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

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NRCS Natural Resources Conservation Service

Portland State UNIVERSITY

Acknowledgements

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  Joe Poracsky, Heejun Chang

  PSU Center for Spatial Analysis & Research (CSAR)

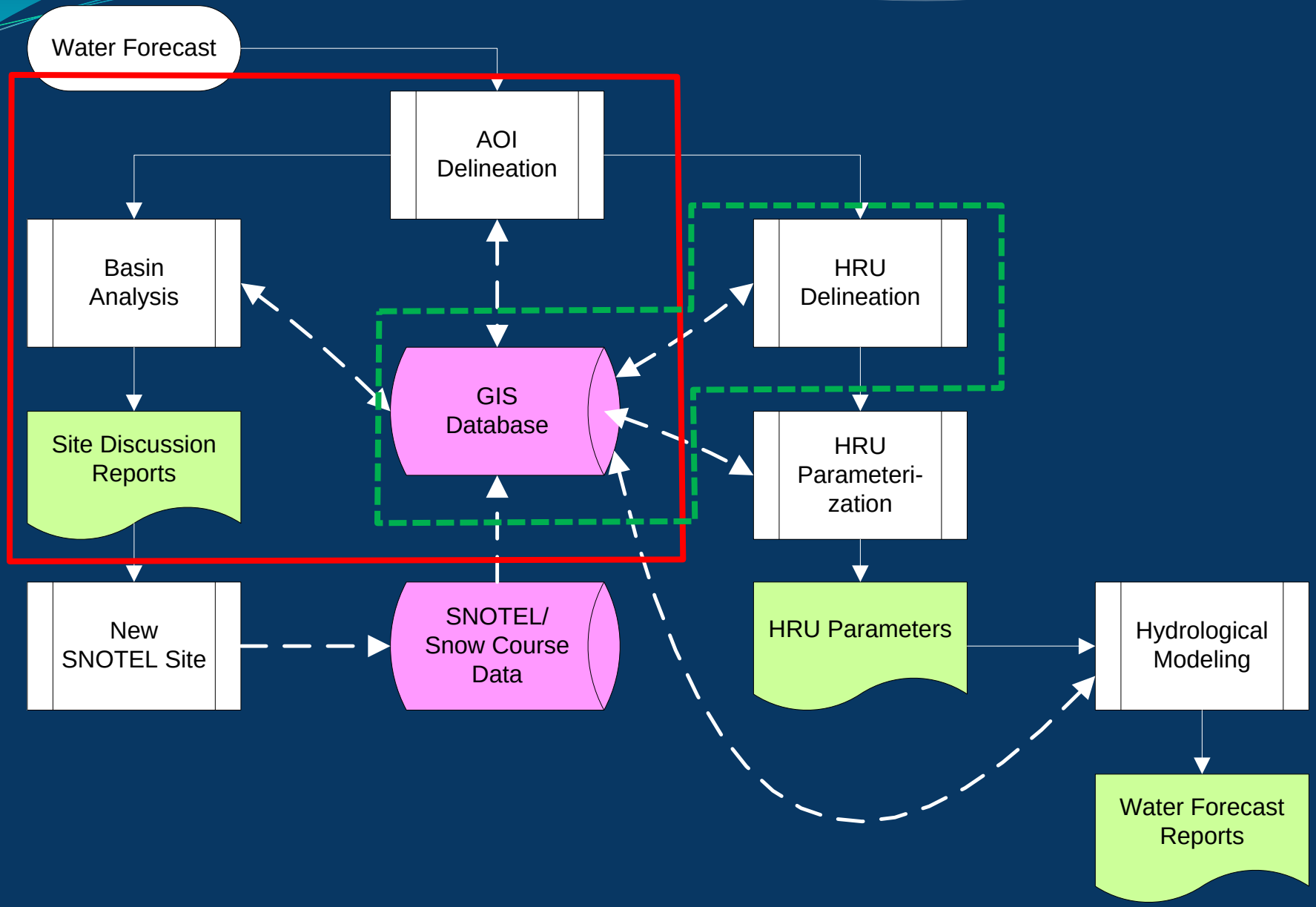
Outlines

- 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

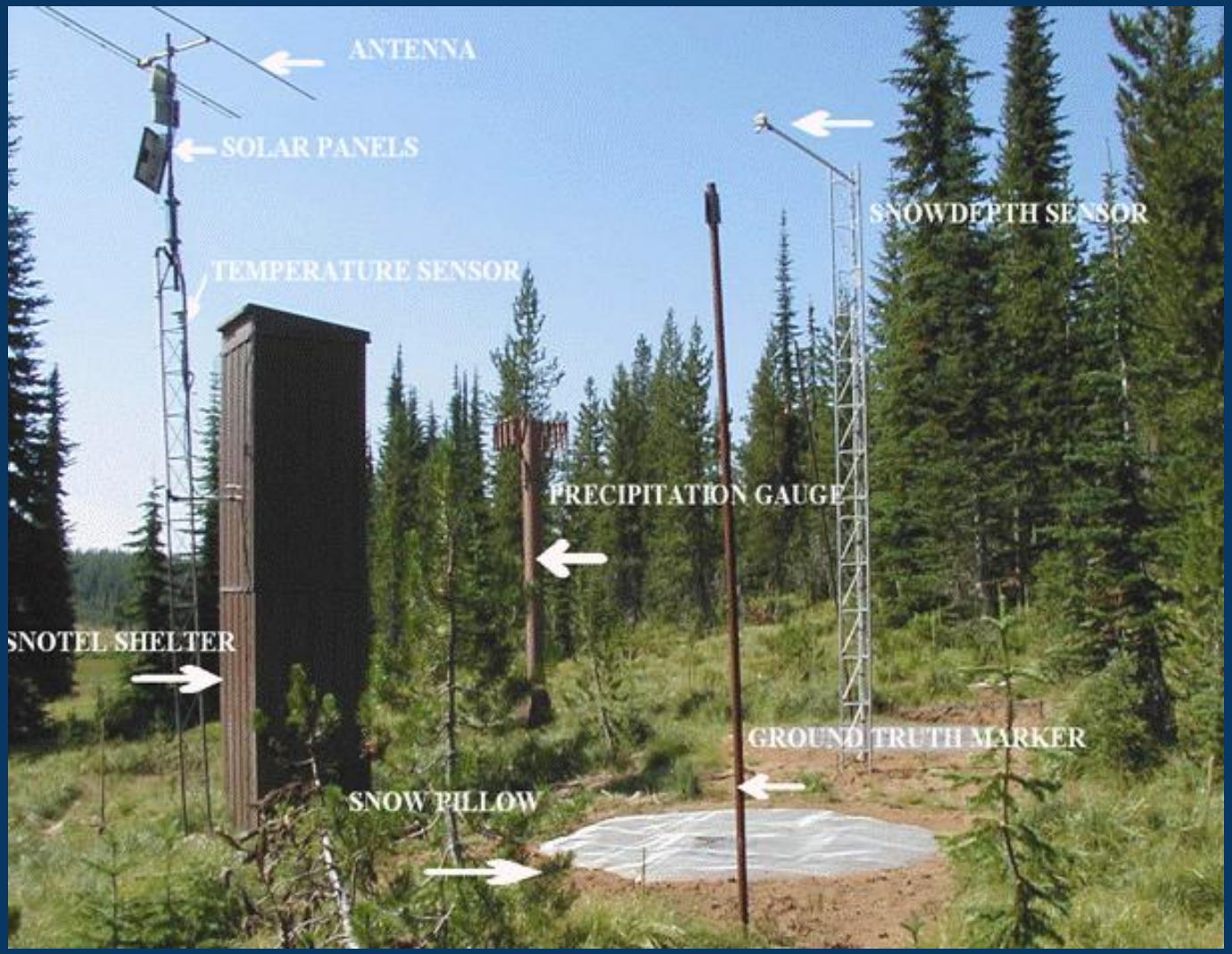


Snow Survey

- 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

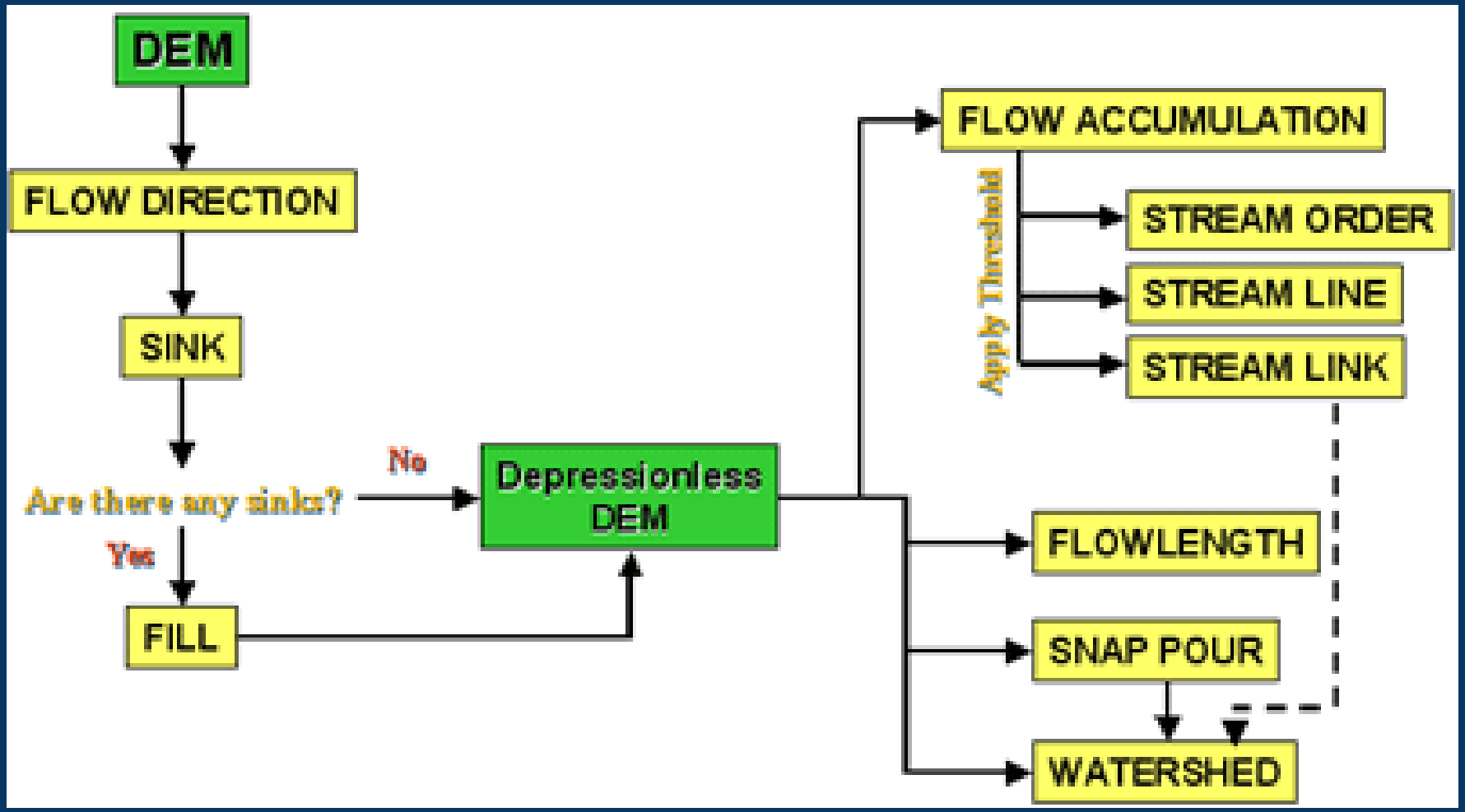


Image source: ESRI ArcGIS Online Help

