The Watershed Characterization and Modeling System (WCMS):

Support Tools for Large Watershed CHIA and NPDES Analyses

by

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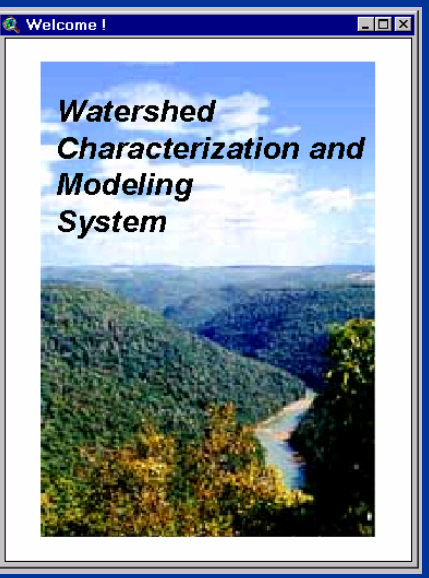

A product of the

Natural Resource Analysis Center

West Virginia University

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NRAC

West Virginia University
Where Greatness is Learned

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WCMS Development Support

- WV Dept of Environmental Protection (WVDEP)
  - Division of Mining and Reclamation (including PECA)
  - Division of Water and Waste Management
- West Virginia University (WVU)
  - WV Ag & Forestry Experiments Station
  - Davis College & Division of Resource Management
  - National Mine Land Reclamation Center
  - WV Water Research Institute
- Other Grants and Support

Primary Acknowledgments

- Larry Evans, Manager, WVDEP/TAGIS helped develop the initial concepts included in WCMS and provided financial support. Larry has continued to support development and integration of GIS, remote sensing, and database technologies in WVDEP which complement and enable advanced applications such as WCMS.
- Mike Strager, WVU/NRAC, has been the primary architect of the GIS capabilities within WCMS since 1995. Mike's insights and views that combine GIS with decision support are reflected in all aspects of the current version of WCMS.

Overview of the Presentation

- Background, development goals, and implications
- Summary of capabilities – What is WCMS?
- History of development – How did WCMS get where it is today? What resources have been used?
- Future plans – Where are current development activities headed?

Background

- Regulatory agencies need:
  - Consistent and reliable sources of information to support analysis and document decisions
  - Time-saving analysis tools
  - Watershed-based analysis for statewide applications

Overall Development Goals

- Bring state-of-the-art GIS capabilities to watershed related assessment and management problems – with emphasis on West Virginia
- Make state-of-the-art GIS capabilities available to a variety of users without requiring GIS specialization

Goals of the WCMS System

- Access and view data by bringing it to the desktop with ArcMAP
- Support activities of WVDEP personnel
- Customized interface for ease of use
- Determine NPDES stream pollutant loadings based on existing mining extents and discharge rates by land cover
- Answer common questions related to water quality modeling and stream flow for use in CHIA evaluation
- ***Note: Usefulness of GIS tools are limited by data availability – data development to support appropriate analyses must be a complementary goal to software development***

WCMS-GIS Modeling System for Watershed Analysis

- Advanced GIS tools for calculation and visualization
- Spatially explicit landscape model
- Decision support tools – multiple criteria and economic analysis
- Hydrological capabilities
  - Stream flow estimation – 30 year average
  - Delineation of watershed drainage area
  - Water quality prediction tools

Requirements for Use

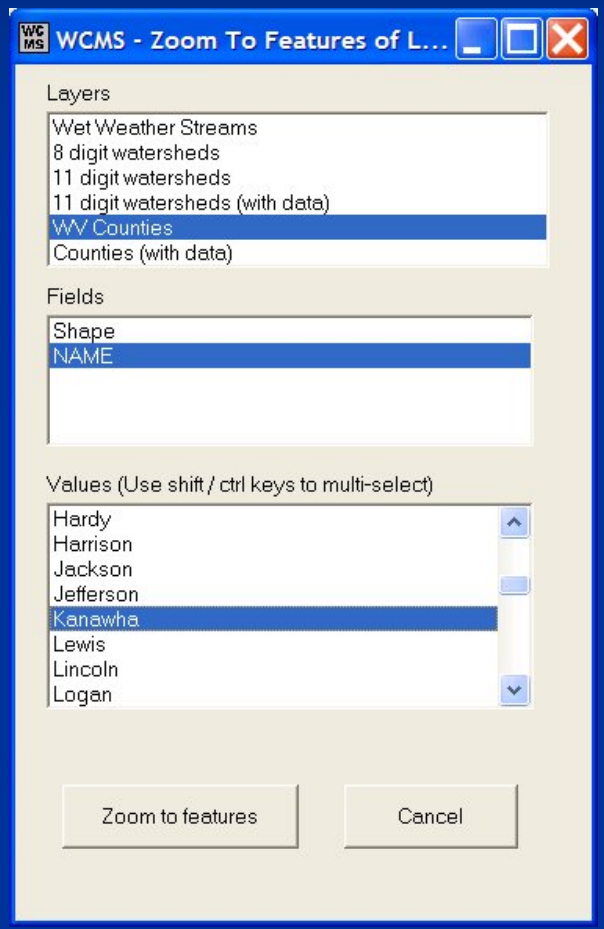
- ArcGIS and Spatial Analyst
- PC platform - Windows 2000/XP or Server 2000/2003
  - Runs in a Citrix environment at WVDEP
- Basic ArcMAP skills
- Available GIS data imported into WCMS

