell Size

Strain Environment Settings		×
¥ General Settings	A	Cell Size
 * Arc Hydro Settings * Cartography Settings * Coverage Settings * Geodatabase Settings * Geostatistical Analysis Settings * Raster Analysis Settings Cell Size * Same as layer Raw dem 27.4116394527398 Mask 		The output cell size, or resolution. The default output resolution, when a feature class is used as input, is the width or the height (whichever is shortest) of the extent of the feature class divided by 250. • Maximum of Inputs - The largest cell size of all input datasets.
↓ ¥ Raster Storage Settings		This is the default. Minimum of Inputs - The smallest cell size of all input datasets. As Specified Below - Constitute the series.
	21	 Same as Layer - Specify an input raster layer on which to base the cell

Join the table in the mfcells shapefile to the cell_alt_table attribute table.

	you want to join to this layer?
n attr	ibutes from a table
. ⊆	oose the field in this layer that the join will be based on:
s	EQNUM
. ch	oose the table to join to this layer, or load the table from disk:
	🛛 cell_alt_table 🛛 🗾 🛱
V	Show the attribute tables of layers in this list
, ch	oose the field in the table to base the join on:
	owid
1-1-	
-Join	
	All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
c	Keep only matching records

Assign the MEDIAN into the ALT field with the Field Calculator:

jelds:	Type:	Functions:
cell_alt_table:COUNT cell_alt_table:AREA cell_alt_table:MIN cell_alt_table:MAX cell_alt_table:RANGE cell_alt_table:STD cell_alt_table:STD cell_alt_table:SUM cell_alt_table:VARIETY cell_alt_table:MAJORITY cell_alt_table:MINORITY cell_alt_table:MEDIAN nfcells.ALT = [cell_alt_table:MEDIAN]	Mumber String Date Advanced	Abs() ▲ Atn() ▲ Cos() ■ Exp() Fix() Fix() □ Int() □ Log() S * / & + - = Load ∑ave Help □
	*	ОК

Identify the active cells (ACTIVE)

The field ACTIVE defines the active and inactive MODFLOW cells. 1= active cell; 0 = inactive cell. Use the Selection->Select By Location tool to select the active cells in the mfcells shapefile with the modelDomain shapefile.

lect By Location ?	>
ets you select features from one or more layers based on where they are ocated in relation to the features in another layer. want to:	
elect features from	-
he following layer(s):	
 hrus_points_Project hrus_points strseg gvrs hrus shapefile modelDomain activeCells natbnd shapefile ✓ mfcells ✓ Original GIS Data ↓ streamgage point 	
Only show selectable layers in this list nat:	न
e features in this laver:	
Imate in a state of the selected features (0 features selected) Apply a buffer to the features in natbnd shapefile Imate of the selected features Imate of the selected features	2

The selection looks like this.



Bring up the Attributes of mfcells table. Make sure that all of the values in the ACTIVE field are set to 0. Click on the Show: Selected button at the bottom of the window. Use the Field Calculator to set the selected (ACTIVE) cells to 1.

	IRUNBND	ACTIVE	PRECIP	ALT	Y	X	SEQNUM	COL	ROW
	0	0	0	2118.342529	2068552.955	-2049371.286	167	15	-5
	0	0	0	2118.342529	2088552.955	-2049171.286	168	16	5
	0	0	0	2118.342529	2088552.955	-2048971.286	169	17	.5
	0	0	0	2118.342529	2088552.955	-2048771.286	170	18	5
	0	0	0	2118.508789	2088552.955	-2048571.286	171	19	5
	0	0	0	2132.501221	2088552.955	-2048371.286	172	20	5
	0	0	0	2159.283203	2088552.955	-2048171.286	173	21	5
	0	0	0	2178.629883	2088552.955	-2047971.286	174	22	.5
	0	1	0	2167.032959	2088552.955	-2047771.286	175	23	5
	0		0	2185.293457	2088552.955	-2047571.286	176	24	5
	0	1	0	2178.372314	2088552.955	-2047371.286	177	25	5
	0	0	0	2159.940674	2088552.955	-2047171.286	178	26	5
	0	0	0	2152.087402	2068552.955	-2046971.286	179	27	5
	0	1	0	2151.937988	2088552.955	-2046771.286	180	28	5
	0		0	2148.435791	2088552.955	-2046571 286	181	29	5
	0	1	0	2128.450684	2088552.955	-2046371.286	182	30	5
	0	1	0	2109 744385	2088552.955	-2046171.286	183	31	5
	0	1	0	2113.769043	2088552.955	-2045971.286	184	32	5
	0	1	0	2124.932861	2088552.955	-2045771.286	185	33	5
	0	1	0	2121.264404	2088552.955	-2045571.286	186	34	5
	0	1	0	2121.869873	2088552.955	-2045371.286	187	35	5
	0	0	0	2119.157715	2068552.955	-2045171.286	188	36	5
	0	0	0	2102.35083	2088552.955	-2044971.286	189	37	5
	0	0	0	2081.291016	2068552,955	-2044771.286	190	38	.5
	0	0	0	2277.146484	2088352.955	-2052171.286	191	1	6
	0	0	0	2214.422119	2068352.955	-2051971.286	192	2	6
	0	0	0	2178.9729	2068352,955	-2051771.286	193	3	6
11	0	n	0	2153 279785	2088352 955	.2051571 286	194	4	6

Fill in the cell precipitation attribute (PRECIP)

The field PRECIP is used for steady state recharge; only active cells have values; inactive cells are blank Load sagehen.data Data File into excel and compute the long term (period of record) means. This is described in Section 2.2 "Computation of Lapse Rates/Monthly Means using Excel" of this document. Using this information, a relationship can be developed to estimate long term PRECIP (recharge) for calibrating a steady state MODFLOW model. This is based on the lapse rates for the Sagehen Creek COOP station and the cell altitude:

PRECIP = 0.002249 + (ALT-1931.518)* 0.00000239718

PRECIP = 0. 002249 0.00463019 + ALT * 0.00000239718

PRECIP = -0.002381196+ ALT * 0.00000239718

Select only the ACTIVE cells again. Use the Field Calculator to input the above equation for PRECIP.

jelds:	Type:	Functions:
FID AREA PERIMETER MFGRID_POL MFGRID_P_1 ROW COL SEQNUM X Y ALT	▲ ♥ <u>N</u> umber ○ Sţring ○ <u>D</u> ate	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sqr() * / &
PRECIP		+ - =
-0.002381196 + [ALT] * 0.00000239718 		Load Save Help
Calculate selected records only	¥	ОК

Results look like this in the table.
wos	COL	SEQNUM	×	Y	ALT	PRECIP	ACTIVE	IRUNBND
21	36	796	-2045171.286	2085352.955	1937.340698	0.002263	1	0
21	35	795	-2045371.286	2065352.955	1942.581543	0.002276	1	0
20	35	757	-2045371.286	2085552.955	1942.603149	0.002276	1	0
20	36	758	-2045171.286	2085552.955	1947.011353	0.002286	1	0
20	34	756	-2045571.286	2085552.955	1947.325928	0.002287	1	0
22	36	834	-2045171.286	2085152.955	1950.000122	0.002293	1	0
21	34	794	-2045571.286	2085352.955	1952.249146	0.002299	1	0
22	35	833	-2045371.286	2065152.955	1953.492065	0.002302	1	0
19	34	718	-2045571.286	2085752.955	1956.049194	0.002308	1	0
19	33	717	-2045771.286	2065752.955	1957.981567	0.002312	1	0
22	34	832	-2045571.286	2085152.955	1958.187866	0.002313	1	0
20	33	755	-2045771.286	2085552.955	1967.658203	0.002336	. 1	0
23	34	870	-2045571.266	2084952.955	1967.85498	0.002336	1	0
19	35	719	-2045371.286	2085752.955	1970.549194	0.002343	1	0
19	32	716	-2045971.286	2085752.955	1971.337891	0.002344	1	0
18	30	676	-2046371.286	2065952.955	1971.383545	0.002345	1	0
18	29	675	-2046571.286	2085952.955	1973.372314	0.002349	1	0
21	33	793	-2045771.286	2085352.955	1975.935059	0.002355	4	0
18	34	680	-2045571.286	2085952.955	1976.958862	0.002358	1	. 0
17	29	637	-2046571.286	2086152,955	1977.084229	0.002358	1	0
17	28	636	-2046771.286	2086152.955	1977.730835	0.00236	1	0
23	35	871	-2045371_286	2064952.955	1978.126953	0.002361	1	0
18	31	677	-2046171.286	2065952.955	1976.273438	0.002361	- 1	0
19	30	714	-2046371.286	2085752.955	1978.988037	0.002363	1	0
18	28	674	-2046771.286	2085952.955	1979.647827	0.002364	1	0
17	30	638	-2046371.286	2086152.955	1981.325806	0.002368	1	0
22	33	831	-2045771.286	2085152.955	1981.508423	0.002369	1	0
18	33	679	-2045771 286	2085952 955	1981 644043	0.002369		0

Fill in the cell IRUNBND attribute

Bring up the HRUs raster (not shapefile) and the activeCell shapefile. The activeCell shapefile

was made in step 3.3.4.



Open up the Attributes of activeCell table and add the field ACT_ID (short integer). Use the Field

Calculator to set the values in ACT_ID to FID + 1.

Eld Calculator	Туре:	Functions:
FID AREA PERIMETER MFGRID_POL MFGRID_P_1 ROW COL SEQNUM ACT_ID	I € Number C String C Date	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sqr()
4CT_ID = [FID] +1	Advanced	+ - = Load Save <u>H</u> elp
Calculate selected records only	¥	OK Cancel

The field ACT_ID will be used in a double-table join using the field SEQNUM.