PRISM Annual Precipitation Distribution

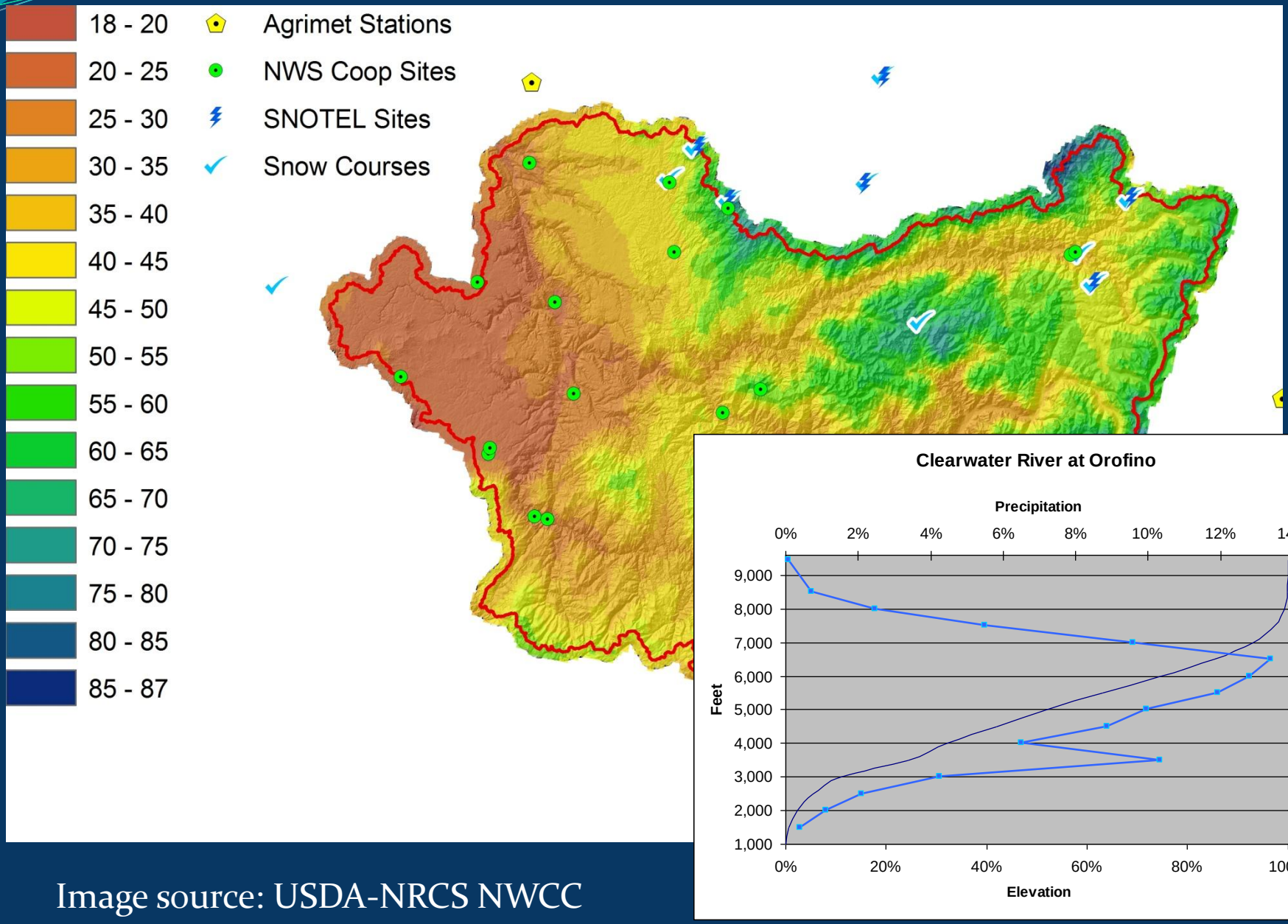


Image source: USDA-NRCS NWCC

Example of Basin Analysis Outcome

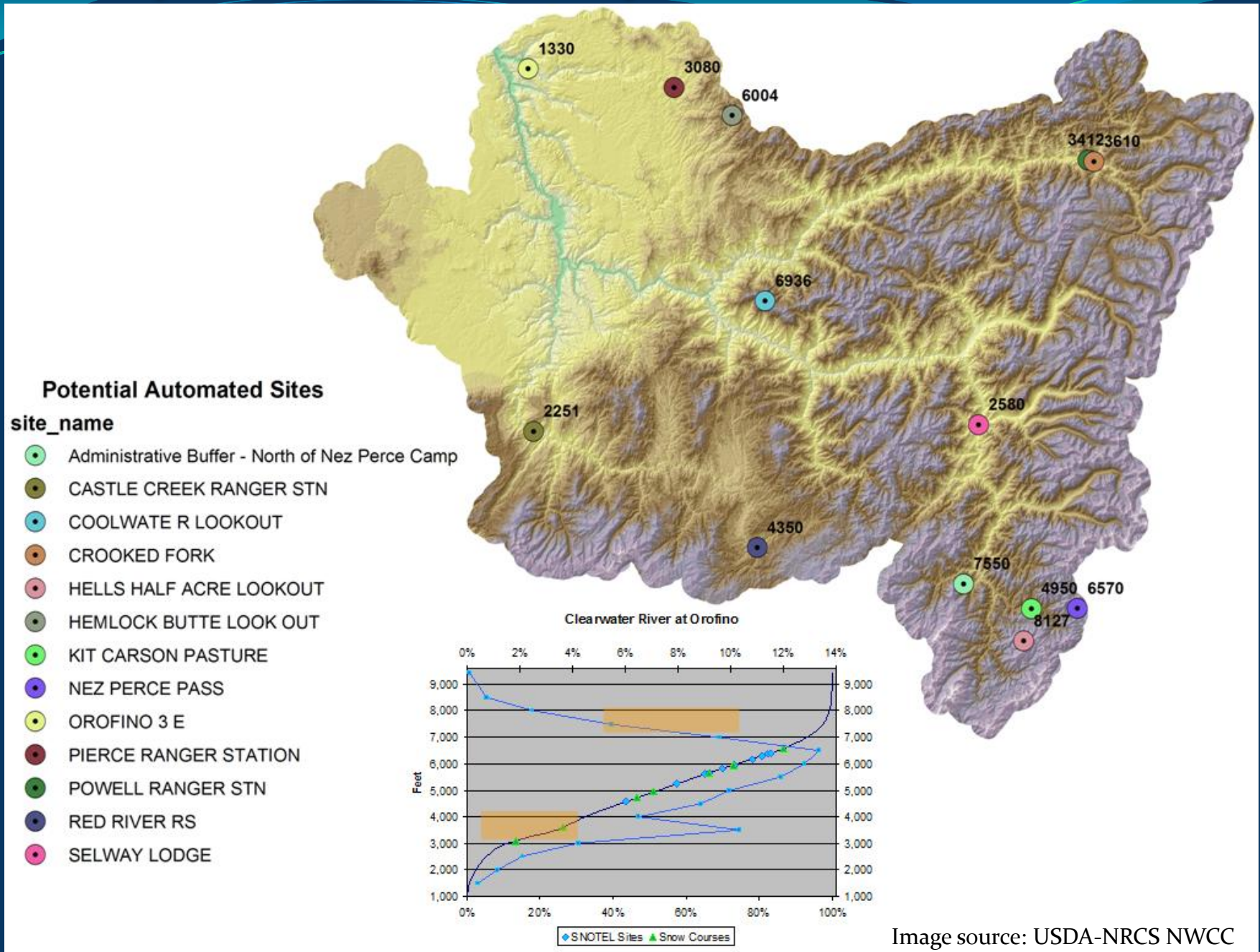
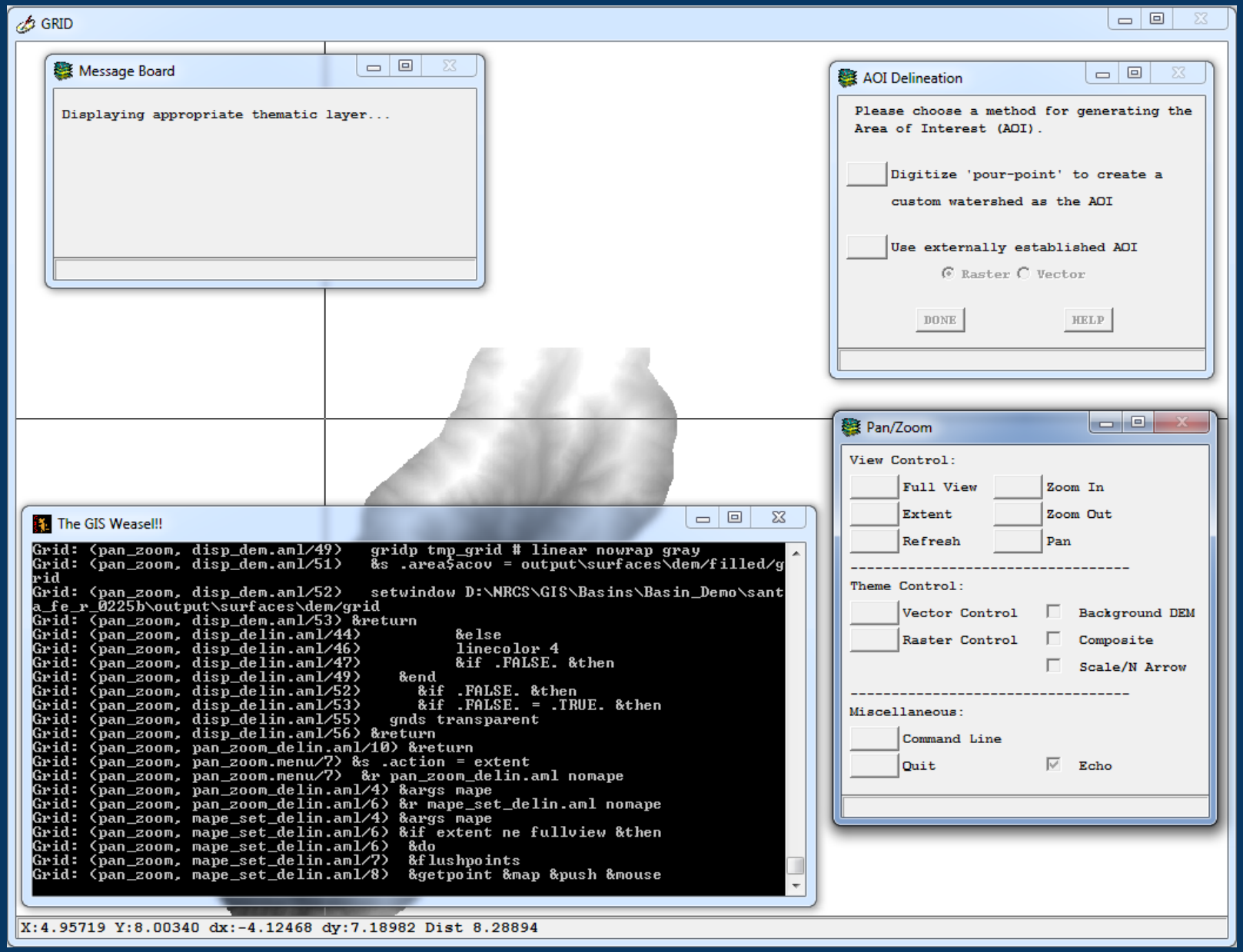


Image source: USDA-NRCS NWCC

The GIS Weasel!!



BAGIS Development Goals

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

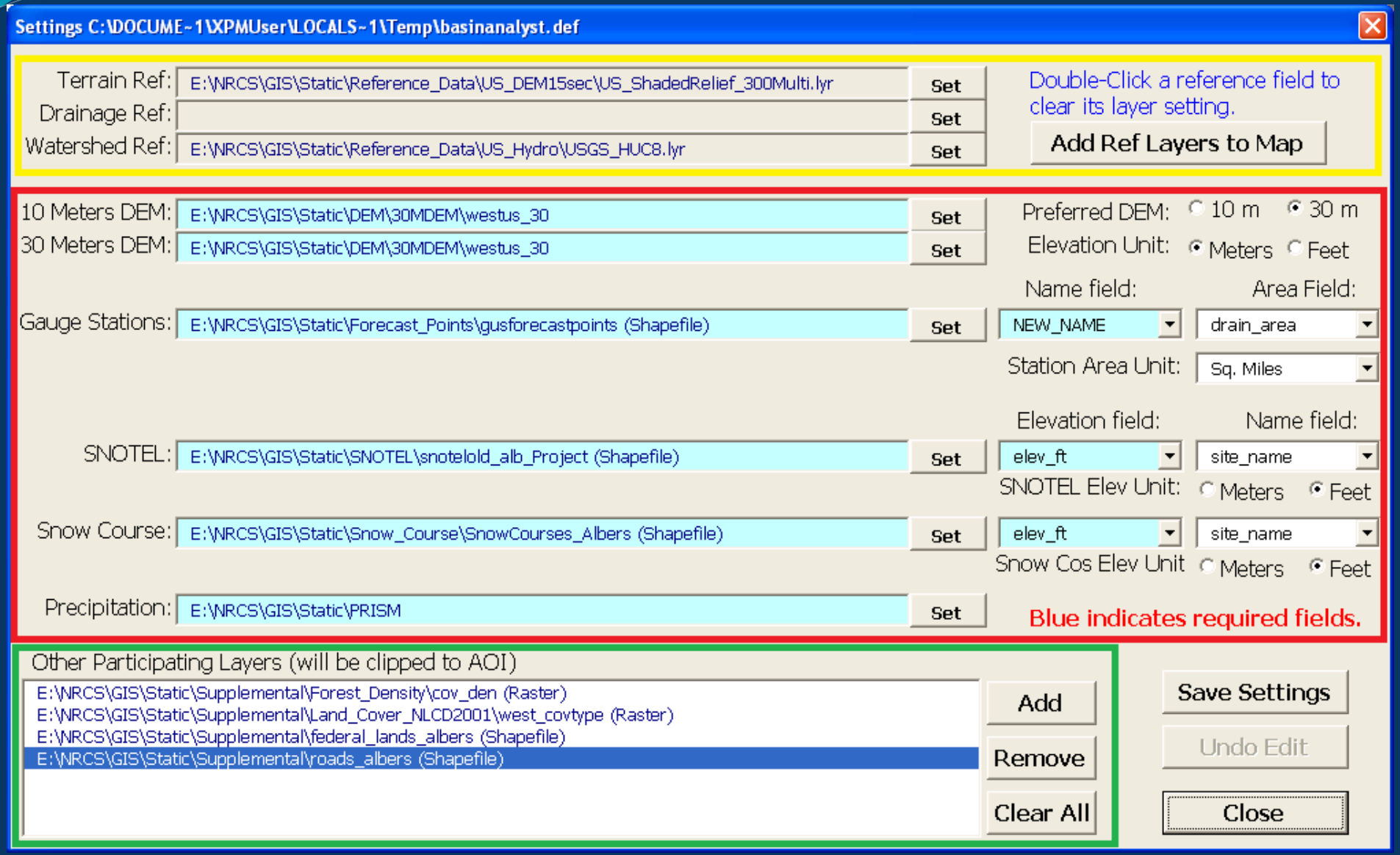
Hardware / Software Environment

- 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

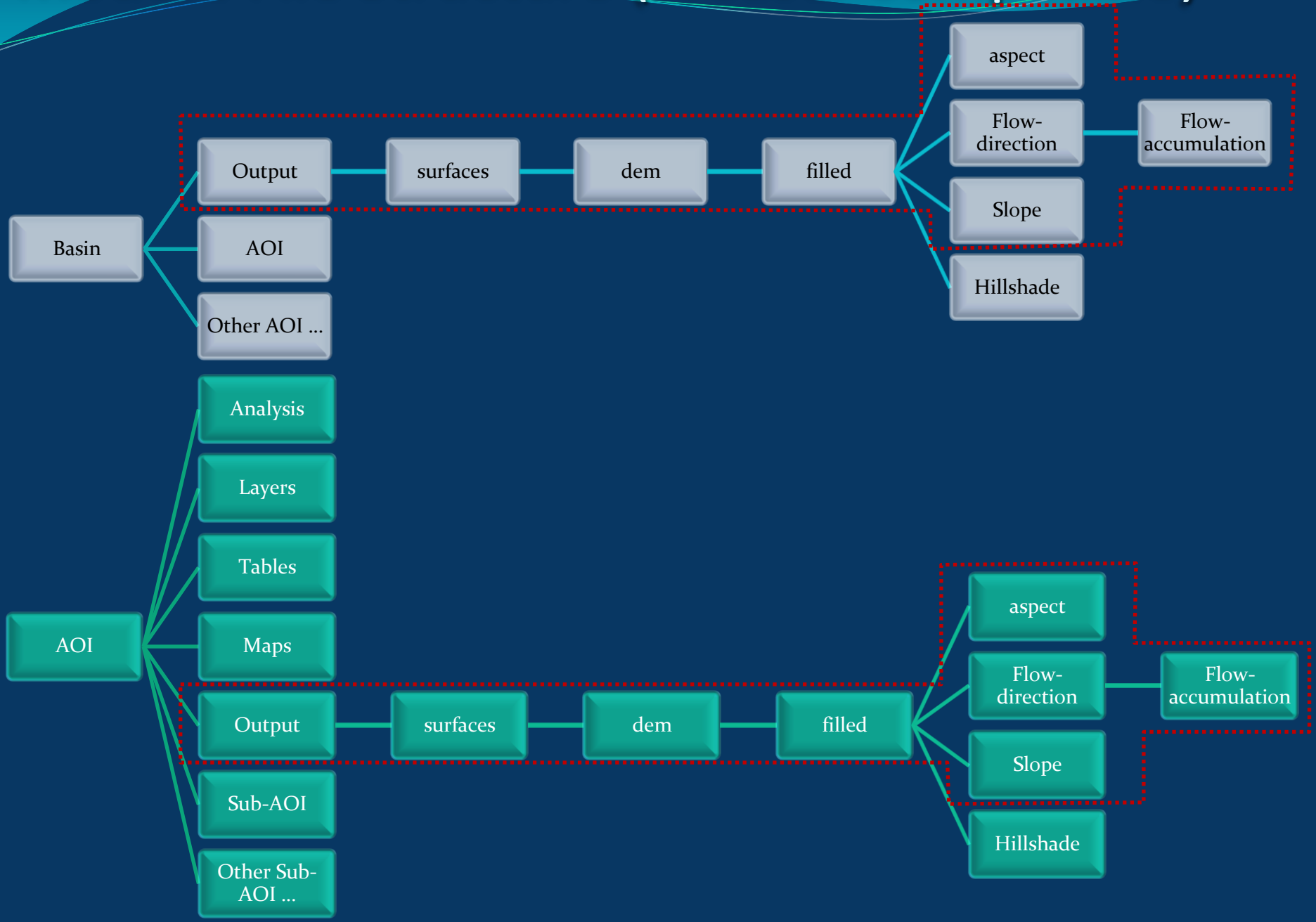
Input Data of BAGIS

- 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)