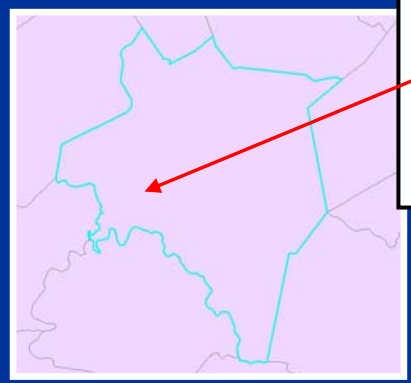
GIS Data Used by WCMS
(Provided for West Virginia)

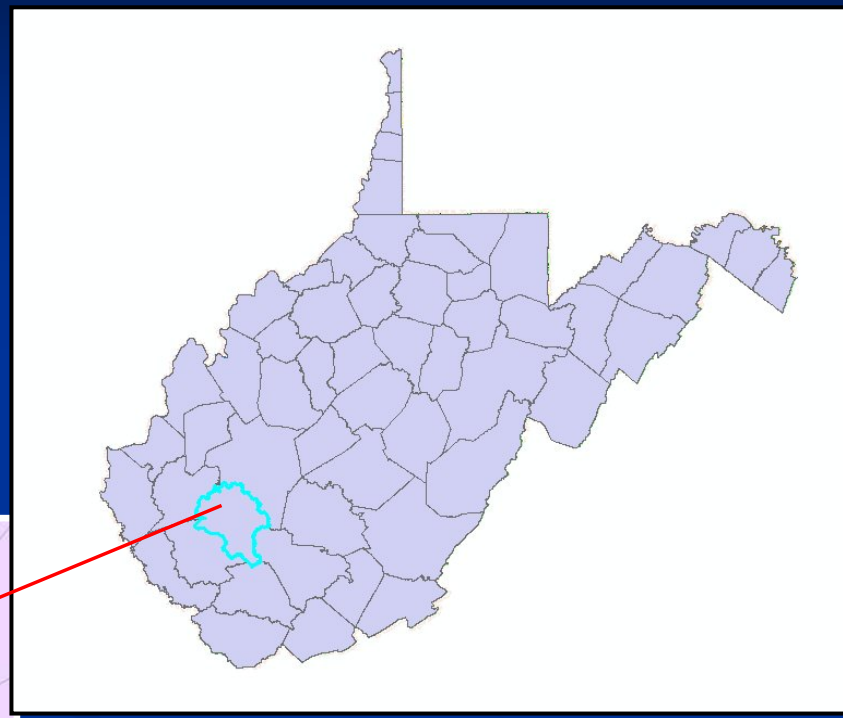
- Raster stream network
- Flow direction grid
- Flow accumulation grid
- Runoff grid
- Cumulative runoff grid
- Hydro-corrected DEM with burned in streams
- 30m DEM (the standard DEM that is not hydro-corrected
- Landcover from the WV GAP analysis project
- Landcover made from MRLC data
- Table of expected mean concentration values
- Layer of critical low flow values
- Layer of USGS gauged watersheds
- Regional stream flow variability curve
- Stream flow variability index

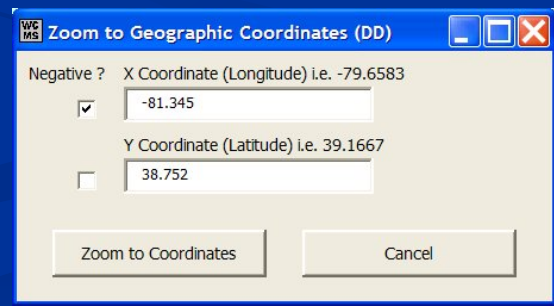
Using WCMS - Defining a Study Area

From list, graphic, or point









WCMS Basic Query Tools

- Elevation tool: Find the elevation of a point
- Elevation profile tool: Creates an elevation profile along a user drawn line
- Slope information tool: Derive the slope along a drawn line
- Polygon area tool: Find the area of a user drawn polygon
- Coordinate tool: Find the coordinates of a point clicked in the display

WCMS Watershed Tools

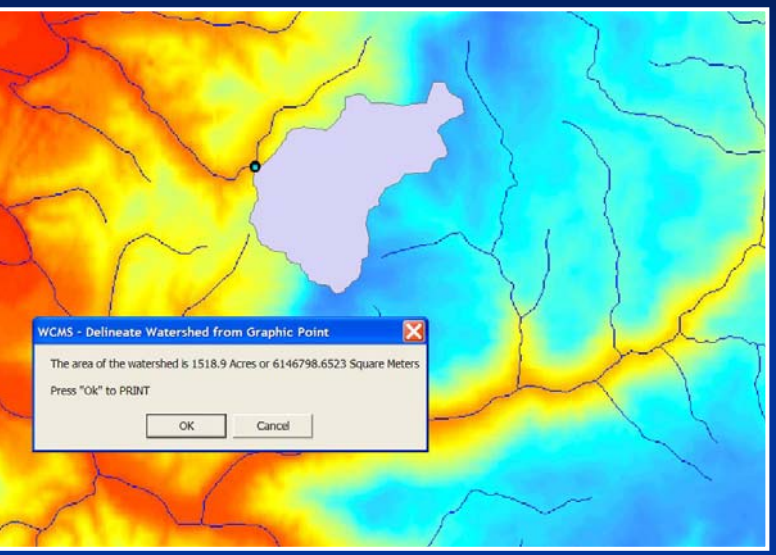
- Trace the path of a raindrop across the landscape (flow direction)
- Find the 30 yr-average annual and monthly streamflow
- Report the drainage area for a stream reach
- Find the 7Q10 flow for a stream locations

