

Basin Analysis GIS for USDA-NRCS National Water and Climate Center Water Forecasting

Geoffrey Duh
Geography, Portland State University

GIS in Action 19th Annual Conference
March 30, 2011. PSU, Portland, Oregon

Acknowledgements

- The project was funded by USDA-NRCS National Water and Climate Center (CESU Agreement #: 68-3A75-4-101)
- Special thanks to:
Jim Marron, Tom Perkins, Angus Goodbody
USDA-NRCS-NWCC

David Banis, James Manzione, Ray Hennings,
Joe Poracsky, Heejun Chang
PSU Center for Spatial Analysis & Research (CSAR)

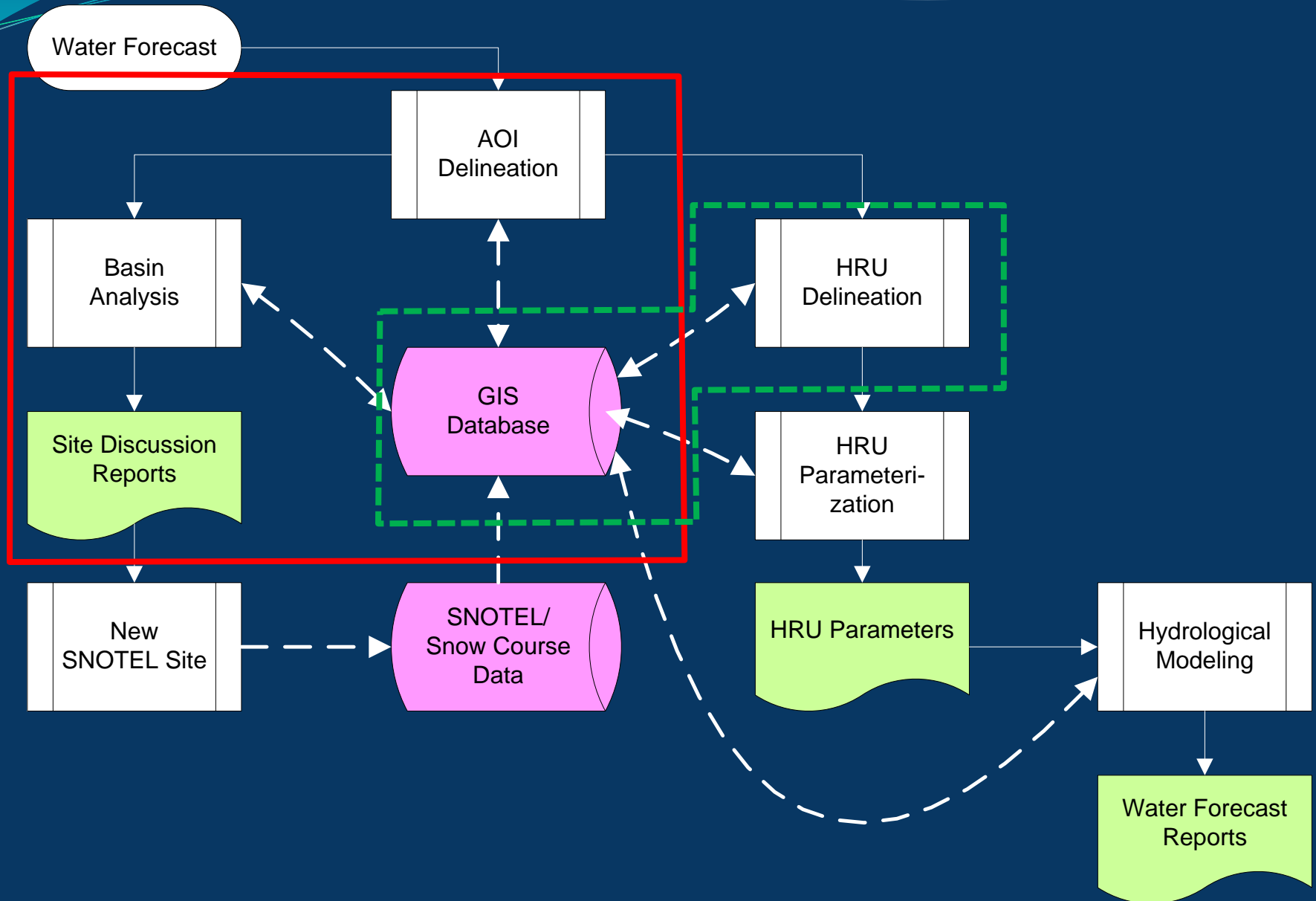
Outlines

- Water forecast at NWCC
- Snow survey and SNOTEL
- Basin Analysis GIS design and implementation
- BAGIS demonstration
- HRU Delineation GIS preview
- Conclusion

USDA-NRCS National Water & Climate Center

- Provides streamflow forecasts for over 740 points in the West.
- US West's high mountain ranges hold a vast snowpack that provides 50 to 80 percent of the year's water supply
- Factors affecting the amount of snowmelt runoff
 - Snowpack
 - Soil moisture
 - Ground water
 - Precipitation patterns / air temperature
 - Vegetation
 - Frequency of storm events

Water Forecasting Components



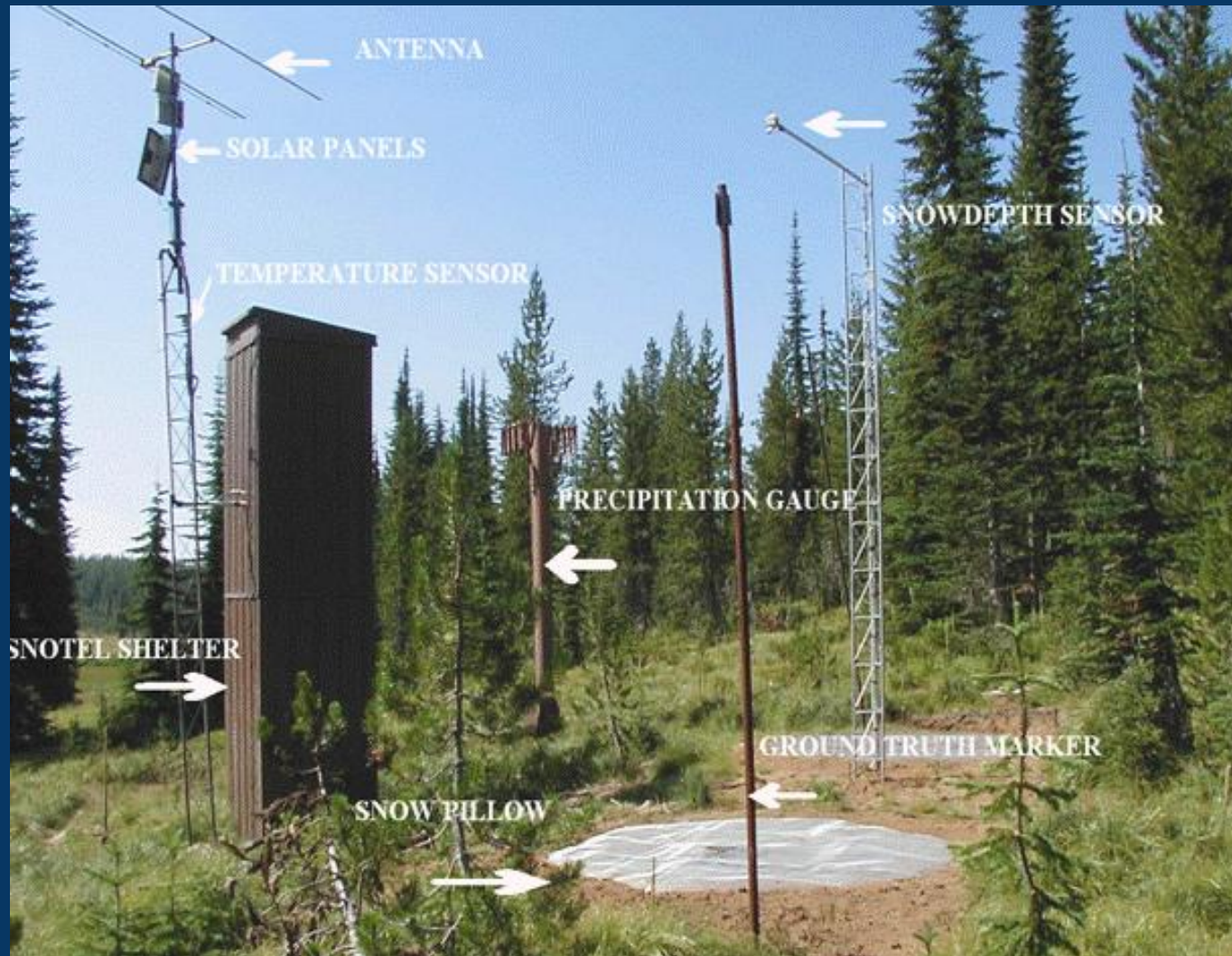
Snow Survey

- USDA-NRCS Cooperative Snow Survey Program (since 1935)
 - Manual data collection by snow surveyors
 - ~1,700 snow courses
- USDA-NRCS SNOTEL (since 1977)
 - Automated radio telemetry data collection
 - ~800 SNOTEL sites



Image source: USDA-NRCS

Snowpack survey - SNOTEL

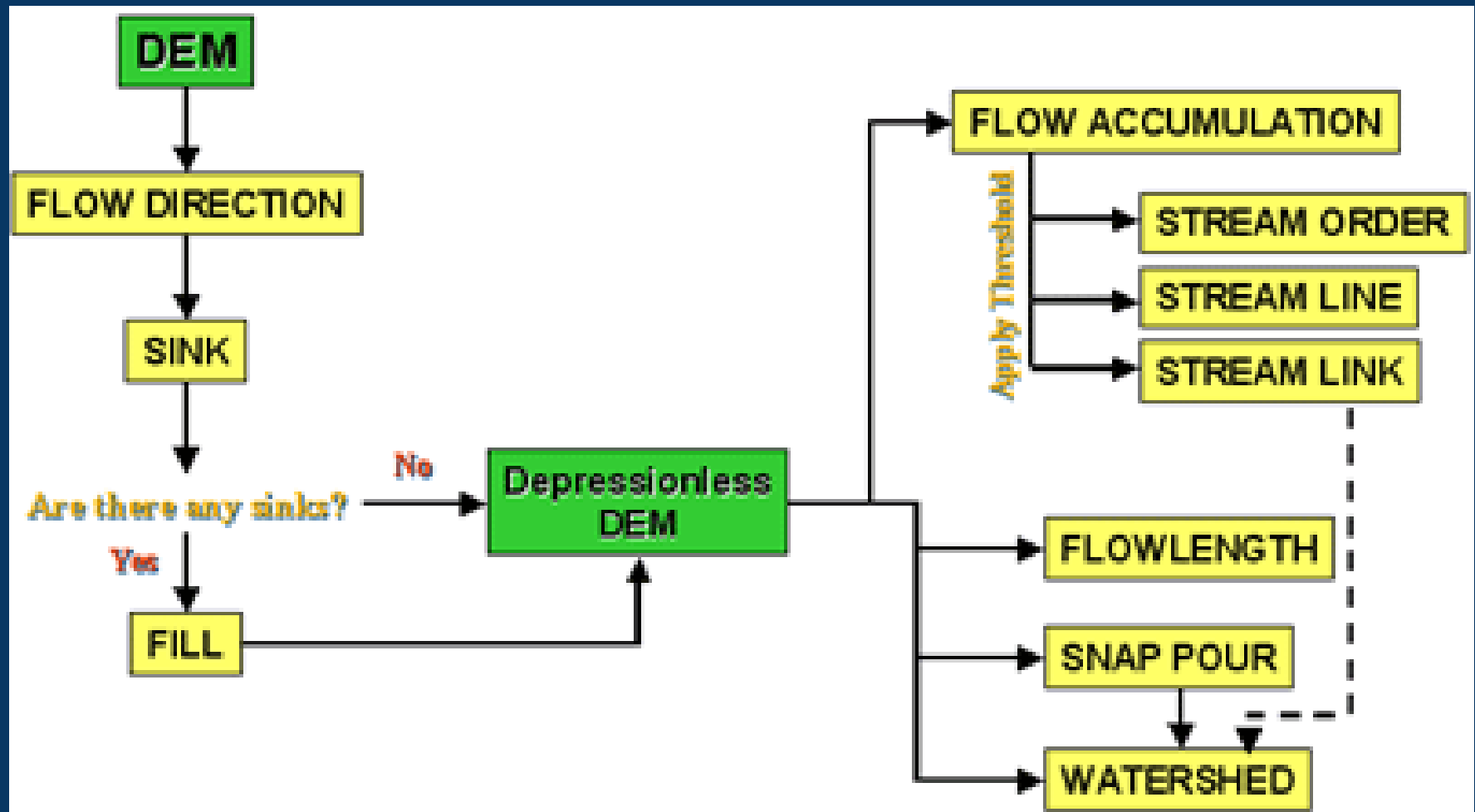


- Craters Meadow SNOTEL -- 5,690 Feet -- Clearwater Basin (Image source: USDA-NRCS http://www.id.nrcs.usda.gov/snow/siteinfo/typical_snotel.html)