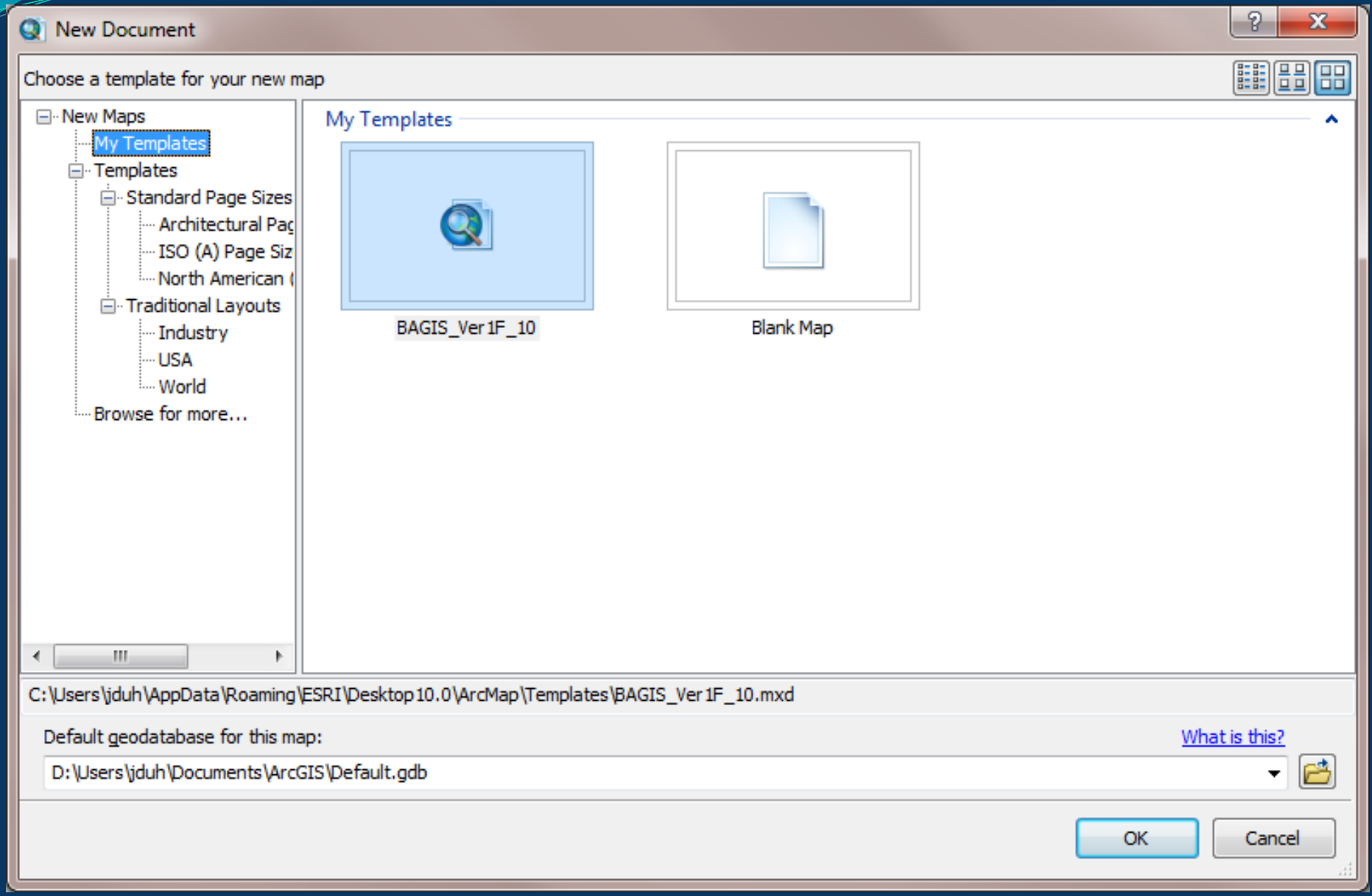
BAGIS Settings Dialog Window



Model's File Structure (Weasel Compatible)



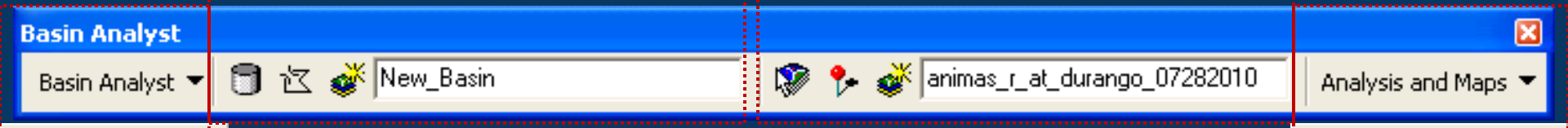
BAGIS - mxt in ArcGIS 9.x and mxd in 10

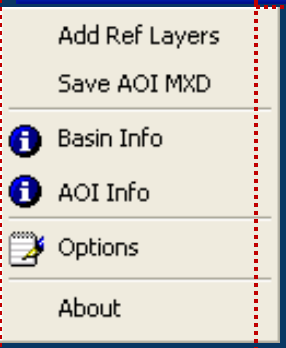


BAGIS Demonstration

Basin Functions

AOI Functions





System Functions

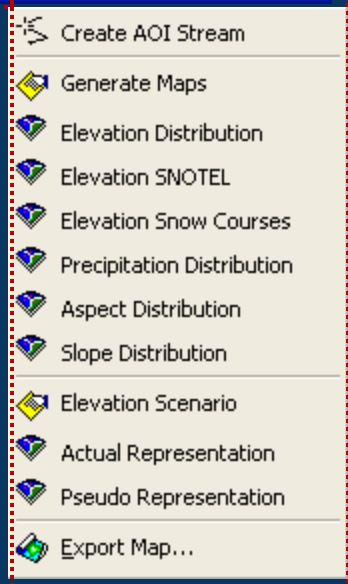
Set Data Sources

Define Basin

Delineate AOI

Run Analysis

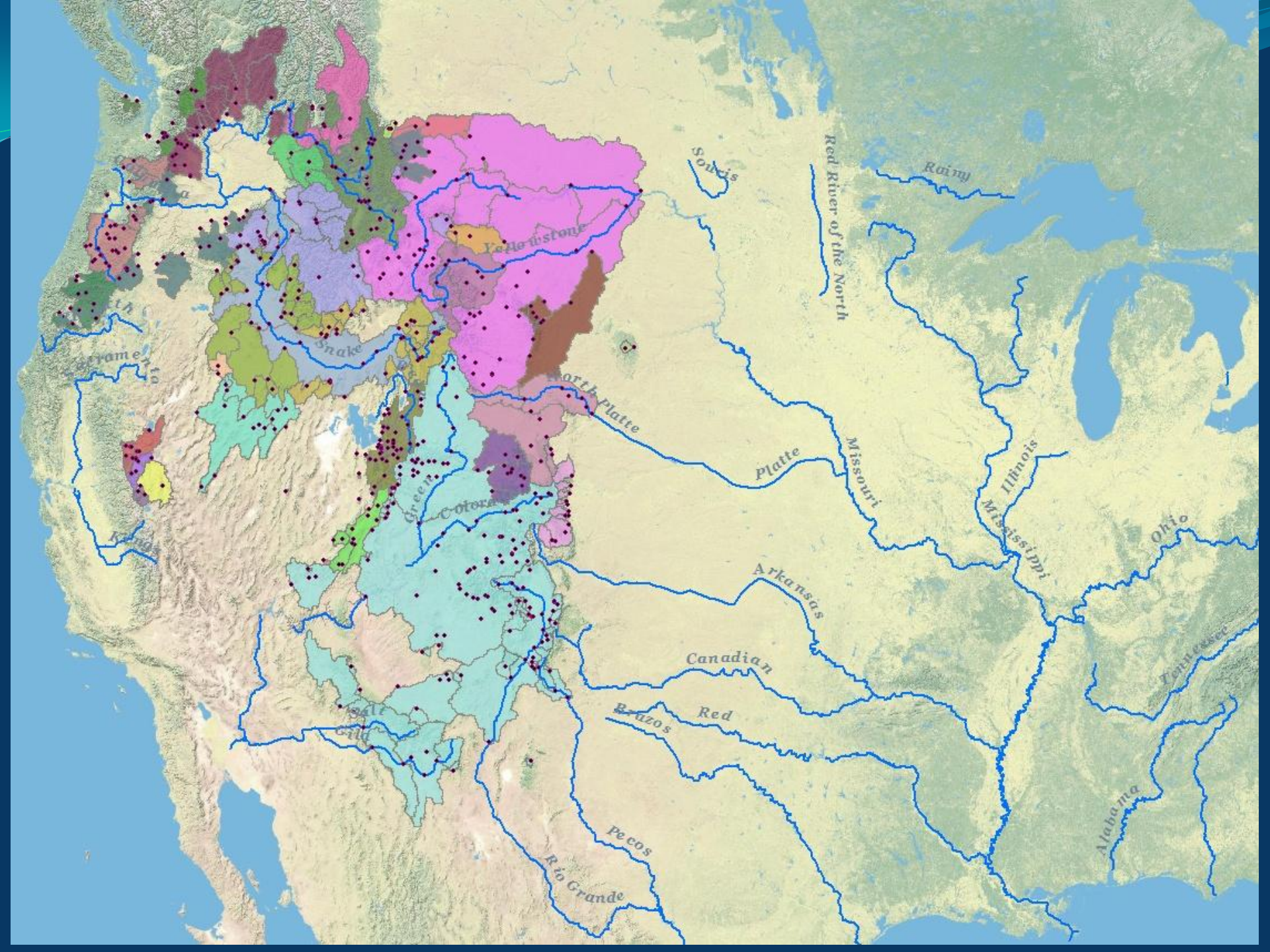
Generate Maps & Reports



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


Sonkis
Red River of the North
Rainy
Yellowstone
Snake
North Platte
Platte
Missouri
Illinois
Mississippi
Ohio
Arkansas
Canadian
Red
Brazos
Pecos
Rio Grande
Alabama
Tennessee

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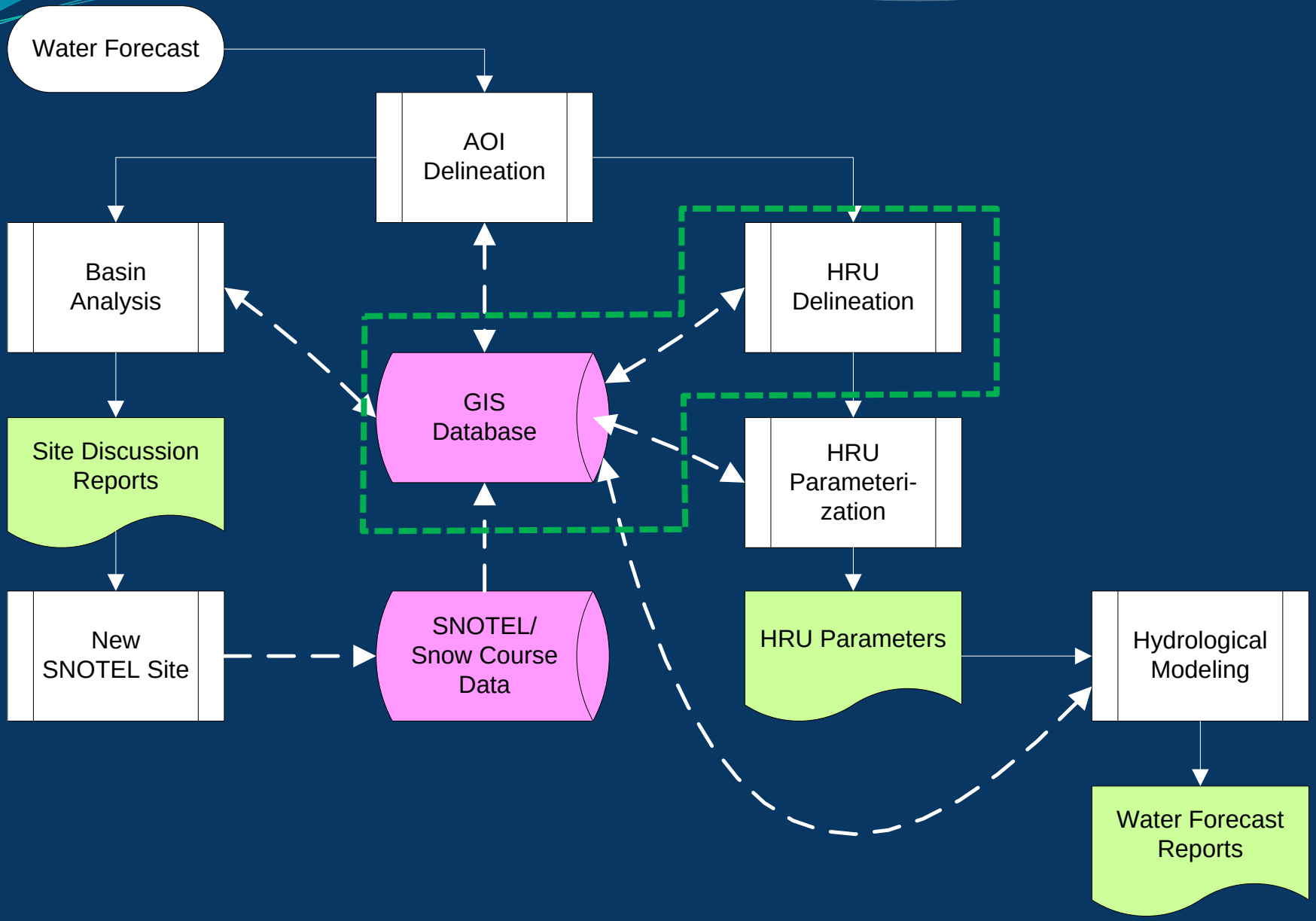
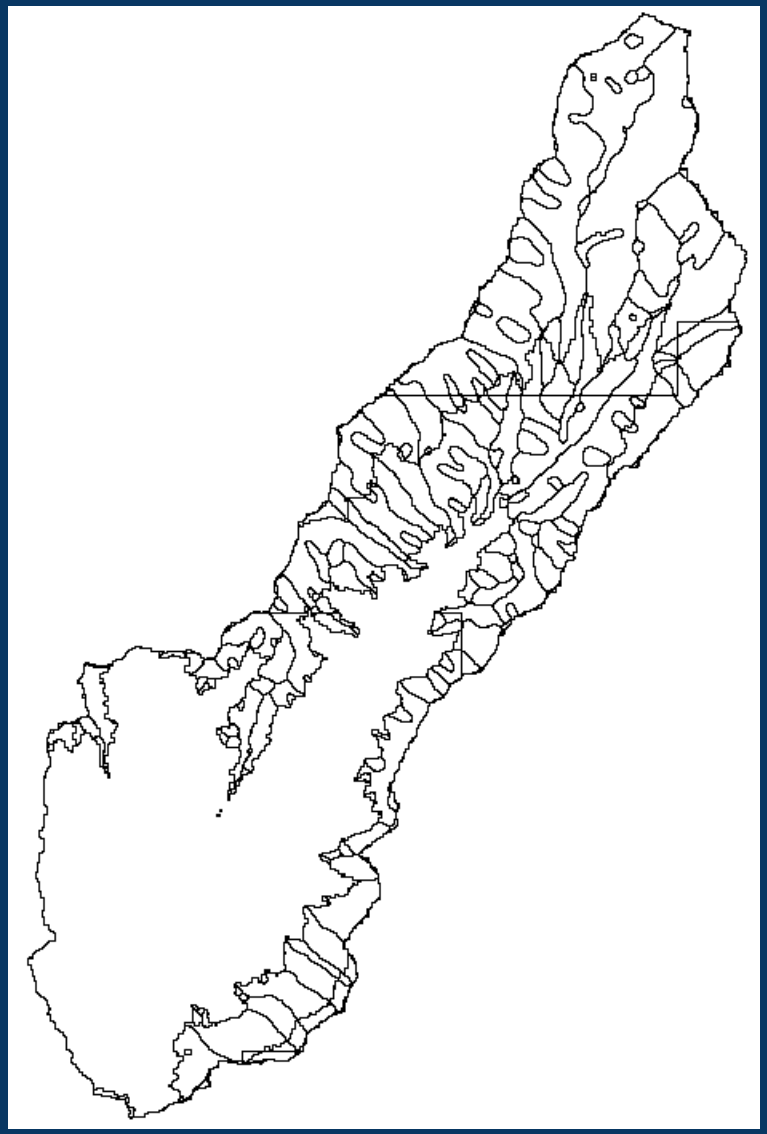
- USDA has the right to distribute BAGIS to any commercial, nonprofit, or government entity partnered with USDA through grant, contract, or collaboration agreement for the ongoing research and projects performed for or in conjunction with USDA.