WCMS Watershed Delineation

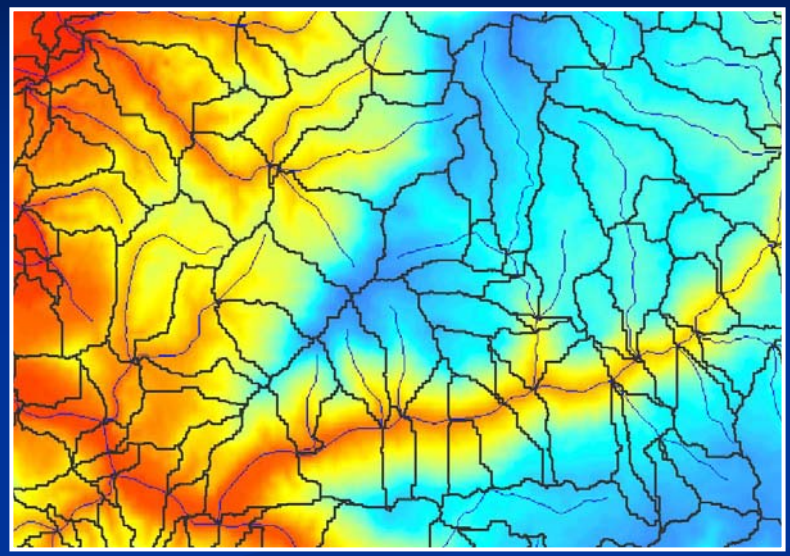
- Delineation watersheds from graphic point(s)
  - Choose a spot on the raster stream
  - Choose any point in the watershed
  - Area of a polygon may be delineated
    - Watershed, mine site polygons
- Delineate drainage paths
- Delineate many watersheds
- Calculate the distance between two points in a stream