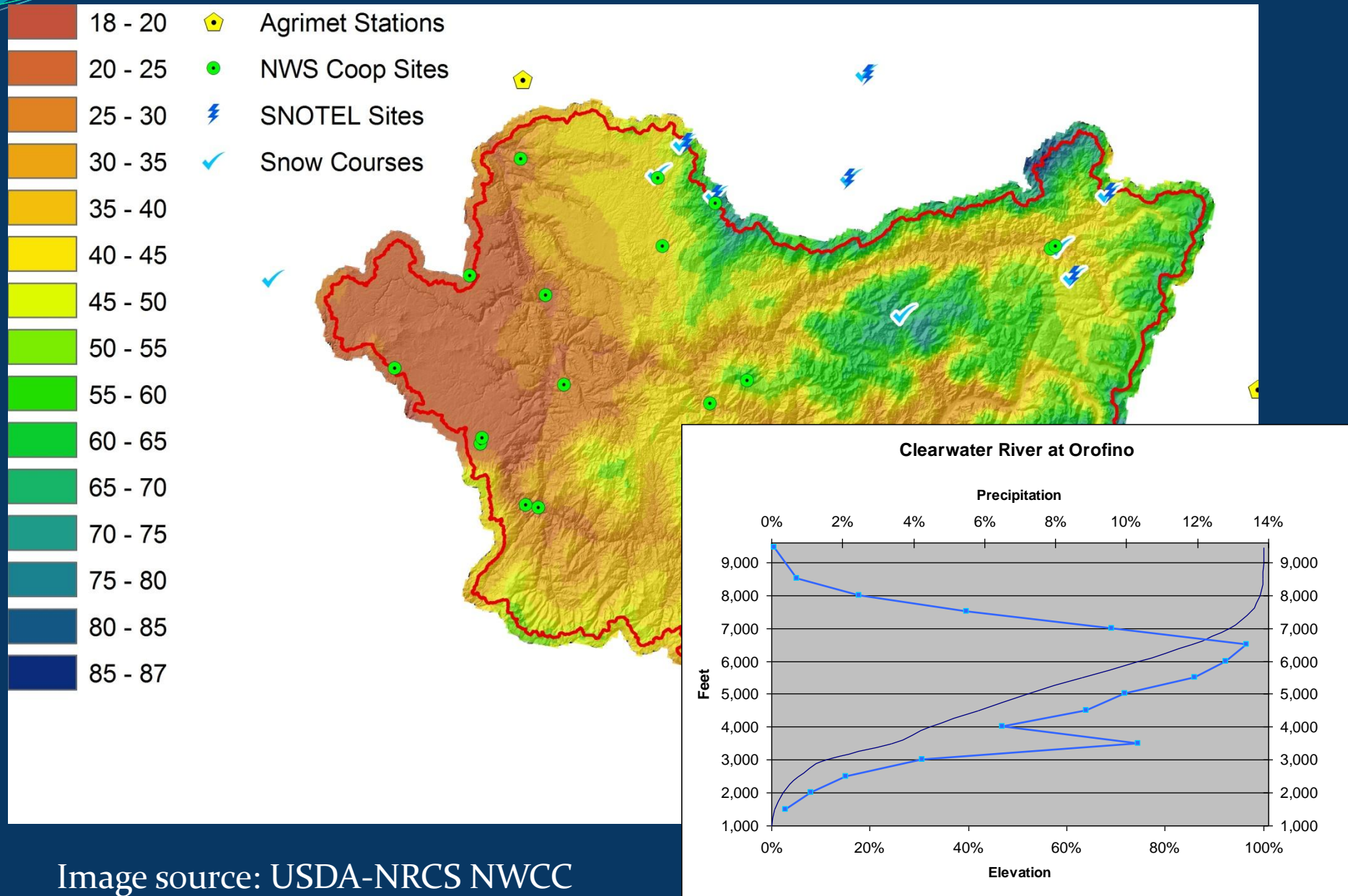
SNOTEL Site Selection Criteria

- Existing SNOTEL sites and snow courses
- Terrain variability
 - Aspect
 - Elevation
- Precipitation variability
- Soil
- Accessibility
 - Access road
 - Slope
 - Land ownership

Watershed (AOI) Delineation Steps



PRISM Annual Precipitation Distribution



Example of Basin Analysis Outcome

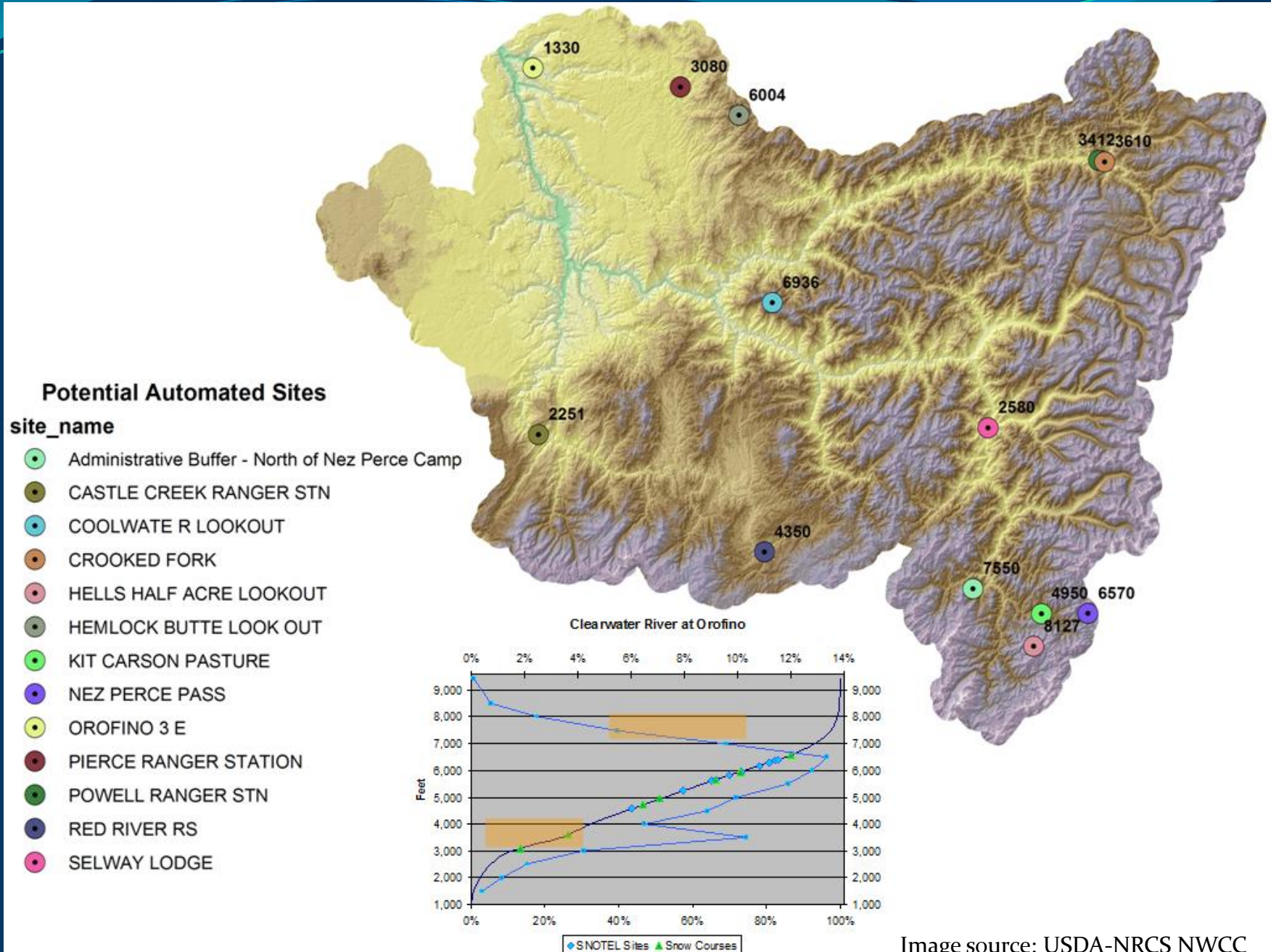


Image source: USDA-NRCS NWCC



The GIS Weasel!!

GRID

Message Board

Displaying appropriate thematic layer...

AOI Delineation

Please choose a method for generating the Area of Interest (AOI).

☐ Digitize 'pour-point' to create a custom watershed as the AOI

☐ Use externally established AOI

☒ Raster ☐ Vector

DONE HELP

Pan/Zoom

View Control:

☐ Full View ☐ Zoom In

☐ Extent ☐ Zoom Out

☐ Refresh ☐ Pan

Theme Control:

☐ Vector Control ☐ Background DEM

☐ Raster Control ☐ Composite

☐ Scale/N Arrow

Miscellaneous:

☐ Command Line ☒ Echo

☐ Quit

The GIS Weasel!!

```
Grid: <pan_zoom, disp_dem.aml/49> gridp tmp_grid # linear nowrap gray
Grid: <pan_zoom, disp_dem.aml/51> &s .area$acov = output\surfaces\dem/filled/g
rid
Grid: <pan_zoom, disp_dem.aml/52> setwindow D:\NRCS\GIS\Basins\Basin_Demo\sant
a_fe_r_0225b\output\surfaces\dem\grid
Grid: <pan_zoom, disp_dem.aml/53> &return
Grid: <pan_zoom, disp_delin.aml/44> &else
Grid: <pan_zoom, disp_delin.aml/46> linecolor 4
Grid: <pan_zoom, disp_delin.aml/47> &if .FALSE. &then
Grid: <pan_zoom, disp_delin.aml/49> &end
Grid: <pan_zoom, disp_delin.aml/52> &if .FALSE. &then
Grid: <pan_zoom, disp_delin.aml/53> &if .FALSE. = .TRUE. &then
Grid: <pan_zoom, disp_delin.aml/55> gnds transparent
Grid: <pan_zoom, disp_delin.aml/56> &return
Grid: <pan_zoom, pan_zoom_delin.aml/10> &return
Grid: <pan_zoom, pan_zoom.menu/?> &s .action = extent
Grid: <pan_zoom, pan_zoom.menu/?> &r pan_zoom_delin.aml nomape
Grid: <pan_zoom, pan_zoom_delin.aml/4> &args mape
Grid: <pan_zoom, pan_zoom_delin.aml/6> &r mape_set_delin.aml nomape
Grid: <pan_zoom, mape_set_delin.aml/4> &args mape
Grid: <pan_zoom, mape_set_delin.aml/6> &if extent ne fullview &then
Grid: <pan_zoom, mape_set_delin.aml/6> &do
Grid: <pan_zoom, mape_set_delin.aml/7> &flushpoints
Grid: <pan_zoom, mape_set_delin.aml/8> &getpoint &map &push &mouse
```

X:4.95719 Y:8.00340 dx:-4.12468 dy:7.18982 Dist 8.28894

BAGIS Development Goals

- Compatibility
 - NWCC SW/HW environment
 - GIS Weasel
- Integrity
 - Data management
 - Process
- Efficiency
 - Computation
 - Workflow
- Usability
 - Interface
 - Functionality

Hardware / Software Environment

- Hardware
 - Microsoft Windows-based PC
 - Fast CPU and disk drives
 - 4 GB of system RAM
 - Sufficiently large disk space
- Software
 - ESRI ArcGIS 9.X or later with Spatial Analyst extension and VBA activated
 - Microsoft Excel and Office 2007 or later
- BAGIS (V1 released: July 2010, Latest version: Ver1_F)
 - Distributed as a map template file (.mxt) in ArcGIS 9.X or as a map document (.mxd) in ArcGIS 10
 - Does not require installation

Input Data of BAGIS

- Input data categories
 - Digital Elevation Model – DEM (ArcInfo grid)
 - Forecast point locations (point shapefile)
 - SNOTEL / Snow course locations (point shapefile)
 - PRISM precipitation (ArcInfo grid)
 - Reference maps (optional)
 - Other participating layers (optional)

BAGIS Settings Dialog Window

Settings C:\DOCUME~1\XPMUser\LOCALS~1\Temp\basinanalyst.def

Terrain Ref: E:\NRCS\GIS\Static\Reference_Data\US_DEM15sec\US_ShadedRelief_300Multi.lyr Set

Drainage Ref: Set

Watershed Ref: E:\NRCS\GIS\Static\Reference_Data\US_Hydro\USGS_HUC8.lyr Set

Double-Click a reference field to clear its layer setting.

Add Ref Layers to Map

10 Meters DEM: E:\NRCS\GIS\Static\DEM\30MDEM\westus_30 Set

30 Meters DEM: E:\NRCS\GIS\Static\DEM\30MDEM\westus_30 Set

Gauge Stations: E:\NRCS\GIS\Static\Forecast_Points\gusforecastpoints (Shapefile) Set

SNOTEL: E:\NRCS\GIS\Static\SNOTEL\snotelold_alb_Project (Shapefile) Set

Snow Course: E:\NRCS\GIS\Static\Snow_Course\SnowCourses_Albers (Shapefile) Set

Precipitation: E:\NRCS\GIS\Static\PRISM Set

Preferred DEM: ☐ 10 m ☒ 30 m

Elevation Unit: ☒ Meters ☐ Feet

Name field: NEW_NAME Area Field: drain_area

Station Area Unit: Sq. Miles

Elevation field: elev_ft Name field: site_name

SNOTEL Elev Unit: ☐ Meters ☒ Feet

Snow Cos Elev Unit: ☐ Meters ☒ Feet

Blue indicates required fields.