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

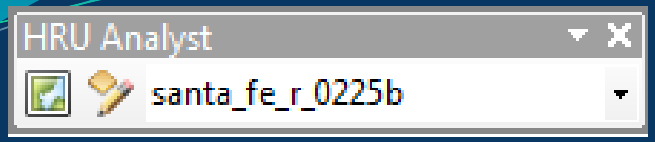
HRU Delineation
Rule Types and Actions

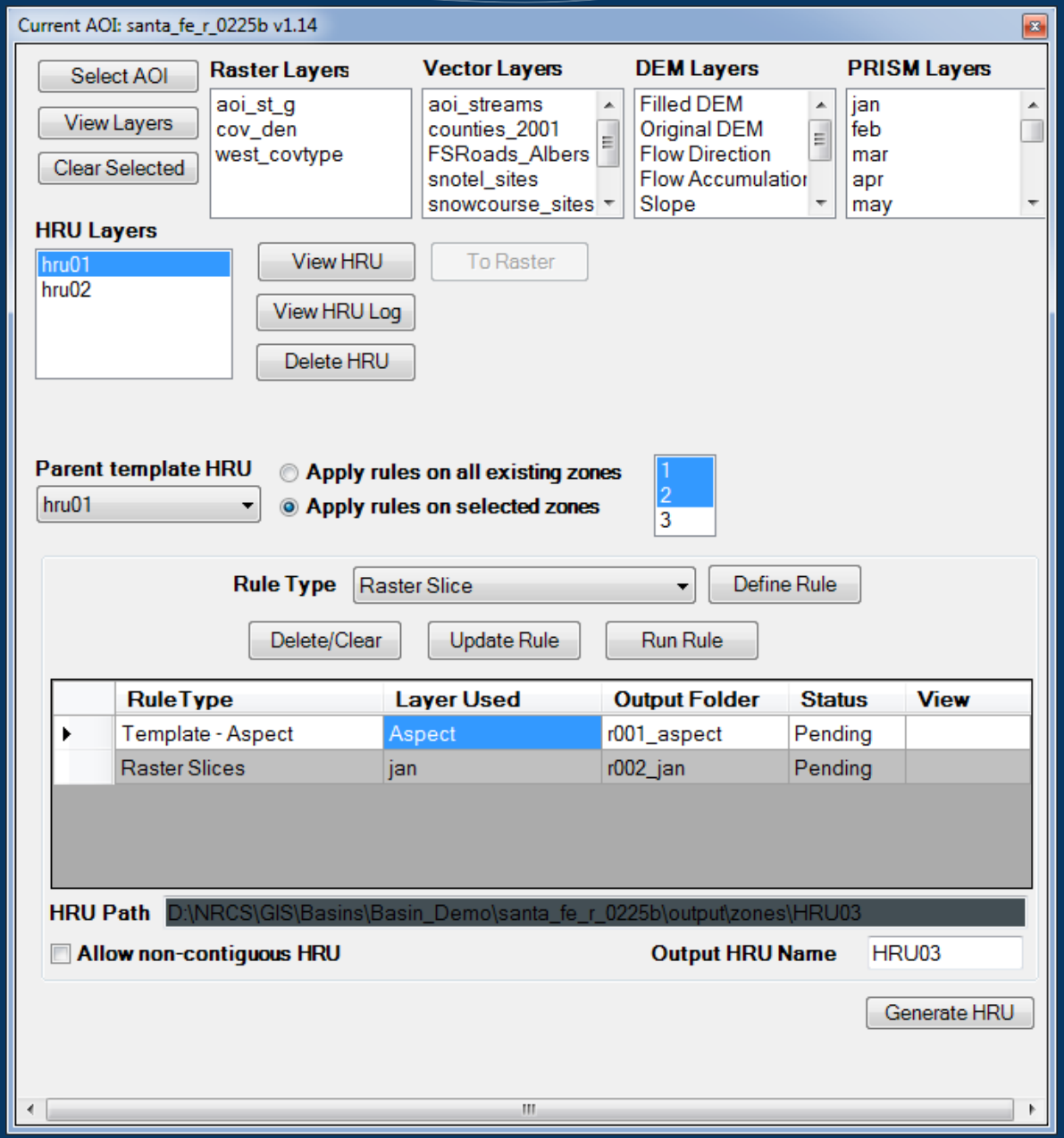
Rule Types	Actions
Contributing Area	Contributing area
Raster reclassification	None or Reclassification
Raster Slice	Slice – equal area/equal interval
DAFlow-Type Zones	Generate grid system
PRISM Precipitation	Customized precip slice
Template - Aspect	Reclassification and filtering
Template - Slope	Filtering,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

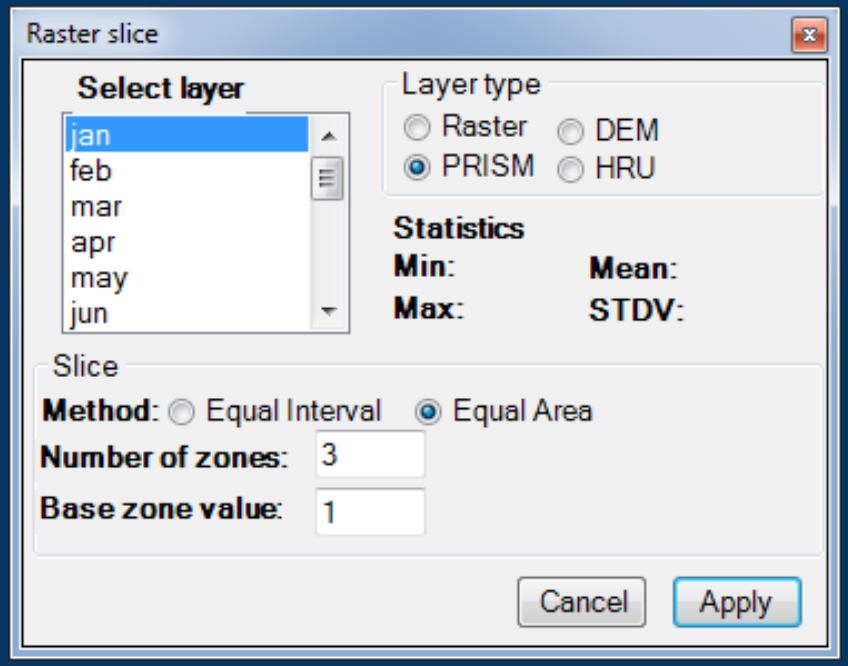
Rule Types	Actions
Eliminate	Eliminate HRU by area or by number
Cookie-Cut	Use a user layer to overwrite portions of HRU
Clustering	Group HRUs into user-specified number of types and dissolve adjacent HRUs that are of the same type.
Zonal statistics by HRU	Add stats to HRU attribute table
PRMS radiation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

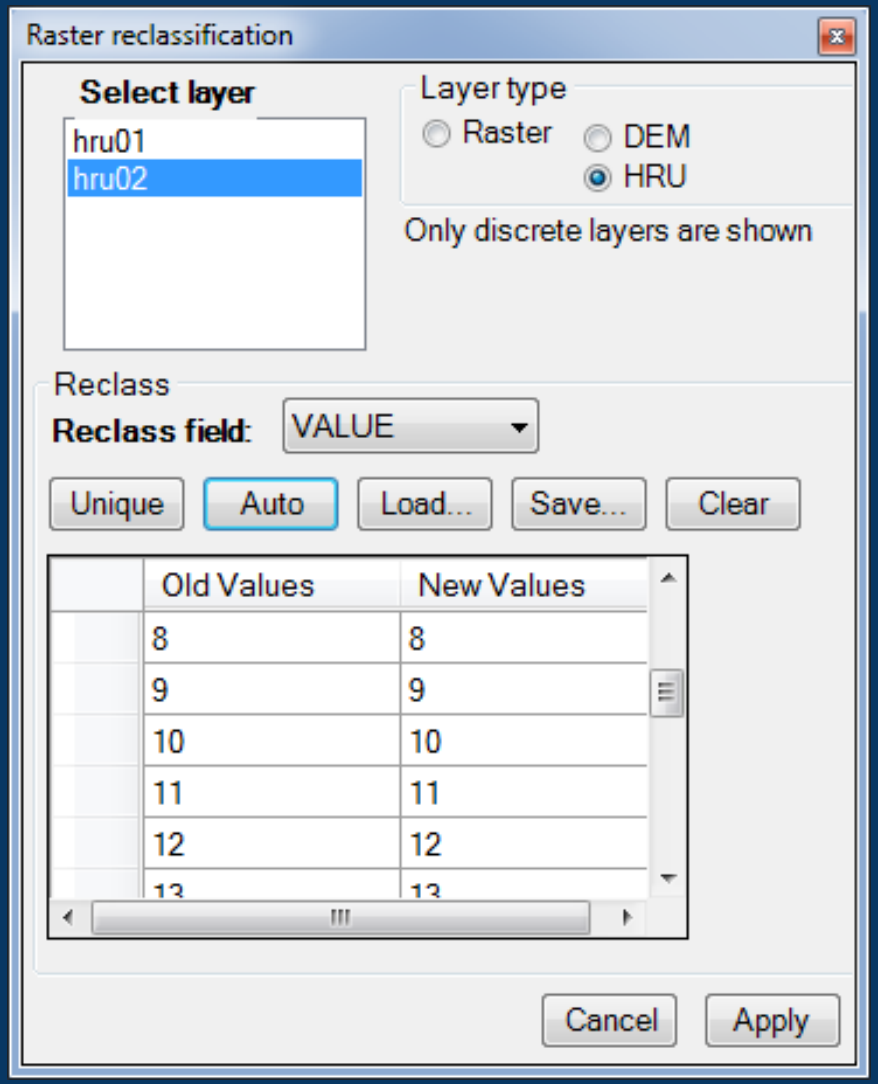
HRU Analyst Toolbar & HRU Delineation Dialog



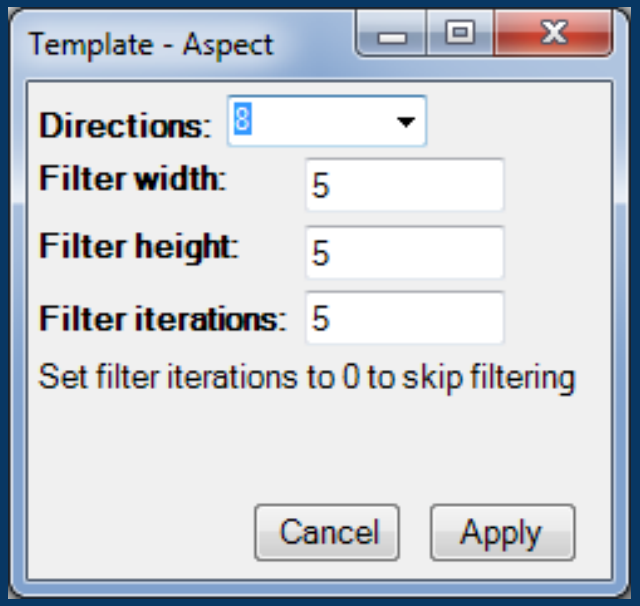


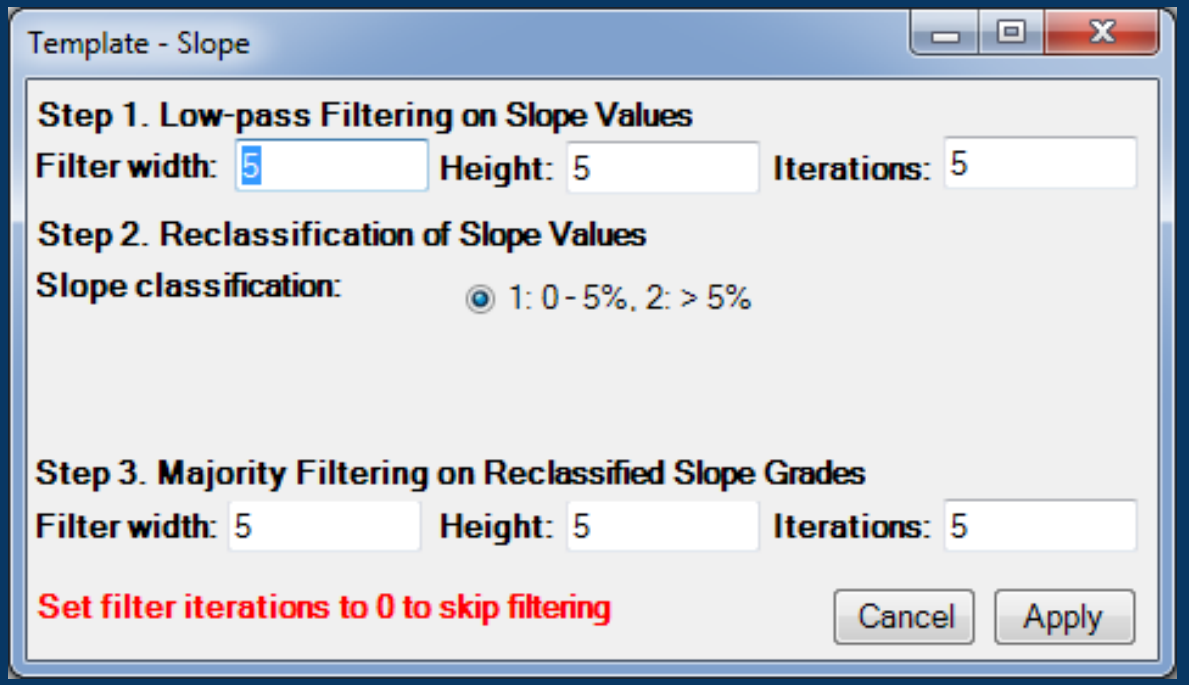
Rules for Defining HRU



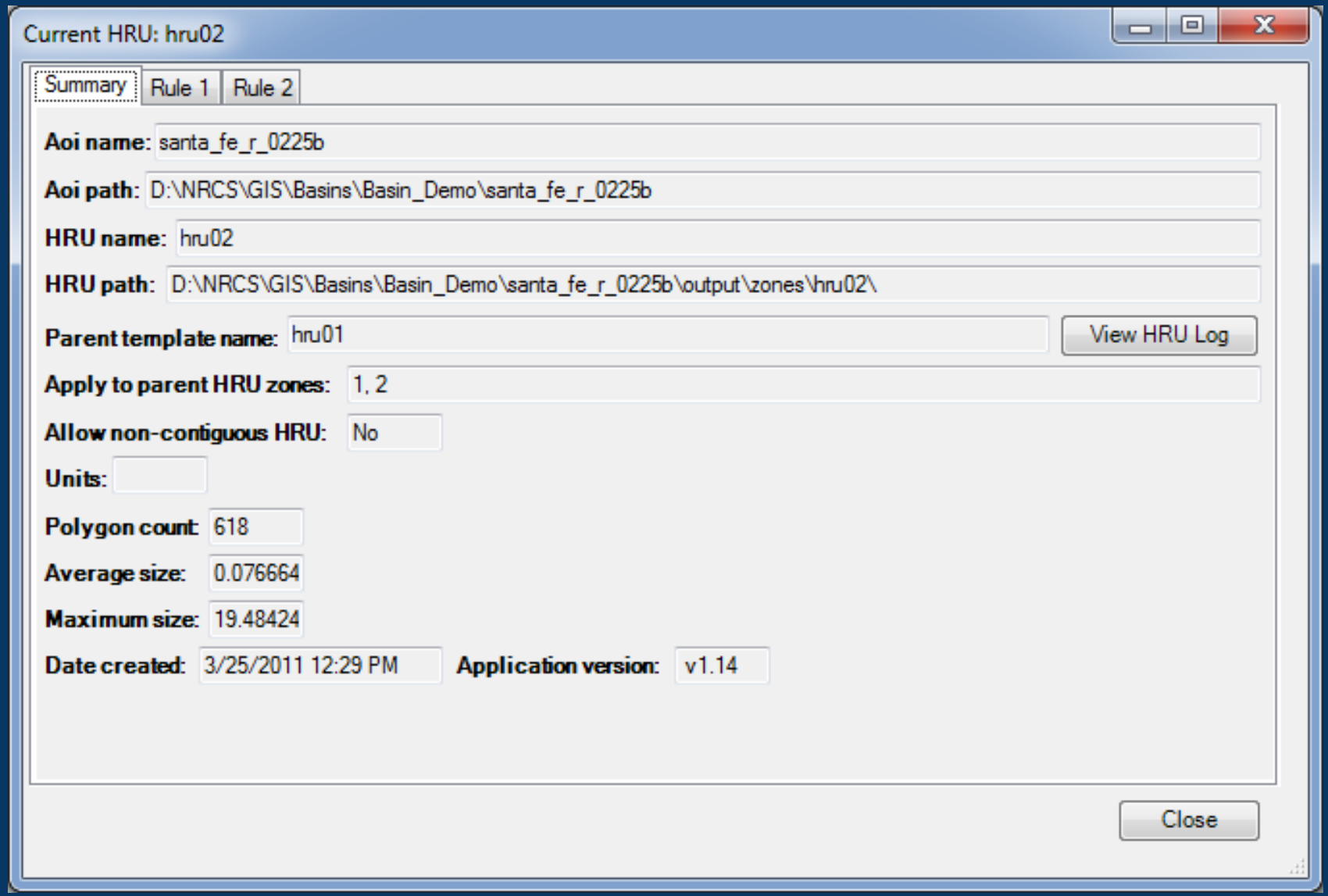


Rules for Defining HRU (cont)