Watershed Delineation

Point



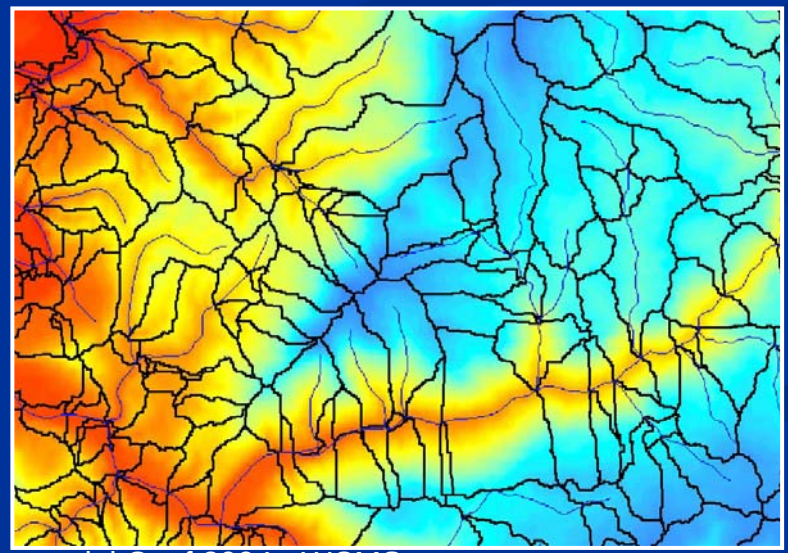
Area Threshold



Segment

Level

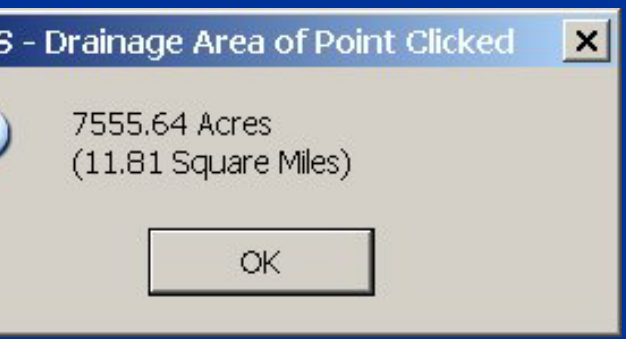
Watersheds

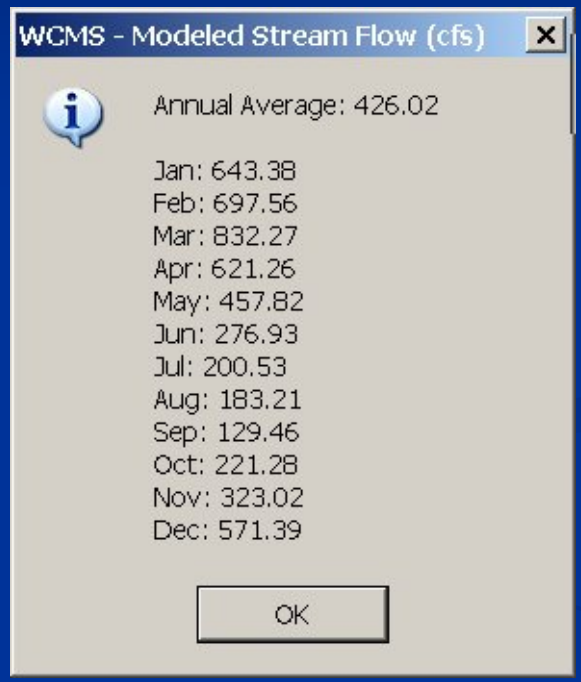


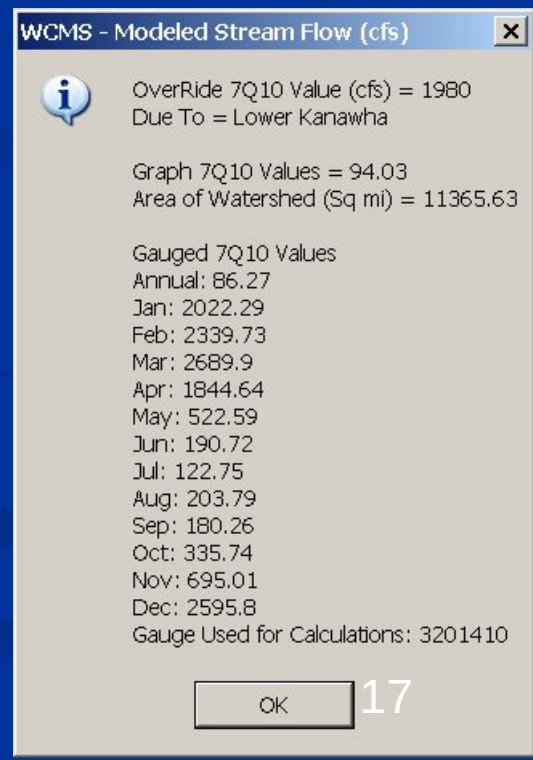
Watershed Tools

Drainage area and flow

k Point on Stream





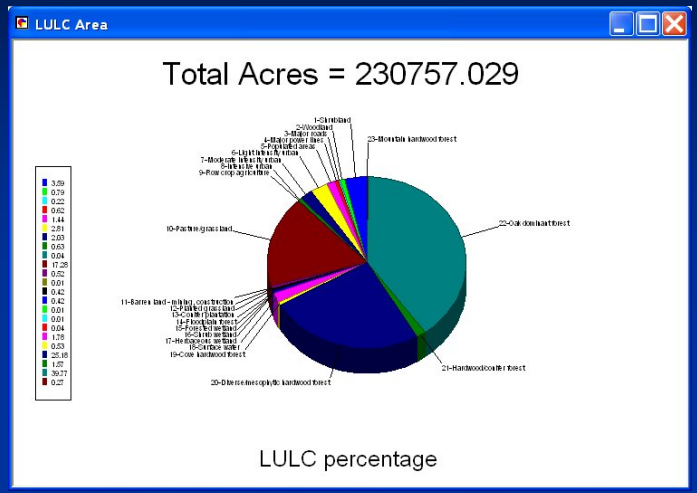


Tabulate Landuse Statistics

Attributes of wcmsTmpLCTable

OID	Value-LULC	Hancock	Hancock%	Brooke	Brook
0	1-Shrubland	16843450.53	7.82	17753785.63	
1	2-Woodland	38167442.58	17.72	41408991.92	
2	3-Major roads	0	0	0	
3	4-Major power lines	180086.07	0.08	75636.15	
4	5-Populated areas	5317941.77	2.47	4953267.47	
5	6-Light intensity urban	18922544.26	8.79	29590843.3	
6	7-Moderate intensity urban	22813303.89	10.59	41263122.2	
7	8-Intensive urban	3693565.38	1.72	4273442.54	
8	9-Row crop agriculture	122458.53	0.06	441210.88	
9	10-Pasture/grassland	33861584.55	15.72	35104178.46	
10	11-Barren land - mining, construction	1071512.14	0.5	670820.63	
11	12-Planted grassland	212501.57	0.1	38718.51	
12	13-Conifer plantation	1846782.69	0.86	2713897.14	
13	14-Floodplain forest	384483.77	0.18	171081.77	
14	15-Forested wetland	29714.2	0.01	177384.78	
15	16-Shrub wetland	8103.87	0	9004.3	
16	17-Herbaceous wetland	49523.67	0.02	61229.26	
17	18-Surface water	13960272.48	6.48	7326801.93	
18	19-Cove hardwood forest	0	0	0	
19	20-Diverse/mesophytic hardwood forest	28277115.39	13.13	24775341.67	