0 Polygon 40000 800 31 30 1 30 30 1 1 Polygon 40000 800 689 68 2 30 68 2 2 Polygon 40000 800 106 105 3 29 105 3 3 Polygon 40000 800 107 106 3 30 106 4 4 Polygon 40000 800 108 107 3 31 107 5 5 Polygon 40000 800 144 143 4 29 143 6 6 Polygon 40000 800 1445 144 4 30 144 7 7 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 177 176 5 23 175 11 <	ID	Shape	AREA	PERIMETER	MFGRID_POL	MFGRID_P_1	ROW	COL	SEQNUM	ACT_ID	
1 Polygon 40000 800 69 68 2 30 68 2 2 Polygon 40000 800 106 105 3 29 105 3 3 Polygon 40000 800 107 106 3 30 106 4 4 Polygon 40000 800 107 106 3 30 106 4 4 Polygon 40000 800 108 107 3 31 107 5 5 Polygon 40000 800 144 143 4 29 143 6 6 Polygon 40000 800 1445 144 4 30 144 7 7 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 176 175 5 23	0	Polygon	40000	800	31	30	1	30	30	1	
2 Polygon 40000 800 106 105 3 29 105 3 3 Polygon 40000 800 107 106 3 30 106 4 4 Polygon 40000 800 108 107 3 31 107 5 5 Polygon 40000 800 144 143 4 29 143 6 6 Polygon 40000 800 1445 144 4 30 1444 7 7 Polygon 40000 800 146 145 4 31 145 8 8 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 176 175 5 23 175 11 10 Polygon 40000 800 177 176 5 24 176 12 <td>1</td> <td>Polygon</td> <td>40000</td> <td>800</td> <td>69</td> <td>68</td> <td>2</td> <td>30</td> <td>68</td> <td>2</td> <td></td>	1	Polygon	40000	800	69	68	2	30	68	2	
3 Polygon 40000 8000 107 106 3 30 106 4 4 Polygon 40000 8000 108 107 3 31 107 5 5 Polygon 40000 8000 144 143 4 29 143 66 6 Polygon 40000 8000 1445 144 4 30 144 7 7 Polygon 40000 8000 146 145 4 31 145 8 8 Polygon 40000 8000 147 146 4 32 146 9 9 Polygon 40000 8000 147 146 4 32 146 9 9 Polygon 40000 800 147 146 4 32 146 9 10 Polygon 40000 800 176 175 5 23 177 11 11 Polygon 40000 800 178 177 5	2	Polygon	40000	800	106	105	3	29	105	3	
4 Polygon 40000 800 108 107 3 31 107 5 5 Polygon 40000 800 144 143 4 29 143 66 6 Polygon 40000 800 1445 144 4 30 144 7 7 Polygon 40000 800 146 145 4 31 145 8 8 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 148 147 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 122 12 Polygon 40000 800 181 180 5 <td< td=""><td>3</td><td>Polygon</td><td>40000</td><td>800</td><td>107</td><td>106</td><td>3</td><td>30</td><td>106</td><td>4</td><td></td></td<>	3	Polygon	40000	800	107	106	3	30	106	4	
5 Polygon 40000 800 144 143 4 29 143 6 6 Polygon 40000 800 145 144 4 30 144 7 7 Polygon 40000 8000 146 145 4 31 145 8 8 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 148 147 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 178 177 5 25 177 13 13 Polygon 40000 800 181 180 5 29 181 15 14 Polygon 40000 800 183 182 5 <	4	Polygon	40000	800	108	107	3	31	107	5	
6 Polygon 40000 800 145 144 4 30 144 7 7 Polygon 40000 800 146 145 4 31 145 8 8 Polygon 40000 8000 147 146 4 32 146 9 9 Polygon 40000 800 147 146 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 177 176 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 144 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5	5	Polygon	40000	800	144	143	4	29	143	6	
7 Polygon 40000 800 146 145 4 31 145 8 8 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 8000 147 146 4 33 147 10 10 Polygon 40000 800 148 147 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 177 176 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 144 14 Polygon 40000 800 183 182 5 30 182 16 15 Polygon 40000 800 184 183 5	6	Polygon	40000	800	145	144	4	30	144	7	
8 Polygon 40000 800 147 146 4 32 146 9 9 Polygon 40000 800 148 147 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 177 176 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 14 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 184 183 5 31 183	7	Polygon	40000	800	146	145	4	31	145	8	
9 Polygon 40000 800 148 147 4 33 147 10 10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 177 176 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 144 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 185 184 5 32 184 18	8	Polygon	40000	800	147	146	4	32	146	9	
10 Polygon 40000 800 176 175 5 23 175 11 11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 178 177 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 14 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 185 184 5 32 184 18	9	Polygon	40000	800	148	147	4	33	147	10	
11 Polygon 40000 800 177 176 5 24 176 12 12 Polygon 40000 800 178 177 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 14 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 185 184 5 32 184 18	10	Polygon	40000	800	176	175	5	23	175	11	
12 Polygon 40000 800 178 177 5 25 177 13 13 Polygon 40000 800 181 180 5 28 180 14 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 184 183 5 31 183 17 17 Polygon 40000 800 185 184 5 32 184 18	11	Polygon	40000	800	177	176	5	24	176	12	
13 Polygon 40000 800 181 180 5 28 180 14 14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 184 183 5 31 183 17 17 Polygon 40000 800 185 184 5 32 184 18	12	Polygon	40000	800	178	177	5	25	177	13	
14 Polygon 40000 800 182 181 5 29 181 15 15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 184 183 5 31 183 17 17 Polygon 40000 800 185 184 5 32 184 18	13	Polygon	40000	800	181	180	5	28	180	14	
15 Polygon 40000 800 183 182 5 30 182 16 16 Polygon 40000 800 184 183 5 31 183 17 17 Polygon 40000 800 185 184 5 32 184 18	14	Polygon	40000	800	182	181	5	29	181	15	
16 Polygon 40000 800 184 183 5 31 183 17 17 Polygon 40000 800 185 184 5 32 184 18	15	Polygon	40000	800	183	182	5	30	182	16	
17 Polygon 40000 800 185 184 5 32 184 18	16	Polygon	40000	800	184	183	5	31	183	17	
	17	Polygon	40000	800	185	184	5	32	184	18	

Now, use the Zonal Statistics as Table(sa) tool using the activeCells shapefile as input. The Zone field is

ACT_ID. The Input value raster is HRUs. Name this table tables\cell_hru_table.

Zonal Statistics as Table		-02
Input raster or feature zone data	<u>^</u>	Output table
activeCells	- 🗃	10.04
Zone field		Output table that will
ACT_ID	•	contain the summary of the
Input value raster		values in each zone.
HRUs	- 🗃	
Output table	_	
C:\markstro\gsflowTraining2009\gis_final\tables\cell_hru_table	i 🗃	
	T	
OK Cancel Environments	< Hide Help	Tool Help

Set the Raster Analysis Cell Size to the Raw DEM.

¥ General Settings	Environment
¥ Arc Hydro Settings	Settings
Cartography Settings	Environment settin
✓ Coverage Settings	specified in this di
Geodatabase Settings	are values that will applied to appropri-
Geostatistical Analysis Settings	results from runnin
Raster Analysis Settings Cell Size	They can be set hierarchically, mer
Same as layer Raw dem 🗾 📓	application you are
27.4116394527398	in, so they apply t
Mask	apply to all proces
l ¥ Raster Storage Settings	within the model; or particular process model. Environment for a process within model will override setting, and enviro set for all process model will override set in the application
	Changing the defa settings that will b a prerequisite to p geoprocessing tas may only be intere

Do a double-join to get the HRU ID information into the mfcells shapefile.

First, join the table in the mfcells shapefile to the table in the activeCells shapefile using the field

SEQNUM.

	Jo you want to join to this layer?
۱a	ttributes from a table
1000	Choose the field in this layer that the join will be based on:
	SEQNUM
2.	Choose the table to join to this layer, or load the table from disk:
	🗞 activeCells 🔹 🔽
	Show the attribute tables of layers in this list
3,	Choose the field in the table to base the join on:
	SEQNUM
- J	oin Options
	• Keep all records
	All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
	C Keep only matching records
	If a record in the target table doesn't have a match in the join table, that record is removed from the requiring target table.

Now, join the table in the mfcells shapefile (field ACT_ID) to the table cell_hru_table (using field Rowid).

attr	/
	ibutes from a table
⊴	noose the field in this layer that the join will be based on:
A	ICT_ID
Cł	noose the table to join to this layer, or load the table from disk:
	🛛 cell_hru_table 📃 🖸
1	 Show the attribute tables of layers in this list
C	noose the field in the table to base the join on:
	owid
Joir) Options
6	Keep all records
	All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
	Keep only <u>m</u> atching records
c	

Use the Field Calculator to copy the values from cell_hru_table:Majority into the field

IRUNBND.

eld Calculator		? ×
<u>F</u> ields:	Туре:	Functions:
cell_hru_table:COUNT cell_hru_table:AREA cell_hru_table:MIN cell_hru_table:MAX cell_hru_table:RANGE cell_hru_table:STD cell_hru_table:STD cell_hru_table:SUM cell_hru_table:VARIETY cell_hru_table:MAJORITY cell_hru_table:MEDIAN nfcells.IRUNBND = [cell_hru_table:MAJORITY]	▲ [×] © <u>N</u> umber © String © <u>D</u> ate	Abs() ▲ Atn() ▲ Cos() Exp() Exp() Fix() Int() ▲ Log() Sin() Sar() ▼ + - Load ≦ave Help ▲
Calculate selected records only		OK

Remove the joins on the mfcells shapefile. Use IRUNBND to label the cells in mfcells. It should look

like this.



After this map has been created, save the Sagehen ArcMap project by clicking File->Save.

The shapefile gis\shapes\mfcells is the vector version of the MODFLOW cell map. The attributes that were added to this shapefile can be used in ModelMuse.

GVR map

Add four fields to the gvrs shapefile attribute table: gvrhruid (short integer), gvrcellid (short integer), gvrcellpct (double), gvrhrupct (double).