Other Participating Layers (will be clipped to AOI)

E:\NRCS\GIS\Static\Supplemental\Forest_Density\cov_den (Raster)

E:\NRCS\GIS\Static\Supplemental\Land_Cover_NLCD2001\west_covtype (Raster)

E:\NRCS\GIS\Static\Supplemental\federal_lands_albers (Shapefile)

E:\NRCS\GIS\Static\Supplemental\roads_albers (Shapefile)

Add

Remove

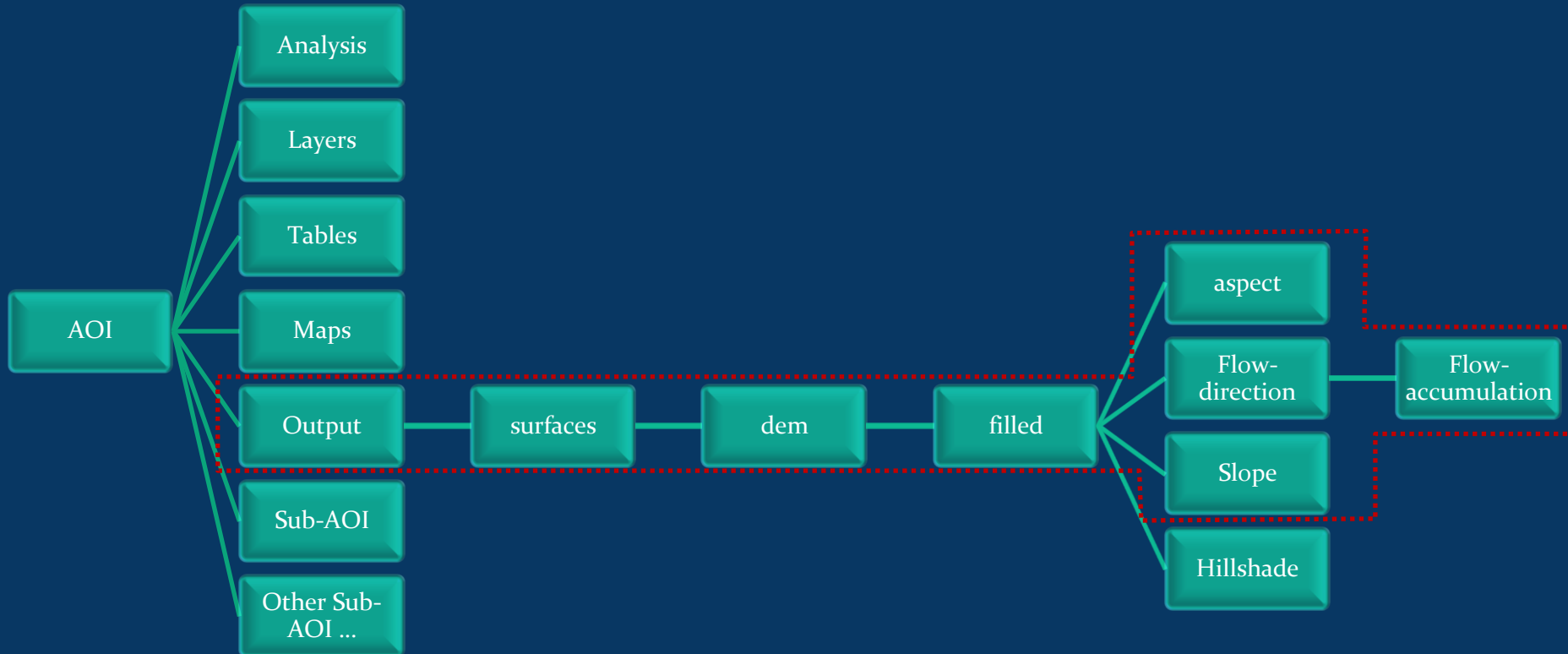
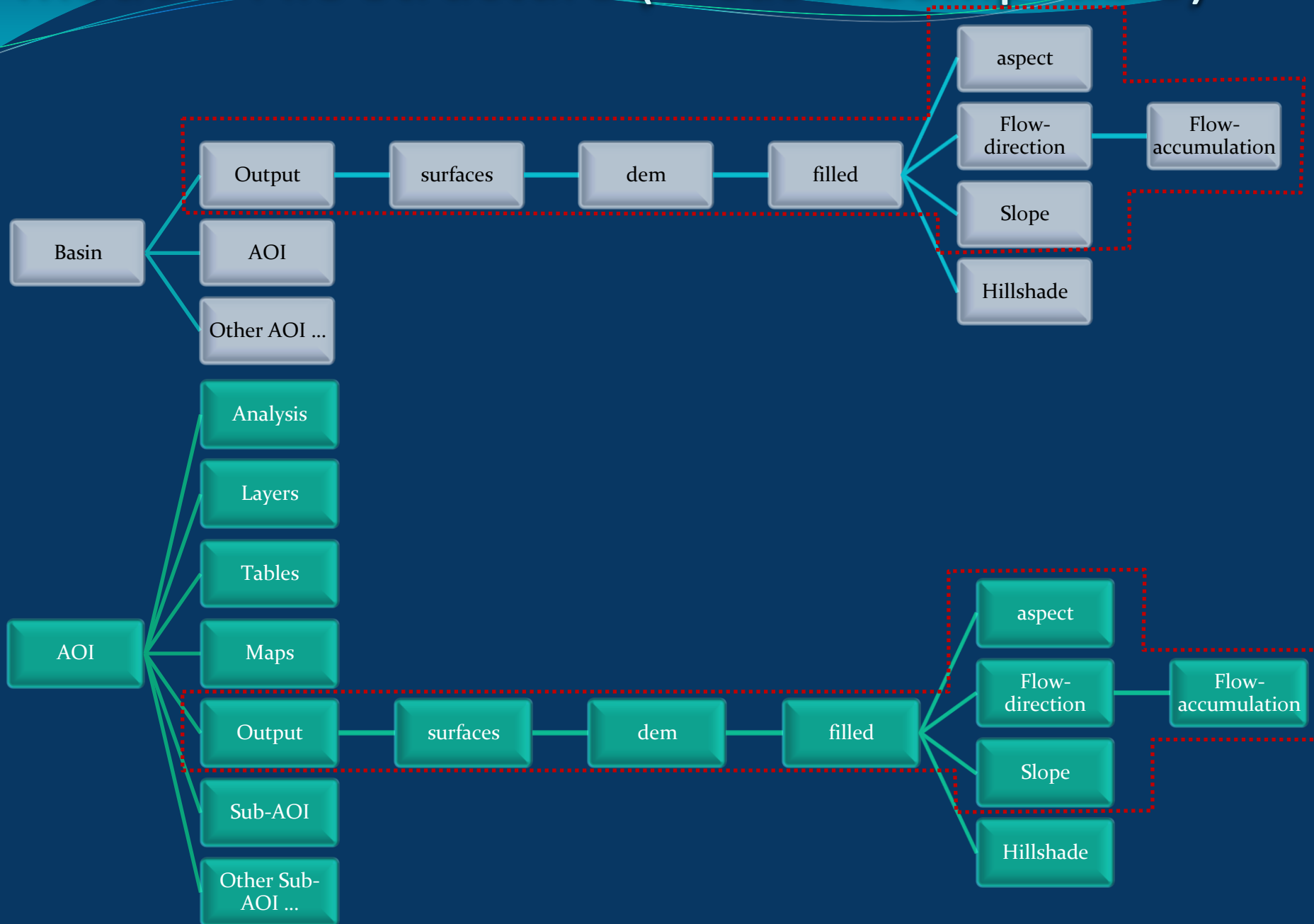
Clear All

Save Settings

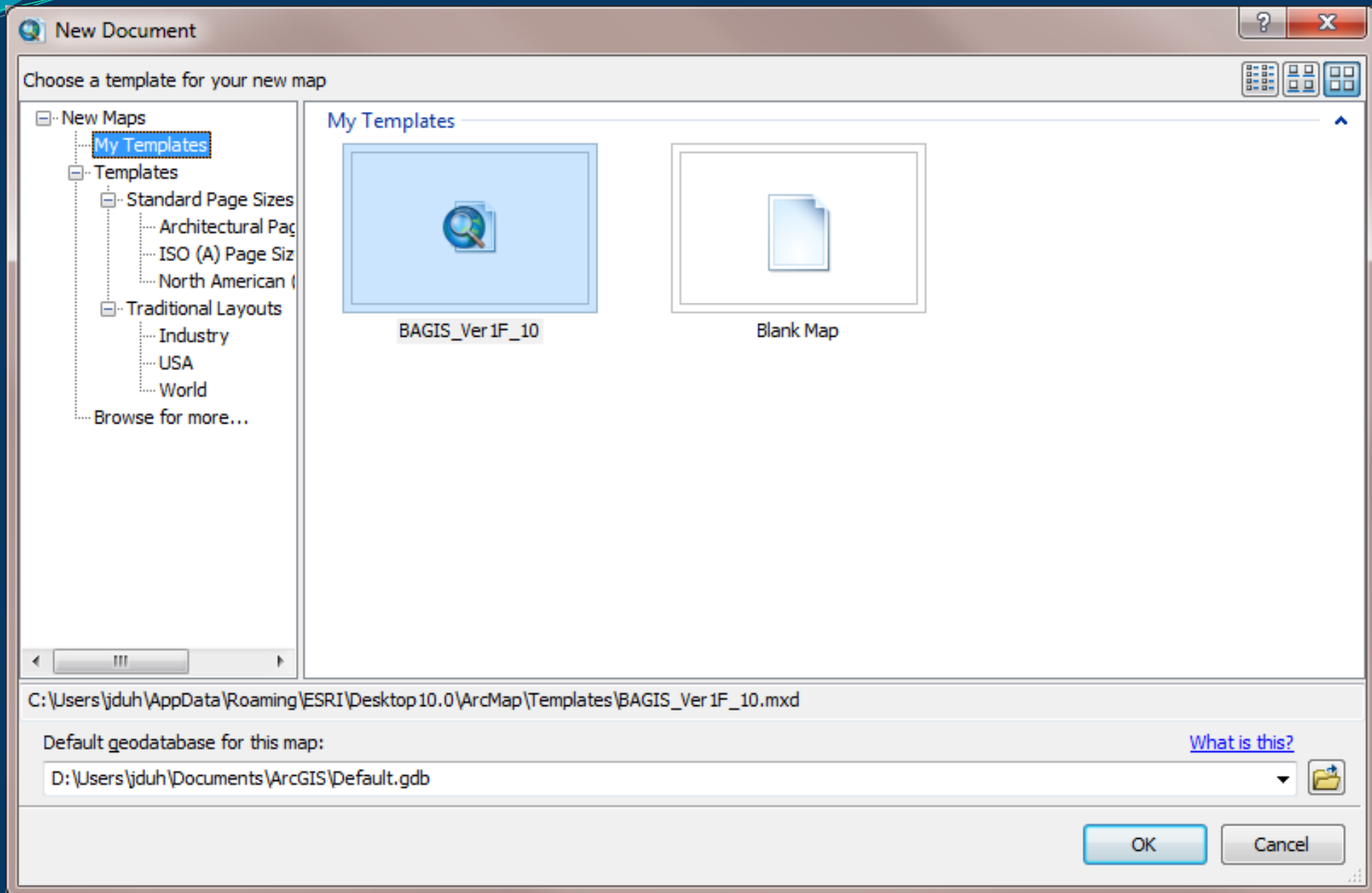
Undo Edit

Close

Model's File Structure (Weasel Compatible)