Record: 1 Show: All Selected Records (of 25) Options

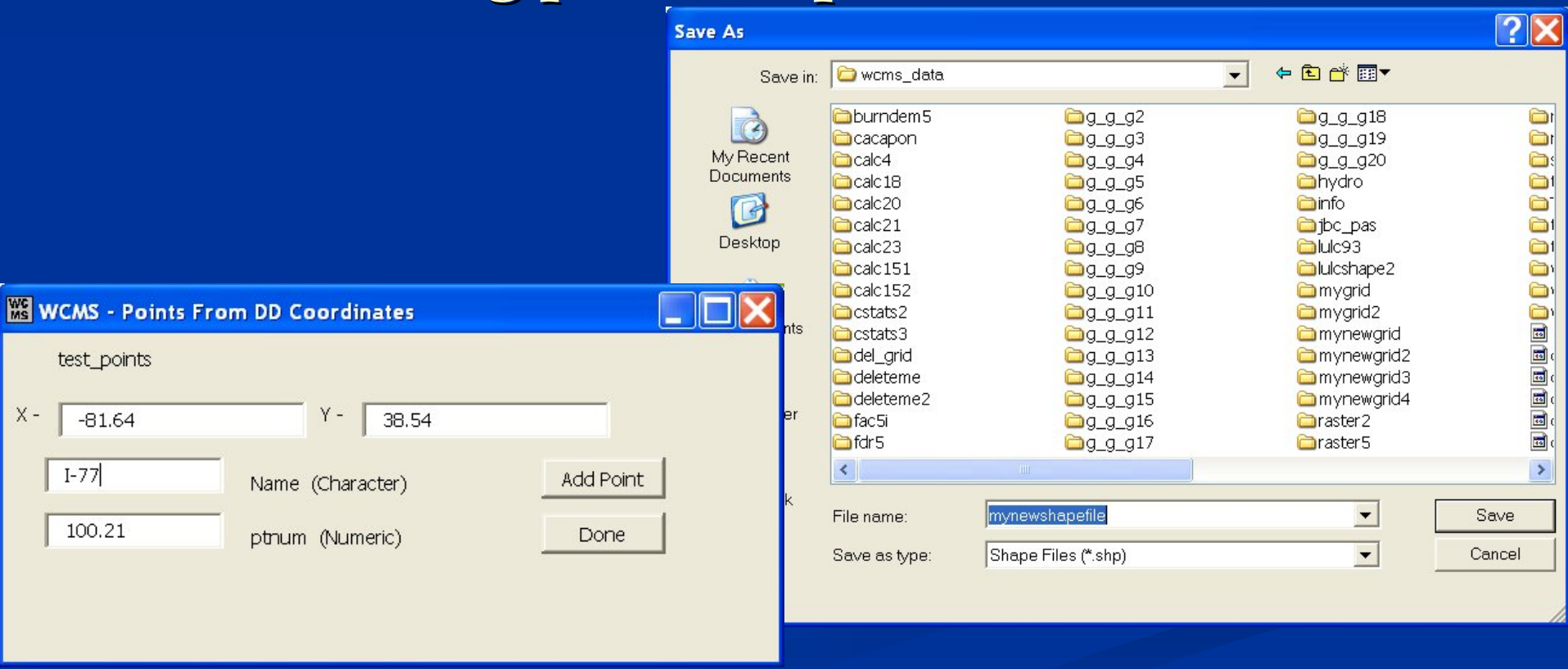


Update/Change Landuse

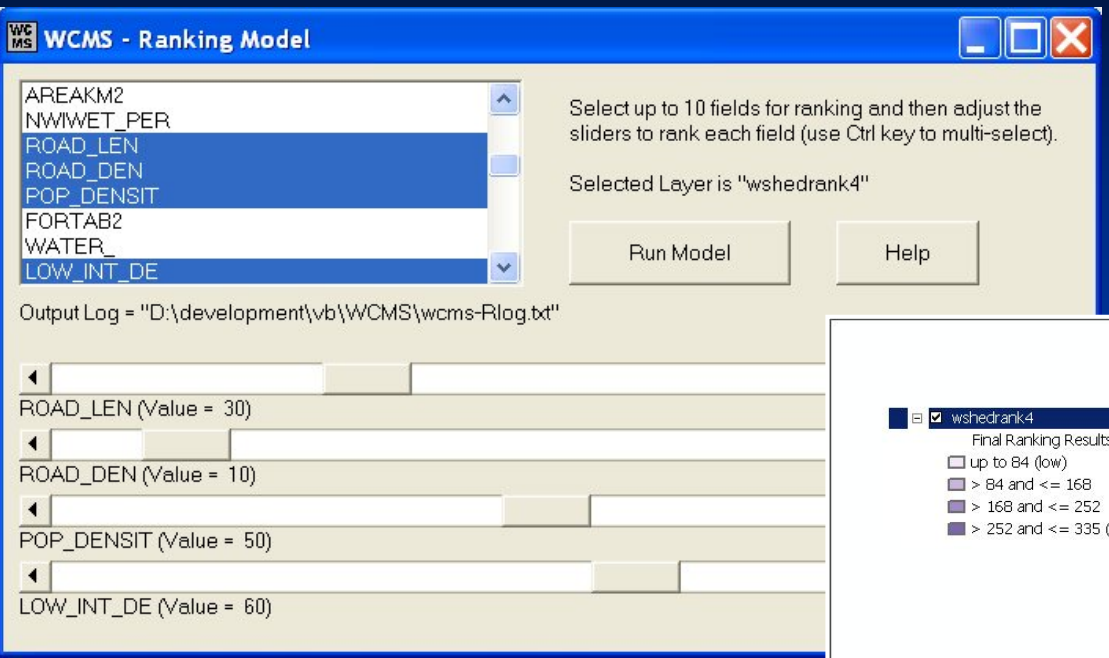
Original Digitize new Update grid