W	COL	SEQNUM	GVR_ID	GVR_AREA	x	Y	gvrcellid	gwrhruid	gvrcellpct	gerhrupet
13	21	477	31	40000	-2048171.286	2086952.955	0	0	0	0
13	22	478	32	40000	-2047971.286	2086952.955	0	0	0	0
13	23	479	33	40000	-2047771 285	2086952.955	0	0	0	0
13	24	480	34	39702.49881	-2047572.02085	2086953.4479	0	0	0	0
13	25	481	.35	264.497118	-2047469.49021	2087020.16939	0	0	0	0
14	19	513	36	2486.701815	-2048493 54662	2066828.13087	0	0	0	0
14	20	514	37	32935.00756	-2048357 88358	2086765.43054	0	0	0	0
14	21	515	38	40000	-2048171.286	2086752.955	0	0	0	0
14	22	516	39	40000	-2047971.286	2086752.955	0	0	0	0
14	23	517	40	40000	-2047771 286	2086752.955	0	0	0	0
14	24	518	41	29860.55293	-2047592.32698	2086766.68994	0	0	0	0
15	20	552	42	6900.079099	-2048301 73572	2086601.77445	0	0	0	0
15	21	553	43	37411.72331	-2048166.15521	2086558.33328	0	0	0	0
15	22	554	44	40000	-2047971.286	2086552.955	0	0	0	0
15	23	555	45	40000	-2047771 286	2086552.955	0	0	0	0
15	24	556	46	14467 98253	-2047633.97388	2086551 6672	0	0	0	0
16	21	591	47	2698 561615	-2048130.06859	2086440.29925	0	0	0	0
16	22	592	48	15999.48123	-2047959.14525	2086410.10599	0	0	0	0
16	23	593	49	13234.81290	-2047782.37775	2086418.56454	0	0	0	0
16	24	594	50	587.196198	-2047658.51375	2086442.73847	0	0	0	0
11	13	393	51	40000.00000	-2049771.286	2087352.955	0	0	0	0
11	14	394	52	38748.95295	-2049574.01631	2087350.30799	0	0	0	0
11	15	395	53	9126.474786	-2049429.60108	2087301.60822	0	0	0	0
12	11	429	54	38166 35922	-2050166.7019	2087152.955	0	0	0	0
12	12	430	55	40000	-2049971.286	2087152.955	0	0	0	0
12	13	431	56	40000.00000	-2049771 286	2087152.955	0	0	0	0
12	14	432	57	40000	-2049571.286	2087152.955	0	0	0	0
12	15	433	6,9,	34140 25204	.2049384 59483	2087145 80507	0	n	n	0

Gvrcellid is the MODFLOW cell id (SEQNUM) which corresponds to the GVR. Set gvrcellid =

SEQNUM using the Field Calculator.

jelds:	Туре:	Functions:
FID AREA HRU_ID AREA_1 PERIMETER ROW COL SEQNUM GRV_ID GVR_AREA X Y	▲ © <u>N</u> umber © String © <u>D</u> ate	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sqr() * / & + - =
[SEQNUM]	A	Load Save Help
Calculate selected records only	<u>.</u>	ОК

Gvrhruid is the PRMS HRU id (HRU_ID) which corresponds to the GVR. Set gvrhruid = HRU_ID

using the Field Calculator.

jelds:	Туре:	Functions:
FID AREA HRU_ID AREA_1 PERIMETER ROW COL SEQNUM GRV_ID GVR_AREA X Y	▲ © Number C String C Date	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sin() * / &
gyrhruid =	Advanced	+ - =
[HRU_ID]		Load Save Help
☐ Calculate selected records only	X	OK Cancel

Gvrcellpct is the decimal fraction that the GVR area covers the MODFLOW cell area. Set gvrcellpct = GVR_AREA / AREA_1 using the Field Calculator. AREA_1 is the area of the MODFLOW cell (40,000 meters2)

Fields:	Type:	Eunctions:
FID AREA HRU_ID AREA_1 PERIMETER ROW COL SEQNUM GRV_ID GVR_AREA X Y gvrcellpct = [GVR_AREA]/ [AREA_1]	Advanced	Abs() Atn() Cos() Exp() Fix() Int() Log() Sin() Sqr() * + Load Save Help
	-	ОК
Calculate selected records only		Cancel

Gvrhrupct is the decimal fraction that the GVR area covers the PRMS HRU area. Set gvrhrupct =

GVR_AREA / AREA using the Field Calculator. AREA is the area of the HRU.

Jeius,	Туре:	Functions:
FID AREA HRU_ID AREA_1 PERIMETER ROW COL SEQNUM GRV_ID GVR_AREA X Y jvrhrupct = [GVR_AREA]/ [AREA]	Advanced	Abs() ▲ Atn() ▲ Cos() Exp() Fix() Int() Log() Sin() Sin() ▼ / & + - Load Save Help

The gvrs shapefile attribute table should look like this when finished.

		WER PREM	Case in 1	SECONOM	COL	ROW	AREA_1	HHO ID	ANCA
206 1 3550.47602 286 3 0.088762 0.002493	286 3 0.088762	3550.47602	1	206	20	8	40000	- 3	1423994.74586
287 2 14011.580731 287 3 0.35029 0.00964	287 3 0.35029	14011.580731	2	287	21	8	40000	3	1423994.74586
266 3 3114.449312 288 3 0.077661 0.002167	288 3 0.077661	3114.449312	3	268	22	8	40000	3	1423994 74586
323 4 37791.54158 323 3 0.944789 0.026539	323 3 0.944789	37791.54158	4	323	19	9	40000	3	1423994.74586
324 5 39771.097609 324 3 0.994277 0.027929	324 3 0.994277	39771.097609	5	324	20	9	40000	3	1423994.74586
325 6 40000 325 3 1 0.02809	325 3 1	40000	6	325	21	9	40000	3	1423994.74588
328 7 33827.820552 326 3 0.845698 0.023756	326 3 0.845696	33827.820552	7	326	22	9	40000	3	1423994.74586
327 8 4672.629409 327 3 0.116816 0.003281	327 3 0.116816	4672.628409	8	327	23	9	40000	3	1423994.74586
360 9 21.056495 360 3 0.000528 0.000015	360 3 0.000526	21.056495	9	360	18	10	40000	3	1423994.74586
361 10 39682,752651 361 3 0,992069 0,027867	361 3 0.992069	39682.752651	10	361	19	10	40000	3	1423994.74586
362 11 40000.000001 362 3 1 0.02809	362 3 1	40000.000001	11	362	20	10	40000	3	1423994 74586
363 12 40000,000001 363 3 1 0,02009	363 3 1	40000.000001	12	363	21	10	40000	3	1423994.74586
364 13 40000.000001 364 3 1 0.02809	364 3 1	40000.000001	13	364	22	10	40000	3	1423994.74586
365 14 35406.954269 365 3 0.885174 0.024865	365 3 0.885174	35406.954269	14	365	23	10	40000	3	1423994.74586
366 15 6264 37914 366 3 0.156609 0.004399	366 3 0.156609	6264 37914	15	366	24	10	40000	3	1423994.74586
399 16 36699.306204 399 3 0.967463 0.027177	399 3 0.967483	39699.308204	16	399	19	11	40000	3	1423994.74586
400 17 40000 400 3 1 0.02909	400 3 1	40000	17	400	20	11	40000	3	1423994.74588
404 40 4000 400 1 4 4000	401 3 1	40000	18	401	21	11	4/10/10	3	142399474586

After this information has been created, save the Sagehen ArcMap project by clicking File->Save.

Making the PRMS Parameter File

Dimension sizes

Start the paramtool by double-clicking on classProblem\paramtool.bat

Set the Dimension Sizes as follows. For this problem, always click on Default when asked about Resize

Dimension:

Copy + - X / All Columns	Rows	Report	Difference	Compare to Defaults	Describe
].\data\sagehen.param			Dimen	sion Size	
- Dimension Sizes	ngv	vcell		1292	-
Parameter Values by Dime	nd	ays		366	
Talameter values by Dime	nhrucell			923	
- D ncascade	nr	ain	1	2	
— 🗋 ndepival	nte	mp		2	
- naw	0	ne	1	1	
D phru	ncas	cade		15	
	ng	gw		15	
	nst	fres	1	0	
- 🗋 nhrucell	nł	nru	1	15	
- 🗋 nmonths	nseg	ment		15	
- 🗋 nsegment	nde	plval		22	
	ncas	cdgw	1	15	
L hssr	no	bs		1	
- 🗋 ntemp	nla	pse		3	
- 🗋 one	nmo	onths		12	
	nfo	m		0	
	nsi	now		0	
	mxr	ISOS		0	
	nd	epl		2	
	nob	ifunc		5	
	ns	sol		0	
	ne	vap		0	
	ns	sr		15	
	nre	ach	16	116	
	1		4		*

This step is setting the dimension sizes (array sizes) in the PRMS modules. To find out what these dimensions are, left-click in a table cell (select it) and then click on the Describe button in the tool bar.

Click on the menu item File->Save when finished. Remember that all edit made in the paramtool tables must be saved to the Parameter File for the edits to take effect when the model runs.

Spatial parameters

Transfer the spatial attributes developed in section 4 to the PRMS Parameter File.

HRU parameters

Start the paramtool by double-clicking on classProblem\paramtool.bat. Click on Parameter

Values by Dimension->nhru in the paramtool tree.

Copy + - X / All Column	IS Rows	Report	Difference	Compare to Defaults	Desc	ribe
C:/markstro/gsflowTraining200		carea_	max	cov_type		
Dimension Sizes	1		0.6	Server the total of the	3	
Parameter Values by Dime	2		0.6		3	
- ncascade	3		0.6		3	_
Badashal	4		0.6		3	_
D ndepival	5		0.6		3	_
- ngw	0		0.6		3	_
- 🗋 nhru	0		0.0		3	-
🔶 🛄 nhru,nmonths	0		0.0		3	-
nhrucell	10		0.0		3	-
- D pmonths	11		0.6		3	
D neogmont	12		0.6		3	
L IIsegment	13		0.6		3	
- D nssr	14		0.6		3	
- 🗋 ntemp	15		0.6		3	

Open the gis\shapes\hrus.dbf in excel. This file contains all of the attribute values that were derived for the gis\shapes\hrus shapefile.

REALLY IMPORTANT: Sort the excel worksheet in ascending order on the HRU_ID column (not the ID column). This will insure that that spatial attributes will be pasted into the PRMS Parameter File in the correct order.

It is also REALLY IMPORTANT that these .dbf files are not save from excel after the content is sorted.