BAGIS - mxt in ArcGIS 9.x and mxd in 10



BAGIS Demonstration

Basin Functions

AOI Functions

Basin Analyst

Basin Analyst ▼



New_Basin



animas_r_at_durango_07282010

Analysis and Maps ▼

Add Ref Layers

Save AOI MXD

Basin Info

AOI Info

Options

About

System
Functions

Set Data
Sources



Define Basin



Delineate AOI



Run Analysis



Generate Maps
& Reports

Create AOI Stream

Generate Maps

Elevation Distribution

Elevation SNOTEL

Elevation Snow Courses

Precipitation Distribution

Aspect Distribution

Slope Distribution

Elevation Scenario

Actual Representation

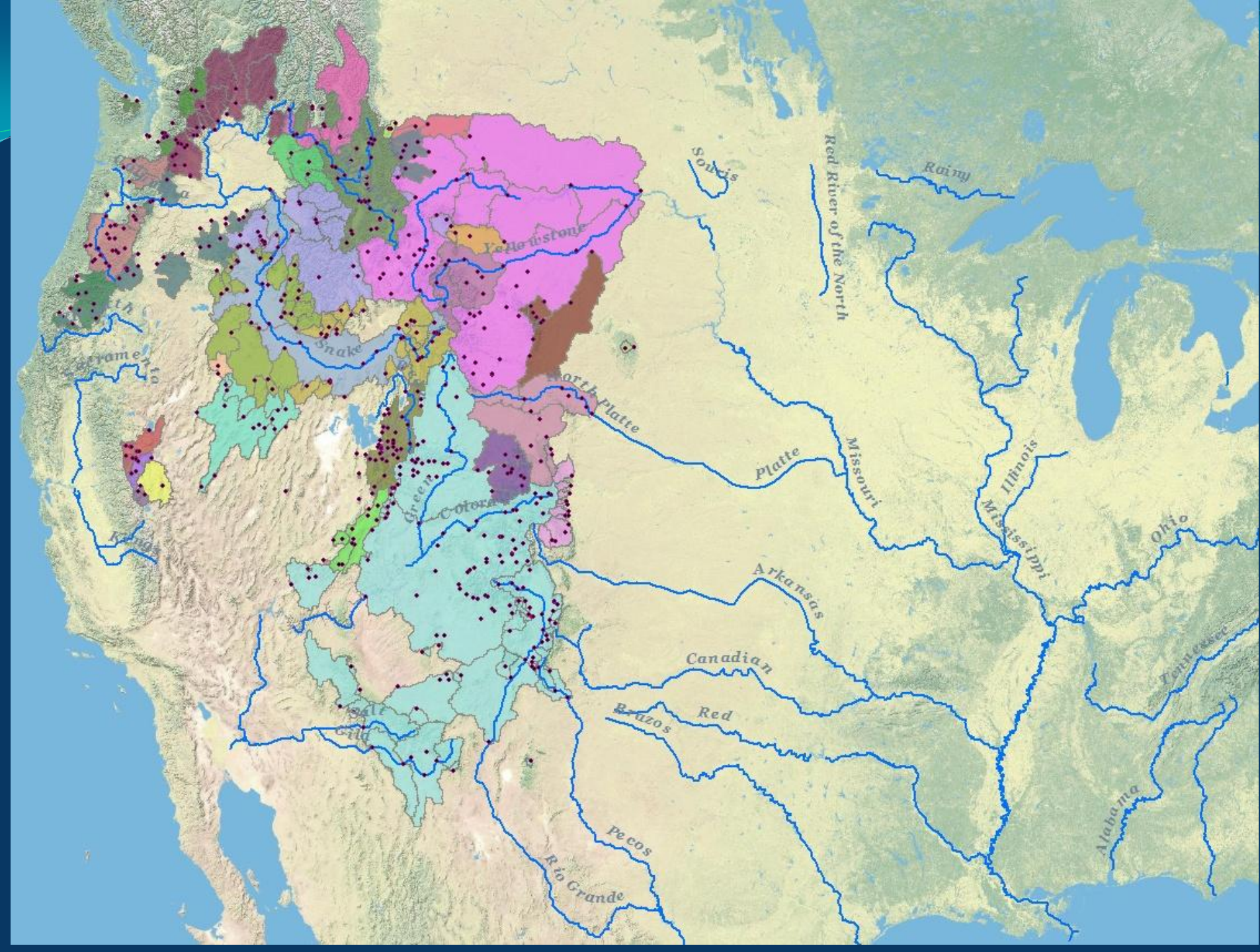
Pseudo Representation

Export Map...

Maps & Tables
Functions

Project Outcomes

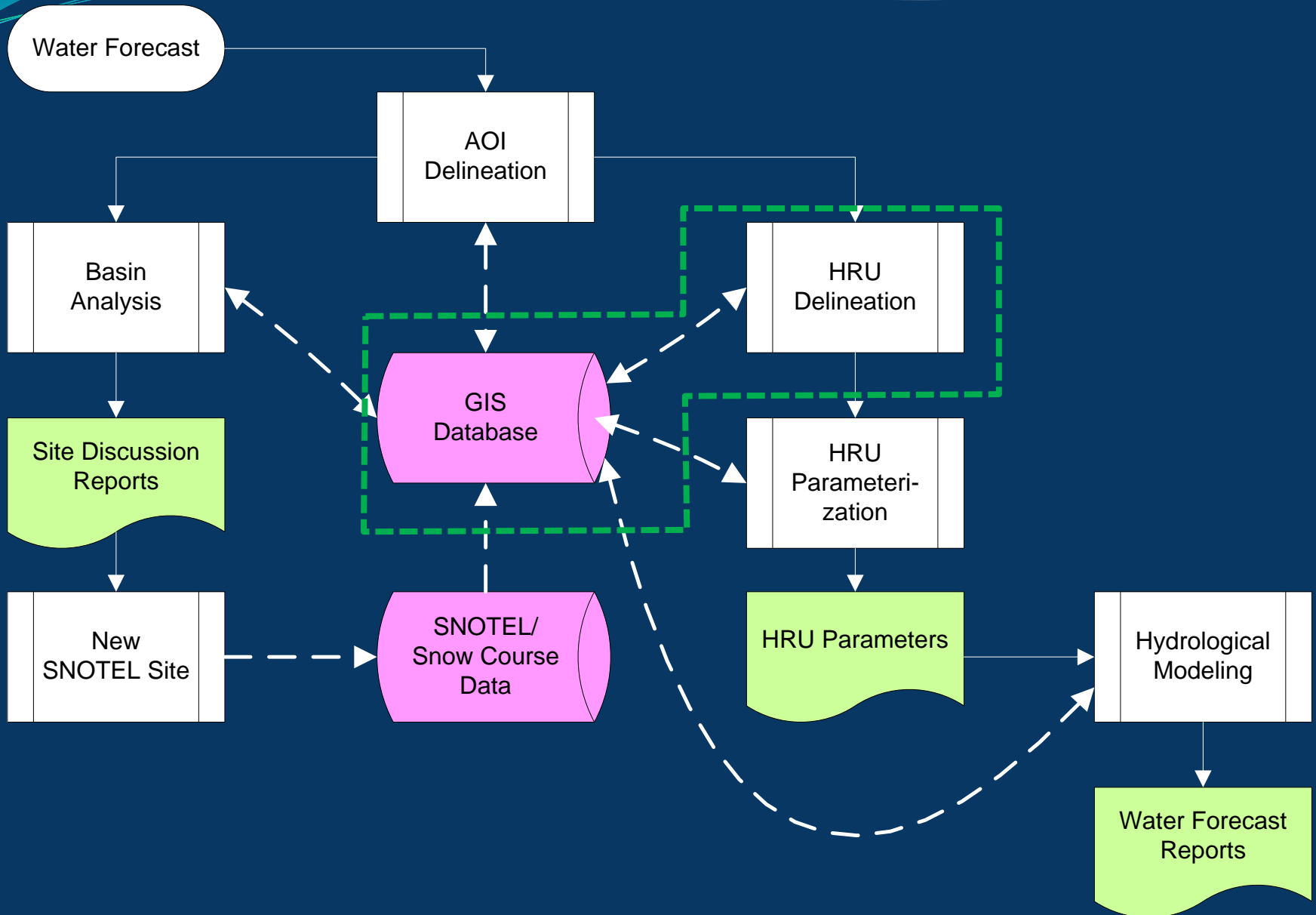
- BAGIS model (for ArcGIS 9.X and 10)
- Data compilation (22 different datasets with hundreds GB of data)
- Model execution (601 AOIs with 700 GB data)
- Final report – BAGIS User's Manual
- BAGIS Website – under construction



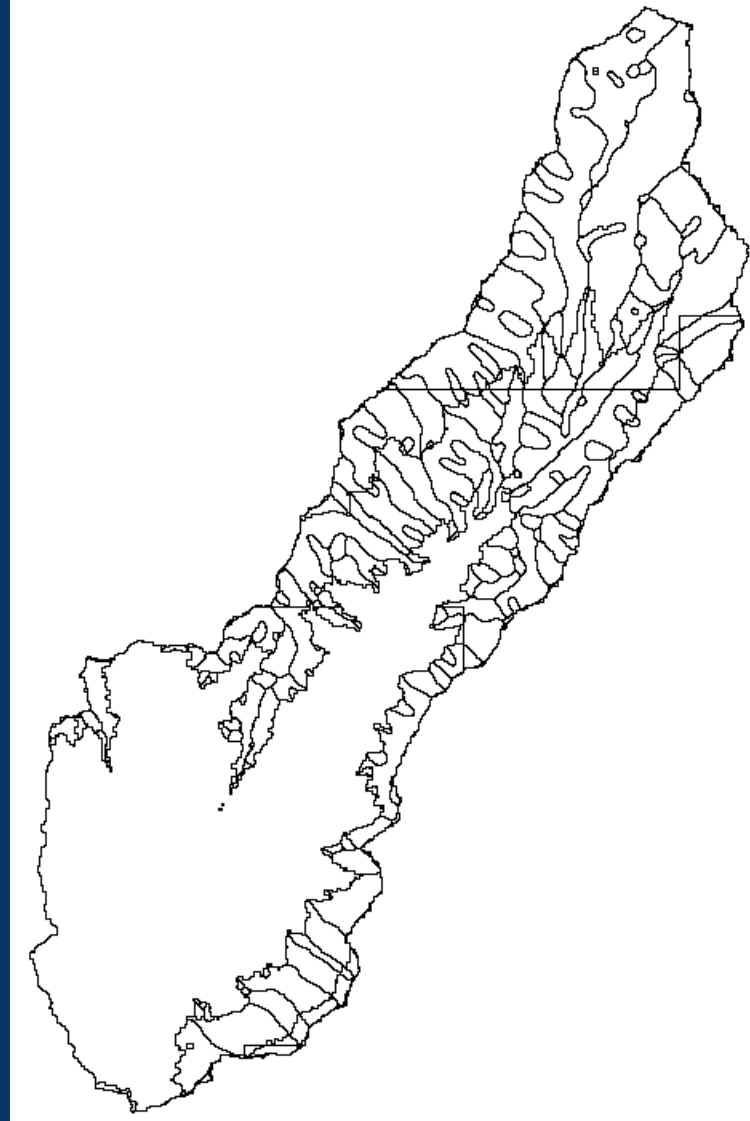
License Restrictions

- USDA has a nonexclusive license to copy, display, and perform BAGIS.
- USDA has the right to distribute BAGIS to any commercial, nonprofit, or government entity partnered with USDA through grant, contract, or collaboration agreement for the ongoing research and projects performed for or in conjunction with USDA.

Hydrological Response Unit Delineation



Hydrological Response Units (HRU)



HDGIS Key Features

- Define HRUs (HRU Delineation)
- Refine HRUs (HRU Post-processing)
- Data management module
- Process logging module

HRU Delineation

Rule Types and Actions

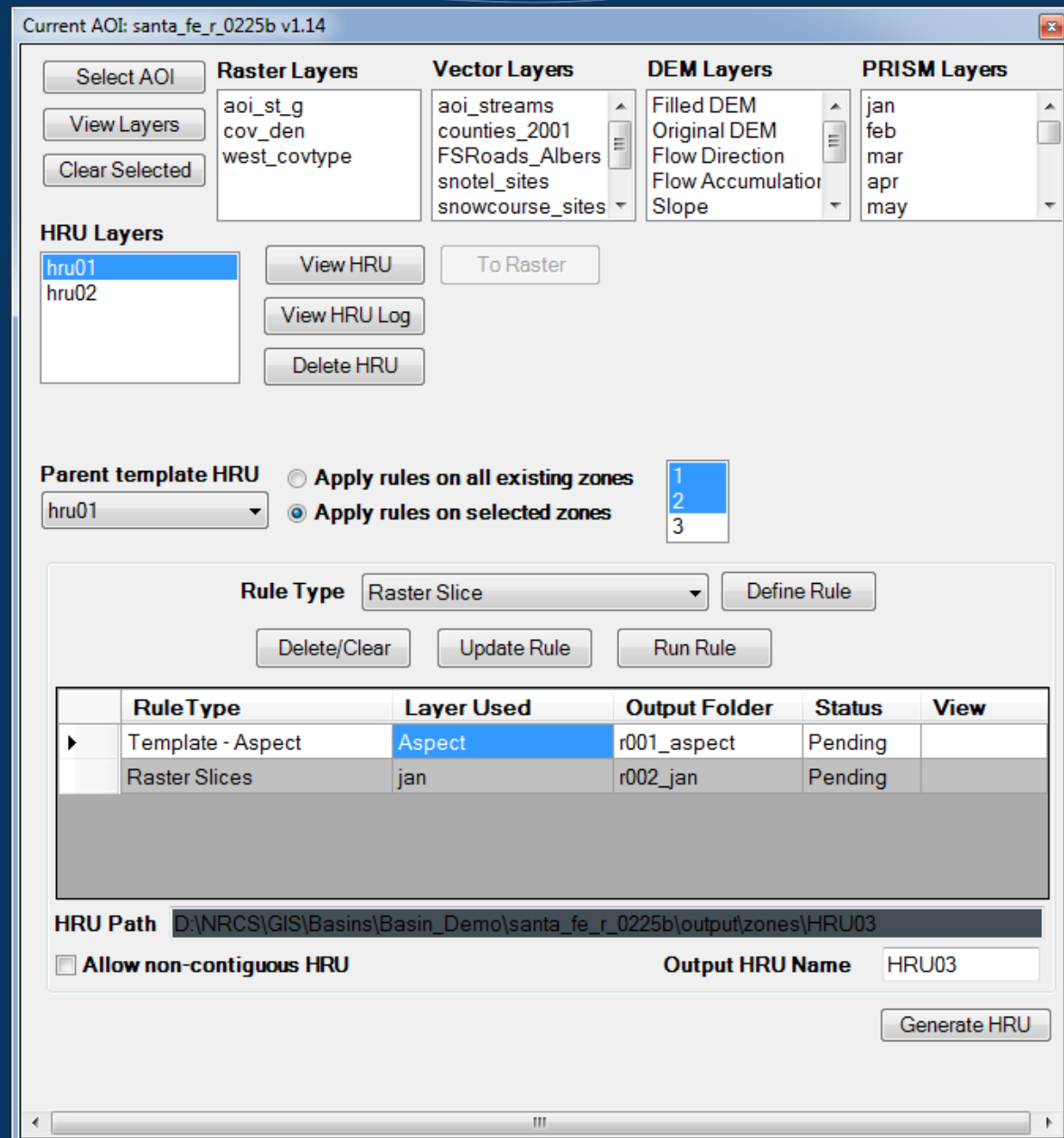
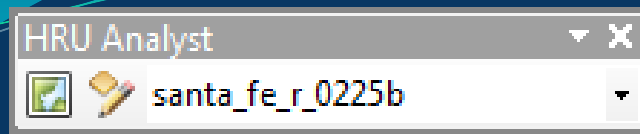
Rule Types	Actions
Contributing Area	Contributing area
Raster reclassification	None or Reclassification
Raster Slice	Slice – equal area/equal interval
DAFlow-Type Zones	Generate grid system
PRISM Precipitation	Customized precip slice
Template - Aspect	Reclassification and filtering
Template - Slope	Filtering, reclassification, filtering
Template - Canopy	Filtering, reclassification, filtering
Template - LULC	Reclassification and filtering
Template - Soil	Rasterizing, reclassification and filtering