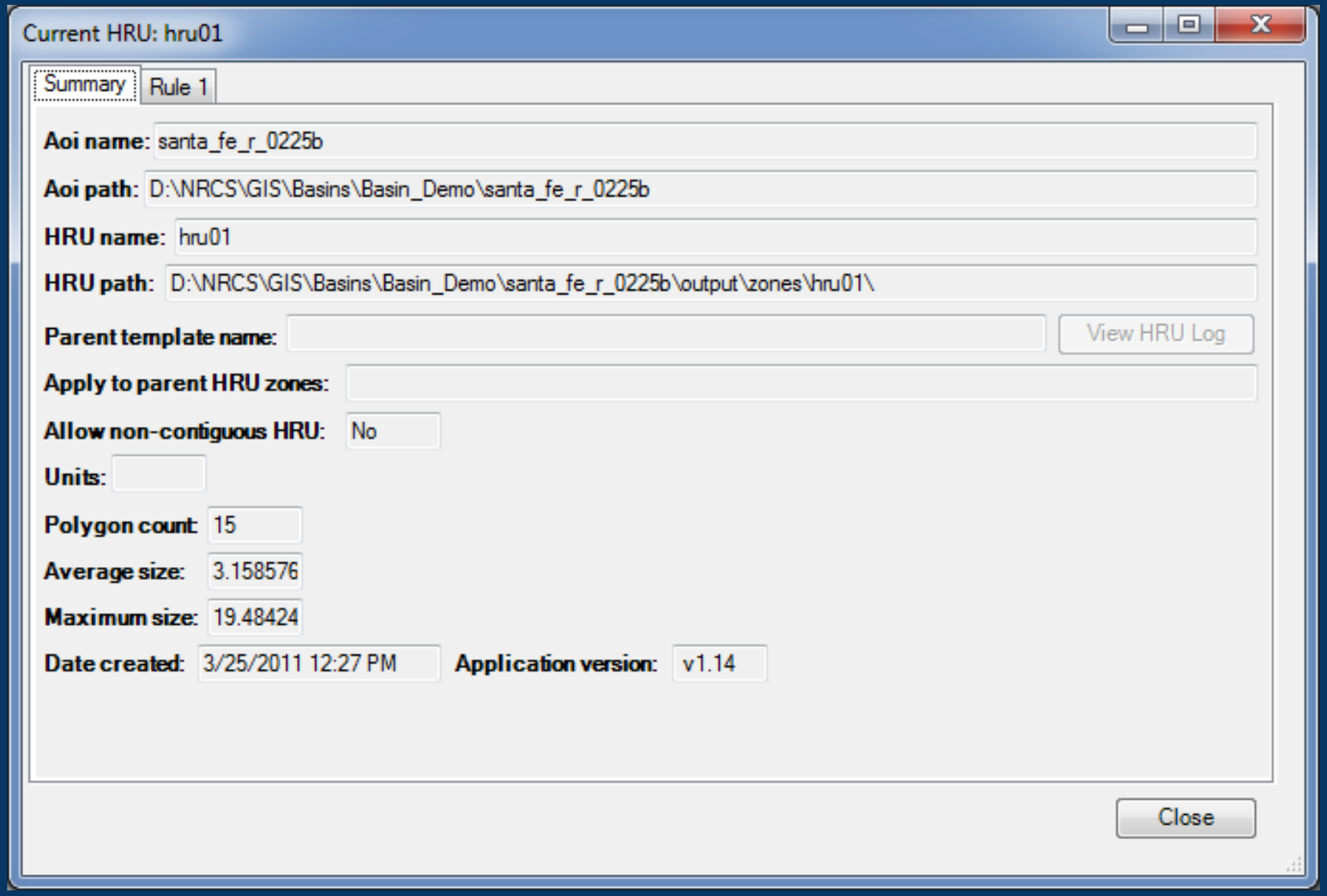




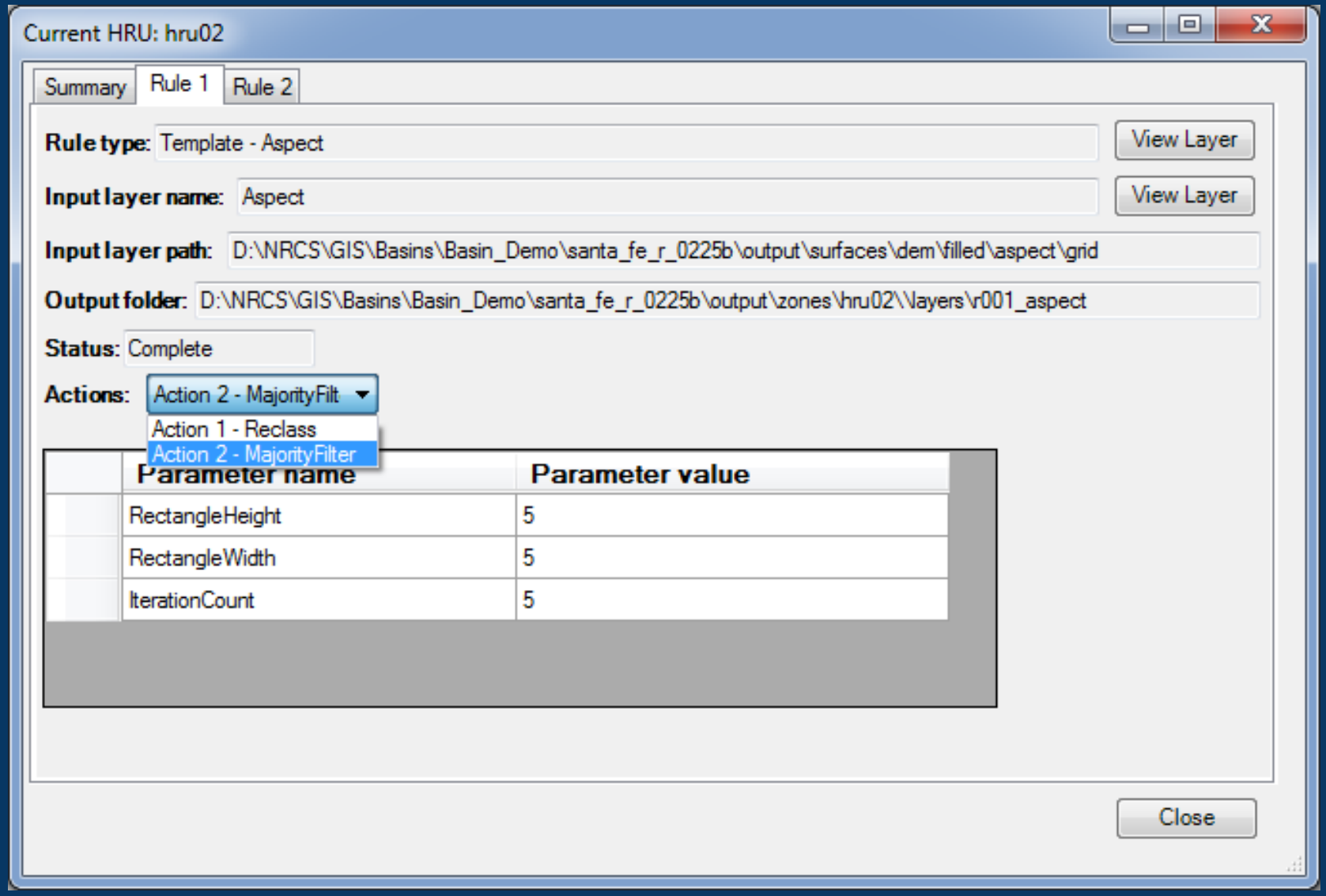
Process Log Viewer



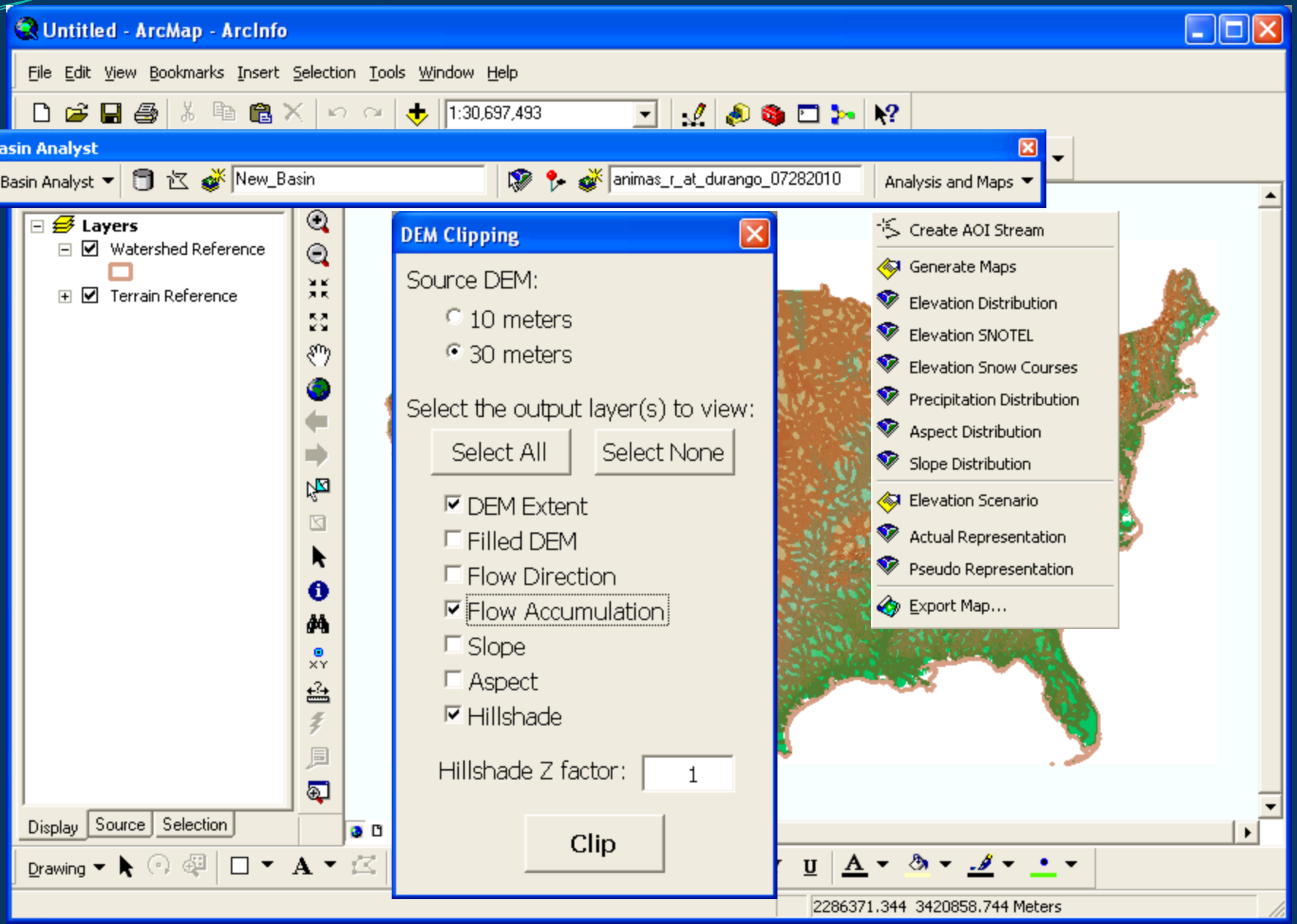
Tracking Parent HRU Log



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**

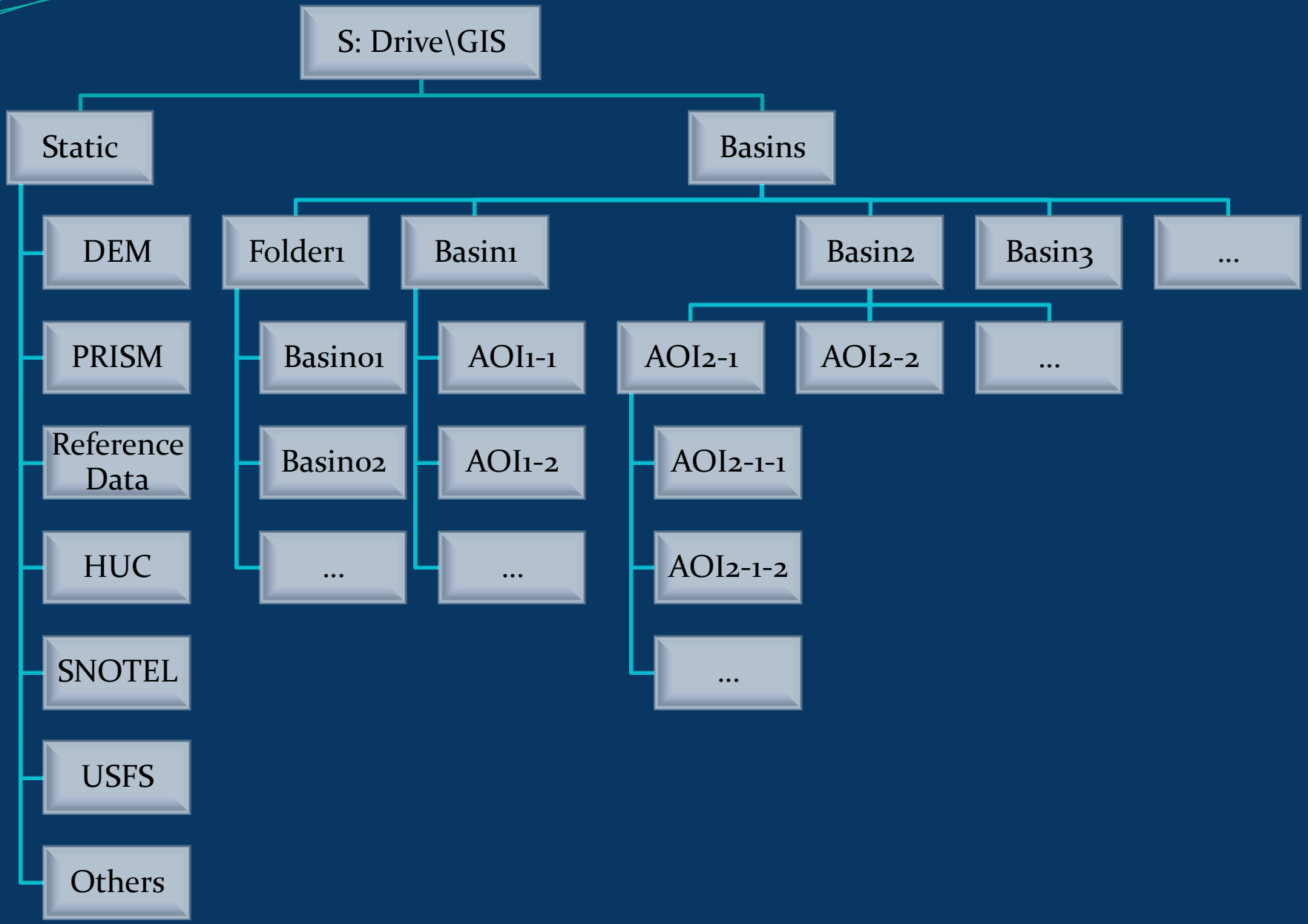