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Column			Sort On		Order	
Sort by	HRU_ID	•	Values	*	Smallest to Largest	-
					ок	Cancel

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	Al	+ (. Je	ID							-	8
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1	ID:	GRIDCODE	AREA	and the second second	HRU_ID	ĸ	Y		cov_type	covden_sum	covden_win	sm_max
2	(6 1	3353375.5	2332000000	1	-2045719.34135000	000 2087725.00	48000000	4	100.00000000000	99.99462127690	4,17599
3		4 2	2793924.6	6238000000	2	-2047130.90382000	000 2087632.150	400000000	4	99.57431030270	99.45342254640	4.17599
4		2 3	1423994.7	4586000000	3	-2048078.65288000	0000 2087158.867	708000000	4	99.61239624020	99.93697357180	4.17599
5	1	1 4	1750602.3	7939000000	. 4	-2050003.32286000	000 2086738.243	15000000	4	99.85205841060	99.76844024660	3.62754
6		5 5	959221.0	3197200000	5	-2048976.96429000	000 2086878.900	31000000	4	99.00108934330	100.0000000000	4.02029
7	15	5 6	4754057.9	3517000000	6	-2049196.11844000	000 2085003.419	49000000	4	100.00000000000	99.81844329830	3.53424
	1	4. 7	2500128.6	9838000000	7	-2050865.38108000	000 2085715.898	000000000	4	99.99549865720	100.0000000000	2.93389
2	1	2 8	953502.5	0702300000	0	-2047311.99535000	1000 2085976.691	1200000000	4	100.0000000000	100.0000000000	4.17599
10	1	7 9	2097563.5	0198000800	9	-2047751.82941000	000 2084828.29	95000000	4	99.78924560550	97.57132720950	4.15664
11	11	1 10	988378.1	1438700000	10	-2046384.28668000	000 2086424.850	60000000	4	100.00000000000	100.0000000000	4.17599
12	-10	6 11	1621637.1	1313000000	11	-2046848.48841000	000 2084656.840	12000000	4	100.00000000000	99.01527404790	4.17599
12		9 12	465801.4	1732400000	12	-2046096.56568000	000 2085800.67	13000000	4	100.00000000000	100.0000000000	4.17599
14	10	0 13	494263.9	7085300000	19	-2045605.90919000	000 2085541.821	52000000	4	100.00000000000	100.0000000000	4.17599
15	1	3 14	219446.4	7814000000	14	-2045199.72958000	000 2085448.165	54000000	4	100.00000000000	100.0000000000	4.17599
16	10	15	2982956.7	1879000000	15	-2046005.03156000	000 2083966.723	66000000	4	92.15986633300	08.91464996340	4.17599
17	+ = brus		-		_			-				
Reb	dy .	-					Avera	pe: 74629	Count: 488	Sum: 27982672	107 C 107 C	1 0

Copy the attributes values, column by column, out of excel and into the appropriate column in the paramtool using cut and paste (ctrl-c and ctrl-v). There are 18 HRU parameters to transfer over:

1. cov_type

- 2. covden_sum (divide by 100 if needed needs to be decimal fraction, not percent)
- 3. covden_win (divide by 100 if needed needs to be decimal fraction, not percent)
- 4. hru_area (use the values in acres, not m2)
- 5. hru_aspect
- 6. hru_elev
- 7. hru_slope
- 8. jh_coef_hru
- 9. rad_trncf
- 10. snow_intcp (divide by 100 needs to be decimal fraction, not percent)
- 11. soil_moist_max
- 12. soil_rech_max
- 13. soil_type
- 14. srain_intcp (divide by 100 if needed)
- 15. tmax_adj
- 16. tmin_adj
- 17. wrain_intcp (divide by 100 if needed)

Open the gis\shapes\hru_centoid_project.dbf in excel.

18. hru_lat - this in the Y coordinate of the HRU in geographical coordinates (Don't forget to sort them by HRU_ID)

Parameters that come from the Gravity Reservoir (gis\shapes\gvrs.dbf) map and go into the nhrucell dimension

Use excel to open the gis\shapes\gvrs.dbf file. Sort the columns on GVR_ID. In the paramtool, click on Parameter Values by Dimension->nhrucell.

- 1. Find the column gvrcellid in excel. Copy and paste the values into the gvr_cell_id column in the paramtool table.
- Find the column gvrcellpct in excel. Copy and paste the values into the gvr_cell_pct column in the paramtool table.
- 3. Find the column gvrhruid in excel. Copy and paste the values into the gvr_hru_id column in the paramtool table.
- 4. Find the column gvrhrupct in excel. Copy and paste the values into the gvr_hru_pct column in the paramtool table.

Copy + - X / All Columns Roy	vs Re	eport Diffe	rence	Compare t	o Defaults	Descri	be	
C/markstro/gsflowTraining2009/class Dimension Sizes Parameter Values by Dimension ncascade ndepival nru nhru nhru nhru nhru nhru nhru nhru	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	gvr_cell_ic 20 20 20 20 20 20 20 20 20 20 20 20 20	gyr 36 37 38 23 24 25 26 27 30 31 32 33 34 45 55 56 66 99 10 11 12 12 12 13 15 15 15 15 15 15 15 15 15 15	cell_pct 0.089 0.35 0.078 0.945 0.994 1 0.846 0.117 0.001 0.992 1 1 1 0.885 0.157 0.967 1 1	gvr_hru_	Id g 286 287 288 323 324 325 326 327 360 1 361 362 363 364 365 366 399 400 401 402	vr_hru_pct 0.002 0.01 0.002 0.027 0.028 0.028 0.028 0.024 0.003 478692E-5 0.028 0	
		4()3	1		403 404	0.028	
	22 23	4:	87 88	0.942		437 438	0.026	
	24	43	39 10	1	_	439	0.028	

To find out what these parameters are, left-click in a table cell (select it) and then click on the Describe button in the tool bar.

Click on the menu item File->Save when finished. Remember that all edit made in the paramtool tables must be saved to the Parameter File for the edits to take effect when the model runs.

Cascade parameters

Normally the cascade parameters (click on Parameter Values by Dimension->ncascade in paramtool) would come from GIS (or other analysis). At this time, the current methods for doing this GIS analysis are beyond a reasonable exercise for this class. Because of the way that the HRU and stream segment IDs were were assigned, it will be quite easy to do this by hand.

Set all the values (15 of them) in the hru_down_id column to the value 0. Because of the way that the HRUs were delineated, all of them drain (cascade) into stream segments (not HRUs).

Set all of the values in the hru_pct_up column to the value 1. This is because there is only one cascade coming from each HRU and all of the area from the HRU contributes to each the cascade.

Set the values in the hru_strmseg_down_id column to be the cascade number: 1 for row 1, 2 for row 2, 3 for row 3, etc. all the way to 15. This is because there is only one destination for each cascade, and it is the stream segment with the ID corresponding to the cascade ID.

Copy the values from the hru_strmseg_down_id column to the hru_up_id column. In the example problem, each cascade connects the corresponding HRU to the corresponding stream segment.

C:/markstro/gsflow/Training2009/class hru_down_id hru_pct_up hru_strmseg_down_id hru_up_id Dimension Sizes 1 0 1 1 1 1 Parameter Values by Dimension neascade 3 0 1 2 3 0 1 3 3 Image: Dimension Sizes 0 1 0 1 <th>Copy + - X / All Columns Ro</th> <th>ws</th> <th>Report</th> <th>Differe</th> <th>ence Compa</th> <th>are to Defaults</th> <th>Describe</th> <th></th>	Copy + - X / All Columns Ro	ws	Report	Differe	ence Compa	are to Defaults	Describe	
Dimension Sizes Parameter Values by Dimension ncascade ndeplval ngw nhru negment nssr nemp one	C:/markstro/gsflowTraining2009/clase		hru_do	wn_id 0	hru_pct_up	hru_strmseg	_down_id	hru_up_id
Parameter values by Dimension nesscade ndeplval ngw nhru ningw	Dimension Sizes	2		0	1		2	
Acascade 4 0 1 4 4 Indeptval 5 0 1 5 6 Ingw 6 0 1 6 6 Inhru 7 0 1 7 1 Inhru 8 0 1 8 6 Inhru, nmonths 9 0 1 9 9 Inhrucell 10 0 1 10 10 Inmonths 11 0 1 11 11 Insegment 12 0 1 13 15 Intemp 16 0 1 14 14 Intemp 15 15 15 15	Parameter values by Dimension	3		0	1		3	3
ndeptval 5 0 1 5 6 ngw 6 0 1 6 6 nhru 7 0 1 7 1 nhru,nmonths 9 0 1 9 9 nhrucell 10 0 1 10 10 nmonths 11 0 1 11 11 nsegment 12 0 1 13 13 nssr 14 0 1 15 15 15 one 0 1 15 15 15 15	ncascade	4		0	1		4	4
ngw 6 0 1 0 0 nhru 7 0 1 7 1 nhru, nmonths 9 0 1 8 0 nhrucell 10 0 1 10 10 nmonths 11 0 1 11 11 nsegment 12 0 1 13 13 nssr 14 0 1 15 15 one 0 1 15 15 15	- D ndepival	5	-	0	1		5	
Image: New part of the second seco	ngw	<u>b</u> 7	-	0	1		7	
[•] Intrunmonths [•] O <td>hhru</td> <td>8</td> <td>-</td> <td>0</td> <td>1</td> <td></td> <td>8</td> <td></td>	hhru	8	-	0	1		8	
Important Important <thimportant< th=""> <thimportant< th=""> <thi< td=""><td>← 🛄 nhru,nmonths</td><td>9</td><td></td><td>0</td><td>1</td><td></td><td>9</td><td></td></thi<></thimportant<></thimportant<>	← 🛄 nhru,nmonths	9		0	1		9	
Immonths II II II III IIII IIIII IIIII IIIII IIIIIIIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	- 🗋 nhrucell	10		0	1		10	1(
Insegment 12 13 12 13 Inser 13 0 1 13 13 Intemp 14 0 1 14 14 Intemp 15 15 15 15	- 🗋 nmonths	11		0	1		11	11
Image: Construction of the second s	nsegment nssr			0	1		12	12
D ntemp D one			3	0	1		13	13
	- D ntemp	14		0	1		14	14
	- D one		9					

Remember that this only works out this way because of the simple way that HRUs and stream segments were developed for this problem.