HRU Post-processing

Rule Types and Actions

Rule Types	Actions
Eliminate	Eliminate HRU by area or by number
Cookie-Cut	Use a user layer to overwrite portions of HRU
Clustering	Group HRUs into user-specified number of types and dissolve adjacent HRUs that are of the same type.
Zonal statistics by HRU	Add stats to HRU attribute table
PRMS radiation plane attributes	Add slope and aspect stats to HRU attribute table

HRU Analyst Toolbar & HRU Delineation Dialog



Rules for Defining HRU

Raster slice

Select layer

- jan
- feb
- mar
- apr
- may
- jun

Layer type

☐ Raster ☐ DEM
☒ PRISM ☐ HRU

Statistics

Min: **Mean:**
Max: **STDV:**

Slice

Method: ☐ Equal Interval ☒ Equal Area

Number of zones: 3

Base zone value: 1

Cancel Apply

Raster reclassification

Select layer

- hru01
- hru02

Layer type

☐ Raster ☐ DEM
☒ HRU

Only discrete layers are shown

Reclass

Reclass field: VALUE

Unique Auto Load... Save... Clear

	Old Values	New Values
	8	8
	9	9
	10	10
	11	11
	12	12
	13	13

Cancel Apply

Rules for Defining HRU (cont)

Template - Aspect

Directions: 8

Filter width: 5

Filter height: 5

Filter iterations: 5

Set filter iterations to 0 to skip filtering

Cancel Apply

Template - Slope

Step 1. Low-pass Filtering on Slope Values

Filter width: 5 Height: 5 Iterations: 5

Step 2. Reclassification of Slope Values

Slope classification: ☒ 1: 0 - 5%, 2: > 5%

Step 3. Majority Filtering on Reclassified Slope Grades

Filter width: 5 Height: 5 Iterations: 5

Set filter iterations to 0 to skip filtering

Cancel Apply

Process Log Viewer

Current HRU: hru02

Summary Rule 1 Rule 2

Aoi name: santa_fe_r_0225b

Aoi path: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b

HRU name: hru02

HRU path: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b\output\zones\hru02\

Parent template name: hru01 [View HRU Log](#)

Apply to parent HRU zones: 1, 2

Allow non-contiguous HRU: No

Units:

Polygon count: 618

Average size: 0.076664

Maximum size: 19.48424

Date created: 3/25/2011 12:29 PM **Application version:** v1.14

[Close](#)

Tracking Parent HRU Log

Current HRU: hru01

Summary Rule 1

Aoi name: santa_fe_r_0225b

Aoi path: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b

Hru name: hru01

Hru path: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b\output\zones\hru01\

Parent template name:

Apply to parent HRU zones:

Allow non-contiguous HRU:

Units:

Polygon count:

Average size:

Maximum size:

Date created: **Application version:**

HRU Rules

Current HRU: hru02

Summary Rule 1 Rule 2

Rule type: Template - Aspect View Layer

Input layer name: Aspect View Layer

Input layer path: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b\output\surfaces\dem\filled\aspect\grid

Output folder: D:\NRCS\GIS\Basins\Basin_Demo\santa_fe_r_0225b\output\zones\hru02\Layers\r001_aspect

Status: Complete

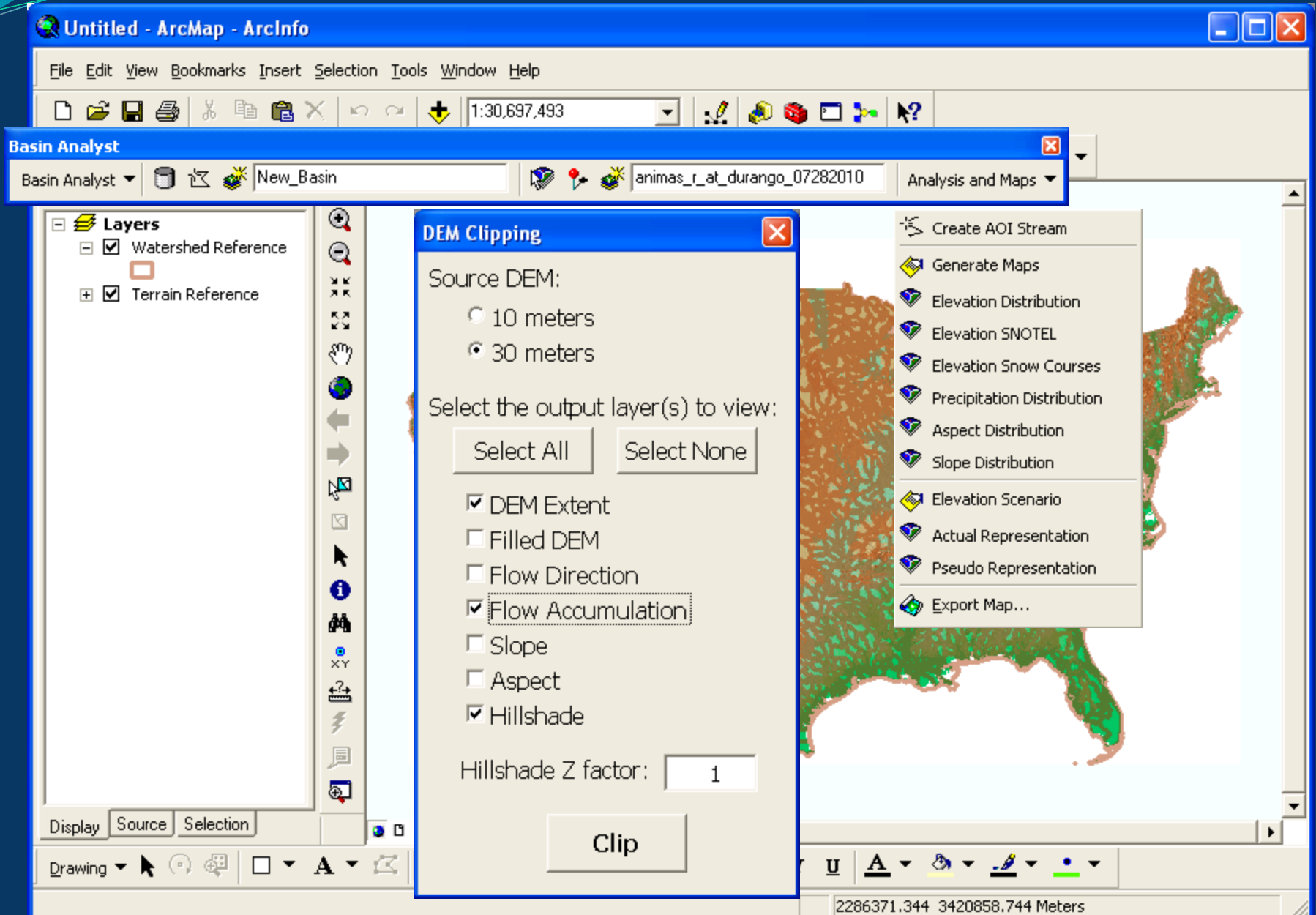
Actions: Action 2 - MajorityFilt
Action 1 - Reclass
Action 2 - MajorityFilter

	Parameter name	Parameter value
	RectangleHeight	5
	RectangleWidth	5
	IterationCount	5

Close



BAGIS Graphic User Interface



Basin Analysis GIS

1. Basin analysis GIS model building - BAGIS
 - Using Windows standard graphic user interface
 - Managing and organizing basin analysis data
 - Preparing terrain datasets for AOI delineation
 - Delineating AOI
 - Performing spatial computation
 - Generating maps and Excel reports
2. GIS data compilation
3. Basin analysis model execution

BASINs and AOIs

Region	#AOIs	Disk Size (GB)
Great Basin	82	44.37
Humboldt_2	10	19.3
Koot_PO_Spok	48	87.3
Lower Columbia	29	9.16
Middle Columbia	25	9.56
Missouri/Platte	110	209.8
Puget_Sound	14	4.27
Snake River	87	125
South Coast	12	4.90
Upper Colorado	160	167.44
Upper Columbia	23	16.2
Walker Lake 2	1	2.77
Total	601	700.05

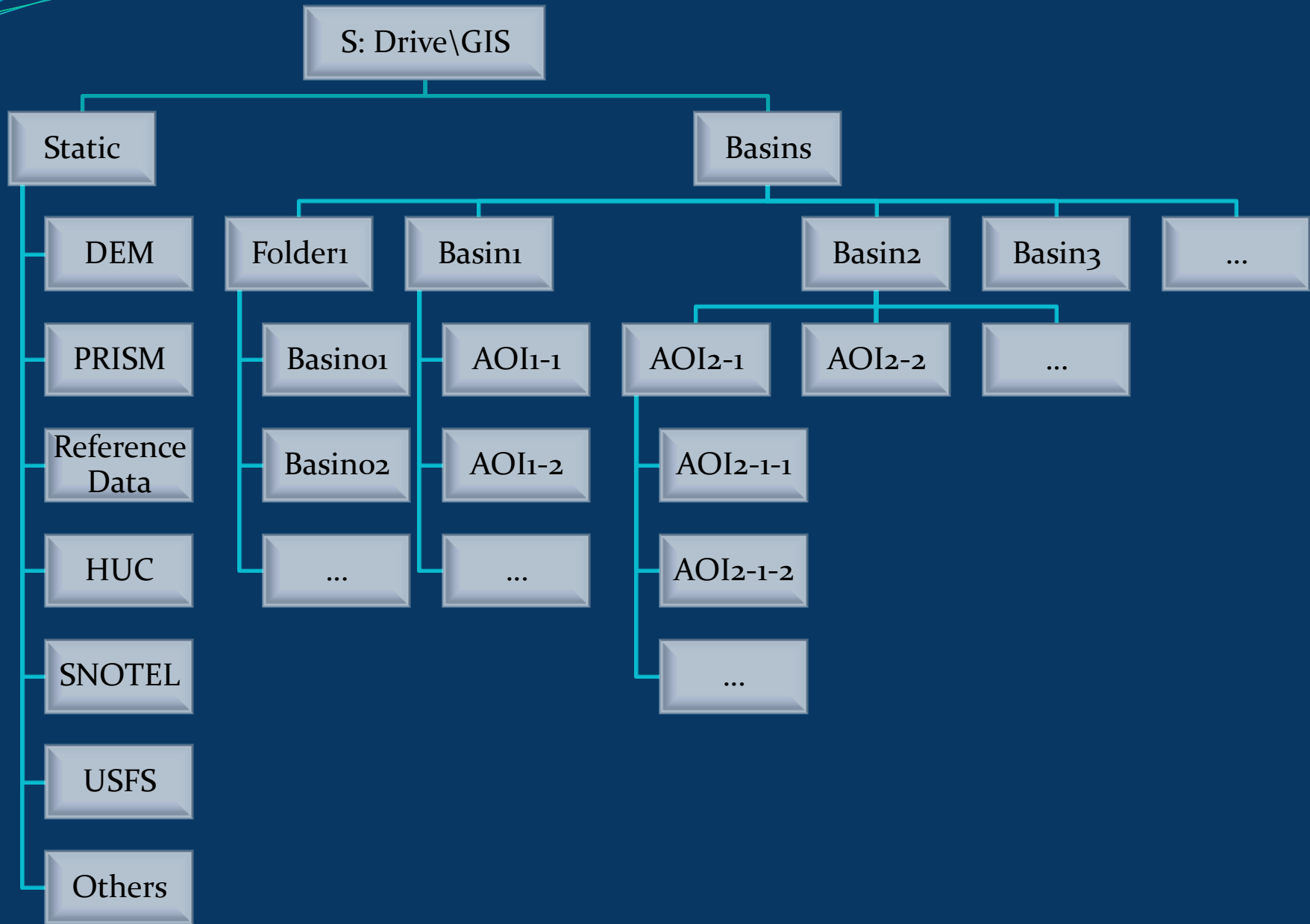
Organization of Input Data

- Input data requirements
 - Raster (Arcinfo grid); vector (ArcGIS shapefiles)
 - Some layers require predefined attributes (customizable at the system settings dialog window)
 - Input data do not need a mandatory organizing structure, except...
 - PRISM precipitation data
 - 12 monthly
 - 4 quarterly
 - 1 annual