Organization of Input Data

- 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

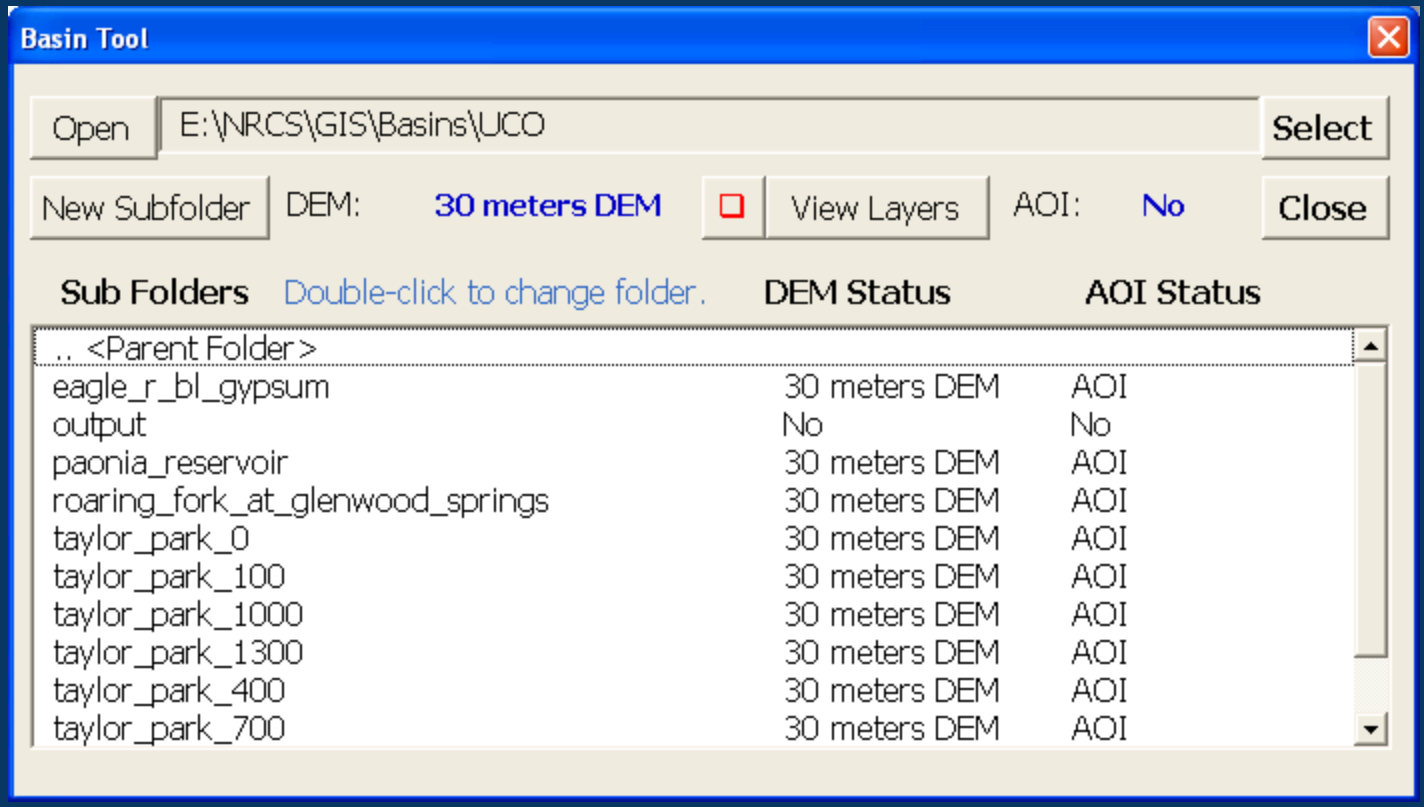
Organization of Output Data

- 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

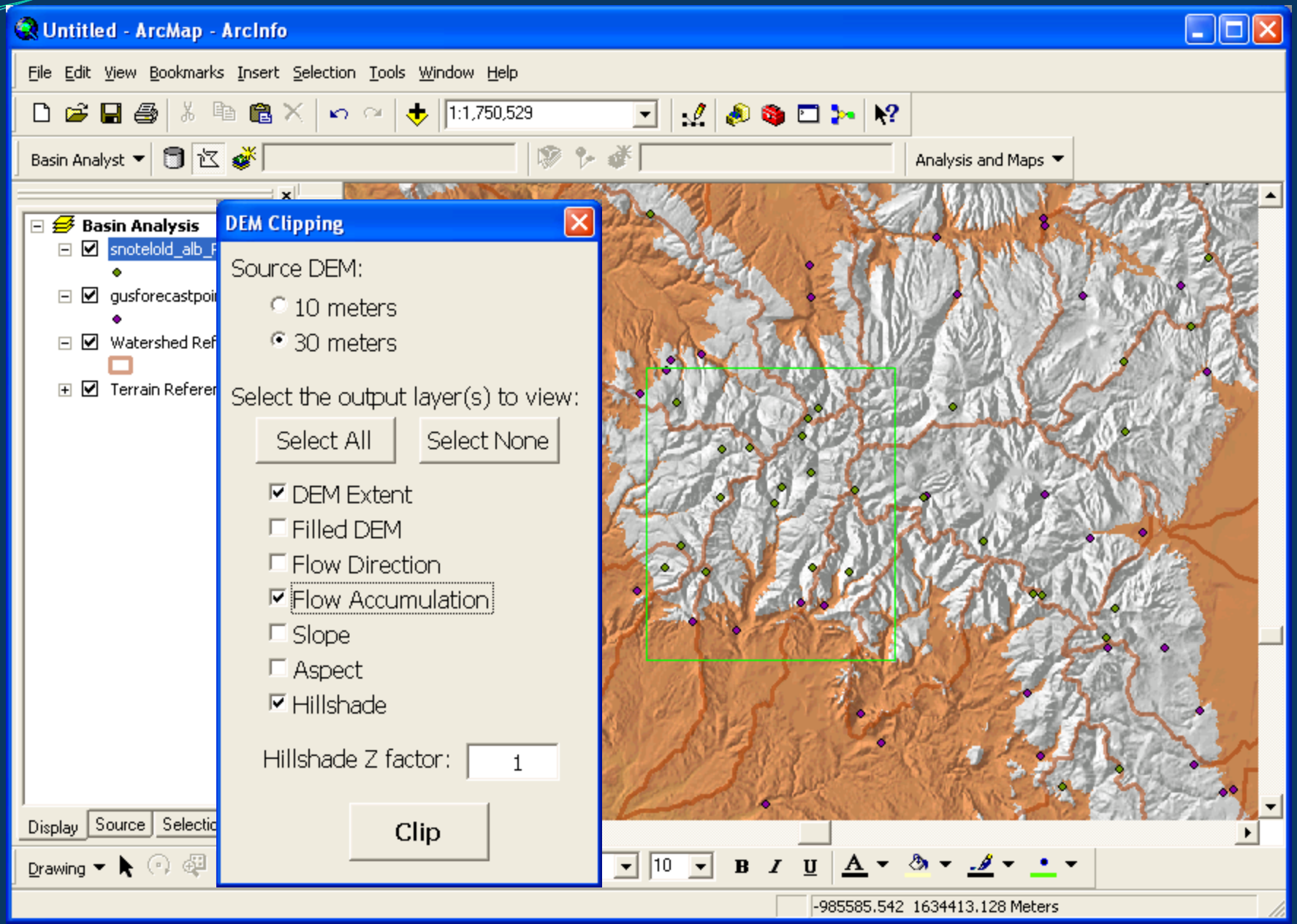
User's File Structure (Recommended)