Repeat the instructions above for the ground water cascade parameters (click on Parameter Values by Dimension->ncascadgw in paramtool). These parameters describe how PRMS routes groundwater from HRU to HRU to streams. Usually these should be set to the same as the surface cascades. If your PRMS model has swales or lakes, you will need to set these different. In the class problem, used the same routing scheme as the surface parameters (ncascade).

Click on the menu item File->Save when finished. Remember that all edit made in the paramtool tables must be saved to the Parameter File for the edits to take effect when the model runs.

Non-spatial parameters

By nhru (click on Parameter Values by Dimension->nhru in paramtool):

- hru_psta set all of these to "1". This means that the "base" precipitation station is the first one (Independence Lake SNOTEL) specified in the Data File.
- hru_plaps set all of these to "2". This means that the "lapse" precipitation station is the second one (Sagehen COOP) specified in the Data File.
- 3. hru_tsta set all of these to "1". This means that the "base" temperature station is the first one (Independence Lake SNOTEL) specified in the Data File.
- hru_tlaps set all of these to "2". This means that the "lapse" temperature station is the second one (Sagehen COOP) specified in the Data File.

By nrain (click on Parameter Values by Dimension->nrain in paramtool):

psta_elev Independence Lake SNOTEL (index = 1) is at 2576 meters. Sagehen COOP (index = 2) is at 1932 meters. Make sure that these units match the units used for parameter hru_elev. The units are meters in the example problem.

By ntemp (click on Parameter Values by Dimension->ntemp in paramtool):

tsta_elev Independence Lake SNOTEL (index = 1) is at 2576 meters. Sagehen COOP (index = 2) is at

1932 meters. Make sure that these units match the units used for parameter hru_elev. The units are

meters in the example problem.

By nrain,nmonths (click on Parameter Values by Dimension->nrain,nmonth in paramtool):

pmn_mo These are the mean monthly precipitation on days with precipitation (storm size) for

Independence Lake SNOTEL (index = 1) and Sagehen COOP (index = 2).

These values (calculated according to Step 2.2) are in the excel file sagehenLapseRates.xls. Copy and paste them into the pmn_mo table using the paramtool.

Copy + X / All Columns Rows Report Difference Compare to Defaults Describe Input/sagehen param 1 2 3 4 5 8 7 8 9 10 11 12 Dimension Sizes - - 0.577 0.574 0.502 0.233 0.204 0.214 0.262 0.402 0.529 0.582 Parameter Values b - - - 0.522 0.543 0.239 0.228 0.166 0.156 0.174 0.293 0.306 0.508 0.485 - neascade - neascady -	sagehen.param e Reset Help	_												-0	2
Input/sagehen.param Dimension Sizes Parameter Values bi Image: Constraint of the second secon	Copy + - X	All	Columns	Rows	Report	Difference	Compar	e to Defaults	Descri	be					
	Input/sagehens Dimension Si Dimension Si Parameter Va ncascade ncascdgw ndepival ngw nhru nhrucell nrain padi_s padi_r nssr nssr neemp one	nths nth n		1 1.577	2 0.574 0.522	3 4 0.503 0 0.543 0	4 1322 1 1323 1	5 6 0.233 0.2 0.228 0.1	7040.2	8 14 0.254 56 0.174	9 0.362 0.293	10 0.402 0.386	11 0 529 0 508	12 0.582 0.485	

Click on the menu item File->Save when finished. Remember that all edit made in the paramtool tables must be saved to the Parameter File for the edits to take effect when the model runs.

Making the MODFLOW Files

Create the MODFLOW Grid Cell map (ModelMuse method)

- 1. Open ModelMuse
- 2. Choose New Modflow Model
- 3. Set data for MODFLOW Grid:

X origin = -2052271.286

Y origin = 2089452.995

This origin is determined from ARC, and is the upper left corner of the model domain in ModelMuse.

🕮 Initial Grid	l.					
Specify init	tial grid (optional)					
38	Number of columns	200	Column width	Layer group name	Bottom elevation	
34	Number of rows	200	Row width	Model_Top	0	
Eat				Upper Aquifer	-10	
2052271	X 0 Grid a Y Vertica	ngle (degre al exagger	ees) ation			
1				? Help X No	ogrid Fi	inish 🔶

Select MODFLOW packages

- 1. Choose "Model|Modflow packages and programs"
- 2. Select "LPF: Layer Property Flow"

MODFLOW Packages					
○ Flow IPF: Layer Prop	LPF: Layer Property Flow packa Comments	ge			~
 Boundary conditions Specified head 					2
Specified flux Head-dependent flu DRN: Drain pc	Use cell thickness to compute (CONSTANTCV)	vertical c	onductan	ce in unconfined	d cells
- DRT: Drain Re	Use starting head to compute (THICKSTRT)	cell thickr	ness in se	lected confined	cells
- EVT: Evapotra	CUse vertical conductance corr	ection (inv	verse of N	IOCVCORREC	TION)
-⊢ GHB: General -⊢ LAK: Lake pa -⊢ RES: Reservo	Lico vortical flow correction un		torod con	ditions liminero	
- I RIV: River pac - I - SFR: Stream-I	-HANI (horizontal anisotropy) -VK (vertical hydraulic conductiv		Value 0	🗖 Use Zone	E Use Multiplier
Solvers − € PCG: Precondition	VANI (vertical anisotropy)	Name	Value	Use Zone	Use Multiplier
- C GMG: Geometric	-SS (specific storage)				
C SIP: Strongly Imp	VKCB (vertical hydraulic condu				
 Observations 					>
MODPATH		0	Number (of HK paramete	rs × Delete
		?	Help	✓ OK	X Cancel

- 3. Select "UZF: Unsaturated-Zone Flow"
- 4. Choose "Use vertical hydraulic conductivity from flow package"
- 5. Change "NSETS2" to 40
- 6. Remove check from "Simulate evapotranspiration"
- 7. Add check to "Print summary UZF budget terms"

8 MODFLOW Packages	
Flow CLPF: Layer Prop HFB: Horizontal F	UZF: Unsaturated-Zone Flow package Comments
Boundary conditions Solvers Observations MODPATH	
	Recharge and discharge location option (NUZTOP)
	Use vertical hydraulic conductivity from flow package
TOTAL STATE	Number of trailing waves (NTRAIL2)
	Number of wave sets (NSETS2) 40
	 Route discharge to streams and lakes (IRUNFLG) Simulate evapotranspiration (IETFLG)
<	The average height of undulations, D (Figure 1), in the land surface altitude
	? Help VK X Cancel

- 8. Select "Boundary conditions|Head-dependent flux|SFR: Streamflow-Routing"
- 9. Include "Unsaturated Flow" beneath streams
- 10. Add check to "Print Streams"

MODFLOW Packages						
Flow C LPF: Layer Prop T HFB: Horizontal F	SFR: Stre	eam-Flow Routing pack ts	kage			
 Boundary conditions Specified head Specified flux Head-dependent flu 						
⊢ DRN: Drain pa DRT: Drain Re T DRT: Drain Re T ETS: Evapotra T EVT: Evapotra GHB: General T LAK: Lake pa	♥ Unsatura ♥ Print Str Streambe ♥ Specify ♥ Specify	ated Flow (ISFROPT) eams (ISTCB2) ed properties (ISFROP y some streambed prop y some streambed prop	 LPF hydraulic c T) Derties using segmenties by reach (can 	onductivites us nt endpoints 't inactivate stre	ed (ISFROPT) eams)	
RES. Reservo	0.0001	Tolerance (L^3/T)	(DLEAK)			
SFR. Stream-I	10	Number of trailing	wave increments (NS	STRAIL)		
Solvers	30	Maximum number	of trailing waves (NS	FRSETS)		
Observations MODPATH	10	10 Maximum number of cells to define unsaturated zone (ISUZN)				
	□ Use transient streamflow routing with kinematic-wave equation (IRTFLG)					
	1	Number of division	is per time step for ki	nematic waves	(NUMTIM)	
	1	Time weighting fac	tor for the kinematic	wave solution (WEIGHT)	
<	0.0001	Closure criterion fo	or the kinematic wave	solution (FLW	TOL)	
			? Help	✔ ОК	X Cancel	

11. Select "PCG: Preconditioned Conjugate Gradient" and type values as shown below.

MODFLOW Packages				
 Flow Boundary conditions Solvers 	PCG: Preconditioned Conjugate Gradient pac Comments	kage		
C GMG: Geometric G GMG: Geometric G SIP: Strongly Imp C DE4: Direct Solv				
 Observations MODPATH 		<u></u>		
	Max. number of outer iterations (MXITER):	400		
	Max. number of inner iterations (ITER1).	200		
	Matrix preconditioning method (NPCOND):	Modified incomplete Cholesky (1) 💌		
	Max. abs. change in head (HCLOSE):	0.005		
	Max. abs. residual (RCLOSE):	0.005		
	Relaxation parameter (RELAX):	1		
	Upper bound of the max. eigenvalue (NBPOL)	Calculated (1)		
	Printout interval (IPRPCG):	1		
	Printing control (MUTPCG):	Solver information (0)		
	Steady-state damping factor (DAMPPCG):	0.1		
< >>	Transient damping factor (DAMPPCGT):	0.97		
	? <u>H</u> e	lp VOK X Cancel		

Set MODFLOW Output Control

- 1. Select "Model|Modflow Output Control"
- 2. Unselect "Compact Budget"

8 MODFLOW Outp	ut Control		
- General - Head - Drawdown - Budget	Budget Compact bu Frequency	ıdqet	
	First N times s	teps and each N't	n time step thereafter 💌
	N = 1 ♣		
	C None	 Binary 	C Listing
		? <u>H</u> elp	VOK X Cancel

Set MODFLOW Units and Other Options

- 1. Select "Model|Modflow Time"
- 2. Set # of stress periods = 2
- 3. Choose "days (4)" for "ITMUNI"
- 4. First stress period -1 to 0
- 5. Second stress period 0 to 300