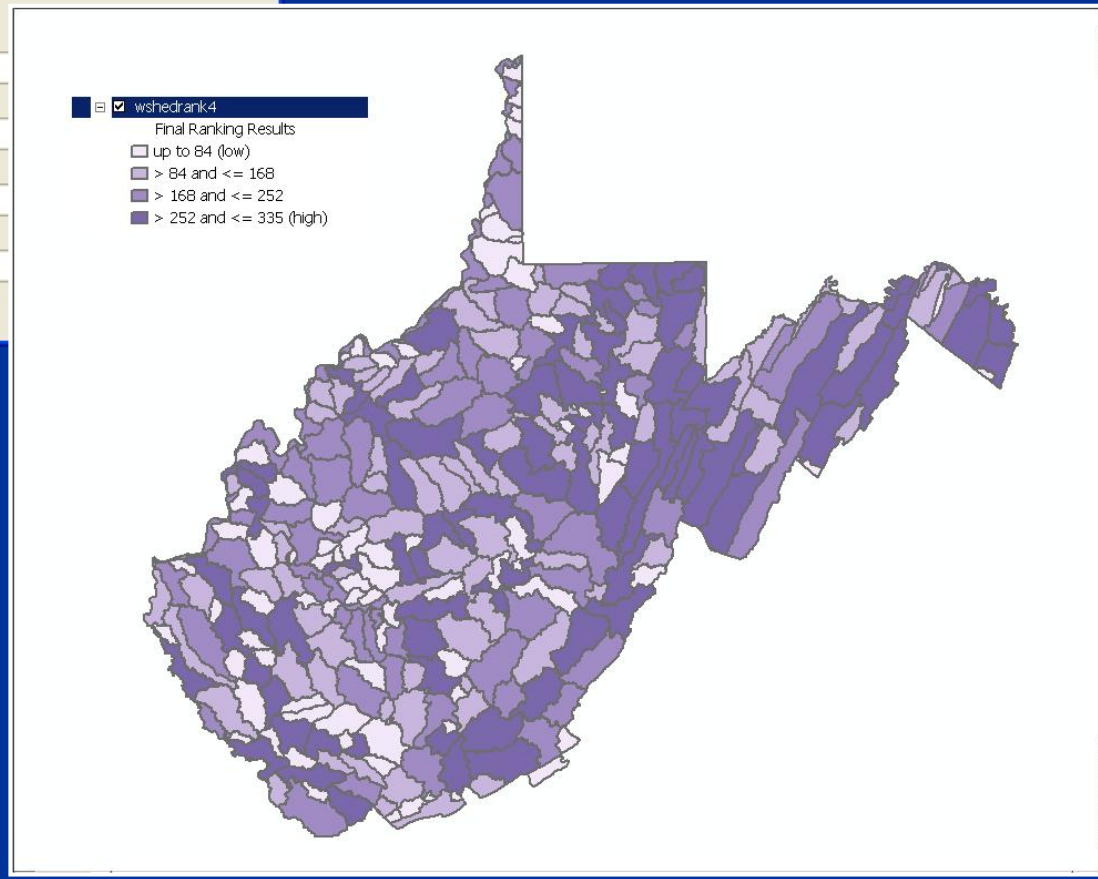
Adding Points

- To create new point shapefile
- Add to existing point shapefile



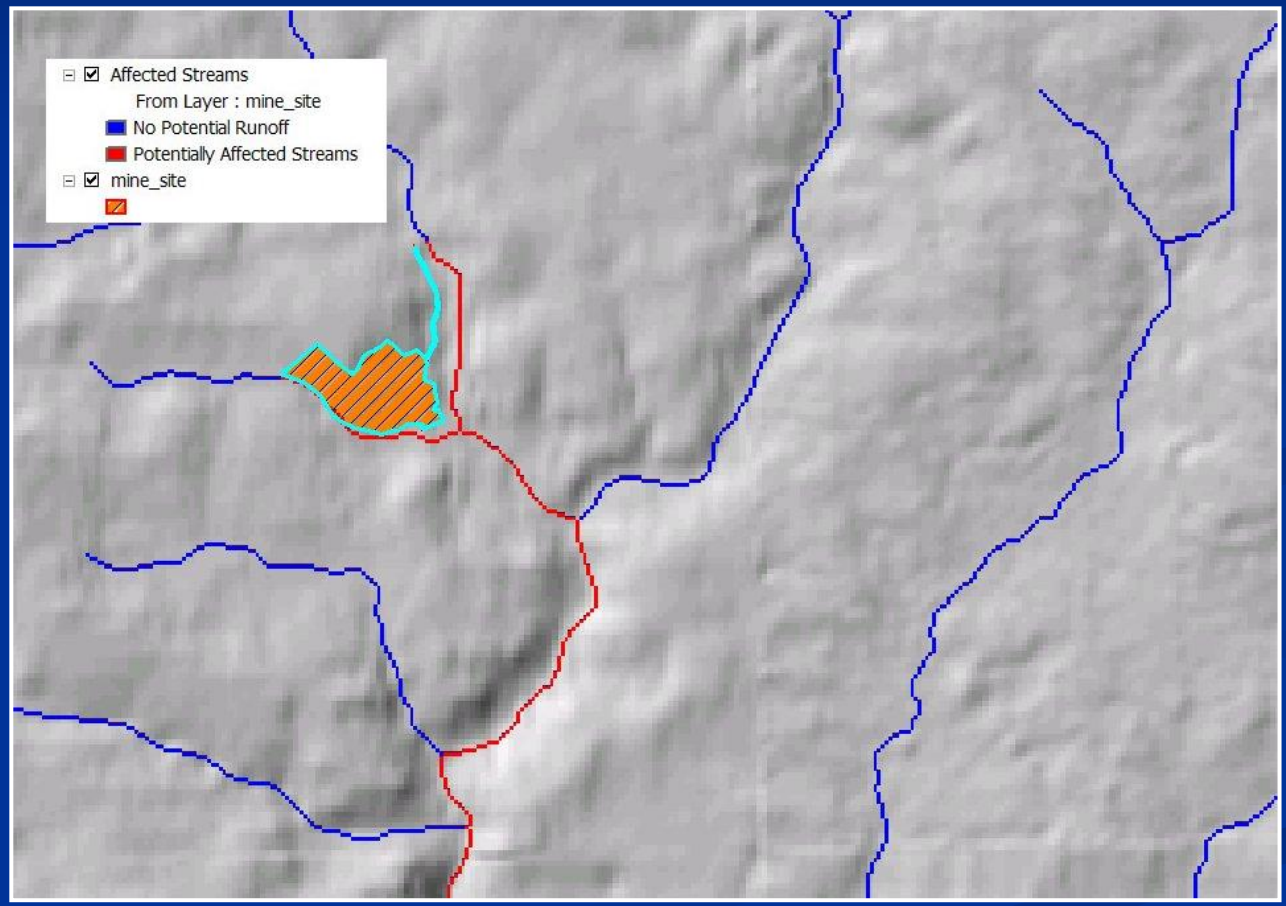
Ranking Model (Multiple Criteria)