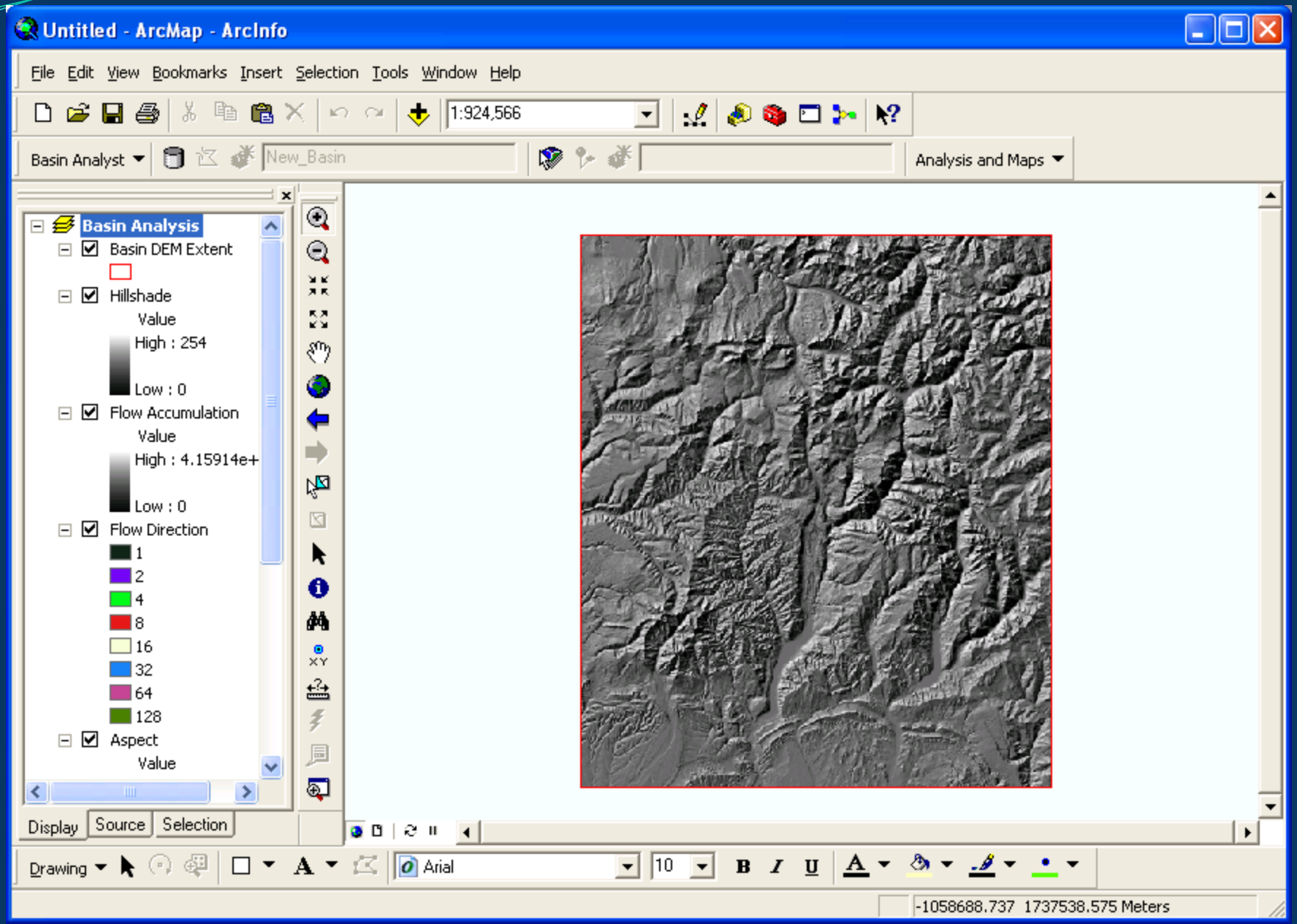
Basin Functions



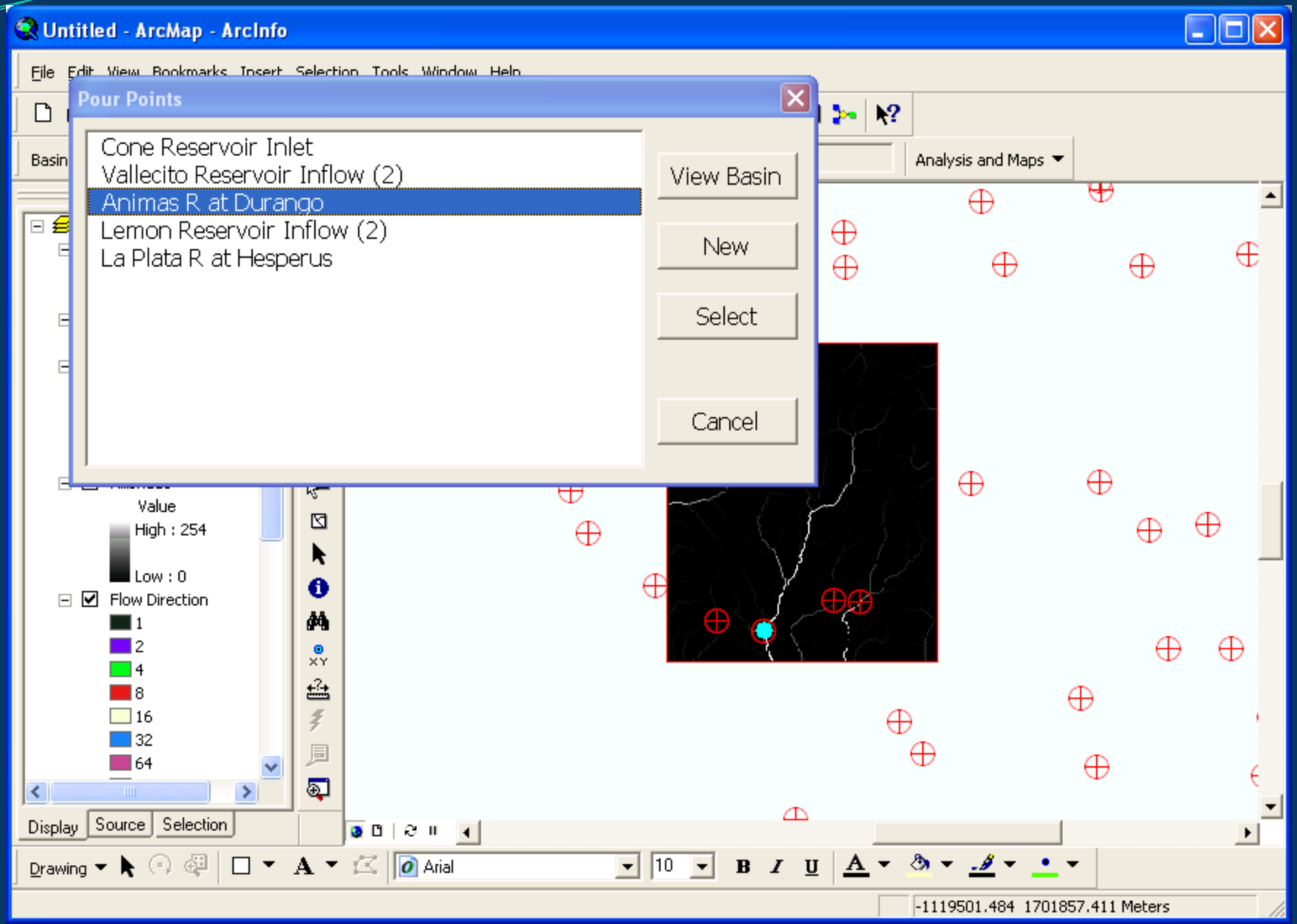
Basin Functions



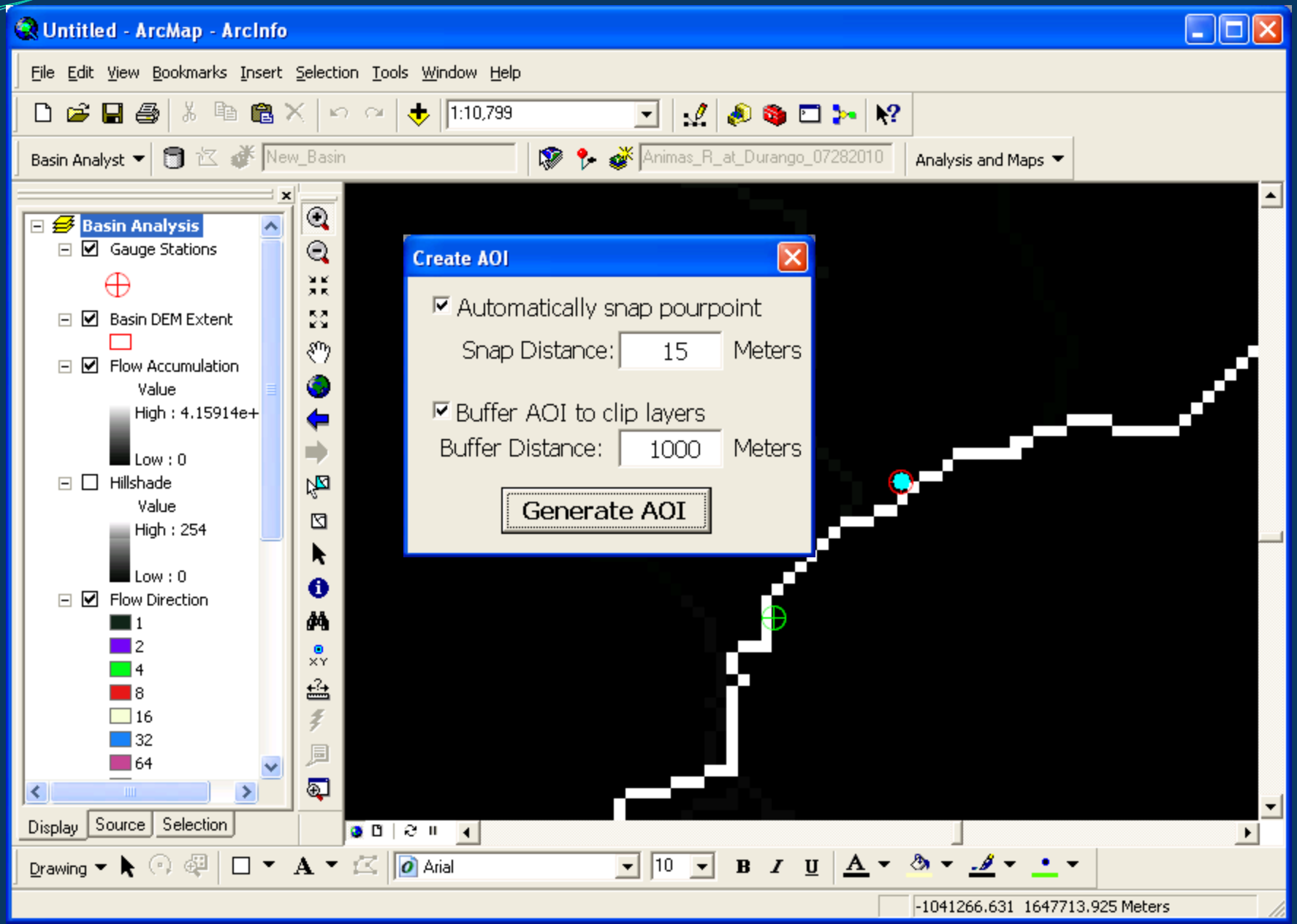
Basin Functions



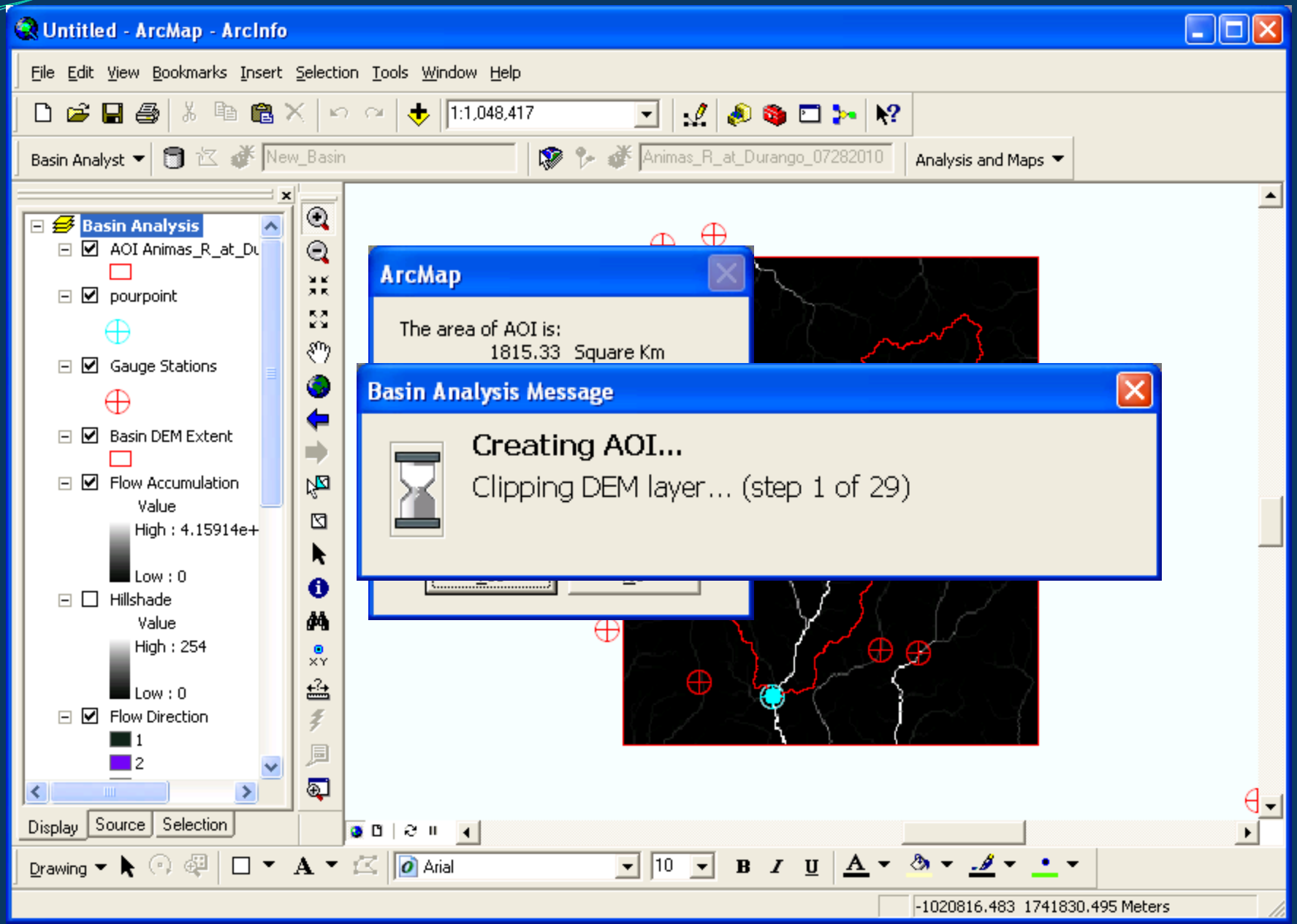
AOI Functions



AOI Functions

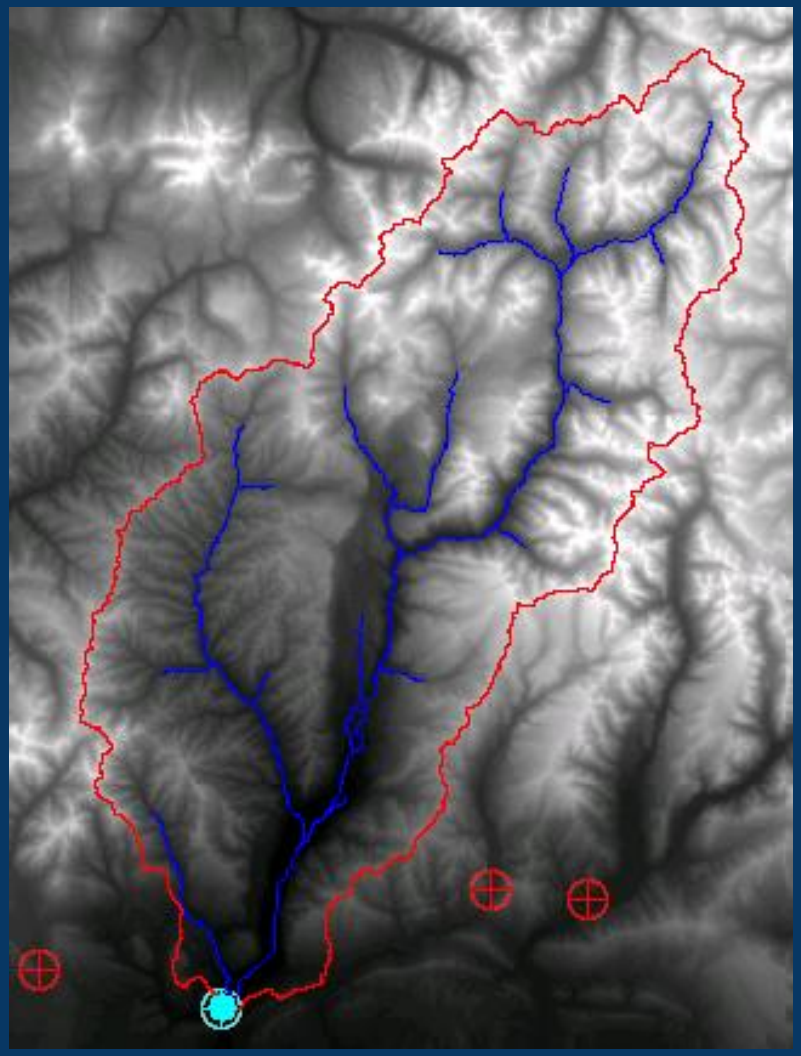


AOI Functions

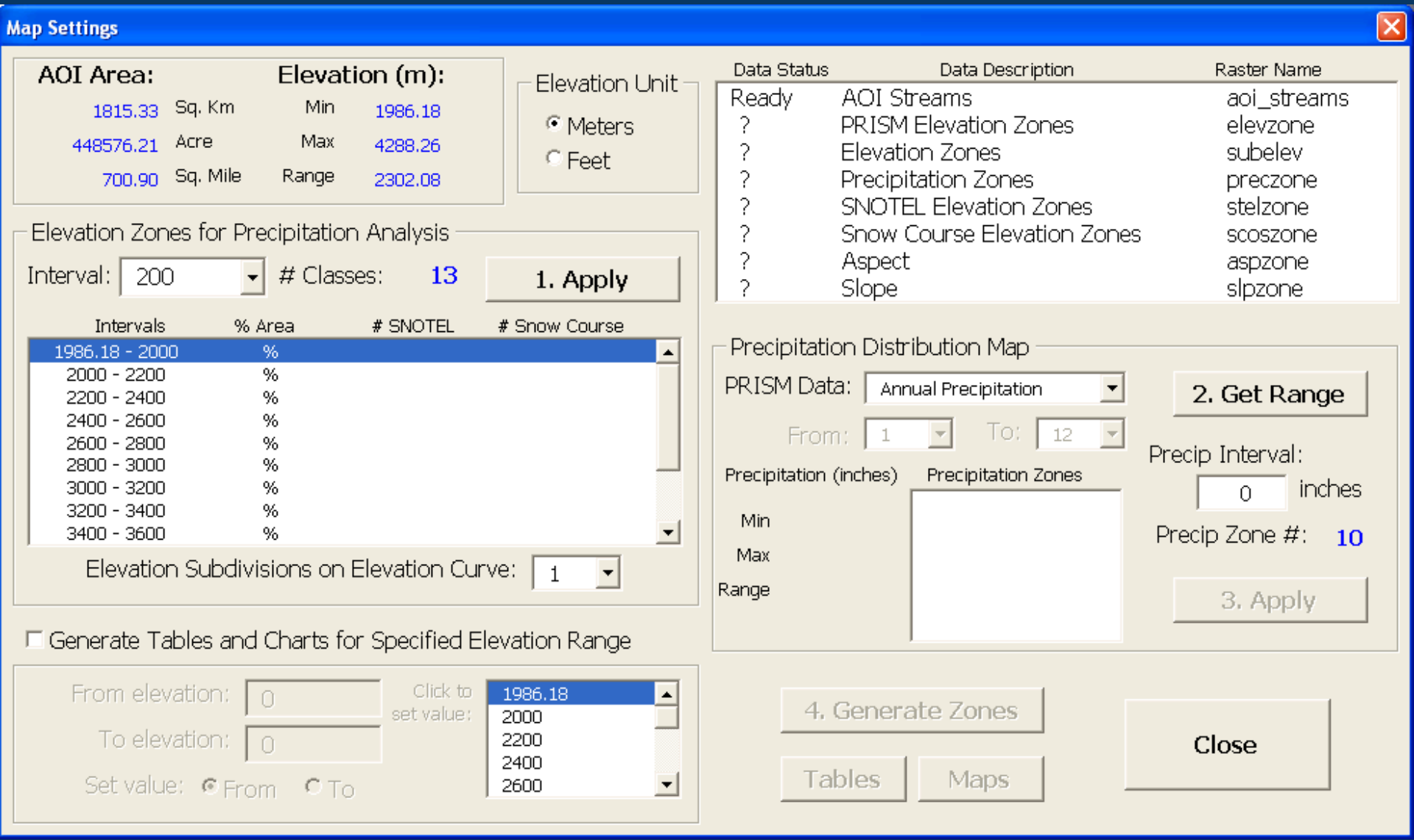


Maps & Tables Functions

- 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...