			Length	Max first time step length	Multiplier	Steady State/ Transient		
			Ö	Ô	Ô	Y		
Stress period	Starting time	Ending time	Length	Max first time step length	Multiplier	Steady State/ Transient	Drawdown reference	Number of steps (calculated)
1	-1	0	1	1	1	Steady state	R	1
2	0	300	300	1	1	Transient	E .	300

6. Select "Model|Modflow Options"

7. Set "LENUNI" = "meters (2)"

B MODFLOW Options			<
Description Options	Wetting		
Basic package option Calculate flow betw Print the start time,	is veen adjacent constant-h end time, and elapsed t	nead cells (CHTOCH) time (PRINTTIME)	
Head value for inactive	cells (HNOFLO)	Length unit (LENUNI)	
-1E20		meters (2)	
Head value for cells that	t become dry (HDRY)	Time unit (ITMUNI)	
-2E20		days (4) 💌	
Copen listing file in te	xt editor when model is a	done	
	? <u>H</u> elp	VOK X Cancel	

- 8. Continue with: "Model|Modflow Options"
- 9. Add check mark to "Wetting Active"

MODFLOW Options	
Description Options Wetting	
Wetting active Wetting Factor (WETFCT) Il Iterations to check for wetting cells (IWETIT) Equation for Rewetting Cells (IHDWET)	
h = BOT + WETFCT (hh-BOT) (0)	
? Help ✔ OK ≯	Cancel

- 10. Select "Model|Modflow Layer Groups"
- 11. Make LAYTYP convertible

😹 MODFLOW Layer G	roups 📃 🗖 🔀					
Upper Aquifer	Basics Discretization					
Midale Aquifer	Layer Group (Aquifer) Name					
	Upper Aquifer					
Layer type						
	Convertible Compute saturated thickness using starting head					
	Method of calculating interblock transmissivity					
	Harmonic mean (0)					
	Method of specifying vertical hydraulic conductivity					
	Vertical hydraulic conductivity (0)					
	? Help ✔ OK ¥ Cancel					

Importing Shapefiles in ModelMuse

1. Select: "File|Import|Shapefiles"



2. Import "mfcells.shp"

Open a Shapefi	ile			? 🔀
Open a Shapefi Look jn: Wy Recent Documents Desktop	ile Shapefiles_: gvrs.shp hrus.shp mfcells.shp strseg.shp	agehen		
My Documents My Computer My Network Places	File <u>n</u> ame: Files of <u>type</u> :	mfcells.shp Shape Files (*.shp)	·	<u>Open</u> Cancel

- 3. Choose "Options" Tab
- 4. Select "import shapes as Objects"
- 5. Choose "Set Values to Intersected Cells"

😻 Import Shapefile - V	V:\GSFLOW_training\2009\	Shapefiles_sagehen\mfce	lls.shp		
Options Data C	oordinate Conversion				
Import shapes a	s objects	Evaluated at	-		
□ Set values of en	closed cells	@ Cells			
Set values of interest	ersected cells	C Cell comer			
F Set values of cel	Is by interpolation				
F Import grid					
Import criterion	True				Edit F()
Import shapes as	a single, multipart obje	ect 🔹			
Imported shapes sl	hould be visible but no	ot selected ·			
Associated third-d	imension formulas				
C Zero	One C Two				
Z-coordinate	0				Edit F()
Higher Z-coordinate	0				Edit F()
Lower Z-coordinate	0				Edit F()
	1				
Number of shapes	= 1292		7 Help	✓ OK	X Cancel

- 6. Select "Data" Tab
- 7. Add check to "ALT", "PRECIP", "ACTIVE", and "IRUNBND"

🛿 Import Shapef	ile - W:VGS	SFLOW_training\200	19\Shapefiles_sageher	Nmfcells.shp		
Options Data	Coord	linate Conversion				
Attribute	Import	Data Set	Interpolation			
AREA	1	New data set	None			
PERIMETER		New data set	None			
MF3 POL	E.	New data set	None			
MF3 POL ID	0	New data set	None			
ROW		New data set	None			
COL		New data set	None			
SEQNUM		New data set	None			
X		New data set	None			
Y		New data set	None			
ALT	R	New data set	None			
PRECIP	R	New data set	None			
ACTIVE	R	New data set	None			
IRUNBND	1	New data set	None			
Select All	Sel	ect None T	oggle			
Number of sha	pes = 12	92		? Help	✓ ok	X Cancel

8. Import "strseg.shp"

Open a Shapef	ile				2 🛛
Upen a Shaper Look jrc My Recent Documents Desktop My Documents My Documents	Shapefiles gws.shp hrus.shp mfcells.shp strseg.shp	sagehen	+ 6 0	÷	
My Network Places	File game: Files of type:	straeg shp Shape Files (*.shp)	2		Open Cancel

- 9. Select "Import Shapes as Separate Objects"
- 10. Select "set values of intersected cells"
| 🗃 Import Shapefile - V | V:\GSFLOW_training\2009 | \Shapefiles_sagehen\strseg.sh | P | |
|---|---------------------------------|-------------------------------|---|----------|
| Options Data Fe | eatures Coordinate Co | nversion | - | |
| Import shapes as | s objects | Evaluated at | | |
| Set values of er Set values of inter | rclosed cells
ersected cells | Cell comers | | |
| E Set values of cel | ls by interpolation | | | |
| F Import grid | | | | |
| Import criterion | True | | | Edit F() |
| Import shapes as | separate objects | - | | |
| Imported shapes sh
Associated third-d | nould be visible but n | ot selected 💌 | | |
| Zero C | One C Two | | | |
| Z-coordinate | 0.5 | | | EditF() |
| Higher Z-coordinate | 0 | | | EditF() |
| Lower Z-coordinate | 0 | | | EditF() |
| | | | | |

- 11. Select "Data" Tab
- 12. Add check mark to "ID"

Import Shapefil	e - W:VGSF	LOW_training\200	9\Shapefiles_sageh	en\strseg.shp		
Options Data	Feature	s Coordinate C	Conversion			
Attribute	Import	Data Set	Interpolation			
ARCID		New data set	None			
GRID CODE		New data set	None			
FROM NODE		New data set	None			
TO NODE	0	New data set	None			
ID	R	New data set	None			
O SEGMENT	F	New data set	None			
Select All	Sele	ct None T	oggle			
blumber of obor				O Links	101	- Connect
Number of shap	es = 15			3 Felb	✓ OK	X Cancel

13. "Features" tab: Define segment #s time data and ICALC (scroll to right)

SER. Stream-FIO	w Routing packag	e <u> </u>	Feature choice	2 🔹 Number	oftimes
Starting time	Ending time	ICALC	Outflow Segments	Diversion Segments	IPRIOR
.1	0	1			
D	300	1			
the second second second second second second second second second second second second second second second se	ac 🔟	•	Streambed top (STRTC	P) STRTHICK) [1	
Segment numbe	CHILENS Object	IDEORCO.CH O		STPCIPIL PLI	

- 14. Import "spring.shp"
- 15. Check "Import Shapes as Objects"
- 16. Check "Set values to intersected cells"

Import shapes a	s objects	Evaluated at	
F Set values of er	nclosed cells	P Cell	
F Set values of inte	ersected cells	Cell comers	
 Set values of cel Import grid 	Is by interpolation		
Import criterion	True		Edit F()
	F		
Import shapes as	separate objects		
Import shapes as Imported shapes sl	hould be visible but n	ot selected	
Import shapes as Imported shapes sl Associated third-d	hould be visible but n hould be visible but n imension formulas	ot selected	
Import shapes as Imported shapes shapes shapes shapes and third-d @ Zero C	iseparate objects hould be visible but n imension formulas One Two	ot selected	
Import shapes as Imported shapes al Associated third-d & Zero Coordinate	iseparate objects hould be visible but n imension formulas One C Two	ot selected	Edt F().
Import shapes as Imported shapes al Associated third-d Coordinate Higher Z-coordinate	inersion formulas One	ot selected	EdtF(). EdtF()
Import shapes as Imported shapes al Associated third-d Coordinate Higher Z-coordinate Lover Z-coordinate	iseparate objects hould be visible but n imension formulas One Two	ot selected	EdtF(). EdtF() EdtF()
Import shapes as Imported shapes al Associated third-d Coordinate Figher 2-coordinate Lover 2-coordinate	iseparate objects hould be visible but n imension formulas One CTwo	ot selected	EditF(). EditF() EditF()
Import shapes as Imported shapes al Associated third-d Coordinate Higher Z-coordinate Lower Z-coordinate	imension formulas One Two	ot selected	EdtF() EdtF() EdtF()
Import shapes as Imported shapes al Associated third-d rezero C Z-coordinate Higher Z-coordinate Lower Z-coordinate	Separate objects hould be visible but n imension formulas One Two	ot selected	Edit F() Edit F() Edit F()

- 17. Choose "Data" tab
- 18. Check "ID", which will become "ID2" because ID is already a data set.