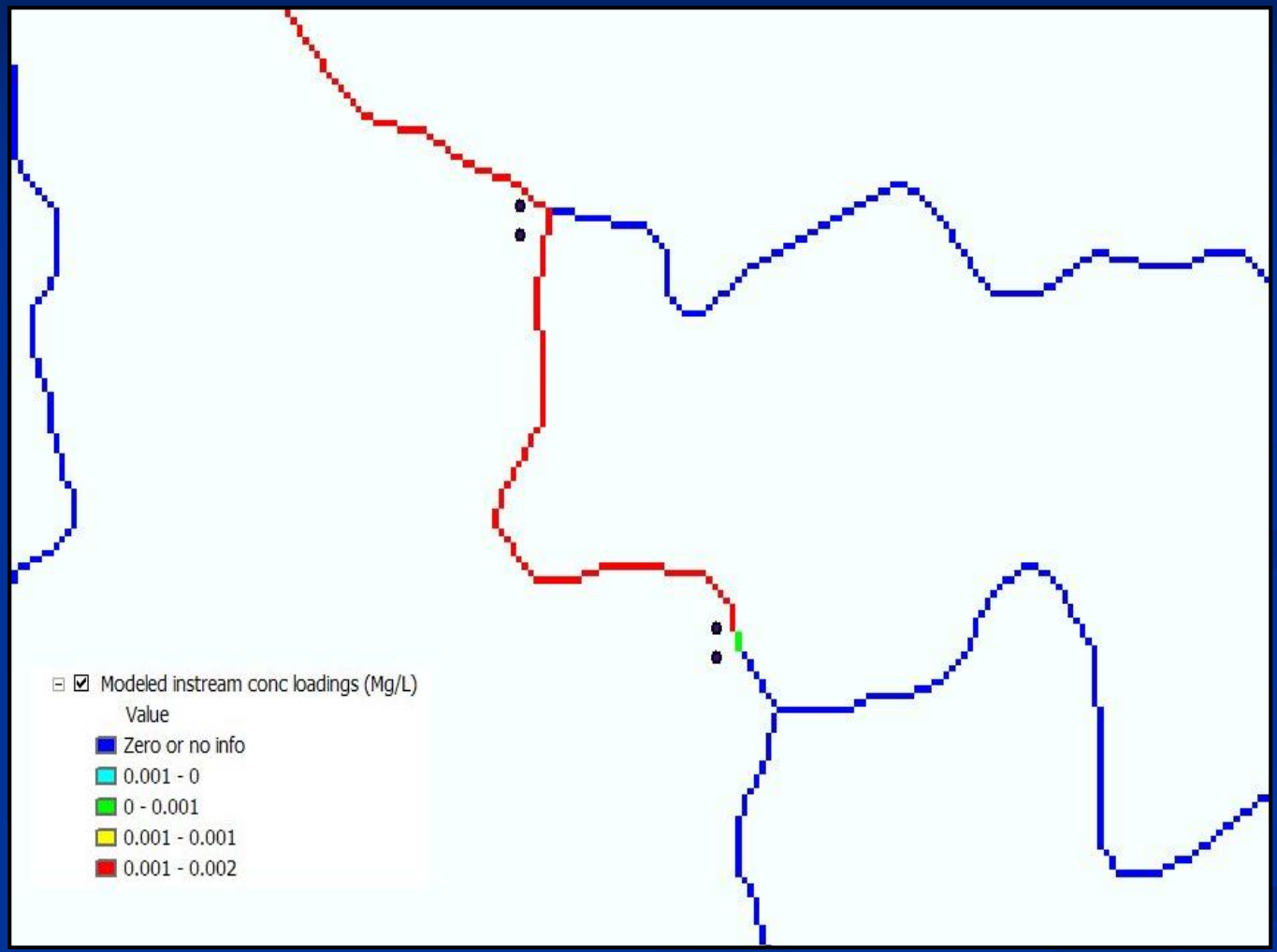


Water Quality Prediction

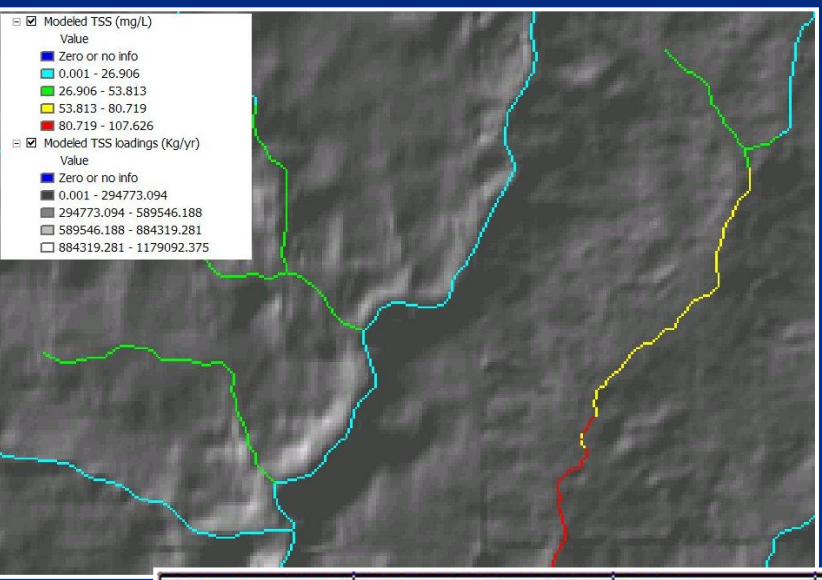
Potentially Affected Streams Results



Water Quality-Average Concentrations

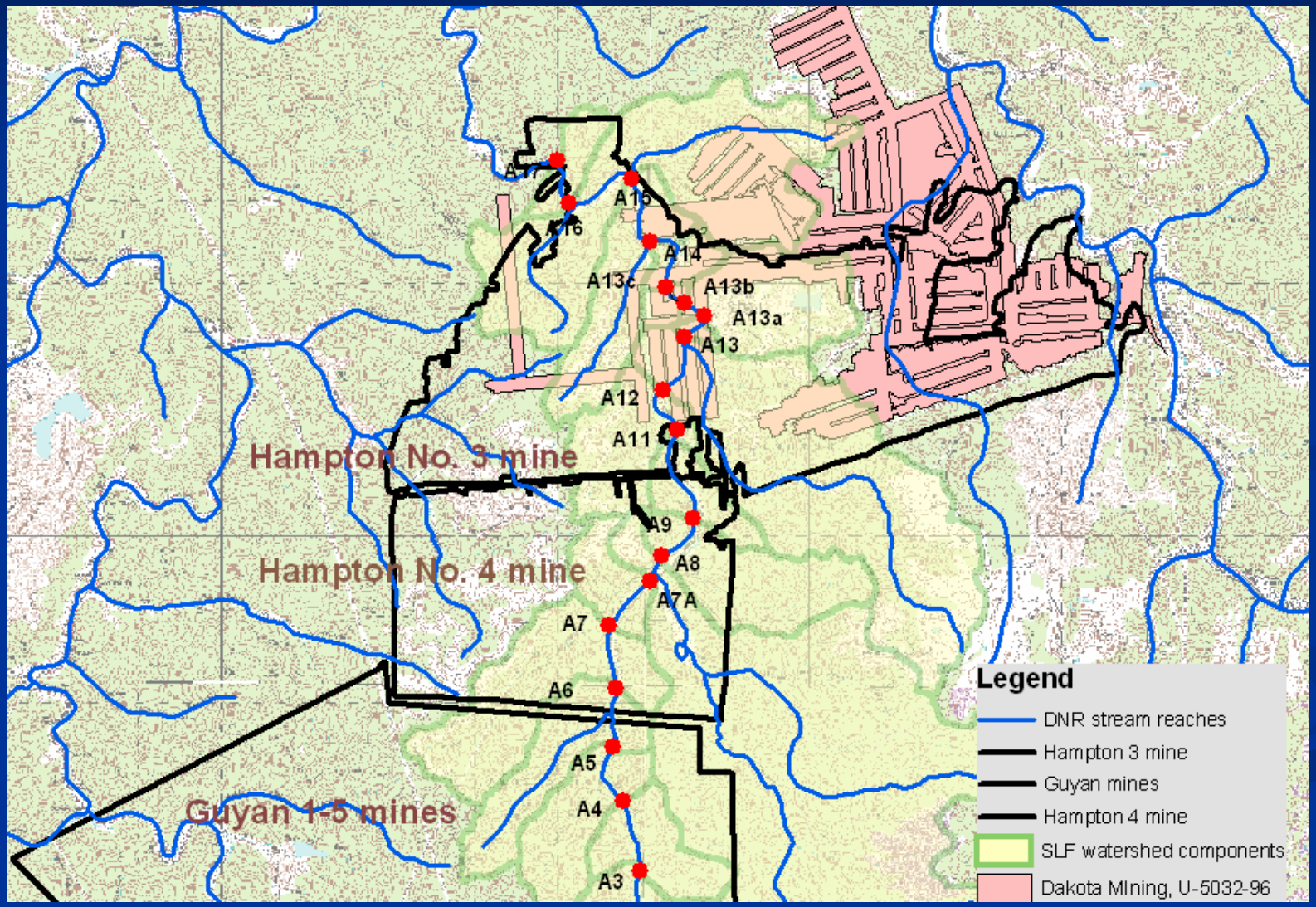


Water Quality - Expected Mean Concentrations from Landuse and Soils



NITROGEN	PHOSPHORUS	TSS	ZINC	BOD	COPPER	LEAD	CADMIUM	CHROMIUM	NICKEL
1890.00	9.00	166000.00	145.90	13300.00	17.30	12.00	0.70	4.90	5.40
2190.00	130.00	70000.00	26.80	4500.00	5.90	3.40	0.50	3.00	4.80
3410.00	240.00	201000.00	23.50	4200.00	5.40	3.10	0.50	2.90	4.70
790.00	6.00	39000.00	24.80	4300.00	5.60	3.20	0.50	2.90	4.70
3900.00	100.00	2200000.00	45.90	6400.00	8.30	5.00	0.50	3.50	5.00
790.00	6.00	39000.00	22.90	4100.00	5.30	3.00	0.50	2.80	4.70

WCMS Example: Analysis of Stream Dewatering/Underground Mining



WCMS – Historical Perspective

- Initial work toward what is now WCMS was initiated in 1990 and has continued to the present
- Primary Steps:
  - ArcInfo (AML) – estimated $30-50,000/user
  - ArcView (Avenue) – estimated $7-12,000/user
  - ArcGIS (Visual Basic) – lower cost

WCMS – Current Development

- Major effort to improve the hydrologic modeling capabilities available to WVDEP/DMR
- Coordinated effort of NRAC and Dept of Civil and Environmental Engineering
- Objective – develop appropriate models of flow for streams in the WV mining region
- Bob Eli will discuss this in depth

Data Development

- Scanned, georeferenced, and digitized mine permit maps for WV
- Completed development of 1:24K NHD
- Developed improved land cover data for WV

Major Investment to Support the CHIA Process

- Since 2001, WVDEP support for WCMS related development made possible by one time PECA funds from OSM is slightly over $1 million
- Supported the transition of WCMS from an ArcView to an ArcGIS application
- Current work concentrates on improved hydrologic and water quality models and integration with WVDEP Oracle databases

Summary

- WCMS remains a work in progress – capabilities continue to expand
- ArcGIS version now being used by WVDEP users
- Usefulness of advanced GIS modeling tools will continue to be data dependent
- Additional data tools developed by WVDEP/TAGIS significantly ease the integration of additional spatial datasets

Future Plans

- Continue to improve and expand capabilities of the ArcGIS WCMS extension
- Port the current Visual Basic version to the Microsoft .Net environment
- Expand the capability to work with other models – supported in the .Net environment
- Improve hydrologic/water quality modeling approach to reflect emerging, spatially explicit, modeling concepts