Organization of Output Data

- Output data categories
 - Basins – basic unit for processing DEM for AOI delineation
 - Area of Interests (AOIs) – basic unit for basin analysis
- Output data requirements
 - Raster (Arcinfo grid); vector (ArcGIS shapefiles)
 - Output data are compatible with GIS Weasel
 - Allow nested AOIs

User's File Structure (Recommended)



Basin Functions

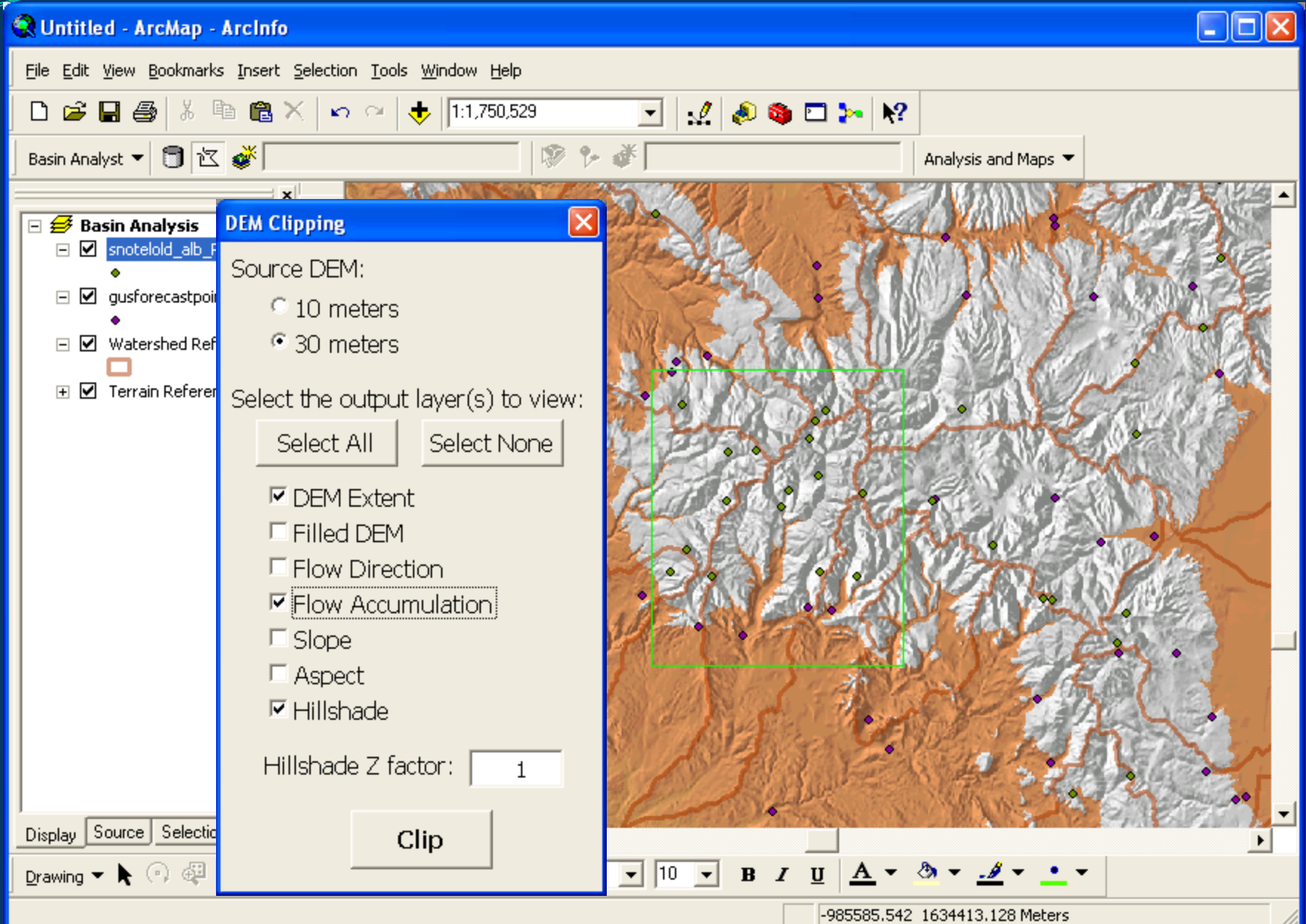
Basin Tool [X]

Open Select

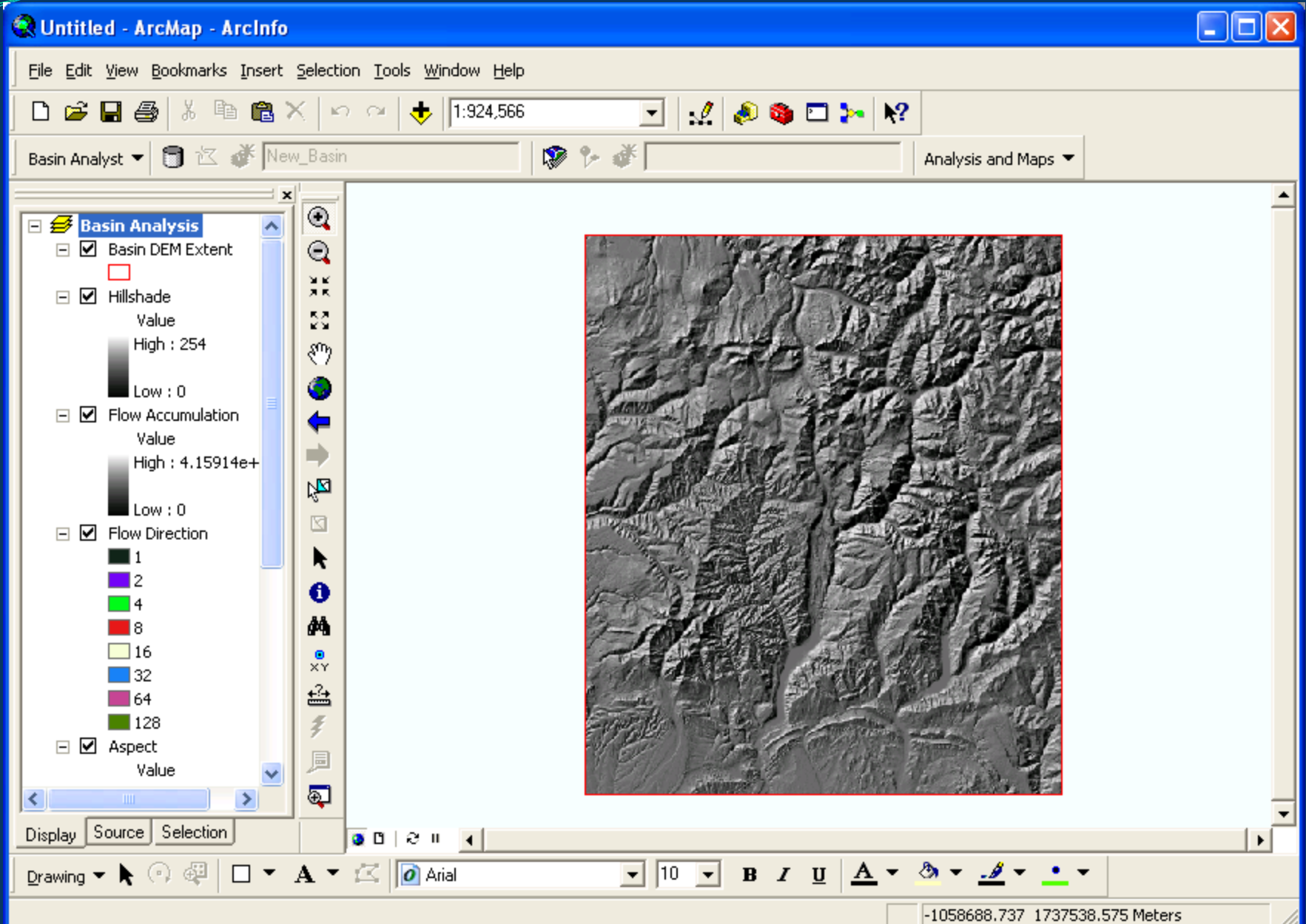
New Subfolder DEM: **30 meters DEM** ☐ View Layers AOI: **No** Close

Sub Folders	DEM Status	AOI Status
.. <Parent Folder>		
eagle_r_bl_gypsum	30 meters DEM	AOI
output	No	No
paonia_reservoir	30 meters DEM	AOI
roaring_fork_at_glenwood_springs	30 meters DEM	AOI
taylor_park_0	30 meters DEM	AOI
taylor_park_100	30 meters DEM	AOI
taylor_park_1000	30 meters DEM	AOI
taylor_park_1300	30 meters DEM	AOI
taylor_park_400	30 meters DEM	AOI
taylor_park_700	30 meters DEM	AOI