🛛 Import S	hapefile	W:VGSFLOW_train	ing\2009\Shapefile	s_sagehen\sprin	g.shp		
Options	Data F	eatures Coord	linate Conversion				
Attribute	Import	Data Set	Interpolation				
ID	1	New data set	None				
LONG83	0	New data set	None				
LAT83	0.	New data set	None				
Selec	t All	Select None	Toggle				
Number of	of shapes	s = 6			P Help	√ OK	X Cancel

Create Point Objects for Cells with Springs

- 19. Select "Object|Select Object by Name"
- 20. Choose "Select none"
- 21. Select all spring objects
- 22. Select "Create Point Object"



- 23. Select each cell with a Springs in it.
- 24. Add check to UZF gages (Print volumes and rates)

🕴 Object Properties						
Properties Data Sets MC	DDFLOW Fe	atures	Vertices			
F SFR: Stream-Flow R			UZF: Unsatu	rated-Zone Flow packag	је	
GAGE: for SFR Stret GAGE: for SFR Stret GZF Unsaturated-Zc		1	Formula			
	Starting E time	Ending time	Infiltration rate			
		imber of	times		· Insert	×Delete
	Print tim cumulati Also print print tim series o	ie, grour ve volur nt rates ie, grour f depths	nd-water head, a nes nd-water head, th and water conte	nd thickness of unsatura nickness of unsaturated : ents in the unsaturated zo	ited zone, ar zone, followe	nd ed by a
				? Help	• ок	X Cancel

Add Additional Springs not Mapped on Topo Map

- 25. Select "Create Point Object"
- 26. Select anywhere on map
- 27. Select "Vertices" tab, and enter in UTM coordinates shown below.
- X, Y coordinates:
 - 28. -2051196.10562, 2085539.7193 (Spring7)
 - 29. -2049368.54429, 2086950.2532 (Spring8)
 - 30. -2046167.2455, 2083356.4582 (Spring9)
 - 31. -2047553.2484, 2084533.9473 (Spring10)

Don't select "OK" yet. Goto "MODFLOW Features" tab

8	Object Prop	perties					
Pr	operties	Data Sets MODFLO	WFeatures Vertices				
	Section Number	X	Y	New			
1	1	2050963.06089178	2088974 06282107	9			
					? Help	✓ок	X Cancel

Create UZF gages for Added Springs

- 1. Select "MODFLOW Features" Tab
- 2. Select "UZF: Unsaturated Zone"
- 3. Add check to UZF gages (Print volumes and rates)

😻 Object Properties							
Properties Data Sets MC	DFLOW Fea	atures	Vertices				
F SFR: Stream-Flow R			UZF: L	Insaturated-Zone	Flow packag	e	
□F GAGE: for SFR Stree UZF: Unsaturated-Zo			Formula				
	Starting E time	inding time	Infiltration rate	2			
	0 🌻 Nu	mber of	ftimes			- Insert	× Delete
\langle	 Print time cumulative Also print Print time series of 	e, grour ve volur it rates e, grour	nd-water hea nes	d, and thickness of d, thickness of un	of unsaturated	d zone, and) wa
	301103 01	-ashars			? Help	✓ OK	X Cancel

Set Stream Segment Information

1. Choose "Object|Select Objects by Name"



- 2. Click on "Select None"
- 3. Add check mark to all "strseg_" objects

🗿 Select Objects	by Name	
Тор		
□ mfcells_1		
⊠strseg_1		
☑ strseg_3		
Østrseg_4		
⊠strseg_5 ⊠strseg_6		~
Selected object	ts = 15	
Include hidde	en objects	
Select All	Select None	Toggle
Select Name	s Containing:	Search Term
? <u>H</u> elp	✓ OK	X Cancel

- 4. Choose arrow selection tool
- 5. Double click on highlighted segments



Specify Segment Information

- 6. Select "MODFLOW Features" tab
- 7. Select "SFR: Streamflow Routing" Select on F() under "Streambed elevation"
- 8. Select "Segment" sub tab

SFR Stream-Flow R	Basic T	ime Ne	, etwork Flows	Segment	Channel Ga	ige		
□ □ GAGE: for SFR Stree □ □ UZF: Unsaturated-Zo	Upstream		Formula					
	Starting	Ending time	Hydraulic conductivity	Streambed thickness	Streambed	Stream width	Stream depth	
	-1	0	0.1	1	ALT	3	0	
	0	300	0.1 F()	1	ALT	3	0	
	Downstre	eam	Formula					
	Downstre	eam Ending	Formula Hydraulic	Streambed	Streambed	Stream	Stream	
	Downstree Starting time	eam Ending time	Formula Hydraulic conductivity	Streambed thickness	Streambed elevation	Stream width	Stream depth	
	Downstre Starting time -1 0	eam Ending time 0 300	Formula Hydraulic conductivity 0.1 0 (1 F()	Streambed thickness 1	Streambed elevation ALT ALT	Stream width 3	Stream depth 0	

9. Set streambed Elevation with User defined "ALT" data set

😻 Formi	ula Edito	or							
ALT									Double-click to insert into formula
ALT			L.		3				Data Sets Optional Required Suser Defined Created from Shapefile ACTIVE1 ALT
Logic	al oper	ators		Numb	ers		Opera	tors ,	AREA ID
=	<>	AND	OR	7	8	9	()	- PRECIP
>	<	NOT	XOR	4	5	6		1	TO_SEGMENT ■ Functions
>=	<=	True	False	1	2	3	+	-	
		Integer o MOD	perators	0	E	-			
				4.	10	To an article	a li da		
					2	Eunctio	n help.	?	Help 🗸 OK 🗶 Cancel

10. Continue with: "Modflow Features" tab.

11. Select: "Unsaturated" sub tab and input values for unsaturated zone beneath streams

12. Select "OK"

Object Properties	
Properties Data Sets MO	DFLOW Features
	Basic Time Network Flows Segment Channel Unsaturated Gage Upstream 3 Edit. Saturated volumetric water content (THTS1) 25 Edit. Initial volumetric water content (THTI1) 4 Edit. Brooks-Corey exponent (EPS1) 0 Edit Max unsaturated Kz (UHC1)
	Downstream 3 Edit 25 Edit 4 Edit Brooks-Corey exponent (EPS2) 0 Edit
< >>	

Set Gage to last Reach in Outflow Segment

- 13. Use Selection arrow double click on last outflow segment
- 14. Choose "MODFLOW Features" tab
- 15. Click on "SFR: Streamflow Routing"
- 16. Select "Gage" sub tab
- 17. Add check mark for "Standard default" output



Set Hydraulic Conductivity for Aquifers

- 1. Select "Create Polygon Object"
- 2. Create Polygon containing all of model grid
- 3. Double click new polygon
- 4. Name object "K_layer1"

Notice range for which object applies. This will be important for multi-layer models

Object Properties Properties Data Sets Evaluated at C Colls C	MODFLOW Features Vertices	Object information (not editable)	
Name K_layer1	Z0	31372 8329448686 Object area 61031706 7287598 Object order	
Color object line	Set object line color		
Set values of enclose Set values of interset Set values of cells by Associated third-dimen Czero Control	ed cells cted cells interpolation sion formulas /* Two		
Z-cootd to	[Model_Top+Upper_Aquiter_1	om//2	tFØ
Higher Z-coordinate	Model_Top	Ed	it F()
Lower 2 coordinate	Upper_Aquifer_Bottom	Ed	it F()
-		? Help	Cancel

- 5. Select "Data Sets" tab
- 6. Choose "Required|Hydrology"
- 7. Add check to variable "Kx" and specify value of "0.06"
- 8. Add checks to "Ky" and "Kz" and set Kz = Kx / 2

Properties Data Sets MODFLOV	V Features Verti	ces		
	Formula	for "Kx" data set		Edit F()
	Data set	comment	Associated mod PHAST: MEDIA MODFLOW LPI MODFLOW BC MODFLOW HU	el data -Kx F HK F TRAN,HY F PARTYP=HK
PHAST-style interpolation		Interpolation di	rection or mixture	
Distance 1 0 Val	ie t 问	Mixture formula		
Distance 2 1 Val	re 2 1	-		EditFO

9. Select "Create Polygon Object"

10. Create 2-3 cell buffer around streams



11. Select "Select Objects" arrow

- 12. Double click new polygon object
- 13. Name object "Alluvium_K"

Object Properties		
Properties Data Sets 1 Evaluated at COS C	AODFLOW Features Vertices Object infor Cell corners Object leng 27327 199	mation (not editable) pth 92375493
Use to set grid cell siz Grid cell size Color object line	e Object are 13775379 Object ord Object ord Object ord	a 18132324 er
Color object interior	Set object fill color	
 Set values of enclose Set values of intersec Set values of cells by 	d cells ted cells interpolation	
Associated third-dimens	ion formulas © Tiwo	
	[Model_Top+Upper_Aquifer_Bottomy2	EditF()
Higher Z-coordinate	Model_Top	Edit F().
.ower Z-coordinate	Upper_Aquifer_Bottom	Edit F().
	7 Help	VOK X Cancel

- 14. Select "Data Sets" tab
- 15. Click on "Required|Hydrology|Kx" and add check mark.
- 16. Type "0.25" in "Formula for "Kx" data set
- 17. Add check mark to "Ky" and "Kz" and set Kz = Kx / 5

Properties Data Sets MODE	LOW Features Vert	ices		
	Py Py	for "Kx" data set		_Edit F()
F Modilow_Initial_Heal F Specific_Storage F Specific_Yield F Wet_Dry_Flag F Wet_Dry_Threshold F WetDry	Data set	comment	Associated mod PHAST. MEDIA MODFLOW LPI MODFLOW BC MODFLOW HU	lei data -Kx F HK F TRAN,HY F PARTYP=HK
PHAST-style interpolation		Interpolation direct	ion or mixture CZCM	
Distance 1 0	Value 1 0	Moture formula		

18. Use "Color grid" to verify Kx



Set Layer Top and Bottom Altitudes

- 1. Choose "Create Polygon Object"
- 2. Put polygon around model grid
- 3. Double click selected polygon



The associated third-dimension formulas should be set to "zero"

Object Properties		
Properties Data Sets	MODFLOW Features Vertices	Object information (not editable) Object length 47657 2139796363
Use to set grid cell si Grid cell size	Ze	Object area 141640017.969971 Object order
Color object line Color object interior Set values of enclose	Set object fill color Set object fill color	
Set values of intersec Set values of cells by Associated third-dimen	cted cells / interpolation ision formulas	
C Zero	C Two (Model_Top+Upper_Aquifer_Botto	edit F().
Higher Z-coordinate Lower Z-coordinate	Model_Top Upper_Aquifer_Bottom	EditF(). EditF().
		? Help ✔ OK X Cance

- 4. Select "Data Sets" tab
- 5. Select "Required|Layer Definition"
- 6. Select "Model_Top" and click on "Edit formula"
- 7. Choose "User Defined| Created from Shapefile" and double click "ALT"

🚳 Object Properties				
Properties Data Sets	MODFLOW Features	Vertices Imported Data	fi 2	
Coptional Required Required Required Required Post Layer Definition Copt Copt Copt Copt Copt Copt Copt C	er_Bottom	mula for "Model_Top" data .T	set	Edit F()
	Dat	a set comment	Associated model (MODFLOW DIS: T	data
∣ ⊢PHAST-stvle interpolati	on		1	
C Use PHAST-style m	terpolation	⊓Interpolation dir ຂ × ຕ γ	ection or mixture C Z C Moc	
Distance 1 0	Value 1 0	Mixture formula		
Distance 2	Value 2 1			EditF()
			? Неір 🗸 ОК	X Cancel