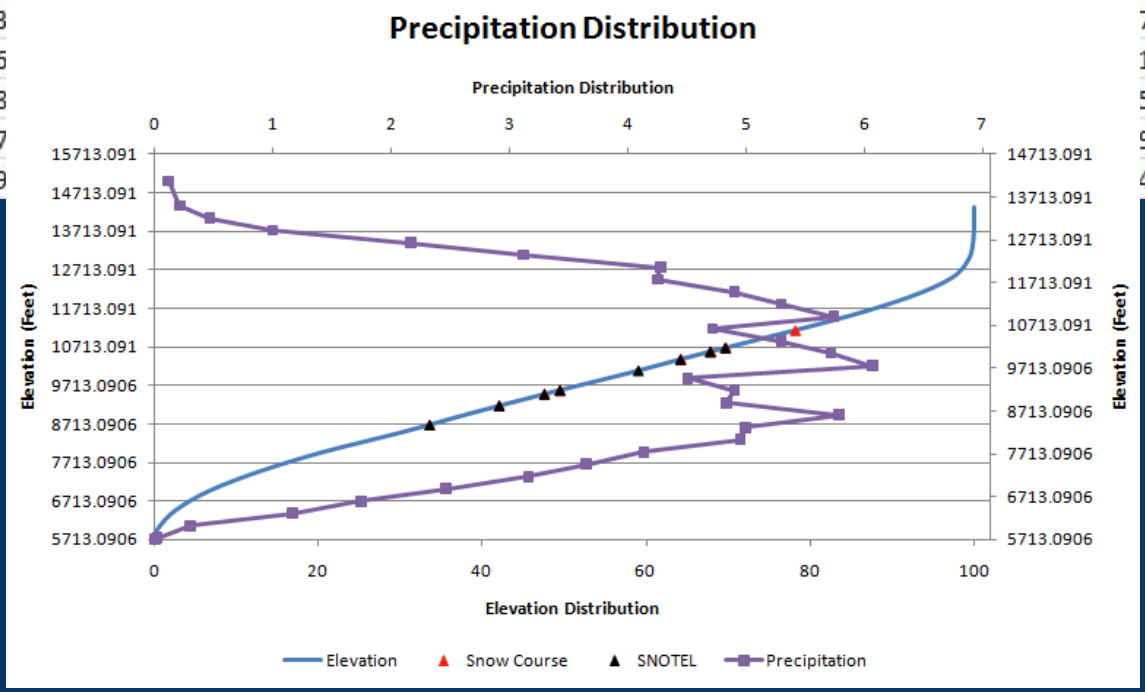


Maps & Tables Functions

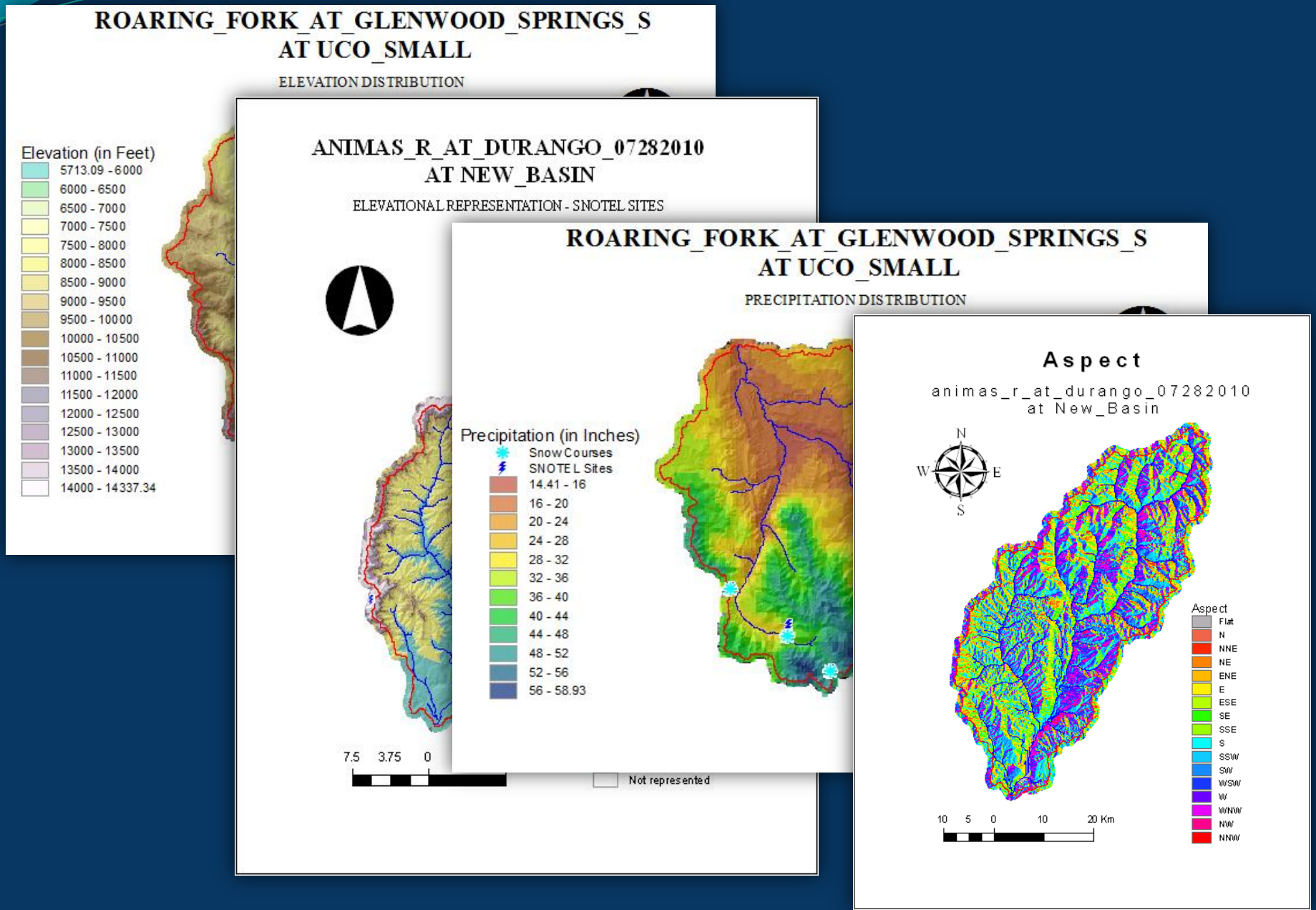


Maps & Tables Functions

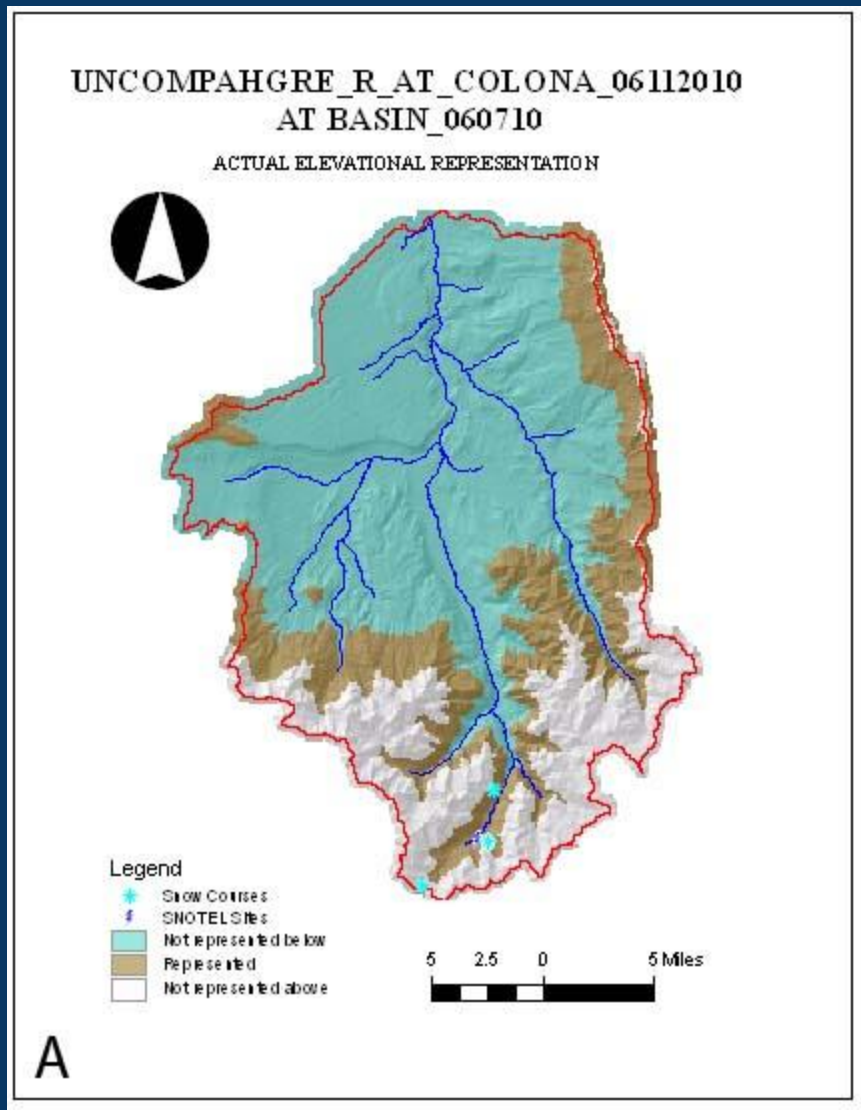
	A	B	C	D	E	F	G	H	I	J	K
1	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	%_AREA	Label
2	2272.87									0	
3	2367.2	1	874885.5	22.002985	22.002985	0	22.002985	0	22.002985	1.449275362	2313.5 - 2367.2
4	2421	1	874885.5	21.93291092	21.93291092	0	21.93291092	0	21.93291092	1.449275362	2367.3 - 2421
5	2474.8	1	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

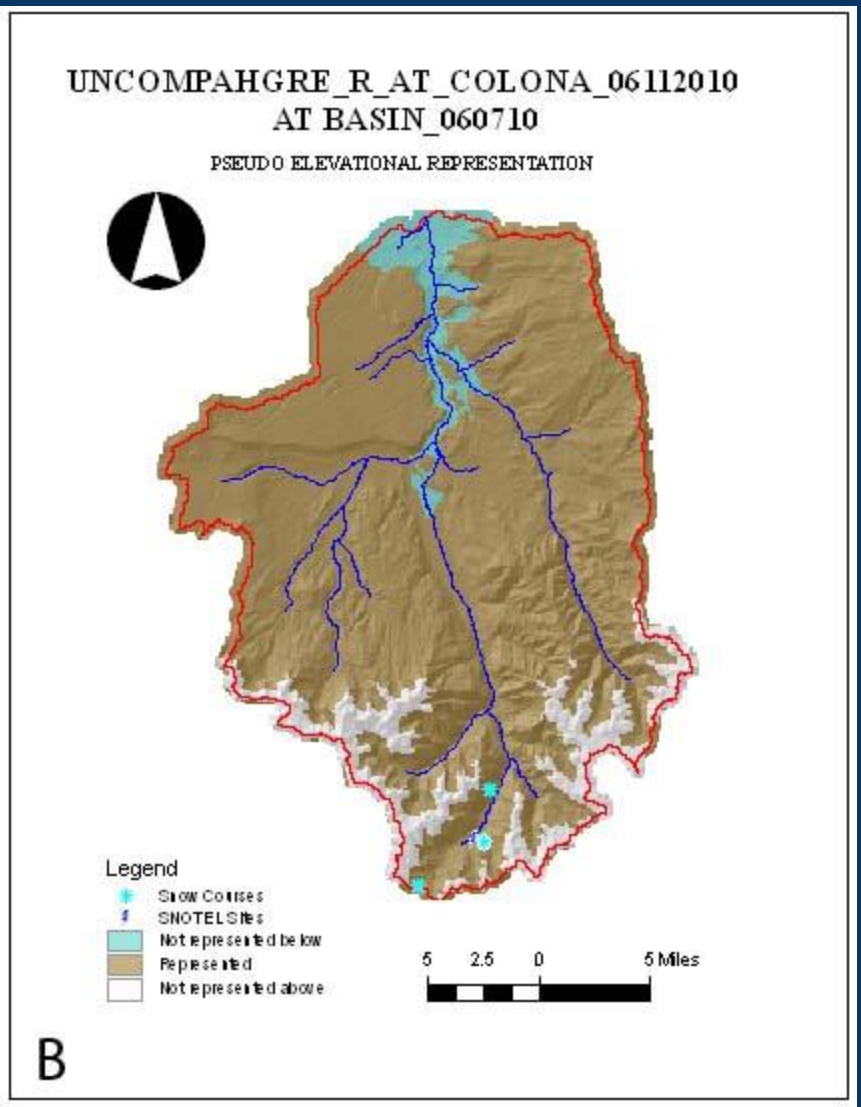


Maps & Tables Functions

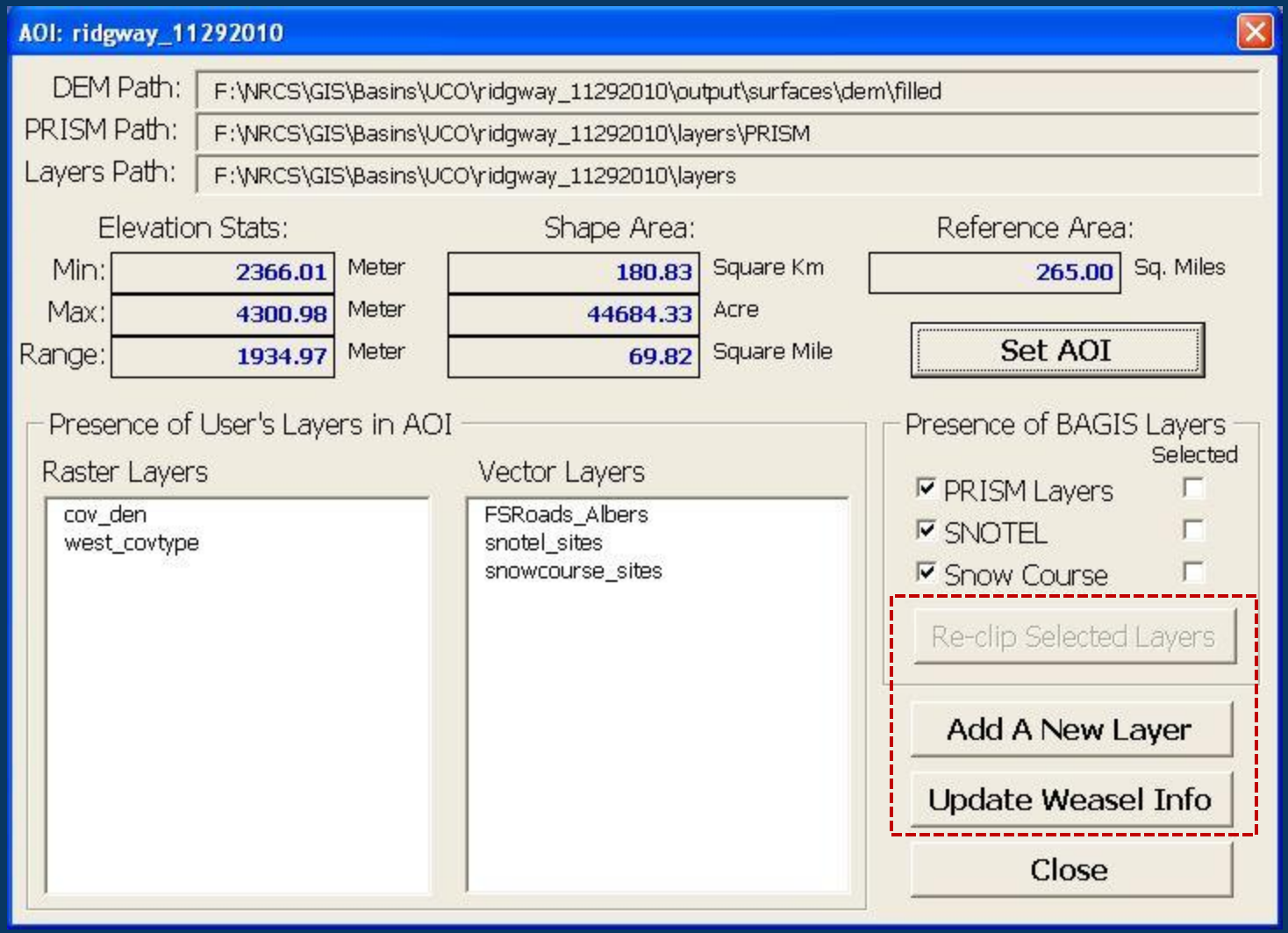


Maps & Tables Functions





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:
Min: 2366.01 Meter
Max: 4300.98 Meter
Range: 1934.97 Meter
Shape Area:
180.83 Square Km
44684.33 Acre
69.82 Square Mile
Reference Area:
265.00 Sq. Miles
Set AOI
Presence of User's Layers in AOI
Raster Layers
cov_den
west_covtype
Vector Layers
FSRoads_Albers
snotel_sites
snowcourse_sites
Presence of BAGIS Layers
Selected
PRISM Layers
SNOTEL
Snow Course
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:
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  - PSU: Ray Henning
- Programmers:
  - Geoffrey Duh, James Manzione

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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