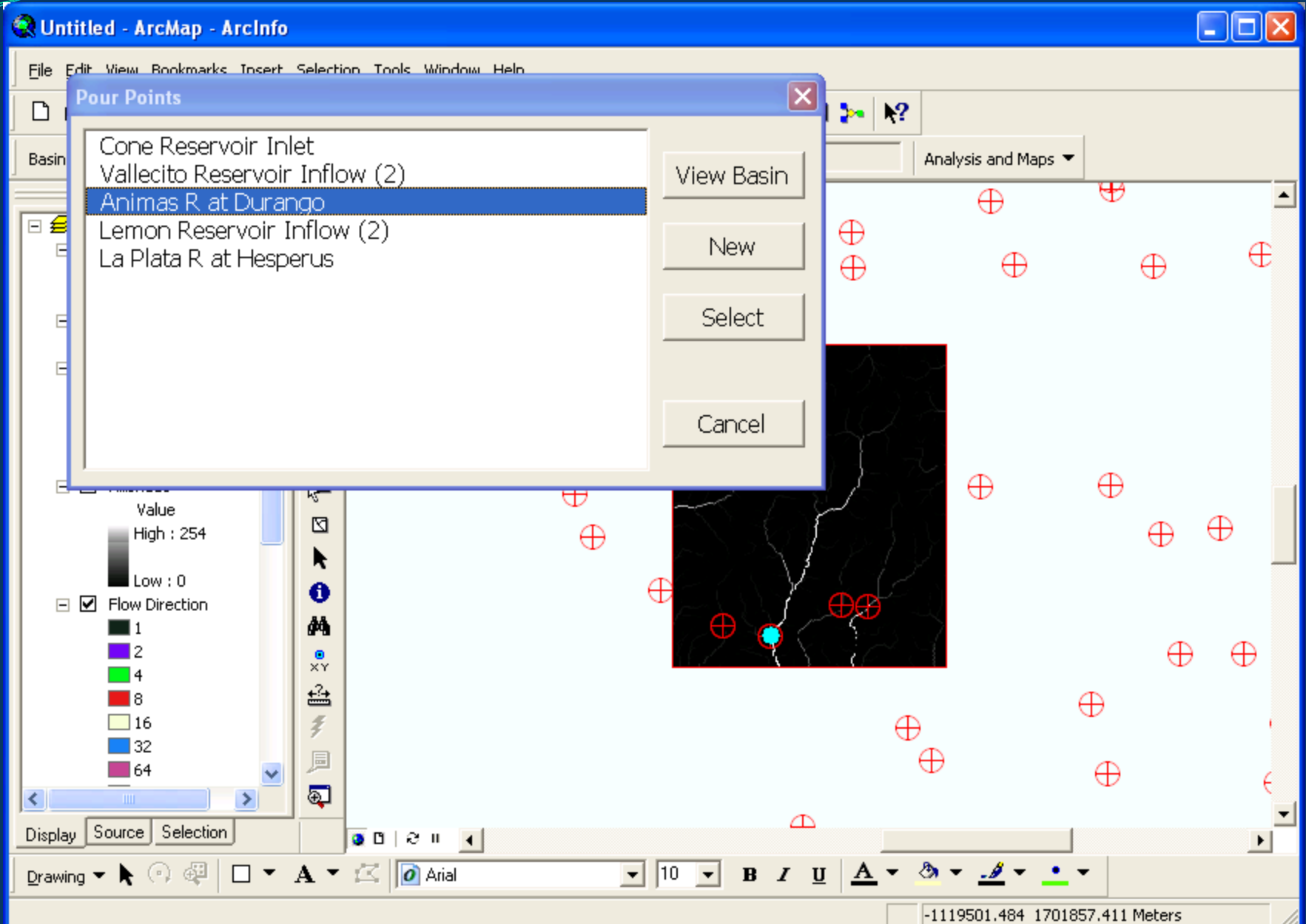
Basin Functions



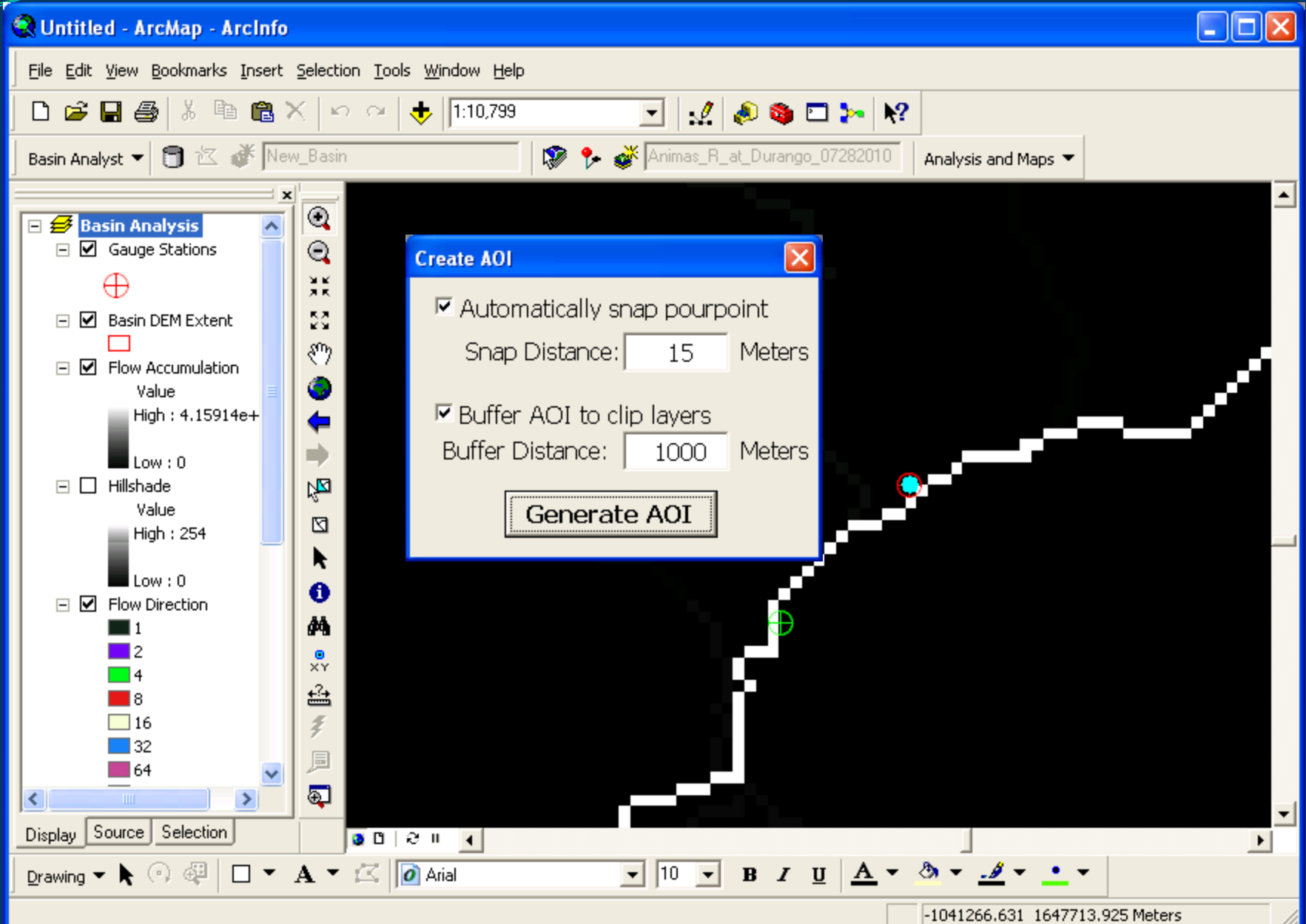
Basin Functions



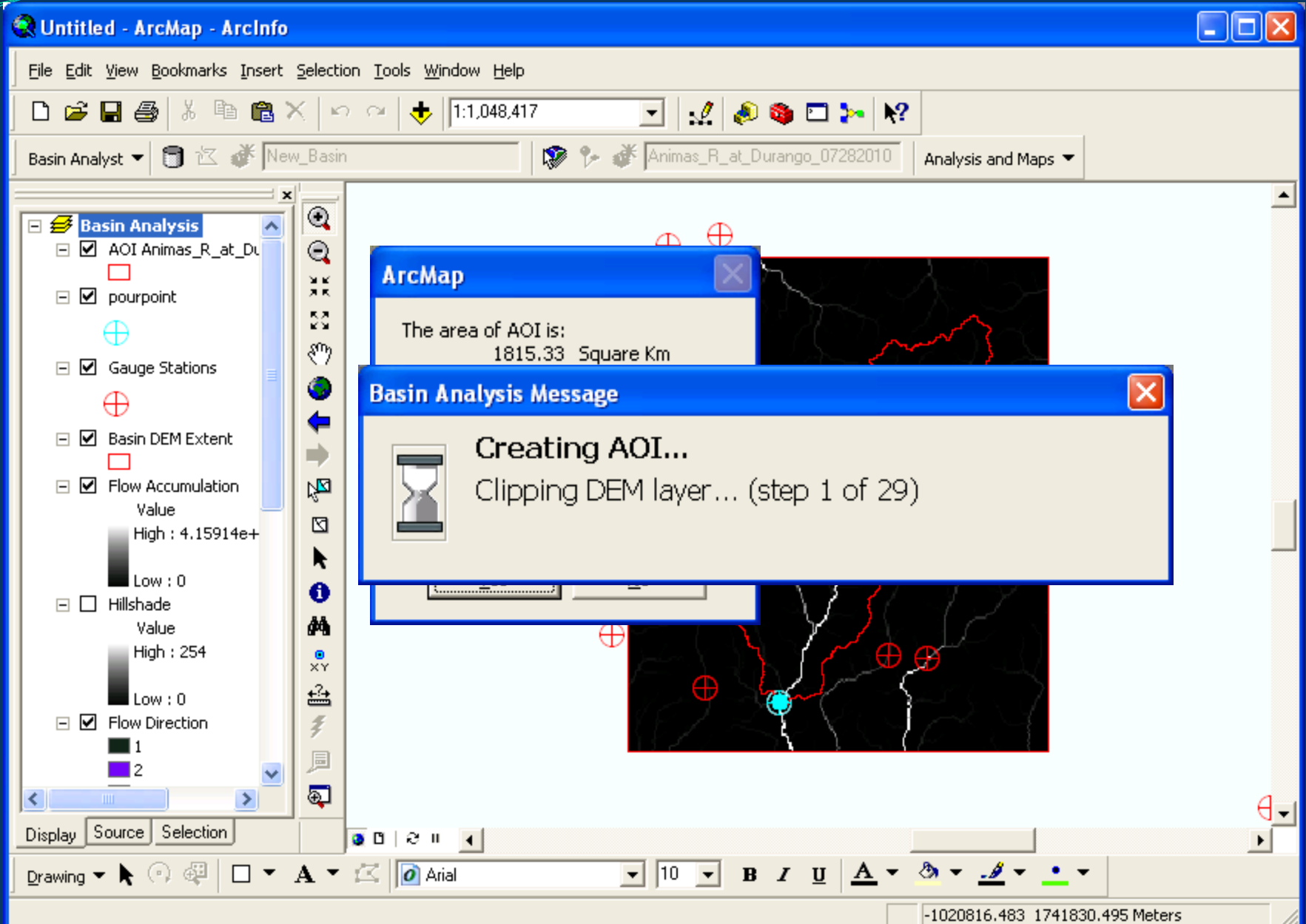
AOI Functions




AOI Functions




AOI Functions



Maps & Tables Functions

 Create AOI Stream

 Generate Maps

 Elevation Distribution

 Elevation SNOTEL

 Elevation Snow Courses

 Precipitation Distribution

 Aspect Distribution

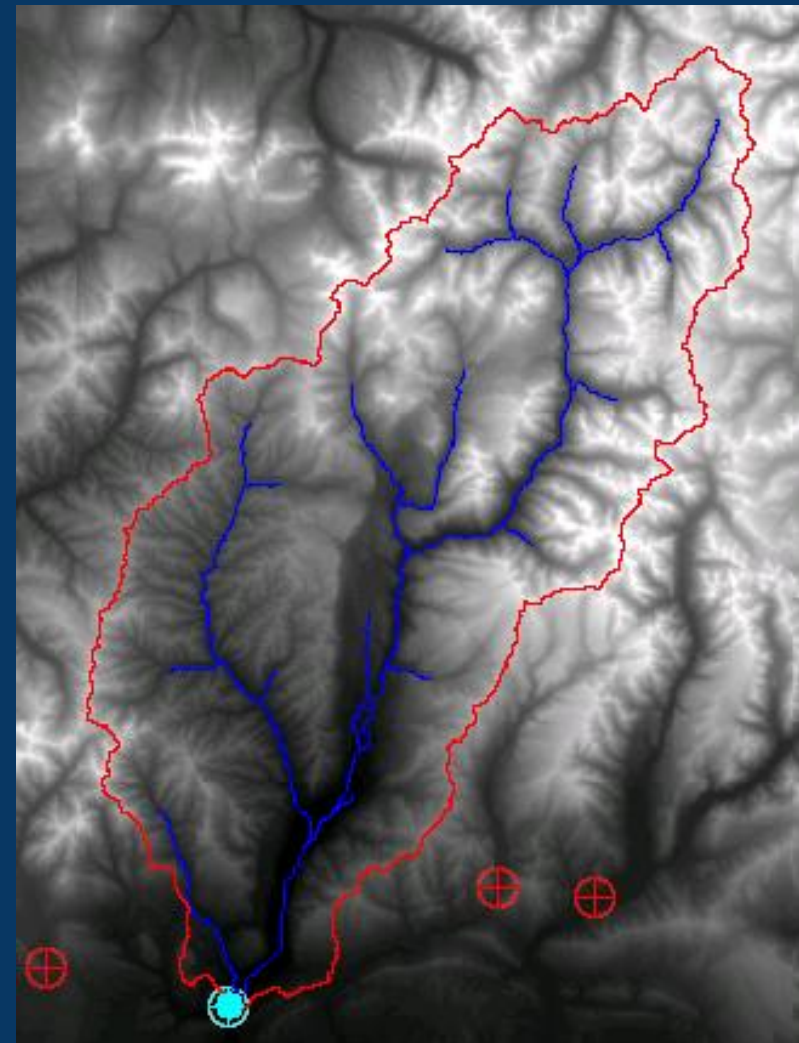
 Slope Distribution

 Elevation Scenario

 Actual Representation

 Pseudo Representation

 Export Map...



Maps & Tables Functions

Map Settings

AOI Area:

1815.33 Sq. Km

448576.21 Acre

700.90 Sq. Mile

Elevation (m):

Min 1986.18

Max 4288.26

Range 2302.08

Elevation Unit

☒ Meters

☐ Feet

Elevation Zones for Precipitation Analysis

Interval: 200 # Classes: 13

1. Apply

Intervals	% Area	# SNOTEL	# Snow Course
1986.18 - 2000	%		
2000 - 2200	%		
2200 - 2400	%		
2400 - 2600	%		
2600 - 2800	%		
2800 - 3000	%		
3000 - 3200	%		
3200 - 3400	%		
3400 - 3600	%		

Elevation Subdivisions on Elevation Curve: 1

☐ Generate Tables and Charts for Specified Elevation Range

From elevation: 0

To elevation: 0

Set value: ☒ From ☐ To

Click to set value:

1986.18

2000

2200

2400

2600

Data Status

Data Description

Raster Name

Ready	AOI Streams	aoi_streams
?	PRISM Elevation Zones	elevzone
?	Elevation Zones	subelev
?	Precipitation Zones	preczone
?	SNOTEL Elevation Zones	stelzone
?	Snow Course Elevation Zones	scozone
?	Aspect	aspzone
?	Slope	slpzone

Precipitation Distribution Map

PRISM Data: Annual Precipitation

From: 1 To: 12

Precipitation (inches)