8. Repeat for "Upper_aquifer_bottom" Set to ALT-120

Dbject Properties			
Properties Data Sets	MODFLOW Feat	ures Vertices Imported D	Jata
⊕		Formula for "Upper_Aquif	fer_Bottom" data set Edit F()
Required Required	er_Bottom	ALT - 120.	
		Data set comment	Associated model data
			MODFLOW DIS: BOTM
PHAST-style interpolati	on]	1
🗖 Use PHAST-style in	terpolation	⊂interpolatio	
Distance 1 0	Value 1	Mixture form	nula
Distance 2	Value 2		Edit F()
			? Help

Check Layer Altitudes

- 9. Select "Color Grid"
- 10. Choose "Data Sets|Requied|Layer definition|Model Top"
- 11. Select "Apply"



Set Wet_Dry Data

- 12. Choose "Create Polygon Object"
- 13. Put polygon around model grid
- 14. Double click selected polygon
- 15. Set associated third-dimension formulas to "Two"

Ø Object Properties			
Properties Data Sets N Evaluated at	MODFLOW Features Vertices	Object information (not edital Object length	ole)
Name wet_dry T Use to set grid cell siz Grid cell size	20 [1	31170.0009751824 Object area 59974620.4570312 Object order	
Color object line	Set object line color Set object fill color	36	
 Set values of enclose Set values of intersec Set values of cells by 	d cells ted cells interpolation		
Associated third-dimens	sion termulas © Two		
Z-coordinate	(Model_Top + Upper_Aquifer_Botto	m)/2.	EditF()
Higher Z-coordinate	Model_Top		Edit F()
Lower Z-coordinate	Upper_Aquifer_Bottom		Edit F()
		? Help ✔OK	× Cancel

- 16. Choose "Data sets" tab
- 17. Choose "Required|Hydrology|Wet_Dry_Flag"
- 18. Click on "Edit formula"
- 19. Type if((ACTIVE1>0),1,0)

🕖 Object Properties					
Properties Data Sets MODFLO	W Features Verti	ces			
F Hydrology Active Active Horizontal_Anisotropy Kx Ky Ky Kz Modflow_Initial_Head Specific_Storage Specific_Yield Wet_Dry_Threshold WetDry	Formula If((ACT)	for "Wet_Dry_Flag" da VE1 > 0), 1, 0) comment	Associa	ated model o	Edit F()
PHAST-style interpolation Use PHAST-style interpolation Distance 1	ue 1 0	Interpolation dire マスーク Y Mixture formula	ection or m	c Mix	
Distance 2 1 Va	ue 2 <u>1</u>				EditF()
		<u></u>	? Help	VOK	X Cancel

- 20. Set Wet_Dry_Threshold=0.01
- 21. Set Wet_Dry=Wet_Dry_Flag*Wet_Dry_Threshold

Properties Data Sets N	ODELOW Features Ve	rfices		
	Sotropy	a for "WetDry" data s Dry_Flag * Wet_Dry_	et Threshold	Edit F()
F Specific_Yield	shold v	it comment	Associated m	odel data IV
F use PHAST style interpolation	ipulator)	Interpolation $\sigma < -\sigma$	direction or mixture	
Distance 1 (0)	Value 3 0	Mixture formul	a	
Distance 2	Vallas 2	_ [EdcEp
			? Help	OK X Cancel

Set Active Cells

- 1. Select "Create polygon object" tool
- 2. Put polygon around model grid
- 3. Double click on selected object
- 4. In "Properties tab" Name object "Active_lay1"

🐻 Object Properties			
Properties Data Sets I Evaluated at Cells	MODFLOW Features Vertices	Object information (not edi Object length	table)
Name Active_lay1		32072.5366097774	
☐ Use to set grid cell sit Grid cell size	ze 1	Object area 64050106 5546875 Object order	
□ Color object line	Set object line color	- [19	
Color object interior	Set object fill color		
 Set values of enclose Set values of intersec Set values of cells by 	d cells ted cells interpolation		
Associated third-dimen	sion formulas		
Z-coordinate	(Model_Top+Upper_Aquifer_Bottor	n)/2	EditF().
Higher Z-coordinate	Model_Top		Edit F()
Lower Z-coordinate	Upper_Aquifer_Bottom		Edit F()
		? Неір 🗸 ОК	X Cancel

- 5. Select "Data Sets" tab
- 6. Choose (with check mark) "Required|Hyrology|Active"
- 7. Select Edit F()
- 8. Choose "User Defined| Created from Shapefile" and double click on "ACTIVE1"
- 9. Type ">0" so formula reads "ACTIVE1>0"

Properties Data Sets MODFL	OW Features Ver	tices		
■ I ⁻ Optional	Formula	for "Active" data set		Edit F()
		Elvo		
	Data se	t comment	Associated mode PHAST: MEDIA-a MODFLOW BAS	I data active IBOUND
PHAST-style interpolation				
Use PHAST-style interpolation		⊂Interpolation dire	C Z C Mix	
Distance 1 0 V	alue 1 0	Mixture formula		

Use "Color Grid" again to check that IBOUND was set correctly

Ne dat o	No. W. USELOW Strategies) 200 NO Data Object Nevigation Nev USELOW STATE AND A REAL NO. 107 - 0. 107 - 0.	Official AUDITON Degelors 1 Contaction Public Pub		s]	
-	- 4 B V R 4		-2 05E6	-2.04E6	
2.0966					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
20056					2.00E6

Set All other Cell Property Data

Layer 1

- 1. Select "Data Sets" tab
- 2. Select "Create Polygon Object"
- 3. Put polygon around model grid
- 4. Double click polygon
- 5. Name object "All_other_properties"

Properties Data Sets I Evaluated at	MODFLOW Features Vertices	Object information (not editable)	
e Cells	Cell comers	Object length	
Name All_other_prop	perties	0biect area	
Use to set grid cell siz	.e	193418315.793457	
Grid cell size	<u>p</u>	Object order	
Color object line	Set object line color	37	
Color object interior	Set object fill color		
 Set values of enclose Set values of intersec Set values of cells by 	d cells ted cells interpolation		
Associated third-dimension Cone	sion formulas • Two		
Z-coordinate	[Model_Top+Upper_Aquifer_Bottor	n)/2 Edit F(
Higher Z-coordinate	Model_Top	Edit F()
Lower Z-coordinate	Upper_Aquifer_Bottom	Edit F()
		? Help ✔OK X Can	cel

- 6. Select "Data Sets" tab
- 7. Choose "Required|Hydrology|MODFLOW_Initial_Head"

- 8. Type: "ALT"
- 9. Add check to "Specific_Storage" and use default values
- 10. Add check to "Specific_Yield" and use default value

🐻 Object Properties		
Properties Data Sets MODFLOW Fea	tures Vertices	
⊕ □ Optional	Formula for "Modflow_Initia	I_Head" data setEdit F()
	ALT	
✓ Specific_Storage ✓ Specific_Yield ✓ Wet_Dry_Flag ✓ Wet_Dry_Threshold ✓ WetDry		BAS: STRT
PHAST-style interpolation	- <u>1</u>	
■ Use PHAST-style interpolation	Interpolation ເຊັ່ນ ເ	direction or mixture Y CZ CMix
Distance 1 0 Value 1	0 Mixture formu	la
Distance 2 1 Value 2	1	Edit F()
		? Help VOK X Cancel

11. Add check to "UZF" and select "Discharge_Routing"

12. Type "IRUNBND"

Don't choose OK YET!

😻 Object Properties					
Properties Data Sets MODFLOW Fea	atures Vertices				
T Optional	Formula for "D		Edit F()		
	IRUNBND				
	Data set comment		Associated model data		
-PHAST-style interpolation				NNRIND	
Use PHAST-style interpolation		Interpolation direction	tion or mb	ture C Mix	
Distance 1 0 Value 1	0	Mixture formula			
Distance 2 1 Value 2	1	4			Edit F()
		?	Help	√ OK	X Cancel

- 13. Choose "MODFLOW Features"
- 14. Add check to "UZF: Unsaturated-Zone Flow"
- 15. Increase "Number of times" to 2
- 16. Set "Infiltration rate" to "PRECIP*0.55" for both times

Don't choose OK YET!

Object Properties						
Properties Data Sets M	DDFLOW	eatures				
GAGE: for SFR Stree		ge				
UZF: Unsaturated-Zo			Formula			
	Starting time	Ending time	Infiltration rate			
	0	300	PRECIP			
	•					
	•					
	2 🔹	Number o	of times		·E Insert	× Delete
	F Print t	me, grou ative volu	ind-water head, a mes	nd thickness of unsatur	ated zone, ar	nd
	E Also p	rint rates				
	F Print to series	me, grou of depth	ind-water head, this and water conte	ickness of unsaturated ents in the unsaturated z	zone, followe	ed by a
				? Help	√ OK	X Cancel

Set IUZFBND for UZF

- 17. Select "Data Sets" tab
- 18. Choose "Required|UZF|UZF_Layer"
- 19. Type in "ACTIVE1" in to "Formula for UZF_Layer" data set
- 20. Choose "OK"

Note: The other option would be to set "UZF_Layer" to imported data set "ALT" and ModelMuse will

determine which layer for each column is the land surface cell.

Object Properties						
Properties Data Sets N	IODFLOW Fea	atures Vertic	ces			
Coptional Required Pr Hydrology Dr UZF Pr Brooks_Corey_Epsilon Pr Discharge_Routing Cland_Surface Saturated_Water_Content RUTE_Lawer		Formula f		Edit F()]		
		ACTIVE	1			
		Data set o	comment	Associated model data		
				02-10	IZF DINU	
PHAST-style interpolatio	n		And the state of the			
Use PHAST-style inte	rpolation		e × c γ	C Z	C Mix	
Distance 1 0	Value 1	0	Mixture formula			
Distance 2	Value 2	1				Edit F()
				? Help	✓ OK	X Cancel

Use Color Grid to check that IRUNBND was set correctly



Link Outflow Segments

- 1. This determines the outflow segment for each segment.
- 2. Choose "All streams"