Precipitation Zones

Min

Max

Range

2. Get Range

Precip Interval: 0 inches

Precip Zone #: 10

3. Apply

4. Generate Zones

Tables

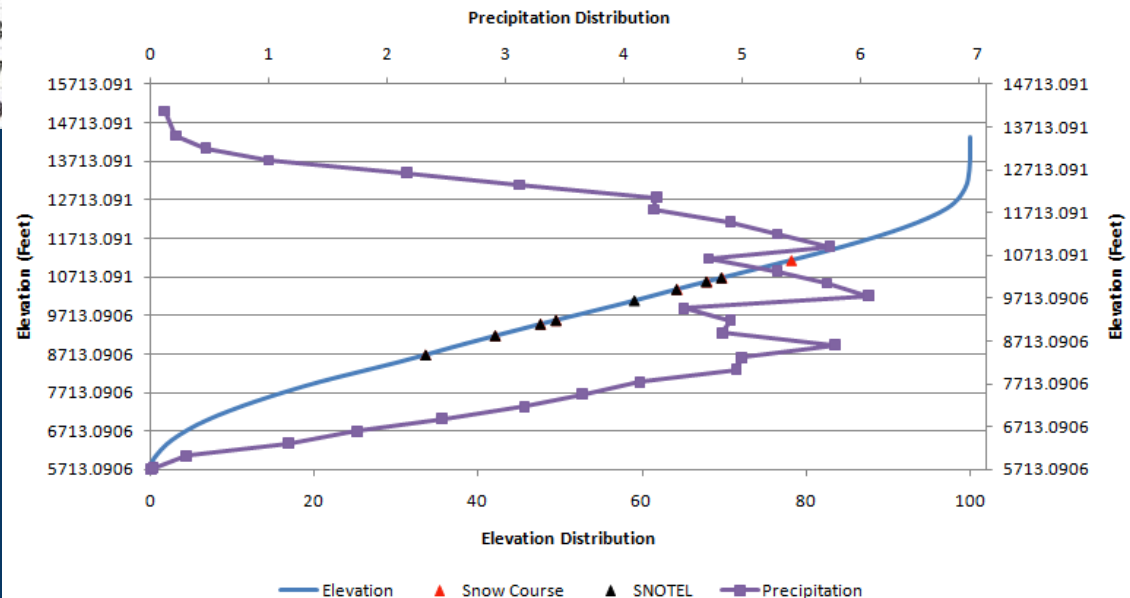
Maps

Close

Maps & Tables Functions

	A	B	C	D	E	F	G	H	I	J	K
1	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	%_AREA	Label
2	2272.87									0	
3	2367.2	1	874885.5	22.002985	22.002985	0	22.002985	0	22.002985	1.449275362	2313.5 - 2367.2
4	2421	1	874885.5	21.93291092	21.93291092	0	21.93291092	0	21.93291092	1.449275362	2367.3 - 2421
5	2474.8	1	874885.5	22.30121231	22.30121231	0	22.30121231	0	22.30121231	1.449275362	2421.1 - 2474.8
6	2528.6	14	12248397	22.76148415	24.65841293	1.896928787	23.51454544	0.532292604	329.2036133	20.28985507	2474.9 - 2528.6
7	2582.4	18	15747939	23.51667976	25.63058281	2.113903046	24.29165459	0.617766321	437.2497864	26.08695652	2528.7 - 2582.4
8	2636.2	13	11373512	23.74157524	27.04781532	3.306240082	25.11686897	0.865966797	326.5192871	18.84057971	2582.5 - 2636.2
9	2690	9	7873969.5	23.75693512	27.32259941	3.565664291	25.15503502	1.098495126	226.3953094	13.04347826	2636.3 - 2690
10	2743.8	3	2624656.5	26.39895058	27.86654472	1.467594147	27.36620712	0.68408972	82.09861755	4.347826087	2690.1 - 2743.8
11	2797.6	2	1749771	28.42652321	29.16862488	0.742101669	28.79757309	0.371050835	57.59514618	2.898550725	2743.9 - 2797.6
12	2851.4	2	1749771	29.83							7.7 - 2851.4
13	2905.2	1	874885.5	30.086							1.5 - 2905.2
14	2959	1	874885.5	31.208							5.3 - 2959
15	3012.8	2	1749771	32.047							9.1 - 3012.8
16	3228	1	874885.5	34.99							4.3 - 3228

Precipitation Distribution

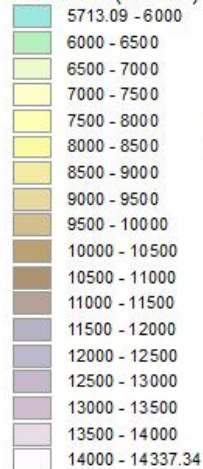


Maps & Tables Functions

ROARING_FORK_AT_GLENWOOD_SPRINGS_S AT UCO_SMALL

ELEVATION DISTRIBUTION

Elevation (in Feet)



ANIMAS_R_AT_DURANGO_07282010 AT NEW_BASIN

ELEVATIONAL REPRESENTATION - SNOTEL SITES



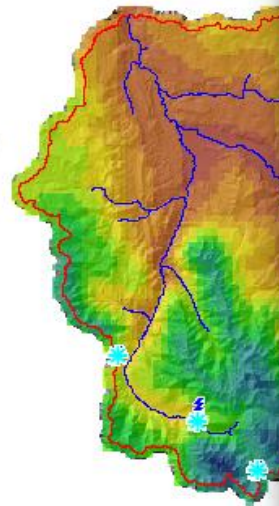
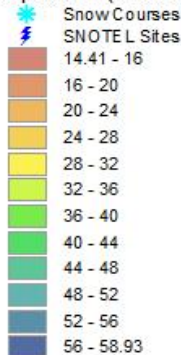
7.5 3.75 0



ROARING_FORK_AT_GLENWOOD_SPRINGS_S AT UCO_SMALL

PRECIPITATION DISTRIBUTION

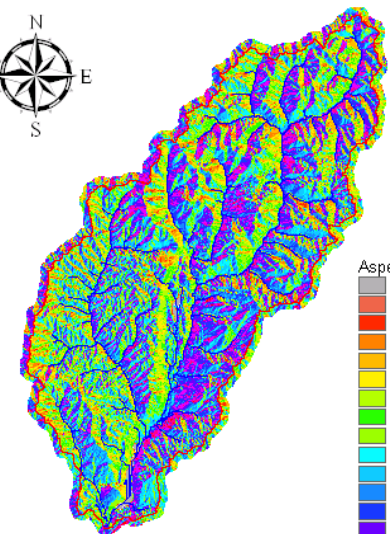
Precipitation (in Inches)



Not represented

Aspect

animas_r_at_durango_07282010
at New_Basin



10 5 0 10 20 Km



Maps & Tables Functions

UNCOMPAHGRE_R_AT_COLONA_06112010
AT BASIN_060710

ACTUAL ELEVATIONAL REPRESENTATION



Legend

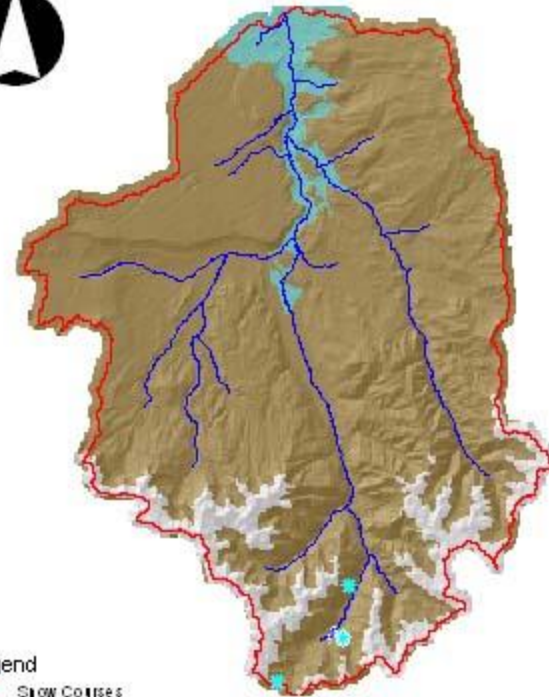
- Show Courses
- SNOTEL Sites
- Not represented below
- Represented
- Not represented above

5 2.5 0 5 Miles

A

UNCOMPAHGRE_R_AT_COLONA_06112010
AT BASIN_060710

PSEUDO ELEVATIONAL REPRESENTATION



Legend

- Show Courses
- SNOTEL Sites
- Not represented below
- Represented
- Not represented above

5 2.5 0 5 Miles

B

Other Tools

AOI: ridgway_11292010 ✕

DEM Path: F:\NRCS\GIS\Basins\UCO\ridgway_11292010\output\surfaces\dem\filled

PRISM Path: F:\NRCS\GIS\Basins\UCO\ridgway_11292010\layers\PRISM

Layers Path: F:\NRCS\GIS\Basins\UCO\ridgway_11292010\layers

Elevation Stats:			Shape Area:			Reference Area:	
Min:	2366.01	Meter		180.83	Square Km	265.00	Sq. Miles
Max:	4300.98	Meter		44684.33	Acre		
Range:	1934.97	Meter		69.82	Square Mile		

Set AOI

Presence of User's Layers in AOI

Raster Layers	Vector Layers
cov_den west_covtype	FSRoads_Albers snotel_sites snowcourse_sites

Presence of BAGIS Layers

	Selected
<input checked="" type="checkbox"/> PRISM Layers	<input type="checkbox"/>
<input checked="" type="checkbox"/> SNOTEL	<input type="checkbox"/>
<input checked="" type="checkbox"/> Snow Course	<input type="checkbox"/>

Re-clip Selected Layers

Add A New Layer

Update Weasel Info

Close

BAGIS Version 1

- Beta period: January – June, 2010
- V1 initial release: July 4, 2010
- V1_B and V1_C: August, 2010
- V1_D: September 3, 2010
- V1_E: October 5, 2010
- V1_F: December 25, 2010 (scheduled)
- Testers:
 - NWCC: Jim Marron, Tom Perkins, Angus Goodbody, ...
 - PSU: Ray Henning
- Programmers:
 - Geoffrey Duh, James Manzione

Disclaimers

- THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Appendix B. Table columns in Excel spreadsheets generated in Basin Analysis

Spreadsheet Name: **Aspect**

Field Name	Data Type	Description
DIRECTION	Number	Aspect direction code (corresponding to the DIRECTION text)
DIRECTION	Text	Text of 16 aspect directions and Flat
COUNT	Number	Number of raster cells within each aspect direction
AREA	Number	Area (square meters) within each aspect direction
MIN	Number	Minimum aspect (degree - 0 for due north)
MAX	Number	Maximum aspect (degree - 0 for due north)
RANGE	Number	Range of aspect (degree - 0 for due north)
MEAN	Number	Average aspect (degree - 0 for due north)
STD	Number	Standard deviation of aspect (degree - 0 for due north)
SUM	Number	Sum of aspect of all the cells in the interval (degree)
%_AREA	%	Percentage of area of aspect directions

Spreadsheet Name: **Area Elevations**

Field Name	Data Type	Description
VALUE	Number	Upper bound of elevation intervals in feet or meters
COUNT	Number	Number of raster cells within each elevation interval
AREA	Number	Area (square meters) within each elevation interval
MIN	Number	Minimum elevation (feet or meters)
MAX	Number	Maximum elevation (feet or meters)
RANGE	Number	Range of elevation (feet or meters)
MEAN	Number	Average elevation (feet or meters)
STD	Number	Standard deviation
SUM	Number	Total elevation of all the cells in the interval
%_AREA	%	Percentage of area of the interval in AOI
%_AREA_ELV	%	Cumulative percentage of area
LABEL	Text	Label of the elevation interval

Spreadsheet Name: **Elevation Curve**
See Area Elevations.

BAGIS Data Catalog

Data Name	Description	Data Type	Sources
Active COOP Sites	COOP Climate Stations	GIS Point	NWCC
Active/Inactive Snow Courses	Existing Snow Courses	GIS Point	NWCC
DEM 10 meters – Western US	USGS NED - 1/3 arc-second	GIS Grid/Raster	The National Map Seamless Server
DEM 30 meters - Alaska	ASTER Global Digital Elevation Map	GIS Grid/Raster	ASTER GDEM
DEM 30 meters - Canada	ASTER Global Digital Elevation Map	GIS Grid/Raster	ASTER GDEM
DEM 30 meters - Western US	USGS NED - 1 arc-second	GIS Grid/Raster	The National Map Seamless Server
Forest Density	Forest Density - From USGS Weasel	GIS Grid/Raster	NWCC
Forest Type / Land Cover	Forest Type - from USGS Weasel	GIS Grid/Raster	NWCC
HUC Basin Boundary	Hydrologic Unit Code Boundary	GIS Polygon	NOAA
Land Management: Federal	Federal lands/areas	GIS Polygon	The National Map Seamless Server
Land Management: Indian	Indian lands/areas	GIS Polygon	The National Map Seamless Server
Land Management: Wilderness	Wilderness lands/areas	GIS Polygon	The National Map Seamless Server
National Atlas -Roads	National Atlas Roads	GIS Line	The National Map Seamless Server
National Atlas -Streams	National Atlas Streams	GIS Polygon	The National Map Seamless Server
National Atlas -Waterbodies	National Atlas Waterbodies	GIS Polygon	The National Map Seamless Server
PRISM annual prcp & monthly prcp	800 meter precipitation data	GIS Grid/Raster	
SNOTEL sites - existing	Existing SNOTEL sites	GIS Point	NWCC
SNOTEL sites - Proposed	Proposed SNOTEL Sites	GIS Point	NWCC
Soil	Soil Data - from USGS Weasel	GIS Polygon	NRCS
USFS Service Roads	Service roads in National Forests	GIS Line	http://svinetfc4.fs.fed.us/vectorgateway/index.html
USGS Gauges (Forecast points)	USGS stream gauges	GIS Point	NWCC

DEM 30 Meters – Western US

